**The Effect of Energy Drinks on Sleep Deprivation in College Students**

Word Count: 4033

**Abstract**

Energy drinks are beverages containing caffeine in combination with other enhancing ingredients to keep the consumer in an alert state. The high caffeine and sugar contents affect heart health as well as vital organs. Additionally, caffeine consumption can affect sleep. Therefore, college students, who are in need of both stable sleeping patterns and energy, are at a loss when consuming energy drinks. This research study examines the correlation between college students' consumption of energy drinks such as, Monster and 5-hour Energy, and sleep deprivation. The study was conducted through survey among one hundred college students in Ventura County. Students at Ventura College, Moorpark College, and California Lutheran University were surveyed, and of the one hundred students, sixty three had consumed one or more energy drinks per week. The findings indicate that many consumers did not see a major impact on sleep mainly in accordance with low consumption rates in this population and age group.

**Keywords**: "caffeine", "energy drinks", "college students", "sleep loss", "deprivation", "adenosine receptors", "health effects"

## Introduction

About nine million energy drinks are bought per day and up to six billion per year in the United States alone at an increasing rate (Sepkowitz 2013). Stimulants including taurine, guarana, and caffeine are major components in many energy drinks. Taurine, an amino acid found in the body, has shown to affect physiological functions, especially at high consumption rates increasing the natural amount. Another major ingredient, guarana, is a stimulant containing the "active component" caffeine (Clauson et. al 2008). But the most vital ingredient in energy drinks is caffeine, which can boost energy through vivifying the heart. An increased amount of adrenaline is released within the body, in turn increasing blood pressure and heart rate (Ross et. al 1984). These drinks are consumed in efforts to increase mental and physical performance, such as: better reaction times, escalated brain function, and general increase in energy (Sepkowitz 2012).


Figure 1. Popular Energy Drinks sold at supermarket (Douillard 2013)

Popular energy drinks include Monster, 5-hour energy, Red Bull, and Rockstar (Figure 1). Whether the need for energy be through sports, school, or social events, young adults find reasons for caffeine consumption daily. Not only do these drinks contain caffeine, but also include ingredients that lead to a boost in caffeine content perception such as taurine, guarana, and sugars, as previously mentioned. Research suggests that energy drinks are often consumed alongside drugs and/or alcoholic beverages (Malinauskas et. al 2007), and people consuming energy drinks are more likely to continue use in combination with these substances (Seifert et. al 2011). The addictive properties

of caffeine can contribute to and stimulate further addictions, leading to an unhealthy lifestyle with an increased risk for countless medical issues. Resulting issues commonly suggest heart adjustments such as an increase in blood pressure or palpitations. This can also increase stimulation of the drinks, or counteract it by leaving the body in a shocked state.

While the suggested amount for a healthy adult of caffeine to be consumed daily is anywhere from three hundred to four hundred milligrams (mg), one energy drink contains eighty to three hundred mg of caffeine, depending on dosage and type (Gunja, Brown 2012). With children, the suggested daily amount is one hundred mg (Kole, Barnhill 2013). According to the Monster energy drinks nutritional facts labeling, one can contains one hundred and sixty mg for a regular drink. Yet, the company also sells various specialized drinks that contains an upward of one hundred and ninety mg of caffeine per can. With the caffeine, taurine and guarana stimulants, and the sugar dosage of about sixty grams, a single can has the ability to contribute to overconsumption and lead to the health concerns discussed. Although energy drinks contain high doses of caffeine, energy shots are another factor that can stimulate the heart and run the body. 5-Hour Energy has about eighty mg of caffeine per shot, but the small amount at a high dosage can prove to be a shock to the body systems (Cole, Barnhill 2013). Although the Food and Drug Administration (FDA) suggests a daily limit, it does not take into account the risks still apparent. High consumption rates in addition to alternate pairings could potentially affect the heart, liver, and other vital organs in the body due to the rush of adrenaline in combination with spiked sugar levels.

Alternate pairings suggest drinks in combination with alcoholic beverages, illicit drugs, prescription medication, and other substances that are ingested with potential to be a stimulant or

depressant. While stimulants such as caffeine lead to the increased adrenaline, depressants have the ability to counteract it. In addition, when consumed in mass amounts, or in combination with other substances, caffeine causes health defects, including cardiovascular issues such as heart palpitations which are irregular heartbeats, or increased blood pressure. Combinations of addictive products at an unhealthy rate have a peaked likelihood of having negative effects on the human body.

