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Original Article

EFFECTS OF ACUTE CAFFEINE INGESTION ON THE PHYSICAL PERFORMANCE OF AMATEUR AMERICAN FOOTBALL ATHLETES

EFEITOS DA INGESTÃO AGUDA DE CAFEÍNA NO DESEMPENHO DE ATLETAS AMADORES DE FUTEBOL AMERICANO

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RESUMO

O objetivo deste estudo foi investigar os efeitos da ingestão aguda de cafeína (5 mg.kg^{-1}) no salto, força isométrica e desempenho de sprints repetidos em atletas amadores de futebol americano. Doze jogadores (24,6 6 ± 3.66 anos e 115,18 ± 24.35 kg de peso corporal) ingeriram uma dose de cafeína (5 mg.kg^{-1}) ou placebo 60 minutos antes de uma sessão de testes que consistia em: 1) Salto contramovimento (CMJ); 2) Meio-agachamento isométrico (IMTP); 3) Corrida de agilidade em L (*3-line drill* = corrida de agilidade de 200 jardas com 2 minutos de repouso entre os sprints). Duas sessões de teste foram realizadas usando um delineamento cruzado duplo-cego durante o período de pré-temporada de treinamento. Resultados indicaram: A ingestão de cafeína melhorou o desempenho do CMJ (p = 0,035), mas não foram observadas diferenças na força no IMTP (p = 0,22) e no desempenho do exercício de agilidade em L (tempo total: p = 0,65 e fadiga (%): p = 0,75) quando em comparação com a condição placebo. Conclusão: A ingestão aguda de cafeína melhorou o desempenho no salto, mas não na força isométrica e no desempenho de sprints repetidos com mudança de direção em atletas amadores de futebol Americano.
Palavras-chave: Recursos ergogêncios. Desempenho. Sprints repetidos. Salto contramovimento.

ABSTRACT

The aim of this study was to investigate the effects of acute caffeine ingestion (5 mg.kg^{-1}) on jump, isometric strength and repeated sprint performance in amateur American football athletes. Twelve players (24.6 ± 3.66 years and 115.18 ± 24.35 kg of body weight) ingested a dose of caffeine (5 mg.kg^{-1}) or placebo 60 min prior to a testing session consisting of: 1) countermovement jump (CMJ); 2) isometric mid-tight pull (IMTP); and 3) 3-line drills (200-yd shuttle runs with a 2-minute rest between sprints). Two testing sessions were performed using a double-blind, counterbalanced, crossover design during a pre-season training camp. Results indicated: Caffeine ingestion improved CMJ performance (p = 0.035), but no differences were observed on IMTP strength (p = 0.22) and line drill performance (total time: p = 0.65, and fatigue (%): p = 0.75) when compared to placebo condition. Conclusion: Acute caffeine ingestion improved jump performance, but not isometric strength and repeated sprint with change-of-direction performance in amateur American Football athletes.
Keywords: Ergogenic aids. Performance. Repeated sprints. Countermovement Jump.

Introduction

Caffeine – 1,2,3-trimethylxantine – is commonly found in drinks, foods and medicines and is also popularly consumed as a nutritional supplement. Studies dating from the 1970s demonstrated that acute caffeine ingestion could enhance e performance[1]. While most studies have focused on endurance-type exercise, in recent years the focus has shifted to investigate the effects of acute caffeine ingestion on high-intensity and intermittent exercise performance[2]. For example, Wellington et al[3] demonstrated that caffeine ingestion (300 mg) resulted in improved performance during repeated high-intensity sprints in semiprofessional rugby league athletes. Similarly, Glaister et al[4] demonstrated that the ingestion of caffeine (5 mg/kg) before repeated 6-s sprints on a cycle-ergometer resulted in higher maximal power output in the caffeine condition compared to placebo in trained men. A meta-analysis published by Salinero et al[5] assessed the effects of caffeine on team sports performance. The authors found that acute caffeine ingestion increased single and repeated jump performance, repeated sprint velocity, and agility, with small but significant magnitudes when compared to placebo.

