CAFFEINE INTAKE IN COLLEGE STUDENTS

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

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ABSTRACT

Caffeine is a widely consumed substance that is readily available through many sources that may influence consumption in the college setting. The purpose of this study was to examine the relationship between caffeine intake and sleep behavior and the effect of campus dining frequency on caffeine intake in college students. Three hundred and fifty students (212 males and 138 females) participated in a 72-hour dietary analysis that provided the students' age, gender, body mass index (BMI), and physical activity level. The students were asked to record dining frequency as well. Ninety-six of the 350 students completed a 7-day sleep diary to complete the sleep analysis. Chi-square tests, regression analysis, and t-tests were performed to analyze relationships and differences between variables. Results showed that there were no significant relationships between caffeine intake and age, gender, BMI, physical activity, sleep time, or frequency of dining and caffeine intake in college students.

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CHAPTER I. INTRODUCTION

Caffeine is the most widely consumed legal drug worldwide (Astrup, Toubro, Cannon, Hein, Breum, & Madsen, 1990). Naturally occurring in plants, beans, fruits, chocolate, coffees and teas, caffeine is readily available for individuals to consume regularly (Heckman, Weil, & Gonzalez De Mejia, 2010). College students may be more likely to consume caffeine due to busy schedules and assignments, social influence, and lack of sleep. Students may also increase caffeine consumption if it is readily available on campus or part of their dining plan. There are many reasons why college students consume caffeine, but an increased consumption during college years may have negative implications on the total amount of sleep that a student will obtain. The impact of caffeine on sleeping schedules may lead to an increase in caffeine consumption and eventually dependence. There is limited research on the relationship between caffeine and sleep in college students. More specifically, no research exists that examines the difference in caffeine intake and amount of sleep over a 7-day period of time. In addition, no research exists examining the relationship between caffeine consumption and dining frequency. The purpose of this study is to assess the effect of caffeine intake on average sleep time per week, physical activity, age, gender, and body mass index (BMI), as well as, the differences in intake of those with and without a meal plan versus those without at North Dakota State University.

Background

Caffeine may influence several factors that affect a college student's health and well-being. Dose-dependent caffeine intake stimulates thermogenesis, increases energy expenditure, increases blood pressure, and decreases heart rate (Astrup et al., 1990). Caffeine appears to have an effect on perceived mood, concentration, and arousal in college students (Pettit & DeBarr, 2011). After consumption of caffeine, college students report being more awake, anxious, energetic, and clear-minded, however; caffeine has no positive benefit on mental performance (Pettit & DeBarr, 2011). Though caffeine may stimulate wakefulness and increase attention span in the average college student, there may be more important negative health implications associated with heavy consumption of caffeine.

College students are a population of interest because their consumption patterns may be associated with changes in their environment living in a college setting. Students increase caffeine consumption when experiencing consuming alcohol and if experiencing lack of sleep (Malinauskas, Aeby, Overton, Carpenter-Aeby, & Heidal, 2007). Furthermore, college students who report higher levels of perceived stress consume more caffeine (Pettit & DeBarr, 2011). Under stress and with the influence of social situations, caffeine consumption may be quite prevalent among college students.

It is important to determine how caffeine consumption affects sleep patterns over a longer period of time. Studies have shown that caffeine consumption throughout the day has an effect on total sleep time, sleep onset latency, and sleep efficiency later in the night (Judice, Magalhaes, Santos, Matias, Carita, Da-Silva, … Silva, 2012; Paterson, Nutt, Ivarsson, Hutson, & Wilson, 2009). Sleep deprivation in college students has been linked to symptoms of depression, increased anxiety, and impaired memory and recall (Nyer, Farabaugh, Fehling, Soskin, Holt, Papakostas, … & Mischoulon, 2013). The consumption of caffeine and its impact on sleep, and subsequently learning, may be more detrimental to college students' academic success than the perceived benefits. The current gap in literature is that there is little information on the relationship between caffeine intake and the amount of sleep obtained over a week-long period. Much of the literature examines caffeine's effect on sleep only over periods of a few days. Also, no studies exist that examine the difference in caffeine intake between students who have a meal plan on campus and those who dine off campus. Those with a greater accessibility to caffeine containing products, such as in the dining center, may be consuming more of these products.

Significance and Purpose

This study examines the difference in caffeine intake among different sleep behaviors of college students at North Dakota State University. By determining the difference of caffeine intake and average hours of sleep per week, future studies can be conducted that pertain to the impact of caffeine on sleep deprivation. If students could be at risk for sleep deprivation, future studies could examine its impact on academic performance.

Research Questions

1. What is the relationship between caffeine consumption and BMI, age, gender, and physical activity on students enrolled in HNES 100: Concepts of Fitness and Wellness and HNES 111: Wellness at North Dakota State University?
2. What is the difference in caffeine consumption and average sleep time per week in a selected sample of college students at North Dakota State University enrolled in HNES 100: Concepts of Fitness and Wellness and HNES 111: Wellness?
3. What is the relationship between caffeine consumption and dining frequency on campus of students at North Dakota State University enrolled in HNES 100: Concepts of Fitness and Wellness and HNES 111: Wellness?

Limitations

Limitations of the study include reliance on self-reported data and the accuracy of the self-reported data collected. The students may not have documented the intake correctly. The reporting of data is a requirement for a class grade regardless of the research study. Other limitations include the subject bias. The data from subjects were only collected from these two classes out of convenience and are not generalizable to the entire college student population. The HNES 111: Wellness class is a general education class and is taken to meet wellness general education requirement. HNES 100: Concepts of Fitness and Wellness class is required for particular majors. General education wellness classes are required of every student, but the students are able to choose from several options.

The scope of the study is limited to North Dakota State University students enrolled in fitness and wellness classes. North Dakota State University is also 81% Caucasian (NDSU, 2014). It is assumed that the participants of the study fulfill the requirements of the course and complete, with accuracy, all necessary components for the data.

Definition of Terms

Body Mass Index: A number calculated from a person's height and weight used to screen for weight categories. Categories include underweight, normal, overweight, obese (CDC, 2014).

NutritionCalc: An online dietary tracking system with 27,000 items from the ESHA database (McGraw-Hill, 2011)

Psychomotor Stimulants: Substances, particularly caffeine, that have physiological and behavioral effects on the body (Rogers, Heatherley, Mullings, & Smith, 2012).

Rapid eye movement (REM) Sleep: the stage of sleep where dreams occur and the brain activity increases, which may affect learning and mental skills (National Institute of Neurological Disorders and Stroke, 2013).

Sleep Onset Latency: The time it takes to fall asleep (The Free Dictionary, 2013).

Sleep Efficiency: The ratio between the total sleep time and total recording time (American Sleep Apnea Association, 2015).

Thermogenic: Relating, caused by, or inducing the production of heat (Merriam-Webster, 2015).

CHAPTER II. REVIEW OF LITERATURE

Caffeine is the most widely consumed legal drugs worldwide that exhibits a psychomotor stimulant effect (Yang, Palmer, & de Wit, 2010). Caffeine is naturally occurring in a variety of substances such as coffee beans, tea leaves, and the cacao bean; the most common sources. Caffeine is found in over 60 different plant sources (Heckman, Weil, & De Mejia, 2010; Rudolph, Farbinger, & Konig, 2012). Synthetic caffeine, chemically identical to natural caffeine, is added to products such as yogurt, chocolate, energy drinks, soft drinks, as well as, some pharmaceuticals (Heckman et al., 2010). Caffeine is associated with an increase in attention, concentration, mood, and arousal (Rudolph et al., 2012). Due to the stimulatory effects of caffeine, it is quite popular and its consumption is widespread throughout all different age groups. Young adults, particularly college students, are frequent consumers of caffeine, especially energy drinks that are specifically marketed to them (Pettit & DeBarr, 2011). There are many reasons why caffeine consumption may be popular among college students including erratic schedules, peer influence, social situations, and lack of sleep. Like other drugs, one can become dependent on caffeine and even build a tolerance to its psychomotor stimulant effects, which would explain why some individuals rely heavily on caffeine to complete routine daily functions (Rudolph et al., 2012).

Effects of Caffeine

Many people seek to reap the psychomotor effects of caffeine, which is the primary reason caffeine intake is so common. There are specific genetic, metabolic, and thermogenic responses in the body that have an effect on individual intake (Yang, Palmer, & de Wit, 2010; Astrup, Toubro, Cannon, Hein, Breum, & Madsen, 1990). Yang and colleagues (2010) determined that genetics have a direct effect on an individual's response to caffeine and personal preference. Genetics also affect the metabolism and thermogenic responses induced by caffeine. Genetic influence on caffeine consumption changes as people age, being most pronounced through adolescent years and then more stable in middle adulthood (Yang et al., 2010). Genetic influence is more pronounced in heavier caffeine consumers. Twin studies have show a large heritability component to taste preference, internal effects of caffeine, and dependence to caffeine (Yang et al., 2010).

