Effect of Acute Caffeine Ingestion on On-Field Performance in Division 1 Female Field Hockey Players

Nicole Danielle Fredricks
Old Dominion University, fredricksnd@verizon.net

EFFECT OF ACUTE CAFFEINE INGESTION ON ON-FIELD PERFORMANCE IN DIVISION 1 FEMALE FIELD HOCKEY PLAYERS

by

Nicole Danielle Fredricks
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Approved by:

Patrick B. Wilson (Director)

Hunter J. Bennett (Member)

J. David Branch (Member)

ABSTRACT

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Nicole Danielle Fredricks
Old Dominion University, 2023
Director: Dr. Patrick B. Wilson

This study aimed to determine the effects of acute caffeine ingestion on on-field performance in collegiate female field hockey players. A placebo-controlled, double-blind, randomized, crossover experimental design was utilized. The participants (N=10) were female division 1 field hockey players (age: 20.0 ± 1.6 years). They competed in two 60-minute, off-season scrimmages separated by two weeks. They were randomly assigned to ingest the caffeine, 3 mg/kg of body weight, or placebo treatment 60 minutes before each scrimmage. They wore a PLAYERTEK (Catapult, Australia) global positioning system (GPS) device to track their total distance, sprint distances, power plays, and zone three and above distance throughout the scrimmages. Other measures included rating of perceived exertion (RPE), rating of fatigue (ROF), and caffeine side effects. The GPS, RPE, and ROF data was analyzed using two-way within-subjects ANOVAs (time x condition), while side effect data were analyzed with Wilcoxon-Signed Rank testing. There was a significant increase in ROF over time during both scrimmages ($p < 0.001$) for both the caffeine and placebo conditions, but no condition or condition-by-time effects. There was a significant condition-by-time ($p = 0.027$) effect for sprint distance, although there were no significant time, condition, or condition-by-time effects for any of the other GPS outcomes. There was no statistical significance between the conditions in change scores for any of the side effects measured. In conclusion, it is unlikely that caffeine at a

dose of 3 mg per kg of body mass elicits major benefits to on-field performance among division 1 female field hockey players who habitually consume caffeine.

This thesis is dedicated to my parents, Jennifer and Tim Fredricks,

for their endless support throughout my academic journey.

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CHAPTER I

INTRODUCTION

Athletes train day in and day out to reach their main goal of winning games or performing well for their respective sports. Besides putting in the work practicing, athletes often look for alternative ways to improve their performance legally. The National Collegiate Athletic Association (NCAA), and the International Olympic Committee (IOC), and the World Anti-doping Agency (WADA) place certain substances on a banned or restricted list. Caffeine, a substance that the NCAA currently restricts and WADA formerly restricted, is one of the most common ergogenic aids that athletes utilize due to its effects on performance and cognitive function (NCAA, 2022; WADA, 2022). Abundant research has been conducted to examine the improvements to endurance performance with acute caffeine consumption (Astorino et al., 2012; Bell & McLellan, 2002; Costill et al., 1978; Cristina-Souza et al., 2022; Doherty et al., 2004; Graham & Spriet, 1991; Pasman et al., 1995; Sampaio-Jorge et al., 2021; Sökmen et al., 2008). In the last several years, considerable research support has emerged for an ergogenic effect of caffeine on anaerobic power and capacity (Grgic et al., 2018) and muscular strength and endurance (Astorino & Roberson, 2010; Grgic & Pickering, 2019; Grgic 2021; Grgic & Del Coso, 2021). However, there is less research and more controversial findings regarding the effect of caffeine on performance for team sport competition. Most of the research on this issue uses lab-based methodologies (Ali et al., 2016; Chia et al., 2017; Astorino & Roberson, 2010; Paton et al., 2001; Schneiker et al., 2006; Stojanović et al., 2019) which cannot be fully applied to actual on-field performance. Advancements in global positioning systems (GPS) technology for athletics have improved data collection and analysis on athletic performance during actual competition. In addition, most of the studies examine the effects of caffeine for male team-sport athletes (Astorino & Roberson, 2010; Bruce et al., 2000; Chia et al., 2017; Duncan et al., 2012; Paton et al., 2001; Salinero et al., 2019; Schneiker et al., 2006; Stuart et al., 2005; Woolf et al., 2009), which again limits the generalizability of the findings due to physiological differences between males and females. To date, no studies have examined the effects of caffeine in actual competition using GPS devices for female field hockey players. Further research is needed to determine any benefits for athletic performance following acute caffeine ingestion for the female athlete population.

Purpose of the Study

This study measured the effects of acute caffeine ingestion on athletic performance during competitive scrimmages for division 1 female collegiate field hockey players.

Hypotheses

- In comparison to the control trial, caffeine ingestion will lead to division 1 female field hockey players having an increase in total distance covered during a game.
- In comparison to the control trial, caffeine ingestion will lead to the division 1 female field hockey players having an increase in sprint distance, power plays, and Z3+ distance.
- In comparison to the control trial, caffeine ingestion will lead to equivalent levels of rate of perceived exertion (RPE) and fatigue despite the greater workloads achieved by the division 1 female field hockey players.

Operational Definitions

- Acute dose of caffeine: A dose of 3 mg of caffeine per kg of body weight ingested 60 minutes prior to competition.

- Elite field hockey player: For this study, a field hockey player is considered elite if they compete in the NCAA at the division 1 level.
- Minimal Post-Injury Rehabilitation: For this study, participants were not included if they have a current injury or an injury within two weeks of the study that prevents them from competing in an entire field hockey game or at their highest level.
- Minimum Hydration Level: To limit the risk of dehydration, participants were given a 16-ounce bottle of water to consume three hours prior to the scrimmage.
- Speed Classifications: There are no current established speed guidelines for female field hockey players, but there are for female soccer players, so those were used in this study. A sprint is movement greater than 12.4 mph, moderate speed is 7.5-12.4 mph, and low speed is less than 7.5 mph (Bradley & Vescovi, 2015; Sausaman et al., 2019).
- Total Distance (TD): The total distance tracked by the PLAYERTEK were collected in yards and collected for each half of the game. There was a TD for the first half and TD for the second half of each scrimmage.
- Borg RPE Scale: Participants quantified their rating of perceived exertion (RPE) by using the Borg 6-20 Scale. A score of a 6 indicates no exertion and a score of 20 indicates maximal exertion (Borg, 1970; Borg, 1982).
- Rating of Fatigue Scale: Participants quantified their level of fatigue on a scale of 0-10. A score of a 0 indicates “not fatigued at all” and a score of 10 indicates “total fatigue and exhaustion – nothing left” (Micklewright et al., 2017).

Limitations

The participants in the study were asked to refrain from any normal intake of caffeine 12 hours prior to each scrimmage. With reliance on caffeine, this could have negatively affected the athlete's performance during the control trial. In addition, the study could not account for any tolerances to caffeine that the athletes may have. An acute dose of caffeine might not have had as much of an impact on a habitual caffeine consumer. Since only eleven players can be on the field at the same time, playing time varied between participants and between the two scrimmages, and therefore cannot be standardized.

Delimitations

The study examined female participants, 18 years or older, that participate in division 1 collegiate field hockey. Participants could not participate if they were returning to play from an injury. Participants consumed a moderate dose of caffeine, 3 mg/kg of body weight.

Significance of the Study

The significance of the study was to provide useful information for athletes and coaches in division 1 female team sports on the use of caffeine consumption with the intention to improve athletic performance during actual competition.

CHAPTER II

LITERATURE REVIEW

Introduction

Due to the unorthodox movements and requirements of team sports, athletes reach high loads of physical demands through various intensity levels during competition. With increasing popularity in team sport analysis, global positioning system (GPS) devices were created, so athletes could wear them during competition and researchers could better understand the movement patterns, intensities, and total work volume accomplished by athletes in a competitive environment. To keep up with the demanding workload, the use of ergogenic aids has become increasingly popular by athletes with the aim to enhance performance. Much research has been conducted on the impact of caffeine as an ergogenic aid for performance, particularly for endurance competition and among males. However, less research has been done on how caffeine effects on-field performance with the use of GPS monitoring, specifically for female team-sport athletes.

Nature of Team Sports

Sports fall into the two major categories of individual and team sports. Broadly defined, team sports require athletes to work together to out-score their opponents (Williams & Rollo, 2015). Well-known team sports include soccer, field hockey, lacrosse, rugby, volleyball, and football. Team sports consist of a stop-and-go nature with many repeated bouts of high-intensity followed by lower-intensity activity (Williams & Rollo, 2015). The activity of team sports varies in both intensity and duration but usually consists of the high intensity activity followed by a recovery period of light or static activity (Drust et al., 2007). Due to the nature of activity in team sports, athletes must be well rounded with the following five components of fitness: aerobic endurance, anaerobic power, muscular strength, flexibility, and agility (Macutkiewicz et al., 2011).

