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Original article

The effect of acute caffeine ingestion on repeated sprint ability in soccer players

O efeito agudo da ingestão de cafeína na habilidade de sprints repetidos em jogadores de futebol

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ABSTRACT

Introduction: Caffeine is an ergogenic resource widely used in different sports. In soccer, the ability of repeated sprints is essential for performance during competition, however, the effects of caffeine in this skill still unclear. **Aim:** to evaluate the acute effect of caffeine intake on the performance of repeated sprints in young soccer athletes. **Methods:** Thirteen athletes from the U-20 soccer category participated in this study. Athletes ingested 5 mg/kg of caffeine or placebo in a double-blind crossover design. One hour after ingestion, the athletes were submitted to the test of 6 sprints repeated of 40 meters with 20 seconds of rest between each sprint. Each sprint time was recorded using the photocell system. For statistical analysis, repeated measures ANOVA (2 x 6) were used. **Results:** A significant difference statistically was found for the time factor ($p < 0.0001$), indicating an increase in the total time spent to complete the test, independent of the condition (caffeine/placebo). No significant difference was found for the condition factor ($p = 0.66$). **Conclusion:** In the present study 5 mg/kg of caffeine does not improve the performance of repeated sprints in young soccer athletes.

Keywords: caffeine; athletic performance; dietary supplements; soccer.

RESUMO

Introdução: A cafeína é um recurso ergogênico amplamente utilizado em diferentes modalidades esportivas. No futebola habilidade de sprints repetidos é fundamental para o rendimento durante a competição, entretanto ainda não se tem clareza sobre os efeitos da cafeína na habilidade em questão. **Objetivo:** avaliar o efeito da ingestão aguda de cafeína no desempenho de sprints repetidos de jovens atletas de futebol. **Métodos:** Foram selecionados 13 atletas da categoria sub-20 de futebol. Os atletas ingeriram 5 mg/kg de cafeína ou placebo em um delineamento cruzado duplo cego. Uma hora após a ingestão os atletas foram submetidos ao teste de 6 sprints repetidos de 40 m com 20 segundos de descanso entre cada sprint. Cada tempo de sprint foi gravado utilizando o sistema de fotocélula. Para análise estatística foi utilizada ANOVA de medidas repetidas (2 x 6). **Resultados:** Foi encontrada diferença estatisticamente significativa para o fator tempo ($p < 0,0001$) indicando um aumento do tempo total gasto para completar o teste independente da condição (cafeína/placebo). Não foi encontrada diferença significativa para o fator condição ($p = 0,66$). **Conclusão:** No presente estudo a ingestão aguda de 5 mg/kg de cafeína não melhorou o desempenho na habilidade de sprints repetidos em atletas jovens de futebol.

Palavras-chave: cafeína; desempenho atlético; suplementos nutricionais; futebol.

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Introduction

Soccer is a complex sport whose performance is influenced by several technical, tactical, psychological and physical factors. Regarding the physical aspect, several demands are required during a match. For example, elite athletes generally run more than 10 km per game at a mean intensity near the anaerobic threshold (80-90% of maximum heart rate). Additionally, high-intensity explosive activities are also required to jump, kick, disarming, turning, sprinting, running with a change of direction and sustaining intense contractions to maintain balance and control of the ball against defensive pressure [1].

During a match, soccer players can perform 10-20 sprints lasting 2-4 seconds, interspersed every 90 seconds [1]. Due to the intermittent high-intensity nature of soccer, players may be required to perform several short or maximum sprints with only short periods of recovery (at rest or low to moderate intensity) during all 90 minutes of the match [2-4]. This is classically called repeated sprint ability (RSA) and is considered an important factor in the game [5]. Sprints are the main actions related to important and significant part of the game: assists and goals scored [6]. It is believed that players with good ability to perform repeated sprints are likely to perform better than athletes who are less able to repeat sprint efforts at similar intensity [7] and that the RSA of one or more players is of great relevance to the result of the game [8].

