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How does the Ergogenic Benefits, Consumption, and Overall Perspective of Caffeine Differ between Athletes in Different Sports?

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How does the Ergogenic Benefits, Consumption, and Overall Perspective of Caffeine Differ Between Athletes in Different Sports?

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Abstract

Caffeine has been a very popular ergogenic aid that has been widely used by athletes at all levels of sports performance (Pickering & Grgic, 2019). The effects of caffeine have shown performance-enhancing symptoms among athletes along with multiple cognitive benefits such as reaction time and overall mood during exercise. According to McArdle, Katch, and Katch (2015), caffeine acts as a stimulant for the central nervous system. It acts as a blocker for adenosine receptors and allows for more neuron firing in the brain as well as increased blood flow from the heart to other body systems. In interest of caffeine's ergogenic effect and overall improvement of performance, there has been several research studies that aim to prove whether caffeine makes a significant difference in quality of athletic performance. Further research is needed to conclude whether these factors affect the benefit of caffeine in everyday athletic performance as well as caffeine use in a competitive field. Therefore, the aim of this study was to determine the ergogenic effects of caffeine among male and female collegiate athletes and how these effects can be correlated to school schedule, hours of practice, competition usage, as well as side effects. It was hypothesized that caffeine will be a very common agent in the benefit of student athletes across a variety of sports with different intended purposes.

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Introduction

According to Tran (2015), caffeine originates from the cocoa bean and has been in use since the 1800s. It was primarily used as a stimulant in order to get over drowsiness and increase alertness in an individual. The drug was often consumed in the morning after waking up to start the day and fight fatigue. It is a drug that is used today and is found in coffees, teas, and has even escalated to common over the counter medications and energy drinks. Caffeine has grown to be loved around the world and can commonly be found in soft drinks and coffees that are stereotypically used by most people to start the day. It can be consumed by the individual as part of a normal diet or sometimes prescribed as a medication to help a person overcome severe drowsiness and sometimes even migraines.

The United States Food and Drug Administration established caffeine as a safe product of consumption. The average caffeine consumption of an active individual was approximately 70-100 milligrams (mg) of caffeine per day (Heckman et al., 2010). It was found that in the age group of children (10-13), soft drinks and tea were the highest consumed products containing caffeine, however in a college setting, energy drinks and coffee intake became more common. The European Food and Safety authority established that safe levels of caffeine consumption in one sitting should be 200 mg of caffeine and should not reach above 400 mg in a single day. When individuals exceed these guidelines, the data and effects of caffeine can be misunderstood. There is a large variability in caffeine consumption and how it can affect the human body. Caffeine can exert wide ranges of effects on the body, both positively and negatively, that partly influence individual's behaviors and opinions regarding caffeine consumption (Nehlig, 2018).

According to Shabir et al. (2018), caffeine acts as an alkaloid metabolic stimulant. It can have powerful physiological effects as it naturally stimulates heart rate, relaxes smooth muscle

structures, such as coronary arteries and bronchi, as well as serve as a diuretic. Caffeine's main purpose is seen with the central nervous system (McArdle et al., 2015). It serves as an interference of a neurotransmitter for adenosine and its respective nerve cell receptor. This triggers the "fight or flight" receptors of the nervous system in an individual and can have various effects with different dosages. However, with the overuse of caffeine, a tolerance is built for the individual and the adenosine receptors. This requires the individual to consume more caffeine in order to retrieve a response from the nerve receptors. Caffeine will have a peak performance in an individual after it transitions into the bloodstream. After the peak the individual will have a decline in performance and enhanced qualities will start to diminish. This decline is known as a "crash" and will allow the body and the receptors to transition to a normal status (Tunnicliffe et al. 2008).

The use of caffeine as a stimulant has been applied to sports due to the ergogenic effect and performance enhancements that improve athletic prowess in an athlete's respective field. Pickering & Grgic, (2019), describe the use of caffeine in sports since 1907 and the uses of the performance-enhancing aid has evolved across wide ranges of aspects in sports. The acute effects of caffeine were seen to improve workouts in athletes and allow for a decrease in fatigue during exercise. This allowed for more repetitions in movements such as bench press and squats. Another effect that was seen was improved performances for running sprint times. The primary ingestion method for athletes was by using a pre-workout supplement or energy drink that was easy to consume before a workout. In a competitive setting, athletes used caffeine as an enhancer to improve performance in time or strength.

The usage of caffeine can have a varying effect dependent on the individual and time of season for the sport. Athletes could use caffeine supplementation purely for competition

purposes, or in an everyday training environment. The ingested caffeine time, or relative practice time was also a factor of scheduling for athletics that could influence caffeine consumption on the athlete basis. Sports that require more anerobic power are more likely to apply caffeine supplementation before their workout routine, as caffeine will have a peaking effect on the central nervous system and offer the athlete the most in its ergogenic aid at time of competition. In more aerobic, long-lasting sessions of exercise, caffeine would have a lower appreciation as the peak effect time will not last the whole session and could cause performance decline due to crashing of the central nervous system.

According to Shabir et al., (2018) caffeine can have an influence on cognitive performance on par with its effect on physical attributes. Caffeine has been seen to improve cognitive performance in relation to sport such as alertness, reaction, concentration, and overall level of fatigue. However, caffeine could have adverse effects on the individual if too much is consumed during performance. These adverse effects can be related to insomnia, increased anxiety, decline in motivation without caffeine, and overall decline in concentration. It is important to educate the community on how too much intake of caffeine can affect performances in the sport as well as outside of sport. School scheduling and practice schedule can play a part in the consumption time of caffeine, which may positively impact the benefits of education and overall performance of the individual.

According to Del Coso and colleagues (2011), the use of caffeine, most prominently the substance guarana, gained popularity among athletes, therefore the National Collegiate Athlete Association (NCAA) set a ban on the substance where if an athlete was found dosing above a certain level, they would be disqualified from the event and stripped of their awards won. The International Olympic Committee (2018) describes that having a urine output of 15 milligrams of

caffeine per milliliter of urine, or roughly 500 milligrams of caffeine would be deemed as illegal, and the athlete will be banned. This was considered a fair amount as a no energy supplement could be sold containing anything above 300 milligrams of caffeine.

In interest of caffeine's ergogenic effect and overall improvement of performance, there has been several research studies that aim to prove whether caffeine makes a dramatic difference in quality of athletic performance. Pickering and Grgic, (2019), goes into detail of several factors that could affect how caffeine works such as type of ingestion, time of day of consumption, amount of caffeine ingested, as well as differences between sex and caffeine. Further research is needed to conclude whether these factors affect the benefit of caffeine in everyday training performance as well as caffeine use in a competition environment.