Within a competition, team-sport athletes have less direct involvement in the play compared to an individual-sport athlete (Drust et al., 2007). Specifically, less than 2% of the total distance traveled for a team-sport athlete during a game is with the possession of the ball (Drust et al., 2007). Therefore, the athletes control how much effort they put into a game with their off-ball movement. The work rate of the athlete directly influences the overall demand of the game (Drust et al., 2007). Many sources claim that team-sport athletes increase their energy expenditure due to the movements in their sports (Drust et al., 2007; Hader et al., 2016; McGuinness et al., 2019). Some of the typical movements in team sports include accelerations, decelerations, change of directions (COD), cutting in front of a defender, attacking skills, tackling skills, passing, jumping, and other sport specific movements (Drust et al., 2007; McGuinness et al., 2019). Specifically for COD while running, an increase in blood lactate concentration, heart rate, and VO_2 supports the idea of an increase in energy expenditure compared to normal running (Hader et al., 2016). Due to the movements and energy expenditure levels, high-level team sports, like soccer, field hockey, and volleyball, are physically demanding.

A study conducted in 2013 examined the effect of repeated high-intensity and sprint activity in a group of women's soccer players for the first half of a game to the second half of a game (Gabbett et al., 2013). They found that the number of high-intensity bouts was very similar from the first to the second half of competition, but the amount of low intensity time between the bouts increased (Gabbett et al., 2013). The difference in length of low intensity activity indicates the fatigue levels and extra need for recovery in the second half of a game, which can be a deciding factor in competition (Gabbett et al., 2013). During a game, professional soccer players perform an average of at least 8 COD movements per minute and triple the number of accelerations compared to the number of sprints during a match (Hader et al., 2016). On average, athletes perform high-intensity sprints for 2-4 seconds with varying amounts of recovery or low-intensity speeds prior to the next bout of high-speed work (Williams & Rollo, 2015). Team sports require sprinting for an average of 1-12% of the total distance for a match (Di Salvo et al., 2010). One study claims that the sprinting average sits at the high end of the range with 11% of the total distance during a game (McGuinness et al., 2019).

Specifically for field hockey, one investigation of female field players found that 92.1% of a game is played at low intensity and 7.9% is played at high intensity (MacLeod et al., 2007). The low-intensity movements can be broken down into standing (11.4%), walking (45.1%), and jogging (35.6%) (MacLeod et al., 2007). The high-intensity movements can be broken down into cruising (5.1%), sprinting (1.5%), and lunging (1.3%) (MacLeod et al., 2007). In addition, field hockey can be classified as a moderate-high intensity sport due to 80% of the game being played above 70% of the athletes' maximum heart rate (McGuinness et al., 2019). All of these calculations for team sport performance metrics are made possible by newly available technology that can analyze data to quantify the demands of sports (McGuinness et al., 2019).

New Technology to Measure Performance and Load in Team Sports

In modern day sports, coaches and players utilize GPS monitors to track on-field athletic metrics. The use of GPS devices to track team-sport performance as well as the validation process of the devices began in 2006, making it a relatively new phenomenon (Aughey, 2011).

The invention of the atomic clock stands at the core for the evolution of GPS devices in team-sport environments (Aughey, 2011). The GPS technology allows coaches, strength and conditioning professionals, and athletes to analyze both low- and high-intensity activities during practices and competitions (Gabbett, 2010). Data from GPS devices can be used to track physiological demands of the athlete as well (Gabbett, 2010). The GPS devices collect objective, field-based data that can be interpreted to measure volume and intensity of the workload of athletes (Choice, 2021). Some of the performance variables that the technology collects include total distance, total sprint distance, top speed, explosive efforts or power plays, number of sprints, distance per minute (m/min), sprints per minute, minutes played, and estimated calories burned (Choice, 2021; Corrales, 2020). Overall, performance and the physical demands in competition vary based on competition level, position, and playing time (Corrales, 2020). The GPS technology allows for a comparison of athlete workload based on their position and playing time (Macutkiewicz & Sunderland, 2011).

McLellan et al. (2011) categorizes the GPS data as external loads and internal loads of the athlete. The external loads consist of the sport-specific movement patterns and profile of activity level (McLellan et al., 2011). The internal loads consist of the physiological response of the athlete to the workload (McLellan et al., 2011). The two types of loads can be objectively quantified by the GPS devices to evaluate the work of the athletes. In order to do so, the data can be organized into different categories based on the speed calculations (Cummins et al., 2013). Previously, the activities of athletes were broken down into three categories: standing/walking/low speeds (<12 km/h), moderate speeds (12.1-20 km/h), and high-speed sprinting (>20 km/h) (Bradley & Vescovi, 2015). Recently, the thresholds have been specified into more categories of intensity. These categories include standing (0-0.1 km/h), walking (0.1-

6.0 km/h), jogging (6.1-8.0 km/h), low-speed running (8.1-12.0 km/h), moderate-speed running (12.1-15.0 km/h), high-speed running (15.1-18.0 km/h), sprinting (18.1-25.0 km/h), and max sprinting (>25 km/h) (Sausaman et al., 2019).

The validity and reliability of the GPS systems used in team sports has received increasing attention. The gold standard for the criterion method of GPS validity is using a trundle wheel to get a distance and comparing that to the distance the GPS tracks (Cummins et al., 2013). For speed, the validity is evaluated by using timing gates to calculate a criterion speed (Cummins et al., 2013). Generally, there is an agreement that the accuracy of the GPS measurements increases with increased distances and decreases with increased speeds (Gentles et al., 2018). Some of the errors of the GPS systems include misrepresentation of position, distance, and speed due frequent COD and high-speed running in the team sports (Gentles et al., 2018). To limit these errors, literature suggests that the sampling frequency of the GPS units should be between 5-15 Hz with superior accuracy at 10 Hz (Gentles et al., 2018). Johnston et al. (2014) found that 10-Hz GPS devices produce greater validity and interunit reliability than 15-Hz GPS devices. Specifically, there was an interunit typical error of measurement of 1.64% for 10-Hz and 8.1% for 15-Hz sampling frequencies for tracking high-speed running (Johnston et al., 2014). For velocity, acceleration, and deceleration measurements, the 10-Hz devices are 3 times more valid and 6 times more reliable than the 5-Hz devices (Varley et al., 2012). For a 15-meter sprint, the standard estimate of error (SEE) for a 10-Hz device is 10.9%, 32.4% for a 1-Hz device, and 30.9% for a 5-Hz device (Castellano et al., 2011; Jennings et al., 2010).

Most of the research using GPS technology in team sports has examined male athletes (Sausaman et al., 2019). A potential reason for the unbalanced research may be due to more funding in men’s sports to buy the expensive GPS equipment (Sausaman et al., 2019). One study suggests that males perform 30% more high-intensity activity during competition than female athletes and often have better performances on the fitness tests (Sausaman et al., 2019). With the magnitude of the differences in male and female performance, more research is needed for female team-sport athletes and GPS technology.

Caffeine as an Ergogenic Aid

In sports, an ergogenic aid can be broadly described as a technique or substance used to enhance performance, energy production, or energy utilization (Silver, 2001; Thein et al., 1995). Ergogenic aids can be broken down into five categories: mechanical, psychological, physiological, pharmacological, and nutritional (Silver, 2001). An example of each type, respectively, includes different shoes, hypnosis, blood doping, steroids, and creatine (Silver, 2001). With increasing popularity of consuming nutritional ergogenic aids in the 1970s, researchers started to look at the actual performance-enhancing effects of the substances (Keisler et al., 2006).

Caffeine (1,3,7-trimethylxanthine), a purine alkaloid of the xanthine class, stands as the most widely used pharmacologically active substance (Pesta et al., 2013). About 90% of the European and North American adult population admit to consuming coffee daily (Pesta et al., 2013). On average, an adult consumes 200 mg of caffeine per day, which equals about 2 cups of coffee (Pesta et al., 2013). Due to its lack of nutritional value, caffeine can be described as a stimulant drug. Prior to January 2004, the International Olympic Committee (IOC) and WADA listed caffeine as a banned substance with an upper urine concentration of 12 μg/ml (Keisler & Armsey, 2006). Although no longer regulated by the IOC (WADA, 2022), the National Collegiate Athletic Association (NCAA) restricts caffeine to no greater than 800 mg (or 15 ug/ml in urine), which equals about 8 cups of coffee (Keisler & Armsey, 2006; NCAA, 2022). After the removal of the restriction by the IOC, Del Coso et al. (2011) performed a study examining the level of caffeine abuse in elite athletes. Out of about 21,000 samples, 99.4% of the samples had less than 12 μg/ml of caffeine, which indicated no systematic abuse of caffeine by the professional athletes (Del Coso et al., 2011).

Caffeine affects both the nervous and musculoskeletal systems (Pesta et al., 2013). Physiologically, the liver metabolizes caffeine via cytochrome P450 enzyme (Keisler & Armsey, 2006). Caffeine is absorbed in the gastrointestinal (GI) tract with peak plasma concentrations occurring 40-60 minutes after ingestion (Keisler & Armsey, 2006). Caffeine has a half-life of about 3-5 hours (Keisler & Armsey, 2006). In addition, intake of a high carbohydrate meal can influence the timing of peak serum caffeine concentrations (Skinner et al., 2013). Skinner et al. (2013) conducted a study that found caffeine concentrations greater in the fasted state compared to the fed state, reduced serum concentration in the fed state, and a delay to peak plasma concentration in the fed state. Due to the differences in caffeine concentrations, athletes must consider the time of caffeine intake in relation to consuming a meal prior to competition.

