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Efeito agudo da suplementação isolada e combinada de carboidratos e cafeína no desempenho físico e técnico de futebolistas

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Orientador: Prof. Dr. Adriano Eduardo Lima da Silva

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Título: EFEITO AGUDO DA SUPLEMENTAÇÃO ISOLADA E COMBINADA DE CARBOIDRATOS E CAFEÍNA NO DESEMPENHO FÍSICO E TÉCNICO DE FUTEBOLISTAS

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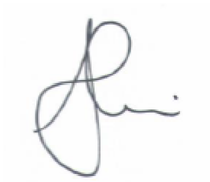

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Para que um homem tenha êxito na vida, Deus lhe concedeu dois recursos: educação e atividade física. Não separadamente, um para a alma e outro para o corpo, mas para estarem juntos. Com estes dois recursos, o homem pode alcançar a perfeição.

- Platão

RESUMO

A ingestão de carboidratos (CHO) e cafeína (CAF) vem sendo rotineiramente investigadas, não somente com o objetivo de aumentar o desempenho físico, mas também para atenuar a queda de desempenho físico e técnico durante os estágios finais das partidas. Portanto, visando contribuir com a discussão do problema, esta dissertação apresenta dois artigos: uma revisão da literatura com os principais efeitos agudos da suplementação isolada ou combinada de CHO e CAF no desempenho físico e técnico de jogadores de futebol; o segundo artigo refere-se a um estudo experimental objetivando investigar se a suplementação isolada e combinada de CHO e CAF administrada durante um período de recuperação de 4h teria efeito em subsequentes parâmetros de desempenho relacionados ao futebol. Treze jogadores de futebol completaram quatro sessões experimentais em um desenho randômico, crossover e duplo-cego. Pela manhã, os participantes realizaram 90 min do Loughborough Intermittent Shuttle Test (LIST). Então, os participantes ingeriram: 1) 1,2 g · kg^{-1} massa corporal (MC) · h^{-1} CHO a uma solução de 20% de CHO imediatamente 1, 2, e 3h após o LIST; 2) uma dose de CAF (6 mg · kg^{-1} MC) 3h após o LIST; 3) a mesma quantidade de CHO combinada com CAF (CHO + CAF); 4) água destilada combinada com cápsulas de celulose (PLA). Após o período de 4h de recuperação os participantes realizaram em sequência (5 min entre cada teste) três testes de salto vertical contramovimento (CMJ), o Loughborough Soccer Passing teste (LSPT) e um teste de sprints repetidos (5 x 30 m). Houve uma tendência da CAF em aumentar a altura do CMJ comparado ao baseline (34,9 ± 4,4 *vs.* 32,9 ± 3,5 cm, p = 0,07), e aumentou significantemente o desempenho no LSPT (40,9 ± 13,0 *vs.* baseline 45,8 ± 11,6 s, p = 0,05). Ambas as ingestões de CHO e CHO + CAF promoveram efeitos negativos na percepção subjetiva de esforço e no prazer-desprazer. Em conclusão, a ingestão isolada de CAF durante um período de 4h de recuperação promoveu um aumento no desempenho de salto e de passe, enquanto não houve benefício quando combinado com CHO.

Palavras-chave: exercício intermitente, fadiga, nutrição, LIST, LSPT.