There is also research indicating the negative side effects of excessive caffeine usage. Varying from a decline in physical and mental ability, the overuse of the product of caffeine can be detrimental to the training aspects of an athlete. According to Shabir et al. (2018), an increased caffeine usage may result in cardiovascular permutations such as increased blood pressure, increased resting heart rate, troubled and irregular breathing, as well as trouble attaining proper recovery from a workout. The need to better educate different athletes on the uses of caffeine will help pinpoint the individual's use of caffeine in an individual of a college level. The educational improvements will provide the athlete with the most ergogenic benefit without the decrease in cognitive of physical performance, as well as promote healthy use of caffeine supplementation.

The purpose of this study was to assess if the usage of caffeine differed among a college population of student athletes. These results were correlated with outside factors affecting caffeine such as class schedule, intended use of caffeine, amount consumed, practice schedule, as

well as assessed the prevalence of any negative side effects due to overuse of caffeine. These results will be compared to gain a better understanding of a college athlete population and if further education of caffeine is needed for students to gain the most ergogenic benefit of the product in their diet.

Operational Definitions

Caffeine: *Common stimulant that is found in coffee and tea which enhances physical and cognitive awareness and activation potential.*

Ergogenic: *Intended to enhance performance, stamina, and recovery*

Anaerobic Training: *Training or specific movement that limits oxygen consumption for a short amount of time.*

Fatigue: *Feeling of exertion after some form of labor, stress, or work.*

Rate of Perceived Exertion (RPE): *A form of measurement on how subjects feel after completing an exercise. How hard one feels the body is working.*

Review of Literature

Caffeine Metabolism and Factors

Caffeine has been a very popular ergogenic aid that has been widely used by athletes at all levels of sports performance (Pickering & Grgic, 2019). The effects of caffeine have shown performance-enhancing benefits among athletes along with multiple cognitive benefits such as decreased reaction time and improved overall mood during exercise. Caffeine can be ingested in several different shapes and forms such as a pill, energy drink, or is found in everyday food and beverages such as coffee. With caffeine being readily available to the public, athletes have utilized this accessible performance-enhancer in order to better improve power output and overall endurance in their respective sports and competitive fields (Pickering & Grgic, 2019).

According to McArdle, Katch, and Katch (2015), caffeine acts as a stimulant for the central nervous system. It acts as a blocker for adenosine receptors and allows for more neuron firing in the brain as well as increased blood flow from the heart to other body systems. Caffeine increases the firing rate of the heart and allows more oxygenated blood to reach the muscles during exercise and transport carbon dioxide away from the site, therefore inhibiting the effect of fatigue in the athlete. According to Thorn and colleagues (2012), caffeine is metabolized in the liver, specifically the cytochrome P450 pathways. It was found that when taken with another substance, such as food, the metabolism of caffeine was significantly reduced. Multiple studies seen in Pickering and Grgic (2019) found that other factors, such as sex and time of caffeine ingestion, could impact the ergogenic effect caffeine has on the athlete.

The type of caffeine that is being digested also could have a role in determining the most ergogenic effect on performance. Caffeine can be administered through regular substances such as coffee. In a study by Trexler, Roelofs, Hirsch, Mock, and Smith-Ryan, (2015) the effects of

coffee and caffeine anhydrous were compared to see which had the greater ergogenic benefits in athletic performance. It was found that subjects who ingested a caffeine anhydrous pill one hour before performance showed greater ergogenic effects in power output and in number of repetitions for bench press, leg press, as well as time improvement for a 20-meter sprint. However, the previous study did not look at which source of caffeine provided the most ergogenic benefits.

In a study done by Pickering and Grgic (2019), it was shown that the dosage of 3 milligrams of caffeine per kilogram (mg/kg) of body weight to 5 mg/kg ingested through a pill were the most effective for improving athletic performance such as reaction time and overall power output of strength. The amount of caffeine varied for each specific tasks and has a different effect on the reaction time, focus, power and fatigue. Caffeine elicits physiological responses that reduces the rate of perceived exertion (RPE) in an athlete. It was found that having roughly 3 mg/kg of caffeine was an appropriate dosage caffeine to achieve a block of adenosine receptors in the body and inhibit fatiguing and overall exertion for aerobic and anaerobic exercise. The amount of caffeine also shares a direct impact on the increase in muscle strength, endurance, and power performance. This is related to the ability to augment muscle fiber conduction and velocity of motor unit recruitment (Pickering & Grgic, 2019). Another study by Fernández and colleagues (2021), supports this claim as they also used the dosage of 3 mg/kg in order to test the effects of caffeine on unilateral and bilateral jumps. Therefore, the recommended dosage of caffeine was found to be 3 mg/kg in order to receive the most ergogenic benefit. The proper dosage will be assessed in this study among the athlete population to determine if caffeine is being used justly by participating athletes.

Pickering and Grgic (2019) describe how the time frame of caffeine ingestion can play a vital role in maximizing the benefits of ergogenic effects. Given its stimulatory role, caffeine may potentially mitigate fatigue and increase performance in morning hours. However, most performance of a given task saw more benefits when performed in the early afternoon. This was shown through Guette and colleagues (2005), as athletes showed a strength performance of 99% of their maximum weight repletion in the afternoon and 90% of their maximum in the morning. This was theorized as most athletes who have morning training had an increase in motivation to perform in the afternoon. (Pickering & Grgic, 2019). Various sports have different practice schedules, some even consisting of practicing once in the morning and once in the afternoon. The time of day will impact caffeine consumption in order to meet the metabolic needs for energy and stimulation to perform in these conditions. It is important to identify which sports include vigorous schedules and how many hours the athlete participates for their season.

The time before exercise when caffeine is ingested also plays a pivotal role. In a study done by Graham (2002), it was found that caffeine ingested through a capsule or supplement created the greatest benefits when ingested 30 minutes to 60 minutes prior to performing a maximal effort cycling exercise. This is due to the caffeine capsule not being fully digested in the digestive tract until around 45 minutes after consumption. This is seen in another study done by Smirmaul, Moraes, Angius, & Marcora (2016), who had participants consume a caffeine pill and then perform a cycling test 60 minutes after consumption. This demonstrates how the athlete population could have various times of consumption for caffeine in order to meet their sport's demands. It is important to distinguish scheduling and time of consumption to gain a better understanding of how caffeine is being consumed.

Caffeine and Specific Sport Training

Lara and colleagues (2015), describes a study in which the consumption of a caffeine drink was compared to aspects of swimming performance. A group of 14 male participants were asked to perform a countermovement jump and maximal handgrip test in order to assess power output. A 50-meter freestyle and a 45 second swim ergometer test were performed to represent the simulation of competitive aspects in swimming, such as racing and fatigue. It was theorized that caffeine would improve aspects such as alertness, vigor, and overall performance in situations of physical and mental stress. The previous study yielded valid results among 14 male participants however, the lack of inclusion of female athletes provided bias of what gender is affected more by the ergogenic effects of caffeine.

