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Cortisol Levels and Voltage Conditions of College Students

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Abstract

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Dissertation Submitted in Partial Fulfillment

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Abstract

There is a limited research base on low voltage brain conditions, which are characterized by electrical activity being measured at below 20 microvolts. The purpose of this study was to examine the relationship between saliva cortisol levels and voltage using an EGG in a college student population. Illuminating this relationship is important to inform how low voltage conditions can affect daily memory and cognitive functioning of undergraduate college students that may be a result of stress. The college student population may be vulnerable to the low voltage condition because of stress from the transition between teenage and adult life and related social and academic pressures. Sapolsky's theory of stress, which hypothesized that high cortisol levels will manifest as a low voltage condition, guided this study. The sample included 60 undergraduate students recruited by flyers distributed on the campus of a liberal arts college. A multiple regression analysis was used to examine the relationship between explain the variables. Although no low voltage was found in this study sample, the study results contribute to positive social change by providing a better understanding for students and staff of brain functioning when exposed to chronic stress and encourage the implementation of programs for managing stress and prevention of stress before it reaches a chronic state and negatively impacts brain functioning.

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Dedication

To my children, Taylor, Nicholas, Chelsea, and Casey, for providing me with the inspiration and the desire to enhance our lives and your futures!

To my Dad, who has been everything to me, and my Mom, who taught me to be strong in the face of despair, may God bless them both.

To my God, who has given me the faith and understanding of where you chose me to be so that I may be the love, faith, hope, light, and joy to others in need.

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Dr. Richard Soutar, for teaching me, guiding me, and mentoring me in the field of Neurotherapy; you have given me so much, not only with your time and knowledge but the inspiration to be to others what you have been to me.

Table of Contents

List of Tables

Chapter 1: Introduction to the Study

Background

College and university students attend institutions of higher education to become more knowledgeable, contributing members of society. However, students are affected by stress during this time in life. According to a large-scale study, college students are likely to become chronically ill because of the negative impact of stress (Adams, Wharton, Quilter, & Hirsch, 2008). Problems such as depression, anxiety, and exhaustion are possible causes of the increased rates of infectious illness. The most concerning outcome for such distressed students are suicide and substance abuse. Wilcox et al. (2010) reported that there were 2,381 deaths from suicide in 2006 among college students between 18 and 22 years old, making it the second leading cause of death among this group. Wilcox et al. estimated that there are 1,100 suicides each year among college students in this age group. The researchers indicated that the American College Health Association's National College Health Assessment evaluated 26,685 students in a total of 40 postsecondary education programs and found that 1.3% of college students attempted suicide and 6.4% seriously thought about suicide (American College Health Association, 2009).

The National Center on Addiction and Substance Abuse (2007) at Columbia University reported that college student substance abuse is a public health concern on campuses nationwide. Chronic use of alcohol and substances threaten the health of the student and the future well-being of the nation's leadership in an extremely competitive global economy. That National Center on Addiction and Substance Abuse also reported that there has been no decline in substance use and abuse among college students from 2007 since it was first examined in 1993 and 1994, with the situation growing worse. These statistics provide evidence that (a) 49.4% of full time college students binge drink and abuse or use prescription drugs and illegal drugs, (b) one in four college students met diagnostic criteria for substance abuse or dependence, (c) the use of prescription drugs has increased significantly, and (d) the use of marijuana has more than doubled. Even more tragic is that the death rate among United States college students due to unintentional alcohol-related injuries increased by 6% between 1998 and 2001, with incidents totaling 1,717 (National Center on Addiction and Substance Abuse 2007). With the increase in use came an increase in injuries resulting from drinking, alcohol related arrests, sexual assaults, and date rapes. Many of these behaviors can be related to stress and the adjustments that these students go through at this time (Gfroerer, Greenblatt, & Wright, 1997).

In the current study, the existence of stress, as determined by cortisol levels, a hormone released by the outer layer of the adrenal gland when a person is under stress, and its relationship to brain functioning was examined. Stress was measured using the quantitative electroencephalograph (QEEG) digital technology device that records electrical patterns at the surface of the scalp (Krauss & Webber, 2005). This activity primarily reflects cortical electrical activity or brainwaves. The QEEG is a noninvasive process. It is not used as a diagnostic tool or as a substitute for any medical diagnosis but to help in the clinical understanding of various dysfunctional states, such as any brain area that is functioning outside of what is considered a normal range (Brazier, 1961).

An underlying assumption is that students who have increased stress will have resultant low brain voltage or brain power. Previous research by Niedermeyer (1999) reported that low voltage conditions were evident in people identified as chronic alcoholics or who reported chronic alcohol use. In this study, chronic alcohol use was used as a covariate to determine if there is a correlation between the two variables (stress and voltage) without the covariate, alcohol use, interfering with the outcome of the study.

Problem Statement

Sapolsky (2004) and Bremner (2004) researched the effects of stress on the brain and reported that damage to the brain is caused by the chronic release of stress hormones prompted by the body's stress response. The hippocampus, which is intricately linked to memory and learning processes, is involved. However, few empirical studies have demonstrated the relationship among feelings of chronic stress, cortisol levels, and brain functioning as determined by the QEEG. Little research to date has focused on the stressors college students meet in their daily lives and how this might affect brain functioning. Previous studies have indicated that elevated cortisol levels are associated with low voltage in the EEG; however, this has not been investigated more recently and not specifically in the college population. The intention of this study is to understand the correlation between these two variables, stress and voltage activity in the brain, in the undergraduate college population. If the results of this study reveal a correlation between elevated stress in the college student population and the EEG reflecting a low voltage condition, educational institution administrators may have more evidence to address levels of student stress by referring students to programs that target stress reduction and therefore optimize brain functioning. School officials will also be better able to effectively educate students about stress and its effects on the brain and body. Many educational institutions offer stress reduction programs, but students may not be aware of them. Faculty can be trained to identify and support students who may be reaching toxic levels of stress by referring them to a program. The faculty and staff may be required to inform students about the programs that are available instead of the student seeking out the programs themselves. The mandatory information can possibly prevent a student from reaching harmful levels by the student participating in a stress reduction program earlier. The staff, particularly the residential life personnel, may also be trained to look for signs and post information about stress reduction programs that are available at the institution as the new school year starts and then again at the times of midterm exams and final exams. Assessing a correlation between a low voltage condition and increased cortisol will also add to the body of knowledge that exists regarding the low voltage condition. Much research is needed in the area of low voltage EEG in the field of psychophysiology. The results of this study may prompt other investigations and examinations of other factors that may be related to brain functioning.

Purpose of the Study

The purpose of the study is to examine whether a relationship exists between elevated cortisol and a low voltage condition in the EEG in the college student population. The results of this study could lead to positive social changes in educational facilities, educating college students, administrators, and faculty about the relationship of stress and brain functioning leading to expanded mental health intervention and prevention programs. Because there is limited research on low voltage conditions, this study is also intended to add to the literature base regarding why the low voltage condition exists. More available information is needed on low voltage conditions in younger populations; because a low voltage condition is not common in younger age groups, research results should be able to provide some insight into why it may occur.

Nature of the Study

A correlational research design was used to explore the relationship between cortisol levels and QEEG voltage readings. Results may be used to make predictions about whether increased levels of cortisol result in low voltage in the QEEG. A hierarchical linear regression was used to examine the relationship between cortisol levels and QEEG voltage levels. This study also included alcohol use as a covariate. Niedermeyer (1999) and van Sweden (1983) both established that elevated alcohol use is strongly associated with low voltage QEEGs. Although the studies available on college students do not mention any particular year in the undergraduate program but instead look at the population as a whole, none are concerned with differences among students in their first year of study compared to the final year or with stress in the freshman year and in the senior year. This study would help to understand if a student may experience more stress in the first year and become more adapted as the program progresses and if they are more acclimated or more able to cope with changes and demands. Researchers such as Byram and Bilgel (2008) believe that stressors, such as peer pressure, academic pressure, and transition to adulthood, remain throughout the entire 4-year program, but the seniors may be more acclimated to these pressures and in turn experience less stress. They may also experience new stress as they consider life after graduation. This study will also gain an understanding of how some of the demographics that vary in the student population are related. Research by Bayram and Bilgel (2008) revealed that students from a rural geographic area experience more depression, stress, and anxiety than those from non rural areas and that the condition affects their quality of life, educational success, and future. It was thought that adjustment needs are greater in rural students because there may be more adjustments needed in the transition from home life to college life.

The study was carried out by collecting two separate saliva samples with 60 participants, as determined by G*Power analysis. An alpha level of .05 was used for the G*Power analysis, meaning that the probability of falsely rejecting the hypothesis is limited to 0.05. Saliva samples were collected at different times within the same day. One sample was taken in the morning, when cortisol levels should be at their peak, and one in the afternoon, when cortisol levels should be significantly decreased (Fisher, Stoolmiller, Gunnar & Burraston, 2007; Salimetrics, 2009). A QEEG was taken on the same day in the morning at the time of the first saliva sample. A linear multiple regression model was chosen at 0.80 power and a large effect size of 0.35 with two predictor variables. The total sample size required was 31 participants per regression. Therefore, 31 freshman and 31 senior participants and 31 rural and 31 urban participants were necessary. Since location and education are independent, a total of at least 62 was necessary. The 62 participants completed a questionnaire (Appendix A) that identified alcohol use. The goal was to have equal representation of males and females in the sample (31 males and 31 females); however, this depended on the students that voluntarily participate. A hierarchical linear regression found if there was a statistically significant relationship between elevated cortisol and low voltage in the EEG.

This study involved numerous bivariate observations, and these bivariate observations looked at the independent variable, cortisol measures, and the dependent variable, the QEEG, for each participant to determine if there is a relationship. Therefore, a multiple regression and multivariate comparisons were performed to assess the combined effect of the independent variable and the two covariates, which are alcohol use and year in the undergraduate program, in predicting QEEG. Cortisol levels should be elevated in the morning approximately 1 hour after waking and then drop significantly in the late afternoon (Fisher et al., 2007; Salimetrics, 2009). If the stress response were activated throughout the day, the cortisol levels would not drop as expected, but would be equal to or greater than the morning measure (Sapolsky, 2004). In this study, the examination of the two samples was evidence of either abnormal or normal cortisol functioning. Under normal conditions, the afternoon score should be lower than the morning scores.

Theoretical Foundation

This study concerns the area of psychology that focuses on the mental processes that includes how individuals think, perceive, remember, and learn, or what is generally known as cognitive psychology. Cognitive psychology studies provide a framework for how people acquire, process, and store information. Clinical applications include improving memory and decision making and enhancing learning.

Sapolsky (2004) focused his research on issues of stress-related neuron degeneration. Stress can impair memory due to the chronic release of cortisol, which is the stress hormone (Sapolsky, 2004). If cortisol is continuously released due to ongoing stress, it can damage or even kill neurons in the area of the brain that is responsible for learning and memory, the hippocampus. Sapolsky's (2004) lab was the first to document the fact that stress can damage the neurons in the hippocampus. Sapolsky's 2002 study linked hippocampal atrophy to chronic stress due to the chronicity of stress hormones released by the adrenal glands, which then has a negative effect on the hippocampus, the part of the brain associated with learning and memory. Sapolsky's conceptual model maintained that the stress response initially saves lives by helping persons to escape predators or capture prey; however, the current lifesaving physical reaction to stress is used for different purposes, such as coping with the busy aspects of contemporary life. The problem Sapolsky discussed is that the stressors are constant, so the response does not turn off. The sympathetic nervous system normally activates and reduces operations of systems not needed for survival. After the stressful event is over, the parasympathetic nervous system helps the body to return to pre crisis conditions. Sapolsky's (2004) conceptual framework explained that continuous stress keeps the sympathetic nervous system activated, and the body does not relax and return to normal. The release of the stress hormone, cortisol, is part of the stress reaction and occurs throughout the day. The normal diurnal cortisol pattern is that cortisol is released in the body upon waking, helping the body to get systems going for the day. In the later part of the day, usually around 4:00 pm or later, the cortisol levels should be at the lowest levels. If an individual is under chronic stress, the cortisol levels will not decrease as they should in the later part of the day (Sapolsky, 2004). Based on Sapolsky's (2004) stress research framework, the in the current study, I examine if cortisol's effect on the hippocampus will be evident in the QEEG. I anticipated that elevated levels of cortisol, indicating chronic stress, would be seen as low voltage as measured by the QEEG.

In this study, the quantitative electroencephalograph (QEEG) was used to measure brain wave activity and to determine if the structures that are involved in memory and learning have decreased activity. I will attempt to understand if a decrease in activity could be the result of increased cortisol in the body due to stress. As Sapolsky (2004) explained, the abundance of cortisol can damage neurons in the hippocampus. In this study, I focused on examining if there is a relationship between cortisol levels and brain functioning.

Research Questions

Research Question 1

Research Question 1 (RQ1): Do the change scores in cortisol predict QEEG voltage levels after controlling for the covariate of alcohol use?

H_{01}: The change scores in cortisol do not predict QEEG voltage levels after controlling for the covariate of alcohol use.

H_{A1}: The change scores in cortisol predict QEEG voltage levels after controlling for the covariate of alcohol use.

A hierarchical linear regression was conducted to assess if the cortisol change scores predict QEEG after controlling for alcohol as a covariate. At the time of each participant's scheduled appointment (at approximately 8:00 a.m. for the QEEG), the first cortisol levels were taken; a second cortisol level was taken the same day at approximately 4:00 p.m. The independent variable is the cortisol change score, calculated by subtracting the morning level from the afternoon level. The dependent variable in this analysis is QEEG voltage level. The covariate is alcohol use.

Alcohol use is a dichotomous variable and was coded as 0 = *does not use* and 1 = *does use*. *Does use* was based on the National Institute on Alcohol Abuse and Alcoholism's (2004) view of chronic drinking as a pattern of drinking that corresponds to five or more drinks on a single occasion generally within approximately 2 hours. Therefore, in this study, *does use* was determined by participants' reporting of five or more drinks per week. According to the *Dietary Guidelines for Americans* (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2010), those who drank moderately were defined as consuming up to one drink per day for women and up to two drinks per day for men.

