The Effects of Heavy Caffeine Consumption on High School Student- Athletes

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1. Introduction

On September 10th, 2022, University of Pennsylvania student Sarah Katz decided to purchase a Panera brand charged lemonade- a beverage containing a startling amount of caffeine; the drink contained 260 milligrams of caffeine in a 20 fluid-ounce container, an amount equivalent to over three cans of regular sized red bull. Sarah Katz had been previously diagnosed with a heart condition known as long QT syndrome type 1, a disorder known to cause irregular heartbeat and a sensitivity to caffeine. Unknowing the contents of the charged lemonade, Katz consumed the lemonade and unfortunately suffered cardiac arrest and passed away. Although caffeine amounts were labeled on the back of the beverage in fine print, the actual content was not disclosed on the container, much less the actual dangers associated with such a high caffeine content beverage. The passing of Sarah Katz and dozens of others could have easily been avoided by correctly labeling caffeinated beverages and educating the public on the dangers associated.

Historically the primary consumers of energy drinks were professional athletes who relied on caffeinated sports beverages to combat fatigue. Nowadays research has shown a contradictory change in the targeted audience for energy drinks. Beverage corporations now focus marketing toward adolescents and high school students. Energy drinks such as Red Bull, Celsius, and Monster have become a staple in on-campus convenience stores and school vending machines. Furthermore, many unseen dangers can result from this change in marketing techniques. To provide a definition, energy drinks are a brand of soft drinks containing high amounts of sugar (at most a quarter cup per can) and legal mental stimulants. Energy drinks emerged for the first time in Europe in the 1960s and have since become a global multi-billion dollar industry. The original goal of energy drinks is to provide alertness to fatigued athletes or to issue a competitive edge in professional sports. They were intended to be consumed prior to sports competitions or games. Energy drinks have always been advertised as improving mental alertness and reactivity. They contain legal stimulants such as taurine, guarana and L-carnitine and high amounts of caffeine that boost mental capacity. Even though energy drinks contain drug-related stimulants, they are not monitored by the FDA (US Food and Drug Administration). Although the intended effects of energy drinks seem positive, they can contrarily have quite detrimental downsides when consumed by the wrong person. Because they raise heart rate and blood pressure, energy drinks can be linked to various cardiovascular and cerebrovascular complications such as seizures, diabetes, insomnia, and even heart failure. Additionally, they are a prominent diuretic agent which can lead to greater fluid loss and dehydration. Energy drinks may be harmless to the majority of people but they can be life-threatening when consumed by someone with a prior heart condition. “High-risk groups include young, caffeine-deficient or caffeine-sensitive pregnant women, competitive athletes, and people with underlying cardiovascular disease.” (Guitezesa-Hellin and Varillas Delago 2021) There is a specific danger posed to teens with underlying heart conditions, especially if they are not aware of them yet. To further complicate the issue, “the effects of chronic high-dose caffeine and taurine intake in children, adolescents, and athletes are not yet known.” (Guitezesa-Hellin and Varillas Delago 2021) Currently, energy drinks are not required to state the caffeine content (if it is included it is in very fine print on the back) or provide any advisory statements. And therefore,

the marketing of energy drinks towards high school students poses many problems that I will examine in my future methodology.

The vast majority of research involving energy drinks has been conducted with professional athletes. Furthermore, many of the research participants are older than 18 and above high school age. And although this demographic may be the primary consumers of energy drinks it is important that research also examines the effects on a younger demographic due to the change in marketing strategies from soft drink corporations. In my research, I will look at how the effects of energy drinks are manifested in high school student-athletes and work to fill this gap in national research.

2. Literature Review

Much of the discussion regarding the effects of energy drinks on student-athletes is laid out in the study by Christina Buxton and John E. Hagan. (Buxton and Hagan 2012) The paper outlines a study conducted by Buxton and her colleagues that surveyed “university student-athletes sampled from seven public universities in Ghana.” The students were all older than 18, further proving my claim that there is little research concerning the demographic of high school student-athletes. Buxton first reviews the less obvious effects of energy drinks and the potential hazards they may impose. She acknowledges the concern that “information regarding the potential negative health effects of an excessive intake is not presented on the labels” of energy drinks. She also claims that athletes are “easily lured to consume these energy beverages” due to the appeal of improving their sports performance. After introducing the dangers imposed from energy drinks she summarizes the results of her study on Ghana athletes. The results of her study suggest that “some athletes had wrong perceptions regarding the benefits of energy drinks” and that “these wrong perceptions are a result of the ignorance of students about the proven positive benefits and negative effects of energy drinks”. Her proposed solution is to raise awareness of the true effects of energy drinks through health education. I believe that the results of my own experiment will be similar to those discovered in this study.