According to Tunnicliffe et al. (2008) caffeine was a very popular agent among Canadian athletes. It was found that caffeine, specifically from coffee, was used frequently in the athlete's diet and used for performance in early morning practices. In a university of various sports with varying practice schedules, it would seem to be more common that students will ingest caffeine early in the morning in order to have the energy and metabolic needs to perform tasks throughout the day. It was also found that overuse of caffeine in the morning led to a various amount of discomfort such as indigestion, gastric withdrawals, sleep disturbances, and interactions with other dietary supplementations. These side effects from an overuse of caffeine should be included in the study to better elucidate how caffeine can negatively impact performance and training if it is used incorrectly.

Similarly, a study done by Pickering & Grgic (2019), the measurement of 3 mg/kg was used as it was the most effective dosage when looking at an overall increase in performance. It was found that the consumption of caffeine improved jump height by 3%. There was no

correlation found in overall muscle power output, but rather caffeine was shown to increase muscle activation and reaction time. The handgrip test showed similar results as there was in increase in performance of the dominant hand by 3-5%. However, no improvement was seen in the nondominant hand. During the 50-meter swim, there was no improvement in swim stroke rate or length in both trials. Participants reduced their time by roughly 3%. The peak power output of the swim ergometer test was also improved by 11%. After the trials, participants were asked to evaluate subjective aspects of the trials such as overall feeling of power, fatigue, and alertness to determine the effects of the caffeinated drink (Lara et al., 2015). As caffeine is commonly supplied in energy drinks, this study took into consideration that most athletes will be ingesting caffeine in this manner.

In athletics, improvement in overall power and efficiency can have a dramatic effect on improvement and skill for the specific sport. In a study by Chtourou and colleagues (2019), vertical jump height and execution can be directly correlated with the block start or to jumping in sports such as basketball and soccer. This study used a dosage of 5 mg/kg. Participants, when performing the jump, had their choice of depth before jump as long as a three second isometric hold was done before jumping. It was found that the effects of the caffeine pill improved vertical jump height as well as reaction time and explosive output. This relates to several aspects of sports, such as blocking in volleyball, jumping to catch in football, and having a faster reaction/prediction in tennis. Psychological and physiological aspects should be considered when analyzing the ergogenic benefit of caffeine.

In almost all sports, every aspect of a race or play should be considered to determine improvements. This includes explosive force outputs from the start and turn segments of the race. Another study by Bloms, Fitzgerald, Short, and Whitehead (2016) showed caffeine

improved overall jump height and execution in collegiate athletes. This study had athletes hold a three second isometric hold before jumping, which can be related to the isometric hold of the swim start. It should be noted there is little research proving vertical jump can be directly correlated with swimming. However, it can be assumed that an improved vertical jump relates to a more efficient muscle activation of muscle groups used in a 50-yard freestyle block start.

In a study by Fernández and colleagues (2021), the use of caffeine was found to improve the efforts of unilateral and bilateral jumps found in elite Jiu-Jitsu athletes. The participants were asked to hold a three-second isometric hold prior to completing the jump which is similar to the starting position before every race. Improved jump efficiency and speed were recorded and correlated to time improvement in racing events. While there is no evidence that Jiu-Jitsu movements are used in all aspects of sports, the use of the unilateral jump can be seen in the start and turn phase of swimming, as well as with to the track start. Improvements with jumping has the potential to improve time in a racing environment. It can also be seen that improvement jumping can help with aspects of basketball and football performance.

According to a study by Astorino and colleagues (2011), the ergogenic effects of caffeine could positively affect the performance of intense resistance. Athletics requires muscle activation from the whole body, and it was shown that reduction of fatigue in muscles through various exercises could improve performance of the sport. These exercises included the barbell bench press, leg press, latissimus rows, and shoulder press. It was found that the ingestion of a caffeine capsule prior to performing these exercises increased the number of repetitions that were able to be performed for exercises such as leg press and latissimus row pulldowns. This can transfer to enhanced endurance and power in those muscle groups and will allow the athlete to be able to

perform at a maximal intensity for longer and lead to time improvement in their respective events (Astorino et al., 2011).

Similarly, in another study by Glaister and colleagues (2012), caffeine was tested to determine if there was an ergogenic effect on short-term maximal cycling and other factors of performance such as awareness and feeling of fatigue. It was shown that the use of caffeine decreased the feeling of fatigue and provided more power output in the participants. The participants were asked to perform a 20-second cycle test at a maximal intensity and then report feelings of fatigue after. This provides an understanding that in a short race, such as the 50-yard freestyle, a sprint event, or a quick play in football caffeine can be used to increase duration of maximal performance.

Some sports require athletes to react to an auditory case, such as a whistle or buzzer, in order to begin every race or to begin the play. Any improvement to reaction time can have an impactful role in improving and gaining the upper hand in certain situations. In a study done by Santos and colleagues (2014), the effects of caffeine were tested to determine if it provided improvement to reaction time and fatigue levels in taekwondo. In this study, the ergogenic effects of caffeine were found to improve reaction time and limit the fatigue in participants performing explosive movements in taekwondo. In racing events, an improved reaction time and muscle stimulus can be incorporated into the early phases of the race and enhancing stride/stroke frequency as well as prediction and anticipation. While the movements in the study do not directly apply to every aspect of sports included in this study, reaction time and level of fatigue can be represented as factors that could contribute to improvements of the athlete at play. The purpose of this study was to determine the ergogenic effects of caffeine among various collegiate athletes in different sports and how caffeine consumption can be correlated to class schedule and

practice schedule. It was hypothesized that the consumption of caffeine will vary based on dependence of anerobic, aerobic, and cognitive factors. It also served as a guide to gain a better understanding of how caffeine is seen in the eyes of a college student athlete population and if it is being used in a correct setting of performance or overall training.