Multiple mechanisms for how caffeine enhance performance have been proposed. Caffeine stimulates the sympathetic nervous system and mobilizes free fatty acids as an energy source, which could help to preserve muscle glycogen stores (Silver, 2001). Pesta et al. (2013) proposes five potential mechanisms: inhibition of adenosine, greater beta-oxidation, inhibition of phosphodiesterase enzymes, increase in post-exercise muscle glycogen, and ability to mobilize intracellular calcium. In regard to the proposed greater beta-oxidation, Collado-Mateo et al. (2020) suggest an increased mobilization of fatty acids rather than increased beta-oxidation, especially in trained individuals. Keisler and Armsey (2006) support the claims that caffeine increases fat oxidation, stimulates the central nervous system (CNS), and acts on the muscle itself. Caffeine readily crosses the blood-brain barrier leading to increased arousal, decreased perceived exertion and other ergogenic effects related to CNS function (Keisler & Armsey, 2006). By binding to the A1, A2A, A3, and A2B adenosine receptors, caffeine inhibits any fatiguing effects of adenosine during exercise (Baltazar-Martins et al., 2020; Ribeiro & Sebastiao, 2010). More often observed in sedentary or lesser-trained subjects, caffeine overall assists metabolically with increased use of fatty acids and decreased use of glycogen stores, enhances skeletal muscle contraction with increased calcium concentrations, and improves cognitive functions like alertness through CNS activity (McDaniel et al., 2010).

For performance enhancements, a dose of 3-6 mg of caffeine per kg of body mass appears to provide the greatest benefits (Baltazar-Martins et al., 2020; Puente et al., 2017; Silver, 2001). For optimal effects, the dosage of caffeine should be taken about 45-60 minutes prior to exercise but may vary based on source of caffeine and type of exercise (Baltazar-Martins et al., 2020). Benefits of caffeine are mostly established for endurance and sprint/power events lasting a few seconds, but less evidence supports the benefit to anaerobic type exercise (Guest et al., 2021; Sökmen et al., 2008). Some of the benefits of caffeine on performance include increases in speed and power, improved length of training, and fatigue resistance (McDaniel et al., 2010). In addition, the stimulation of the brain by caffeine can allow for more precise cognitive abilities for completing athletic tasks (McDaniel et al., 2010). The fatigue resistance effects of caffeine have been examined since the early 1900s (Keisler & Armsey, 2006). Notably, caffeine enhances performance by decreasing the athlete's rating of perceived exertion (RPE), which allows the athlete to work at greater intensities for longer periods (Doherty & Smith, 2005; Glaister & Gissane, 2018; Keisler & Armsey, 2006; Pesta et al., 2013). Most results for showing caffeine's performance enhancements come from laboratory-based tests on athletes. More studies during an actual sporting competition are needed to determine the practicality and application of caffeine for performance enhancing in sports.

Previous Studies on Caffeine and Performance in Team-Sport Athletes

The effect of caffeine on endurance performance has been well documented in the literature (Astorino et al., 2012; Bell & McLellan, 2002; Collomp et al., 1992; Costill et al., 1978; Cristina-Souza et al., 2022; Doherty et al., 2004; Graham & Spriet, 1991; Pasman et al., 1995; Sampaio-Jorge et al., 2021). In addition to endurance performance, the effect of caffeine on team-sport athletes has also received research attention. Most of the research simulates team-sport activities through various fitness tests or drills to mimic the demand of the activity (Davis & Green, 2009; Duncan et al., 2012; Schneiker et al., 2006; Stuart et al., 2005; Woolf et al., 2009). Studies that use sport-specific methodologies with shorter durations display the benefits of caffeine to performance compared to ones that use general fitness tests (Davis & Green, 2009). One study had a group of male athletes complete a match-simulated activity that examined the ability to repeat sprints in the first half of a match compared to the second half (Schneiker et al., 2006). They found that the caffeine group had greater sprint work and peak power in the second half compared to the control group, which suggests the benefits of caffeine on the intermittent sprint performance in team sports (Schneiker et al., 2006). Stuart et al. (2005) reported improvement on tasks requiring speed, power, and high motor skills in male rugby players following caffeine supplementation.

Most of the research on field hockey focuses on male players. One study had the male athletes complete two field hockey related tests, Hockey Slalom Sprint Dribble Test and

Chapman Ball Handling Test, while already fatigued (Duncan et al., 2012). Caffeine appeared to delay any detriments to skill execution during fatigue (Duncan et al., 2012). Another study on male field hockey players found an increase in high-intensity running during the match after caffeine consumption using a GPS system (Del Coso et al., 2016).

Multiple systematic reviews and meta-analyses have focused on effects of caffeine on team-sport performance. Gomez-Burton et al. (2021) found 18 primary studies that examined the effect of caffeine and performance in adult female team-sport athletes. They found small increases in team-sport skills, countermovement jump height, and handgrip strength with caffeine compared to placebo and no effects for RPE, squat jump height, agility, and repeated agility between the two groups (Gomez-Bruton et al., 2021). This was the only review that looked at research with female participants only.

In a different review with 74% male participants, Chia et al. (2017) found a majority of the studies that examined caffeine and ball-sport athletes to have improvements in sprint performance and vertical jump. Astorino and Roberson (2010) conducted a systematic review that found eleven of the seventeen studies to show improvements in team-sport performance and power after caffeine ingestion. Two systematic reviews on male soccer players agreed that acute caffeine ingestion caused improvements in jump height, repeated sprint ability, agility, total distance, and number of sprints (Mielgo-Ayuso et al., 2019; Salinero et al., 2019). Across 21 meta-analyses, Grgic et al. (2020) noted the ergogenic effects of caffeine on muscular endurance and strength, anaerobic power, and aerobic endurance, which all act as key components of success in team sports.

Not all literature supports the idea that caffeine brings benefits to performance for team-sport athletes. One study on male soccer players found no differences in sprint performance and fatigue levels for the caffeine and control conditions (Paton et al., 2001). Another study found a similar result in that running performance of the athletes did not significantly change with a 6 mg/kg dose of caffeine ingestion in the evening but did find detrimental effects to the sleep quality of the athlete (Ramos-Campo et al., 2019). This is an important finding due to the importance of sleep to athletes for recovery and preparation purposes, which should be taken into consideration while considering caffeine consumption. Three studies found no improvements in performance for basketball players (Brown et al., 2013; Scanlan et al., 2019; Tan et al., 2020). At the NFL combine, some male football athletes consumed caffeine prior to their tests, and it did not cause any significant benefits to their bench press, 40-yard dash, and 20-yard shuttle (Woolf et al., 2009).

Caffeine Research in Female Athletes

The majority of research regarding caffeine's effect on athletic performance examines male team-sport athletes in a simulated competitive setting (Astorino & Roberson et al., 2010; Chia et al., 2017; Mielgo-Ayuso et al., 2019). Few studies look solely at female team-sport athletes and the effects of caffeine on their performance. In a study of female volleyball players, Perez-Lopez et al. (2015) reported increased standing and jumping spike, squat jump, and countermovement jump performance as well as a decrease in agility test time following 3 mg/kg of caffeine supplementation. A study specifically looking at female team-sport athletes found an increase in eccentric strength and power of the knee flexors, but no change in isometric, concentric, or countermovement jump performance (Ali et al., 2016). This finding is important for female athletes because lower body muscular strength and power are critical to successful performance and minimizing injuries (Ali et al., 2016). In women's handball athletes, it was found that acute caffeine ingestion improved handball skills such as throwing velocity, sprint speed, accelerations, and decelerations (Munoz et al., 2020). Similarly, Lara et al. (2014) examined the effects of 3 mg per kg of body weight of caffeine for women's soccer players and used a GPS tracking device to track on-field performance. They found increases in CMJ height, peak speed during the run test, and, for the game, increase in total distance, number of sprints, and high-speed running (Lara et al., 2014). Only two studies (Del Coso et al., 2012; Lara et al., 2014) have used GPS monitoring to assess on-field performance after caffeine ingestion in samples from specific, female team-sport athlete populations.

Potential Side Effects of Caffeine

Caffeine supplementation comes with both benefits and risks to an athlete. Some notable negative effects of caffeine for exercise performance, which tend to occur more often at high caffeine doses, include anxiety, jitters, inability to focus, GI discomfort, restlessness, tachycardia, and diuretic issues (Pesta et al., 2013; Silver, 2001). Even twenty-four hours after exercise, multiple symptoms including GI problems, increased urine output, and headache can persist for an athlete (de Souza et al., 2022). In a systematic review on the side effects associated with caffeine supplementation in athletes, de Souza et al. (2022) determined the dose of 3 mg of caffeine per kg of body weight to be optimal. This lower dose of caffeine can provide ergogenic benefit to athletes while providing the lowest amount of side effects.

Summary

After reviewing the literature on the ergogenic effects of caffeine, there is a lack of research on female team-sport athletes, specifically field hockey players, and the effect of caffeine on field performance. The new technological advances in GPS technology allow for monitoring physical on-field demands, which allows professionals to analyze the data to compare workloads for players, positions, and different days. It is well established that caffeine benefits endurance performance in athletes, but there are controversial findings related to on-field, sport-specific performance benefits from caffeine. To date, there is no study that has solely looked at female field hockey players on-field performance after caffeine consumption through GPS monitoring.