Multicollinearity is the evidence of a relationship between the independent variables in a multiple regression, meaning a change in one variable causes a change in the other, and together they cause a change in the dependent variable.

Research Question 2

Research Question 2 (RQ2): For freshmen, do the change scores in cortisol predict QEEG after controlling for the covariate of alcohol use?

H_{02}: For freshmen, the change scores in cortisol do not predict QEEG after controlling for the covariate of alcohol use.

H_{A2}: For freshmen, the change scores in cortisol predict QEEG after controlling for the covariate of alcohol use.

A hierarchical linear regression was conducted to assess if the change scores in cortisol predicted QEEG after controlling for covariates for freshmen only. In the first block of the hierarchical linear regression, the covariates were entered, and the model was tested. In the second block, the predictor variables were entered, and the full model was tested. Cortisol levels were taken at 8:00 a.m. and then again at 4:00 p.m. during the same day. The independent variable is cortisol change score and was calculated by subtracting the morning level from the afternoon level. This is a continuous variable. The dependent variable in this analysis is QEEG and was measured in microvolts. The covariates included alcohol use. Alcohol use is a dichotomous variable and was coded as 0 = *does not* and 1 = *does use*. This analysis will investigate freshman only.

Research Question 3

Research Question 3 (RQ3): For seniors, do the change scores in cortisol predict QEEG after controlling for the covariate of alcohol use?

H_{03}: For seniors, the change scores in cortisol do not predict QEEG after controlling for the covariate of alcohol use.

H_{A3}: For seniors, the change scores in cortisol predict QEEG after controlling for the covariate of alcohol use.

A hierarchical linear regression was conducted to assess if the change scores in cortisol predicted QEEG after controlling for covariates for seniors only. In the first block of the hierarchical linear regression, the covariates were entered, and the model was tested. In the second block, the predictor variables were entered, and the full model was tested. The independent variable is cortisol change score and was calculated by subtracting the morning level from the afternoon level. This is a continuous variable. The dependent variable in this analysis is QEEG. The covariates included alcohol use. Alcohol use is a dichotomous variable and was coded as 0 = *does not* and 1 = *does use*. Only senior students were investigated in this analysis.

Research Question 4

Research Question 4 (RQ4): Is there a statistical difference between the freshman and senior student regression models with cortisol change scores predicting QEEG after controlling for covariate of alcohol use?

H_{04}: There is no difference between the freshman and senior student regression models with cortisol change scores predicting QEEG after controlling for covariate of alcohol use.

H_{A4}: There is a difference between the freshman and senior student regression models with cortisol change scores predicting QEEG after controlling for covariate of alcohol use.

A Levene's test for homogeneity of regression was conducted to assess if there is a difference in the strength of the regression for cortisol change scores predicting QEEG after controlling for covariates by group (freshman vs. senior). The Levene's test assesses the homogeneity of error variances across the two groups. The homogeneity of error variances tests whether or not the dispersion was different among the two groups. If the test is significant, it will suggest that the two groups' dispersion is different, thus showing a significant difference in the two groups' regression models.

Research Question 5

Research Question 5 (RQ5): For rural participants only, do the change scores in cortisol predict QEEG after controlling for the covariate of alcohol use?

H_{05}: For rural participants only, the change scores in cortisol do not predict QEEG after controlling for the covariate of alcohol use.

H_{A5}: For rural participants only, the change scores in cortisol predict QEEG after controlling for the covariate of alcohol use.

A hierarchical linear regression was conducted to assess if the change scores in cortisol predicted QEEG, after controlling for covariates, for rural participants only. In the first block of the hierarchical linear regression, the covariates were entered, and the model was tested. In the second block, the predictor variables were entered, and the full model was tested. The independent variable is cortisol change score and was calculated by subtracting the morning level from the afternoon level. This is a continuous variable. The dependent variable in this analysis is QEEG. The covariates included alcohol use. Alcohol use is a dichotomous variable and was coded as 0 = *does not* and 1 = *does use*. Only rural participants were investigated in this analysis.

Research Question 6

Research Question 6 (RQ6): For urban and suburban participants only, do the change scores in cortisol predict QEEG after controlling for the covariate of alcohol use?

H_{06}: For urban and suburban participants only, the change scores in cortisol do not predict QEEG after controlling for the covariate of alcohol use.

H_{A6}: For urban and suburban participants only, the change scores in cortisol predict QEEG after controlling for the covariate of alcohol use.

A hierarchical linear regression was conducted to assess if the change scores in cortisol predicted QEEG after controlling for covariates for urban and suburban participants only. In the first block of the hierarchical linear regression, the covariates were entered and the model was tested. In the second block, the predictor variables were entered, and the full model was tested. The independent variable is cortisol change score and was calculated by subtracting the morning level from the afternoon level. This is a continuous variable. The dependent variable in this analysis is QEEG. The covariates included alcohol use. Alcohol use is a dichotomous variable and was coded as 0 = *does not* and 1 = *does use*. Only urban or suburban participants were investigated in this analysis.

Research Question 7

Research Question 7 (RQ7): Is there a statistical difference between the rural and non rural regression models with cortisol change scores predicting QEEG after controlling for covariate of alcohol use?

H_{07}: There is no difference between the rural and non rural regression models with cortisol change scores predicting QEEG after controlling for covariate of alcohol use.

H_{A7}: There is a difference between the rural and non rural regression models with cortisol change scores predicting QEEG after controlling for covariate of alcohol use.

A Levene's test for homogeneity of regression was conducted to assess if there is a difference in the strength of the regression for cortisol change scores predicting QEEG after controlling for covariates by group (rural vs. non rural). The Levene's test assesses the homogeneity of error variances across the two groups. By testing the homogeneity of error variances, it tested whether or not the dispersion is different among the two groups. If the test is significant, it will suggest that the two groups' dispersion is different, thus showing a significant difference in the two groups' regression models.

The assumptions of normality and homoscedasticity were assessed using scatter plots. The absence of multicollinearity was assessed through examination of the variance inflation factors (VIF) for each independent variable; VIF values over 10.0 will suggest the presence of multicollinearity (Stevens, 2009).

Definition of Terms

Alcohol use is the consumption of five or more alcoholic drinks per week (National Institute of Alcohol Abuse and Alcoholism, 2004).

Cortisol is a steroid hormone released by the adrenal glands in response to stress (Talbott, 2007).

Flight or fight response is a stage in the stress response that activates the sympathetic nervous system, priming one for either fighting or fleeing (Sapolsky, 2004).

Low voltage is defined by any magnitude or power produced by the brain that is lower than normal for the average adult. This was determined by the New Mind Database analysis (Soutar & Longo, 2011).

Quantitative electroencephalograph (QEEG) is a digital recording of the brainwave activity that is a result of bioelectrical potentials within the brain. Cortical electrical activity, also known as brainwaves, is quantitatively recorded using digital technology (Brazier, 1961).

Rural is a nonmetropolitan area of "residents in incorporated places having up to 2,500 persons" or an average of 15 people per square mile (U.S. Census Bureau, 1995).

Urban is a metropolitan area "with a population density of an average of 2,760 people per square mile" or a minimum of 1,000 per square mile (U.S. Census Bureau, 1995).

Voltage, also known as magnitude or power, indicates the power or magnitude of the brainwave activity; the unit for the frequency is reported in hertz (Soutar & Longo, 2011).

Assumptions

An assumption of this study is that if the cortisol levels are equal to or higher in the afternoon than the morning, it will predict a low voltage QEEG. Another assumption is that those participants who have elevated afternoon cortisol levels have increased stress. In this study, I assumed that the stress can be attributed to many factors, particularly the adjustment and pressures related to academics, socializing, and adulthood. A final assumption is that a correlation exists between elevated cortisol levels and low voltage conditions in the participants.

Limitations

Limited research exists on the topic of low voltage conditions in EEG recordings. A limitation of the study is that the participants will not have had a QEEG, and there will be no baseline QEEG. The college where the sample was drawn includes students from many states and nations; this will help decreased the limitation of generalizing the findings. Another possible limitation is that participants may not have honestly answered the questionnaire regarding alcohol consumption. To reduce this possibility, participants were informed that the answers were strictly confidential and no information would be released to anyone. Regarding individual differences and limitations of this study, no screening for various personality traits or characteristics or assessment of coping skills took place, and there was no way of knowing which students may be better able to cope with stress. A drawback to this study would be that it did not examine the factor of support; thus, there is no way of understanding if a better support system, either at home, from peers, or others helps eliminate or reduce stress in the undergraduate college years.

Significance of the Study

The purpose of the study was to examine the relationship between cortisol and QEEG voltage levels using alcohol use as a covariate. Understanding these relationships may contribute to social change because educators will have an increased knowledge about how stress can affect brain functioning, and they can, in turn, better educate students on the effects of chronic stress, specifically its effects on the brain. College and university administrators can institute programs to identify and prevent stress and intervene with those students who are experiencing high levels of stress.

Chapter 2: Literature Review

Introduction of Literature

Chronic stress and the chronic release of the stress hormones, particularly cortisol, have a direct effect on the hippocampus, a brain structure involved in learning and memory (Sapolsky, 2004). An extensive literature review from 1940 to the present was conducted using various databases such as PsycINFO and PsycARTICLES. The search revealed minimal research has been published regarding low voltage activity. Searches were also done using the Academic Complete Search and Multidisciplinary Database through the Walden University Library and databases from Association for Applied Psychophysiology and Biofeedback (AAPB), *The Journal of Neurotherapy*, and general searches on the internet. There was some interest in this topic in the early 1940s and 1950s. Niedermeyer (1999) explained low voltage (i.e., activity under 20 microvolts) and revealed that a low voltage condition is evident in persons with chronic alcoholism. Stern (2005) supported Niedermeyer and noted that a generalized low voltage condition is likely attributed to degeneration or metabolic issues. According to Stern, between 30% and 60% of individuals diagnosed with Huntington's disease have this condition. Interest in low voltage activity subsided sometime after the 1950s, and there is little or no mention from there on.

The transition to college and a more autonomous personal life entails many changes for young adults who leave home to pursue a postsecondary education (Byram & Bilgel, 2008). These individuals are met with psychological and psychosocial changes, including demanding academic workloads, new social burdens, and the stress of planning and preparing for professional careers. There has been much research on these topics; however, few studies have examined the brain functioning of this group in terms of brain electrical activity measured with the QEEG. Brain functioning research using measures such as the QEEG may shed greater light on the mechanisms involved in cognitive and memory processing.

College and university students who face stressors can have (a) more chronic illness (Adams et al., 2008) and illicit drug use (DeSantis et al., 2008), (b) increased suicides rates (Schwartz, 2006), and (c) more exhaustion (Law, 2007). Students experiencing confusing emotions and stressful major life events also may increase their use of alcohol (Rose, Shaw, Prendergast, & Little, 2010). Researchers like Bayram and Bilgel (2008) described high rates of depression, anxiety, and stress in this group of young adults but did not explore how these conditions relate to brain activity. Several teams of researchers across the past 15 years, including Billiot, Budzynski, and Andrasik (1997) and Rose et al. (2010), provided evidence that variables such as fatigue and alcohol have a direct effect on brain functioning because of decreased activity in the hippocampus related to cell death. This can also be true when an individual experiences continued or chronic stress. In this present study, the direction and strength of the correlation between cortisol levels and electrical activity in the cortex was investigated. The intention of this research was to (a) add to the body of knowledge in the field of psychophysiology with a specific interest in the college population and (b) help practitioners who are working with this population to understand the need for interventions on a cellular level of brain functioning and provide prevention measures to address potential problems so that the student can have a more positive experience and better well-being.

Mental health is a major concern on college and university campuses. Bayram and Bilgel (2008) provided evidence in their study that examined the prevalence of depression, anxiety, and stress in an undergraduate population of Turkish students. Bayram and Bilgel believed that the problem of stress, anxiety, and depression in this population could have a direct impact on the quality of life, their educational successes, and future occupational successes. The social and intellectual pressures and challenges experienced by this group can also lead to depression, anxiety, and stress. Bayram and Bilgel measured depression, anxiety, and stress using the Depression Anxiety and Stress Scale (DASS-42). The DASS-42 is a self-administered instrument that was revised for the Turkish study. The reliability coefficients of the revised instrument were 89.1, 82.6, and 85.9 for depression, anxiety, and stress as reported by the authors. The limitation of using this tool is that it is a self-report measure. Self-reporting can be skewed if a student does not report accurately because of social demand characteristics or extraneous variables, like mood or time of day tested. However, it was reported by the researchers that the participating students were assured that there would be no negative consequences if they chose not to participate and information provided would be anonymous. The researchers also collected demographic data including family income, family educational background, and scholarship and grant status to further explore variables that mediate the level of stress experienced by students.

Moderate to severe anxiety was found in 2.17% of all participants (Bayram & Bilgel, 2008). The data were subdivided into three categories related to the degree of anxiety experienced by the participant (i.e., normal, mild, and severe). Anxiety was higher in females and first- and second-year students. Bayram and Bilgel (2008) attributed this finding to feelings associated with transitioning from home to adult life; third- and fourth-year students may be better adjusted than first- and second-year students. The first- and second-year students may be more vulnerable to stress and anxiety than students who have had a few years to adjust and transition. Bayram and Bilgel also found that students from lower income families had more depression and stress at this time but reported little anxiety. Students who reported higher incidences of satisfaction had less anxiety and stress. Students who were from rural geographic areas were higher in depression, stress, and anxiety, which could indicate that the adjustment from rural living to college life was a greater change and required a greater adjustment in that period of transition. Bayram and Bilgel's findings differed from previous research because they found higher averages for the normative data but showed increases when looking at a college student population. The authors also indicated that previous studies showed greater depression, stress, and anxiety in females (e.g., Adewuya, Ola, Olutayo, Mapayi, & Oginni, 2006; Wong, Cheung, Chan, Ma, & Tang, 2006). Bayram and Bilgel showed that there was a weak relationship among depression, anxiety, stress, and gender. However, depression was more prevalent among females.