One article of similar design is the study by Rita Costa and her colleagues in which “30 healthy young female adults aged between 18 and 22 years old” were subjected to an experiment testing the correlation between high caffeine consumption from energy drinks and its direct effects on the cardiovascular and cerebrovascular systems. (Costa et al. 2023) Once again the study was conducted including adults over the age of 18, further proving the gap I am defending. Costa’s study focuses on the direct effects of caffeine on the body. The methodology and experimentation methods from this study heavily influenced my own and are the reason I chose to include an examination of heart rate in my own methodology. In her research, Costa found that “after the consumption of 250 mL of Redbull there was a decrease in carotid and middle cerebral artery velocities as well as a decrease in cardiac output associated with a decrease in heart rate and a slight increase.” This means that while under the influence of heavy caffeine, your heart is not able to provide adequate oxygen into the bloodstream. The lack of oxygen can be a direct cause of increased heart rate and future heart complications. The purpose of this study was to determine how prevalent of an issue energy drinks are and to try and determine the exact risks associated with consuming high amounts of caffeine. Because of this study, I will be evaluating the heart rate of my study participants.

Another paper that was highly influential to my research is the article “Knowledge, Consumption Pattern, and Adverse Effects of Energy Drinks among Asian Population: A Cross-Sectional Analysis from Malaysia” written by Ali Haeder Mohammad and his colleagues.

This study, much like my own research, aims to discover what limited knowledge participants had about energy drinks and analyze “the association between respondents' demographic data and their consumption patterns”. It was found in this study among countless others that the majority of adults have extremely little understanding of the true effects of energy drinks. The survey questioned both male and female participants in Malaysia with the “median age of participants being 23 years.” The overwhelming result of this study is that “healthcare professionals in Malaysia, such as doctors and pharmacists, should play a crucial role in disseminating reliable sources of information for EDs among Malaysians.” Meaning that it should be the responsibility of healthcare professionals to spread awareness of the potential harm of energy drinks. Although this article examines a demographic that is different from the one I will be reviewing, it provides a solid basis for my surveys and establishes a conclusion that ties into my own.

Finally, the last significant paper that heavily influenced my own research is an experimental study conducted by Gutierrez-Hellin and Varillas-Delgado published in 2021. This paper further examines the extent to which caffeine directly affects sports performance. The author concludes that these drinks “benefit individuals when exercising,” and have other beneficial outcomes such as “improving recovery time” and “increasing the efficiency of the exercise.” Because of this article, I decided to include the question “How many hours do you practice your sport a week?” in my primary questionnaire. This question helped me evaluate how reliant students are on caffeine in their sports performance and the perceived benefits/actual benefits. The article cites recent studies that have proved that caffeine and taurine, working together respectively, can “correlate positively with an improved athletic performance in a range of sporting situations.” Multiple studies are listed by the authors showing positive effects in sports such as cycling, volleyball, tennis, and swimming. Furthermore, the study investigates caffeine dependence. Caffeine dependency is when an avid caffeine consumer gets attached to the substance and experiences symptoms similar to addicts going through withdrawal when trying to cut out the substance. The researchers write that once an individual develops a dependency on caffeine it “makes caffeine even more damaging.” I decided to ask the question “How often do you drink caffeine?” to help determine which of my participants may have developed an intense craving for caffeine or dependence.

To conclude my literature review, multiple studies conducted all over the world prove there is a flaw in global research regarding caffeine intake and high school-age student-athletes. Although I was able to find numerous studies reciting their findings involving professional athletes, I was unable to find any studies that researched caffeine intake in relation to high school student-athletes. Furthermore, multiple studies collectively prove that caffeine can be extremely dangerous to those with heart complications due to its nature of increasing blood pressure and heart rate. The multiple authors all cite the theme that the numerous hazards of energy drinks are not clearly presented on the label- and that this may be the most concerning fact of the matter.