In the pursuit of competitive success, many athletes use dietary supplements as an immediate strategy for improving physical performance during the sporting event. A nutritional ergogenic aid commonly consumed by athletes of different competitive levels and sports is caffeine (1,3,7 trimethylxanthine). It has been reported, for example, that 74% of elite athletes use caffeine as an ergogenic aid before or during a sporting event, with a higher prevalence in endurance-like sports [9]. There are currently a large number of studies evaluating the acute effect of caffeine intake on performance. The ergogenic effect has been found in several sports, mainly in activities with great dependence on aerobic capacity [10-13].

In recent years, several studies have demonstrated that caffeine ingestion can also increase performance in anaerobic activities involving maximal voluntary contractions [14,15] and muscle power measured with vertical jumps [16] or Wingate test [17]. However, the effect of caffeine on high-intensity activities may be dependent on the type of test applied. Data from a recent meta-analysis demonstrated that acute caffeine ingestion did not improve performance in repeated sprints when evaluating the total work done over the sprints, the best sprint or the last sprint times [18]. It is important to highlight that in the referred meta-analysis, of the total of eight studies included, only three involved athletes of competitive level and no study included only soccer athletes. It has been observed, in soccer athletes, that caffeine can be used to improve performance in jumping activities, sprints and distance covered during the game [19]. However, the effect of caffeine on young soccer athletes is still poorly known, especially in RSA. The aim of this study is to evaluate the effect of caffeine on RSA in under-20 soccer athletes. The hypothesis is that acute caffeine intake results in an improved sprint capacity in young soccer athletes.

Methods

Sample

Thirteen male soccer players (age 19.31 ± 0.51 years) were selected from the under-20 category of Rio Branco Atlético Clube. The inclusion criteria were athletes enrolled in the *Espírito Santo* Football Federation and competing in the aforementioned category. Athletes who were returning from injury or diagnosed with cardiovascular, metabolic and bone-joint diseases were excluded. All athletes included in the study had participated in the pre-season and had the same training routine, with a frequency of 6 days a week and an average duration of 2 hours a day, divided between physical and technical-tactical training. The data collection period was in the final stages of preparation for the state championship and included athletes who work in various positions: goalkeeper, midfielders, strikers, full-backs, and defenders. The participants received clarifications on the study proposal and the risks involved and signed an informed consent form for their participation in this research. All participants also responded to the daily caffeine consumption questionnaire. The experimental group was recruited by convenience among the athletes of the team according to availability for participation. A posteriori calculation with the sample group of 13 participants, considering the 3% improvement in performance as the smallest worthwhile change and with an alpha value of 0.05 indicated a statistical power of 0.93. The protocols used in the study were approved by the Ethics Committee for Human Research of Federal University of Espírito Santo (protocol 55993816.6.0000.5542), and complied with the rules of Resolution 466/12 of the Brazilian National Health Council on research involving human beings.

Procedures

The study consisted of 2 test sessions with one-week interval between sessions. For the first session, players were randomly divided into two groups (caffeine or placebo) from the draw of closed envelopes containing the initials of each player's name. In the following week, conditions were changed, and the group that received caffeine in the first session received a placebo, and vice versa. The draw and the preparation of the solutions were carried out by an independent researcher who did not participate in the test application and data analysis. Therefore, it was a cross-sectional, randomized study with double-blind control. Athletes ingested 5 mg/kg of caffeine diluted in 200 ml of flavored water or a placebo solution containing only 200 ml of flavored water 1 hour before the experimental protocol, without any knowledge of the exact content (caffeine or placebo) within the solutions.

Participants were also instructed not to consume any caffeine-based food or supplement in a 24-hour period prior to the tests, so that it would not directly interfere with the blood caffeine concentration. The measurement of body mass was performed prior to the first session using a digital scale (*PLENNA ®, São Paulo, Brazil*). All sessions took place at *Campo do Ouro Preto in Goiabeiras, Vitória, ES, Brazil*, between 2 pm and 4 pm during the normal training period.

Repeated sprints ability test

The ability to perform repeated sprints (RSA) was assessed following a protocol of 6 maximum 40 meters sprints, with a 180° change of direction after 20 meters (the repeated-shuttle-sprint ability test, RSSA). Between each sprint a passive rest was performed for 20 seconds [20]. For the application of this protocol, athletes warmed up with a light-intensity running for about 5 minutes. To measure the sprint times, a photocell system and the Speed Test software (*CEFISE Biotecnologia, São Paulo, Brazil*) were used.