Metabolism

Caffeine is metabolized by cytochrome P-450, an enzyme responsible for digestion in the gastrointestinal tract (Yang et al., 2010). The A_1 and A_{2A} receptors in the central nervous system are responsible for transmitting the main components of caffeine to the brain and producing a response. A_{2A} receptors are responsible for behavioral effects of caffeine like caffeine-induced anxiety and sleep changes in subjects. These receptors are also responsible for the rewarding properties of caffeine like increased alertness and concentration. Polymorphisms, or DNA variations, in this receptor may be associated with negative responses to caffeine, like jitteriness (Yang et al, 2010). Negative responses could influence individual preference. Those who have a positive response experience increased release of dopamine, which is also released upon administration of other drugs like cocaine, amphetamine, and opioids (Garrett & Griffiths, 1997; Yang et al., 2010). The release of dopamine occurs in two phases and is increased with lower doses of caffeine (Garrett & Griffiths, 1997). Caffeine even has a significant effect on increasing metabolic and thermogenic responses in those who moderately consume caffeine and may have already built a tolerance. Astrup et al. (1990) concluded that caffeine has a dose-dependent effect on plasma lactate and triglycerides. An increase in plasma lactate is an indicator of the thermogenic response of the Cori cycle, which is the conversion of glycogen and glucose to lactate. An increase in plasma triglycerides may be due to an inhibition of lipolysis, or the breakdown of fat (Astrup et al., 1990). Additionally, caffeine was found to have a significant effect on energy expenditure by burning an extra 3-40 calories per hour after only 100 mg administration (Astrup et al., 1990). An increase in energy expenditure may be beneficial in weight loss and increasing metabolic action.

In addition to the release of dopamine and increased metabolic action, caffeine has been associated with reducing symptoms of Parkinson's disease and delaying the onset of the disease by stimulating the dopaminergic system (Heckman et al., 2010). Caffeine may act as a protective mechanism for DNA damage by UV radiation, which would help prevent skin cancer caused from sun exposure (Heckman et al., 2010).

Though there are some benefits related to caffeine consumption, other studies have illustrated that the detrimental effects outweigh the benefits. Stimulant drinks contain caffeine, which may have a negative effect on metabolism and behavior (Finnegan, 2003). Caffeine is usually rapidly absorbed from the gastrointestinal tract and remains concentrated in the blood stream for about 4-5 hours before it is metabolized by the liver (Heckman et al., 2010). Excessive intake of caffeine, as well as withdrawal from caffeine, has shown to increase headache, nausea, anxiety, restlessness, palpitations, blood pressure, and gastrointestinal disturbances (Finnegan, 2003). Though there is still a need for research to examine the negative effects of caffeine ingestion, Finnegan (2003) stated that caffeine plays a role in conditions such as sleeplessness, depression, mental illness, cardiovascular disease, low infant birth weight and spontaneous abortion during pregnancy. Caffeine's reaction on inflammatory markers has also been examined and has been found to increase interleukin 6, tumor necrosis factor α (TNF-α), amyloid A, and C-reactive protein (Heckman et al., 2010). Caffeine has also become increasingly popular in conjunction with alcohol among college students, which may cause increased agitation and a greater perceived drunkenness (Finnegan, 2003). Caffeine in combination with alcohol, however, has no significant effect on blood alcohol levels or cardiovascular activity (Finnegan, 2003).

In addition to metabolism, caffeine has also been shown to increase physical activity. Caffeine is a stimulant that is also used sometimes as an ergogenic aid for those looking to improve physical performance (Schrader, Panek, & Temple, 2013). Because of its potential as an ergogenic aid; caffeine may influence a desire to complete physical activity. Schrader et al. (2013) examined the effects of acute and chronic caffeine ingestion in sedentary adults to determine if caffeine with physical activity would enhance physical activity levels. Thirty-five individuals received either 3 mg/kg of caffeine or a placebo of 0 mg/kg. After 30 minutes post consumption, the participants were given a "liking of physical activity" and rating of perceived exertion (RPE) scales. Schrader et al. (2013) found that female participants increased liking of physical activity more in the caffeine group than the placebo; however, there was no difference in the male group. Additionally, baseline caffeine intake was higher in the placebo group (99.6±32.8 mg) than the caffeine group (63.2± 15.4 mg). Those with a BMI of greater than 25 kg/m^2 showed a significant decrease in RPE. Those who consumed caffeine exercised significantly longer than those who took the placebo (Schrader et al., 2013). If caffeine has a significant effect on exercise time and likability, then it may influence the amount of physical activity that students obtain during their college years.

Influences on Consumption

Not only is caffeine widely used in social settings in combination with alcohol, college students may also be interested in consuming it for its potential psychomotor and alertness benefits during lectures and stressful exams. Few studies have been conducted to determine the effect of caffeine on cognitive functions to determine if it enhances performance and mental ability (Rogers & Dernoncourt, 1997; Rogers, Heatherley, Mullings, & Smith, 2012). Caffeine has the most benefit to those who have already built up a tolerance and are experiencing withdrawal by helping them return to their "normal" state (Rogers & Dernoncourt, 1997; Rogers et al., 2012). Among individuals facing a withdrawal, caffeine reduces task-related fatigue and improves the degraded performance from the lack of caffeine consumption (Rogers & Dernoncourt, 1997). Consumers who do not consume caffeine regularly experience more anxiety and jitteriness, which negatively affects their mental alertness. By returning dependent users to a normal state, dependent consumers will be more apt to continue the use of caffeine.

Both high consumers and low consumers experience a decrease in sleepiness regardless of daily consumption (Rogers et al., 2012). A reduction in sleepiness may have a positive influence on the consumption of caffeine. College students may be especially susceptible to sleepiness due to academic demand and the structure of the college lifestyle. Social demands, on top of academic requirements, may also have a negative effect on consistent and adequate sleep schedules required for overall health and well-being. Loss of sleep due to increasing use of technology may also increase caffeine consumption. Adolescents have been shown to spend about one to two hours a night multitasking with different types of technology after 9 pm (Calamaro, Mason, & Ratcliffe, 2009). Calamaro et al. (2009) studied 100 subjects between the ages of 12 and 18; 85% of them reported losing sleep due to technology use late at night, which led to increased caffeine intake the following day. About 33% of the students fell asleep in class. Of those who fell asleep in class, 76% had higher caffeine consumption. A decrease in sleep, related to technology use late at night, can be correlated to an increase in caffeine consumption

(Calamaro et al., 2009). Though the study was conducted with adolescents, the learned behaviors may carry over into college years.

College students engage in significant screen time and as technology has become a primary source of communication, there may be an increase in the number of students who are looking at screens late at night. Looking at a bright screen decreases melatonin production, which is a hormone released in the dark that enhances sleepiness and disrupting the hormone makes it harder to fall asleep. (Calamaro et al., 2009). This lack of sleep related to technology, may consequently promote students to use caffeine throughout the following day to offset the feeling of sleepiness.

As caffeine intake increases in teenagers and adolescents, the risk of this habit persisting through college increases. Orbeta, Overpeck, Ramcharran, Kogan, and Ledsky (2006) surveyed a national sample of adolescents between the sixth and tenth grade to determine their caffeine consumption patterns. Of the 15,686 students who were surveyed, most reported drinking carbonated beverages more than once a day. Coffee intake was much lower probably due to age. The consumption of soft drinks was positively correlated with feeling tired and having difficulty sleeping (Orbeta et al., 2006). Regardless of the form of caffeine, the prevalence of caffeine intake in younger populations exists.

Bernstein, Carroll, Thuras, Cosgrove, and Roth (2002) determined the relationship between caffeine consumption and dependency behaviors in teenagers . To determine tolerance, 36 adolescents were surveyed concerning their desire to use, desire to continue use of, and withdrawal symptoms of caffeine. The average student consumed around 3.2 mg/kg/day (M 151.1± 86.9 mg) of caffeine primarily from soft drinks. Twenty-two percent of the students met the criteria for caffeine dependency. Those who indicated a dependence on nicotine or other drugs reported a higher caffeine intake. Anxiety and depression scores were also higher in those who were caffeine dependent (Bernstein et al., 2002). With caffeine dependence and consumption increasing in a younger population, there may be a high likelihood of the habit persisting through to college years and consequently increasing the number of college students who become avid caffeine consumers.

Caffeine Consumption in College Students

Caffeine consumption in college students is influenced by environmental, physical, and mental factors. College is a time of increased focus, stress, and motivation, which all may contribute to caffeine intake. Malinauskas et al. (2007) examined various influences that increase caffeine consumption among college students. Out of the 496 participants surveyed, 51% reported consuming more than one energy drink in a month. The most common reason for consuming caffeine was insufficient sleep. The second most common reason for increased consumption was studying for an exam (Maulinauskas et al., 2007). Pettit & DeBarr (2011) surveyed 136 college students to assess their energy drink consumption and found that 70% of their subjects reported drinking at least one energy drink in the past thirty days. Fifty-nine percent reported at least one energy drink in the last week. Both studies reported that greater caffeine intake was directly related to higher perceived stress levels (Maulinauskas et al., 2007; Pettit & DeBarr, 2011). During a high stress time, when increased attention and focus is needed, caffeine may be consumed to enhance performance and mood.

Caffeine certainly has an effect on psychomotor performance, especially for habitual consumers. Peeling and Dawson (2007) observed students in a 75-minute college lecture to investigate the effects of caffeine on concentration and arousal compared to a placebo. Compared to the placebo, students who consumed caffeine reported feelings of energy, anxiousness, clear-mindedness, having better concentration, and feeling more awake. Due to the effects of caffeine on concentration and alertness, it is no wonder that caffeinated beverages have become a popular choice of beverages among students. Though students are consuming caffeine to reap its potential acute benefits, intake of caffeine has been associated with disturbed sleep patterns (Lund Reider, Whiting & Prichard, 2010; Drapeau, Hamel-Hebert, Robillard, Selmaoui, Filipini, & Carrier, 2005; Stasio et al., 2011). This could potentially affect a student's well-being and academic performance long term.

