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Ronaldo Angelo Dias da Silva * , Rafael de Oliveira Idelfonso , Bruno Pena Couto , Marcos Daniel Motta Drummond

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Caffeine Supplementation Does Not Increase Performance on Professional Soccer Official Matches

Ronaldo Angelo Dias da Silva [1,*], Rafael de Oliveira Idelfonso [1], Bruno Pena Couto [2] and Marcos Daniel Motta Drummond [1]

[1] Laboratory of Nutrition and Sports Training, Physical Education School, Federal University of Minas Gerais, Belo Horizonte, Brazil
[2] School of Health and Behavioural Sciences, University of the Sunshine Coast, Sippy Downs, Queensland, Australia
* Correspondence: ronaldoedfisica@gmail.com; Tel.: +55-31-97300-2122

Abstract: The aim of the present study was to investigate the acute effect of caffeine supplementation on performance in official soccer matches. In double-blind, randomized crossover design, 13 professional soccer players performed two complete matches, with Caffeine (CAF) (6 mg/kg) and placebo (PLA) supplementation. Two-way repeated measures ANOVA showed that there was no effect of supplementation on the total distance covered ($p = 0.536$; $ŋp^2 = 0.033$) or the total distance covered at different speeds ($p = 0.453$; $ŋp^2 = 0.048$), acceleration or deceleration ($p = 0.387$; $ŋp^2 = 0.063$) number of sprints ($p = 0.521$; $\mu^2 = 0.035$) Heart Rate mean ($p = 0.484$; $ŋp^2 = 0.042$) Heart Rate maximum ($p = 0.110$; $ŋp^2 = 0.199$), Rate Perceived Effort ($p = 0.151$) or efficiency index ($p = 0.480$). Therefore, acute caffeine supplementation not effective to increase the performance of soccer players in official matches.

Keywords: Sports Nutrition; Dietary Supplements; Athletic Performance

1. Introduction

Considering the physical demands in official soccer matches, and the large number of games played during the season, soccer players can present acute and chronic fatigue, causing a decrease in physical performance [1,2]. Thus, the search for strategies to increase performance and reduce fatigue is constant in high-performance sports. A common strategy is the use of nutritional supplementation [3].

Among the nutritional ergogenic resources, caffeine is widely investigated in the scientific literature. This substance acts mainly by stimulating the central nervous system, enhancing cognitive functions, alertness, and also acting as an adenosine antagonist. This may explain the reduction in the effects of fatigue on athletes that ingest caffeine [4,5]. Caffeine can increase the availability of calcium in the myofibril and optimize the substrate availability during the exercise, increasing the oxidation of free fatty acids and reducing glycogen mobilization [4,5]. Such effects can prolong exercise tolerance and increase sports performance.

Despite caffeine being extensively researched in soccer, most studies investigated the effect on the player's physical performance in tests or simulated matches [6]. The few studies that have analyzed simulated soccer matches, which cannot replicate the demands of official matches, found divergent results [7–9]. Del Coso et al. [7] and Lara et al. [8], investigated the effect of caffeine in simulated matches of 2x40-minute halves with a 15-minute interval. The results showed that caffeine increases running distance, running distance at high intensity, and the number of sprints. In contrast, Pettersen et al. [9] observed no significant differences between caffeine and placebo with regard to distance running, high-intensity running, or sprint number. It is known that physical performance in soccer can be affected by numerous factors that cannot be controlled [10], particularly in official matches, but we don't find any study that investigated the caffeine supplementation on non-controlled official matches.

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Therefore, it is necessary to investigated the effect of caffeine supplementation in official matches. To the best of our knowledge, no studies with caffeine supplementation have been carried out with professional soccer players in official soccer matches. Therefore, the aim of the present study was to investigate the acute effect of caffeine supplementation on physical performance and psychophysiological variables during official soccer matches. The hypothesis is that caffeine supplementation will increase the physical performance with optimized physiological and psychological responses.