Statistical analysis

Data were analyzed for normality (Gaussian distribution) using the *Shapiro-Wilk test*. As they presented normal distribution, parametric tests were used for all variables. Repeated measures ANOVA (2 x 6) was used for the following factors: condition (placebo/caffeine) and time (6 sprints). When needed, the *Sidak post-hoc test* was used. In addition, total time, mean time, and fatigue index in the RSSA was assessed with the Student's paired t-test. The fatigue index was calculated as suggested by Glaister *et al.* [21]:

Fatigue = (100 x (total sprint time ÷ ideal sprint time)) - 100.

Total sprint time is the sum of the 6 sprints performed during the entire protocol. The ideal sprint time is equal to the best sprint multiplied by 6. All results obtained were expressed as mean and standard deviation (SD). The statistical conclusions were discussed at a 5% significance level. For statistical analysis, the GraphPad Prism software version 8.01 was used.

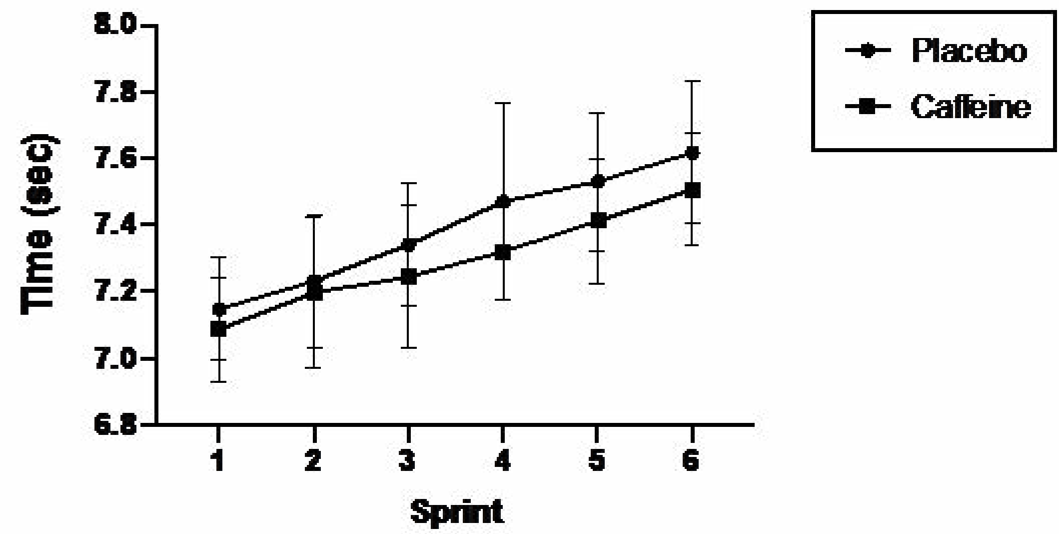
The effect size (ES) was calculated with Cohen's D according to the following equation [22]:

TE=(Mean1 - Mean2)/((SD1+SD2)÷2)

Statistical analysis was also performed with magnitude-based inferences [23] to determine performance changes between placebo and caffeine conditions for each sprint, total time, mean time and fatigue index. Inferences were calculated using the difference between the averages and the 90% confidence interval with the spreadsheet available at: http://sportsci.org/resource/stats/index.html. A 3% change in performance was considered the smallest worthwhile change as found in previous studies evaluating the effect of caffeine on the performance of anaerobic activities [17].