When individuals are experiencing emotional distress, they are more likely to have problems with physical health because the body's natural reaction to stress decreases the strength of immune response (Bremner, 2004). Adams et al. (2008) studied 18- to 24-year-old university students to further explore the relationship between students' mental health and acute infectious illness. They hypothesized that the deteriorating mental health of a student could make them more likely to experience an acute infectious illness. The infectious illnesses examined included bronchitis, ear infection, sinus infection, and strep throat. Adams et al. addressed a gap in the existing literature at the time regarding infectious disease and mental health. In previous studies, college students were not targeted as a population, whereas other researchers examining adults in general found associations between adult mental health and infectious illness or illness. Adams et al.'s quantitative study had a large sample of 47,202 college students who were selected from the American College Health Association's National College Health Assessment Data. Collecting data from this extensive database made it possible to obtain such a large sample size. Adams et al. looked at the social problem of depression, anxiety, and exhaustion in college students. Based on the information revealed by the American College Health Association, college students experience higher-than-normal rates of infectious illness, especially during times of high stress. It was also stated that the increased infectious illness affects productivity, functioning, and general health.

College students are at a critical development period when they are forming habits that will probably remain with them into their adulthood; the high risk of unhealthy behaviors and the practices they acquire during this time of transition can be detrimental to their health and their academic success (Adams et al., 2008). Research was strengthened by its large sample size and was the first of a nationwide sample on this topic, helping with generalization. The survey tool used in the study had limitations, however. Each school that participated was able to choose whether they wanted to use an online version or a standard pencil and paper survey, affecting the validity of the tool because there was no way to control for completion rates, the care with which the students completed the answers, and the susceptibility to answer incorrectly or falsify information that may have varied between versions of the tool.

To increase accuracy of data collection, the researchers omitted any of the surveys that were between one and four standard deviations from the mean results. Adams et al. (2008) added variables that were not used in other studies (e.g., alcohol consumption, number of recent sex partners, body mass indexes that were below 15 and above 45) because these situations could have created greater risk of a variety of health issues and concerns. The surveys were carefully evaluated by a team that included a variety of college health professionals to ensure reliability and validity.

Adams et al. (2008) identified four dependent measures that provided data regarding the presence of infectious illness: bronchitis, ear infection, sinus infection, and strep throat. The independent variable was the incidence of depression and anxiety within a 12-month time frame. Students who reported depression and were being clinically treated were omitted from the concluding data. The 5-item Likert-type scale was used to measure negative affect such as feelings of hopelessness, being overwhelmed, exhaustion, and sadness or depression, as these were thought to interfere with the functioning of the student. Some of the covariates identified were smoking, binge drinking, physical activity, and sleep. Adams et al. found that the absence of depression and anxiety had a strong positive correlation to decreased incidences of infectious illness.

A notable part of Adams et al.'s (2008) study was that exhaustion and acute illness had a strong relationship; 29% of participants with chronic illness reported feeling overwhelmed or exhausted. Students with higher levels of exhaustion were more likely to be ill, and the correlation regressed accordingly. Adams et al. found that students who had greater amounts of depression, anxiety, and exhaustion had a higher incidence of acute infectious illness. The implications of the study can be applied to other educational facilities and can indicate a need for programs that will help students with better self-management and personal skills to reduce the depression, stress, and feelings of being overwhelmed and, in turn, reduce illness.

College Student Stressors

DeSantis et al. (2008) explained that college students report feeling stressed, overwhelmed, anxious, and depressed from academic pressures. Many times these students do not have the support to help them deal with these intense feelings. Many college students tend to turn to peers for support, which may lead to unhealthy ways of coping. An increasing number of students reported symptoms related to stress, anxiousness, and being overwhelmed and then turn to the use of illegal prescription drugs to alleviate those feelings. According to DeSantis et al., many students who feel they need to be more academically successful will cope by using drugs that were prescribed for attention deficit hyperactivity disorder (ADHD). To investigate the social problem of the increasing trend of illicit use of stimulants among college students, DeSantis et al.

used both quantitative and qualitative methods to study 1,811 undergraduate students at a large, public, southeastern U. S. research university to provide a greater understanding of the reasons, methods, precipitating factors, motives, and access routes to the drugs. Surveys were administered to students across three semesters, with researchers conducting 175 in-depth interviews to understand students' perception and use of stimulant drugs like the ones prescribed for ADHD.

Results from DeSantis et al.'s (2008) survey indicated that 65% used these illicit drugs for better concentration, 59.8% to help them study, and 47.5% to increase alertness; others reported using illicit drugs to get better grades, fight fatigue, and increase energy. Surprisingly, the illicit drugs were rarely used for recreational purposes. A significant limitation of this study was that the participants were taken from a convenience sample. Participants were students enrolled in an introductory communications class at the university. DeSantis et al. excluded 78 students from the data set who reported having a legal prescription for ADHD medication; 34% of the remaining participants reported using ADHD medications illegally. There was an equal representation of illegal users between genders, with most (94%) being Caucasian.

The interviews revealed that many of the students were not very concerned about the use of illegal drugs, and many did not seek any information about the drug; it was considered "normal." Many of the users in DeSantis et al.'s (2008) study had limited understanding of the negative implications of use, such as physiological or psychological side effects, and legal consequences. Use increased during times of higher stress and anxiety (e.g., finals week). The researchers concluded the increase in use could likely be due to the availability of the drug, the casual attitude toward the use of the drugs, and the consistent reports of successful use of the drug as stated above.

DeSantis et al. (2008) followed previous studies, such as McCabe et al. (2005), who conducted an investigation of the increased use of illicit ADHD medications among college students. They studied multiple sites with 10,904 students in an undergraduate program in the United States by administering surveys and found that 41% of the participants reported illegal use of prescription stimulants in the past 12 months. Consistent with DeSantis et al.'s (2008) study, the majority of illegal users were Caucasian. Students who were enrolled in academic programs with more competitive admission standards also had higher rates of use.

Another study similar to DeSantis et al.'s (2008) was that of Teter et al. (2006), who investigated the same topic but focused on ethnicity and motivation. Teter et al. found that Caucasian and Latino students were more likely to engage in illegal use of stimulants drugs than African American and Asian students. Teter et al. reported that regardless of ethnicity, many students indulged in illicit use of ADHD medications to enhance their performance academically. Teter et al. found that 65% of the participants reported use to increase their concentration, 59.8% reported use to aid in studying, and 47.5% used to increase attention. The difference between Teter et al. and DeSantis et al. was that 31% of participants used the drug illegally to "get high" and 29.9% reported using just for experimenting.

Although these studies provide a better understanding about the abuse of stimulants and the etiology of the use, they lack the scope of a connection to brain functioning and how the use of these stimulants can negatively affect brain functioning. DeSantis et al. (2008), McCabe et al. (2006), and Teter et al. (2006) evidenced that stress related to academic pressures may lead many students to seek alternative ways to cope. Sapolsky (2004) clearly stated that stress and the stress hormone released by the adrenal glands negatively affects the brain, especially the hippocampus, which is involved in learning and memory. In this study. I examined whether there is a relationship between the stress students experience and brain functioning.

QEEG Recording

Before QEEGs, the only way to record this activity was on paper with a traditional polygraph (Krauss & Webber, 2005). However, over the last 25 years, advances in technology have resulted in devices to record and measure brainwaves in a more efficient manner. Brainwave functioning is now analyzed in various ways, for example, magnitude or power across the scalp (Krauss & Webber, 2005). The QEEG is a bioelectrical potential that is recorded from the head by way of electrodes and specialized equipment. The QEEG indicated that the brain's electrical signals (EEG) contained regular patterns and could be understood by their frequency; therefore, the QEEG records that electrical activity by way of electrodes placed on the major hubs of the brain. The Fast Fourier Transformation (FFT) is an algorithm, which is a device used for separating the EEG frequencies and calculating them into quantitative data (Cooley & Tukey, 1965). The recorded information can also be compared to a normative database to further understand where current functioning deviates from normal functioning. The New Mind Database was developed by New Mind in 1995 (Soutar, 2011) and is used as a normative database. The database is used to compare a set of readings to what is determined normal. The database used in this study, The New Mind Database, can be used for all stages of development and includes a population that was drawn from a representative sample. The population includes people from diverse ethnic and cultural backgrounds. According to Thatcher (1998), the United States ethnic population includes 18% African-Americans, 3% Asian, 12% Hispanic, and 63% Caucasian. Socioeconomic status and handedness were also considered for the population criteria. A detailed neurological questionnaire for the population included information about whether the person had an uneventful prenatal, perinatal and postnatal period, no disorders of consciousness, no head injury with cerebral symptoms, no history of central nervous diseases, no convulsions of emotional, febrile, or other nature, and no abnormal deviation with regard to mental and physical development. If anyone answered “yes” to any of these questions, they would be excluded. A number of databases are available today, and clinicians have discretion about which one to use.

Preceding the QEEG was the identification of brainwave rhythms. The first human electroencephalograph (EEG), a device to measure brainwave rhythms, was recorded by Hans Berger in 1929, when he identified the first brainwave rhythm, which he called alpha (Reilly, 2005). Berger then identified other brainwave rhythms that are common to the brainwave activity. Today, they are known as beta, theta, and delta. The measures recorded at the scalp are the result of electrical potentials and provide an observation of cerebral activity. Measurable surface potentials known as voltage are produced by neurons in the higher layers of the cortex. The higher or outer layers are considered the processing layers of the brain. The predominant brainwave signals are generated by large pyramidal cells evident in the four lobes of the brain that are designated the frontal, parietal, occipital, and temporal lobes. The measurable signals happen when activity of cortical cells are excited or depolarized in unison, providing a harmonic potential, which is the summation of many small electrical potentials. The brain potentials are able to reach the scalp and be recorded at the site of the electrode by a process known as volume conduction. This measure of the cellular activity helps clinicians listen in on the brain's activity (Reilly, 2005). Electrodes are placed at 20 different locations on the scalp, currently known as the International 10-20 system. According to Reilly, the system was developed by a committee of the International Federation of Societies for Electroencephalography and Clinical Neurophysiology to ensure that the electrodes were placed in standardized locations.

Lubar (1997) explained that when an individual experiences any psychiatric, psychological, or physical symptom, electrical activity in the brain of those individuals is somehow dysregulated. Lubar provided a comprehensive explanation about the neocortical dynamics and the EEG. The power is driven by rapidly acting neurotransmitters. The entire brain is home to over 100 billion neurons, with each of these neurons having more than 200 connections with other neurons. The brain also houses more than 250 neuromodulators, neurohormones, peptides, and transmitters. The amount of activity in the brain is difficult to determine. The discipline of neuroscience has assisted in the comprehension of this highly complex system from a molecular, neuronal level and behavioral level. Within the neocortical dynamics there are interactions of several types.

An EEG is a graphical recording of the electrical activity produced by the brain and recorded. The EEG is the recording of electrical activity along the scalp that is produced by the firing of neurons within the brain. Lubar (1997) also stated that the process of learning involves assemblies of cells and that they are constantly changing with new learning. The brain has 100 billion neurons, and some are continually lost and, while some cannot be replaced, new neurons are developed with new learning. The more the brain is stimulated, the more connectivity it has, creating new cell assemblies and new circuits as knowledge is acquired. Lubar explained that the EEG is a recording of the electrical activity over 19 locations around the cortex that is compared to a normative data base to identify the areas of dysregulation.

When individuals have frontal lobe under activation, they may be experiencing ADHD). This is identified by an increase in the slow wave activity in the 4 to 7 hertz frequencies. Activity in the 4 to 12 hertz range in the central and frontal parts of the brain has also been associated with ADHD (Lubar, 1997). This gives a clear picture that a disorder such as ADHD has neurological markers.

The EEG is a recording of the actual brainwave activity in a visual representation. However, the QEEG differs from the EEG because it transforms the EEG data into quantitative data that can be used to determine correlates of brain activity with psychological, psychiatric, and physical disorders. The QEEG was developed over time with the first discovery of electrical activity in the brains of rabbits and monkeys in 1875 by Richard Canton, a physician (Swartz & Goldensohn, 1998). In 1912, Vladimir Vladimirovich Pravdich-Neminsky, a Russian physiologist, published his work on the first EEG recorded on an animal. In 1914, Napolion Cybulski, a scientist, revealed the first photographed EEG of an experimentally induced seizure. In 1924, Hans Berger recorded the first human EEG and invented the first electroencephalogram. In 1934, the first EEG laboratory was opened at Massachusetts General Hospital. The American EEG society began in 1947, and the first International EEG congress was held in 1953, when Aserinsky and Kleitman defined REM sleep with the EEG (Swartz & Goldensohn, 1998).

William Grey Walter developed a device in 1950 that allowed the mapping of electrical activity across the brain's surface (Swartz & Goldensohn, 1998). Years later, Nuwer (1997) described the digital EEG as an acquisition of the paperless recording of the EEG by a computer-based device. The main purpose at the time was to save paper and the visual aspect of the EEG. The difference between the digital EEG and the QEEG was defined as the processing of mathematical digitally recorded EEG. The QEEG was named because of the numerical component of measuring the EEG. According to Thatcher and Lubar (2008), Berger was the first to publish a study using the Fourier transformation to analyze the EEG. Thatcher and Lubar (2008) reported that Berger understood the importance of quantification and objectivity when evaluating the EEG.

The QEEG had the ability to reliably understand brain functioning by the distribution of the brain's electrical activity and compare the EEG to normative databases. The QEEG is known to be stable and reliable. For example, Thatcher and Lubar (2008) explained that stability and reliability have been documented throughout scientific literature. Salinsky (1991) reported that test-retest reliability was impressive and explained that repeated samples 20 seconds in length were 82% reliable, after 40 seconds the reliability increased to 90%, then at 60 seconds the reliability increased to 92%. In 1988, Gasser, Verleger, Bacher, and Sroka determined that 20 seconds of recording was sufficient to adequately reduce the variability characteristic in the EEG. Hamilton-Bruce, Boundy, and Purdie (1991) found a statistically high reliability when the same recording of EEG was independently examined by three different individuals. Thatcher (2010) extensively examined the validity and reliability of the QEEG and reported that the QEEG has high levels of split-half and test-retest reliability being greater than 0.9 and remains stable with high test-retest reliability over days and weeks. The QEEG was also examined for predictive validity and other validity measures were significant. The predictive validity was established by significant and replicable correlations with accurate predictions of results and performance on neuropsychological tests. Content validity was established by correlations with independent measures including magnetic resonance imaging (MRI), positron emissions tomography (PET) and the single-photon emission computerized tomography (SPECT). Scientific literature demonstrates significant correlations for a variety of clinical disorders. For example, Linden, Monastra, and Lubar (2001) studied the reliability and validity of the QEEG for ADHD conducted on 469 participants and found the QEEG to be considerably reliable with $r = .96$ consistent with the Attention Deficit Disorders Evaluation Scale. The sensitivity of the QEEG-derived attentional index was 90% and specificity was 94%.