Caffeine (C8H10N4O2) also affects hormones found in various body systems (Figure 2).

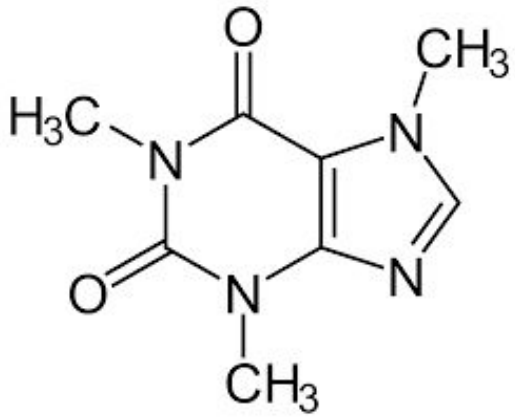



Figure 2. Chemical Structure of Caffeine (Webb 2013)

It is a stimulant that alerts the Central Nervous System and plays a major role in attentiveness and sleep. Hormones such as adenosine are naturally found in the body to help the process of sleep and vasodilation, a decrease in blood pressure. Yet, adenosine antagonists are the receptors which signal the body to wake. A study conducted by researchers Bjorness and Greene qualified that "elevated levels of Ado [were noticed] after [six] hours of sleep deprivation". But, this hormone, when bound to adenosine receptors, creates a relaxed state (Bjorness, Greene 2009). This relaxed state could result in sleep, where blood vessels are dilated and blood pressure is lowered under these conditions. However, caffeine binds to adenosine receptors throughout the body and act as an "adenosine-receptor antagonist" such that adenosine cannot bind (Piirainen et. al 2010). Subjects ingesting caffeine are unable to enter this relaxed state. Thus, college students in need of both stable sleeping patterns and energy, are at a loss when consuming energy drinks. Sleep deprivation is a direct result of this and can impact subjects

by creating unhealthy sleep patterns. Poor sleeping patterns can affect the brain's ability to learn and function properly.

Energy drink companies target marketing towards ages eleven to eighteen (Seifert et. al 2011) with the intention to attract youth towards energy drinks and continue consumer consumption growth as they age. Yet, the majority of consumers are college students looking to boost performance throughout busy college schedules. College students suggested consuming energy drinks in preparation for a upcoming exam or for mixing at parties is common (Gunja, Brown 2012). Stimulation from caffeine as well as other excitant ingredients leads to dangers of addictive behaviors, heightened in younger stages of life (Webb 2013). Since numerous college students consume these drinks on a daily basis, it is a concern to the growth and development of many people in the United States and in the world as they age. Educating youth and young adults on healthy habits can lead to a decrease in consumption. Due to the major consumption of drinks by this age group, increased knowledge on the topic can be beneficial to students for future consumption. Prevention and awareness about risks is a step towards removing energy drinks from the dietary supplements category and shifting the focus on safety instead of income. Due to caffeine related deaths and injuries in the past century, data application and survey results aim to analyze causes. In turn, preventing sleep deprivation post-consumption of energy drinks to allow college students to actively participate in healthy lifestyles.

## Purpose

Health of young adults is a major concern, especially due to age having the ability to increase risk of health problems developing in the future. The high levels of caffeine stimulants and sugar contents contain determinants that affect heart health as well as vital organs. If these defects occur early on they can spring into worse outcomes throughout the body with age. Lack of sleep for college students in need of stable sleeping patterns has the likelihood of sleep deprivation. The main purpose of this research is to further understand the correlation of caffeine content and its effects on sleep patterns to bring awareness and identify a solution.

## Research Question

The focus of my research study was based off of the question that follows: Does energy drink consumption lead to sleep deprivation among college students?

## Hypotheses

My hypotheses are based on factors such as time of consumption, amount of consumption, and alternate pairings consumption.

Null Hypothesis: There is no direct correlation between energy drink consumption and sleep deprivation among college students.

Alternative hypothesis: Energy drink consumption directly leads to sleep deprivation in college students.