Results

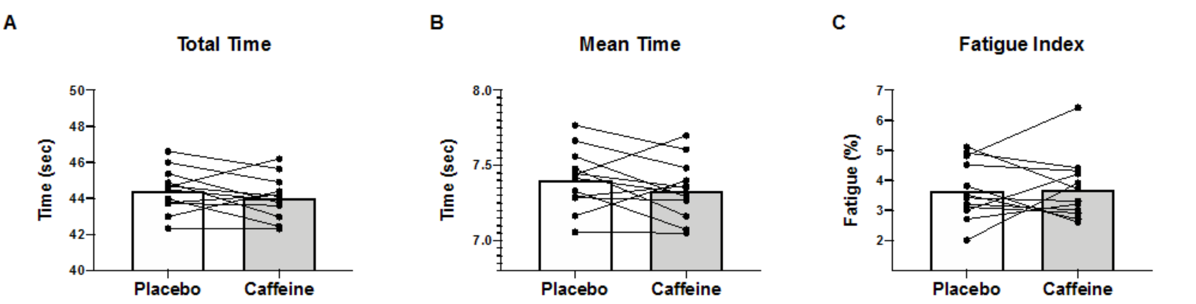
A significant difference in the main effect for the time factor was observed ($p < 0.001$) indicating an increase in the total time spent to complete the test regardless of the condition (caffeine or placebo). No significant difference was found for the condition factor ($p = 0.223$) or interaction ($p = 0.83$), indicating that despite the sprint time increasing over time, caffeine ingestion did not influence this outcome (Figure 1).



Data expressed as mean and SD. The repeated measures ANOVA (2 x 6) revealed a main effect for the time factor ($p < 0.001$)

Figure 1 - Time taken to complete the ability test for repeated sprints under placebo and caffeine conditions

As illustrated in Figure 2, the total RSSA time (Figure 2A, $P = 0.07$); mean sprint time (Figure 2B, $P = 0.66$); and fatigue index (Figure 2C, $P = 0.33$) did not differ between the placebo and caffeine conditions.



Data expressed as mean and SD.

Figure 2 - Total (A) and average (B) time, as well as the fatigue index (C) in the test of capacity of repeated sprints in the placebo and caffeine conditions

Magnitude-based inference analysis indicated a small effect size for the caffeine group in all sprints, best sprint, total sprint time, mean sprint time and fatigue index. However, this effect size was less than 3% and classified as trivial for performance (Table I).

Table I - Analysis of the results from the Magnitude-Based Inference to assess the effect of caffeine on the performance of repeated sprints (placebo condition vs caffeine condition)

		Effect chance (%)		
	Effect size	Positive	Trivial	Negative
Sprint 1	0.39	0.8	99.2	0
Sprint 2	0.16	1.7	98.1	0.3
Sprint 3	0.48	6	94	0
Sprint 4	0.69	22.2	77.8	0
Sprint 5	0.61	9.7	90.3	0
Sprint 6	0.58	7.6	92.4	0
Best sprint	0.59	5.9	94.1	0
Total time	0.59	2.9	97.1	0
Mean time	0.55	0.4	99.6	0
Fatigue index	0.23	0	100	0

Discussion

The objective of this work was to evaluate the effect of acute caffeine ingestion (5 mg/kg) on RSA in youth soccer players. The results of this study suggest that the ingestion of 5 mg/kg of caffeine results in no improvements of performance during repeated sprints with changes of direction.

Classic studies in the scientific literature have already demonstrated the ergogenic effects of caffeine ingestion on physical performance, especially in prolonged exercise with aerobic predominance [10-13]. However, in recent years studies have observed that caffeine ingestion can also promote ergogenic effects on short-term anaerobic-predominant activities [14,16,24]. Still, when it comes to the RSA, results are controversial. For example, Glaister *et al.* [25] recruited 21 male college students and applied a protocol composed by twelve 30m sprints with no change of direction and rest interval of 35 seconds between sprints after the ingestion of caffeine (5 mg/kg body weight) or placebo, in a crossover and double blinded experimental design. Authors concluded that caffeine ingestion resulted in a positive effect on performance in the first three sprints (~ 0.06 seconds for the best sprint), with no differences to the total time of sprints compared to the placebo group. Furthermore, a higher fatigue index was observed in the caffeine group (1.2%), probably due to the greater drop in performance during the final sprints of the protocol.