ABSTRACT

The carbohydrate (CHO) and caffeine (CAF) ingestion have been routinely investigated not only to enhance soccer physical performance, but also to attenuate the decline of technical and physical performance during the final stages of the match. Therefore, aiming at contributing to the discussion of the problem, this dissertation presents two articles: a literature review of the main acute effects of isolated and combined CHO and CAF supplementation on physical and technical performance of soccer players; the second article refers to an experimental studying aiming to investigate whether isolated and combined CHO and CAF supplementation administrated during a 4-h recovery period would have effect on subsequent performance parameters related to soccer. Thirteen male soccer players completed four experimental trials in a randomized, double-blinded, and crossover design. In the morning, participants performed a 90-min Loughborough Intermittent Shuttle Test (LIST). Then, participants ingested: 1) 1.2 g · kg^{-1} body mass (BM) · h^{-1} CHO of a 20% CHO solution immediately after and 1, 2, and 3 h post LIST; 2) a dose of CAF (6 mg · kg^{-1} BM) 3 h post LIST; 3) the same amount of CHO combined with CAF (CHO + CAF); 4) distilled water combined with cellulose capsule (PLA). After a 4-h recovery period the participants performed in sequence (5 min between each test) three countermovement jump test (CMJ), a Loughborough Soccer Passing test (LSPT) and a repeated sprint test (5 x 30 m). CAF tended to improve CMJ height compared to baseline (34.9 ± 4.4 vs. 32.9 ± 3.5 cm, $p = .07$), and significantly improved LSPT performance (40.9 ± 13.0 vs. baseline 45.8 ± 11.6 s, $p = .05$). Both CHO and CHO + CAF ingestion promoted negative effects on RPE and pleasure-displeasure. In conclusion, the isolated ingestion of CAF during a 4-h recovery period leads to an improvement in jump and passing performance, while there is no benefit when combined with CHO.

Key words: intermittent exercise, fatigue, nutrition, LIST, LSPT.

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2º artigo: artigo de resultados

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LISTA DE ABREVIATURAS E SIGLAS

ALT – Enzima alanina aminotransferase

AST – Enzima aspartato aminotransferase

BM – Body mass, Massa Corporal (MC)

CAF – Cafeína

CHO – Carboidrato

CK – Enzima Creatina Quinase

CMJ – Countermovement Jump, Salto Vertical Contramovimento (SVC)

CNS – Central Nervous System, Sistema Nervoso Central (SNC)

FAS – Felt arousal scale

FFA – Free Fat Acids, Ácidos Graxos Livres (AGL)

FS – Feeling Scale

HR - Heart Rate, Frequência Cardíaca (FC)

ICC - Interclass Correlation Coefficient

[La] – Concentração de lactato

LDH – Enzima lactato desidrogenase

LIST – Loughborough Intermittent Soccer Test

LSPT – Loughborough Soccer Passing Test

LSST – Loughborough Soccer Shooting Test

MG – Muscle Glycogen, Glicogênio Muscular (GM)

PLA – Placebo

RPE – Rating of Perceived Exertion Scale

RST – Repeated Sprint Test

SFTB – Soccer Field-Test Battery

ST – Square Test

TEM - Typical Error of Measurement

VO_{2max} – Consumo máximo de oxigênio

VO_{2peak} – Pico de consumo de oxigênio

vVO_{2peak} – Velocidade correspondente ao pico de consumo de oxigênio

YYIRT – Yo-Yo Intermittent Recovery Test

SUMÁRIO

1 INTRODUÇÃO GERAL

Durante os 90 minutos de uma partida de futebol, os atletas de elite percorrem, em média, 10-12 km, a uma intensidade próxima ao segundo limar ou a 70-80% do consumo máximo de oxigênio ($VO_{2máx}$) (STOLEN et al., 2005). Contudo, essa distância não é percorrida de forma contínua, exigindo do atleta a realização de esforços de alta intensidade e curta duração (*sprints*), intercalado por períodos de menor intensidade (recuperação ativa) ou com pausas completas (recuperação passiva). Dessa maneira, pode-se conceituá-lo como uma atividade de natureza intermitente (JEFFREYS, 2004).

No futebol, é comum a realização de duas sessões de treinamento por dia, onde frequentemente se adota uma programação com sessões de treino no período da manhã e da tarde, intercaladas por períodos de 3 a 6 horas de recuperação (TAYLOR et al., 2011). Contudo, os jogadores podem iniciar os jogos e as sessões de treino com baixos níveis de glicogênio muscular (GM), devido, entre outros fatores, aos hábitos alimentares e ao número excessivo de jogos e treinos (KIRKENDALL, 1993; HAWLEY et al., 1994).

Consequentemente, é comum a utilização de estratégias nutricionais que visem o aumento do desempenho de jogadores de futebol. Dentre as estratégias rotineiramente investigadas, destacam-se a ingestão de carboidratos (CHO) e cafeína (CAF), não somente com o objetivo de aumentar o desempenho físico, mas também para atenuar a queda de desempenho técnico durante os estágios finais das partidas (ALI; WILLIAMS, 2009; FOSKETT et al., 2009).