## Methods

The design of the study was reading peer reviewed papers followed by primary data collection via survey. Peer reviewed articles and academic journals were obtained through online databases including PubMed-NCBI and Google Scholar. Searches performed employed keywords such as “caffeine”, “energy drinks”, “college students”, “sleep loss”, “deprivation”, “adenosine receptors”, and “health effects”. The sources range from the years 1984 to 2017, encompassing all topics discussed in the study. Each article provided a moderately different study, each contributing to the formation of the literature review. The articles cover caffeine content and specific effects of energy drinks on body systems. Others discussed the role of caffeine on receptors enabling sleep to occur during a relaxed state. The final group of papers covered general health effects including heart health, the Central Nervous System, and sleep deprivation. Although a sizable amount of articles were collected, only about twenty of the articles were applied directly to the study.

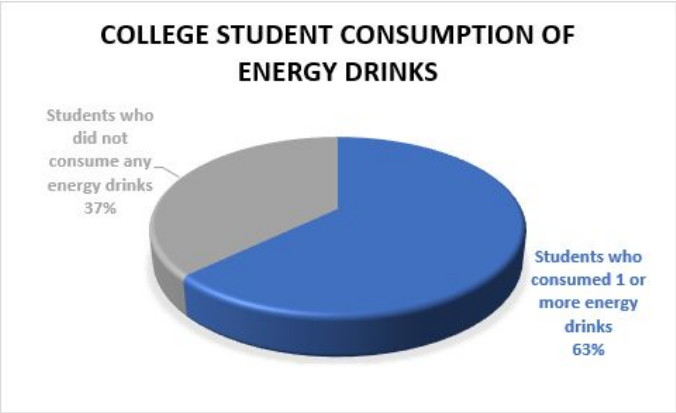
In addition to the literature review, a survey was conducted of one hundred subjects attending colleges within Ventura County. The survey contained eleven questions concerning each student’s consumption rates, if any, and other factors with the potential to impact the resulting sleep patterns. Subjects were chosen at random from California Lutheran University, Moorpark College, and Ventura College. The study’s focus group was targeted at students between ages eighteen and twenty five, which is the average age range of the majority of college students. In addition, type of drink, amount of drink, and time of consumption during the day were questioned. Age, number of units per semester, gender, and school were all questions covered in the survey determined to leave out of results due to lack of applicability. Although the

survey focused on energy drinks and what may have influenced consumption the literature review focused on the health aspects in addition to sleep that may still affect it. Each factor was applied to determine if there was a significant impact on sleep of the anonymous subjects surveyed. A complete copy of the survey is attached as Appendix B.

Data was collected from the surveys conducted and compiled into Excel sheets. Data analysis was performed once all data was tabulated, using the Chi Squared method. The program JMP Statistical Software was applied and data was entered to obtain probability numbers, or the p-values. Post-data collection, data was categorized, applying the information to charts, graphs, and inserted in the study. The values applied contributed to the assumption that numerous factors contribute to sleep loss in relation to caffeinated energy drinks.

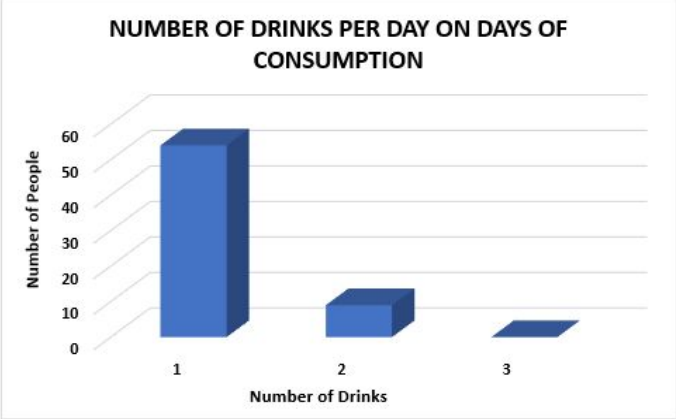
Primary data collection proved to be the most effective and provided a perspective on consumption in the Ventura County region. Although there is current research similar to the study design, the goal was to understand what influences students to consume the beverages. It was proven that the schools did not play a role in consumption rates, but was apparent that caffeine has grown in popularity. With a firsthand perspective on consumers and effects of the drinks, the results have a greater impact. A statistical study gathered from varied regions is relevant, but has a weaker impact than that of a study in a surrounding area with evidence compiled of people in the community. The reality of the problem allows awareness to spread more effectively.