Ermolao *et al.* [26], on the other hand, tested the effect of caffeine (300 mg) and carbohydrate (26.7 g) ingestion on repeated sprints performance (11 sprints of 20 m with interval of 20 seconds) in 11 amateur soccer players and observed no changes in the total and mean time, as well as mean and peak power during the sprints. Similar results were found by Paton *et al.* [27] with 16 male students and practitioners of different competitive sports (basketball, hockey and rugby) who performed ten 20 m sprints with no change of direction after the ingestion of caffeine (6 mg/kg) or placebo. Authors concluded that the effect of caffeine was insignificant for mean speed (+0.1% in caffeine condition) and fatigue index (+0.7% in caffeine condition).

RSA has been positively associated with performance in several sports [28,29], being of great importance for athletic performance. Barnes *et al.* [30], for example, investigated the main changes in physical and technical parameters in the English football league by analyzing 14.700 matches between the 2006/07 and 2012/13 seasons. Among the variables analyzed, an increase of 50% in high-intensity running actions was observed, demonstrating the growing importance of this ability for soccer due to the characteristics of the modality that involves acceleration, deceleration, and changes of direction. In the present study, RSA was assessed using a specific protocol developed for soccer athletes that includes sprint with changes of direction [20]. In addition, it employed a sample composed of athletes from the same sport modality and familiar with this type of test, therefore, less variations in daily performance are expected [11]. Considering that difference in performance observed in the repeated sprints test is usually small, it is important to use homogeneous samples and validated tests for this population [31] to minimize performance variations between test sessions, which could mask the effects of supplementation. The present study found that caffeine does not improve RSA in young soccer players using a specific and validated protocol for this population involving repeated sprints with a change of direction. These findings are corroborated by Pereira *et al.* [31] who evaluated the RSA in 24 under-15 soccer players performing the same repeated sprints protocol and supplemented with caffeine (6 mg/kg) or placebo. Caffeine did not improve RSA based on mean sprint time, best sprint time and fatigue index.

Several protocols have been used to assess RSA with different parameters, such as number of sprints, distance traveled, rest intervals, and presence or absence of changes of direction [25-27, 31].

Although there are differences among the protocol used to assess RSA, it is possible to observe that fatigue develops quickly with decreases in performance, frequently observed after the first sprint, possibly as a result of peripheral factors (substrate depletion, such as phosphocreatine, and accumulation metabolites, such as H+ protons and inorganic phosphate) and neural (such as reduced muscle activation and motor unit recruitment) [4,32]. A hypothesis based in the literature is that caffeine could exert an inhibitory effect on neuromuscular fatigue by various mechanisms such as increased recruitment of motor units and the improved excitation-contraction coupling due to changes in activity of Na+/K+ ATPase and greater mobilization of calcium from the sarcoplasmic reticulum [33].

One study evaluated whether caffeine ingestion with essential amino acids could alter muscle recruitment capacity in a running protocol with a total duration of 40 minutes. During this protocol, the RSA was evaluated with a protocol involving 6 sets of 4 x 4-second sprints with a rest interval of 8 seconds between each sprint. Reductions in electromyographic (EMG) activity of the quadriceps were observed from 1st to 6th set for all groups tested, but the group supplemented with caffeine only showed minor reductions in EMG activity when compared to placebo. However, this effect did not translate into benefits in performance during sprints [34].

RSA can be influenced by the athlete's initial state of fatigue. This is particularly important when the player needs to perform a set of sprints in the final stages of each half of the game when fatigue may become more prevalent. Some studies have evaluated the effect of caffeine on RSA using protocols of repeated sprints at different moments: before, during and after a protocol that simulates the physical demands of soccer game.

Kopec *et al.* [35] evaluated 11 male athletes of different team sports with a protocol of 6 sprints of 20 m in a straight line with intervals of 25 seconds between sprints performed before, in the middle and at the end of a simulated game of 60 minutes. Statistical analysis was performed with magnitude-based inference. No effect of caffeine was observed for the 1st set performed, but a possible positive effect of caffeine was found for the 2nd set with ES = 0.32 (74/21/5 probability percentages) and for the 3rd series with ES = 0.37 (72/24/4 probability percentages) when the total sprint time was evaluated. It has also been found possible better performance for the best sprint in the 2nd series ES = 0.36 (76/20/4) and the 3rd series ES = 0.48 (86/12/2) in the caffeine supplemented group compared to placebo group. The authors suggested that caffeine could have an ergogenic effect on the performance of repeated sprints in situations in which athletes are already fatigued.