American football is the United States' most popular sport and is growing in popularity with amateur leagues in South America, Europe, and Asia. The game is comprised of repeated short and maximum-intensity bouts during four 15-minutes quarters[6]. American football is a demanding sport that places significant physiological and physical demands on its players. Physiologically, athletes engaged in football must possess cardiovascular endurance to sustain the intensity of the game, as matches consist of short bursts of high-intensity activity interspersed with periods of rest. For example, Iosia and Bishop[7] analysed games from the first division of collegiate American football in the United States and found that the plays, on average, lasted 5.23 seconds, while the rest periods between plays were on average 46.9 seconds. Similarly, in the National Football League (the USA professional American Football league), average play is reported to be 5.0 seconds in duration, with 26.9 to 36.4 seconds of rest interval between plays[8]. Such results emphasize the intermittent nature of the sport. Regarding the predominant energy systems, it is emphasized the significant contribution of anaerobic systems (i.e., PCr and glycolytic systems) to ATP regeneration[9]. As for the components of fitness required for the sport, muscular strength and power are crucial for executing explosive movements such as sprinting, tackling, and blocking, as well as speed and agility to navigate the dynamic and unpredictable nature of the game[6]. Physically, American football requires athletes to be of diverse body types, with linemen typically possessing greater size and strength, while positions like wide receivers and cornerbacks prioritize speed and agility[9].

Although caffeine supplementation has been extensively studied in team sports such as soccer and rugby[5], the effects of caffeine on physical performance in American football players has received less attention. For example, it has already been observed that in soccer athletes caffeine can be used to improve performance in jumping, sprinting and distance covered during the match[10]. In Rugby athletes, improved performance was observed in the countermovement jump and in the Yo-Yo IR-2 test and a reduction in the fatigue index during the repeated sprint test[11]. Therefore, considering the scarcity of studies on American football players and caffeine supplementation, this study aimed to investigate the effect of acute caffeine supplementation (5 $mg.kg^{-1}$) on jumping, isometric strength and repeated sprint performance in amateur American football athletes. Given the ergogenic effects of caffeine on anaerobic tasks, we hypothesize that caffeine ingestion will result in improved performance.

Materials and Methods

Participants

Twelve male amateur American football athletes (3 defensive linemen, 6 offensive linemen, 1 running back and 1 wide receiver) with an average age of 24.6 ± 3.66 and 115.18 ± 24.35 kg/bw participated in the study. Athletes have a practical experience of 12.5 ± 3.48 years and competing in the Brazilian National Championship (BFA and CBFA first division leagues). To reduce the variability of individual response to caffeine due to habitual caffeine consumption, only participants with a daily intake of less than 250 $mg.d^{-1}$ were selected. Average daily consumption was assessed using a questionnaire as proposed by Maughan[12]. This study was approved by the Human Research Ethics Committee (protocol number 55993816.6.0000.5542) and complies with the 1964 Declaration of Helsinki.

Protocol

This study used a within-subjects, double-blinded crossover design. The investigation aimed to examine the effect of acute caffeine ingestion on vertical jump performance, isometric strength, and repeated sprints with change-of-direction. The study was carried out on 3 alternate days. On the first day, participants received detailed information about the study and completed the testing protocol for familiarization. On the second and third days (with an interval of 48

hours) participants performed the same test protocol but under two different supplementation conditions: caffeine (5 mg.kg^{-1} diluted in 400 mL of flavored solution) or placebo (400 mL of flavored solution). The drink was ingested 60 minutes before the test protocol. Participants were instructed to maintain the same eating pattern on the two test days but avoid drinks and supplements that contained caffeine. The experimental design is illustrated in Figure 1.