3. Methodology

The design of this study is a short questionnaire surveying participants' experience with energy drinks. My methods went through much trial and error and I eventually decided to redo my entire research process in a simpler format. For the final questionnaire, I developed a survey, intending to establish participants and obtain any prior knowledge or experience with energy drinks. I first asked close friends to complete the questionnaire, and then I expanded it to

general students within my school by posting a QR code in classrooms and the restrooms. The study was open to all students in grades 9-12 but included two questions at the bottom that were only for student-athletes to fill out. The goal of this section was to uncover the connections between sports activities and energy drink consumption and knowledge. All students consented to the use of their data in my presentation and paper but no confidential information was collected.

My methodology went through many reforms. Initially, I had two surveys and an experimental portion of my research. The surveys asked questions to determine the participants' experience with energy drinks and it was required that all participants be student-athletes (whether it was for a school-sponsored sport or a club). The experimental portion of the study was completed individually by each participant and then the results were recorded into a second research questionnaire. Each participant was asked to purchase a device capable of recording their heart rate throughout the day (many already owned one or borrowed a friend's) and an energy drink of their choice containing 200mg of caffeine (most Red Bull and Celsius brand drinks contain 200 mg). I also provided a Fitbit watch to a few students who didn't have one and gave the option to use an app on smart devices to track heart rate instead of a watch. They were then instructed to drink the entire beverage between the hours of 7:45 and 8:15- recording their new heart rate every hour or so. Although these methods provided a detailed and unique research process it was very difficult to continue as I had very little participation and learned that caffeine affects people in varied ways. Because of this, I would need many more research participants, and this simply was not possible in my limited school environment. As a solution, I combined both past surveys into a new and improved one and I eliminated the tangible research section. Instead of completing two surveys and consuming an energy drink participants now only had to complete one maximized survey. I kept results from the old surveys and added some of the responses into my new survey in order to keep the answers from my first participants.

For the new survey, the criteria for participants is that they must be in high school and enrolled in grades 9-12. I made an effort to ensure a wide variety of demographics in my survey group, allowing for a closer representation of survey data. My study also involved 3 respondents who participated in the study as control participants while having never consumed an energy drink. Although the majority of participants were female, both male and female students were tested. Additionally, all participants completed the survey anonymously.

The new survey consisted of ten total questions and a disclaimer. The first two questions were solely to determine who my demographic was for the survey. Question one asked the participant's gender and question two asked for grade level (9th, 10th, 11th, or 12th). I included question one because I wanted to analyze if there was a difference between answers given by male and female students. I also let students choose "prefer not to say" as an option in question one. Furthermore, this led me to advertise my survey more to males at my school as most of my first participants were female. Question three asked "How often do you consume an energy drink" and the options were once a month, once a week, two or three times a week, and every day. I detailed that "energy drinks" did not include coffee or tea beverages containing caffeine. I consider this question to be the most important in my questionnaire because I was then able to determine which participants would be affected the most by consuming energy drinks. Question four asked "What do you believe is the appropriate age to begin drinking energy drinks" and the options were less than 12, 13-17, or 18+. This question brings my survey into the section discussing ethics and morals in an attempt to discover my participants' standings on the correct

usage of energy drinks. Similarly, question five asked “Have you ever seen a warning label on an energy drink” and the options were yes or no. This was partially a trick question as most energy drinks do not contain a warning label. For example, Red Bull, Monster, and Celsius, some of the highest consumed energy drinks by adolescents, do not contain a label and disclose the caffeine content in very fine print under the nutrition facts. Question six asked “Why would you drink an energy drink” with response options being to reduce fatigue, to help concentrate in school or studying, and to enhance sports performance. Question six determined how adolescents have been affected by false advertising regarding energy drinks, as energy drinks should never be consumed to help with sports performance. Question seven asked “What symptoms do you experience” and included many options and a space for students to write their own responses. Students selected what they have experienced and the options were, chest pain, headaches, anxiety or nervousness, dieresis (increased urination), shaking or jittery, lightheadedness, and increased focus or concentration. The next questions were for student-athletes to complete only and question eight asked what sport they were in and question nine asked how many hours a week they practiced with options in three-hour intervals stopping at 12+. (If they were involved in two or more sports at once I asked them to include the total for all of the sports if they were in season at the same time). This question helped me determine how intensely each participant was involved in their sport and the average hours of my entire sample. The last question simply asked participants to check a box if they agreed to be included in my research paper and presentation anonymously.

