SCIENTIFIC JOURNAL OF SPORT AND PERFORMANCE

ORIGINAL ARTICLE

The effect of acute caffeine ingestion on physical performance in elite European competitive soccer match-play

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ABSTRACT

The present study examined the effect of acute caffeine ingestion (150 mg) on the physical performance of elite European soccer players during official competitive match-play. The current investigation was a parallel-group design that collated data from a cohort of 19 male outfield players from an elite European soccer team (mean ± SD, age 26 ± 4 years; weight 80.5 ± 8.1 kg; height 1.83 ± 0.07 m; body-fat 10.8 ± 0.7%). Players were classified and matched by position and grouped accordingly: centre defender (CD) n = 5, wide defender (WD) n = 3, centre midfield (CM) n = 7, wide forward (WF) n = 2, and centre forward (CF) n = 2. For all performance variables, the mean values were compared in caffeine consumers vs. non consumers using independent-sample t-tests, with significance set at $p < .05$. Cohen's d was used to quantify the effect size, and was interpreted as trivial (<0.2), small (0.2-0.5), medium (0.5-0.8), and large (>0.8). For all examined variables, there were trivial or small non-significant ($p > .05$) trivial or small differences between caffeine consumers and non-consumers. The findings of the present research did not confirm the study hypothesis, once running and accelerometry-based variables did not improve with the caffeine ingestion of 150 mg. Therefore, the caffeine supplement used in this study is not suggested for improving performance in the variables analysed.
Keywords: Performance analysis, Physical conditioning, Football, Soccer, Caffeine, Match performance, Supplementation.

Cite this article as:
Morgans, R., Rhodes, D., Orme, P., Bezuglov, E., Di Michele, R., Teixeira, J., & Oliveira, R. (2023). The effect of acute caffeine ingestion on physical performance in elite European competitive soccer match-play. *Scientific Journal of Sport and Performance*, 2(3), 402-409. https://doi.org/10.55860/BDXS3572

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Submitted for publication June 04, 2023.
Accepted for publication June 13, 2023.
Published June 20, 2023.
Scientific Journal of Sport and Performance. ISSN 2794-0586.

doi: https://doi.org/10.55860/BDXS3572

INTRODUCTION

Caffeine is a commercially available drug that is widely used by athletes across many sports around the world. Previous research has shown that high numbers of athletes consume some form of caffeine around competition (Del Coso et al., 2012). The potential benefits of caffeine supplementation have previously been documented (Del Coso et al., 2012; Burke, 2008; Mielgo-Ayuso et al., 2019; Stadheim et al., 2021; Tallis et al., 2021). Although, some of these studies have tended to be laboratory-based investigations with less understanding of the effects of caffeine on physical and physiological performance in "*real-world*" settings.

From the perspective of performance enhancement for soccer match-play, the consumption of caffeine may have various advantages. These include the enhancement of oxygen utilisation, increased carbohydrate utilisation, improved power performance, enhanced cognitive function, and increased time to fatigue (Hogervorst et al., 2008; Mielgo-Ayuso et al., 2019; Stadheim et al., 2021). However, it is important to note that the required dosage and timing of ingestion to attain these performance enhancements may vary between individuals (Burke, 2008). It is also important to consider the potential detrimental effects of consuming high amounts of caffeine. In particular, in soccer, many matches across the season are played late in the evening, where caffeine ingestion may affect players ability to sleep following the match, which may in turn be unfavourable for the recovery processes that need to occur before resuming training for the subsequent match (Drake et al., 2013; Nedelec et al., 2015). Furthermore, some individuals may be more sensitive to caffeine which may cause anxiety, nausea or migraine onset (Tallis et al., 2021).