Entretanto, apesar do crescente número de estudos realizados visando analisar os efeitos isolados e combinados da suplementação de CHO e CAF no desempenho específico de futebolistas, a literatura ainda apresenta resultados conflitantes sobre os efeitos das suplementações de CHO e CAF em diversos aspectos do desempenho físico e técnico (ALI et al., 2007; RUSSELL et al., 2012; FOSKETT et al. 2009; DEL COSO et al., 2012; GANT et al., 2010).

Portanto, visando contribuir com a discussão do problema, esta dissertação apresenta dois artigos: um de revisão da literatura com os principais efeitos agudos da suplementação isolada ou combinada de CHO e CAF no desempenho físico e técnico de jogadores de futebol; o segundo artigo refere-se a um estudo experimental objetivando comparar os efeitos agudos da suplementação isolada e combinada de CHO e CAF no desempenho do futebol após um curto período de recuperação, utilizando um desenho contrabalançado, randomico e duplo-cego.

2 COLETÂNEA DE ARTIGOS

1º artigo: artigo de revisão

ANDRADE-SOUZA, VA; LIMA-SILVA, AE. Isolated and combined acute effects of carbohydrate and caffeine supplementation on soccer performance

Revista que será submetido: Sports Medicine

ABSTRACT

Carbohydrate (CHO) and caffeine (CAF) supplementation have been largely utilized as a nutritional strategy to improve soccer performance. The aim of this review is to describe the isolated and combined effects of CHO and CAF supplementation on performance during specific tasks involved with soccer game skills. The first part of this review is focused on the effects of isolated CHO ingestion, which has been described as positive to shooting performance, but controversial on sprint, agility and passing performance. The mechanism to explain these controversial effects is not fully understood, but it may be independent of blood glucose. We furthermore describe the effects of CAF ingestion on soccer performance. CAF has a positive effect on jump, peak running speed, sprint performance and passing skills. The possible positive physiological effects of CAF improving soccer performance include: increased release of catecholamine and glycolytic rate, increased alertness, and decreased pain and fatigue perception. Finally, the combined ingestion of CHO and CAF seems to increase jump and sprint performances, and time to exhaustion in a high-intensity interval running when compared to CHO alone. However, the mechanism responsible for this addition effect is not clear. The effect of this combined supplementation on skills performance is also not clear and the comparison with CHO and CAF ingestion independently is defective. Further studies should compare the effects of CHO + CAF with isolated CAF and CHO ingestion.

Key words: Intermittent exercise, sports drink, muscle glycogen, fatigue, nutrition.

1. Introduction

During a 90-min soccer match, elite-level soccer players run approximately 10 to 12 km (except the goalkeepers who cover ~ 4 km) at an intensity close to the lactate threshold or 70-80% of maximal oxygen uptake (VO_{2max}).[1,2] However, this distance is not covered continuously; instead, the athletes perform high-intensity, short-duration efforts (sprints) interspersed by low-intensity periods (active or passive pauses), classifying soccer as an intermittent sport.[2,3] Soccer performance depends on many factors involving physical, technical, tactical and mental proficiencies. In this context, a range of skills are required, including jumping, kicking, passing, tackling, turning, sprinting, changing pace, and sustaining forceful contractions to maintain balance and control of the ball against defensive pressure.[1]

It is now well established that the level of muscle glycogen (MG) stored is likely to be an important factor, delaying fatigue onset.[4] It has been reported that there is a strong relationship between the initial MG content and the total distance covered during the soccer game.[5,6] Furthermore, the MG depletion during the game ranges from 20 to 90% of the pre-exercise values.[7] This reduction in MG stores can reduce the physical performance, mainly at the end of the game, when MG is almost fully depleted. Interestingly, it has been observed that more goals scored in this part of the end of the match.[8] This has been explained by the interrelationship of several factors, including increased risk-taking by the team that is losing, tactical changes, mental and physical fatigue that leads to a fall in concentration and technical errors, being almost all of these factors indirectly associated with MG depletion.[8]