## Results




Of the one hundred participants, 63% of subjects have consumed one or more energy drinks. The remaining 37% had suggested never consuming an energy drink.

Figure 3. Overall consumption rates of college students in Ventura County




There were fifty four consumers that drank one energy drink on days of ingestion. The remaining nine drank two drinks and none drank three energy drinks.

Figure 4. Number of drinks consumed by college students on days of consumption

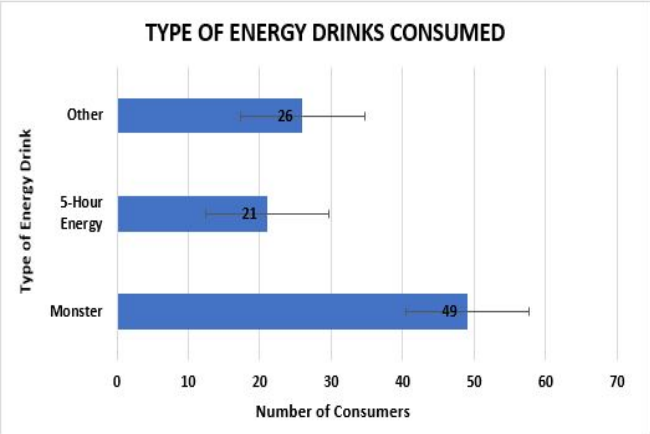



Figure 5. Type of drink and number of college student consumers

Although there were sixty three consumers, a handful of subjects consumed more than one type of drink. The data represents the number of times each drink was consumed, but does not represent the number of consumers. Of the sixty three, forty nine subjects have consumed Monster, twenty one subjects have consumed 5-Hour Energy, and twenty six have consumed various other energy drinks.

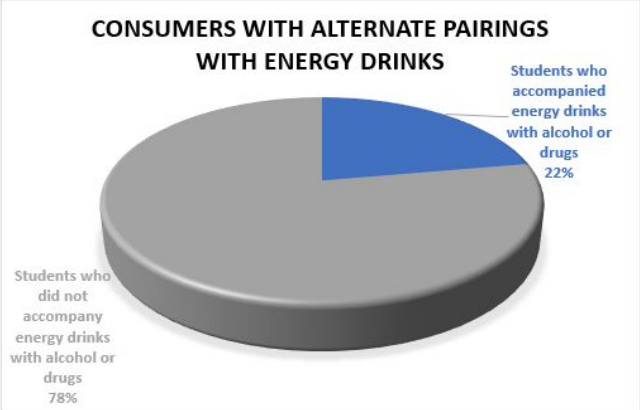



Figure 6. Alternate pairings with energy drinks of the consumers

Of the sixty three consumers, about 78% did not consume energy drinks with any other substance or fluid. The other 22% consumed with either alcohol, prescription medication, or illicit drugs.

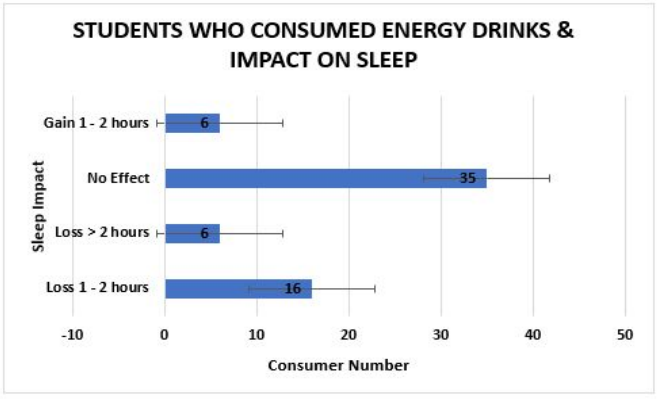



Figure 7. Consumers and their impact on sleep measured in hours

Of the sixty three, six subjects gained one to two hours of sleep. Thirty five subjects experienced no sleep loss whereas six lost over two hours of sleep, and sixteen lost between one to two hours of sleep.