Methods

This research design was model after Lara and colleagues (2015), and Mielgo-Ayuso and colleagues (2019). Participants in this study were asked to complete a survey on their own individual use of caffeine supplementation. This survey asked for the specific sport of the athlete and the schedule of the season for the sport at the time of the survey. This was to determine a baseline of different usages within a sport specific context. Specific sports with combined men and women members were grouped together. The training schedule was included in the survey in order to determine how much the individual is participating in their respective sport. Credit hours were also included to give insight on the individual's academic load and gives an indication of class and practice scheduling together. The survey also includes if caffeine is consumed on a regular basis to determine if the individual uses caffeine every day or only for competition purposes. The time of day of caffeine consumption is important to see what the individual uses caffeine for. These purposes could vary from a cup of coffee or energy drink before an early morning lift or practice to just having a cup of coffee in the middle of the day due to fatigue from classes. This will help gain more insight on how caffeine is being consumed throughout the day. The next question was to determine what specific caffeine supplement was consumed and how many milligrams of caffeine were consumed on a daily basis. This gives insight into the type of caffeine consumed, which can be compared to standards set by the Food and Drug Administration. The amount of caffeine can be compared to standard guidelines of health and safety to see if college individuals are following the recommended intake of caffeine and gaining the most ergogenic benefit without experiencing withdrawals and negative side effects. Nutritional values were provided for the most common forms of caffeine usage and consumption methods, such as coffee and most commonly used energy drinks. This supplied the study with

adequate information on what was the most available form of caffeine consumption for the student population. The participants were also asked if they felt that caffeine helped to improve performance of their overall athletics. This question helps distinguish psychological aspects of caffeine such as motivation and overall feeling when using the product. Finally, the negative side effects of caffeine are listed in an effort to determine if any of the participants in the study are suffering from the overuse of caffeine. These symptoms include; insomnia, difficulty concentrating, fatigue, increased anxiety, headache, decline in performance of their respective sport, indigestion, rapid heartbeat, excessive urination, and trouble breathing. The design of this survey was to assess and understand how caffeine is being used among the participant population and distinguish a potential correlation between sports.

Participants

This study was designed to target the student athlete population of Gardner-Webb University. The average age of participants is between 18-23 years. The survey was sent to the Student Athlete Advisory Committee (SAAC) and then distributed to all sports at Gardner-Webb. These sports include soccer, baseball, softball, swimming, wrestling, golf, basketball, lacrosse, football, tennis, and volleyball. On average the student athlete population of Gardner-Webb is 594 athletes, this makes up roughly 20% of the entire student population. The participants were asked to complete this survey in the current season of their sport which varies. All participants gave consent to have their data shown in the study, as well as to complete the survey with complete honesty. Participants in this study represented various positions and roles for their respective sports, which also varied among data analysis. Each sport and position contain different amounts of anerobic and aerobic exercise as well as duration and speed of play.

These factors were taken into consideration for comparing caffeine usage amongst the student athlete population.

Research Design

This study is a quantitative study design in order to determine how the usage and consumption of caffeine varied amongst a student athlete population at Gardner-Webb University. The data collected during this study was both exploratory and descriptive as it applied to human performance, physiological, and cognitive factors derived from consuming caffeine. This exploratory result was derived from expanding upon research done by Pickering and Grgic (2019), through examining the ergogenic effects of caffeine in relation to benefits found in sports performance. The descriptive results gathered from this study were the overall feeling of caffeine use on the individual as well as any negative side effects experienced.

Procedure

The procedure of this study was submitting the survey to SAAC in order to have a connection to all sports associated with Gardner-Webb University. SAAC representatives from each sport were responsible for distributing the survey to their respective teams and having them complete it in a timely manner. Once the results were collected, the data was transferred for comparison to determine the most common answers among the student athletes. The most received answers were determined and compared to see how the consumption of caffeine differs among sports and their respective demands. Subjective questions were included to gain a better understanding of how caffeine impacts an athlete's performance and competition ability. This Multi-Athlete Caffeine Analysis was then recorded, and results were shown side-by-side to determine caffeine consumption. The popular answers were correlated to determine if any outside factors had an influence on the role of caffeine consumption amongst the individual.

Ethical Consideration (Human Protection)

All participants that were involved in this study were aware and informed of all procedures and could withdraw from participating in this study at any time. The records and identity of the participants were to remain confidential once the participants signed a confidentiality agreement. However, there was no regulation or guideline set that athletes could not share their own results with each other.

Bias

Potential bias in this study includes a certain bias towards completing the survey with complete integrity. In order to help dismiss this potential bias, the identifiers for the participating group were asked to complete the survey with no outside influence and purely answer the questions as they only applied to them. There is some personal bias as the researcher has personal opinions of caffeine and its usage for in season competition. In addition, another bias is participant bias. Even though all athletes were encouraged to fill out the survey, not every single athlete filled out the form. This can create gaps and even outliers for some sports that filled out the survey completely. There is also bias with how much a certain individual consumes caffeine when compared to their teammates. An individual who consumes more caffeine could have an impact when comparing caffeine usage across the respective sport. It is also bias if one individual has more knowledge and education regarding the usage of caffeine and other supplementation.

Assumptions

It was assumed that the participants involved in this study would have different schedules as well as different practice demands in terms of their respective sport. Also, it was assumed in this study that all Division 1 college athletics involved in this study complete a similar practice schedule and intensities throughout the season. It was also assumed in this study that both male and female involved would have a similar ergogenic response to caffeine consumption. It was assumed that all athletes have some form of experience with consuming caffeine and are familiar with its usage.

Limitations

One limitation in this study was that the participants used were college athletes of selective sports. They cannot represent a whole student athlete population. Another limitation was the quality of caffeine consumption as most athletes are not familiar with the exercise physiology of consuming caffeine and only do it purely for aid and energy related to practice or competition. This was done to fill a small gap in research regarding the ergogenic effect of caffeine and its influence on a student athlete population and how it is being consumed. Additionally, the skill and ability may vary for each athlete as well as their intended usage of caffeine consumption based on the demands and needs of their respective sport. To fix this, a longer study would be needed to educate the participants in a similar manner regarding the demands of their respective sport. Another limitation could be the habitual use of caffeine seen in the everyday student athlete at a university. More athletes could be using caffeine as a means to start the day and not for athletic or ergogenic benefit. They could also be overusing the supplement which may increase tolerance as well as have a negative impact on their

performances during practices. A final limitation was the sample size used in this study. The sample of participants was large and the limitation was due to participants' self-selection.

Results

A total of 176 athletes consented to fill out the questionnaire regarding caffeine consumption at Gardner-Webb. The questionnaire separated the responses by sport, current season, credit hour enrollment, consumption of caffeine, time of day of consumption, method of consumption, average milligrams of caffeine consumed, a subjective field of how caffeine affected performance, and any side effects of a result of consuming caffeine.