The use of caffeine supplementation in soccer is prevalent through various methods of ingestion including sports/energy drinks, tablets, chewing gum, gels, and specially formulated "*caffeine shot drinks*" (Mielgo-Ayuso et al., 2019). Previous research has attempted to better understand the effects of caffeine supplementation on soccer performance using simulated soccer match-play (Del Coso et al., 2012). The authors assessed the effects of ingesting 3mg of caffeine per kilogram of body mass versus a decaffeinated control drink on repeated sprint ability, maximal jump and physical performance during the simulated soccer match. An improvement in repeated sprint ability and an increase in distance covered at high intensity during the simulated match was reported. Further to this, Ellis et al. (2019) found that smaller doses of caffeine (1-3 mg/kg) may also be beneficial to the performance characteristics of elite adolescent male soccer players during a series of physical tests.

There seems to be a lack of empirical evidence highlighting the effects of caffeine supplementation on physical performance during actual "*real-world*" elite soccer match-play. Furthermore, it would appear that more research is warranted to fully understand the optimal dosage and timing required to elicit performance benefits from caffeine supplementation in official competitive soccer match-play. To address this gap in the literature, the present study examined the effect of acute caffeine ingestion (150 mg) on the physical performance of elite European soccer players during official competitive match-play. It was hypothesised that acute caffeine ingestion would improve physical performance in elite soccer match-play.

METHOD

Participants and study design

This study examined 19 male soccer players over a full season in an elite European league. The participants had been playing soccer for a minimum of 10 years. During a regular week and study period, players were instructed to maintain normal daily food and water intake, and no additional dietary interventions were undertaken. Specific caffeine ingestion was restricted to 45-minutes prior to kick-off on match-day.

The current investigation was a parallel-group design that collated data from a cohort of 19 male outfield players from an elite European soccer team (mean ± SD, age 26 ± 4 years; weight 80.5 ± 8.1 kg; height 1.83 ± 0.07 m; body-fat 10.8 ± 0.7%). Players were classified and matched by position and grouped accordingly: center defender (CD) n = 5, wide defender (WD) n = 3, center midfield (CM) n = 7, wide forward (WF) n = 2, and center forward (CF) n = 2. Goal-keepers were excluded from the investigation due to the specific nature of their match activity and their low running demands (Ingebrigtsen et al., 2015; Bradley et al., 2009). The sample were initially recruited based on squad selection across 30 league matches (home matches n = 15, away matches n = 15) in the 2021-22 season. Only data recorded during home and away official league matches were included in the present study. The sample was further sub-divided into caffeine users (n = 9) and non-caffeine users (n = 10). Data were only included in the analyses as starting player when the participant was selected in the starting line-up and match playing time exceeded 30-minutes of the match and they completed three (10%) or more league matches. Participants competed in a median of 43% (range = 10 to 93%) of league matches during this phase. All data evolved as a result of employment in which players were routinely monitored over the course of the competitive season. Nevertheless, approval for the study from the club was obtained (Winter and Maughan, 2009) and all participants provided written informed consent. The study was performed in accordance with the Helsinki Declaration principles and ethical approval was granted by the local Ethics Committee of Sechenov University (N 22-21 dated 12/12/2021). To ensure confidentiality, all data were anonymised before analysis. Participants were fully familiarised with the experimental procedures within this study due to regular protocols implemented as part of the clubs' performance monitoring strategy.

Design and procedures

The study period involved all match performance across the 2021-2022 season. The training sessions performed during the investigation were representative of a typical training micro-cycle implemented within elite soccer, involving a periodised training week encompassing low-, moderate-, and high-intensity sessions leading to competitive match-play.

All participants performed several familiarisation sessions one week prior to the first experimental session (first league match). The participants ingested a commercially available caffeine supplement (150 mg caffeine and 2 g L-Citrulline DL Malate; SIS®, London, UK) of 60 mL of cold cola flavoured solution or a flavoured solution alone, which was used as a placebo. Solutions were considered identical in flavour and colour by two researchers involved in the study. Participants were asked to follow their normal match-day diet and pre-match routines and abstain from caffeine consumption (in drinks and supplements) 24-hours prior to experimental sessions (match-play). All experimental sessions commenced in the afternoon or evening (12:30 to 19:00) with an interval of 6-7 days between matches. Fifteen minutes following the consumption of caffeine or placebo solutions, participants performed a generic individual warm-up consisting of body-weight exercises and dynamic stretching of relevant lower limb musculature, followed by a specific pitch-based team warm up protocol consisting of additional dynamic movements, running at various speeds over different distances and football specific practices (passing, small-sided games and positional activities) where hydration was *ad libitum*. The complete warm up protocol consisted of 22-minutes of activity.