The QEEG is reliable and valid and can be valuable in obtaining information about undergraduate students and their current concerns. The QEEG can provide a clearer understanding of brain functioning when exposed to stressors and possible increased cortisol levels.

Low Voltage EEGS

Research about low voltage EEGs is scarce, but Niedermeyer (1999) provided a classical piece of literature on the subject of the normal EEG (recording of brainwave activity). No current literature is available. Niedermeyer, a leading researcher in the field of EEG, provided a comprehensive description of the range of bands, including their creation. Scientists identify each wave and the frequency it measures in hertz. Niedermeyer described the bands from delta, which is the slowest (measuring below 3.5 hertz), followed by theta (4-7 hertz), alpha (8-13 hertz), beta (above 13 hertz), a second beta band higher than beta (14-30 hertz) and gamma (the fastest at above 30 hertz). The EEG amplitude represents the EEG voltage that is plotted against time and is measured from peak to peak; any frequency can be considered outside of the normal range if it is displayed by excessive voltage and is consistent throughout all frequencies. Niedermeyer stated that the issue of "low voltage can indicate a life-threatening decline of cerebral voltage output whereas the vast majority of low voltage records are 'desynchronized' and a variant of normalcy" (p. 150). This statement indicates the importance of the low voltage condition, but research on the condition is limited.

For the normal EEG, that which is considered average for a particular developmental stage, Niedermeyer (1999) explained the recording of low voltage, which is lower than normal EEG, but does so in technical terms that can be difficult for a layperson to understand. Niedermeyer provided some reasons for the low voltage condition, including desynchronization of activity, genetic factors, late stages alcoholism, post-concussion syndrome, and posttraumatic neurosis. The low voltage condition is evident in a comatose individual, indicating a true decrease in cerebral activity, and is not because of any desynchronization. A notable point in Niedermeyer's text indicates the prevalence of low voltage conditions in individuals ranging from 0 to 20 years old is only 1%, but as the normal individual progresses through the developmental stages, the potential for the low voltage condition increases. Individuals from ages 20 to 39 have 7% incidence of low voltage conditions, and those aged 40 to 69 years have an 11% incidence. Thus, the low voltage condition is less common in the younger population. The low voltage condition in a child younger than 10 years is abnormal if found during a state of being awake and alert. In the childhood stages, the EEG has a healthy amount of power, measured in voltage. As people age and progress along the developmental stages, they tend to lose neuroplasticity. A young person is unlikely to have a decreased amount of power in the EEG. In diseases of the basal ganglia, such as Huntington's chorea, an increased incidence of low voltage conditions is present that can be attributed to a loss of activity in the cortex. The low voltage condition has been predominantly associated with chronic alcoholics. A lack of scientific research exists on the topic of low voltage EEG activity. Although Niedermeyer provided a comprehensive and detailed report on the normal EEG, research is needed in other areas than those mentioned and the low voltage EEG.

Stress and Brain Functioning

Mills, Reiss, and Dombeck (2008) explained the natural stress response. When there is a perceived stressor (threatening situation), the sympathetic nervous system prepares for a "flight or fight" response and triggers the hypothalamic-pituitary-adrenal axis (HPA), which involves both the brain and the nervous systems. The hypothalamus releases corticotrophin releasing hormone (CRH), which activates the pituitary gland. The pituitary releases adrenocorticotropin (ACTH) into the bloodstream. As the process continues, the ACTH then triggers the adrenal gland, which is located at the top of the kidneys, to release cortisol, cortisone, epinephrine (adrenalin), and norepinephrine (noradrenalin). Cortisol will immediately elevate the glucose levels in both the brain and the bloodstream. The increased glucose in the brain helps promote better attention and quicken cognitive processing. The cortisol diverts blood away from all nonessential systems such as the immune, digestive, and reproductive systems and drives it toward muscles and the brain to enhance physical functioning to better concentrate on the perceived stress. The release of cortisol communicates to the hypothalamus to slow down the production of CRH. The epinephrine and norepinephrine elevate heart rate, blood pressure, and energy levels and reduces reaction time. However, when stress is constant the "alarm system" stays activated and leaves an abundance of cortisol and other stress hormones. These overages can interrupt bodily processes and interfere with neurotransmitter activity, placing the individual at risk for a variety of health problems. Most likely the hippocampus, an essential part of the brain, will be damaged (Mills et al., 2008).

Kirschbaum, Wolf, May, Wippich, and Hellhammer (1996) explored the effects of elevated cortisol on the brain and memory in healthy adults in two separate studies. In the first of the two studies, 13 students were paid to participate and were asked to refrain from any activities that would increase stress, such as exercise, smoking, large meals, and any drinks with low pH, for approximately 1 week prior to the study. They were exposed to the “Trier Social Stress Test.” This test has been proven to provoke moderate psychosocial stress. The researchers carefully planned the series of events and conducted the study in the part of the day that would not interfere with the circadian rhythms of the participants because they affects cortisol production. After the stress test, the participants were given memory tests that were adjusted to identify differentiation between both hippocampus-mediated memory and non-hippocampus-mediated memory. In the second study, a total of 40 randomly assigned male volunteers followed the same restricted activities as the participants in the first study. They were divided into an experimental group and a control group. The control group was given a placebo and the experimental group was -given 10 milligrams of hydrocortisone acetate and the same memory tests as the first group.

The results of the first study indicated an increase in salivary cortisol as a result of the stress test. Men had a greater increase in cortisol than women (Kirschbaum et al., 1996). In the second study no significant differences were present in the cortisol levels between the groups, but cortisol was elevated 1 hour after either the application of the cortisol or conclusion of the memory test. Overall, the placebo group was able to recall more on the hippocampus memory test, identified as declarative memory, than the experimental group that received the cortisol application. The experimental group made as many as twice the number of errors as the control group. No treatment effects for non-hippocampus memory (procedural memory) between groups were found (Kirschbaum et al., 1996).

The implication of the two studies is that increased cortisol significantly impaired declarative memory, which is a function of the hippocampus (Kirschbaum et al., 1996). The study was adequately designed and organized and had few limitations. The results of this study clearly showed that there could be damage in the hippocampal regions of the brain, causing decreased functioning in the electrical activity. The decreased electrical activity would be evident in the QEEG. According to Kirschbaum et al., the results of this study supported previous research with animals and clinical observations that implied that cortisol elevation damaged both simple and more complicated forms of declarative memory but did not significantly impact procedural memory.

Both depression and psychosocial stress are conditions that were reported among college students (Bayram & Bilgel, 2008) and may indicate that depression is in some way linked to psychosocial stress. A number of researchers investigated the activation of the HPA system. The HPA system is directly involved in the process of cortisol secretion as a result of stress and the fight or flight activation. To further look at the role of cortisol levels and effects on serotonin uptake in depressed individuals, Tafet et al. (2001) tested the hypothesis that the overactive HPA axis causes hyper-cortisolism, a possible implication in the damaged process of serotonergic neurotransmitters. They examined the possible correlational relationship between these variables using a mixed method design that involved a total of 28 participants aged 36 to 60 years with a mean age of 44.8 years. The participants were recruited from the Department of Psychiatry at a hospital in Buenos Aires. The depressed patients were drawn from the hospital while the patients with major depressive disorder (MDD) were recruited from the outpatient program. The control group of healthy controls was drawn from hospital staff. Each participant interviewed was compared to the DSM-IV for diagnostic criteria that correlated with both MDD or generalized anxiety disorder (GAD). Each of the participants was then tested via blood analysis for cortisol levels at 8:00 a.m. when cortisol levels should be elevated and at 4:00 p.m. when the levels should be decreased, and normal ranges were identified. Both cortisol levels and serotonin uptake activity were measured.

According to Tafet et al. (2001), previous researchers determined that cortisol enhances the uptake of serotonin. In depressed individuals there is not enough serotonin in the synaptic area, and the depressed individual is usually given a serotonin reuptake inhibitor so that more of the serotonin can remain at the synapse to alleviate some of the depressive symptoms. Tafet et al. explained that prior studies left a gap in the hypothesis that the mechanism of cortisol on serotonin could provide a molecular relationship between the overactive HPA in those who are chronically stressed and the dysfunctional serotonergic system of those who are depressed. Of the 28 participants in their study, 8 were identified as MDD, 12 identified as GAD, and 8 were the healthy control group. The results were notable because the mean for the control group cortisol level was 18.8ng/dl in the morning and 8.6ng/dl in the afternoon, for a ratio that was less than 50%. The GAD group measured at 17.7ng/dl in the afternoon, which was significantly higher than the 8.6ng/dl mean, but the morning levels were within normal ranges. The ratio for this group was higher than 50%. The researchers concluded that the circadian rhythm was dysfunctional and caused cortisol secretion to remain elevated in the afternoon. The group with MDD also had an increase in cortisol in the afternoon, but, consistent with the GAD group morning levels, were within normal ranges. As expected, the serotonin uptake measured by the peripheral blood lymphocytes indicated that the control group showed an increased response to serotonin uptake, whereas the group with MDD and GAD showed no elevation. The researchers found statistically significant differences between the control group and GAD group and between the control group and MDD group, but no difference between the MDD and GAD groups. They also reported statistically significant differences between the serotonin uptake and plasma cortisol levels in the afternoon. The elevation in the afternoon was significantly correlated with the response in the serotonin uptake after incubation with cortisol (Tafet et al., 2001). This research shows a link between cortisol and chronic stress and chronic stress and the development of depression. In college students, many studies show that chronic stress, anxiety, and depression are major concerns for students (Adams et al. 2008; Byram & Bilgel, 2008).

Stress and the Brain

The present study investigated the relationship between stress and the continued release of cortisol, which is the result of chronic stress, with a low voltage condition in the EEG to understand if elevated levels of cortisol can predict a low voltage condition in the QEEG. According to Duff (2005), low voltage is likely to have an etiology that is either degenerative or metabolic. Some rare metabolic causes are hypothermia, hypoglycemia, and hypothyroidism. Duff reported alcoholism can cause low voltage EEG and exhausted adrenals, a condition that occurs when the adrenal glands are overactive or overworked and can have the same effect on brain power. Duff's research showed a strong connection between stress and gastrointestinal issues, which can have a negative effect by exhausting the adrenals, destroying brain cells, and limiting the immune response. The stress and exhaustion of the adrenals can be strongly correlated with low EEG power.

Bremner (2004) argued that diagnoses of posttraumatic stress disorder, anxiety disorder, depression, alcohol and substance abuse disorders, dissociative disorders, and borderline personality disorder and stress are strongly related. According to Bremner, these disorders are similar and often comorbid because of overlapping symptoms. As mentioned previously, the extended release of cortisol damages the hippocampus, which is involved in learning and memory. An adequate release of cortisol is essential and beneficial for improvement of cognition and attention because of its stimulating effects in the prefrontal cortex. However, at extreme levels, the brain will begin to shut down and experience physical damage (Bremner, 2004).

Bremner (2004) studied MRI techniques that were used on individuals with posttraumatic stress disorder (PTSD) and found that the volume of the hippocampus was actually smaller than controls. Bremner explained that the continued experience of stress and its related processes decreases the production of neurotrophins in the hippocampus and causes an inhibition of hippocampal neurogenesis, the growth of new neurons. After looking at the MRIs of subjects, Bremner found that the long-term dysregulation of cortisol and norepinephrine caused the brain to resemble those patients who have organic memory problems or early dementia. He hypothesized that these symptoms were significantly correlated with the effects of stress on the hippocampus. His findings were consistent with the majority of stress literature reviewed. The release of cortisol aids in survival by redistributing energy and suppressing other systems that are not immediately needed during times of fear or survival such as the reproductive system, immune systems, digestive systems (Mills et al., 2008). However, the long-term effects cannot only damage brain function but are also correlated with gastric ulcers and thinning bones (Bremner, 2004).

Bremner (2004) studied patients who were veterans of war diagnosed with PTSD and those who were survivors of childhood physical and sexual abuse and found similar results; that is, the hippocampus indicated loss of neurons and there were memory and cognitive deficits. These findings can be related to hypercortisolism because of chronic release under stress or stressful conditions. The overall findings were that chronic elevated cortisol can negatively affect mood, lead to depression and fatigue, impair the immune system and result in frequent or chronic physical illness, and can increase the rate of cancers. These findings can explain some of the earlier studies that indicated college students have more frequent chronic illness and increased rates of depression, stress, and anxiety (e.g., Adams et al., 2008).

Increased cortisol was also connected to an increase in deposition of intra-abdominal fat, which is also related to an increase in mortality and obesity in general.

Stress, as Bremner (2004) stated, can negatively affect the cardiovascular system with elevated risks for heart disease. Bremner linked the negative effects, physical illness and increased risks and neuronal damage on the brain. The death of cells or decreased neurogenesis can be related to low voltage EEGs in the college population because at that stage of development, neuronal damage is not likely to occur from aging (Niedermeyer, 1999).

Low Voltage EEGs and Current Research

Considerable evidence exists that the college population is at heightened risk for chronic illness, suicide, and impaired cognition (Adams et al., 2008). Bremner (2004) noted a statistically strong significance in the relationship between increased or prolonged exposure to cortisol and the damage to the areas of the brain such as the hippocampus, which is involved in memory and cognition. Information in the existing literature about low voltage EEG among this population is scarce, but researchers have linked low voltage to both chronic alcohol use and metabolic issues (Duff, 2005). Stern (2005) noted that "generalized low voltage activity is more likely to have an etiology that is degenerative or metabolic" (p. 196). Stern reported that the results may point to degenerative diseases like Huntington's, Alzheimer's and Creutzfeldt-Jakobs, which show low voltage EEGs. For example, Stern reported that between 30% and 60% of persons diagnosed with Huntington's disease have significantly low voltage EEGs. Some metabolic causes are hypothyroidism, abnormal parathyroid functioning, and chronic alcoholism. Literature on the topic of low voltage EEG is extremely rare.