Caffeine's Effect on Sleep

Sleep is an important component in maintaining overall well-being in college students. Caffeine consumption can interfere with the total sleep time, which may affect a student's performance or contribute to an even higher caffeine intake. Judice, Magalhaes, Santos, Matias, Carita, Armada-Da-Silva, Sardinha, and Silva (2012) studied 30 males between the ages of 20 and 39 to assess the effect of caffeine on daily activities; total sleep time being one of the activities. Over a four day period, caffeine significantly decreased total sleep time even after adjusting for covariates like physical activity (Judice et al., 2012). Paterson, Nutt, Ivarsson, Hutson and Wilson (2009) studied 12 males between the ages of 21 and 34 to determine the effects of caffeine on sleep-onset latency, total sleep time, and sleep efficiency throughout the night. Caffeine intake caused a significant increase in sleep onset latency. Total sleep time and sleep efficiency were significantly decreased with the administration of caffeine; however, there was no significant effect of caffeine on rapid eye movement (REM) sleep (Paterson et al., 2009). A decline in total sleep time in college students could promote caffeine consumption to counter balance the effects of lack of sleep. Caffeine intake will acutely prevent the sleepy feeling that occurs, but unfortunately reduces time spent sleeping later. Ultimately, students could end up relying on caffeine and sacrificing important sleep time.

Drapeau et al. (2005) studied the effects of caffeine supplements on sleep variables in young and middle-aged adults. Ages of the young adults ranged from 20-30 years with the middle aged ranging from 40-60 years. When given caffeine throughout the day and before sleeping, researchers found that caffeine increased sleep latency and decreased sleep efficiency and total sleep time. There were no significant differences between age groups. Each participant was a moderate caffeine consumer, which suggests that tolerance does not diminish caffeine's effect on sleep. Negative effects on sleep due to caffeine consumption mirror the effects of insomnia (Drapeau et al., 2005; Paterson et al., 2009).

Since caffeine consumption during the morning is a common practice among consumers, it is important to discuss the effects of caffeine intake in the morning relative to sleep patterns at night. Landolt, Werth, Borbely and Dijk (1995) investigated the effect of caffeine (200 mg) taken in the morning on sleep in nine men from a university in Europe. All subjects were habitual caffeine consumers prior to the study and asked to abstain from caffeine 24 hours before the study. The caffeine group, who consumed caffeine at 7 AM, experienced significantly less total sleep time and sleep efficiency. Since there were low levels of caffeine present in the saliva before the subjects went to sleep, the observations suggest that caffeine may stay in the saliva even hours after administration, which is why sleep may be disturbed during the night (Landolt et al., 1995). Landolt et al., (1995) provides some evidence that caffeine consumption in the morning can remain in the system to produce lasting effects.

Caffeine, Sleep, and College Students

Insufficient or poor quality sleep is related to stress (Lund et al., 2010), anxiety (Stasio, Curry, Wagener & Glassman, 2011), and increased caffeine intake, which in turn has a significant effect on sleep latency, sleep deficiency, and total sleep time in college students (Lund et al., 2010; Drapeau, Hamel-Hebert, Robillard, Selmaoui, Filipini, & Carrier, 2005; Stasio et al., 2011). If college students are deprived of sleep, consuming caffeine to counter balance the effects of sleep deprivation will only contribute to a cyclic pattern. Several studies have focused on college students' reasons for consuming caffeine and the effect of caffeine related to sleeping habits. Lund et al. (2010) evaluated the sleeping behaviors of college students, between the ages of 17 and 24, and the potential outcomes related to inadequate sleep. With an equal distribution of age and race, the researchers concluded that college students chronically restrict themselves from sleep, with fewer hours of sleep obtained throughout the week. Decreased sleep was associated with a decrease in mood and higher levels of stress. It was also associated with more missed classes, drug use, and higher alcohol intake. The biggest predictor of decreased sleep quality was stress. The most common causes of stress were academic, which was reported by 39% of the population, or emotional, which was reported by 25% of the population (Lund et al., 2010).

Energy drinks, a type of caffeinated beverage, are also associated with decreased sleep quality, sleep latency, total sleep time, and sleep efficiency in college students (Stasio et al., 2011). A questionnaire completed by 61 male college students concluded that increased energy drink consumption was associated with sleep disturbances, as well as, acute disturbances in mood. The increase in depressed mood, irritability, tiredness, and agitation may have been due to an increase in anxiety, which was also significantly linked to increased caffeine consumption

(Stasio et al., 2011). Caffeine's effects on sleep time and mood have an effect on sleep patterns. This could indicate why students seem to be lacking necessary sleep.

Sleep disturbances have also been associated with depression, anxiety, and cognitive and physical impairments (Nyer et al., 2013). Nyer et al. (2013) studied 287 college students over several years and discovered that students with the presence of sleep disturbances had poorer memory and recall skills. Those who had depressive symptoms, in addition to sleep disturbances, exhibited more anxiety and cognitive and physical impairments (Nyer et al., 2013). Sleep disturbances in college students may negatively impact their academic performance, which makes determining the factors influencing sleep time important to determine in the college population.

Caffeine and College Dining

There is currently no research on the relationship between caffeine intake and frequency of going to the college residence dining centers. Coffee shops and cafes have become accessible on some college campuses. North Dakota State University (NDSU), in particular, is a campus that offers a coffee shop within the resident's dining center. Roxanne England, the manager of the dining center, stated that NDSU is one of two campuses nationwide to provide a coffee shop in the dining center and include it in the students meal plan (personal conversation, January 29, 2014). Though there is no research on caffeine and dining frequency, there is some research that has examined the influences of college dining.

Racette, Deusinger, Strube, Highstein, and Deusinger (2010) examined the effects of dining on campus and the changes in students' dietary, exercise, and weight patterns. The greatest increase in overweight and obesity occurs between the ages of 18-29 years. Body weight increased in about 70% of the participants, and the mean weight increase was 4.1 kg. Though there was an increase in body weight, Racette et al. (2010) found no correlation between the weight gain and lack of physical activity, which indicates it was likely due to caloric intake. An increase in caloric intake at the dining centers may contribute to an increase in caffeine intake if calorie containing caffeine foods and beverages are readily available on campuses or located in the dining hall, similar to NDSU.

In addition to accessibility, marketing is an important tool that may influence a student's dining patterns. The marketing of a coffee shop in a dining center may be enough to influence caffeine consumption of the students who participate in a meal plan. Peterson Duncan, Null, Roth, and Gill (2010) examined the perceptions and selections of healthful foods after a short-term marketing intervention that occurred in the dining center of a Midwestern University. After 3 weeks of increased social marketing to influence behavior, overall healthy eating behaviors improved. Peterson et al. (2010) concluded that relevant and appealing messages targeted at college students have the potential to improve healthful choices in the dining hall. Boek, Bianco-Simeral, Chan, and Goto, (2012) also examined the differences in food selections by students at a college dining center and concluded that food choices in the dining center are influenced by external cues in addition to the environment. Out of the students who participated, 58.6% reported enjoying a larger food court area and 16.5% of students reported enjoying more of a café setting (Boek et al.,, 2012). Both of these options are offered at the NDSU resident dining center. Because the coffee shop is directly inside the dining center, students who have a meal plan or use the dining center more often may be apt to consume more caffeine. If students who have a meal plan consume more caffeine than those who do not, the location, accessibility, and setting of coffee shops on campus may have an impact on caffeine consumption in college students.

Summary

It is clear that caffeine taken throughout the day increases sleep latency and decreases total sleep time which results in chronic sleep deprivation among college students (Lund et al., 2010; Drapeau et al., 2005; Paterson et al., 2009; Stasio et al., 2011). Caffeine consumption is also associated with disturbances in mood and increased stress and anxiety among college students (Lund et al, 2005; Stasio et al., 2011). Because of the increased stress, workload, and responsibility of a college student, adequate sleep becomes an important lifestyle factor. Without adequate sleep, students may face problems with their academic career and overall health, so it becomes important to examine factors that influence a disturbance in sleep patterns. Caffeine, being one of the most widely used substances today, may have a detrimental impact on the sleeping patterns of college students as consumption increases. Because of the psychomotor effects of caffeine, it may be the beverage of choice to potentially enhance academic performance and combat sleepiness in college students although it carries significant consequences.

CHAPTER III. METHODS

The purpose of this study is to determine the difference in caffeine consumption of college students based on average sleep time over the course of a week. This study also assessed caffeine consumption in relation to frequency of eating at dining halls. The relationship of caffeine between physical activity and BMI was further assessed.

By analyzing dietary data and sleeping patterns, the researchers were able to determine the relationship between caffeine consumption and the average time spent sleeping throughout the week. This study has examined caffeine intake over a 72-hour period, which gives a good representation of average caffeine consumption and how consumption may affect the students' sleep schedule on a typical night. The student's self-reported hours spent sleeping per night for 7 consecutive days.