Two common nutritional strategies employed by athletes are carbohydrate (CHO) and caffeine (CAF) supplementation, both of which can influence CHO metabolism during exercise.[9-11] Considering CHO supplementation, soccer players have been reported to initiate a game with low MG levels due in part to an insufficient CHO dietary intake and repeated days of training and matches.[12] The main mechanisms supporting CHO supplementation during a match have been proposed to be either a reduction in the MG depletion rate[13] or better maintenance of blood glucose levels during exercise.[14] In addition, it has been observed that blood glucose is a major energy source for the brain,[15] and changes in blood glucose levels could influence important factors for performance such as cognition, mood, motivation and motor skill.[16]

The ergogenic effects of CAF have also been investigated.[17-19] Caffeine increases the activation of the sympathetic nervous system and decreases the pain perception by blocking the adenosine receptors, producing an analgesic effect.[20] Originally, it was proposed that CAF would increase free fatty acids (FFA) oxidation, with a subsequent glycogen sparing.[21] However, recent investigations have not corroborated with this hypothesis[22] and it has been assumed that CAF could act in alternative pathways,[20] including: 1) increased calcium efflux from sarcoplasmic reticulum, 2) increased Na^+/K^+ ATPase activity, 3) increased release of catecholamine and glycolysis rate, and 4) improved cognition performance (i.e., increasing alertness).[20,22-25]

Thus, considering that it is well established that CHO ingestion enhances performance by maintaining plasma glucose concentration and increasing CHO oxidation,[26] whilst CAF potentially acts via alternative pathways,[22] it has also been recently postulated that the combination of these two ergogenics supplements could have an additive effect on soccer performance.[27,28] The mechanisms by which the combination of CHO + CAF could improve performance are not fully elucidated, but it has been proposed that CAF could potentiate CHO effects by increasing intestinal glucose absorption[29] and exogenous CHO oxidation.[30] Indeed, some studies have demonstrated that CAF has an additional benefit compared to CHO supplementation alone during intermittent sports.[27,28,31] Hence, this combined strategy may provide an effective supplementation regimen during training and competition as it is easy to administer and there is a low reported incidence of side effects.

Therefore, the aim of this review was to describe the evidences supporting the use of isolated and combined CHO and CAF supplementation to improve the performance during specific tasks linked to soccer game skills. We operationally divided the review into 3 sections: 1) isolated effect of CHO ingestion on soccer performance; 2) isolated effect of CAF supplementation on soccer performance; and 3) combined effect of CHO and CAF supplementation on soccer performance. We considered only studies that had verified the effects of CHO supplementation consumed up to 1.5 h before the exercise and/or during the soccer performance tests. Studies that used CHO diet manipulation were not considered. In addition, studies with CAF were considered when supplementation was offered from 2 h before to during the exercise.

A search was conducted in the PubMed and Scielo databases (no lower date limits; studies with humans; male; articles published up to April 14, 2013). Initially, we used the following keywords for each section: 1) ‘carbohydrate’, ‘soccer’, and ‘performance’; 2) ‘caffeine’, ‘soccer’, and ‘performance’; 3) ‘carbohydrate’, ‘caffeine’, ‘soccer’ and ‘performance’. The search yielded 57 potentially eligible studies. The reference lists of all articles were fully and carefully checked. We identified articles that met the following criteria: (a) articles that investigated the effects of CHO, CAF or CHO + CAF supplementation on soccer performance; (b) studies involving soccer players; and (c) studies that had a randomized and double-blind design. A total of 18 studies (section 1: 9 articles; section 2: 6 articles; section 3: 3 articles) were compiled and included in the review.

