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The Effects Of Caffeine On Early Second Half Sprint Performance In NCAA DIII Women's Soccer Players

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Abstract

Objective

The purpose of this study was to examine the effects of caffeine on early second half sprint performance in 21 NCAA DIII women's soccer players. The caffeine dosage attempted to approximate a liquid dosage many student athletes typically consume.

Design

In a randomized double blind repeated measures design, subjects began the protocol after ingestion of caplets containing 3 $mg \cdot kg^{-1}$ of caffeine (CAF) and after ingestion of placebo (PLA) caplets. Pre-game, warm-up, and first half conditions were designed to maximize external validity.

Methods

An adapted version of the Loughborough Intermittent Shuttle Test was applied to replicate first half activity. Sprint performance was measured with the Running Based Anaerobic Sprint Test. Mean power, maximum power, and minimum power, were assessed under each condition. Repeated measures MANOVA was used to determine if there were significant mean vector differences between the trials.

Results

Although mean, maximum, and minimum power in the CAF trial increased 3.2%, 3.4%, and 4% respectively, MANOVA results showed

no statistically significant differences in the mean vector for power variables (Λ = .752, $p > .05$).

Conclusions

The lack of statistical significance in this study is likely attributed to the relationship between a small, although contextually plausible, relative caffeine dosage and an extended exercise time. The results also suggest caffeine ingestion of 3 $mg \cdot kg^{-1}$ should not be considered capable of improving sprint performance at the start of the second half.

Keywords: Ergogenic, Loughborough, methylxanthine, power, running based anaerobic sprint test (RAST)

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INTRODUCTION

Soccer requires both continuous endurance exercise and repetitive sprinting[7, 21]. Regulation time is made up of two 45 min halves with approximately 15 min between periods. If overtime is included in a particular match, the total time would extend to 110 min[23]. Total sprint repetitions and distance covered while sprinting can help distinguish elite from moderate soccer players. Players that have the ability to sprint more often and for longer distances during a match are typically capable of playing at higher levels[26, 24]. Lastly, elite players exhibit increased sprint performance in both the first and second halves of a match as compared to players of lesser ability[21].

Caffeine is considered the most widely used ergogenic and psychoactive substance on earth. Habitual consumers include an estimated 80% of the world's population[18]. Since 1907 when Rivers & Webber[27] reported that caffeine increased total work during exercise, many other researchers have published data describing caffeine's ergogenic properties. The majority of that research has been dedicated to endurance exercise[18, 29]. Research focusing specifically on high intensity repetitive work has provided little consensus[15, 18, 34]. A smaller body of research

has focused upon how caffeine affects repetitive sprint performance within the context of a continuous sport[29].

Concerns regarding the safety of caffeine use independent of other ergogenic aids have decreased in recent years. The World Anti-Doping Agency removed caffeine from its list of banned substances in 2004. It was removed for several reasons including caffeine's prevalence within many commonly consumed foods, lack of evidence for it being a dangerous molecule, and considerable variability in clearance rates and dosing effects between individuals[35]. The National Collegiate Athletic Association (NCAA) still has a ban in place for caffeine levels $\geq$ 15 $\mu g \cdot l^{-1}$ in urine[22]. Although caffeine is still regulated by the NCAA the threshold is outside of the range of realistic consumption patterns of most student athletes. According to Spriet & Graham[30], a 70kg individual must consume at least 5-6 cups of coffee within an hour of an exercise bout lasting 1-1.5 hrs in order for post exercise caffeine levels to approach even 12 $\mu g \cdot l^{-1}$ in the urine. Partially because only extreme caffeine ingestion is capable of increasing concentrations to dangerous levels, the substance remains a widely popular ergogenic aid that is often used by athletes at many levels[5, 30].

The purpose of this study was to assess mean power, maximum power, and minimum power in sprint performance with and without caffeine ingestion in female NCAA DIII soccer players after

exercise that was designed to replicate the physiological demands of the first half of a soccer match. Because of the substantial amount of evidence indicating caffeine extends time to exhaustion in endurance activities and the growing amount of data indicating sprint performance within continuous exercise also improves, it was hypothesized that mean, maximum, and minimum power in the caffeinated trial would be greater when compared to the non-caffeinated trial.