4. Findings

Eighty-five individuals participated in my study, of these three were control participants and had never before consumed an energy drink. All of the responses were deemed usable thus creating a 100% usability rate. The sample consisted of thirteen participants in ninth grade 15.3%, twenty-two in tenth grade 25.9%, twenty-seven in eleventh grade 31.8%, and twenty-three in twelfth grade 27.1%. Of the respondents eighteen were male and sixty-five were female creating a ratio of 21.2% male and 76.5% female. Two students selected “prefer not to say " in the gender category 5%.

The findings of my improved survey are such- thirty-seven non-athletes filled out my survey 43% and forty-eight student-athletes 57%. The results consisted of athletes from fourteen different sports filled out my study with representation from, softball, swimming, water polo, volleyball, tennis, basketball, soccer, martial arts, track/cross country, football, dance, gymnastics, and cheerleading. The majority of participants were in cheerleading 31% or track and field 23%.

	ONCE A MONTH	ONCE A WEEK	2/3 TIMES A WEEK	EVERYDAY
ATHLETES (41)	22%	17%	32%	30%
NON-ATHLETES (37)	22%	16%	27%	35%

When asked the question “How often do you consume energy drinks” 22% of nonathletes reported once a month, 16% once a week, 27% two or three times a week, and 35% reported every day. While for athletes the same was true for once a month 22%. Then athletes reported 17% for once a week, 32% for two or three times a week, and 30% for every day. While I

hypothesized that athletes would consume energy drinks more often because of sport exhaustion, this isn't necessarily true as both athletes and nonathletes consumed energy drinks relatively the same amounts. The percentages vary by only 5% ever or by two participants, therefore proving that sports participation does not relate to energy drink consumption.

	REDUCE FATIQUE	CONCENTRATE IN SCHOOL/STUDYING	ENHANCE SPORTS PERFORMANCE
ATHLETES (30)	70%	17%	13%
NON-ATHLETES (35)	60%	40%	NA

For the next question “Why do you drink energy drinks” 60% of nonathletes chose to reduce fatigue and 40% chose to help concentration in school and studying. However, athletes chose to reduce fatigue 70%, concentrate on school and studying 17%, and enhance sports performance 13%. The results conclude that athletes drink energy drinks most often to reduce fatigue and 10% more often than nonathletes do. So, although sports players are less likely to pick up and drink energy drinks, they are more likely to consume them for the purpose of lowering exhaustion. Furthermore, non-athletes are much more likely to consume energy drinks to help in school and studying compared to student-athletes creating a difference of 23%. Reasons for this may be that student-athletes are more likely to stay up late completing homework after practice and therefore need energy drinks to provide energy. Another reason for the results is that 13% of athletes report using energy drinks to enhance their sports performance while non-athletes did not have this answer choice and therefore only had to pick from increasing their chances of selecting to reduce fatigue or concentration in school/studying. Lastly, the effects of energy drinks last 4-6 hours and can keep students up late at night if they are consumed further into the day. Athletes’ practices/games are most likely to be after school so athletes who drink energy drinks before games/practice for sports performance may not sleep as well, creating a need for another energy drink the next day to reduce fatigue. This creates a never-ending cycle of dependency on energy drinks.

The next section of my survey asked the question “What is the appropriate age to begin drinking energy drinks”.The results are such that 3% selected less than 12, 82% chose between 13 and 17, and 15% chose 18 and above. The vast majority believed that 13-17 is the appropriate age and this reflects my hypothesis that energy drinks are being marketed by corporations to a younger generation; When in reality above 18 is the recommended age to begin consumption by brand companies and children under 12 are practically prohibited. The next question titled “Have you ever seen a warning label on an energy drink” had the results of 50.7% yes and 49.3% no. The results were 50/50. I find this interesting because large brand companies such as Red Bull, Monster, and Celsius do not contain any sort of warning label on the can. Most cans have milligrams of caffeine listed in very fine print on the back and no disclaimer or warning. Smaller corporations may include warning labels but they are not often sold in convenience stores and are specialty drinks that are harder to find. The 50/50 results further show the lack of advertisement on the many harms of high caffeine consumption.