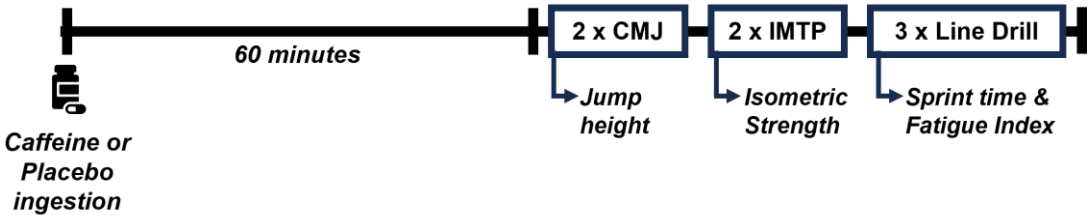

Figure 1. Experimental design used in the study. Caffeine or placebo were ingested in two separate days in a randomised and crossover manner with double-blinded design. CMJ: countermovement jump; IMTP: isometric mid-tigh pull.

Source: authors

Lower-limb power performance was assessed with the countermovement jump (CMJ). Participants were directed to start by placing their hands on their hips, squatting to a depth they chose, and then jumping as high as they could. They made two attempts aof the CMJ, with a 15-second rest between each trial. The average height of the two jumps was recorded. Jump height was determined by measuring flight time using a jump mat (Jump system, CEFISE, Brazil).

The isometric mid-tight pull (IMTP) was utilised as a measure of lower body strength. The IMTP was performed using a portable force transducer (PowerDin, CEFISE, Brazil). Subjects performed the IMTP on a bar attached to the force transducer with their shoulders placed over the bar in a position similar to that of the second pull of a power clean[13]. Participants performed two IMTP trials with 5 minutes of recovery between each trial and were instructed to pull as "fast and hard" as possible for 5 seconds and received loud verbal encouragement. Each participant's best trial, as determined by the highest peak force, was selected for analysis. Participants wore the same footwear for each testing session.

Participants also performed a line drill consisting of sprinting with 180 degrees change of direction. As described by Hoffman et al[14], subjects sprinted forward from a two point stance to the 10-yd (9.1 m) and back to initial line, than to the 20-yd line (18.3 m) and back, to the 30-yd line (27.4 m) and back, and then to the 40-yd line (36.6 m) and back. The total distance was 200 yd (182.9 m). Participants performed 3 sets of the line drill with 2 minutes of rest between each set. The sprint time of each set, the total sprint time and the fatigue rate (the percentage decline from the first to the last sprint) were determined. For time measurement, a photocell timing gate system was used (Speed Test, CEFISE, Brazil).

Statistical Analysis

Sprint times during the three sets of line drill were assessed using a 2-way repeated measures analysis of variance (ANOVA). Bonferroni post hoc analysis was used when a main and/or interaction effect was found.Total sprint time and fatigue rate during the line drill, CMJ height and IMTP strength were analysed using paired sample t-tests for each variable. A p-value of 0.05 was used to establish statistical significance. Cohen's d was calculated as following: ($Mean_{CM}$ - $Mean_{Placebo}$) / SD_{Pooled}. Partial eta square (partial η^2) was calculated using the following equation: Sum of squares / (Sum of squares + Residual error). The statistical software

GraphPad Prism version 8.2.1 (GraphPad Software, Inc., San Diego, CA, USA) was used for all analysis.

Results

Caffeine ingestion resulted in improved CMJ performance (placebo: 27.96 ± 5.5 cm; caffeine: 29.83 ± 6.7 cm; p = 0.035, Cohen's d = 0.30; Figure 2A). On the other hand, the maximal isometric strength during the IMTP was not different between caffeine and placebo conditions (placebo: 203.9 ± 12.71 kgf; caffeine: 206.4 ± 10.25 kgf; p = 0.22, Cohen's d = 0,26; Figure 2B).