2. Carbohydrate supplementation and soccer performance

A growing number of studies have investigated the effects of CHO supplementation on physical and technical performance in soccer (Table I). Nine articles investigating the impact of CHO supplementation on physical performance were found. The results were conflicting, particularly considering sprint and agility performance. Three studies observed positive effects on sprint performance with CHO intake,[32-34] while the other two studies showed no effect.[35,36] Similarly, one study indicated that CHO ingestion had an effect on agility performance,[37] whilst another demonstrated no effect.[38] Several studies have indicated that CHO supplementation appears to attenuate the decline in shooting performance, mainly towards the end of the game.[32,26,37] However, results regarding the effects of CHO intake on passing performance were also controversial.[32,33,36,39] Additionally, CHO supplementation may be linked with an increased alert state during the match.[40]

Aiming to examine the effects of a CHO-electrolyte drink on sprint performance during a soccer game, Guerra et al.[34] found that professional soccer players ingesting CHO (300 ml of a commercially available sports drink containing 6% CHO) every 15 min during a soccer match simulation increased the number of sprints in the first half of the match, compared to the group receiving placebo (PLA). However, the athletes supplemented did not perform the second half of the match significantly better than athletes from non-supplemented group. Non-supplemented athletes had a higher body mass loss after the game ($p < 0.05$).

Similarly, Ali et al.[32] demonstrated that the athletes were able to performed 15 m sprints faster in the CHO trial (6.4% CHO) during a prolonged intermittent high-intensity shuttle running protocol (Loughborough Intermittent Shuttle Test - LIST) following a MG depletion protocol, when compared to PLA (mean 15-m sprint time: 2.50 ± 0.13 vs. 2.53 ± 0.13 s, CHO vs. PLA respectively; $p < 0.05$). Subsequently, Ali & Williams[33] showed that, although not statistically significant, there was a trend ($p = 0.15$) for the sprint performance following a MG depletion protocol to be higher in the CHO trial (6.4% CHO) in the last block of the LIST, compared to the PLA (2.70 ± 0.12 s vs. 2.76 ± 0.16s, respectively).

In contrast to these studies, Russell et al.[36] showed that sprint performance was reduced throughout a soccer match simulation and the supplementation of 6% sucrose did not influence this pattern of response ($p < 0.05$). This finding agrees with Clarke et al.[35], who demonstrated that CHO ingestion (6.4% CHO) had no significant effect on peak power output during running sprints ($p > 0.05$). Interestingly, both studies were performed without a prior MG depletion.

The physiological mechanism explaining this discrepancy between the results is not fully understood, but it may be independent of blood glucose. Plasma glucose concentrations increased after CHO ingestion in all of the reported studies, but a delay in the fatigue appearance and enhance in the performance was observed in only some of them, suggesting that a reduced decline or even an increase in the sprint performance throughout the soccer match after CHO ingestion may not be directly associated with blood glucose maintenance. One alternative explanation is that the effect of CHO supplementation on sprint performance may be linked with the level of pre-exercise MG stores. In this regard, studies in which CHO supplementation improved sprint performance were conducted after an exercise protocol designed to reduce MG stores,[32,33] or in non-controlled pre-exercise MG levels.[34] However, studies that attended for a control of the pre-exercise MG levels (with a standardized breakfast/snack or diet), and that not performed exercise-depleting protocol[36,37] were not able to find any effect of CHO supplementation on sprint performance.

Carbohydrate supplementation has also been associated with agility performance.[41] However, only two studies have analyzed the effect of CHO supplementation on agility performance in soccer players and these two studies have produced conflicting results. Currell et al.[37] demonstrated a significantly greater agility performance (+2.0%) in recreational soccer players with CHO supplementation (7.5% maltodextrin solution, 6 $ml.kg^{-1}$ Body Mass [BM] 30 min before the exercise, 4 $ml.kg^{-1}$ BM in halftime and 1 $ml.kg^{-1}$ BM every 12 min during the test) compared to PLA ($p < 0.05$). Agility performance was significantly decreased throughout a 10 x 6 min exercise protocol (see Ekblom[42]) in PLA, but it was attenuated with CHO ingestion ($p < 0.05$). In contrast to these results, Abbey and Rankin[38] did not find CHO supplementation (6% CHO) to affect agility performance. The agility test was applied at each 15 min of an intermittent protocol (see Kingsley et al.[43]) using two different CHO supplements (honey or sports drink). However, the players were supplemented 30 min before and during the 10 min "halftime" of the intermittent protocol, while Currell et al.[37] provided CHO beverages at each 15 min of the exercise protocol. Therefore, it is possible that a greater rate of CHO ingestion may have a greater impact on agility maintenance. In addition, possible effect of diet and pre-exercise MG levels before the exercise cannot be fully disregarded. However, considering there are only two studies investigating the effect of CHO on agility, future studies are necessary to verify if CHO supplementation can improve agility performance in soccer players.