There have been no studies that utilize NutritionCalc Plus to collect dietary data. NutritionCalc Plus is an ESHA database that contains over 27,000 food items and a 365-day calendar. It is a dietary self-assessment tool to track diet and health goals with the ability to track up to 3 profiles at a time. NutritionCalc Plus utilizes the user's height and weight to calculate BMI (McGraw-Hill, 2011).

Participants

The participants were college students enrolled in one of four sections of wellness classes at North Dakota State University in students enrolled in Health, Nutrition, and Exercise Science (HNES) 100: Concepts of Fitness and Wellness class and HNES 111: Wellness. The population, selected because of convenience, recorded their dietary intake for a 72-hour period, which included two weekdays and one weekend day. Participants completed the informed consent to allow researchers to use data generated from a required assignment. In addition to the 72-hour dietary intake, students also provided their height, weight, physical activity, and the weekly frequency of eating at the dining hall. Those who failed to record 72 hours of dietary intake, those who did not correctly use NutritionCalc Plus and the sleep analysis software as instructed to produce reliable data were excluded from the study. Two individuals were also excluded due to excessive caffeine intake over 1000 mg. In total, 350 students were eligible to participate in the study. Assessing food records of 29 individuals, Basiotis, Welsh, Cronin, Kelsay, and Mertz (1987) determined that 3 days is the minimum length of time needed to record dietary intake to accurately assess energy intake.

Study Design

The study is a descriptive cross-sectional analysis of the relationship of caffeine to average sleep time per week. An additional analysis was completed to assess the relationship of caffeine to the frequency of a student eating in a residence dining hall. The dietary data was assessed through nutrition analysis software called NutritionCalc Plus (10th ed., McGraw-Hill Global Education Holding, LLC, New York City, NY). The students self-reported 72 hours of dietary data. The sleep diary was recorded through Connect® (Connect® computer software, McGraw-Hill Global Education Holding, LLC, New York City, NY) over a consecutive 7-day period. Dining frequency, per week, was recorded by willing participants on the top of their informed consent. Physical activity, height, and weight were recorded through the NutritionCalc Plus program. Physical activity was selected on a categorical scale of light active, active, and very active. BMI is calculated using the height and weight that the students entered. The university Institutional Review Board (IRB) approved the use of the data collected for analysis (Protocol # HE14166).

Procedure

At the beginning of the semester, an informational session regarding portion size and basic nutrition was given by the research team to all potential participants. This was done with the intention that the dietary education presentation would help the students accurately interpret and record their portion sizes for a more precise calculation of caffeine intake. The students were instructed how to enter their dietary data into NutritionCalc Plus, in addition to, a basic nutrition lecture provided by the instructor. Dietary data was collected during the middle of the semester using an assigned 72-hour period according to the instructor's schedule. The students were instructed to record everything they had consumed within this 72-hour period, including the portion size that was consumed. The software analyzed the dietary intake providing the researchers and students actual nutrient and caffeine intake. Sleep time was assessed over 7-days in a self-reported sleep diary, but the assignment was only required for two of the classes. After the instructor had evaluated the assignment, de-identified reports generated by NutritionCalc Plus were coded for analysis.

Students were asked to record the number of times they eat at the dining halls per week on the top of their informed consent. A quantitative approach determined the impact of the independent variable, caffeine intake by age and gender, on the dependent variables of average sleep time, body mass index (BMI), physical activity, and campus dining.

Instrumentation and Measurement

NutritionCalc Plus software was available for the students to input their dietary record, which estimated caffeine intake, as well as, their age, height, weight, and thus calculated their BMI. Personal health portfolio was used for students to report a sleep diary. All of the data was self-reported. The sleep analysis was self-reported in McGraw Hill's personal health portfolio sleep diary through Connect®.

Statistical Analysis

SAS (SAS Institute Inc. 2008. SAS/STAT® 9.3 User's Guide. Cary, NC: SAS Institute Inc.) was used to conduct the descriptive tests, chi-square tests, regression analysis, and t-tests were used to analyze the data. Descriptive tests were performed to complete characteristic data. Chi-square tests were performed to analyze categorical data. Regression analysis was performed to examine relationships among continuous data. T-tests were used to analyze sleep data. Statistical significance was set at $p < 0.05$ for all tests.

BMI, caffeine, and sleep/week were collapsed into categorical data. BMI was categorized into underweight/normal (<25 kg/m^2) or overweight/obese (≥ 25 kg/m^2). Caffeine was categorized into none, light (1-50 mg), and moderate (>50 mg) levels based on intake in milligrams. Sleep was categorized into <8 hours or ≥8 hours per week. Dining data was collapsed into three categories based on the types of meal plans offered. Those who did not eat at the dining center were put into the 0 times per week category and it was assumed they did not have a meal plan. Those who ate at the dining center 1-10 times per week were assumed to be on the block plan. Finally, those who ate at the dining center 11+ times per week were assumed to be on the unlimited dining plan. Activity level was also classified into 3 groups based on the student's self-assessed activity level.

CHAPTER IV. CAFFEINE INTAKE AND SLEEP IN COLLEGE STUDENTS

Abstract

Caffeine has the potential to influence sleep behaviors and decrease total sleep time. Caffeine may have a strong influence on sleep patterns in college students. The purpose of this study was to assess the relationships between caffeine intake and physical activity, age, body mass index (BMI), and average sleep time in college students. Participants were 350 students (212 male and 138 female; mean age 19.2 ± 1.61 years) enrolled in a Wellness course at a Midwestern university. Students analyzed a 72-hour dietary record using NurtitionCalc Plus software. Of those 350 students, 96 also completed a 7-day sleep self-assessment. Chi-square test, t-tests, and regression analysis were used to examine relationships between variables. Mean caffeine intake was 33.29 ± 50 mg. No significant relationships between caffeine and any of the variables were found. Caffeine had a slight positive correlation with age after a regression analysis was performed ($p = 0.059$). Caffeine has no direct relationship with gender, age, BMI, activity level, or average sleep throughout the week.

Introduction

Caffeine is the most widely consumed legal drug, similar in popularity to alcohol and tobacco (Astrup, Toubro, Cannon, Hein, Breum, & Madsen, 1990). Naturally occurring in beans, fruits, chocolate, coffees and teas, caffeine is readily available for individuals to consume regularly (Heckman, Weil, & Gonzalez De Mejia, 2010). There are many products that people consume without being aware of the caffeine content. Due to the availability of a wide variety of caffeine containing products on the market, individuals can easily consume caffeine without realizing the amount of potential effects. Table 4.1 provides caffeine amounts for selected common substances.

Table 4.1.
Caffeine in Common Substances (Burke, 2008)

Food/Drink	Serving	Caffeine (mg)
Instant Coffee	8 oz	60 mg
Brewed Coffee	8 oz	80 mg
Espresso Shot	2 oz	107 mg
Tea	8 oz	27 mg
Hot Chocolate	8 oz	5-10 mg
Chocolate Milk	60 g	5-15 mg
Coca-Cola	12 oz	49 mg
Pepsi	12 oz	40 mg
Red Bull	8 oz	80 mg
AMP Energy Drink	16 oz	143 mg
PowerBar Sports Gel	40 g	25 mg
No-Doz Supplement	1 tablet	200 mg
Extra Strength Excedrin	1 tablet	65 mg

Even though there are many reasons why college students consume caffeine, students often do not consider that increased consumption may directly influence the metabolic system, physical activity frequency, and duration of sleep. Caffeine appears to have an effect on perceived moods, concentration, and arousal in college students. According to Pettit & DeBarr (2011), after consumption of caffeine, college students reported being more awake, anxious, energetic, and clear-minded. Since caffeine may stimulate wakefulness and increase attention span in the average college student, consumption of caffeine in the college setting may be prevalent.

College students increase caffeine consumption under adverse circumstances such as increased sense of stress, insufficient sleep, and while studying for exams (Malinauskas, Aeby, Overton, Carpenter-Aeby, & Heidal, 2007). Furthermore, college students who report higher levels of perceived stress consume more caffeine (Pettit & DeBarr, 2011). Due to psychological stress, heavy academic workload, and increased concentration during classes, caffeine consumption could be quite prevalent among students in college. College is a time of increased focus, stress, and workload, which all may contribute to caffeine intake. Malinauskas and colleagues (2007) examined various influences that increase caffeine consumption among college students and 51% reported consuming caffeine more than once a month due to insufficient sleep, needing a boost of energy, and when studying for an exam (Maulinauskas et al., 2007). Pettit & DeBarr (2011) surveyed 136 college students and 59% reported consuming the caffeine equivalent to one energy drink in the last week. Both studies reported that greater caffeine intake was directly related to higher perceived stress levels (Maulinauskas et al., 2007; Pettit & DeBarr, 2011).

Specific metabolic actions that occur after the consumption of caffeine may influence the BMI of a regular consumer (Astrup et al., 1990). Caffeine increases metabolic and thermogenic responses even in those who moderately consume caffeine and have already increased tolerance. An extra 3-40 kilocalorie/hour increase in energy expenditure can occur depending on the amount of caffeine administered (Astrup et al., 1990). An increase in energy expenditure may be beneficial in weight loss and increasing metabolic action, which could ultimately have a positive impact on BMI in college students.