Data collection

League match performance data were collected using a two-camera optical tracking system (InStat, Moscow, Russia) that was installed to record and examine the technical and physical match performance during competitive league fixtures. The matches were filmed using two full HD, static cameras positioned on the centre line of the field, not less than 3-metres from the field and 7-metres in height. A consistent 25 Hz format was provided. Data were linearly interpolated to 50 Hz, smoothed using a 5-point moving average and then down-sampled to 10 Hz, which allowed analysis of all player actions with and without the ball. The installation process, reliability, and validity of InStat have been previously reported (FIFA, 2019). Technical and physical performance was analysed using the InStat Analysis Software System and exported to the Microsoft Excel software for further analyses. InStat provided written permission to allow all match data to be used for research purposes.

The physical match activity profile included: total distance covered (m/min); high-intensity distance (m/min; total distance covered 5.5 - 7m/s); sprint distance (m/min; total distance covered >7m/s); acceleration distance (m/min distance covered during accelerations +3m/s^{-2}); deceleration distance (m/min; distance covered during decelerations +3m/s^{-2}). For all variables, the mean individual seasonal value was calculated for each player and used for subsequent analyses.

Statistical analysis

All data are presented as the mean ± standard deviation (SD). For all performance variables, the mean values were compared in caffeine consumers vs. non consumers using independent-sample t-tests, with significance set at $p < .05$. Cohen's d was used to quantify the effect size, and was interpreted as trivial (<0.2), small (0.2-0.5), medium (0.5-0.8), and large (>0.8). The analysis was conducted using the software R, version 4.2.0.

RESULTS

Table 1 shows the mean values for the examined distance metrics in players having consumed or not consumed caffeine before match play. For all examined variables, there were trivial or small non-significant ($p > .05$) trivial or small differences between caffeine consumers and non-consumers.

Table 1. Comparisons of match physical performance variables in caffeine between consumers and non-consumers.

Variable	Caffeine consumers	Caffeine non consumers	*p*-value	Cohens' d
Total distance (m/min)	116.0 ± 8.9	118.4 ± 8.6	.62	0.24
High-intensity distance (m/min)	8.49 ± 2.49	8.60 ± 1.79	.91	0.05
Sprint distance (m/min)	1.15 ± 0.30	1.46 ± 0.76	.30	0.49
Acceleration distance (m/min)	1.63 ± 0.31	1.63 ± 0.31	.98	0.01
Deceleration distance (m/min)	0.58 ± 0.15	0.58 ± 0.10	1.00	0.00

DISCUSSION

The aim of this study was to analyse the effects of acute caffeine ingestion on the physical performance of elite European soccer players during official competitive match-play. The main findings showed no differences between groups which could be related to the fact that only 150 mg were administered by the caffeine consumers group. Considering the average weight of the participants, this represents approximately 1.8 mg/kg. This finding is in line with previous studies (Burke et al., 2008; Coso et al., 2012) that only found significant improvements in performance with higher dosages (>3 mg/kg). In fact, the lower dosages (<2 mg/kg) were not included in a systematic review on the effects of acute caffeine ingestion on team sports performance based on previous studies showing no effects of such low caffeine (Burke et al., 2008; Del Coso et al., 2012; Astorino et al., 2010; Del Coso et al., 2012; Turley et al., 2015). Even so, there are contrasting research that suggests that lower doses (<3 mg/kg) can be beneficial for psychological and physical performance in similar magnitudes, although this may vary across individuals (Spriet, 2014).