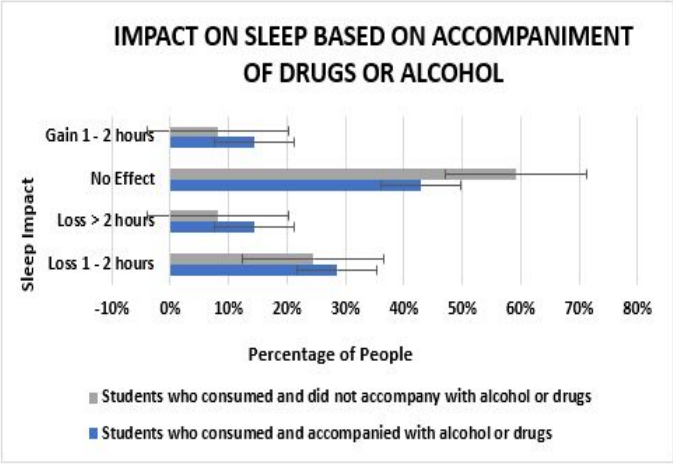



Figure 8. Alternate pairings and impact on sleep versus no pairings

Non-Accompaniment Consumers (NAC), shown in the gray, had similar results to consumers accompanying energy drinks with alternate pairings. Almost 60% of NAC did not lose any sleep with almost 45% of Consumers (C) also suggesting no loss of sleep. The same number of subjects, about 17% each category who gained sleep also lost over two hours of sleep. Finally, about 25% of NAC lost one to two hours of sleep while 30% of C lost the same amount of sleep. Over 5% of consumers without accompaniment of other substances gained sleep, with the Consumers (C) accompanying with other substances showing 10% gain.

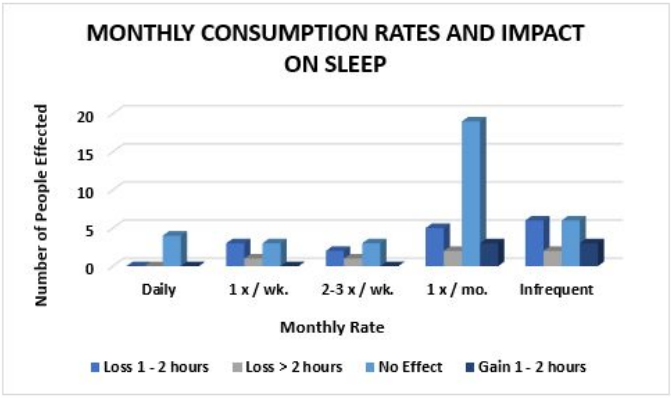



Figure 9. Monthly consumption rates and impact on sleep (number affected)

The daily consumers were the lowest in numbers while the majority of consumers ingested drinks once a month. Over ten infrequent users experienced no effect or one to two hour loss. About five noticed a large sleep loss or slight gain of one to two hours. Nearly twenty monthly consumers experienced no loss with below five in each category losing or gaining sleep. Consumption one to three times a week had similar results, less than five people saw loss, no effect, or a gain. The daily consumers all experienced no loss. The

data would suggest that the frequency of energy drinks consumed has little to no difference for sleep loss.

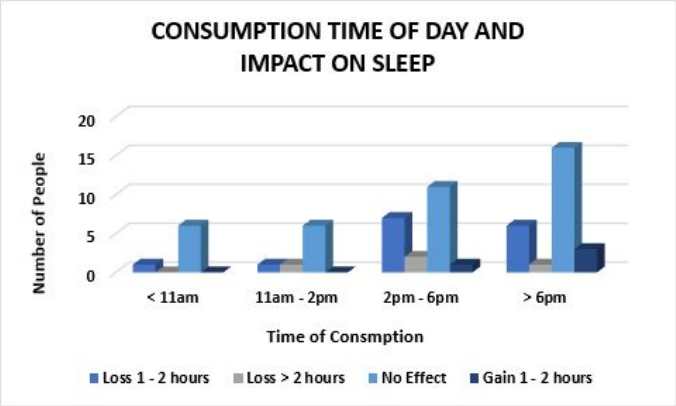



Figure 10. Consumption Time and Impact on Sleep

The chart tracks the time of day in which participants consumed energy drinks. The time least consumed was prior to 11 am and the time most consumed was after 6 pm. The second highest category was loss of one to two hours followed by an even amount of large loss and one to two hour gain. The majority of people in each category experienced no effect.