Because of its potential as an ergogenic aid, caffeine may influence a desire to complete physical activity. Schrader et al. (2013) examined the effects of acute and chronic caffeine ingestion in sedentary adults to determine if caffeine consumed with physical activity would enhance physical activity levels and found that female participants increased liking of physical activity more in the caffeine group than the placebo. Also, those who consumed caffeine exercised significantly longer than those who took the placebo (Schrader et al., 2013). If caffeine has a significant effect on exercise time and likability, then it may influence the amount of physical activity that students obtain during their college years.

Several studies have shown that caffeine consumption throughout the day has an effect on total sleep time, sleep onset latency, and sleep efficiency (Judice, Magalhaes, Santos, Matias, Carita, Da-Silva, … Silva, 2012; Paterson, Nutt, Ivarsson, Hutson, & Wilson, 2009). Judice et al. (2012) observed caffeine significantly decreased total sleep time by 45 minutes, on average in males, over a four-day period. Paterson et al. (2009) determined that caffeine intake caused a significant increase in sleep onset latency by an average of 17 minutes. Total sleep time decreased by 34 minutes average and sleep efficiency decreased by 4% on average with the ingestion of caffeine (Paterson et al., 2009). A decline in total sleep time in college students could promote caffeine consumption to counter the effects of lack of sleep. Caffeine intake can acutely prevent the sleepiness feeling that occurs, but unfortunately can reduce time spent sleeping. Furthermore, sleep deprivation in college students has been linked to symptoms of depression, increased anxiety, and impaired memory and recall (Nyer, Farabaugh, Fehling, Soskin, Holt, Papakostas, … & Mischoulon, 2013).

Irregular schedules, exams, stress, and lack of sleep are only a few of the possible influences on caffeine intake. Like other drugs, one can become dependent on caffeine and even develop a tolerance to its psychomotor effects, which would explain why some individuals rely heavily on caffeine to complete routine daily functions (Rudolph et al., 2012). The purpose of this study is to assess the relationships between caffeine intake and physical activity, age, body mass index (BMI), and average sleep time in college students at a Midwestern University.

Methods and Measurement

This study has been approved by the university's Institutional Review Board for the Protection of Human Participants in Research.

Dietary intake was determined over a 72-hour period through the use of NutritionCalc Plus (10^{th} ed., McGraw-Hill Global Education Holding, LLC, New York City, NY) in four sections of general education wellness classes The students were instructed how to enter foods listed on their 72-hour personal food record into NutritionCalc Plus to potentially reduce the chance of misreporting or entering of data. Name, age, height, weight, foods listed on the 72-hour food record, and self-reported physical activity based on a scale of lightly active, active, or very active were entered by each participant. NutritionCalc Plus calculated BMI using the equation of body weight in kilograms (kg) divided by height in meters squared (m^2). Sleep time was assessed over 7-days in a self-reported sleep diary. This assignment was only required for two of the four classes. Personal health portfolio was used for students to report a sleep diary (Connect® computer software, McGraw-Hill Global Education Holding, LLC, New York City, NY).

Participants

The study included 352 students who were enrolled in one of the four wellness classes and had an average age of 19.2 ± 1.61. Participants were excluded if the student failed to report 72-hours of dietary intake or if there was any missing required data.

Statistical Analysis

Student reports generated by NutritionCalc Plus were analyzed through SAS/STAT® 9.3 (SAS Institute Inc., Cary, NC, 2008). All of the students' names were replaced with a numerical identifier. BMI, age, gender, caffeine intake (mg) and average hours of sleep per week were entered into the spreadsheet for analysis. Statistical significance was set at a value of $p < 0.05$.

BMI, caffeine, and sleep/week were collapsed into categorical data. BMI was categorized into underweight/normal (<25 kg/m^2) or overweight/obese (≥ 25 kg/m^2). . Participants who consumed 0 mg of caffeine were classified into the "none" consumption group. Those who consumed > 0 mg and ≤ 50 mg were classified as "light" consumers. Those who consumed >50 mg of caffeine were classified as "moderate" consumers. Two of the participants were removed because of caffeine intake exceeded 1000 mg and were outliers. This amount is the equivalent of over 10 cups of coffee per day.

To assess mean sleep of the participants and its influence on caffeine consumption, the participants were divided into two groups, those who had less than 8 hours of sleep and those who slept 8 or more hours. The average hours of sleep over the 7 days was used in order to examine the hours of sleep a student would typically obtain. Only two of the course sections participated in the sleep analysis assignment and a total of 96 students provided informed consent, which is the reason for fewer sleep subjects.

Activity level was also classified into 3 groups based on the student's self-assessed activity level. Activity was measured based on the activity level that the student selected in the NutritionCalc Plus.

Results

Of the 350 participants included in the study, the mean age was 19.3 ± 1.6 years (range 18-31 years). As seen in Table 4.2, 212 (61%) of the participants were male with a mean age of 19.5 ± 1.9 years and 138 (39%) were female with a mean age of 18.9± 0.98 years. Mean BMI was 23.8 kg/m^2 (range 17-43 kg/m^2). The majority of the participants, 70%, were within the underweight/normal category with a BMI of 25 kg/m^2. The remaining 30% were categorized in the overweight/obese category with a BMI ≥ 25 kg/m^2. Those who were lightly active consisted of 65 males and 59 females for a total of 121 (35%). The active group consisted of 108 males and 61 females (48%) and the very active group consisted of 41 males and 20 females (17%).

Table 4.2.
Demographics, Body Mass Index, Activity Level, Caffeine Intake, Mean Sleep/Week of Participants

Characteristic	Total n=350	Men n=212	Women n=138	P value
Age (years)[1]	19.3±1.61	19.5 ± 1.9	18.9 ±0.98	0.001
BMI[1]				0.17
Underweight/Normal (<25)	244 (70)	142 (67)	102 (74)	
Overweight/Obese (≥25)	106 (30)	70 (33)	36 (26)	
Activity Level[1]				0.05
Light Active	121 (35)	65 (31)	59 (42)	
Active	168 (48)	108 (51)	61 (44)	
Very Active	61 (17)	41 (19)	20 (14)	
Caffeine Intake (mg)[1]	33.29 ± 50	33.9±49.7	32.2±50.7	0.79
Mean Sleep/ Night (hours)[2]	8 ± 1.1	8 ± 1	8 ± 1	0.96

[1]Chi-square test set at a significance of $p < 0.05$
[2] T-test with pooled equal variances set at a significance of $p < 0.05$

As seen in Table 4.2, mean caffeine intake for all of the participants in the study was 33.29 ± 50 mg (range 0-295 mg.). There were no significant differences between mean intake of caffeine for males (33.9±49.7 mg) and females (32.2 ±50.7 mg), X^2 (2, N = 350) = 0.47, p =0.79. A total of 106 (30%) participants reported consuming no caffeine, while 244 (70%) participants reported consuming some amount of caffeine over the 72 hours.

As seen in Table 4.3, of those who consumed caffeine, 47% were classified as light consumers with 23% participants classified as moderate consumers. Of the none consumers, 58% were males. Of the light consumers, 62% were males. Lastly, of the moderate consumers, 59% of them were males. Most students fell in the light caffeine group, but the intakes in the light group were not very high. The moderate intake category was equal to a little less than one cup of brewed coffee, which is about 60 mg (Burke, 2008).

Table 4.3.
Demographic Influence on Caffeine Intake (mg)

	Total n= 350 (%)	0 mg n= 106 (%)	>0 - ≤50 mg n= 165 (%)	> 50mg n=79 (%)	P-value
Age[1]					0.059
18	105 (30)	32 (30)	45 (27)	28 (35)	
19	152 (43)	41 (39)	84 (51)	27 (34)	
20+	93 (27)	33 (31)	36 (22)	24 (30)	
BMI[1]					0.50
Underweight/normal	244 (70)	75 (71)	113 (68)	56 (75)	
Overweight/Obese	106 (30)	31 (29)	52 (22)	23 (25)	
Activity Level[2]					0.26
Lightly Active	121 (35)	33 (31)	62 (38)	26 (33)	
Active	168 (48)	49 (46)	77 (47)	42 (53)	
Very Active	61 (17)	24 (23)	26 (16)	11 (14)	
Gender[2]					0.76
Male	212 (61)	62 (58)	103 (62)	47 (59)	
Female	138 (39)	44 (42)	62 (38)	32 (41)	

[1] Regression analysis set at a statistical significance of $p < 0.05$
[2] ANOVA (GLM procedure) set at a statistical significance of $p < 0.05$

Using a regression model, characteristics like gender, activity level, and BMI, showed little influence on caffeine consumption with age showing only a trend in influencing caffeine consumption (Regression procedure, F= 3.60, p= 0.059). As seen in Table 4.4, BMI showed no significant influence on caffeine intake (Regression procedure, F=0.45, p=0.50), as well as, activity level (GLM procedure, F=1.37, p=0.26). Lastly, linear regression analysis showed no differences between gender and caffeine consumption (GLM procedure, F=0.09, p=0.76) (Table 4.3). Out of the 106 participants who did not report consuming caffeine, 30% of them were under the age of 18, 39% were 19 years old, and 31% were 20 or over. Out of the 165 participants that were classified as light consumers, 27 % were 18 years old, 51% were 19 years old, and 22% were ≥ 20 years old. Moderate consumers were evenly divided among age groups: 35%, 34% and 30% for 18, 19 and ≥ 20 years old respectively. BMI was also categorized into two groups: those who were underweight/normal and those who were overweight/obese. The majority of those who reported not consuming caffeine, 71% were classified as underweight/normal while the remaining 29% were classified as overweight/obese. Of the light consumers, 68% were underweight/normal while 22% were overweight/obese. Of the moderate consumers, 75% were classified as underweight/normal and the remaining 25% were overweight/obese.