Several studies were designed to analyze the effect of CHO ingestion on soccer-related technical performance (passing and shooting). Ostojic and Mazic[39] analyzed the effects of CHO supplementation (7% CHO) on performance during specific technical soccer tests. The players consumed the fluid (CHO or PLA) immediately before and every 15 min during the tests. Prior to the specific tests (dribbling, precision, coordination and power), athletes performed a match, where the group that consumed the CHO solution formed a team and the PLA group the opposing team. The authors found that the CHO team dribbled faster and had a higher passing accuracy than the PLA team (12.9 ± 0.4 vs. 13.6 ± 0.5 s and 17.2 ± 4.8% vs. 15.1 ± 5.2%, respectively, $p < 0.05$), but there were no differences in coordination and power between them. The authors attributed the deterioration in accuracy and dribbling in the PLA group to a reduction in blood glucose. However, in both groups, the blood glucose concentration did not reach to a hypoglycemia state.

Corroborating these results, Currell et al.[37] observed that CHO supplementation significantly increased the technical performance during a specific soccer protocol. The exercise protocol consisted of 10 blocks with 6 min of exercise each, separated by the time necessary to perform physical and technical performance tests. In the CHO condition, athletes ingested a 7.5% maltodextrin solution (6 $ml.kg^{-1}$ BM 30 min before the exercise, 4 $ml.kg^{-1}$ BM in halftime and 1 $ml.kg^{-1}$ BM every 12 min during the test). The authors found that ingestion of CHO was associated with significantly greater dribbling and shooting performances (3.2% and 3.5%, respectively, $p < 0.05$) compared to PLA. Carbohydrate supplementation also improved heading performance by 1.2%, but this increase was not significant ($p > 0.05$).

Similarly, Ali et al.[32] conducted a passing (Loughborough Soccer Passing Test - LSPT) and a shooting (Loughborough Soccer Shooting Test - LSST) tests before and after a LIST protocol. On the evening before the main trial, participants performed a glycogen-reducing cycling exercise. When the subjects returned on the laboratory in the following morning, they ingested a volume equivalent to 5 $ml.kg^{-1}$ BM before and 2 $ml.kg^{-1}$ BM every 15 min of the LIST of either commercially available energy drink or artificially sweetened solution without CHO. Shooting performance was maintained after the LIST in the CHO condition, but deteriorated after PLA (CHO: + 0.06 ± 0.5 points and PLA: - 0.13 ± 0.4 points, $p < 0.05$). The passing performance also showed a tendency to be maintained after the CHO condition, but was not statistically significant (CHO: 50.5 ± 5.5 to 50.8 ± 4.8 s and PLA: 51.2 ± 5.4 to 54.0 ± 5.3 s, $p > 0.05$).

Using a similar protocol, Ali and Williams[33] showed a decrease of ~ 3% in passing performances after the LIST in a CHO trial, and a decrease of ~ 14% in a PLA trial, but this decrement was not statistically significant ($p = 0.07$). In addition, passing performance was improved in the first 45 min and at the last 15 min with CHO supplementation. Russell et al.[36] also evaluated the influence of CHO beverages on the quality of technical performances before, during and after soccer match simulation. Players ingested a 6% (3.5 $ml.kg^{-1}$ BM) sucrose or PLA solution 10 min before each half and after 15, 30, 60 and 75 min of exercise. Despite no difference in shooting precision between the trials, the rate of decrease in shot speed was attenuated with CHO compared with PLA (-5.2 ± 0.1% vs. -10.5 ± 0.1%, respectively).