Rose et al. (2010) provided information that shows a correlation between alcohol dependence and neurotoxicity but did not provide any statistical analysis indicating the strength of the relationship. Rose et al. indicated that a relationship between increased cortisol and chronic stress can affect the success of sobriety and the development of disorders. Rose et al.'s article is notable because it indicates that alcohol users showed an increased amount of cortisol as a response to triggers or cues and that the cortisol response was dulled in those individuals who use alcohol chronically compared to drinkers who indulge moderately. The results of this study showed a link between hypo cortisol functioning as a risk marker for alcohol susceptibility. The researchers attempted to close the gap in the existing literature about the causes of cognitive deficits and neuroanatomical damage associated with chronic alcohol use and identify social problems in the area of treatment outcomes. They also sought to clarify misunderstandings of why treatments are not as effective as they could be and why users in treatment tend to relapse. Rose et al. (2010) stressed an overlooked reason for why disorders develop initially. This research can also be applied to educational institutions when there are students who are being treated for alcohol or substance use.

Rose et al.'s (2010) research questioned how chronic alcoholism alters brain concentrations of glucocorticoids and the role of glucocorticoids in the creation of cognitive decline that is subsequent to the cessation of alcohol consumption. Rose et al. failed to indicate the details of the study, such as the population, how it was drawn, and the gathering of the data and how it was examined, but clearly and comprehensively described the findings, that alcohol use and its related behaviors are triggered by stress and this process may be the physiological attempt to compensate for the interference in cortisol processes. The findings show a strong relationship in the cortisol functions and the desire to indulge in alcohol. The findings used various participants such as those who were dependent, those who desire to cease use and those who seek to develop some control over their use, and social users with and without risks factors for becoming dependent. Overall, the conclusion is that cortisol has the potential for being an antecedent and a result of dangerous drinking. Rose et al. also indicated that cortisol is a major risk factor in the relapse of a drinker and the maintenance of excessive drinking. The mechanism of action is that the increased brain levels of glucocorticoids after cessation from chronic alcohol use have implications in many aspects of dependency. Rose (2010) established that this process also plays a key role in cognitive deficits, which is consistent with earlier research and studies regarding how the increase of cortisol damages both memory and cognition by hippocampal damage (Sapolsky, 2004).

Sapolsky (2004) also implied that the increased levels of hormone could be related to the reduced glucocorticoid release in response to increased stress during the time of abstinence from use. This is mainly because of the release of ACTH from the pituitary gland, which controls the release of glucocorticoids from the adrenals. It is also thought that the increased concentrations of glucocorticoids are key factors in the motivation to drink (Rose, 2010). Researchers showed the importance of understanding the entire system when looking at the HPA alterations and the possibility that the HPA changes alter the central nervous system (Sapolsky, 2004). The confirmation of the role of cortisol in both the degeneration and brain functioning, the effect cortisol has on the success of treatment, and the part in motivation to indulge in this negative behavior will help in several ways. First, the understanding will help inform pharmacological interventions to make such treatment more effective and have prolonged effects. Second, the understanding will help contribute to policies and intervention techniques aimed at reducing drinking levels. If this information is shared with the public on more personal level, professionals can help individuals before a disorder or dependence develops. This research can lead to further research on how the relationship with cortisol affects the voltage of brain activity

Low Voltage EEGs and Chronic Fatigue

Cortisol continues to be targeted in the studies of brain functioning. EEG patterns of patients diagnosed with chronic fatigue syndrome were studied by Billiot et al. (1997), who examined EEG patterns and the connection to chronic fatigue syndrome in 28 female patients with and 28 without chronic fatigue. Billiot et al. noted that chronic fatigue syndrome is strongly related to depression. The researchers determined the correlation using the Beck Depression Inventory. The participants in the study with chronic fatigue were determined to be in the severe range. Billiot et al. also determined that depression was a major antecedent to chronic fatigue.

Billiot et al. (1997) noted that a social problem associated with chronic fatigue syndrome was that those with chronic fatigue syndrome consistently reported cognitive difficulties. Billiot et al. indicated that some of the previous studies showed impairment in cognition as a result of, not a precursor to, chronic fatigue. This observation was consistent with information that correlates chronic fatigue with depression, and that depression is, in part, related to other conditions such as stress and anxiety. In this study, Billiot et al. attempted to clarify the differences in the relationship between neurological impairment and chronic fatigue and compare to patterns found in the EEG. Billiot et al. included 56 participants, 28 of the participants were female with a diagnosis of chronic fatigue and the other 28 were females without a diagnosis of chronic fatigue. Participants were recruited by newspaper advertisements and announcements in chronic fatigue support groups within the community and the control group was recruited from the University of Florida, which was also in the local community. The researchers used a global symptom questionnaire that was created for the study. The instrument was a 7-point scale (0 = *none,* 6 = *extreme or severe*). A questionnaire was also used to collect information about the participants' sleep. Because these scales were developed just for this study, there were no reliability and validity measures. Another scale that was used was the Profile of Fatigue-Related Symptoms (PFRS), which consisted of 54 questions divided into sections that tracked four domains—emotional distress, cognitive difficulty, fatigue, and somatic symptoms. The PFRS has been shown to have acceptable validity; test-retest reliability scores reported were .7 on the fatigue scale and 0.86 for the emotional distress scale (p. 21).

One hypothesis was that chronic fatigue participants would have an EEG pattern different from the control group and that the differences in those patterns would be even greater when the participants were performing a difficult task. Another hypothesis in this study was that those with chronic fatigue who rated greater difficulties in sleep, fatigue, cognitive difficulties, emotional distress, and somatic symptoms would negatively correlate with peak alpha frequencies (identified as 8-12 hertz). The 8-12 hertz range is where the majority of energy is generated (Billiot et al., 1997). Participants with chronic fatigue were required to be diagnosed by a qualified physician. Of the participants, 8 had full time employment, 3 were employed part time and 17 were unemployed. Twelve of those with the diagnosis were taking antidepressants. The researchers were careful to control for age differences and participants were matched for age because EEG patterns tend to change over the lifespan (Niedermeyer, 1999). The experimental group was aged 26 to 73 and the ages of control group ranged from 24 to 74 years. The results indicated that those with chronic fatigue had significant psychological differences compared to the control group and that the participants with chronic fatigue and depression differed from the controls in overall neuropsychological performance. The researchers determined that depression does not satisfactorily explain cognitive impairment; the only variation between chronic fatigue patients and depressed individuals was the symptoms of fatigue. Another significant result was that there were no neuropsychological differences between chronic fatigue and a depressed patient except that reaction time on tasks was delayed compared to controls. The experimental group had a negative correlation with peak alpha (8-12 hertz) with rating scales, and peak frequency (4-20 hertz) was negatively correlated with theta to beta ratios on the total fatigue score. During the difficult task, peak frequency correlated negatively with total cognitive deficits. No differences were found in EEG patterns between the employed and unemployed participants or between the chronic fatigue group who were taking antidepressants and those without medications (Billiot et al., 1997).

The importance of this study was the determination that chronic fatigue symptomology is evident in physiological EEG and that definitive results showed more severe impairments in those with chronic fatigue than the controls, as indicated by higher micro voltage activity in the slower frequencies. The condition of higher activity in the slower frequencies is associated with cognitive difficulties. One major limitation of this study was that the demographic area was limited which may reduce generalizability. The researchers also indicated a need for further studies in which data from a full cap (meaning all brain areas) EEG recording because this study only included one active channel. Research is still needed to determine the etiological factors for chronic fatigue. The results showed a connection between chronic fatigue, depression, and EEG patterns. The researchers reported that the EEG changes show reliability and may help in treatment programs and protocols that attempt to normalize brainwave activity.

Present Study

There seemed to be interest in low voltage activity in the 1940s through the 1960s. During that timeframe low voltage conditions were related to Huntington's disease and chronic alcohol use; however, little information exists in the literature in the years that followed. Thus, further research is needed that specifically relates to the social, psychological, physical, and academic concerns of the college student population. A strong connection exists between these conditions and heightened cortisol, which is known to cause damage to the cortex, especially the hippocampus, which is responsible for memory and cognition (Sapolsky, 2004). The missing piece of information is that the physical EEG of these individuals can be altered resulting in low voltage conditions. The researcher anticipated that the results of the present study about the possible relationship between cortisol and low voltage activity would provide information about how increased cortisol can affect brain functioning and prompt further investigations into low voltage conditions that may be the basis of interventions for prevention, treatment, and increased awareness of the physical changes in the brain.

Chapter 3: Research Method

Introduction

The purpose of the study is to examine the relationship between cortisol levels and low voltage condition in the EEG in the college student population. The prediction is that when cortisol levels are elevated, a low voltage condition will be indicated on a QEEG. A quantitative research design, specifically hierarchical linear regression, was chosen because it was the most suitable design to examine the relationship between the cortisol levels and the QEEG. Hierarchical linear regression had an advantage over the typical multiple regression because the typical regression includes all of the predictor variables into the regression at once and examines the overall effect. However, hierarchical linear regression is a more step-by-step approach for looking at how the model changes from just the covariate of alcohol use to the covariate of alcohol use and the change in cortisol.

Stress in college student populations could be accounted for by the stress of transition from home life to a more autonomous life and the entrance into adulthood during the first years of college; however, stress may subside over the course of the undergraduate program as students become more familiar or acclimated to the changes (Bayram & Bilgel, 2008). In this study, the effect of elevated cortisol on the voltage of individuals' EEG, as measured by the QEEG, was examined.

In the present study, correlations between undergraduate students' cortisol levels (as determined by a cortisol swab test) and QEEG scores were assessed. Cortisol levels were taken initially in the morning when they should be at the highest and again in the later part of the afternoon when the cortisol levels should have decreased. QEEGs were collected as a measure of the magnitude of electrical activity in the brain, measured as voltage. A random sample of approximately 62 college students between the ages of 18 and 22 years were chosen as participants. Because Stern (2005) and Niedermeyer (1999) found a correlation between low voltage conditions and chronic alcohol use, participants were screened for chronic alcohol use, as this may be the cause of a low voltage condition and that participant may meet exclusion criteria. The participants who reported indulging in alcohol three or more times per week over a period of 3 months were considered chronic and were excluded. Those who reported binge drinking were also excluded. The definition of binge drinking was consistent with the research by Courtney and Polich (2009), who defined binge drinking as at least five alcoholic drinks consumed at the same session. The College Alcohol Study (CAS) completed at Harvard's School of Public Health concluded that five drinks for a male and four drinks for a female will bring the individual's blood alcohol content (BAC) to 0.08 gram percent or above (Courtney & Polich, 2009). Another covariate examined is the year in the undergraduate program. I examined if there is more stress in the first year of college compared to the final year. Stress was identified by the levels of change in cortisol for the freshman students as compared to the senior students.

Research Design

Hierarchical linear regression was used to examine the relationship between cortisol and voltage in the EEG. The analysis included the results of both saliva samples and a QEEG, which was administered to the chosen sample with equal representation of male and female participants and included participants from rural, suburban, and urban locations and various demographic backgrounds. Participants also participated in a cortisol swab test that included collecting a saliva sample once in the morning, approximately between 8:00 am when the normal cortisol should be elevated and again at approximately 4:00 pm, when the cortisol levels should have dropped significantly. At the first appointment at approximately 8:00 am, participants were then given a QEEG. The QEEG was analyzed for voltage condition. The QEEG indicated if the electrical activity was within normal levels, overactive, meaning either one or two standard deviations above normal levels, or underactive, meaning either one or two standard deviations below normal levels, to determine if there is a low voltage condition. Along with the two measures, cortisol and QEEG, the participants also completed a short questionnaire that provided information regarding the year in their undergraduate program (i.e., freshman, sophomore, junior, or senior) and the demographic status for covariate analysis. The questionnaire also addressed if there is any chronic alcohol use. Research by Niedermeyer (1999) indicated a correlation between chronic alcohol use and low voltage EEGs.

Participants

Sixty-two individuals of both genders between the ages of 18 and 22 participated. The participants were from a variety of geographical locations and attended a liberal arts college in the North East United States. According to school statistics, a total of 1,531 students attend, and the student body consists of students from 30 different states and 22 countries. Males represent 41% of the population, and females represent 59%; 12% of the population is African American, Latino, Asian American, or Native American. This age group was chosen because it is the average age of college students that participate in an undergraduate program (American College Health Association, 2009). The age groups chosen should have normal cortisol levels without the presence of depression, anxiety, and stress and are not likely to have low voltage EEGs due to aging.

The sampling method was a cluster sampling, which allowed me to choose a particular college to make up the population. Because of the diversity of students in college, I anticipated that the participants represented a variety of geographical areas, including rural, urban, and suburban areas and allowed for greater generalization. The sample size of 62 was needed to achieve appropriate statistical power for the analysis to determine significance at .05 levels and to allow for normal attrition. G*power analysis indicated that for the effect size of .05, a large effect, the sample size should be 62.

Ethics and Codes

The American Psychological Association's Ethics and Code of Conduct (2002) requires that an individual's participation in this study be based upon informed consent and Institutional Review Board (IRB) oversight. These standards require that researchers provide accurate information about the nature of the study. The IRB's oversight also ensures that the study is conducted according to protocol (IRB approval #06-21-13-093242).

Participants were advised about the purpose of the study, its expected duration, and the procedures associated with the study. Participants were also advised of their unconditional right to decline participation at any time throughout the study and the potential research benefits. The participants were given every opportunity to ask questions or obtain information about the study, ensuring that their decision to participate was voluntary and rational.

Standard 4.01 of the Ethics Code requires that the researcher respect the privacy and dignity of the participants in the study by protecting confidential information and requires discussion with participants about the limits of confidentiality and the foreseeable potential uses of the information generated during the course of the study.

Each identified participant consented to complete the measurement tools: two separate cortisol saliva swabs and a QEEG. The participants were screened for exclusion criterion (excessive alcohol use). Gender, ethnicity, geographical area, and other demographic information were not used as a basis for exclusion. Any participant under the age of 18 years old or over the age of 22 years and any individual between the ages of 18 to 22 in a graduate program were was excluded.