Table 1: Sport Analysis

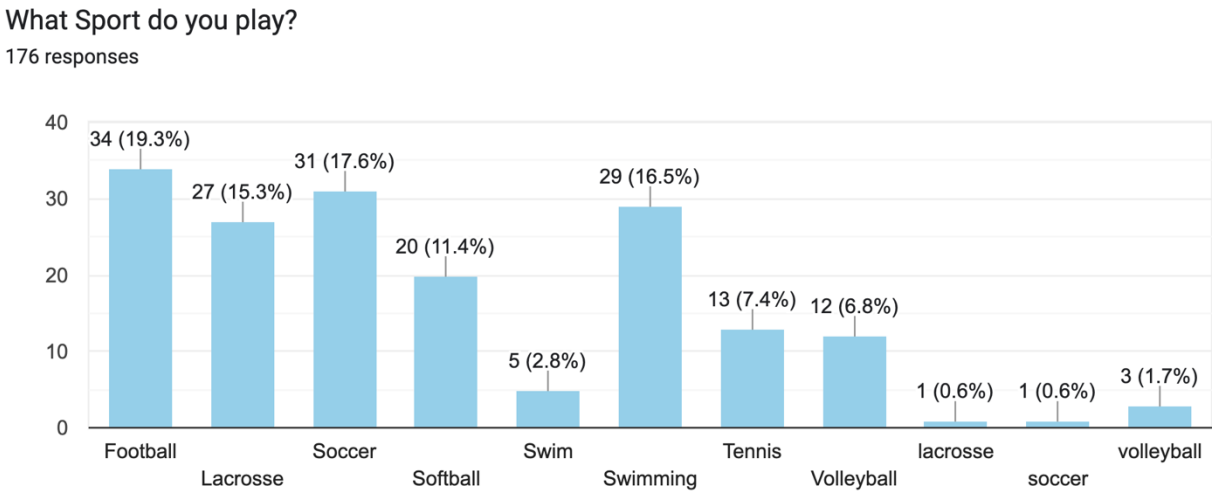

Table 1 describes the participation of sports who filled out the questionnaire. It should be noted that combined gender sports (such as soccer, swimming, and tennis) were grouped together as the purpose of this study did not account for gender differences within a sport. It should also be noted that the survey did not account for different spellings of the sports and those will be grouped in together as one sport. The survey found active participation from 7 sports of Gardner-Webb University out of 12 teams. The participation from within each sport in the study was over 70% of the active roster for the athletes.

Table 2: Season of Sport Assessment

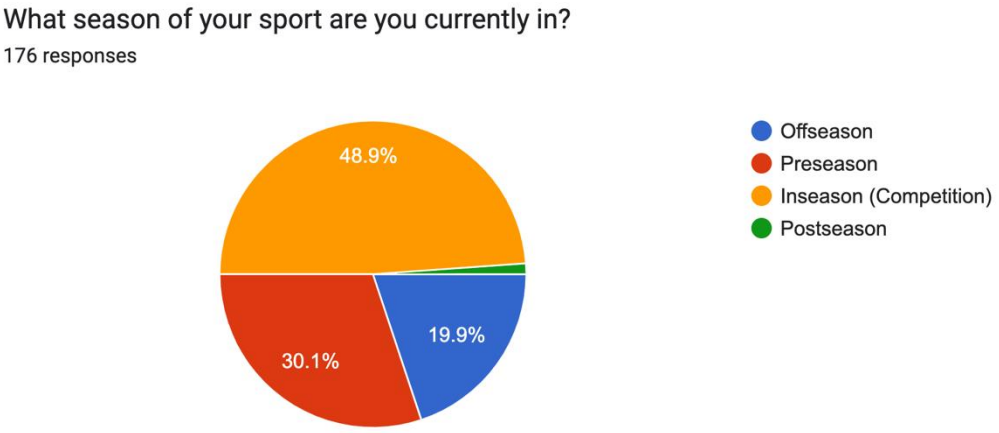

Table 3: Training Schedule Assessment

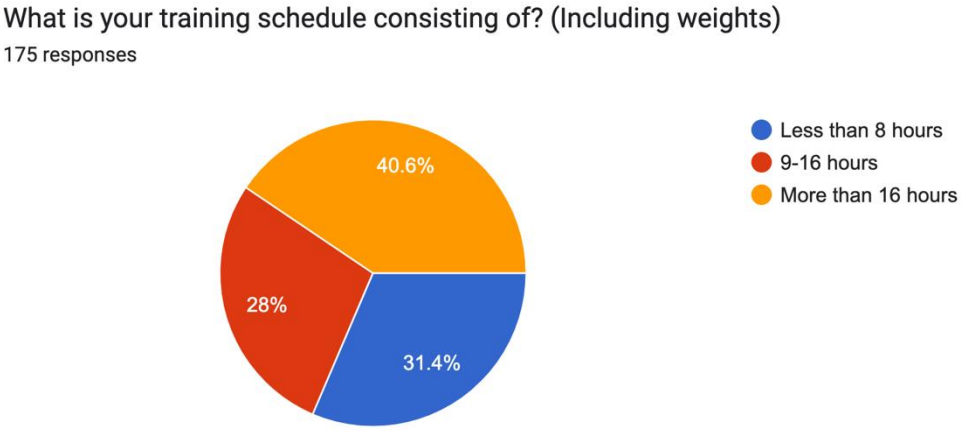

Table 2 and 3 relate to the training schedule and season of the participants at the time of the questionnaire. 49% of athletes were actively in season or at competition during the course of the survey while a majority of others were participating in preseason events. The training schedule of 40% of participants were more than 16 hours a week. 31% of participants were under or at 8 hours per week of training. There was a high correlation value between season of sport and hours of training seen in the results.

Table 4: Caffeine Consumption Assessment

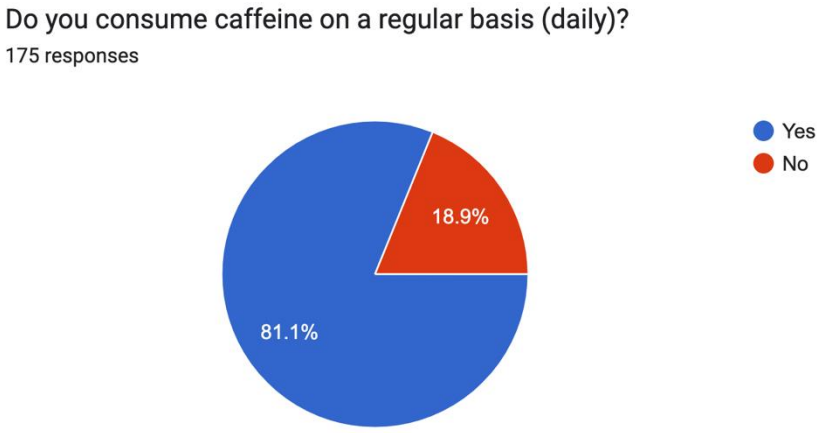

Table 4 assesses the daily consumption of caffeine among active participants. It was found that 81% of participants consumed caffeine on a daily basis. The 19% of other participants do not consume caffeine daily.