2. Materials and Methods

Thirteen elite professional soccer players (26 ± 4,5 years, 74 ± 6kg, 179 ± 5cm, VO_{2Max}: 54 ± 3 $mL.kg^{-1}\cdot min^{-1}$, body fat percentage: 9 ± 3%) performed two complete competitive matches, one after ingesting placebo (PLA) capsules and another ingesting Caffeine supplementation (CAF) capsules. The interval between the matches was one week. The capsules were ingested 60 minutes before the matches. This interval time was necessary for the peak of caffeine concentration in the blood to occur as close as possible to the match time [7]. Both PLA and CAF capsules were identical, but the PLA capsules contained starch and the CAF capsules contained 400mg of Caffeine, approximately 6mg/kg [6]. Goalkeepers were not included in the sample. Only players who trained in pre-season and who were considered ready by medical department were included in the study. In addition, the players were instructed not to change their diet or consume any nutritional supplement during the study. They were also instructed to not ingest other stimulant substances for up to 12 hours before each match.

During the official matches, all players wore a device with a global positioning system (GPS) with a sampling frequency of 10 Hz, and 200Hz 3D accelerometer, gyroscope and magnetometer (Polar Team® Pro System; Polar Electro Oy, Kempele, Finland). This system has showed good accuracy and reliability during low-speed running (0.00–13.99km/h; ICC=0.99, TEM = 5.05%), high speed running (14.00–19.99km/h; ICC = 0.99, TEM = 1.06%) and very high-speed running (≥20.0 km/h; ICC=0.99, TEM = 2.89%) [11]. The performance analysis included distances covered from 3.00km/h to 6.99 km/h (RD1), 7.00km/h to 14.99 km/h (RD2), 15.00km/h to 19.99km/h (RD3), 20.00 km/h to 24.99 km/h (RD4) and above 24.99 km/h (RD5) [12]. The number of accelerations was quantified between 2.00 and 2.99 m/s^2 (AC1), and above 2.99 m/s^2 (AC2), and decelerations between -2.00 and -2.99 m/s^2 (DC1), and less than -2.99 m/s^2 (DC2) [13]. The mean (HRmean) and maximum heart rate (HRmax) were also analyzed. The Training Impulse (TRIMP) was calculated by dividing zones of intensities relative to the HRmax (zone 1: 50 to 60% of HRmax; zone 2: 60 to 70% of HRmax; zone 3: 70 to 80% of HRmax; HRmax; zone 4: 80 to 90% of HRmax; zone 5: 90 to 100% of HRmax), and the accumulated time in each zone was be multiplied by its value and the results obtained were added [14]. The physical efficiency index (EI) was also analyzed, which is the ratio of the running distance per minute divided by the average of the percentage of HRmax. The Rate Perceived Effort (RPE) was measured 30 minutes post-match using the Training Intensity Subjective Rating Scale and the score awarded was multiplied by the regular total match time (90 minutes) [15].

Statistical analysis

The normality and sphericity of data variances were verified using the Shapiro-Wilk and Mauchly test. The Wilcoxon test was used to verify if there was a difference in the total time the players remained on the field in the matches of the situations. The paired t-test was used to verify differences in RPE and two-way ANOVA of repeated measures (supplementation x match time) was used to verify possible differences in the mechanical and physiological variables. When relevant, BonFerroni's post-hoc was employed to identify where these differences occurred. The square partial ETA (ηp^2) was used to verify the effect size. Descriptive data analyses to summarize the results of the study variables are presented as mean ± standard deviation and confidence interval (CI95%). For all statistical tests, the significance level adopted was α = 0.05 and the SPSS software version 20.0 was used for data analysis.

3. Results

The Wilcoxon test showed that there were no differences in the time players remained on the field when they ingested the placebo when compared to taking the caffeine supplementation ($p = 0.813$; 92.4 ± 7.8min and 91.3 ± 9.2min, respectively).