The ages of the participants were chosen to target a particular stage in continued education programs. The ages 18 to 22 are considered to be the typical ages for undergraduate students (American College Health Association, 2009).

Measures

The cortisol swab tests were done with an oral swab that was taken two times, once in the morning when cortisol levels should be at their highest and again in the latter part of the day, approximately around 4:00 pm, when the cortisol levels should be lower. I took the swabs both times using Salimetrics Oral Swab (SOS) kits. The Salimetrics Laboratory reported the performance characteristics for the cortisol analysis to be accurate. The Salimetrics Laboratory reported that the sensitivity limit is determined by interpolating the mean minus 2 standard deviations for 10 sets of duplicates at 0 ug/dL standard, and the minimum concentration of cortisol that can be distinguished from 0 is 0.003 ug/dL. The laboratory also reported on the correlation with serum, determined by assaying 49 matched samples using the Diagnostic Systems Laboratories serum Cortisol EIA and the Salimetrics HS Salivary Cortisol EIA and found the correlations between saliva and serum was statistically significant at r (47) = 0.91, $p < 0.0001$.

The collection procedure was a noninvasive process, limiting the risks of any adverse effect. The saliva collection kit required passive drool to be collected by a cotton swab, which was then secured into a provided vial. The participants were required to refrain from alcohol use 12 hours prior to sample collection and to refrain from eating a major meal within 60 minutes of the collection. Participants were told to avoid dairy products for approximately 20 minutes prior to the collection. At the time of collection, it was explained how to prepare the mouth and collect the saliva via the swab. The saliva collection was recorded with time and date of collection. Recording the time and date of the collection when samples are obtained is important because of the diurnal variation in cortisol levels. Keeping samples cold is also important to avoid any bacterial growth in the specimen; therefore, the samples were refrigerated within 30 minutes of collecting and kept frozen at or below -20 degrees Celsius within 4 hours after the collection. The samples were stored at this temperature for long-term storage. The samples on all participants were then shipped to the Salimetrics Laboratory for processing after collection. Salimetrics Laboratories is Clinical Lab Improvement Amendments (CLIA) certified. According to the United States Department of Health and Human Services (2012), using a certified laboratory will ensure quality lab testing. The lab processing included one sample to be tested in two separate wells and provided three results, one for each well and a mean. The duplicate test ensured accuracy. To ensure sanitary conditions, each of the samples was taken from a sealed sample kit provided by the laboratory and allowed the student to collect his or her own sample from his or her mouth. This protected both the participants and me from exposure to saliva and participant exposure to my interference during the collection. As directed by the lab, the samples were stored in a freezer until packaged with dry ice and shipped to the laboratory for analysis.

EEG Recording

A Lexicorp EEG Cap, which has the electrodes permanently placed in the cap to ensure accuracy of placement, was used in this study. The electrodes were injected with electro gel used as an electrical conductor. Two electrodes, one placed on each ear, were used as a ground and reference. The recordings were taken in an eyes-closed condition. The electrical activity was then fed through a computer system and recorded quantitatively. The equipment also included an Atlantis 2 x 2 made by Brainmaster Technologies. The output from the measured recordings was in Excel format. These quantitative measures were compared with a clinical database to be correlatively analyzed. The New Mind Database was the database used for the correlative analysis. The analyzed results are presented in a brain map, which indicates areas within the four lobes of the brain and how they measure correlatively to normal limits. When the quantitative measures are compared to the database, an analysis can be made as to whether the values are normal, low, or high. A map was produced that indicates the areas of measures and revealed whether they were within normal limits. The map also showed areas that are either 1 standard deviation or 2 standard deviations from normal in either direction; the determination of global low voltage included the summary of the quantitative data having an overall average in all frequency ranges below 20 microvolts. The existing literature by Niedermeyer (1999) identified low voltage conditions as below 20 microvolts.

Data Analysis

All data were entered into the Predictive Analytics Software (PASW), the 18.0 version for Windows. PASW was the Statistical Packages for the Social Sciences (SPSS) but was changed to PASW for the 18.0 version. Descriptive statistics described the sample demographics and the identified variables used in the analysis. The calculations included frequencies and percentages for nominal (categorical/dichotomous) data, such as gender, geographical location, and grade level. The means and standard deviations were also calculated for continuous (interval/ratio) data, such as age.

Justification

Because there are numerous bivariate observations in the analyses, multiple regressions and multivariate comparisons were also conducted to assess the collective effect of the independent and dependent variables to reduce the risk of Type I errors or the probability of rejecting the null hypothesis when it is true, suggesting that a relationship exists only by chance (Stevens, 2009).

Hierarchical linear regression was conducted to assess if the independent variable (cortisol changes levels) predicts the dependent variable (voltage condition in the QEEG criterion) after controlling for the covariates (alcohol use and year in school) entered in the first block. Hierarchical linear regressions are an appropriate analysis when the goal of research is to assess the extent of a relationship among a set of dichotomous or interval/ratio predictor variables on an interval/ratio criterion variable. The examination of freshman year compared to senior year may help to understand if after some experience, the student may have less stress.

Chapter 4: Results

The purpose of this study was to examine a possible relationship between elevated cortisol and brain functioning, which could indicate stress and a low voltage condition in the QEEG of a group of college students. The results of this study could drive changes in how educational institutions look at, manage, and educate their students about stress and the potential negative consequences of chronic stress.

The research questions of this study were as follows:

RQ1: Do the change scores in cortisol predict QEEG voltage levels after controlling for the covariate of alcohol use?

RQ2: For freshman, do the change scores in cortisol predict QEEG voltage after controlling for the covariate of alcohol use in freshman?

RQ3: For seniors, do the change scores in cortisol predict QEEG voltage after controlling for the covariate of alcohol use in seniors?

RQ4: Is there a statistical difference between freshman and senior student regression models with cortisol change scores predicting QEEG voltage after controlling for the covariate of alcohol use?

RQ5: For rural participants only, do the change scores in cortisol predict QEEG voltage after controlling for the covariate of alcohol use in students of a rural background.

RQ6: For urban and suburban participants only, do the change scores in cortisol predict QEEG voltage after controlling for the covariate of alcohol use in students of an urban or suburban background.

RQ7: Is there a statistical difference between rural and non rural student regression models with cortisol change scores predicting QEEG voltage after controlling for the covariate of alcohol use.

In this chapter, I will include a review of the purpose, research questions, and hypotheses. I will describe the data collection, including the time frame and the actual recruitment and response rates. I will also include information about participants' characteristics and description and, finally, the results of the data analysis. Results will be presented in table form. In the final portion of this chapter, I will summarize the answers to the research questions.

Data Collection

I recruited participants at the beginning of the academic school year by visiting the campus and posting flyers on bulletin boards campus wide. Potential participants called me and asked questions about the research and what their participation would involve. There were a total of 64 participants who signed up, and all but four completed the data collection. All data collection was completed by the end of the first semester and carried out as planned; the only discrepancy was in the total number of participants. The goal of the study was to have sample of 62 college students, but over a 3-month period only 60 participants were included in the study. All participants complied with taking the first of the two saliva swabs within 1 hour after waking and were able to return at approximately 4:00 p.m. for the second swab. All participants were within 20 minutes of the goal times for saliva collection. All storage and shipping of saliva samples were carried out as planned. There were no discrepancies with any of the saliva samples or

QEEGs.

Results: Descriptive Statistics

A total of 60 participants took part in the study. The majority of the participants were female (85%) and had between one and five drinks per week (65%); 30% did not drink, 2% had between six and 10 drinks, and 3% had more than 10. Most of the participants were Caucasian (48, 80%). The most common program of study of participants was psychology (26, 43%). The majority of the participants were in their first year at school (39, 65%) and had moderate stress (33, 55%), with “academic” being listed as the greatest stressor. The majority was not diagnosed with a stress-related disorder (49, 82%) and was not taking medications (33, 55%). A total of 15 participants (25%) had a traumatic brain injury, and 12 participants had a concussion in the past (20%). Most of the participants were from a non rural location (40, 67%). Frequencies and percentages for participant demographics are presented in Table 1.

Table 1

Frequencies and Percentages for Participant Demographics

Demographic	*n*	%
Gender		
Female	51	85
Male	9	15
Drinks per week		
0	18	30

Table continues

Demographic	*n*	%
1 – 5	39	65
6 – 9	1	2
10+	2	3
Ethnicity		
African American	2	3
Asian	2	3
Caucasian	48	80
Hispanic	5	8
Other	3	5
Program		
Art	1	2
Art history	1	2
Biology	7	12
Biology/Psychology	1	2
Business	3	5
English	2	3
Music	1	2
NPSY	1	2
Nursing	3	5
OTHER	1	2
Performing Arts	1	2
Political Science	2	3
Psychology	26	43
Sociology	2	3
Spanish	2	3
Speech	1	2
Undecided	5	8
Freshman	39	65
Sophomore	9	15
Junior	8	13
Senior	4	7
Stress		
Mild	23	38
Moderate	33	55
Severe	4	7
Stressor		
Academic	53	88
Social	1	2
Financial	1	2

Table continues

Demographic	*n*	%
Independent living	1	2
Social	4	7
Diagnosed with stress-related disorder		
No	49	82
Yes	11	18
Taking medication		
No	33	55
Yes	27	45
Traumatic brain injury		
No	45	75
Yes	15	25
Concussion		
No	48	80
Yes	12	20
Location		
Rural	20	33
Non-rural	40	67

Note. Percentages may not total 100 due to rounding error.

Age of the participants ranged from 18 to 22 years. The average participant was 18.92 years (*SD* = 1.06). The average number of healthcare visits for that year among the students was 1.63 (*SD* = 1.80). The average number of mental health professional visits was 0.50 visits (*SD* = 1.94). The average SB1 (first saliva sample) score among the students was 0.47 ug/dL (*SD* = 0.28). The normal range of saliva scores is between .0112 to 1.348 ug/dL. The normal range of the second saliva sample (SB2) is ND (none detected) to 0.359 ug/dL. On average, the second saliva score decreased to 0.17 ug/dL (*SD* = 0.16). The voltage sum ranged from 16.45 mv (micro-volts) to 56.56 mv, with an average of 32.05 mv (*SD* = 8.59). The normal range would be any value over 20.00 mv. Means and standard deviations for continuous characteristics among the students are presented in Table 2.

Table 2

Means and Standard Deviations for Continuous Characteristics

Characteristic	*M*	*SD*
Age	18.92	1.06
Health care visits	1.63	1.80
Mental health professional visits	0.50	1.94
SB1	0.47	0.28
SB2	0.17	0.16
Voltage sum	32.05	8.59

Research Question 1

Do the change scores in cortisol predict QEEG voltage levels after controlling for the covariate of alcohol use?

To examine Research Question 1, a hierarchical linear regression was conducted to assess if the change in cortisol levels (from SB1 to SB2) predicted the voltage sum after controlling for alcohol use. Alcohol use was dichotomized into no drinks per week versus one or more. Prior to analysis, normality was assessed by viewing a P-P plot of the residuals. The plot showed no strong deviation from normality, and the assumption was met. Homoscedasticity was assessed by viewing a scatterplot of the residuals and predicted values. There was no pattern found in the scatterplot, and thus the assumption was met.

Results of the linear regression did not show significance in the first step (with only alcohol use), $F(1, 58) = 1.17$, $p = .285$, $R^2 = .02$, suggesting that alcohol use did not predict the voltage sum. Once the change from SB1 to SB2 was added into the model, the results of the regression still did not show significance, $F(2, 57) = 1.23$, $p = .299$, $R^2 = .04$, suggesting that the change in cortisol levels did not predict the voltage sum. Because the linear regression model was not significant, the individual predictors were not examined further. Since no significance was found, Null Hypothesis 1, the change scores in cortisol do not predict QEEG levels after controlling for alcohol use, cannot be rejected. Results of the regression are presented in Table 3.

Table 3

Results for Hierarchical Linear Regression With Cortisol Change Scores Predicting QEEG Levels

Source	*B*	*SE*	β	*t*	*P*
Alcohol use	-2.01	2.47	-.11	-0.81	.420
Change in cortisol	4.00	3.52	.15	1.14	.260

Note. $F(2, 57) = 1.23$, $p = .299$, $R^2 = .04$.

Research Question 2

For freshman, does the change in cortisol predict QEEG after controlling for the covariate of alcohol use?

Research Question 3

For seniors, does the change in cortisol predict QEEG after controlling for the covariate of alcohol use?

Research Question 4

Is there a statistical difference between the freshman and senior student regression models with cortisol change scores predicting QEEG after controlling for the covariate of alcohol use?

To examine Research Questions 2 and 3, the hierarchical linear regression conducted for Research Question 1 was split into two separate models. One model examined freshman only. Because of the low sample size, the second model used sophomores through seniors. Alcohol use was dichotomized into no drinks per week versus one or more. Prior to analysis, normality was assessed by viewing a P-P plot of the residuals. The plot showed no strong deviation from normality, and the assumption was met. Homoscedasticity was assessed by viewing a scatterplot of the residuals and predicted values. There was no pattern found in the scatterplot, and thus the assumption was met.

Results for the model for freshman did not show significance when the change in cortisol levels were added, $F(2, 36) = 2.22$, $p = .124$, $R^2 = .11$, suggesting that the change in cortisol levels did not predict the voltage sum for freshman only. Results of the regression came out similarly for sophomores and above, $F(2, 18) = 0.73$, $p = .496$, $R^2 = .08$, suggesting that the change in cortisol levels did not predict the voltage sum for sophomores through seniors. Because significance was not found in the models, Null Hypotheses 2 and 3, the change scores in cortisol do not predict QEEG after controlling for alcohol use for freshman (H2) and seniors (H3), could not be rejected. Results of the hierarchical linear regressions are presented in Table 4.

Table 4

Results for Hierarchical Linear Regression With Cortisol Change Scores Predicting QEEG Levels Split by Grade

Source	*B*	*SE*	β	*t*	*p*
Freshman					
Alcohol use	-5.68	2.95	-.32	-1.92	.062
Change in cortisol	0.89	4.66	.06	0.19	.849
Sophomore and above					
Alcohol use	4.00	4.50	.20	0.89	.386
Change in cortisol	5.12	5.96	.20	0.86	.402

Note. $F(2, 36) = 2.22$, $p = .124$, $R^2 = .11$ for freshman. $F(2, 18) = 0.73$, $p = .496$, $R^2 = .08$ for sophomores and above.