**Discussion**

The study was designed to qualify if energy drinks, in addition to circumstances surrounding consumption, lead to sleep deprivation. After recording responses of the one hundred subjects, it was found that 63% of the subjects had consumed energy drinks at one point in their lives. The other 37% had never consumed an energy drink and were excluded for a large part of the study (Figure 3). The number of consumers was noticeably higher than the amount of non-consumers, so the study continued with drink types and consumption rates. Yet, after running the Chi Squared Test to verify the significance of the statistic, the suggestion of low significance was observed. The significance level of 0.05 was used for t-testing and making conclusions. With the significance level aiming to be measured below 0.05, the results came up with 0.096. Although there is implication of insignificance and adjustment needed, the study continued.

The vast majority of consumers had only ingested one drink on days of consumption (Figure 4). About fifty subjects had only ingested one drink while the other portion of consumers drank two drinks, or did not fully consume a drink. The two focus drinks of the study were Monster and 5-Hour Energy. The results concluded that, of the sixty three consumers, forty nine had consumed Monster, twenty one had consumed 5-Hour Energy, and twenty six had consumed various other drinks, with the main contender being Red Bull (Figure 5). Again, significance was tested and came back as insignificant results. With the p-value coming out to be 0.159, the data yet again was seemingly disproved likely due to the low level of participants. Many consumers had ingested multiple types of energy drinks, so the data was recorded based off of each drink type consumed, not the number of consumers. Due to the fact that only 14.3% of the students surveyed consumed more than one energy drink per day coupled with the fact that the amount of caffeine contained in one drink is within the allotted suggested range for daily limit, one could imply that the impact to sleep would be minimal.

After learning this, it was discovered that 22% of consumers combined energy drinks with alternate pairings which include: alcoholic beverages, illicit drugs, and/or prescription medication (Figure 6). While alcohol acts as a depressant and has the ability to cancel the effects of caffeine stimulation, when induced it can shock the body and lead to blood pressure swings as well as heart palpitations. The remaining 78% were equally impacted by the drinks, but did not obtain additional possible effects as did the consumers with alternate pairings. The next series of questions regarded regular amount of sleep in accordance with sleep lost post-consumption. Again, non-consumers were not included in this grouping for the data applied solely to the subjects able to note effects of the drinks. Reportedly, six of the subjects noticed a gain in sleep

ranging from one to two hours. The largest notable category was the thirty five subjects who observed no gain or loss (Figure 7). Finally, twenty two consumers noticed sleep loss, with sixteen subjects noticing one to two hours loss and the remaining six noting over two hours of sleep loss. Results led to a more in-depth focus on the impact of alternate pairings on sleep loss in correlation of each other. According to Figure 8, with the exception of subjects losing no sleep, all consumers with alternate pairing ingestion had greater impacts on sleep than non-paired consumers. Although the majority of consumers noticed no effect, loss of one to two hours followed with the second highest amount of people. The loss of greater than two hours and gain of one to two hours were equal, suggesting that the alternate pairings likely had a small yet noticeable impact.

Other factors impacting sleep in accordance with consumption were frequency rate of consumption and time of day. Again, it is apparent that no effect trumps the other time groupings. With the majority of subjects consuming energy drinks once a month, it was apparent that no effect may have had to do with the fact that the distributed monthly use had little impact since caffeine levels were only spiked averaging at twelve times per year. Infrequent users were also common and experienced a range of results. Due to their inconsistent consumption, it is likely that days of consumption were particularly stimulating for their bodies; sparked by the concept that their bodies are not prone to ingesting high levels of caffeine and varied stimulants. The low level of consumers ingesting energy drinks one to three times a week had similar results to each other, suggesting that loss was common and likely due to overstimulation. Finally, the daily consumers all noticed no effect. Since consumption is daily, it is clear that subjects' bodies grew used to the stimulation and the little sleep they may be obtaining is consistent due to the common influence in