METHODS

Three field tests were utilized in this study. First, as described by the Loughborough Intermittent Shuttle Test (LIST) protocol, $\dot{V}O_{2peak}$ was estimated using the 20 m progressive shuttle run test[24, 25]. Because the subjects' collegiate soccer program completes a similar shuttle run test at least one time per year, each subject was familiar with the progressive shuttle run test.

Second, as a means of replicating the physiological demands placed upon an athlete in a soccer match, an adapted version of the LIST was used[24]. The LIST protocol has been implemented previously in studies using soccer players as subjects[8, 10, 20, 24]. To replicate an entire game of soccer, the LIST protocol contains six 15 min periods of timed fixed distance shuttle running. Each period is separated by 3 min of rest. The following pattern was used throughout each 15 min period: 3 x 20 m walk, 1 x 20 m maximal sprint, 4 s active recovery, 3 x 20 m

sprinting at 55% $\dot{V}O_{2peak}$, and 3 x 20 m sprinting at 95% $\dot{V}O_{2peak}$[24]. Because the study was designed to measure early second half sprint performance, only half (3 periods of 15 min) of the LIST protocol was implemented.

Third, the Running based Anaerobic Sprint Test (RAST) was used to assess sprint power. Developed in the United Kingdom at Wolverhampton University, RAST data allows for the calculation of mean power, maximum power, and minimum power[6, 36]. The RAST protocol includes six 35 m sprints separated by 10 s of active recovery time between sprints. A time for each sprint was recorded for use in calculating sprint performance. Because the subjects' collegiate soccer program uses the RAST to assess sprint performance at least one time every year, all subjects were familiar with the RAST.

The subjects in the study were 21 female soccer players currently participating in the NCAA DIII. The mean subject age and weight were 19.6 yrs (SD = 1.24) and 62.8 kg (SD = 7.01) respectively. Mean $\dot{V}O_{2peak}$ was 46.04 $ml \cdot kg^{-1} \cdot min^{-1}$ (SD = 2.94). Subjects self-reported caffeine consumption patterns. Mean days per week consumption was 5 (SD = 1.6) while mean servings per day was 1.5 (SD = 0.82). Subject demographic and CAF dosage data are represented in Table 1. All subjects were cleared for competition by the institution's medical staff in accordance with the appropriate institutional guidelines. Participation in

the study was voluntary. Institutional Review Board, Athletic Department, and Women's Soccer Program approval for the administration of this study were obtained prior to the beginning of the study.

Table 1

Subject demographic data.

Source	Mean	SD
Age (yrs.)	19.6	1.24
Weight (kg)	62.8	7.01
$\dot{V}O_{2peak}$* (ml·kg^{-1}·min^{-1})	46.05	2.94
Dosage** (mg)	188.41	21.03

* Estimated from 20m progressive shuttle run test performance

** Represents a relative dosage of 3 mg·kg^{-1}

N = 21

Subjects reported to the Human Performance Laboratory three times. During the first meeting, subjects completed informed consent forms and anthropomorphic data was collected. Because the LIST protocol requires the use of the progressive shuttle run test developed by Ramsbottom et al.[23] to obtain estimated $\dot{V}O_{2peak}$, subjects also completed that protocol during the first

meeting. Lastly, during the first meeting researchers familiarized the subjects with the LIST testing procedures.

The two remaining meetings were separated by 48 hrs. To control for circadian and diurnal effects, individual subjects were tested at the same time of day for each trial. Upon arrival, subjects were asked to drink water and consume caffeinated (CAF) or placebo (PLA) caplets. A randomized double blind procedure was used for determining the order in which caplets were ingested. CAF caplets contained 3 mg of caffeine for every kilogram of subject body weight. PLA caplets contained white flour.

Upon arrival, subjects ingested the assigned caplets, and then rest for 20 min. That time period was designed to replicate the pre-game meeting that typically occurs in a locker room before a match. At the conclusion of 20 min of rest, the subjects were asked to perform a standardized 25 min warm-up. Following the warm up, subjects were asked to rest for 10 min. That 10 min rest was designed to replicate the period of time between warm-up and kick off. Subjects were asked to drink 250 ml of water during the rest. After the rest period, subjects completed three 15 min periods of the LIST protocol for a total of 45 min of intermittent sprinting.