The next section of my survey asked participants to select which symptoms they experience when they consume energy drinks.

67	NUMBER	PERCENT
CHEST PAIN	9	14%
HEADACHES	24	36%
ANXIETY OR NERVOUSNESS	24	36%
DIERESIS	20	30%
SHAKING OR JITTERY	45	67%
LIGHTHEADEDNESS	15	22%
INCREASED FOCUS OR CONCENTRATION	41	62%

The largest percentage was 67% reported experiencing shaking or jittery behaviors that were not normal to their day-to-day lives. After this, 62% report experiencing increased focus or concentration, the advertised effects of energy drinks. With this information, it can be concluded that energy drinks satisfy their intended effects 62% of the time within my studied demographic. Next, 36% of individuals report experiencing headaches and another 36% report increased anxiety or nervousness. 30% experience dieresis, an increase in urination, and 22% experience lightheadedness as a symptom. But, the most alarming effect of all is that 14% experienced chest pain, which in most severe cases can be indicators of seizures, heart palpitations, an irregular heart rate, and even heart attack. It is extremely alarming that so many individuals experience this as it should most likely be talked about or brought to a medical professional. This further proves my claim that energy drinks are pervasive issues with detrimental effects in today's society.

The last section of my survey examined statistics regarding student athletes' involvement in sports. I surveyed athletes from a total of fourteen sports ranging from martial arts to cheerleading and volleyball, and 48 total athletes. A graph is included to display the answers to the question “What sport(s) do you play.” The majority of athletes were in cheerleading with a total of 15 and 31%, the next largest category was track and field with 11 participants and 23%, and then with both 5 participants and 10% was football and dance/drill team. I also found that 11 of my athlete participants were involved in two or more sports 23% of the total athletes. When asked the question “How often do you participate in your sport” answers were less than 3- 10%, 3 to 5- 16%, 6 to 7- 10%, 8 to 9- 31%, 10 to 11- 10%, and more than 12- 24%. The majority of athletes have longer than 8 hours of practice per week. I also discovered a correlation between athletes practicing greater than 10 hours per week and how often they consume energy drinks. All athletes who practice >10 hours per week selected either that they drink energy drinks every

day or ⅔ times per week. 15% of participants have more than 10 hours of practice per week AND drink energy drinks every day. 13% of participants have more than 10 hours of practice per week AND drink energy drinks ⅔ times per week while no athletes practicing over 10 hours drink energy drinks once a month or once a week. This data shows that athletes who put more time and energy into their practices, workouts, or games often rely on energy drinks to push themselves in athletic abilities and to provide essential energy. This relates to my previous claim that high school student-athletes build early dependencies on energy drinks and are stuck in what is called a “fatigue cycle”- the longer athletes practice the more they rely on energy drinks on a daily basis. This is because athletes with longer and more practices per week stay up later doing workouts and school work and get less sleep. Because of this lack of sleep they feel the urge to consume an energy drink in the morning or right before practice. Practices are often after school or later in the day meaning there usually is not enough time for the effects of the caffeine to wear off before they go to sleep- this disrupts sleep schedules and leaves this athlete stuck in a cycle of not being able to sleep well and needing the necessary energy from caffeine to keep moving the next day. Overall, caffeine dependencies are often present, there are many alarming side effects present by all participants, and there is a lack of advertisement from large-name brands.

Throughout my data collection process and research analysis, I ran into many issues that could be considered limitations to my research. In this section, I will explain these limitations and their possible outcomes within my findings. Early on, a common issue I encountered was that I possibly did not have a large enough sample size to qualify my studies. To remedy this I designed a simpler and more appealing study to gain more responses from students. Additionally, I decided to advertise my study by hanging a QR code leading to my new survey in hallways, and restrooms, and distributing it to teachers to assign or hang in their classrooms. Another larger limitation to my data collection is that some of my participants regularly consume caffeine, while others had never tried an energy drink prior to my experiment. This may drastically change the effectiveness of energy drinks on their bodies. Additionally, because of this all participants had different expectations for how the drinks would affect them and this likely also affected the outcome of the experiment. Another limitation I found in the demographics of my respondents was that the vast majority of my participants were female. 74% of respondents were female as compared to 26% male. As many of my participants ended up being friends or relations, it was more difficult for me, a female, to find males willing to complete my survey. This likely impacted my data because men will have different opinions than women on many of the questions I asked or could react to energy drinks differently. Another issue I encountered similar to this was that the vast majority of the student-athletes I questioned participated in cheerleading. There were other sports represented, but not as many as I would have liked to see.