Mechanical Variables

Two-way repeated measures ANOVA showed that there was no effect of the Caffeine supplementation on the total distance covered ($p = 0.536$; $ŋp^2 = 0.033$). However, the total distance covered in the first half is greater than the distance in the second half ($p = 0.003$; $ŋp^2 = 0.523$) both in the PLA ($p = 0.025$; CI95% = 98.66 – 1225.95) and CAF ($p = 0.008$; IC95% = 269.25 - 1473.36). When analyzing separately the total distance covered at different speeds, no significant difference was found between PLA and CAF ($p = 0.453$; $ŋp^2 = 0.048$; CI95% = -40.14 – 84.57). However, the total distance covered in RD2 was greater in the first half than in the second half ($p = 0.001$; $ŋp^2 = 0.968$; CI95% = 265.93 – 670.37). The same occurred for RD3, which was higher in the first half when compared to the second half ($p = 0.005$; $ŋp^2 = 0.968$; CI95% = 40.17 – 183.59).

Regarding the accelerations, it was not observed the effect of supplementation for the total number of actions in AC1 ($p = 0.387$; $ŋp^2 = 0.063$), but the first half showed a greater number of actions in AC1 than the second half ($p = 0.005$; $ŋp^2 = 0.488$; CI95% = 2.91 - 13.46). Similar results were observed for the number of actions in AC2, which showed no difference between situations ($p = 0.643$; $ŋp^2 = 0.018$), but was greater in the first half than in the second half ($p = 0.008$; $ŋp^2 = 0.455$; CI95% = 0.84 - 4.16). Similar results were also found for the number of actions in DC1, which did not show significant changes regardless of supplementation ($p = 0.073$; $ŋp^2 = 0.244$), but was higher in the first half ($p = 0.007$; $ŋp^2 = 0.471$; CI95% = 3.36 – 16.79). However, this behavior was not observed for the number of actions in DC2, there was no significant changes due to supplementation ($p = 0.758$; $ŋp^2 = 0.008$) or match time ($p = 0.057$; $ŋp^2 = 0.270$).

As for the number of sprints, there was no change in relation to this variable, regardless of supplementation ($p = 0.521$; $\mu^2 = 0.035$) or match parts ($p = 0.608$; $ŋp^2 = 0.023$). However, the maximum speed reached by the players in the PLA situation was higher than in the CAF ($p = 0.035$; $ŋp^2 = 0.320$; CI95% = 0.11 – 2.71). Table 1 below presents the mean and standard deviation values of these variables.

Table 1. Mean and standard deviation of mechanical variables.

	Placebo		**Caffeine**	
	1st half	2nd half	1st half	2nd half
TD (m)	4714 ± 376*	4051 ± 997	4707 ± 363*	3835 ± 908
RD1 (m)	1969 ± 156	1759 ± 318	1910 ± 144	1748 ± 485
RD2 (m)	1986 ± 317*	1616 ± 592	2026 ± 334*	1464 ± 398
RD3 (m)	531 ± 151*	434 ± 152	540 ± 140*	414 ± 123
RD4 (m)	165 ± 78	168 ± 51	175 ± 56	145 ± 56
RD5 (m)	61 ± 35	76 ± 49	54 ± 25	63 ± 47
AC1 (n)	43.3 ± 8.5*	36.1 ± 12.0	42.5 ± 6.6*	33.3 ± 9.2
AC2 (n)	11.5 ± 4.8*	9.3 ± 3.6	11.5 ± 4.5*	8.3 ± 3.8
DC1 (n)	40.2 ± 10.3*	31.7 ± 8.9	39.0 ± 10.3*	27.3 ±7.0
DC2 (n)	12.6 ± 4.6	11.1 ± 4.45	12.8 ± 3.4	10.4 ± 4.2
Sprint (n)	4.9 ± 3.1	4.9 ± 2.5	4.8 ± 2.2	4.2 ± 2.9
Speed (km/h)	31.6 ± 3.5**	31.3 ± 2.9**	29.9 ± 1.7	30.2 ± 2.6

Notes: TD = total distance; RD1 = total distance traveled at speeds from 3km/h to 6.99 km/h; RD2 = total distance traveled at speeds from 7km/h to 14.99 km/h; RD3 = total distance traveled at speeds from 15km/h to 19.99km/h; RD4 = total distance traveled at speeds from 20 km/h to 24.99 km/h; RD5 = total distance traveled at speeds of 25 km/h. AC1 = total shares with acceleration between 2 and 2.99 m/s^2; AC2 = total shares with acceleration above 3 m/s^2; DC1 = braking between -2 and -2.99 m/s^2; DC2 = braking less than -3 m/s^2; Sprint = number of actions when reaching 25km/h; Speed = maximum speed; * significant difference ($p < 0.05$); ** significant difference between situations (placebo vs caffeine) ($p < 0.05$).