CHAPTER III

METHODOLOGY

Research Design

A placebo-controlled, double-blind, randomized, crossover experimental design was used in this study. The sample size of the study was determined by the availability of qualified participants at the university. The participants were blinded to the treatment they received at each trial. They ingested a capsule of an acute dose of caffeine, 3 mg/kg body mass, or an identical capsule with an inert substance one hour prior to the start of two scrimmages. The two off-season scrimmages mimicked the length of an actual field hockey game and were separated by a two weeks' time. Participants wore a Catapult sports bra with a pocket for the GPS device (PLAYERTEK, Catapult, Australia). The device tracked multiple performance variables throughout the scrimmages. Perceptual responses and side effects were also measured before, during, and after the scrimmages.

Participants

Prior to a field hockey practice, the members of the Old Dominion University (ODU) field hockey team were presented with information on the study. Following the presentation, members of the team voluntarily expressed interest in participating. This study received approval of the Director of Intercollegiate Athletics and the field hockey coaching staff. The protocol and informed consent document were submitted to ODU's Institutional Review board for approval. Participants received a verbal explanation of procedures and also provided written consent.

In order to be eligible to participate, each participant needed to be 18 years or older and a division 1 collegiate field hockey player who practiced 3-5 times a week and was not in competition season. In addition, each participant had to be a moderate caffeine drinker, defined as consuming caffeine at least 4 days/week, so their body is familiar with the effects of caffeine. Participants were excluded if a current or recent injury would prevent them from competing at their highest ability during a full-length competition. All goalkeepers were excluded from the study due to the nature of their position compared to a field position. In addition, participants were excluded if they had any allergies or aversions to gelatin or rice flour. A total of 10 players participated in the study (age: 20.0 ± 1.6 years; mass: 66.2 ± 7.9 kg).

Procedures

At the Division 1 level, field hockey competition season occurs in the fall semester. In the spring semester, members of the ODU field hockey team participate in intense off-season training. Although not competing for a real championship, the field hockey team has multiple scrimmages against other universities throughout the spring. This study utilized two of the planned spring scrimmages for data collection.

Participants were randomly assigned to either the caffeine treatment or placebo treatment prior to the first scrimmage. For the second scrimmage, participants received the opposite treatment than the first scrimmage, so both treatments were received. For the caffeine treatment, an acute dose of caffeine powder (Blackburn Distributions, Burnley Lancashire, England), 3 mg/kg body weight, was put into a white gelatin capsule (size 0Gelatin Capsules, XPRS Nutra, UT, USA) that the participants ingested. For the placebo treatment, rice flour was put into an identical capsule that the participants ingested. Rice flour was used as the inert substance because the small dosage (~150-200 mg) of this carbohydrate provided would not elicit effects on the participants. The investigators collecting the study data were blinded to treatment order until all the data were collected. This was accomplished by having an individual not involved with data collection generate a randomization list (via https://www.sealedenvelope.com) and associated treatment packages.

For each day of testing, participants refrained from any source of caffeine within 12 hours of data collection. A food log was administered to participants, and they were asked to record their food intake prior to the first scrimmage. They were then asked to replicate their food intake prior to the second scrimmage. In addition, participants were given a 16-ounce bottle of water to consume three hours before each scrimmage to establish a minimum hydration status. Participants were asked to arrive at their athletic facility one and a half hours prior to the start of the scrimmage to allow them to put their uniform on. Exactly one hour prior to the start, the participants were given their capsule to ingest with about 250 mL of water. The one-hour timeframe allowed for peak plasma concentrations to occur during the scrimmage (Keisler & Armsey, 2006). Thirty minutes prior to the start, each participant completed a 25-minute standardized warm-up consisting of a dynamic body warm-up and field hockey skills.

The off-season scrimmages used in this study replicate a complete field hockey game. They consisted of four, 15-minute quarters with a 2-minute break between the first and second and third and fourth periods and a 10-minute halftime. One of the scrimmages was formatted where the participants played against one team, while the other scrimmage consisted of playing one university for the first half of the game and a different university for the second half of the game. The length of quarters and breaks between quarters were not affected by this format.

The second off-season scrimmage occurred two weeks after the first. This allowed for proper recovery of the athletes from competition and for an appropriate washout period. In addition, the week between the scrimmages mimicked the real competition season of having about a week in between games. The first scrimmage was played at 1:30pm and the second scrimmage was played at 3:30 pm. The temperature was 71 °F with a dew point of 62 °F and a humidity of 73% around the start of the first scrimmage and was 79°F with a dew point of 56°F and a humidity of 45% around the start of the second scrimmage (Weather Underground).

Instruments

This study utilized 10-Hz GPS technology (PLATERTEK, Catapult, Australia) to track the on-field performance. The GPS unit of 10 Hz has been found to have greater validity and reliability compared to devices of 1 Hz, 5 Hz, and 15 Hz (Johnston et al., 2014; Scott et al., 2016). Compared to criterion methods for tracking speed and distance, the 10-Hz device produced statistically equivalent values (Johnston et al., 2014). It also produces an intraclass correlation coefficient of greater than 0.8 and repeatability coefficient of 1.9% (Johnston et al., 2014). The PLAYERTEK was turned on prior to the standardized warm-up and turned off after the standardized cool-down. The timeframe for the GPS can be altered so the data are only from the scrimmage and the warm-up and cool-down are eliminated. The device tracked total distance, total sprint distance, number of power plays, and zone three or above distance. A power play is an explosive movement, like an acceleration, classified by the athlete generating over 20 W/kg of power for longer than one second (Volume Metrics, Catapult). The speed classifications are divided into five different zone increasing in the speed threshold with Z3+ being above 7.0 m/s for the subjects. The data were divided into first half and second half totals. Playing time was determined by examining the activity charts produced on the PLAYERTEK software that displayed when the participants were standing still on the sideline and active on the field during each half.

During halftime and at the conclusion of each scrimmage, the participants rated themselves on the Borg RPE scale. This rating ranges from 6-20, with 6 being no exertion and 20 being maximum exertion (Borg, 1970; Borg, 1982). At these same two time points, as well as before taking the treatments, participants also rated themselves on a fatigue scale from 0-10 with 0 being “not fatigued at all” and 10 being “total fatigue and exhaustion – nothing left” (Mickelwright et al., 2017). The rating of fatigue scale has a high level of validity for tracking fatigue perceptions during exercise (Mickelwright et al., 2017). In addition, the participants completed a series of 100-mm visual analog scales prior to taking the treatment and following each scrimmage. The questions regarded potential negative side effects associated with caffeine consumption including anxiety, GI disturbances, shakiness, nausea, headache, and quickened heart rate. Multiple other studies have used similar surveys to measure side effects and subjective perceptions (Cesareo et al., 2019; Hurley et al., 2013; Marikadis et al., 2007; Newbury et al., 2022). After providing their post-game RPE, ROF, and completing the side effect visual analog scale, participants guessed which condition they thought they received that day.

Prior to the first scrimmage, participants completed the Caffeine Consumption Questionnaire – Revised version (CCQ-R; Irons et al., 2016). This questionnaire required participants to note how many times per week they consume different serving sizes of caffeinated coffee, decaffeinated coffee, iced coffee, soda, energy drinks, tea, hot chocolate, chocolate milk, different chocolate or caffeine containing foods, and over-the-counter caffeinated medications. The CCQ-R provides average, minimum, and maximum estimates of caffeine intake (mg/day) given that caffeine content is variable even within the same types of food. The CCQ-R has been found to be a valid estimation of caffeine consumption (Irons et al., 2016).

Statistical Analysis

The number of participants (n) included in the study was limited to the number of eligible players on the ODU field hockey team and to those of which who chose to participate. A power calculation had indicated that 15 participants were needed for a large effect size (0.8). In similar studies, a sample size of about 10-15 participants has been used (Ali et al., 2016; Munoz et al., 2020; Perez-Lopez et al., 2015; Portillo et al., 2017; Puente et al., 2017; Stojanovic et al., 2019). Mean (SD) or median (interquartile range) values are the descriptive statistics used for the quantitative variables with a normal or non-normal distributions, respectively. Normality was checked using the Shapiro-Wilk test and by inspecting histograms and Q-Q plots. For data that are normally distributed, two-way ANOVA (time x condition) was used to examine whether changes in the GPS and perceptual (RPE, rating of fatigue) outcomes differed overtime between the caffeine and placebo conditions. In the case of time effects with no interaction effect, pairwise comparisons with a Bonferroni correction were applied. Side effect data (including change scores from pre-to-post scrimmage) were non-normally distributed, and therefore the Wilcoxon Signed-Rank Test was used to test for between-condition differences. The significance level was set to $p \leq 0.05$. IBM SPSS Statistics 28 (IBM, Armonk, NY, USA) was used for the analyses.

CHAPTER IV

RESULTS

Caffeine Intake and Experimental Blinding

The average estimated caffeine intake for the participants (n=10) was 199 ± 96 mg/day. The minimum estimated caffeine consumption was 94 ± 47 mg/day, and the maximum estimated caffeine consumption was 346 ± 165 mg/day.

Of the 10 participants, 80% guessed the caffeine condition correctly and 70% guessed the placebo condition correctly. One participant guessed the same condition twice.

Dietary Intake

Table 1 displays the average intake of energy and macronutrients for each condition. A paired sample, two-sided t-test indicated no statistical difference for kilocalories (p=0.670), carbohydrates (p=0.425), protein (p=0.903), and fat (p=0.786) between the placebo and caffeine condition.