Out of those who reported consuming no caffeine, 31% were lightly active, 46% were active, and 23% were very active. Out of the participants who were light consumers, 38% were lightly active, 47% were active and 16% were very active. Out of those who were moderate consumers 33% reported being lightly active, 53% reported being active, and 14% reported being very active. Out of those students who reported no consumption of caffeine, 58% were male and 42% were female. Out of the "light" consumers, 62% were male and 38% female and lastly 59% of the "moderate" consumers were male and 41% were female (Table 4.3).

As seen in table 4.4, 64% of participants reported 8 hours or more of sleep each night on average. The remaining 36% slept ≤8 hours on average each night. The mean caffeine intake for those who slept ≤ 8 hours each night was 33.4 ± 48.9 mg whereas the mean caffeine intake for those who slept > 8 hours each night was 23.3 ± 36 mg ($t(94) = -1.07$, $p = 0.29$). There was no significance between groups.

Table 4.4.
Sleep Groups and Differences in Caffeine Intake (mg)

Mean hours of sleep/week (hrs)	n	Mean	P-value
< 8	61(64)	33.4±48.9	0.29
≥ 8	35 (36)	23.3±36.0	

T-test set at a statistical significance of $p < 0.05$

Discussion

Few relationships were present between caffeine intake and selected variables. There were no significant relationships between caffeine intake and BMI, gender, activity level, or sleep. The trend toward significance between age and caffeine suggests that an increase in age may lead to an increase in caffeine consumption. Older students may be consuming more caffeine as classes become more involved or if there is an increased need for focus and attention as their academic career progresses; nevertheless the results fail to demonstrate this.

Unlike several studies that suggest that caffeine has an influence on sleep time, sleep onset latency, and sleep efficiency (Judice et al., 2012; Paterson et al., 2009), the current study showed no relationship between caffeine intake and average sleep time during the week (Table 4.5). Although the current study found no significant relationships, other studies have examined caffeine's effects on sleep at higher concentrations than this study. Astrup et al. (1990) examined the effect of caffeine at concentrations between 100 mg and 400 mg. Other studies have used 200 mg as the standard for examining relationships (Drapeau et al., 2006; Landolt et al., 1995). The results obtained in the current study were determined by the average hours of sleep over a 7-day period and were divided into two categories of $<$ 8 hours of sleep and $\geq$ 8 hours of sleep. This study did not assess each individual night of sleep or each individual day of caffeine intake. The data represents the average dietary intake over 72 hours and average amount of sleep over 7 days.

Unlike Schrader et al. (2013), who concluded that caffeine had a positive influence on physical activity, the current study showed no relationship between caffeine and physical activity. There was also no significant relationship between caffeine intake and BMI. Though previous studies have examined an effect of caffeine on energy expenditure, it is unclear in the current study whether the increase in energy expenditure plays a role in BMI reduction since there was no relationship between the two variables (Astrup et al., 1990). It is important to note, however, that there may not have been enough caffeine consumed to produce any thermogenic effect. Gender played no significant role on caffeine consumption in college students. Anything less than a moderate level of intake may have been insufficient to trigger changes in sleep or the other comparisons that were done. Since most studies have used above 100 mg, the average caffeine consumed in this study may not have been enough.

Hallissey, Agel, Lian, Kim, Hoffman, and Policastro (2010) found that students who slept less than seven hours a night had a significantly higher BMI than those who slept greater than seven hours (Hallissey et al., 2010). Unlike the current study, Hallissey separated hours slept during the week and hours during the weekend to examine the differences. This would have been beneficial for the current study. Separating the hours of sleep during the week from the weekend may be more predictive of how sleep may be affected during the week when classes take place.

There were several limitations in this study that would need to be addressed for further studies. The study was done at a Midwestern university so the data is not generalizable. All of the data were self-reported and entered by the students. Though there was an informative lecture on how to enter the data correctly, the data could have been misrepresented. Other limitations in the study include the data accessed from the 72-hour food record. Researchers were only given the results of the analysis of the total 72-hour food record and not each individual day so the researchers could not see each item the individuals consumed, but just the total caffeine intake over 72 hours.

It would be beneficial for future studies to use more reliable methods of tracking data, like sleep analysis software that each student could wear while they sleep. It would also be beneficial if there was access to the actual food diary to examine where the highest sources of caffeine were consumed. Future studies could also examine the differences in age and caffeine consumption. It would be interesting to determine if students consume more caffeine as they progress through college and if that has any effect on their academic performance and sleep schedule. Further research with a larger and less homogenous population needs to be done to examine if caffeine has a negative or positive influence on sleep in order to make recommendations for college students.

The conclusion of this study suggests that caffeine has no direct relationship with gender, age, BMI, activity level, or average sleep throughout the week.

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CHAPTER V. CAFFEINE INTAKE OF COLLEGE STUDENTS IN DINING CENTERS

Abstract

Currently, there are no studies that examine the effect of caffeine intake in those with a meal plan compared to those without a meal plan on a college campus. The purpose of this study was to examine the relationships between caffeine intake in college and dining frequency at Midwestern University. The participants included 350 students (212 male and 138 female; mean age 19.2 ± 1.61 years) enrolled in a Wellness course at the university. Students completed a 72-hour dietary record in NurtitionCalc software. Out of the participants, 44%, had a meal plan and visited the dining center 11+ times per week. The students that visited the dining center 1-10 times per week accounted for 21% of the population. The rest of the students, 35%, did not eat at the dining center at all during the week. There were no significant relationships between any of the dining frequency groups and BMI, physical activity, gender, or caffeine intake; however as age increased, frequency of attending the dining centers decreased ($p < 0.0001$). A trend for significance was shown when comparing dining 0 times per week and 1-10 times per week on caffeine intake ($p=0.09$). Nevertheless, the conclusion was that dining arrangements made no difference in caffeine consumption, but age had a significant impact on dining frequency.

Introduction

As students enter college, most are given the option or may be required to participate in campus dining. Many schools offer unlimited dining plans, which provides the student with a buffet-style setting, allowing them to consume as little or as much as desired. In addition to unlimited dining, some campuses offer coffee shops and cafes on campus that students can access. Since caffeine can be easily accessible on some college campuses, students may be consuming more in a college setting. This may occur, especially, if they have unlimited access or are on a meal plan that includes coffee shops or cafes. NDSU offers a coffee shop that is located directly in the residence dining center that students have access to, which is included in their dining meal plan (NDSU dining, 2014).

Caffeine is the most widely consumed legal drug, similar in popularity to alcohol and tobacco (Astrup, Toubro, Cannon, Hein, Breum, & Madsen, 1990). College is a time of increased focus, stress, and motivation, which all may contribute to caffeine intake. Malinauskas, Aeby, Overton, Carpenter-Aeby, and Barber-Heidel (2007) examined the different influences that increase caffeine consumption among college students. Out of the 496 participants surveyed, 51% reported consuming more than one energy drink in a month. The most common reason for consuming caffeine was insufficient sleep followed by needing a boost of energy and studying for an exam (Maulinauskas et al., 2007). Pettit & DeBarr (2011) surveyed 136 college students to assess their energy drink consumption and found that 70% of their subjects reported drinking at least one energy drink in the past 30 days, and 59% reported at least one in the last week. Both studies reported that greater caffeine intake was directly related to higher perceived stress levels (Maulinauskas et al., 2007; Pettit & DeBarr, 2011). Stress increases caffeine consumption among college students (Pettit & DeBarr, 2011).

Caffeine has an effect on psychomotor performance, for habitual college consumers. Peeling and Dawson (2007) observed students in a 75-minute college lecture to investigate the effects of caffeine on concentration and arousal compared to a placebo. Caffeine intake increased feelings of energy, anxiousness, clear-mindedness, and students reported they felt more awake compared to those who took the placebo. Students reported better concentration and being more aroused compared to those who did not have caffeine (Peeling & Dawson, 2007). Due to the effects of caffeine on concentration and alertness, it is no wonder that caffeinated beverages become a popular choice of beverages among students.

Some universities offer cafeterias that are designed in a “buffet-style” for students to have unlimited access to food and beverages. There are also several other coffee shops located throughout campus for students. According to Roxanne England, the dining services manager, NDSU is only the second other campus in the nation to offer a coffee shop directly in the dining center (personal communication, January 29, 2014). Racette, Deusinger, Strube, Highstein, Deusinger, (2010) examined the effects of dining on campus and the changes in students’ dietary, exercise and weight patterns because the greatest increase in overweight and obesity occurs between the ages of 18-29 years.