Physiological Variables

Two-way repeated measures ANOVA showed that there was no effect of supplementation on absolute values (p = 0.524; ŋp² = 0.035; CI95% = -1.87 – 3.49) or percentages (p = 0.484; ŋp² = 0.042; CI95% = - - 0.93 – 1.85) of the HRmean and there was also no statistically significant difference for the absolute values (p = 0.769; ŋp² = 0.007; CI95% = -5.40 – 4.09) and percentages (p = 0.684; ŋp² = 0.014; CI95% = -2.87 – 1.94) of the HRmax. However, regardless of supplementation, there was an effect of moment (1st half vs 2nd half) on HRmean values both for absolute values (p = 0.001; ŋp² = 0.977; CI95% = 10.17 – 12.36) and percentages (p = 0.001; ŋp² = 0.969; CI95% = 5.12 – 6.41), which were higher in the first half than in the second half. However, in relation to absolute HRmax (p = 0.110; ŋp² = 0.199; CI95% = -6.69 – 0.77) and percentage (p = 0.101; ŋp² = 0.209; CI95% = -3.43 – 0.34) no significant differences were found. As for TRIMP, there was also no change due to supplementation (p = 0.606; ŋp² = 0.023), but this variable was higher in the first half when compared to the second half (p = 0.002; ŋp² = 0.550; CI95% = 11.86 – 43.21). Table 2 below presents the heart rate values of the PLA and CAF situations in the first and second half.

Table 2. Mean and standard deviation of physiological variables.

	PLA		CAF	
	1st half	2nd half	1st half	2nd half
HRmean (bpm)	169 ± 12*	158 ± 12	168 ± 11*	157 ± 11
HRmax (bpm)	188 ± 11	191 ± 14	189 ± 10	192 ± 12
HRmean (%)	87 ± 6*	81 ± 6	86 ± 6*	81 ± 6
HRmax (%)	97 ± 6	98 ± 7	97 ± 6	99 ± 6
TRIMP	155 ± 37*	127 ± 42	152 ± 32*	124 ± 43

notes: HRmed = mean heart rate; HRmax = maximum heart rate; TRIMP = training impulse. * statistical difference between the first half and the second half (p < 0.05).

Psychological Variable and Efficiency Index (EI)

RPE showed no difference (p = 0.151; CI95% = -0.258 – 1.48) between PLA (7.8 ± 1.0) in relation to CAF (7.2 ± 1.4). As for the EI, there was no significant change due to supplementation (p = 0.480; ŋp² = 0.042), but it was lower in the second half when compared to the first half (p = 0.005 ŋp² = 0.501; CI95% = 0.06 – 0.29) in both PLA (1st time: 1.15 ± 0.13; 2nd time: 1.01 ± 0.26) and CAF (1st time: 1.16 ± 0.11; 2nd time: 0.94 ± 0.22).

4. Discussion

The aim of the present study was to investigate the acute effect of caffeine supplementation on physical performance and psychophysiological variables in official soccer matches. The main hypothesis formulated was that acute caffeine supplementation would increase the players physical performance. However, the results of the present study indicated that there was no statistically significant difference for any of the mechanical or psychophysiological variables investigated.