Table 1. Descriptive Statistics of Pre-Scrimmage Dietary Intake.

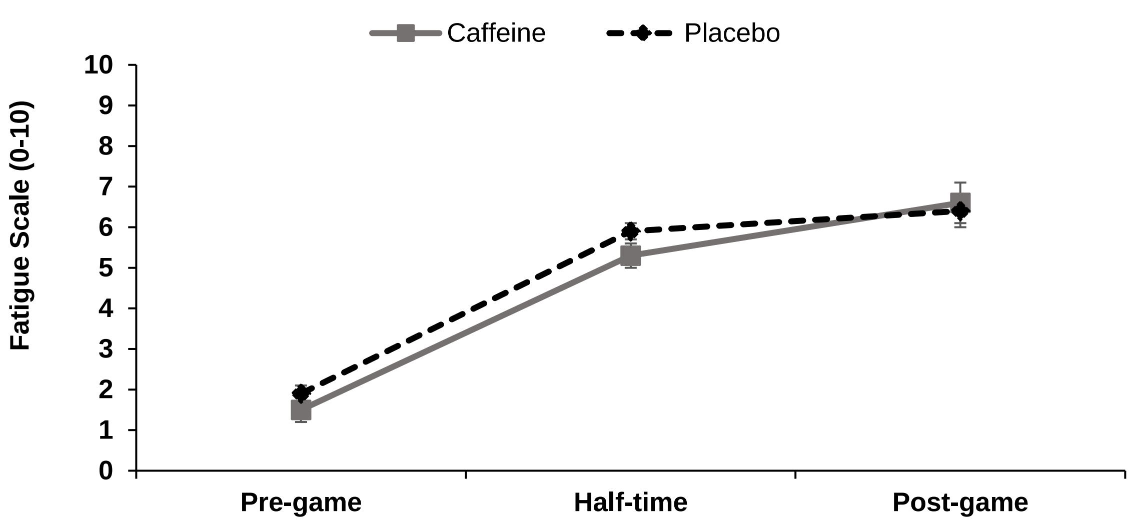
	Caffeine Condition Mean ± SD	Placebo Condition Mean ± SD
Energy (kcal)	565 ± 249	598 ± 254
Carbohydrate (g)	58 ± 54	66 ± 52
Protein (g)	31 ± 12	30 ± 9
Fat (g)	24 ± 12	25 ± 11

Fatigue and Rate of Perceived Exertion

With sphericity assumed, a 2-way ANOVA on the Fatigue Scale showed no significant condition main effect ($p=0.343$) and no condition-by-time interaction ($p=0.225$). There was a significant effect of fatigue over time ($p<0.001$). Pairwise time comparisons on the Fatigue Scale indicated statistically significant increases from pre-game to half-time ($p<0.001$) and from pre-game to post-game ($p<0.001$). There was no significant difference from half-time to post-game ($p=0.115$). Figure 1 displays the significant changes on fatigue over time.

A 2-way ANOVA showed no statistical significance for RPE between conditions ($p=0.861$), over time ($p=0.168$), or by condition-by-time ($p=0.168$). For the caffeine condition, the average RPE rating was 13.4 ± 1.5 at half-time and 14.7 ± 2.6 at post-game. For the placebo condition, the average RPE rating was 13.7 ± 1.5 at half-time and 14.2 ± 1.9 at post-game.

Figure 1. Change in Fatigue Scale over time. Values are mean±SE.

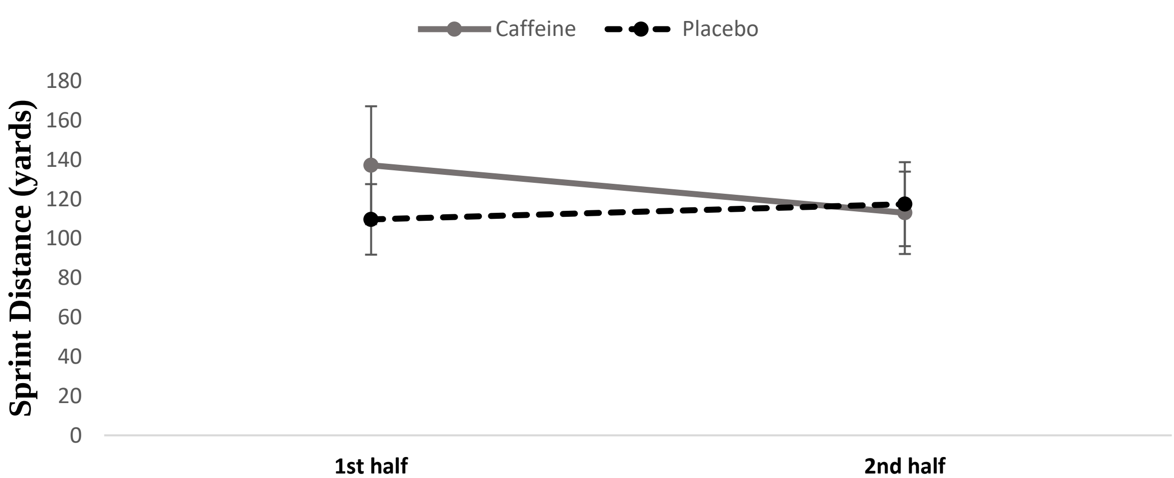


Global Positioning System Data

The PLAYERTEK device did not capture one participant's data for one of the games, so that participant was not included in the analysis of the GPS data. For the caffeine condition, the average total distance covered was 2910 ± 856 yards in the first half and 2747 ± 625 yards in the second half. For the placebo condition, the average total distance covered was 2955 ± 876 yards in the first half and 2689 ± 1044 yards in the second half. With sphericity assumed, the two-way ANOVA showed no significant condition effect (p=0.975), time effect (p=0.217), or condition-by-time interaction (p=0.712).

For the caffeine condition, the average sprint distance was 137 ± 90 yards in the first half and 113 ± 63 yards in the second half. For the placebo condition, the average sprint distance was 110 ± 54 yards in the first half and 117 ± 64 yards in the second half. Figure 2 displays that there was a statistically significant condition-by-time interaction (p=0.027) for sprint distance. There were no significant condition (p=0.609) or time (p=0.452) effects for sprint distance.

Figure 2. Change in Sprint Distance over time. Values are mean±SE.



For the caffeine condition, the average number of power plays was 13.6 ± 6.9 in the first half and 14.0 ± 4.7 in the second half. For the placebo condition, the average number of power plays was 12.0 ± 4.2 in the first half and 11.2 ± 4.0 in the second half. There were no significant main effects for number of power plays between conditions (p=0.108) or over time (p=0.879) and no condition-by-time interaction (p=0.523).

For the caffeine condition, the average Z3+ distance covered was 1129 ± 385 yards in the first half and 1070 ± 229 yards in the second half. For placebo, the average Z3+ distance covered was 1136 ± 368 yards in the first half and 983 ± 381 yards in the second half. There were no significant main effects for Z3+ distance between conditions (p=0.591) or over time (p=0.168) and no condition-by-time interaction (p=0.407).

Table 2 displays the descriptive statistics for the GPS data with playing time (in minutes) accounted for. Only 8 participants data were used due to one player not having activity charts produced and saved by the PLAYERTEK software. There were no significant condition (p=0.420), time (p=0.920), or condition-by-time (p=0.408) effects for total distance per minute played. There were no significant condition (p=0.747), time (p=0.588), or condition-by-time (p=0.315) effects for sprint distance per minute played. For power plays per minute, there were no significant condition (p=0.219), time (0.563), or condition-by-time (0.570) effects. For Z3+ distance per minute, there were no significant condition (p=0.877), time (p=0.766), or condition-by-time (p=0.151) effects.

Table 2. Descriptive Statistics for GPS Data Accounting for Playing Time

	1st Half Caffeine Mean ± SD	2nd Half Caffeine Mean ± SD	1st Half Placebo Mean ± SD	2nd Half Placebo Mean ± SD
Total Distance (yards/min)	133 ± 28	137 ± 10	144 ± 16	138 ± 20
Sprint Distance (yards/min)	7 ± 5	7 ± 4	6 ± 3	7 ± 4
Power Play (PP/min)	0.71 ± 0.38	0.77 ± 0.24	0.64 ± 0.25	0.66 ± 0.21
Zone 3+ (yards/min)	56 ± 17	58 ± 11	60 ± 15	55 ± 10

Caffeine Side Effects

The side effects measured presented a non-normal distribution with a predominant right skew. Table 3 displays the median (25^{th} – 75^{th} percentile) for each side effect measured pre-game and post-game for each condition. The change scores, post-game minus pre-game, for the caffeine and placebo conditions were calculated for each side effect. There was no statistical significance between the conditions change scores for anxiety ($p=0.721$), GI disturbances ($p=0.678$), shakiness ($p=0.678$), nausea ($p=0.916$), headache ($p=0.263$), and quickened heart rate ($p=0.767$).