To examine Research Question 4, a Levene's test was conducted to assess if there were differences between the freshman model and sophomore through seniors models. Results of the Levene's test did not show significance, $F(1, 58) = 0.12$, $p = .736$. This suggests that there were no differences between the freshman and sophomore through senior models. Because significance was not found, Null Hypothesis 4, there is no difference between the freshman and senior student regression models, cannot be rejected.

Research Question 5

For rural participants only, do the change scores in cortisol predict QEEG after controlling for the covariate of alcohol use?

Research Question 6

For urban and suburban participants only, do the change scores in cortisol predict QEEG after controlling for the covariate of alcohol use?

Research Question 7

Is there a statistical difference between the rural and non rural regression models with cortisol change scores predicting QEEG after controlling for covariate of alcohol use?

To examine Research Questions 5 and 6, the hierarchical linear regression conducted for Research Question 1 was split into two separate models. One model examined rural participants only. The second model used non rural participants only. Alcohol use was dichotomized into no drinks per week versus one or more. Prior to analysis, normality was assessed by viewing a P-P plot of the residuals. The plot showed no strong deviation from normality, and the assumption was met. Homoscedasticity was assessed by viewing a scatterplot of the residuals and predicted values. There was no pattern found in the scatterplot, and thus the assumption was met.

Results for the model for rural participants did not show significance when the change in cortisol levels was added, $F(2, 17) = 1.01$, $p = .384$, $R^2 = .11$, suggesting that the change in cortisol levels did not predict the voltage sum for rural participants only. Results of the regression came out similarly for non rural participants, $F(2, 37) = 0.71$, $p = .499$, $R^2 = .04$, suggesting that the change in cortisol levels did not predict the voltage sum for non rural participants. Because significance was not found in the models, Null Hypotheses 5 and 6, the change scores in cortisol do not predict QEEG after controlling for alcohol use for rural (H5) and non rural (H6) participants, could not be rejected. Results of the hierarchical linear regressions are presented in Table 5.

Table 5

Results for Hierarchical Linear Regression With Cortisol Change Scores Predicting QEEG Levels Split by Location

Source	*B*	*SE*	β	*t*	*p*
Rural					
Alcohol use	-0.53	3.78	-.03	-0.14	.890
Change in cortisol	8.12	5.85	.32	1.39	.183
Non-rural					
Alcohol use	-3.45	3.43	-.17	-1.00	.322
Change in cortisol	1.37	4.66	.05	0.29	.770

Note. $F(2, 17) = 1.01$, $p = .384$, $R^2 = .11$ for rural participants. $F(2, 37) = 0.71$, $p = .499$, $R^2 = .04$ for non rural participants.

To examine Research Question 7, a Levene's test was conducted to assess if there were differences in the rural and non-rural models. Results of the Levene's test did not show significance, $F(1, 58) = 0.21$, $p = .649$. This suggests that there were no differences between the rural and non rural models. Because significance was not found, Null Hypothesis 7–there is no difference between rural and non rural student regression models cannot be rejected.

Summary

Of the 60 students who volunteered to participate in the study, the majority of the participants were Caucasian female freshmen in the psychology program at Hartwick College. The majority reported that academics were the main source of their stress. Three percent of the participants reported drinking 10 or more drinks per week, 30%

indicated that they did not drink at all, and 65% had between one and five drinks per week. Responses of participants who reported never being diagnosed with a stress related disorder and those not taking any medications were consistent, indicating that there were no students who were taking medications for a stress-related disorder. There were minor discrepancies in levels of stress between those from rural geographical areas and those from non-rural areas (these included suburban and urban areas).

All of the participants were between the ages of 18 and 22 years. The average cortisol measure for the participants was 0.47 ug/dL for the morning sample and 0.17 for the afternoon sample. These measures are consistent with what would be expected from the normal diurnal variation for cortisol. The mean for voltage from all 60 participants was 32.05, which indicated that the average for the participants was not considered low voltage.

When analyzing the first research question regarding the relationship of change in cortisol levels that predicted QEEG voltage levels, the results showed no statistical significance in cortisol change scores that would predict the QEEG. In other words, because the results showed that the average participant had a normal cortisol level when comparing the morning sample, which should be higher, to the afternoon sample, which should be lower, there should be no prediction of a low voltage condition. These findings caused the null hypothesis to not be rejected.

Research questions two and three concerned the variables for freshman and seniors; thus, the linear regression was split into two models in which one examined freshman and the other examined seniors. Because of the low sample size, the latter model combined the other levels of the undergraduate program, which included sophomore, juniors and seniors or non-freshman. Each of the models showed no statistical significance, suggesting that the change in cortisol levels did not predict the QEEG voltage. Again, the null hypothesis could not be rejected. The fourth research question asked if there was a significant difference between freshman and sophomore through seniors. The results showed no significant differences, and the null hypothesis could not be rejected.

As with research questions two and three, questions five and six had similar outcomes. Because of the low sample size, these models also had to be split into two models, one for rural participants and the other for non-rural participants. The results of this examination indicated no statistical significance, supporting the assumption that there was no reason to believe that the change scores in cortisol levels predicted voltage in the QEEG. Finally, research question 7 asked if there was a difference in the rural and non-rural models and resulted in no differences between the two groups. The null hypothesis was not rejected. Further discussion about these results appears in Chapter 5.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this study was to examine whether a relationship exists between elevated cortisol and a low voltage condition in the EEG in the college student population. This goal of this study was to shed light on some of the reasons that this condition may exist in a population that should normally not be affected. A hierarchical linear regression model was used to examine the relationship between cortisol and QEEG voltage levels. Alcohol use was identified as a covariate because previous research indicated that the low voltage condition was associated with chronic alcohol use. There is a vast amount of research related to college students and stress (Adams & Wharton, 2008; Adewuya & Olutayo, 2006; Bayram & Bilgel, 2008 , ; DeSantis, Webb & Noar, 2008), but there is little research in the traditionally aged college student population that has looked at the possibility that stress may be implicated with the damage of neurons in the hippocampus, an area that is associated with learning and memory. The undergraduate population experiences stress for many reasons, and it is thought that freshmen may be experiencing more stress and seniors less as they have acclimated to their new way of life. It was also the nature of the study to examine if those from a rural geographical background experience more stress than those from a non rural area, as indicated by previous research on the topic (Bilgel, 2008). The saliva samples indicated whether an individual has more stress hormone than what is considered normal. Then by taking a QEEG, it is possible to identify the level of voltage to see if there is a correlation between having increased amounts of cortisol and a low voltage condition. The findings of this study can provide a framework for educational institutions to help students be more aware of stress and the implications it has not only on their physical well-being but on their mental well-being.

The results showed that the college students who participated in the research did not have increased levels of cortisol that would indicate elevated stress and did not have voltage conditions that would be considered low. Thus, the null hypotheses were not rejected; the change in cortisol levels did not predict the voltage in the QEEG of each participant.

Interpretation of Findings

When comparing this study to the current literature, the results of this study found that college students reported experiencing a high amount of stress; 38% reported mild stress, 55% reported a moderate amount of stress, and only 7% reported severe amounts of stress. An overall 88% of participants reported feeling stress. The most significant stressor of the participants was the category “academics.” All but two of the students had a voltage that was below 20 microvolts and the average sum voltage was 35.05 mv. The cortisol levels that were taken at two different times, once in the morning when cortisol levels should be at their highest, and again in the afternoon before a major meal at approximately 4:00 pm when cortisol should be significantly decreased. The Salimetrics Labs (2009) indicated that only three participants had cortisol levels that were higher in the afternoon than the morning. According to Sapolsky’s (2004) research, increased cortisol in the afternoon would indicate that the individual may be experiencing chronic or increased stress. Sapolsky also hypothesized that the increased cortisol can damage neurons or even cause neuronal death. If neurons were damaged or terminated in the hippocampus, they would not be producing any electrical activity; hence, there would be a decrease in voltage. As Sapolsky (2004) explained, a stressor is either sensed or anticipated by the individual, and this stress activates components of the stress response hormonally. Two hormones vital to the stress-response are epinephrine and norepinephrine and are released by the sympathetic nervous system. Glucocorticoids are another class of hormones important to the stress-response and are steroid hormones; when secreted by the adrenal gland, they act similar to epinephrine. Epinephrine acts immediately, and glucocorticoid activity is over the course of minutes or hours. The perceived stressor causes the hypothalamus to secrete a variety of releasing hormones into the hypothalamic-pituitary system. The main releaser is called CRH (corticotrophin releasing hormone). Within seconds of the stressor, the CRH triggers the pituitary to release ACTH. When the ACTH is released into the bloodstream and reaches the adrenal gland, it then triggers glucocorticoid. Both the glucocorticoids and the secretions of the stress-response account for the main effect of what happens to the body during stress. The stress response prepares the body for a significant expenditure of energy so that the body is ready for the physical demands of survival. Cortisol is a glucocorticoid hormone that is synthesized from cholesterol by enzymes in the adrenal cortex. The effects of cortisol are experienced throughout the body and impact several homeostatic mechanisms. While the main target of cortisol is metabolic, it can also affect the immune system and even memory. Normal cortisol levels have no opposing effects on the hippocampus, but excess cortisol can overwhelm the hippocampus and cause atrophy by damaging neurons. Sapolsky's study has indicted that adults who have elevated cortisol levels exhibit significant memory deficits resulting from hippocampal damage. The exact age at which this happens is unclear. It may be the case that the average undergraduate student has not experienced enough stress or increased cortisol to have a negative effect on the hippocampus. Sapolsky's research did not specifically look at the age group that was targeted for this study, 18- to 22-year-olds, which could mean that the chronicity of stress would need to be over an extended period of time in order for the stress to become damaging to the individual's brain functioning. Because of the age of the participants, it may be that the stress is not as chronic as it would be for an average adult as indicated by Sapolsky's (2004) research.

The results of this study indicated that of the three participants who had higher cortisol levels in the afternoon, only one of them had a low voltage condition that was under 20 microvolts. Two of the three with increased cortisol had voltages that were above 20 microvolts and would not be identified as having increased cortisol relating to the reported stress. There were a total of four participants who had voltages of below 20 microvolts, and one of them had a record of decreased cortisol. It was understood from this study that the change scores did not predict a QEEG voltage level that would be considered low voltage. This study found that a large majority of participants, 88%, reported feeling stressed but did not show cortisol levels that were increased in the afternoon sample. This finding would be inconsistent with Sapolsky's (2004) research that stated increased cortisol can damage neurons. Neurons become damaged in three ways: First it can interfere with the brain's glucose supply; second, it can interfere with the function of neurotransmitters; and third, it can cause an invasion of calcium into brain cells.

This data were examined after controlling for the covariate of alcohol use. Rose (2010) reported that increased stress could be correlated with increased alcohol use by causing changes in the HPA system during and after chronic alcohol intake. Rose (2010) reported that glucocorticoids are increased during acute and excessive alcohol consumption but also during the initial phases of alcohol withdrawal. The glucocorticoid response to stress is significantly reduced after the cessation of chronic alcohol use. Although there is no mention of what length of time constitutes chronic alcohol use, Rose's (2010) study indicated long-term alcohol drinking. The students in this study were only 18 to 22 years old, and it is possible that even if drinking was initiated at a young age, the use is not long-term enough to be considered damaging. Previous research on QEEG reported that chronic alcohol use was consistent with low voltage conditions (Niedermeyer, 1999). Because research on the topic of low voltage is scarce, there is no information other than the report that the low voltage condition is associated with individuals who report chronic alcohol use. In this study, information about any consistency with earlier research was limited because the participants reported minimal alcohol use. There may have been more understanding of the correlations had the students reported significant use of alcohol. Although participants reported moderate stress, none of them had any indication of low voltage in their QEEG. The information collected from this study did not indicate that the amount of stress that was reported by each of the participants led to increased or chronic alcohol use. As with Sapolsky's

(2004) research, Rose did not identify the participants to be between the ages of 18 to 22 years old as did this particular study leading to the idea that prolonged stress, beyond the ages that were studied in this study, could lead to increased or chronic alcohol use.

When examining the data for the freshman participants, the change in cortisol did not correlate with a low voltage condition. The data for this study collected 39 freshman cortisol levels and QEEG out of the 60 participants and found that the freshman reported as much stress as the other participant who were in other levels in their undergraduate program. I thought that freshmen may have been experiencing more stress because the transition from home to college would be more significant (Byram & Bilgel, 2008).

Byram and Bilgel (2008) found that those who transition to college and become more autonomous tend to be more anxious and depressed and experience greater stress. Byram and Bilgel reported that students from a rural geographic area experience more depression, stress, and anxiety than those from non rural areas and that the condition affects their quality of life, educational success, and future. Byram and Bilgel (2008)It is thought that the adjustment for rural students is greater than it is for those who were from other non rural areas. In the 60 participants that were studied, rural students made up 33% of the participants, and 67% were identified as having a non rural background. There were no consistencies with the current study and that of Byram and Bilgel. The rural students reported no more stress than those of a non rural background, nor were those from the non rural group more stressed than the rural group. The inconsistencies in this study were not only in the area of rural students but also were evident in the area of alcohol use. The students from a rural area did not report any increased stress over those from a non rural background, making it difficult to find any similarities to Byram and Bilgel's study, nor did the students who participated in this study report any significant use of alcohol, making it difficult to find any correlations to previous studies. The information collected in this study led to the understanding that there were no differences in change scores for rural students compared to non rural or were there change scores in cortisol as related to alcohol use. Those who did report alcohol use did not report chronic use and therefore did not result in cortisol predicting QEEG voltage.