5. Discussion

Here I will discuss the meaning of my findings and their implications to my sample group. Through my research process, many of my hypotheses were proven correct, however, some were negated as a result of my findings. Additionally, within this section, I will suggest actions that could be taken to minimize the number of injuries and deaths related to caffeine intake, and I will review the implications for further use of energy drinks.

To begin, I was able to support parts of my hypothesis but not all. I hypothesized that energy drinks are being falsely advertised to a younger audience and are resulting in dangerous

side effects and dependencies, especially in athletes. I found that the first was true, that energy drinks are being advertised to younger audiences. I found that 30-35% of my participants drink energy drinks every day- showing that the intense consumption of energy drinks builds a reliance on caffeine way too early into adolescence. Furthermore, I found that only 15% reported 18 and above as the appropriate age to consume caffeine drinks showing that the other 85% believe consuming energy drinks before the age of 18 is appropriate. Next, I also discovered many alarming side effects which therefore goes along with my hypothesis. I found that only 4% reported experiencing no side effects (5%), this is alarming because major brands advertise zero side effects to their drink. Additionally the vast majority (67%) reported experiencing at least shaking and jittery at a minimum. And, 9 participants (14%) reported experiencing chest pain which is a major concern, and should seek medical advice. Chest pain from energy drinks can be a sign of future caffeine-related seizures, irregular heart rates, heart palpitations, and even heart attacks. Next, I found that dependencies are present as many experience fatigue cycles due to light night practices and studying. And lastly, my hypothesis that caffeine intake is most common in athletes was negated by my results. I found that the percentages of participants who were drinking caffeine and how often were extremely similar with no more than a 5% difference. Overall, three of the major categories of my hypothesis were indeed true and one was negated.

After all of this is said, I have some beliefs as to what the next steps taken should be. During my personal research, I discovered the alarming fact that the FDA (Food and Drug Administration) has no role in the marketing or selling of energy drink beverages. This means that there are no present regulatory actions taken to ensure the safety of their use or the validity of their marketing. The federal Food, Drug, and Cosmetic Act states that all conventional foods/beverages and dietary supplements shall be regulated by the FDA. Energy drinks are excluded from this act as they are not considered a dietary supplement and therefore are not under the jurisdiction of the FDA. Should the FDA be involved, the public would be more aware of the many aspects of the consumption of energy drinks.

Another suggestion for future use of energy drinks is to more clearly label the cans with the milligrams of caffeine content and to better advertise the dangers of caffeine on the can. About 50% of students reported that they have never seen a warning label on an energy drink, and this is a truly alarming number. If a simple disclaimer were pasted on the label many injuries and caffeine-related deaths could be avoided; further proving the point that the FDA should regulate caffeine beverages. If the FDA were involved, including a disclaimer could become mandatory and many related injuries could be avoided.

A final suggestion would be to require heart screenings in American public schools. My study has proven that at least 50% of teenagers are unaware of existing heart conditions they may pose and therefore are at high risk of heart complications as a result of drinking high amounts of caffeine if high schools held mandatory heart screenings which could be administered by the school nurse, students with heart issues could be diagnosed and provided with aid, avoiding caffeine-related deaths and injuries. Further, schools could require a brief section teaching about the detriments of consuming energy drinks at an early age in their health and wellness curriculum. Mandatory education and heart screening will completely minimize caffeine related deaths and over dosage.

6. Conclusion

Now, in conclusion of my research process, I found that energy drinks are a prevalent issue in modern society as proved by my survey. I evaluated a gap in global research through my methods and found that the impacts of energy drinks are true for highschool student athletes as well as professional athletes. And lastly, in order to ensure the health of all consumers new regulations need to be instituted.

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