Table 3. Descriptive Statistics of Side Effects

	Pre-Caffeine	Post-Caffeine	Pre-Placebo	Post-Placebo
Anxiety	3 (0-8)	2 (0-13)	5 (1-15)	12 (2-18)
GI disturbances	3 (0-9)	4 (0-15)	5 (1-10)	2 (0-11)
Shakiness	2 (0-5)	9 (1-27)	2 (1-11)	6 (0-27)
Nausea	2 (0-3)	3 (0-7)	2 (0-3)	2 (0-6)
Headache	3 (0-16)	2 (0-6)	2 (1-4)	2 (0-10)
Quickened heart rate	3 (0-12)	25 (3-41)	2 (0-12)	13 (1-47)

Data shown as median (25^{th}-75^{th} percentile)

CHAPTER V

DISCUSSION

The purpose of this study was to measure the effects of acute caffeine ingestion on athletic performance during competition for division 1 female collegiate field hockey players. The use of ergogenic aids, including caffeine, has become popular for athletes wanting to enhance performance during competitions. The creation and wide-spread use of GPS technology has allowed for in-depth tracking of athletes on-field performance metrics (Gabbett, 2010). This study analyzes on-field performance for division 1 female collegiate field hockey players in response to caffeine through GPS technology, fatigue and RPE scales, and response to side effects There were three primary hypotheses associated with this study. First, in comparison to the control trial, caffeine ingestion will lead to an increase in total distance covered. Second, in comparison to the control trial, caffeine ingestion will lead to an increase in sprint distance, power plays, and Z3+ distance. Third, in comparison to the control trial, caffeine ingestion will lead to equivalent levels of RPE and ROF despite the greater workloads achieved. The following discussion addresses each of these hypotheses based on the findings of the study.

GPS Analysis

There has been a widespread increase in the use of GPS technology for tracking athletes' performance within athletic programs (Aughey, 2011; Choice, 2021; Gabbett, 2010). By tracking different metrics like total distance, sprint distance, and power plays, the athlete's total workload can be quantified by strength and conditioning professionals (Choice, 2021). Most of the research on GPS technology has consisted of male athlete populations across various sports, with little focus on female athletes and the sport of field hockey. One study looked at changes in sprint distance during field hockey games after caffeine ingestion, but for male field hockey players only (Del Coso et al., 2016). Comparison between that study and the present one should be done cautiously due to potential differences between male and female field hockey players. The greater strength that males possess in comparison to females allows them to make more powerful passes that can go more than half the length of the field. These powerful passes cause greater running distance for male field hockey players (Lidor & Ziv, 2015). The constant sequence of passes can make the game back and forth over a long distance. Female players have a relatively lower capability to make these extremely long passes, which makes their running back and forth over a lesser distance as they build up their player with smaller passing sequences.

A different study used GPS monitoring to assess on-field performance after caffeine ingestion in female soccer players (Lara et al., 2014). Similar to our study, they used a dosage of 3 mg of caffeine per kg of body weight and analyzed total distance and sprint distance in games between caffeine and placebo trials. They found a significant increase in total distance and sprint distance for the caffeine condition compared to the placebo (Lara et al., 2014). Our study did not find any significant differences between conditions for total distance (p=0.975), but did find significant condition-by-time effect (p=0.027) for sprint distance. Since the Lara et al. (2014) study looked at female soccer players, the discrepancy in the findings could be due to the different nature of the two sports. For example, players in that study participated in simulated matches that lasted 80 minutes (two 40-minutes halves), which equated to more distance covered (7250-7750 yards) than in the present study (5,640-5,660 yards). Additionally, Lara et al. (2014) had 18 participants while this present study only had 9 for the GPS analysis. To the authors knowledge, there are no other studies examining field hockey performance using GPS technology to compare our study with.

The analysis of the GPS data displayed no significant differences in total distance, power plays, or Z3+ distance between conditions, over time, and by condition-by-time. The only significant finding from the GPS data was a condition-by-time effect ($p=0.027$) for sprint distance. Additionally, our study accounted for playing time in each match by dividing each GPS variable by minutes played in each half of the scrimmage. With playing time accounted for, there were no significant differences across all the GPS variables. This adds to the argument that the significant finding for sprint distance without playing time accounted for might have been by chance. These results reject the first two hypotheses and support a lack of an effect of caffeine on on-field performance in field hockey.

RPE and Fatigue Analysis

Caffeine works as an ergogenic aid by its ability to mask fatigue and decrease RPE (Keisler & Armsey, 2006). With the perception of a lower work rate, some studies have found athletes to work at greater intensities for longer durations after consuming caffeine (Doherty & Smith, 2005; Glaister & Gissane, 2018; Keisler & Armsey, 2006; Pesta et al., 2013). There were no significant condition, time, and condition-by-time effects for RPE. There were no significant condition and condition-by-time effects for fatigue. Although equivalent levels of fatigue and RPE were found between conditions, these results reject the third hypothesis because there were not greater workloads achieved between the conditions.

Our study found a significant difference on fatigue over time ($p<.001$) with significant increases from pre-game to half-time and from pre-game to post-game. This is an expected finding as athletes will become more fatigued from the start to the end of a game. There was no difference between the fatigue level from half-time to post-game, so the major change in feelings of fatigue occurred during the first half of the game.

Side Effects

Caffeine comes with the risk of developing side effects that could last over 24 hours (de Souza et al., 2022; Pesta et al., 2013; Silver, 2001). The development of these side effects, if strong, could hinder performance. The dosage of 3 mg per kg of body weight has been designated as optimal for eliciting ergogenic effects while limiting side effects (de Souza et al., 2022). Our study found no statistical significance between conditions for anxiety, GI disturbances, shakiness, nausea, headache, and quickened heart rate. Athletes consume caffeine to enhance performance while minimizing the occurrence of ergolytic side effects, so this is an important finding for athletes. These results suggest that the moderate dosage of caffeine should not negatively impact an athlete's performance with the development of side effects.

Limitations and Logistical Issues

Multiple limitations arose throughout this study. The sample size of the study was limited to the number of players on the field hockey willing and able to participate, which results in ten players. This number fell to 9 players due to a malfunction in the GPS technology for one of the scrimmages for one participant. This number fell further to 8 players when accounting for playing time in the GPS analysis due to a lack of activity charts developed by the PLAYERTEK software for one participant. A larger sample could have potentially changed the significance of the data. Calculated from the average body weight of the subjects, the average dose of caffeine administered in the study was 198.6 ± 23.7 mg of caffeine. This value is very similar to the average estimated intake for the participants of 199 ± 96 mg/day. With the dosage being very similar to the average daily consumption, the given dosage of caffeine might not have been strong enough to elicit performance effects for habitual caffeine consumers.

Multiple logistical issues came up throughout the study including time of day variations for the games, technology failures, and game format. One scrimmage was two hours later than the other scrimmage. This difference in time of day could have affected the energy level, alertness, hunger, and other factors that would influence an athlete's performance, though it seems unlikely that a 2-hour difference would lead to large changes in these factors. Additionally, although formatted the same in terms of game length (60 minutes), one scrimmage had the players competing against different teams in the first and second half. The different skill levels of the teams compared to the participants could have altered the intensity levels of the two halves of the game.

Conclusion

The main purpose of this study was to determine if a moderate acute dose of caffeine would elicit on-field performance benefits to division 1 female collegiate field hockey players. Overall, the results of this study do not support caffeine as an ergogenic aid—at least at the dosage given among habitual users—for female field hockey players looking to improve on-field performance. This study was the first study to examine the effects of caffeine consumption on the female field hockey player population using modern-day GPS technology. Future research examining the same population with similar methodology should use a larger sample to examine any potential benefits.

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APPENDIX A

BACKGROUND QUESTIONNAIRE

BACKGROUND QUESTIONNAIRE

ID: ________________

Age: _______

Current Caffeine Intake:

- How many days per week do you consume at least one of these items? _______________
  - Coffee (hot/iced), tea, soda, energy drinks, hot chocolate, chocolate milk

Current Field Hockey Status:

- How many days per week do you play field hockey? _______________
- Do you have any current injuries preventing you from competing during a full-length competition? Yes No
- Are you a field player or a goalkeeper? Yes No

Food Allergies and Intolerances:

- Do you have an allergy or aversion to gelatin? Yes No
- Do you have an allergy or aversion to rice or rice flour? Yes No
- Do you have any food allergies? If yes, please list below.
  - ____

APPENDIX B

RECRUITMENT FLYER

Participate in a Research Study on Caffeine and Field Hockey Performance

The study will involve:

- Taking caffeine and placebo capsules before two scrimmages
- Filling out questionnaires and reporting levels of exertion and fatigue during the scrimmages

To be eligible:

- Be aged 18+ years
- Currently playing for the ODU field hockey team
- No injury precluding participation in field hockey
- Field players only, no goalkeepers
- Habitual caffeine drinker
- No allergies or aversions to gelatin or rice flour

Contact persons: Ian Winter (iwint001@odu.edu) or Dr. Patrick Wilson (pbwilson@odu.edu)

APPENDIX C

INFORMED CONSENT DOCUMENT

INFORMED CONSENT DOCUMENT
OLD DOMINION UNIVERSITY

PROJECT TITLE: Effect of Acute Caffeine Ingestion on On-Field Performance in Division 1 Female Field Hockey Players

INTRODUCTION

The purposes of this form are to give you information that may affect your decision whether to say YES or NO to participation in this research, and to record the consent of those who say YES. This form describes what would be asked of you if you participate, as well as the procedures, risks, and benefits involved with participating.