We didn't find other studies that investigated caffeine supplementation on elite official matches. Were found only three studies that investigated the effects of caffeine supplementation on simulated matches [7–9]. Del Coso et al. [7] had investigated the effect of caffeine in simulated matches (11-a-side, in an artificial grass field, 2x40-minute halves, 15-minute interval), found that caffeine significantly increased the total running distance (7352 ± 881 meters in the placebo; 7782 ± 878 meters in the caffeine condition). Also in this study, caffeine supplementation significantly increased high-intensity running distance (13.1 - 18.0 km/h), and the number of sprints (>18.0 km/h) (30 ± 10 in caffeine condition; 24 ±8 in the placebo condition). However, the HRmean and HRmax were not significantly affected. Lara et al. [8], using the same experimental design as the previous study, also found a significant difference between placebo and caffeine supplementation in total running distance (6.64 ± 1.618 vs 7.08 ± 1.501 m, respectively), in running distance at speeds above 18 km/h (161 ± 99 vs 216 ± 103 m, respectively), and in the number of sprints above 18 km/h (16 ± 9 vs 21 ± 13, respectively), however, the sample consisted of female athletes. Corroborating the results of the present study, Pettersen et al. [9] did not observe significant differences between caffeine and placebo regarding total distance running (10.062 ± 916 meters vs 9.854 ± 901 meters), high intensity running (>19.8 km/h; PLA: 557 ± 178 m vs CAF: 642 ± 240 m), sprint distance (>25.2 km/h; PLA: 109 ± 58 m vs CAF: 112 ± 69 m) or acceleration/deceleration counts (>2m/s) PLA: 123 ± 31 vs CAF: 126 ± 24).

The possible explanation for the divergent results of these three previous studies may be related to several factors such as the different forms of supplementation used in these studies, the intake of energy drinks that, in addition to caffeine, contained other substances such as sodium bicarbonate and taurine [7–9]. Furthermore, performance in the soccer game can be affected by numerous variables, such as physical fitness [16,17], competitive level [18,19], artificial turf versus natural grass [20,21], heat stress due to environment temperature [22,23], ball possession, and player/team technical standard [24,25]. Soccer is an unforeseeable sport and so many variables are impossible to control, therefore, they may still have influenced the results since the data collection was performed in official matches. Other studies need to be carried out in complete and official matches to therefore investigate the specific effects of caffeine on soccer performance. Furthermore, as the effects of caffeine supplementation depend on individual responses, there may be both high and low responses to different doses of this substance [26,27], even depending on the habitual consumption of this substance [28]. As the mechanisms of action of caffeine are related to fatigue [4,5], its effects may be evidenced in longer matches (extra time), or in atypical environments (heat or cold extreme and high altitudes), which was not the case in the present study.

To the best of our knowledge and limitations, no studies were found that investigated the effect of caffeine supplementation on HR and TRIMP in official matches, which limits our discussion. However, for both variables there was a reduction in the second half when compared to the first half. This corroborates with the specialized literature in team sports [29].

Regarding the RPE in matches, unlike other studies that in general use the Borg Scale [30], the present study used the Training Intensity Subjective Rating Scale by Morandi et al. [15]. This scale was used because the athletes were already familiar with it. The only study that presented the RPE in collective matches was by Lara et al. [8], who found no significant difference between caffeine supplementation and placebo. Taking into account the caffeine action mechanisms [4,31] it was expected that this supplementation would decrease the RPE. However, the systematic review that investigates this supplementation in team sports [32] most of studies corroborate the results found in the present study.

Regarding the EI, this variable can be sensitive to detect changes in the training state of soccer players [33]. This is because EI is a variable that allows the simultaneous evaluation of external and internal loads [34]. An example was presented by Suarez-Arrones et al. [33], who evaluated the EI for elite soccer players during official matches in a European championship. The results of the study showed a lower EI value in the second half of the match, compared to the first. Therefore, if any difference was found in the efficiency index between caffeine supplementation and placebo, we could speculate that either the player made less physiological effort to cover a greater distance, which would increase the EI, or the opposite. However, in the present study, caffeine was not able to influence the EI.

5. Conclusions

Acute caffeine supplementation is not effective enough to increase the players physical performance or to positively influence the psychophysiological variables in official soccer matches. Finally, all these results should be carefully interpreted as there are some limitations in this study, like the number of official matches analyzed and sample size. It is worth mentioning that more studies on caffeine supplementation in official matches and competitions are needed.

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

Data Availability Statement: The data presented in this study are available on request from the corresponding author (RAD Silva) with an appropriate reason.

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Conflicts of Interest: The authors declare no conflict of interest.

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