Upon completion of the LIST protocol, subjects were asked to rest 15 min. They were also asked to drink 250 ml of water.

The 15 min rest was designed to replicate the half time period between the first and second halves of a match. When the half time period was over, subjects performed the RAST protocol. The only difference between the two trials was the composition of the caplets ingested prior to the start of the protocol. Both the LIST and RAST protocols were completed in the institution's Field House. RAST sprint times were recorded using the Probotics *Just Run* timing system. Upon completion of the RAST protocol, subjects completed a 10 min cool down exercise.

The subjects were asked to prepare similarly for each of the two trials. A dietary log was completed by each subject 48 hr prior to the first LIST testing procedure. Subjects were asked to duplicate dietary consumption during the time between the first and second LIST protocols[10]. Subjects were also asked to abstain from caffeine for 48 hr prior to each trial[5].

In a study designed to assess both the reliability and validity evidence of the RAST, Zagatto et al.[36] reported test-retest intra-class correlation coefficients for maximum power, mean power, and fatigue index: 0.92, 0.97, and 0.70 respectively. To assess validity evidence, Zagatto et al.[36] compared RAST data to Wingate Anaerobic Test data. RAST data significantly correlated with Wingate data for maximum power ($r = .46$), mean power ($r = .53$), and fatigue index ($r = .63$). The

researchers concluded the RAST is a reliable and valid means of assessing anaerobic power.

In a study designed to assess both the reliability and validity evidence of the LIST, Nicholas et al.[24] tested 7 trained soccer and rugby players on two occasions. Using the test re-test method to assess reliability. No significant differences were reported. Validity assessment included no significant differences when comparing LIST heart rate, blood lactate, and body mass change to data from players during and after a soccer match [24].

Repeated measures multiple analysis of variance (MANOVA) was used to analyze RAST data. Mean vector differences in power output data between CAF and PLA trials were assessed. Version 18 of SPSS was utilized for all statistical calculations.

RESULTS

The independent variables were CAF and PLA treatments. The dependent variables were mean power, maximum power, and minimum power. A repeated measures multiple analysis of variance (MANOVA) was used to analyze mean differences of the vector scores for power.

Table 2

Descriptive statistics for power variables (watts) over caffeine (CAF) and placebo (PLA) trials.

Source	Mean	SD
CAF Mean	269.43	31.63
PLA Mean	261.19	30.05
CAF Max	307.29	39.43
PLA Max	297.15	32.18
CAF Min	241.38	30.42
PLA Min	232.05	29.70

Descriptive statistics for power variables in CAF and PLA trials are displayed in Table 2. Mean power increased from 261.19 – 269.43 Watts from PLA to CAF trials, while maximum power increased from 297.15 – 307.29 Watts. Minimum power increased from 232.05 – 241.38 Watts. Although mean, maximum, and minimum power in the CAF trial increased 3.2%, 3.4%, and 4% respectively, repeated measures MANOVA results showed no statistically significant differences in the mean vector of power variables ($F = 1.4$, $df = 4$, $\Lambda = .752$, $p > .05$, $n^2 = .25$, ES = .57). Based on the medium effect size (ES = .57), a post hoc power analysis was conducted (power = .8, alpha = .05)[19].

DISCUSSION

The purpose of the study was to determine if a caffeine dosage of 3 $mg \cdot kg^{-1}$ of body weight would increase RAST sprint power at the start of the second half of a soccer match. The mean dosage was 188.41 mg. It is plausible a college athlete could ingest this dosage in liquid form prior to a soccer match. The relative dosage was kept low deliberately so that outcome data could realistically be applied to pregame caffeine consumption patterns in collegiate athletes.