RESEARCHERS

Patrick Wilson, PhD, RD, Responsible Project Investigator, Associate Professor in the Department of Human Movement Sciences, which is a part of the Darden College of Education and Professional Studies at Old Dominion University.

Nicole Fredricks, master's student in the Exercise Science program at Old Dominion University, under the supervision of Dr. Patrick Wilson.

Ian Winter, PhD student in the Applied Kinesiology program at Old Dominion University.

DESCRIPTION OF RESEARCH STUDY

You have been asked to participate in a study examining how acute caffeine ingestion affects the on-field performance of Division I collegiate female field hockey players. The study will compare the effects of consuming caffeine and no caffeine before field hockey scrimmages. To do so, participants are assigned to consume caffeine an hour before one of their off-season scrimmages and a placebo one hour before another one of their scrimmages. Below is a description of the study procedures.

You will attend a baseline visit, either at the Human Performance Laboratory or in a room at the L. R. Hill Sports Complex, in which you will review the consent form with an investigator. If you decide to participate, you will complete a questionnaire that asks about demographics, field hockey participation, current injuries, and food allegories/intolerances. Next, you will complete a questionnaire on your intake of caffeine from foods and beverages. Finally, your weight will be taken with a digital scale; this information will be used to calculate the dose of caffeine you will be given later on.

On the day of the first scrimmage, you will complete a standard warm-up and scrimmage, which are part of regular team training. This means that they are not technically a part of study participation, but they are still described here for context. The warmup will consist of 25 minutes of dynamic body movements and field hockey skills. The scrimmage will consist of four, 15-minute quarters with a 2-minute break between the first and second and third and fourth quarters and a 10-minute halftime.

If you participate in the experiment, you will be randomly assigned to consume a caffeine capsule or a placebo capsule before the first off-season scrimmage. Specifically, you will ingest the capsule 1 hour prior to the scrimmage for maximal effect. The capsule will either contain caffeine, 3 mg per kg of body mass (about the amount in 2 cups of coffee), or rice flour, an inert substance. You will be asked to refrain from any source of caffeine within 12 hours of data collection. In addition, you will be asked to fill out a food log for the morning prior to the first scrimmage. You will be given a 16-ounce water bottle to consume on the morning of the scrimmage to establish a minimum level of hydration. You will be asked to arrive to the facility one and a half hours prior to the scrimmage and will be given about 250 mL of water along with the capsule one hour prior to competition.

Data to be collected before, during and after the scrimmage will include the following:

- Performance metrics using a global positioning system (GPS) tracker that's worn in a sports bra
  - Total distance, total sprint distance, energy expenditure, top speed, number of sprints, distance per minute, power score, and work ratio
- Ratings of perceived exertion on a 6-20 scale
- Ratings of fatigue on a 0-10 scale
- Caffeine side effects questionnaire in the form of a Visual Analog Scale
- A guess as to whether you think you received caffeine or a placebo

After the first scrimmage, the same exact procedures will be implemented at another one of your regularly scheduled scrimmages roughly 1-2 weeks later. The only difference is that if you received the caffeine capsule before the first scrimmage, you would then receive the placebo capsule (and vice versa) before the second scrimmage. You will be asked to replicate your food intake from the morning of the first scrimmage.

If you say YES, then your participation will require about a 90-minute time commitment above and beyond what you would normally do at your soccer practices. Upwards of 16 subjects will be participating in the study.

EXCLUSIONARY CRITERIA

The following are required to be eligible for participation:

- Current ODU field hockey player
- 18+ years of age
- Habitual caffeine consumer, defined as consuming sources like coffee, tea, energy drinks, etc. at least 4 days per week

In addition, if any of the following apply you may not be allowed to participate:

- An injury precluding participation in an entire field hockey match
- Goalkeepers
- An allergy or aversion to gelatin and rice flour

RISKS AND BENEFITS

You will be asked to consume a moderate dose of caffeine prior to one of the two scrimmages. There is a chance that you will experience temporary symptoms from consuming caffeine (restlessness, anxiety, upset stomach, sleep disturbances, etc.). The dose used in this study is typically well tolerated by most people and usually isn't associated with severe side effects. Regardless, an athletic trainer will be on site in case you experience a serious event.

In addition, there is a small risk that your data may be seen by individuals other than the investigators. To protect against this risk, the investigators are collecting minimal sensitive information and will replace your name on files and forms with alphanumeric ID codes.

And, as with any research, there is some possibility that you may be subject to risks that have not yet been identified.

BENEFITS: There are no direct benefits of participating in this study. The results of this study have the potential to expand society's knowledge related to the ergogenic effect of caffeine on performance during an elite female field hockey match.

COSTS AND PAYMENTS

The researchers want your decision about participating to be absolutely voluntary. You will receive no payment for your time or to help defray incidental expenses associated with participation (e.g., parking, travel).

NEW INFORMATION

If the researchers find new information during this study that would reasonably change your decision about participating, then they will give it to you.

CONFIDENTIALITY

Precautions will be taken to ensure your data remain confidential. Once the data are collected, your name or other identifying information will be removed and replaced with an alphanumeric ID code. All data will be stored according to this alphanumeric ID code in locked cabinets and/or on password-protected computers and secure network servers. A master list linking your name and alphanumeric ID code will be stored in a locked cabinet and/or on a secure computer network. Your name and ID code will only be referenced together in this master list. This list will be destroyed once the data analysis is complete. The results of this study may be used in reports, presentations, and publications; but the researcher will not identify you. De-identified raw data files may be deposited in online repositories or shared with other researchers for purposes of scientific transparency, but no identifiable information will be shared. Of course, your records may be subpoenaed by court order or inspected by government bodies with oversight authority.

WITHDRAWAL PRIVILEGE

It is OK for you to say NO. Even if you say YES now, you are free to say NO later, and walk away or withdraw from the study at any time. Your decision will not affect your relationship with Old Dominion University, or otherwise cause a loss of benefits to which you might otherwise be entitled. The researchers reserve the right to withdraw your participation in this study, at any time, if they observe potential problems with your continued participation.

COMPENSATION FOR ILLNESS AND INJURY

If you say YES, then your consent in this document does not waive any of your legal rights. However, in the event of an injury arising from this study, neither Old Dominion University nor the researchers are able to give you any money, insurance coverage, free medical care, or any other compensation for such injury. In the event that you suffer injury as a result of participation, you may contact Patrick Wilson, PhD, at 757-683-4783 at Old Dominion University, Dr. Tancy Vandecar-Burdin, the current IRB chair at 757-683-3802 at Old Dominion University, or the Old Dominion University Office of Research at 757-683-3460 who will be glad to review the matter with you.

VOLUNTARY CONSENT

By signing this form, you are saying several things. You are saying that you have read this form or have had it read to you, that you are satisfied that you understand this form, the research study, and its risks and benefits. The researchers should have answered any questions you may have had about the research. If you have any questions later on, then the researchers should be able to answer them:

Patrick Wilson, PhD, RD
Associate Professor
Human Movement Sciences
Old Dominion University
Phone: 757-683-4783
Email: pbwilson@odu.edu

Nicole Fredricks
Graduate Student
Human Movement Sciences
Old Dominion University
Phone: 610-213-2596
Email: nfred001@odu.edu

If at any time you feel pressured to participate, or if you have any questions about your rights or this form, then you should call Dr. Tancy Vandecar-Burdin, the current IRB chair, at 757-683-3802, or the Old Dominion University Office of Research, at 757-683-3460.

And importantly, by signing below, you are telling the researcher YES, that you agree to participate in this study. The researcher should give you a copy of this form for your records.

Subject's Printed Name & Signature	**Date**

INVESTIGATOR'S STATEMENT

I certify that I have explained to this subject the nature and purpose of this research, including benefits, risks, costs, and any experimental procedures. I have described the rights and protections afforded to human subjects and have done nothing to pressure, coerce, or falsely entice this subject into participating. I am aware of my obligations under state and federal laws and promise compliance. I have answered the subject's questions and have encouraged him/her to ask additional questions at any time during the course of this study. I have witnessed the above signature(s) on this consent form.

Investigator's Printed Name & Signature	**Date**

APPENDIX D

CAFFEINE CONSUMPTION QUESTIONNAIRE – REVISED

Caffeine Consumption Questionnaire-R

Please answer the following questions as accurately as you can. **Indicate how many servings per week you normally consume of each item. Use the pictures to help guide your responses.**

Do you drink coffee at least once a week?

- Yes
- No

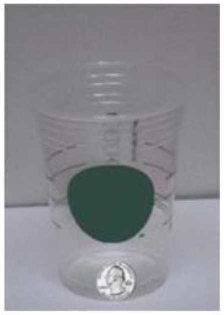
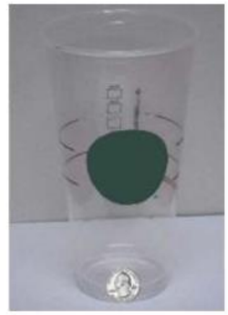
Please indicate how many servings of coffee you consume, on average, each week.

			
8 oz. coffee (short)	12 oz. coffee (tall)	16 oz. coffee (grande)	20 oz. coffee (venti)

Please indicate how many servings of **decaffeinated** coffee you consume, on average, each week.