Table 5: Time of Day of Caffeine Consumption Analysis

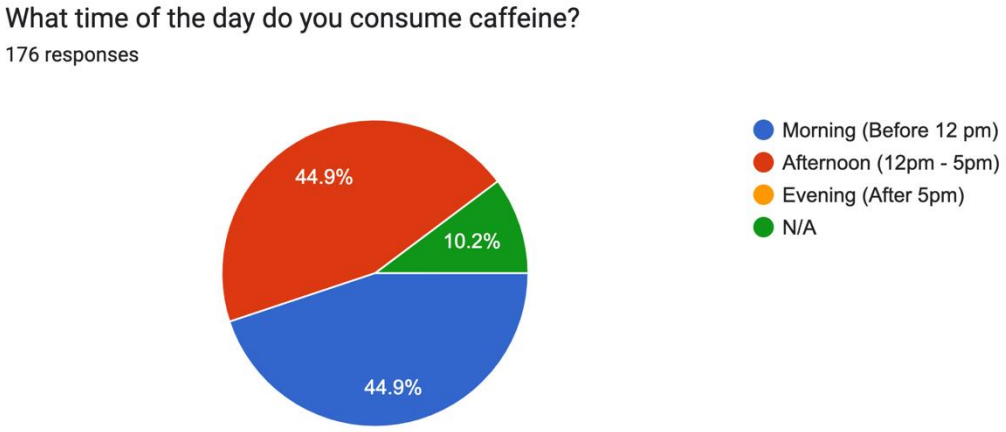

Table 5 shows the differences between participant's time of consumption for caffeine. It was shown that 45% of participants consumed caffeine in the morning. The morning was labeled as anything before 12 PM. 45% of participants consumed caffeine in the afternoon, which was labeled between 12 PM and 5 PM of a given day. Finally, 10% of participants labeled "Not

Available" as their time of consumption. No participant labeled consuming caffeine in the evening or after 5 PM.

Table 6: Source of Caffeine Assessment

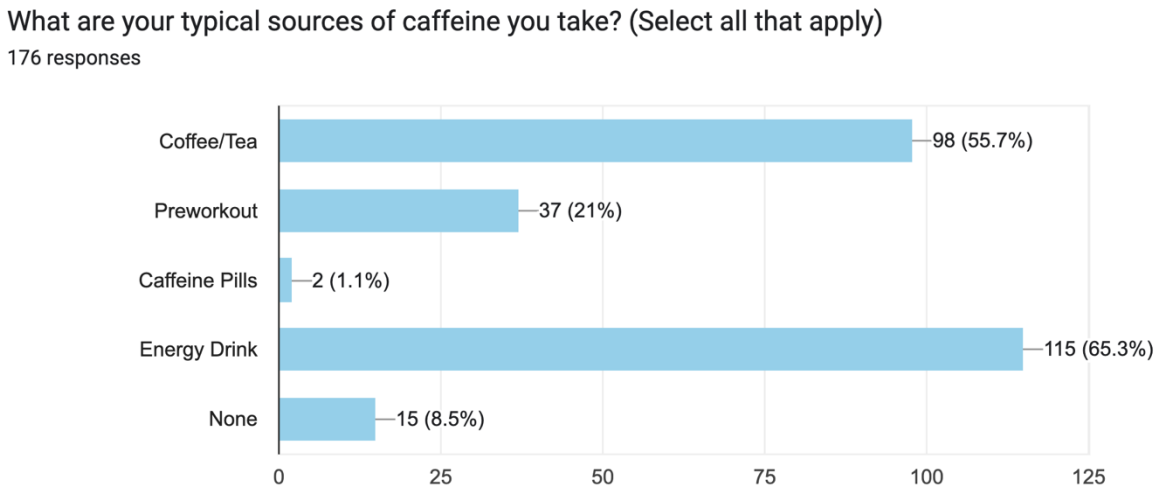

Table 6 describes the different sources of caffeine used by participants. It should be noted that the participants were allowed to select multiple answers for this question. It was shown that 65% of participants consumed caffeine in the form of an energy drink. 56% of the responses saw that coffee and tea were highly consumed sources of caffeine. This showed a strong correlation to individuals who labeled that their highest time of consumption was in the morning. 21% of responses showed preworkout being used. Caffeine pills were a consumption method used by 2% of the participants. Participants also labeled none as a caffeine consumption method if they did not actively consume caffeine.

Table 7: Average Milligrams of Caffeine Analysis

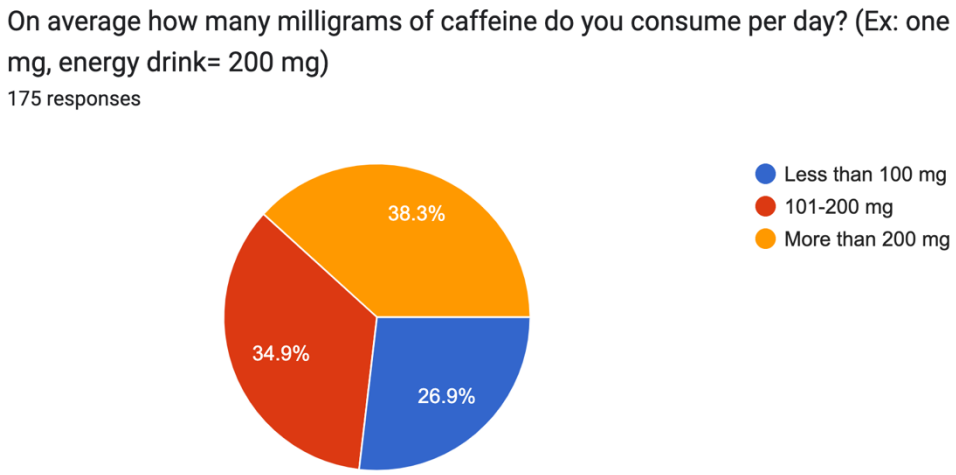

Table 7 graphs the average dosages of caffeine present among the active participants in this study. Roughly 40% of participants was averagely drinking more than 200 milligrams of caffeine in a day. 35% of the active participants consumed between 101-200 milligrams of caffeine. The other 27% of participants consumed less than 100 milligrams of caffeine per day. A correlation was found between amount of caffeine consumed and method of consumption.