Other studies have differed in work assessment, dosage, and results. Schneiker et al.[28] reported statistically significant increases in power and work output in male team sport athletes during the caffeinated trials of an approximately 90 min intermittent cycle ergometry sprint test after a 6 $mg \cdot kg^{-1}$ dosage. In a study designed to study the effects of 6 $mg \cdot kg^{-1}$ (delivered in two doses of 3 $mg \cdot kg^{-1}$) on cycling work at 12 and 33°C, Ganio et al.[9] found statistically significant work increases in caffeine trials independent of temperature. Lorino et al.[17] compared placebo and a 6 $mg \cdot kg^{-1}$ dosage and reported no statistically significant differences in Wingate test power output variables. Gant et al.[10], provided a 3.7 $mg \cdot kg^{-1}$ caffeine dosage to male soccer players in a study that compared sprint times throughout the LIST protocol. They reported a statistically significant decrease in sprint times during the caffeine trials within the final 3 blocks of exercise in the

LIST protocol. Lastly, Del Coso et al.[4] reported no statistically significant second half running distance differences after a 3 $mg \cdot kg^{-1}$ dosage in male soccer players.

In the previously mentioned studies, work data were collected throughout the protocols. Considering the **half-life** of caffeine doses less than 10 $mg \cdot kg^{-1}$ are estimated to range between 2.5 – 10 hrs, this study dosage might have induced significant sprint performance differences if the RAST assessment had been placed earlier in the LIST protocol[18].

Early second half sprint performance was deliberately chosen in this study because improvement of sprint performance in the second half is contextually more important when compared to the first half. It is well established that goal scoring increases as soccer games progress. From a study of three consecutive World Cup Tournament matches (1998, 2002, 2006) Armatas et al.[1] reported an upward trend for goals scored in the second half as compared to the **first**. They also reported a statistically significant increase in goals scored after the 76^{th} minute in 1998 and 2006.

A precise locus of control for the ergogenic effects of caffeine remains undefined. Although direct influence on intracellular calcium mechanisms, increased lipid metabolism, and glycogen sparing within working muscle have historically been implicated, they are currently not considered capable of

governing improved performance at the dosage level used in this study[12, 14, 13, 16, 31].

Neural mechanisms are still receiving considerable attention. The ability of caffeine to antagonize adenosine receptors within both central and peripheral neurons is rising to the surface as the probable locus of control under normal physiological conditions. Because caffeine and its fellow methylxanthines are lipid soluble, the locus of control is likely in the central nervous system[2, 3, 13].

The lack of statistical significance in this study is likely attributed to the relationship between relative dosage and time. Although the 3 $mg \cdot kg^{-1}$ dosage has been shown to increase time to exhaustion in endurance athletes, the dosage also represents the bottom of the approximated range (3–9 $mg \cdot kg^{-1}$) for eliciting the ergogenic effects of caffeine[13]. This study was within the proposed **half-life** of caffeine but the protocol lasted over 2 hrs before the RAST test was implemented. Therefore, the relationship between a small relative dosage and an extended exercise time represents a possible explanation for why the RAST results showed differences that did not reach statistical significance.

Although no statistical significance was found, mean, maximum, and minimum power data indicate the subjects performed better during the CAF trial. Because sports are not played

within the parameters of inferential statistics, the data suggest there is practical application for the results. Any increase in performance that is derived legally and safely has the capacity to positively impact the outcome of a game, especially if that performance increase occurs late in the game. That being stated, the lack of statistical difference between trials in this study indicates a predictable improvement in early second half sprint performance should not be sought by the application of a 3 $mg \cdot kg^{-1}$ caffeine dosage. As stated earlier, the dosage represents a plausible pre-game consumption for an NCAA DIII women's soccer player.

There are considerable mysteries still surrounding caffeine's effects on growth and development in young people[33]. Therefore, as a practitioner it is even more critical to guide young athletes towards habits which are not only best for performance in the present but also for years into the future. As in any arena, it is critical to consider the population you are working within. When training elite international caliber athletes, caffeine dosing may be an appropriate and/or necessary ingredient for continued improvement. According to the results of this study, when training younger collegiate athletes, greater emphasis should be placed upon habits which predictably improve performance.

CONCLUSION

In conclusion, caffeine's ergogenic effects on performance in intermittent sprint sport athletes have received considerably less attention when compared to its effects on endurance athletes[32]. There has yet to be consensus on its ergogenic value at varying dosages within this population. Furthermore, according to Goldstein et al.[11], caffeine research dedicated to women is minimal and more studies are necessary to illuminate caffeine's specific ergogenic effects in women. To the best of the authors' knowledge, this is the first study to utilize a 3 $mg \cdot kg^{-1}$ dosage in female soccer players to help define the ergogenic effects of caffeine.

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