Contrary to these previous results, Abbey and Rankin[38] found no significant differences in shooting performance after the ingestion of two different solutions containing 6% CHO (honey-sweetened and sport drink) compared with PLA. However, rate of CHO consumption (30 min before and during the half time) and total amount (1.0 $g.kg^{-1}$ BM) may have been insufficient to produce improvement on shooting performance. Furthermore, there was no previous MG reduction, reinforcing the notion that positive CHO supplementation effect may be linked with the initial MG levels.

Although less attention has been given to psychological effects of CHO supplementation on soccer performance, Backhouse et al.[40] analyzed the effects of CHO supplementation (6.4% CHO) on rating of perceived exertion,[44] dimensions of pleasure-displeasure,[45] and perception of activation[46] during a high-intensity intermittent exercise performed by soccer players. It was demonstrated that the perception of activation was higher in the CHO compared to PLA during the last 30 min of exercise (minute 75: 4.1 ± 0.3 vs. 3.0 ± 0.3, CHO vs. PLA, $p < 0.05$; 90 min: 3.8 ± 0.4 vs. 2.7 ± 0.4, CHO vs. PLA, $p < 0.05$). These results suggest that improved performance after CHO supplementation may be partially linked with an increased CNS function during vigorous exercise and a greater alert state during the final moments of the match.[47]

Taken together, these findings suggest that the CHO ingested before and during (~ 15 min intervals) an intermittent exercise, such as soccer, may improve technical performance, mainly during the final stages of the exercise. However, it is not clear whether CHO supplementation improves sprint and agility performance. Therefore, this should be investigated using a more-controlled pre-exercise MG stores.

Table I. Summary of CHO supplementation effects on soccer performance. Studies are showed in chronological order.

Study	n	Level (Country)	VO_{2max} ($ml.kg^{-1}.min^{-1}$)§	Prior Depletion Protocol	Fasting time	CHO Supplementation and Concentration	Task
Ostojic and Mazic[39]	22	Profesional (Yugoslav)	55.2 ± 8.9	Yes (soccer match)	4 h	5 $ml.kg^{-1}$ BM before and 2 $ml.kg^{-1}$ BM every 15 min (7% CHO)	Precision (rate)* Power (s) Coordination (rate) Dribble (s)*
Guerra et al.[34]	20	U17(Brazil)	NR	No	No	300 ml every 15 min (6% CHO)	Time spent running (min)* Sprints performed (number)*
Clarke et al.[35]	12	University (England)	59.3 ± 6	No	3 – 4 h	7 $ml.kg^{-1}$ BM every 15 min or same amount divided in only two doses (before and at halftime) (6.4% CHO)	Power output sprint (W)
Ali et al.[32]	16	Healthy players (England)	56.0 ± 1.6	Yes (cycling protocol)	> 12 h	5 $ml.kg^{-1}$ BM before and 2 $ml.kg^{-1}$ BM every 15 min (6.4% CHO)	LSPT LSST** Mean 15-m sprint (s)*
Backhouse et al.[40]	17	University (England)	59 ± 0.8	Yes (cycling protocol)	> 12 h	8 $ml.kg^{-1}$ BM before and 3 $ml.kg^{-1}$ BM every 15 min	LIST

						(6.4% CHO)	
Abbey and Rankin[38]	10	NCAA Division I (United States)	50.1 ± 4.4	No	> 8 h	8.8 $ml.kg^{-1}$ BM 30 min before and in 10 min of halftime (6% CHO)	High- intensity run (s) Agility (s) Ball-shooting (rate)
Ali and Williams[33]	17	University (England)	59 ± 3.1	Yes (cycling protocol)	> 12 h	8 $ml.kg^{-1}$ BM immediately before and 3 $ml.kg^{-1}$ BM every 15 min (6.4% CHO)	LSPT Mean 15-m sprint (s)
Currell et al.[37]	11	Recreational (England)	NR	No	No	6 $ml.kg^{-1}$ BM 30 min before, 4 $ml.kg^{-1}$ BM in halftime and 1 $ml.kg^{-1}$ BM every 12 min (7.5% Maltodextrin)	Agility (s)** Ball-dribbling (s)*** Heading (cm) Kicking accuracy (points)*
Russell et al.[36]	15	Profesional Academy players (England)	52.4 ± 0.8	No	No	500 ml at breakfast + 3.5 $ml.kg^{-1}$ BM 10 min before each half and every 15 min of each half (6% sucrose)	Shooting Test* Passing Test Dribbling Test Sprint speed