The rationale of the present research was based on studies that supported a positive effect on performance with lower dosages of caffeine (Ellis et al., 2019; Ranchordas et al., 2018). For instance, a recent study found positive performance results with 1 – 2 mg/kg in U-17 youth soccer player (Ellis et al., 2019). Specifically, the change of direction tests of both legs, peak power, mean power, and peak velocity improved with a 2 mg/kg caffeine dose compared to a placebo. Additionally, 1mg/kg of caffeine improved peak force in the control group when compared to the placebo group. Jump ability and aerobic capacity were also improved with 1 – 2 mg/kg of caffeine. Meanwhile, Ranchordas et al. (2018) analysed whether caffeinated gum (200 mg) influenced performance in a battery of soccer-specific tests in male university soccer players (U-20). The authors found that Yo-Yo Intermittent Recovery Test Level 1 distance and countermovement jump were improved by the chewing of caffeinated gum. However, these studies had significantly younger participants than those of the present research which may be an interesting variable to consider in future research (i.e., performing comparisons for different age groups).

Moreover, it is relevant to acknowledge that only two studies were found to analyse running and accelerometry-based variables in match activity in U-18 soccer players, using a higher dosage of 6 mg/kg (Pettersen et al., 2014) and in semi-professional soccer players using a 3 mg/kg dose of caffeine (Del Coso et al., 2012). On the one hand, Pettersen et al. (2014) found no significant effects while Del Coso et al. (2012) found that total distance covered at a speed higher than 13 km/h was improved. The distinct participants, methodologies (including caffeine dosages) and result suggest that more research is warranted.

It seems that this was the first study that analysed professional soccer players from the same team with a limited number of participants. Finally, the non-existence of a pre- versus post-comparison could also strengthen the results and should be considered in future studies.

Considering the non-existent research in professional soccer players through official matches with running and accelerometry-based variables, this study suggests more research with professional soccer players with higher dosages of caffeine (i.e., > 3 mg/kg) which may provoke different effects as suggested in previous studies (Burke et al., 2008; Coso et al., 2012) is required.

CONCLUSIONS

The findings of the present research did not confirm the study hypothesis, once running and accelerometry-based variables did not improve with the caffeine ingestion of 150 mg. Therefore, the caffeine supplement used in this study is not suggested for improving performance in the variables analysed.

AUTHOR CONTRIBUTIONS

Conceptualization: Ryland Morgans, Dave Rhodes, Eduard Bezuglov, Jose Teixeira, Toni Modric, Sime Versic and Rafael Oliveira. Methodology: Ryland Morgans. Software: Rocco Di Michele. Validation: Ryland Morgans, Eduard Bezuglov, Rafael Oliveira and Rocco Di Michele. Formal analysis: Rocco Di Michele. Investigation: Ryland Morgans, Dave Rhodes, Patrick Orme, Jose Teixeira, Toni Modric, Sime Versic and Rafael Oliveira. Resources: Ryland Morgans and Eduard Bezuglov. Data curation: Ryland Morgans. Writing—original draft preparation: Ryland Morgans, Patrick Orme, Rocco Di Michele and Rafael Oliveira. Writing—review and editing: Ryland Morgans, Eduard Bezuglov, Dave Rhodes, Jose Teixeira, Toni Modric,

Sime Versic, Rocco Di Michele and Rafael Oliveira. Visualization: Ryland Morgans and Rocco Di Michele. Supervision: Ryland Morgans. Project administration: Ryland Morgans. All authors have read and agreed to the published version of the manuscript.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

ETHICS STATEMENT

The study was performed in accordance with the Helsinki Declaration principles and ethical approval was granted by the local Ethics Committee of Sechenov University (N 22-21 dated 12/12/2021).

INFORMED CONSENT STATEMENT

Informed consent was obtained from all subjects involved in the study.

ACKNOWLEDGEMENTS

The authors want to thank all the players, and medical staff involved in the study for the professionalism shown throughout. The authors also want to state that the results of the present study do not constitute endorsement of any products.

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