In addition to the research questions, I did not find that stress led to increased visits to a healthcare professional. There was an average of 1.63 visits per student. This finding was not consistent with that of Adams et al. (2008), who found that college students that reported feelings of stress had higher rates of chronic illness. This study discovered that out of 60 participants, only 11 or 18% had been diagnosed with a stress-related disorder, but 88% of the student participants reported feeling stressed. This is also inconsistent with research that indicated stress compromises and weakens the immune system, causing more illnesses needing attention by a health care provider (Adams et al., 2008). DeSantis et al. (2008) concluded in their study that the college participants reported feeling stressed, overwhelmed, anxious, and depressed from academic pressures. The present study did not measure feelings of anxiety, being overwhelmed, or depression, but the reports of stress were related to academic pressures. The participants in this study did report that they were feeling stressed and that the academic pressures were the main reason for their stress; however, the cortisol levels in these participants did not indicate that there was an increase in cortisol, the stress hormone. One possibility for the reporting of stress is that each individual had perceived stress: Each of the participants did report stress, so they in fact felt stress. Cohen, Kamarch, and Memelstein (1983) indicated that stress can be perceived differently by everyone, which is why they used a scale that can measure the perception of stress called the Perceived Stress Scale (PSS). Cohen et al. (1983) reported that the scale can provide an important perspective about the relationship between stress and pathology. This scale was developed to measure the degree to which events in an individual's life are evaluated as stressful. This scale could have shed further light on the current study on perceived stress in order to ascertain the relationship between perceived stress and cortisol levels (physiological stress).

Through this study, I attempted to understand if cortisol levels had any effect on brain functioning, which was prompted by Sapolsky's (2004) research that explains that stress kills neurons. The idea is if neurons are killed or damaged, there is limited electrical activity. Sapolsky's studies (2002, 2004) focused on the hippocampus, the area of the brain that is directly associated with learning and memory. Sapolsky further indicated that the stress response that activates the sympathetic nervous system releases cortisol into the body in an attempt to help the body to survive. This same theory was noted by Lipton (2005), who reported the function of the stress response and that when an individual experiences stress, the stress activates the stress response, and the sympathetic nervous system floods the system with cortisol and over time. The duration and severity of cortisol released into the system will eventually have a negative effect on the body and damage neurons in the area when learning and memory takes place, the hippocampus. Lipton's (2005) research nicely mirrors Sapolsky's.

Both researchers, Lipton (2005) and Sapolsky (2004), stated that the chronicity of the stress that is experienced by the average individual today continually releases cortisol into the system that can potentially be harmful to the brain. I attempted to understand if Sapolsky's theory was evident in a group of participants in an undergraduate program, and if the stress related to the academic situation would have an effect on their brain functioning. The findings of this study are inconsistent with Sapolsky's theory; however, in the current study, I did not look at the duration of stress that is needed to potentially damage neurons in the brain. It is not clear from the literature what exact time duration constitutes "long-term stress." Following students into a graduate program and on to a career beyond college would help to understand what duration under stress can have a negative effect on brain functioning, particularly neurons in the hippocampus. The results are more consistent with Niedermeyer's (1999) reports of the rarity of low voltage condition in this population. Niedermeyer reported that the low voltage condition only occurs in less than 1% of the population of 18 to 21 year olds. There is a possibility that stress needs to be long term chronic stress before it becomes a threat to the physiology as indicated by Sapolsky (2004). Sapolsky's research did not look specifically at the college student population but at the average adult. Because the majority of cortisol was within normal ranges, determining if stress really does damage neurons is difficult.

Bennett and Baird (2005) attempted to define when a human brain fully develops. Previous research seemed to indicate that significant anatomical changes continue to occur after the age of 18. The researchers tracked a group of college freshman to find that during the first year, students are faced with changes that include cognitive, social, and emotional encounters. The students studied were those who had relocated more than 100 miles for college. It was found that changes continued to occur and were specific to regions that were associated with integrating emotion and cognition, and these changes were found in the part of the brain that takes information from the body and applies it in navigating their world. The researchers found that the brains of 18-year-old students are very dissimilar to that of an individual who is in the mid-20s; this led them to believe that the brain reaches full adult maturity much later than originally thought. This information may explain the results of the current study: The 18 to 22 year old brain may not have been affected by such factors as stress due to the continued development that is expected. The effects of stress may not yet be evident on the younger brain of the undergraduate students.

Limitations of the Study

As indicated in the first chapter, one of the major limitations of this study is that each of the participants did not have a QEEG prior to this study; therefore, there is no initial baseline comparison data to see if perhaps in the past, they had experienced a low voltage condition that changed over time. I assumed that the participants answered the questions about alcohol use honestly, and I indicated that the information was strictly confidential. However, participants may have not answered 100% honestly because I was present when they completed the questionnaire. The study also included a limited amount of participants. Out of the 60 participants, 43% were in the psychology program, 65% were freshman, 85% were female, and 80% were Caucasian. These statistics limit the generalizability of the results. I anticipated there would be approximately 30 male and 30 female participants. I also expected a greater diversity of ethnicity and year in the program. The lack of diversity limits generalization of the findings.

Recommendations

There is a need for further research of low voltage condition because it is still unclear what may cause a low voltage condition other than chronic alcohol use. Research indicated that chronic stress may lead to this condition (Sapolsky, 2004), however there are various reasons that should be considered. It would be beneficial to understand other situations that may damage or kill neurons such as brain injury that can be a result of participating in the sport of football, soccer, or other contact sport. There is also physical damage that can occur and that could be any insult to the brain that can kill neurons by starving them of their essentials, such as oxygen and/or nutrients. When there is a spinal cord injury, neurons lose their connection between the brain and muscles. The food supply can also have a damaging effect on brain functioning. There are many chemicals and toxins that have been introduced to the food supply that may have a negative effect on neurons. The results of this study did not indicate any threat to the college student population from stress, but some research is needed on other sources that may contribute to a low voltage condition.

This study included 60 college students who did not report extensive or excessive use of alcohol. Additional research could uncover the relationship, if any, between reported chronic use and binge drinking by students in other larger colleges or universities and the damage or death of neurons in the brain from alcohol use. Further research should be conducted about the use of illicit drugs that builds on the research of DeSantis et al. (2008) about academic performance and brain functioning with the use of such substances. Such research would be valuable because of the epidemic of stimulant drugs used to keep students studying longer and later than needed (DeSantis et al., 2008).

The present study looked at the entire brain. Another topic related to this study that warrants further exploration is in the area of memory and learning. Research involving QEEG recordings of just the temporal lobes of college students with excessive or continued stress would add to the existing body of research and reinforce Sapolsky's (2004) observations that the damage or death of neurons in the hippocampal areas are a result of stress. The QEEG recordings at the temporal sites would be directly related to the hippocampus. Thus, if stress were present, there would be limited or decreased electrical activity at those sites. Pre and post assessments of memory and status of academic success related to brain function should be made.

Implications

One of the goals of this study is to effect positive social change on an organizational level. Each of the students that participated in the study, a majority of whom were in the psychology program, demonstrated interest in the way their brain functioned and their levels of stress. The questions presented to me about stress along with the excitement about getting the report of their brain functioning showed their interest in stress and their individual functioning.

Specific to positive social change, the perception of stress on the student can be addressed in a positive way. Educational institutions can better prepare students to recognize and prevent stress. Many of the students reported that they would be interested in participating in stress reduction education. Many were interested in the early signs of stress, although they were reluctant to express interest in programs labeled as stress reduction programs. This suggests that some of the newer more contemporary programs and education would be best for this population. Yoga and meditation, although older practices, can be introduced in a more fun and recreational approach that appeals to the younger generation.

Colleges and universities can better educate staff and residential life staff to recognize stress in its early stages and refer students to the appropriate programs before stress becomes problematic. A task force could be developed by students to obtain the best ideas on what programs would be more appealing to the student body.

Conclusion

Stress is pervasive and is responsible for debilitating situations for students that include dropping out of college or universities and unhealthy behaviors such as illicit drug use or even suicide (Bayram & Bilgel, 2008). The American Psychological Association (2007) warned that stress is the number one reason for the majority of visits to the doctors for people of all ages. Young persons must understand and be educated on the mental, physical and spiritual implications of stress. If young students are educated to manage, intervene in, and prevent the negative effects of stress, they are more likely to make stress reduction practices part of their daily lives.

The brain is the main source of our being, and we get only one life. Young students need to be taught to cherish and maintain their lives and encourage growth in their lives to ensure peak performance for many years to come. There is a continued growth in the awareness of the importance of the human brain as more programs are developed toward brain health. This generation can grow into the next generation of teachers, parents, and adults who have a positive focus on the importance of brain health. This focus will have an effect on reducing many of the brain-based illness and disorders seen today, helping people to live healthier and happier lives.

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Appendix A: Participant Questionnaire

Participant # ____________________ Date Completed __________

How many times during the current school year did you visit a health care professional? #_____

How many times during the current school year did you visit a mental health professional? # _____

How many alcoholic drinks do you consume in a week?

1 to 5 ____ 5 to 10____ 10 or more_____

What is your ethnic background? White______ Hispanic _______African American____ Other (identify)______

What geographical area did you reside prior to attending school?

Rural _______ Urban________ Suburban _________

What is your area of study? ________________________________

What academic year are you in?

Freshman _____ Sophomore _____ Junior _____ Senior ______

What is your perceived level of stress?

Mild ________ Moderate ________ Severe _______

In your opinion, what is the greatest stressor?

Academic __________ Social __________ Independent Living ___________

How many close relationships do you have

None _____ 1 to 3 ______ 3 to 5 _______ 5 or more _________

Have you been diagnosed with a stress related illness? Yes ______ No _____

Do you take any medication? Yes ______   No ______

Are you aware of any programs at your school to help with stress?   Yes ____ No ____

How likely are you to use any programs that are available?
Not likely ______   Likely _____ Highly Likely _______

Have you ever had a head injury? Yes ______ No ______

Have you ever had a concussion? Yes _____ No _____

If yes, how many? _______

Curriculum Vitae

Adriana Steffens, PhD candidate, BCN

Education

2009 – *Ph.D. (ABD) Psychology/Educational Track*

Expected date of Completion is June 2014

Walden University, Minneapolis, MN

Dissertation Topic: Relationship Between Cortisol Levels and Low Voltage Conditions in the Brains of College Students (Partnered with Hartwick College Neuroscience Dept.)

2004 – 2009 Master of Science in Psychology

Walden University, Minneapolis, MN

Thesis topic: Sibling Abuse and Adolescent Depression

2001 - 2003 Bachelor of Science in Psychology/Human Development

SUNY Empire State, Cobleskill, NY 12043

2006 - Present Board Certification in Neurotherapy-Associate Fellow

Biofeedback Certification Institute of America, Wheat Ridge, CO

2006 – 2009 Completion of Mentoring Requirements for QEEG and Neurofeedback

New Mind Academy, Atlanta Georgia

Dr. Richard Soutar

2009-Present Certified Active Parenting Educator

Active Parenting, Kenesaw, GA

July 2003 *New York State Teacher Certification Examination*

Passed Liberal Arts and Sciences Exam

Experience:

June 2006 – Present *Owner and Founder*

Mind Matters Neurotherapy Centers

Clinical Psychophysiologist

Board Certified Neurotherapy Provider

*Provide Quantitative Electroencephalograph and the correlative analysis for patients and their families

*Provide neurotherapy training for psychiatric and psychological disorders and benefits for overall well-being.

*Provide education to client and family factors that involve overall health and well being, including but not limited to; nutraceuticals, nutritional intake and environmental toxins,

*Collaboration with other service providers including psychologists and psychiatrists, county services such as DSS for various counties and probation services.

*Collaboration with treatments teams at various treatment facilities.

June, 2005 -2008

Berkshire Farm Center and Services for Youths

Family Specialist

*Provide education to youths who are at risk of placement and their families to enable the youth to remain in the community and home.

*Services are provided to maximize the opportunity for the youth and family to successfully remain together.

*Intensive treatment oriented for relationship with the family centered on the goal of helping the family members resolve their own problems

*Instruct parents with Psycho educational material to and help children take responsibility for their behaviors.

*Provide therapeutic contact with child and family on a face to face basis

*Establish treatment goals

*Utilize various therapeutic techniques and modalities to achieve desired outcome

*Facilitate parental consultations with school staff

*Advocate for clients in court

*Develop community support networks.

2002 - 2004

Delaware Academy Schools

Teacher - Per Diem

*Provide instruction to students and follow curriculum.

*Specialization in Special Education 8-1-1 and 12-1-1

*Individualized instruction for children with behavior, disciplinary and emotional disturbances

1981 – 1991

Grumman Aerospace Corporation

Staff to President of Personnel, Robert Foster

*Monitor all budget and compensation

*Assist President in all areas of employee compensation

Publications:

September 2007

The Daily Star

Oneonta, NY 13820

Neurotherapy Can Address Health Concerns for Many

March 2009

The Daily Star

Brain Mapping Can Help Patients

Memberships:

January 1, 2013

Board of Director Member – Treasurer/Chair

Southeast Biofeedback and Clinical Neuroscience Association

Basic board member duties are to ensure adherence to state, local and non-profit rules and regulations. Duties also include decision making for funding and investments, allegation of funds for families with disabilities, fund raising, overseeing various committees under the board of directors and decision making for various aspects of the entire organization

December 2012 - Present

Board of Director Member

Family Resource Network

Basic board member duties are to ensure adherence to state, local and non-profit rules and regulations. Duties also include decision making for funding and investments, allegation of funds for families with disabilities, fund raising, overseeing various committees under the board of directors and decision making for various aspects of the entire organization

2012 Completion of the Board of Directors Training provided by NYCON

July 2012 - Present

Board of Directors Member – Secretary/Executive Committee

Friends of Recovery Delaware and Otsego County

Duties are to ensure adherence to state, local and non-profit rules and regulations. Duties also include decision making for funding and investments, allegation of funds for families with disabilities, fund raising, overseeing various committees under the board of directors and decision making for various aspects of the entire organization

April 2004 - Present

National Center for Complimentary Alternative Medicine

2004 - 2006

American Psychological Society

2007-Present

Association for Applied Psychophysiology and Biofeedback

2000 - Present

American Psychological Association

Volunteer Work

1992 - 1996

Our Lady of Perpetual Help

Lindenhurst, NY 11757

1998 - 2004

St. Peters Roman Catholic Church

Delhi, NY 13753

Certified Religious Education Instructor

2000 - 2008

Indian Hills Council

Girl Scouts of America

Troop Leader

2003 - 2007

Delaware Academy Schools

Parent Teacher Association