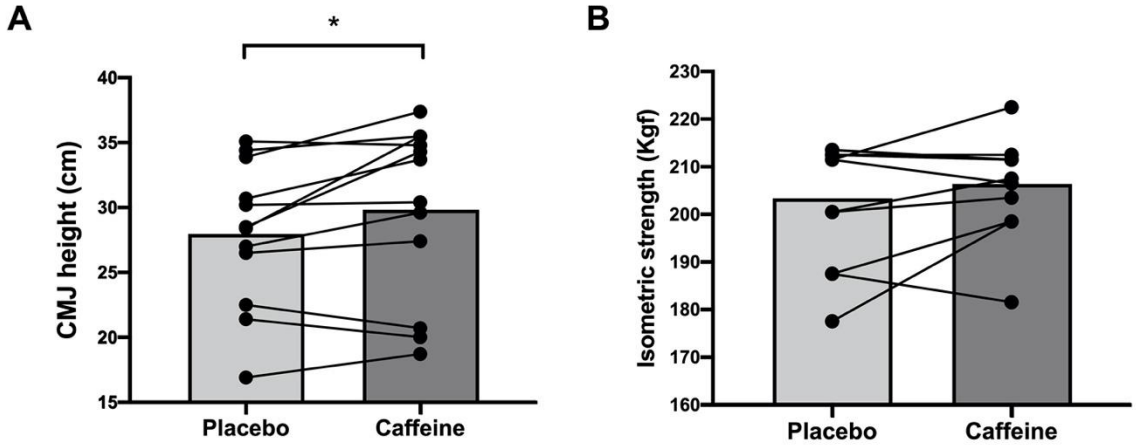

Figure 2. Tests: **(A)** CMJ height. **(B)** Maximal IMTP strength. * P = 0.035.
Source: authors

Caffeine supplementation did not improve performance during three sets of the 200m line drill when compared to placebo. Sprint time increased from the first to third set in both conditions (set main effect: p < 0.001, partial $\eta^2 = 0.78$; caffeine main effect: p = 0.65, partial $\eta^2 = 0.02$; interaction: p = 0.80, partial $\eta^2 = 0.02$; Figure 3A). When total time to complete the drills and the fatigue rate were analysed, there were also no differences observed between conditions (placebo: 156.6 ± 22.0 sec; caffeine: 154.8 ± 25.85 sec; p = 0.65; Cohen's d = 0.07; and placebo: 20.99 ± 12.77%; caffeine: 19.30 ± 12.98%; p = 0.77; Cohen's d = 0.13; Figures 3B and 3C, respectively).

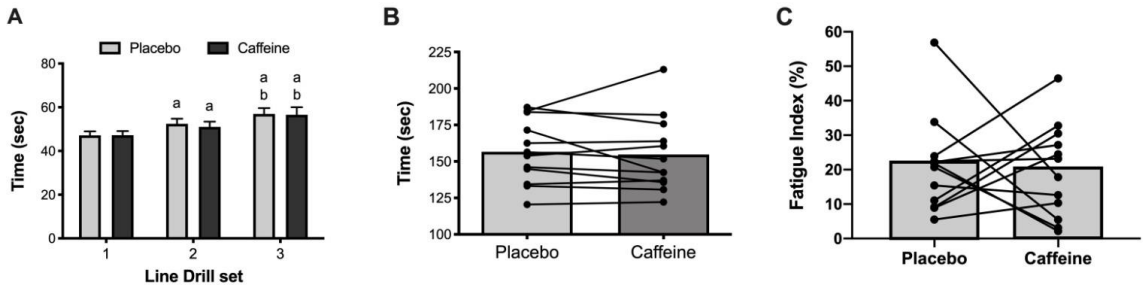

Figure 3: **(A)** Performance times on three sets of the line drill in placebo and caffeine conditions. a = p < 0.05 vs drill set 1; b = p < 0.05 vs drill set 2; **(B)** total time of three sets of the line drill; and **(C)** fatigue index during the line drill.
Source: authors

Discussion

The current study investigated whether acute caffeine ingestion enhances vertical jump, isometric mid-tight pull and repeated sprint performance in amateur American football players. The results suggest that caffeine can promote an increase in CMJ performance, but no effect on IMTP or repeated sprint ability.

A meta-analysis has demonstrated that in team sports athletes, caffeine ingestion can result in increased vertical jump height (effect size = 0.19)[5]. In the present study, acute caffeine supplementation led to an average increase of 6.7% in jump height when compared to placebo condition. Sabol et al[15] tested three doses of caffeine (2, 4 and 6 $mg.kg^{-1}$) in active men and found that all doses promoted an increase from 3.7 to 4.1%. Similarly, Bloms et al[16] found an increase of 4.1% in CMJ height after the ingestion of 5 $mg.kg^{-1}$ of caffeine in collegiate athletes. Muscular power and rate of force development seems to be one of the major predictive qualities for success among high-performance athletes[17-19]. In sports that involve fast movements, changes in direction, jumps, throws and kicks, such as American Football, muscular power positively affects the execution of these motor actions[20].