Table 8: Caffeine Purpose Analysis

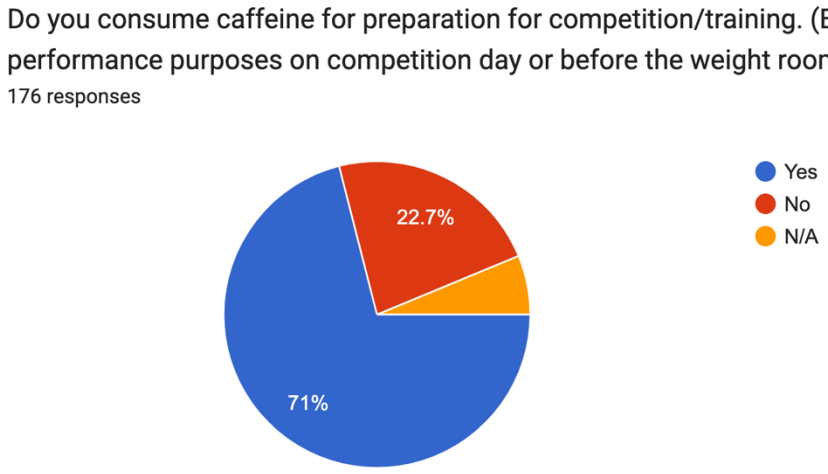

Table 8 describes how caffeine is used among the student athlete population. It factors out if caffeine is used in season for training and competition purposes. It was shown that 71% of the participants use caffeine in relation to their training or competition. Among the participants 23% choose not to use caffeine in their training or competition. The not available section was used primarily for those who do not consume caffeine at all.

Table 9: Subjective Performance

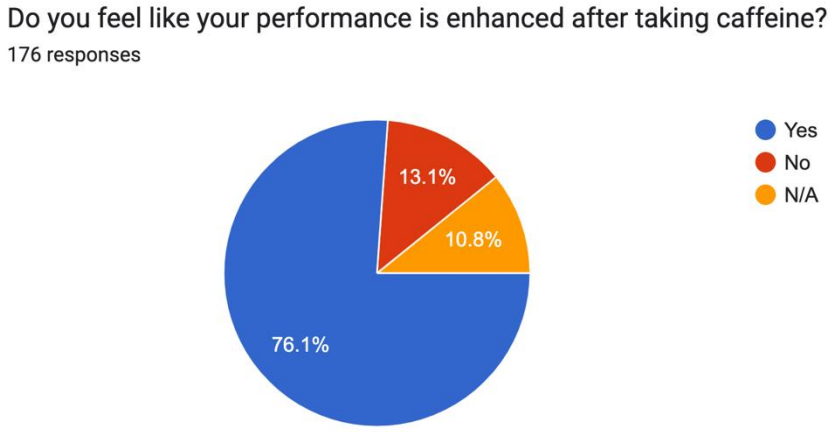

Table 9 describes a subjective evaluation of how the participants view the ergogenic effects of caffeine. 76% of the survey population emphasized that they felt that caffeine improved their performances within their sport. 13% of participant felt as though caffeine had no improvement value to their respective sport. The 10% of "not available" was chosen only for those who did not consume caffeine and had no subjective opinion on the ergogenic benefit of caffeine.

Table 10: Caffeine Side Effects

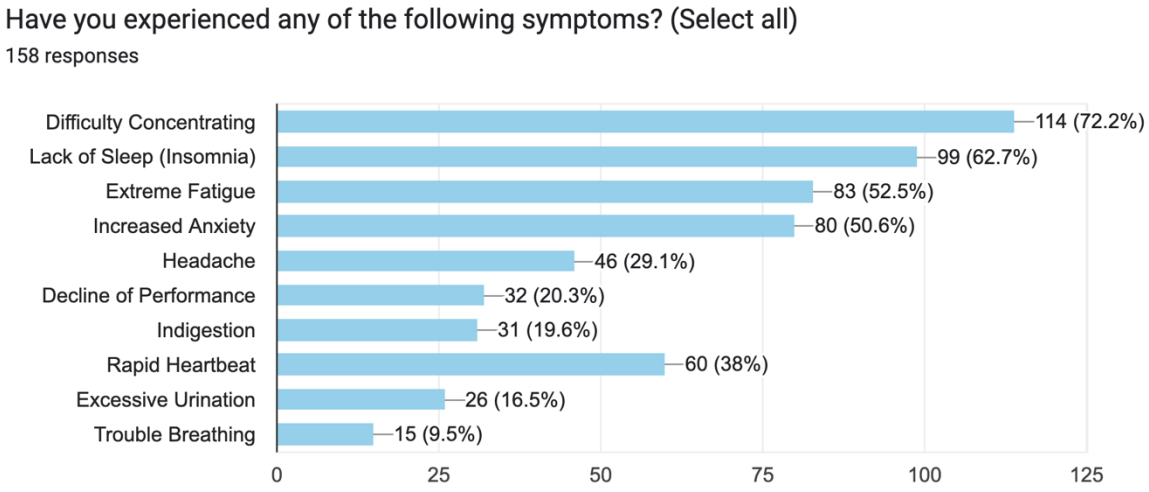

Table 10 lists common symptoms that can occur after an individual consumes caffeine. The participants were allowed to select all symptoms that applied after caffeine consumption. It was shown that 72% of participants had difficulty concentrating after consuming caffeine. 62% of participants also reported insomnia. There is a correlation for time of consumption and with specific side effects of caffeine. Extreme fatigue and increased anxiety were shared among 50% of the participants. 38% of the responses noted rapid heartbeat as a common symptom after consuming caffeine. The lower spectrum of the student athlete population saw symptoms such as indigestion, troubled breathing, and excessive urination.

Discussion

The results of this study indicate that caffeine is a popular agent that is used amongst a college student athlete population. It was also shown that participation was spread out across the sports teams at Gardner-Webb University. Among 12 teams, 7 chose to participate in this study. The survey was distributed to the Student Athlete Advisory Committee (SAAC) to further distribute the survey to all the teams. A limitation to this study was that there was no way to force participation and have every athlete at Gardner-Webb University included. The sample size of this study became 176 responses to represent the athlete population of Gardner-Webb. Further data should be added to gain a better understanding of Division 1 athletes as a whole community. Another limitation of this study is participant bias. Some participants could have answered the questions incorrectly or untruthfully about caffeine consumption.

Table 2 and 3 relate to the current season and training hours of the participants at the time they completed the survey. On average the active participation of the athletes was training 16 or more hours a week. The offseason NCAA rule requires athletes to complete no more than 8 hours of training. There was a correlation found between active season of the athlete and caffeine consumption. It was found that the longer the practice schedule, the greater the increase in caffeine consumption rate daily among the athletes. Sports such as swimming, football, volleyball, and soccer emphasized inseason training and having a higher caffeine consumption. The sports analyzed involved high aerobic activity lasting long periods with the inclusion of anaerobic qualities such as short sprints or plays that require high energy outbursts. According to Keane et al., (2020) having a schedule with more early practices as well has having two sessions of training in a day promotes the need to consume caffeine and carbohydrates throughout the day. As seen with the following sports, multiple have an early morning session as well as an

afternoon session. The remaining sports was found to be in the preseason of their training. This included participating in training that was less than 16 hours. It was found that as the intensity and length of training increased, there was a increased demand and increased consumption of caffeine.