consumption (Figure 9). The final factor of the study in correlation with energy drinks was time of day the drinks were consumed. Yet again, the “no effect” category towers over the remaining options. Figure 10 represents the times of day of consumption, where many subjects stated they consumed at more than one time per day. The majority of consumers ingested energy drinks after 6 pm. Besides the peak of no effect, it is apparent that many of the consumers lost sleep. The second highest consumption time was between 2 and 6 pm. A large majority of consumers at this time lost sleep. It is implied that the later the time of day, the later consumers would ingest alternate pairings to the drinks, thus leading to the potential gain or loss depending on what was ingested. Between 11 am and 2 pm the majority of consumers did not have an effect, and although some did, it is logical that little to no impact on sleep would occur due to the gap between consumption time and sleep time. The final time, before 11 am, had similar results to the surrounding times with no effect having the highest number of people followed by a one to two hour loss in sleep.

The data expresses numerous patterns that lead to a result. Energy drinks were consumed by over 60% of college students surveyed. Stimulants in Monster and 5-Hour Energy specifically lead to sleep loss, yet also seemingly contribute to gain and lack of an effect on the body. Alcohol and drugs are able to influence whether sleep is lost, gained, or stagnant, in accordance with the time of day, amount, and consistency at which each was consumed.

**Sources of Error**

Human error is the main potential source of error in the research. Due to the fact that there were ranges provided for in the survey, there is room for misjudgment due to the need for circling the answer that seemed most applicable to them. In addition, it is possible for misinformation to be provided if subjects misread a question or did not want to provide the whole answer. It is probable that the sample size (n=100) was not large enough, due to the fact that only sixty three of the subjects were used throughout the basis of research. In addition, out of these consumers, the vast majority only consumed one drink, leading to a potential flaw in the research for the caffeine dosage is below the suggested amount. The personal perception of sleep is dependent solely on memory of the subjects. Since the physiological makeup is different in each individual, impacts vary depending on the person or due to adaptation to caffeine consumption. Due to this, there is a variation within actual results and perception of results. The combination of this with the low sample of consumers lead to the insignificance of the p-values provided by statistical analysis.

**Conclusion**

Due to the high p values throughout the study, the acceptance of the null hypothesis is concluded. This hypothesis states there is not a direct correlation between energy drinks and sleep deprivation in college students. The null was statistically more sound due to the fact that 63% of the one hundred test subjects consumed energy drinks (Fig 3). The low number of consumers in combination with factors such as low consumption rates led to skewed results. With 85.7% of consumers only ingesting one drink, many were below the suggested daily dosage. The physiology of the body varies with the person, and does play a role in caffeine's effect, in addition

to the concept of personal perception varying from the reality due to the study's design. Due to lack of prior knowledge about the survey, students were asked on hand to recognize how much sleep they potentially lost after consumption. Although the data did not express a significant correlation between sleep deprivation and consumption of energy drinks, approximately 35% of participants noted sleep loss. This loss ranged upwards of one hour and is relevant. Due to outlying factors, the data suggested the null hypothesis, yet it still is apparent that there is a connection between the two factors, and with proper data collection would come the scientifically implied correlation between sleep deprivation and energy drink consumption at higher doses.

**Further Work**

Once more work on energy drinks has been conducted, I would like to focus on educating about consumption and healthy alternatives to the drinks. Also, I would like to further explore the cardiovascular impacts of these diseases. Although the stimulation caused by adenosine receptors is a factor, I would like to study the physiology of how specifically the heart and other vital organs are impacted. I would be curious to test if heart health directly correlates to sleep and if it can lead to further diseases or less sleep due to other variations of caffeine dosages. Another factor I would be interested into researching more would be more specifics of consumer habits. For example, I would question pre-existing diseases, amount of exercise, all caffeine consumption (including the types), and ask more questions on sleep quality, in relation to the basis of my survey, the Pittsburgh Sleep Quality Index (Appendix A). This would allow me to understand each factor that plays a role in sleep deprivation and better understand a solution in order to prevent the loss.

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## Appendix

A. Pittsburgh sleep quality index :

http://www.opapc.com/uploads/documents/PSQI.pdf

B. Survey administered in Ventura County :

https://docs.google.com/document/d/12GHTnIA-x8rlJ6J6jKhmC1VNQ3Ge7YpdwWFzDdCZMQE/edit?usp=sharing