Marketing is an important tool that may additionally influence a student’s dining choices. The marketing of a coffee shop in a dining center may be enough to influence caffeine consumption of the students who participate in a meal plan. Peterson, Duncan, Null, Roth, and Gill (2010) examined the perceptions and selections of healthful foods after a short-term marketing intervention that occurred in the dining center of a Midwestern university. By increasing the social marketing to influence behavior, after 3 weeks, overall healthy eating behaviors improved. Peterson et al. (2010) concluded that relevant and appealing messages targeted at college students have the potential to improve dining behavior. Boek, Bianco-Simeral, Chan, and Goto (2012) also examined the differences in food selections by students at a college dining center and concluded that food choices in the dining center are influenced by external cues in addition to the environment. Out of the students who participated, 58.6% reported enjoying a larger food court setting and 16.5% of students reported enjoying more of a café setting (Boek et al., 2012). Both of these options are offered at the university resident dining center.

Because the coffee shop is directly inside the dining center, students who have a meal plan or use the dining center more often may be apt to consume more caffeine. If students who have a meal plan consume more caffeine than those who do not, the location, accessibility, and setting of coffee shops on campus may have an impact on caffeine consumption in college students. Currently, there are no studies that examine the effect of caffeine intake in those with a meal plan compared to those without a meal plan who have access to a coffee shop in their meal plan. The purpose of this study was to examine the relationships between frequency of dining and caffeine intake, age, gender, BMI, and physical activity.

Methods and Measurement

This study has been approved by the university's Institutional Review Board for the Protection of Human Participants in Research

Dietary intake was examined over a 72-hour period through the use of NutritionCalc Plus (10^{th} ed., McGraw-Hill Global Education Holding, LLC, New York City, NY) in four different wellness classes at the university. The classes chosen to study were HNES 100: Concepts of Fitness and Wellness and HNES 111: Wellness. Each course is divided into two large, lecture style classes. The students in each of the classes were instructed how to enter foods listed on their personal food record into NutritionCalc Plus. This helped to reduce the chance of misreporting or entering of data. Name, age, height, weight, foods listed on the 72-hour food record, and self-reported physical activity based on a scale of lightly active, active, or very active were entered by each participant. NutritionCalc Plus calculated BMI using the equation of body weight in kilograms (kg) divided by height in meters squared (m^2).

The students were also asked to record the number of times they ate at the dining center on average per week on the informed consent. It was assumed that those who did not attend the dining center at all during the week did not have a meal plan. Those who went to the dining center 1-10 times per week were assumed to have a block plan option, which is a specific number of meal plans that ranges from 25 to 100 meals per semester. Those who ate at the dining center 11 or more times were assumed to have the unlimited meal plan option.

Participants

The study included 352 students aged 19.2 ± 1.61years who were enrolled in one of the four wellness classes. Participants were excluded if the software was used incorrectly, the student failed to report 72-hour dietary intake, or if there was any missing necessary data.

Statistical Analysis

Student reports generated by NutritionClac Plus were analyzed through SAS/STAT® 9.3 (SAS Institute Inc., Cary, NC, 2008). All of the students' names were replaced with a numerical identifier. BMI, age, gender, caffeine intake (mg) were entered into the spreadsheet for analysis. Statistical significance was set at a value of $p < 0.05$.

BMI, caffeine intake, dining frequency were collapsed into categorical data. BMI was categorized into underweight/normal (<25 kg/m^2) or overweight/obese (≥ 25 kg/m^2). Participants who consumed 0 mg of caffeine were classified into the "none" consumption group. Those who consumed > 0 mg and ≤ 50 mg were classified as "light" consumers. Those who consumed >50 mg of caffeine were classified as "moderate" consumers. Two of the participants were removed because of caffeine intake exceeded 1000 mg and were outliers. Activity level was also classified into 3 groups based on the student's self-assessed activity level. Activity was measured based on the activity level that the student selected in the NutritionCalc Plus. Dining frequency was also collapsed into groups of 0 times/week, 1-10 times/ week, and 11+ times/week. Dining data was collapsed into three categories based on the types of meal plans offered. Those who did not eat at the dining center were put into the 0 times per week category and it was assumed they did not have a meal plan. Those who ate at the dining center 1-10 times per week were assumed to be on the block plan. Finally, those who ate at the dining center 11+ times per week were assumed to be on the unlimited dining plan.

Results

Of the 350 participants included in the study, the mean age was 19.3 ± 1.6 years (range 18-31 years). As seen in Table 5.1, 212 (61%) of the participants were male with a mean age of 19.5 ± 1.9 years and 138 (39%) were female with a mean age of 18.9± 0.98 years. Mean BMI was 23.8 kg/m^2 (range 17-43 kg/m^2). The majority of the participants (70%) were within the underweight/normal category with a BMI of 25 kg/m^2. The remaining 106 (30%) were categorized in the overweight/obese category with a BMI ≥ 25 kg/m^2. Those who were lightly active consisted of 65 males and 59 females for a total of 121 (35%). The active group consisted of 108 males and the very active group consisted of 41 males.

As seen in Table 5.1, mean caffeine intake for all of the participants in the study was 33.29±50 mg (range 0-295 mg.). A total of 106 (30%) participants did not report consuming any caffeine, while 244 participants reported consuming some amount of caffeine over the 72 hours. Out of those who consumed caffeine, 165 (47%) were classified as light consumers with 79 (23%) participants classified as moderate consumers. Out of those who consumed no caffeine, 58% were male. The light consumers consisted of 62% male. The moderate consumers consisted of 59% male.

Table 5.1.
Demographics, Body Mass Index, Activity Level, Dining Frequency, and Caffeine Intake of Participants

Characteristics	Total N=350	Men n = 212	Women N=138	P value
Age (years)[1]	19.3±1.61	19.5 ± 1.9	18.9 ±0.98	0.001
BMI[1]				0.17
Underweight/Normal (<25)	244 (70)	142 (67%)	102 (74)	
Overweight/Obese (≥25)	106 (30)	70 (33%)	36 (26)	
Activity Level[1]				0.05
Light Active	121 (35)	65 (31)	59 (42)	
Active	168 (48)	108 (51)	61 (44)	
Very Active	61 (17)	41 (19)	20 (14)	
Dining Frequency (times/wk)				0.09
0	122 (35)	77 (36)	45 (33)	
1-10	74 (21)	45 (21)	29 (21)	
11+	154 (44)	90 (43)	64 (46)	
Caffeine Intake (mg)[1]	33.29 ± 50	33.9±49.7	32.2±50.7	0.79

[1]Chi-square set at a significance of $p < 0.05$
[2] ANOVA (GLM procedure) set at a significance of $p < 0.05$

Using the Chi-square test, demographic characteristics showed little influence on dining frequency per week, except for age (Table 5.2). Dining frequency had a significant negative correlation with increasing age (X^2 (4, N=350) = 83.9, p<0.0001). Of those who ate at the dining center 0 time/week, the majority (54%), were over the age of 20. Of those who at the dining center most frequently, 11+ times per week, 94% of the students were 18 or 19 years old. Dining frequency showed no significant relationship with BMI (X^2 (2, N=350) = 0.4, p=0.82). Most of those who reported eating at the dining center 11+ times per week were classified as underweight/normal (70%). Those who ate at the dining center 1-10 times per week consisted of 69% underweight/normal participants. Lastly, 68% of participants who went to the dining center 0 times per week were classified as underweight/normal.

Dining frequency also had no significant relationship with activity level (X^2 (4, N=350) = 0.7, p=0.95). Of those who went to the dining center 0 times per week, 34% were lightly active, 50% were active, and 17% were very active. Participants who went to the dining center 1-10 times per week consisted of 38% lightly active, 44% active, and 18% very active. Lastly, those who ate at the dining center 11+ times per week consisted of 34% lightly active, 48% active, and 18% very active. There were no significant differences between gender and dining frequency (X^2 (2, N=350) =0.62, p= 0.73). Those who ate at the dining center 0 times per week consisted of 63% male. Those who ate at the dining center 1-10 times per week consisted of 61% male and those who ate at the dining center 11+ times per week consisted of 58% male.

Table 5.2.
Influence of Dining Frequency (Times/Week)

	Total n= 350	0 times/wk n=122	1-10 times/wk n=74	11+ times/wk n=154	P-value
Age[1]					
18	105 (30)	18 (15)	27 (36)	60 (39)	<0.0001
19	152 (43)	38 (31)	29 (40)	85 (55)	
20+	93 (27)	66 (54)	18 (24)	9 (6)	
BMI[1]					
Underweight/normal	244 (70)	83 (68)	51 (69)	110(71)	0.82
Overweight/Obese	106 (30)	39 (32)	23 (31)	44 (29)	
Activity Level[1]					
Lightly Active	121 (35)	41 (34)	28 (38)	52 (34)	0.95
Active	168 (48)	61 (50)	33 (44)	74 (48)	
Very Active	61 (17)	20 (16)	13 (18)	28 (18)	
Gender[1]					
Male	212 (61)	77 (63)	45 (61)	90 (58)	0.73
Female	138 (39)	45 (37)	29 (39)	64 (42)	

[1] Chi-square test with statistical significance p <0.05

The mean caffeine intake of those who went to the dining center 0 times per week was 36.4 ± 61 mg. The mean caffeine intake of those who went to the dining center 1-10 times per week was 23.9 ± 40 mg. The mean intake of those who went to the dining center 11+ times per week was 35.3 ± 44 mg. When making comparisons of caffeine intake between groups, there were no significant differences in the relationship between dining frequency and caffeine intake.

The difference in caffeine intake between those who do not go to the dining center and those who go 1-10 times per week approached significance (GLM procedure, p= 0.09).