			
8 oz. decaffeinated coffee (short)	12 oz. decaffeinated coffee (tall)	16 oz. decaffeinated coffee (grande)	20 oz. decaffeinated coffee (venti)

Please indicate how many servings of **iced** coffee you consume, on average, each week.

			
12 oz. iced coffee (tall)	16 oz. iced coffee (grande)	24 oz. iced coffee (venti)	31 oz. iced coffee (trenta)

Soda

Do you drink soda at least once a week?

- Yes
- No

Please indicate how many servings of **soda** and **diet soda** you consume, on average, each week. Some sodas do not contain caffeine. Examples include: Sprite, 7-Up, Orange soda, and Root Beer.

			
12 oz. soda	16.9 oz. soda	20 oz. soda	32 oz. soda

Energy Drinks

Do you drink energy drinks at least once a week?

- ○ Yes
- ○ No

Please indicate how many servings of energy drinks you consume, on average, each week.

			
2 oz. Energy Shot	8.4 oz. energy drink	12 oz. energy drink	16 oz. energy drink

Teas

Do you drink tea at least once a week?

- ○ Yes
- ○ No

Please indicate how many servings of tea you consume, on average, each week.

			
8 oz. tea	12 oz. tea (tall)	16 oz. tea (grande)	24 oz. tea (venti)

Chocolate Beverages

Do you drink chocolate beverages at least once a week?

- Yes
- No

Please indicate how many servings of hot chocolate you consume, on average, each week.

8 oz. hot chocolate (short)

12 oz. hot chocolate (tall)

16 oz. hot chocolate (grande)

20 oz. hot chocolate (venti)

Please indicate how many servings of chocolate milk you consume, on average, each week.

8 oz. chocolate milk (short)

12 oz. chocolate milk (tall)

16 oz. chocolate milk (grande)

20 oz. chocolate milk (venti)

Food

Do you consume any food that contains caffeine (food including chocolate or coffee are prime examples)?

○ Yes

○ No

Please indicate how many chocolate bars (**purely chocolate**) you consume, on average, each <u>week</u>.

	 Chocolate Bars (1.55 oz.)	 Mini Chocolate Bars
	[ ]	[ ]

Please indicate how many candy bars (snickers, twix, butterfinger, etc.) you consume, on average, each <u>week</u>.

	 Candy Bars (full size)	 Mini Candy Bar
	[ ]	[ ]

Food containing **<u>chocolate</u>** (4 oz. servings)

	Please indicate how many servings of the following foodstuffs (4 oz.) you consume, on average, each <u>week</u>. servings
Yogurt	[ ]
Ice cream	[ ]
Baked goods	[ ]

Food containing coffee (4 oz. servings)

	Please indicate how many servings of the following foodstuffs (4 oz.) you consume, on average, each week. servings
Yogurt	
Ice cream	
Candy	
Baked goods	

Mint or Gum containing caffeine (Jolt gum, Alert Energy gum, Foosh mints, Hero mints, etc.)

	Please indicate how many pieces of the following foodstuffs you consume, on average, each week. pieces
Mint	
Gum	

Drugs

Do you consume any of the following over-the-counter caffeinated drugs?

	Please enter how many days each week you consume the drug(s), the serving size of each dose, and the number of times you consume the drug(s) each day.		
	days	serving size	amount
Vivarian			
NoDoz			
Excedrin			
Vanquish			
Anacin			
Dristan			
Xendrine			
Trimspa			
Other			

APPENDIX E

FOOD LOG INSTRUCTIONS

Food Record

Instructions:

- Complete the record up until the scrimmage takes place. If you wait until after the scrimmage, your records are more likely to be inaccurate.

- Please try to replicate your food intake for the second scrimmage with your intake from the first scrimmage.

- Write down ***everything*** you eat and drink, no matter how big or small. Try to be as ***descriptive*** as you can by including brand names of foods and by using the wording that is on the packaging of the food.

- Try to accurately record the amount of food you are eating. If you are portioning food yourself, use measuring cups to help accurately identify how much you are eating.
  - Meat, poultry, fish, and cheese are best described by ounces (3 ounces is = to about a deck of cards)
  - Beverages can best be listed in fluid ounces
  - Vegetables, cut fruit and grains like rice, pasta, cereal, and oatmeal can be described in cups (1 cup is = to about the size of a fist)

- Make sure to also record:
  - Plain water
  - All condiments (1 Tbsp. butter, 2 tsp. ketchup, 2 Tbsp. salad dressing, etc.)
  - Dietary supplements that contain energy
  - The time of day you eat

ID:______________________________ Date:____________________

Food Record:
Morning of Scrimmage One

Example

Time	Food or Beverage	Amount
7:30 am	Whole wheat bread (Sara Lee)	2 slices (90 calories/slice)
	Peanut butter (Jiff)	2 Tbsp.
	Milk, skim	12 ounces
	Banana, large	1
10:15 am	Nature Valley granola bar	1 (100 calories per package)
	Powerade	16 oz (70 calories)

Food Record:
Morning of Scrimmage Two

Time	Food or Beverage	Amount

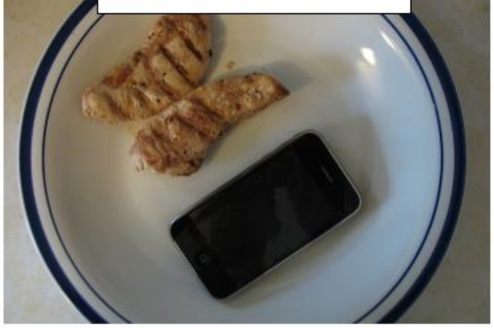
1/2 cup rice, pasta, oatmeal, etc.

1 cup rice, pasta, oatmeal, etc.

1 cup vegetables

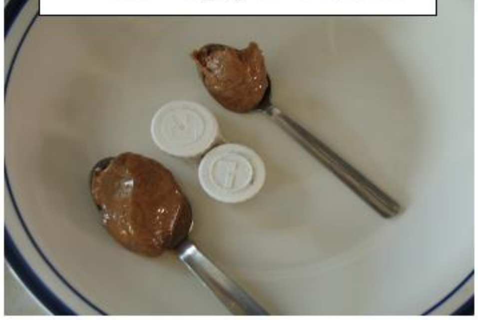
1/4 cup nuts

4 oz chicken



-1.5 cup spaghetti with red sauce
-2 oz parmesan cheese
-2 cups romaine lettuce
-2 Tbsp. balsamic dressing
-large banana
-10 oz skim milk

1 T. & 1 tsp. peanut butter



APPENDIX F

CAFFEINE SIDE EFFECT VISUAL ANALOG SCALE

ID: ________________ Date / Time: ___________ / __________

<u>Circle one</u>

Pre-scrimmage Post-scrimmage

Place a mark on each line to rate how you are currently feeling from no feeling of the characteristic to extreme feelings of the specific characteristic.

No anxiety — Extreme anxiety

No gastrointestinal disturbances — Extreme gastrointestinal disturbances

No shakiness — Extreme shakiness

No nausea — Extreme nausea

No headache — Extreme headache

No quickened heart rate — Extreme quickened heart rate

VITA

NICOLE FREDRICKS

4700 POWHATAN AVENUE NORFOLK, VA 23508

Education

EXPECTED IN DECEMBER 2026
Doctor of Physical Therapy
University of Delaware, Newark, DE
EXPECTED IN DECEMBER 2023
Master of Science: Exercise Science
Old Dominion University, Norfolk, VA

- GPA: 4.0
- Division I Student Athlete, Field Hockey

MAY 2022
Bachelor of Science: Exercise Science, Minor in Psychology
Old Dominion University, Norfolk, VA

- GPA: 4.0, Perry Honors College Graduate
- Division I Student Athlete, Field Hockey
- Dean's List honoree each semester; 3x NFHCA D1 Scholar of Distinction

Work History

FEBRUARY 2022-DECEMBER 2022
Physical Therapy Technician | Best Life Physical Therapy and Sports Medicine | Virginia Beach, VA

- Assist physical therapists in administering exercises and warming-up patients, scheduling appointments, and cleaning the practice.

FALL 2021-CURRENT
Field Hockey Coach | Vault Athletics and Fitness | Virginia Beach, VA

- Coach and mentor elementary to high school age girls in team, small group, and private lessons to enhance their field hockey skills.

APRIL 2020-JUNE 2021
Delivery Service | Instacart & Door Dash Employee | Philadelphia Region, PA

- Shopped and delivered groceries for people unable to get to grocery stores during the COVID-19 pandemic.

Involvement

Student Athlete Advisory Committee (SAAC) | Fall 2019-December 2022

- Advocate for student-athletes needs at the university, conference, and national level. Currently, work with the community outreach committee.

Time Management Plan Representative | Winter 2022-Present

- Communicate with the athletic compliance office and approve athletic schedules in accordance with NCAA guidelines.

Morgan's Message Member | Winter 2022-Present

- Member of the club looking to increase awareness and support for student-athletes mental health and well-being.

Team Captain | January 2022-Present

- Utilize my work-ethic and communication skills to lead my collegiate team.

Volunteer Work

Mercy Chef's Meals | Fall 2020-Present | Norfolk, VA
Big Blue Kids Club | Fall 2020-Present | Norfolk, VA
Workplace Health Screening | February 15, 2022 | Virginia Beach, VA