The IMTP is a safe and time-efficient maximal strength test[13], and has been associated with jump, sprint, and agility ability in athletes[21,22]. Previous investigations have reported positive effects of caffeine on isometric or isokinetic maximal voluntary contraction (MVC), as evidenced by the meta-analysis published by Warren et al[23]. When a sub-analysis was performed assessing the type of contraction, isometric MVC presented a higher effect size (0.37), compared to isokinetic MVC (0.2) and isotonic contraction (0.16). Contrary to these results, no differences were observed between the caffeine and placebo conditions on the IMTP in this study. Similarly, performance during the 200 m line drill was not improved in response to caffeine ingestion. The line drill used in this study, and previously by Hoffman et al[14], involves acceleration, deacceleration and a 180 degrees change of direction in a repeated manner. Previous work investigating the effects of acute caffeine ingestion on repeated sprinting ability, with or without change of direction, have reported equivocal results. For example, Pontifex et al[24] demonstrated that caffeine ingestion (6 $mg.d^{-1}$) improved repeated sprint moderately-trained male athletes, corroborating data from Carr et al[25] with team-sport players. On the other hand, others have failed to find positive effects of caffeine in repeated sprints performance in team-sports athletes[26-28]. Based on the current and previous data, it cannot be concluded that acute caffeine ingestion is effective to improve sprint performance in team-sports players. The diverging results may be explained by gender, age and training status differences among participants.

A further evaluation of the individual values in placebo and caffeine conditions demonstrated a variability in the effect of caffeine on performance. For example, for CMJ, eight participants (66.6%) improved jump performance by more than 3%. However, two participants exhibited reduced performance in CMJ (detriment of more than 6%) in caffeine condition and another two did not present any meaningful differences between conditions. The existence of responders and non-responders to caffeine may can be explained by the presence of polymorphisms as in the CYP1A2 gene. For example, Guest et al[29] tested the effects of two caffeine doses (2 and 4 $mg.kg^{-1}$) and placebo (no caffeine) in 101 competitive male athletes and measured polymorphisms in the CYP1A2 gene. They found that the ingestion of 4 $mg.kg^{-1}$ of caffeine resulted in a mean improvement of 4% in the cycling time. However, when the participants were divided according to their genotypes the authors found that the performance was improved by 4.8% in those with the AA genotype, with no significant effects on the participants with the AC genotype and worsened by 13.7% in the CC genotype after the higher dose of caffeine. It is possible that differences in the effects of caffeine ingestion between participants could be explained by variations on the CYP1A2 or other genes related to caffeine

metabolism and action. However, is important to note that other studies have found no relation of CYP1A2 gene polymorphisms and effects of caffeine on performance[30,31].

Conclusion

The aim of this study was to investigate the effects of acute caffeine ingestion (5 mg.kg-1) on jump, isometric strength and repeated sprint performance in amateur American football athletes. Acute caffeine ingestion resulted in improved CMJ performance, with no effects on IMTP strength and performance during a 200 m line drill consisted of repeated sprints with change-of-direction. Caffeine has been used as an ergogenic aid to improve performance in team sports[5] and enhance strength and power [2,23], but it is not known whether this positive effect also extends to the physical performance of American football athletes. Therefore, this study contributes to the literature indicating that caffeine ingestion can be a safe, practical and legal strategy to improve jump performance, which can be important, especially to receivers and defensive backs in American football. In the present study caffeine did not improve isometric strength and repeated sprint ability, the individual athlete responses should be considered as data suggested a considerably inter-individual variability. For athletes from the National Collegiate Athletic Association (NCAA), a precaution is needed, as caffeine is considered a controlled substance, with maximal urinary caffeine concentration of 15 ug/mL being permitted.

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