Discussion

Few relationships were present between caffeine intake and the selected variables. The only significant relationship between the variables were dining frequency and age was most likely due to the fact that incoming freshman are required to purchase a meal plan if they are living in the residence halls. Once students leave the residence halls, at the university where they current study took place, they are no longer required to have a meal plan. There were no relationships between dining frequency and BMI or physical activity. No differences were shown between genders and dining frequency. There was no relationship between dining frequency and caffeine intake; however, there was a trend toward significance between dining frequency of 1-10 times per week compared to those who did not have a meal plan. Those who went to the dining center 1-10 times per week consumed more caffeine. The students that have a block plan, with a limited number of meals per semester, may be utilizing their meal plan to have access to the coffee shop that is located in the dining center more often. Unlike those who have no access to the coffee shop, those with a block plan might be spending more time in the coffee shop and therefore consume more caffeine.

There were several limitations to this study design that should be addressed in future studies. This study was done at a Midwestern university so the data is not generalizable. All of the data was self-reported by the students so it could have been misrepresented. Another limitation is the data obtained from the 72-hour food record. The researchers only had access to the total amount of caffeine consumed over the 72 hours and not the amount of caffeine that was consumed each individual day. The researchers also had no record of the sources of caffeine that the students were consuming. It may have been beneficial to the research team if the students distinguished what kind of meal plan students had and the location of most of their dining on campus. Future studies would benefit from tracking meal swipes of each participant instead of using self-reported frequency.

Future studies would benefit from using more detailed methods of tracking dietary patterns and dining frequency. For those who are consuming caffeine in the dining hall, it is unclear whether the caffeine is coming from access to coffee shops and cafes or from other sources. Future studies could also compare the caffeine intake from universities that have coffee shops available to students in the dining center versus a university that does not have any. Future studies could also examine the effect of marketing of a coffee shop and how that may influence caffeine consumption.

The current study may be beneficial for universities looking to utilize a coffee shop in their dining center or include coffee shops in the student meal plan. Though the data approached significance, the major conclusion to be found was that dining arrangements made no difference in caffeine consumption.

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CHAPTER VI. SUMMARY

Caffeine has been shown to have negative implications on sleep patterns including total sleep time, sleep onset latency, and sleep efficiency (Judice et al., 2012, Paterson et al., 2009). It has been found to have an influence on metabolism and energy expenditure (Garret & Griffiths, 1997; Astrup et al., 1990). Caffeine has also been associated with mood disturbances and increased anxiety and stress in college students (Lund et al., 2005; Stasio et al., 2011). This study examined the effects of caffeine intake on average sleep per week, body mass index (BMI), and physical activity in college students. Additionally, the study examined the relationship of dining frequency at the dining halls on caffeine intake in college students. A 72-hour dietary record was completed by students at a Midwestern university to assess caffeine intake. A sleep diary was recorded over 7 days and the average hours of sleep for the week was used to examine the relationship between caffeine and sleep throughout the week. Additionally, the relationships of caffeine intake and dining frequency to BMI, physical activity, gender, and age were assessed in college students.

The results of the study showed that there were no significant relationships between caffeine intake and average hours of sleep obtained throughout a week. Out of the students that consumed any caffeine, most fell into the light group with less than 50 mg of caffeine, which may not have been enough caffeine to affect sleep patterns. The amount of caffeine intake also may not have been enough to influence the other variables like BMI or physical activity. Most students obtained 8 hours or more of sleep on average throughout the week. This study examined the average amount of sleep obtained over a week period to get a better representation of sleep deprivation over a longer period of time. There were no significant relationships between caffeine intake and BMI, physical activity, gender or age.

Caffeine had no significant effect on BMI in college students so it may not have a significant impact on metabolism. Previous studies have examined the effect of caffeine on metabolism and energy expenditure, but the amount the students were consuming may not be enough to produce significant changes in BMI (Astrup et al., 1990). The population for the current study was split into two BMI categories for a more even distribution of data; however, future studies would benefit from examining the effect of caffeine on all of the BMI categories to get a better representation of caffeine intake differences among the different BMI groups.

There was a trend toward significance between caffeine and age, which may suggest that students are consuming more caffeine as they progress through college. This study indicates that caffeine intake was no different between genders. More importantly, this study suggests that caffeine does not seem to have any effect on the amount of sleep obtained over a week period. Caffeine may have acute implications during the week when classes take place, which is why it would be beneficial for future studies to examine the differences in caffeine intake during the week compared to the weekend and how that may affect sleep schedules. The negative implications that caffeine has shown in previous studies (Judice et al., 2012, Paterson et al., 2009) may just be affecting the student's sleep schedule acutely and may not be causing sleep deprivation over a longer period of time. Future studies could examine the relationships between caffeine and sleep in those with a higher caffeine intake if the amount of caffeine dictated the participants in the study. More variety in the sleep categories (e.g. <6 hours, 6-8 hours, 8-10 hours, etc.) may also strengthen the relationships between caffeine intake and sleep.

In addition to sleep, the relationship between dining frequency and caffeine intake was examined. The university that the current study took place at has a coffee shop directly in the resident's dining center. Therefore, students with a meal plan have easy access to caffeine, as it is included in the meal plan. After examining the differences between those who do not have a meal plan (0 times/week), those on a block plan (1-10 times/week), and those with unlimited dining (11+ times/week), there was no significant relationship between caffeine intake and the different frequencies. Those who visited the dining center 1-10 times/week seemed to have a slightly higher caffeine intake than those who did not eat at the dining center. This may have been due to the limited amount of meals provided throughout the semester, so students may have utilized the coffee shop more. Unlike those with unlimited or no access to the coffee shop, those with a block plan may take more advantage of the coffee available to them. In addition to caffeine intake, the relationship of dining frequency on BMI, physical activity, age, and gender was examined. There were no significant relationships between dining frequency and BMI or physical activity. There were also no differences between genders. There was, however, a significant relationship between dining frequency and age. This was most likely due to the requirement of a meal plan when living in the residence halls. Because younger students had a higher dining frequency in the dining halls, it is assumed that freshman and sophomore students that are currently living in the residence halls utilize the dining halls more.

There were several limitations to the current study that may have affected the results. All of the data was self-reported, which could have caused over-reporting or under-reporting of correct portions consumed. Also, students self-reported their dining frequency per week, which would have been more accurately represented if the meals were counted through the dining system. Physical activity, height, and weight were also self-reported, which could have resulted in students over or underestimating their physical activity level. BMI could have also been miscalculated if the students entered their height and weight wrong. Since the data was conducted at a Mid-western university in four college classes, the data is not generalizable to the public.

This study has concluded, based on the current data, that caffeine does not show any relationship to average sleep per week in college students. Also, dining frequency, with or without a meal plan, has no relationship to caffeine intake in college students. Neither dining frequency nor caffeine had any influence on BMI or physical activity. Future studies could further this research by examining acute caffeine intake on sleep patterns and the differences between the weekends and weeknights. Also, future studies could assess the utilization of coffee shops and cafes on campus and whether or not availability has an effect on caffeine intake in college students. Future studies should also examine he utilization of these coffee shops, in addition to soda machines and other caffeine sources, to understand the total consumption of college students. This would give a larger scale representation of caffeine utilization. It would also be interesting to see if caffeine, in addition to sleep patterns, has any effect on academic performance in college students. College students may be consuming less caffeine than previously examined (Pettit & DeBarr, 2011; Malinauskas et al., 2007). If true, caffeine may not negatively influence college students' health and wellness; however, further research is needed for a better understanding of caffeine's effects on the well being of college students.

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APPRENDIX. IRB APPROVAL

NDSU NORTH DAKOTA STATE UNIVERSITY

February 18, 2014

FederalWide Assurance FWA00002439

Dr. Ardith Brunt
Department of Health, Nutrition & Exercise Sciences
EML 351E

IRB Approval of Protocol **#HE14166, "Nutritional intake of college students"**
Co-investigator(s) and research team: **Elizabeth Hilliard, Sarah Hilgers-Greterman, Samantha Fuhrmann, Michelle Caldarone**

Approval period: 2/18/14 to 2/17/15 **Continuing Review Report Due: 1/1/15**

Research site(s): **NDSU** Funding agency: **n/a**
Review Type: Expedited category # 5
IRB approval is based on original submission, with revised: consent form (received 2/13/14).

Additional approval is required:

- prior to implementation of any proposed changes to the protocol (*Protocol Amendment Request Form*).
- for continuation of the project beyond the approval period (*Continuing Review/Completion Report Form*). A reminder is typically sent two months prior to the expiration date; timely submission of the report is your responsibility. To avoid a lapse in approval, suspension of recruitment, and/or data collection, a report must be received, and the protocol reviewed and approved prior to the expiration date.

A report is required for:

- any research-related injuries, adverse events, or other unanticipated problems involving risks to participants or others within 72 hours of known occurrence (*Report of Unanticipated Problem or Serious Adverse Event Form*).
- any significant new findings that may affect risks to participants.
- closure of the project (*Continuing Review/Completion Report Form*).

Research records are subject to random or directed audits at any time to verify compliance with IRB regulations and NDSU policies.

Thank you for cooperating with NDSU IRB procedures, and best wishes for a successful study.

Sincerely,
Kristy Shirley

Kristy Shirley, CIP
Research Compliance Administrator

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