According to Graham (2002), caffeine is seen in regular diets in the form of morning coffee or tea, as well as pre workout potential in the afternoon. In a college environment, consuming caffeine on a daily basis is normal for the everyday student. However, continuing consumption may have an impact on increased tolerance levels as well as promote a need for the individual (Tran, 2015). This can be seen in Tables 4 and 5 varying on time of caffeine consumption. Most notably, athletes were seen to consume caffeine daily, mostly in the morning, labeled as before 12 PM. According to Tran (2015) a popular form of consumption for students has also been found in energy drinks. Energy drinks have been defined as a beverage with stimulant compounds that include caffeine. Energy drinks are consumed in the afternoon and used before competition and training as they contain more caffeine than a cup of coffee. On average it is seen that energy drinks contain 200 milligrams of caffeine anhydrous providing more stimulant for the athlete (Chtourou et al. 2019). Table 6 broadens the view of how athletes consume caffeine. It was shown that coffee and energy drinks were the most available options for athletes and the most used by the athlete population. According to Tunnicliffe (2008) coffee was used as a dietary supplement for Canadian athletes to help start the day and improve morning training regardless of sport. For this study it can be assumed that most athletes drink coffee as it is a readily available resource in several locations on Gardner-Webb campus. Coffee may not have the readily available stimulants compared to preworkouts and energy drinks, but in some cases, athletes with lower tolerances could in fact achieve ergogenic aid from a standard

cup of coffee, which averages 85 milligrams of caffeine. In understanding energy drinks and preworkout, other metabolic stimulants are incorporated in the substance to improve ergogenic aid performances. These substances include beta-alanine and L-citrulline (McCormack & Hoffman., 2012). The two substances work together with caffeine to improve response time, focus, energy endurance, as well as overall strength activation and output. The lowest form of caffeine consumption was the use of caffeine pills. This is because the other forms of consumption are readily available as drinks or flavored powder, which is more appealing than standard pills. In this study it, was shown that energy drinks and coffee were the most appealing in a student population at Gardner-Webb University.

Another important factor of analyzing caffeine consumption is the amount of overall caffeine the individual intakes daily to prove effective ergogenic results in regard to their sport. According to Pickering & Grgic (2019), the most efficient dosage of caffeine was found to be 3 milligrams of caffeine per kilogram of body weight. The average of weight among a college athlete varies based on the demands and roles of their respective sport. According to McArdle et al. (2015) the average weight and size for collegiate sports such as football, wrestling, and basketball, male athletes showed an average of weighing 75 kilograms. For endurance-based athletes the average weight was 60 kilograms. Using Pickering & Grgic (2019) as a guideline for caffeine supplementation, it would make the most efficient caffeine dosage between 180-225 milligrams of caffeine. In table 8 the college athlete population of Gardner-Webb University is seen to consume more than 200 milligrams of caffeine daily with some athletes consuming between 101-200 milligrams. This can be assumed that most athletes are consuming an excess of caffeine daily and are experiencing negative side effects of caffeine usage, this is seen in Table 10 of the results. Athletes who consume caffeine daily will build a tolerance in adenosine

receptors and often experience a crash after consuming too much caffeine in order to perform for training. This surplus will have an impact in competition as it will require more caffeine to be used in order to reach ergogenic results. It was found in this study that more education is needed to help athletes reach and manage ergogenic results from the use of caffeine supplementation. It should also be noted that the overuse of caffeine can increase a demand or tolerance of caffeine in the individual leading to a decline in performance.

It was found that athletes of Gardner-Webb University used caffeine as a means of improving performance and felt that it was assistive in the demands of the weight room as well as on the field of their respective sport. According to Jodra et al. (2020) caffeine was used among elite athletes to achieve more strength and explosive power when performing a one repletion max and for time improvement varying across sports. In this study the time improvement can only be seen used by swimming. The other sports included in this study include, football, soccer, volleyball, softball, lacrosse, and tennis. These sports are more endurance based as there is a time limit of play. According to Astorino et al. (2011), caffeine supplementation was used in accordance with resistive weight training to improve strength and power among sports. It was found in this study that caffeine was used in a similar manner for the athletes.

The overuse of caffeine can have a decline on performance for college athletes and the overreliance of the supplement has been shown to affect the ability to respond to outside stimuli that is a very important aspect of all sports included in this study. As seen in Table 10, a list of negative side-effects was presented to the athletes regardless if they consumed caffeine on a regular basis to gain a better understanding of the physiological applications of caffeine. The negative side effects included difficulty concentrating at a task at hand, anxiety, insomnia, fatigue, headache, indigestion, excessive urination, troubled breathing, and rapid heartbeat. The

side effects of caffeine usage were examined and studied prior to the study and it was found that regardless of caffeine, students experienced these daily. According to Pickering & Grgic (2019), caffeine overstimulation can have a decline in performance value if used too often and if too much caffeine is used in one sitting. When analyzing the results most students were seen to use caffeine and experience all the side effects. While the study could not determine if caffeine was the driving factor for the side effects, they were acknowledged among the athlete population. This brings a better understanding that more education is needed before using caffeine as an additional supplement for sports performance. Caffeine is seen in coffee and energy drinks and acts as a diuretic. As more caffeine is consumed it is seen that the individual will experience indigestion as well as frequent urination which excretes the caffeine from the body. Even though caffeine is seen to improve responsiveness and reaction time (Santos et al., 2014), it was seen that overstimulation makes it difficult to focus on the task at hand for the individual and therefore, a decline in performance was seen. As seen in this study, proper education is needed to enhance the usage of caffeine and limit the various negative effects of overstimulation for the athletes.

There were several limitations present in this study. The first limitation was the participation of athletes in the survey. The sample size of 176 is a large participation factor but it cannot conclude the caffeine consumption for a complete Division 1 program. It can be used however, for educational purposes to analyze how athletes view caffeine and its supplementation across various sports. Also, it should be noted that not all sports of Gardner-Webb University chose to participate in this study as only 7 of 12 teams completed the survey. Another limitation of this study is that there was no regulation of participants when completing this study. Participants were asked to be honest but there could be some bias in regard to how much caffeine

an individual can consume. This limitation also presents an implication with athletes who already consume caffeine and have an increased tolerance prior to participating in the study. Finally, there is a limitation on the effect of caffeine and correlation to class schedule and academic function. It was seen that an increase in credit hours could have an impact regarding caffeine consumption, especially in addition to a sports schedule. The survey did not account for the combination of caffeine supplementation with academic purposes and purely focused on athletic aid and point of view. To improve the study from its limitations, a more in depth and longer survey will be needed to gain better participation and educate athletes about the use and consumption of caffeine. The purpose of this study was to analyze how different sports and athletes use the supplement of caffeine as an ergogenic aid. It was also used to understand how outside stimuli may contribute to the need for caffeine consumption.

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