Another study [36] also evaluated the effect of caffeine on RSA at different stages of the game. Twelve female amateur athletes of different sports were included (netball, basketball and football) and performed a protocol consisted of repeated sprints (3 sets of 6 x 20 m sprints) before, during and after a simulated court game protocol involving four 15-minute periods. The ES was considered important when ≥ 0.5. The authors did not observe any improvement in RSA performance with isolated caffeine supplementation for any of the series evaluated (at the beginning, middle and end of the protocol), since the TE were lower than 0.46 for all sprint variables.

Results at this study also point to a higher ES in favor of caffeine group (ES ≤ 0.59) as in the studies mentioned above. However, this ES was classified as trivial for performance in our study. This difference in classification is explained by the ES adopted by the studies when applying the magnitude-based inference. Our study adopted as the smallest worthwhile change an improvement of ≥ 3% in performance. Kopec *et al.* [35] used the value of 0.8% in the performance, which corresponds to the lowest ES (0.2) suggested by Cohen to be adopted in social sciences and behavioral research [22,37]. Nevertheless, classification of ES suggested by Cohen may does not apply to all research areas [38], and the magnitude of a significant effect in one area may be insignificant in another [22]. From a practical point of view, a 3% improvement represents approximately 1.33 seconds in total time of sprints, which could represent an important competitive advantage in situations of dispute for the ball, for example. In contrast, a 0.8% difference in performance, as adopted in the study by Kopec *et al.* [35] would mean just over 0.355 seconds in total time in a repeated sprints sequence. Although small differences can have great practical application in track and field events (e.g., 100 and 200m), in soccer this very small difference may not be enough to allow an athlete to outrun an opponent or to maintain control of the ball. Therefore, considering the small effect observed, our results indicate that acute caffeine supplementation does not improve RSA in young soccer athletes. The result of the present study is also corroborated by meta-analysis studies [18,39] that did not find positive effects of caffeine in improving RSA performance or have indicated that this difference is very small (TE = 0.15), considered trivial for performance [40].

The present study used a convenience sample from an under-20 soccer team and with a relatively small sample of 13 players. For statistical analysis, a 3% change in performance was adopted as the smallest worthwhile change for the statistical analysis resulting in an acceptable statistical power (0.93). Our results indicated that the effect of caffeine on RSA performance is no greater than 3%, but we cannot say that the ergogenic effect does not exist. For some sports, small differences (for example: 1% improvement in performance) can define 1st and 2nd places, as in the 100 meters track and field event. Therefore, studies with a larger sample size applied to athletes from other sports may be important to assess the potential effect of caffeine on sprint capacity. In addition, it has been shown that responses to caffeine ingestion may depend on genetic characteristics (as polymorphisms in the CYP1A2 and ADORA genes) [41]. As the present study did not perform a genetic characterization of its participants, a complete understanding of the individual responses to caffeine ingestion is limited.

Conclusion

Acute caffeine ingestion (5mg/kg of body weight) did not improve performance of repeated sprints with changes in direction in young soccer players.

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Conflict of interest statement
The authors of the present study declare to have no conflicts of interest.

Academic link
This study in part of the Master Dissertation of Mauro Antônio Guerra Jr, supervised by Prof. Dr. Lucas Guimarães Ferreira at the Post-graduation Program in Physical Education (PPGEF) of the Federal University of Espirito Santo (UFES).

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Authors' contributions
Conception and design of the research: Guerra Jr MA, Borgo, LP, Souza H, Caldas LC, Guimarães-Ferreira L. **Data collection:** Guerra Jr MA, Borgo, LP, Souza H. **Analysis and interpretation of the data:** Guerra Jr MA, Souza H, Azevedo AP, Caldas LC, Guimarães-Ferreira L. **Statistical analysis:** Guerra Jr MA. Caldas LC, Guimarães-Ferreira L; **Manuscript Writing:** Guerra Jr MA, Azevedo AP, Caldas LC, Guimarães-Ferreira L. **Critical review of the manuscript for important intellectual content:** Guerra Jr MA, Caldas LC, Guimarães-Ferreira.

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