Legend: VO_{2max} = maximum oxygen uptake; § = values are Mean ± SD; * = $p < 0.05$; NR = not reported; ** = $p < 0.01$; *** = $p < 0.001$; BM = Body mass; LSPT = Loughborough Soccer Passing Test; LSST = Loughborough Soccer Shooting Test; LIST = Loughborough Intermittent Shuttle-Running Test; CHO = carbohydrate.

3. Caffeine ingestion and soccer performance

In the last decade, there has been an increasing number of studies investigating the effects of caffeine supplementation on physical and technical performance in soccer (Table II). Six studies investigated the effects of CAF supplementation on physical performance during soccer skill tasks. The results suggest that CAF has a positive effect on jump performance,[48,49] peak running speed, and sprint performance during a simulated soccer match.[49] Controversially, some studies failed to find any effect of CAF on repeated-sprint exercise performance.[48,50] The effects of CAF ingestion on performance during progressive and intermittent exercises were also conflicting.[51,52] Only one study has investigated the effects of CAF ingestion on passing performance, and observed that CAF supplementation increased passing accuracy.[48]

During a simulated soccer game, Del Coso et al.[49] analyzed the effects of a caffeine-containing energy drink (3 $mg.kg^{-1}$ BM), consumed 60 min before the exercise, on the total distance covered and running speed during a simulated match. The authors found that the total distance covered at the end of the first half and during the total match were higher ($p < 0.05$) after the caffeinated drink than the PLA. Additionally, the caffeinated drink was associated with a significantly higher distance covered in the higher intensity zones (Zone 4: 8.1 to 13.0 km/h; Zone 5: 13.1 to 18.0 km/h; and Zone 6: running speed higher than 18 km/h; $p < 0.05$), and reduced the distance covered in the walking zone (Zone 2: 0.5 - 3.0 km/h, $p < 0.05$). The total number of sprints performed during the match increased with the caffeinated drink (30 ± 10 vs. 24 ± 8, $p < 0.05$). However, a relevant limitation of that study is that caffeinated energy drink contains other stimulants such as taurine, glucoronolactone, and B-group vitamins that were not included in the placebo drink.

On the other hand, studies analyzing the effects of CAF on repeated-sprint performance in soccer players have produced conflicting results. Machado et al.[50] investigated the effects of CAF (5.5 $mg.kg^{-1}$ BM, consumed 45 min before the exercise, CAF n = 8, PLA n = 7) on performance during multiple sprints (12 sets of 10 x 20 m, with 10-s interval between sprints and 2 min of active recovery between sets). They found no significant differences between groups for the total time of execution (9023.1 ± 22.2 and 9026.6 ± 25.3 s, for CAF and PLA group, respectively, $p > 0.05$). However, performances during the series were not reported; CAF could have an effect on a particular series, mainly at the beginning of the protocol.[53] On the other hand, Del Coso et al.[49] found that supplementation with a caffeinated energy drink increased the mean peak running speed during a repeated sprint test (7 x 30 m with 30 s of active recovery between repetitions) compared to the control drink. Despite the smaller CAF dose used in Del Coso et al.[49] than in other studies,[48,50-52] this discrepancy as mentioned before may be because the energy drink had other stimulants.

Effects of CAF were also investigated on muscle power, which is usually measured indirectly in soccer players by vertical jump height. Del Coso et al.[49], using repeated vertical jumps at each 15 seconds interval, found that a caffeinated energy drink significantly increased the mean jump height and the total power generated, in comparison with a decaffeinated beverage ($p < 0.05$). However, despite caffeinated energy drink contains other stimulants, it is important to underline that Foskett et al.[48] also found an improved jump height performance after pure CAF supplement (6 $mg.kg^{-1}$ BM, consumed 60 min before the exercise). Reiteratively, a relevant limitation of that study is that caffeinated energy drink contains other stimulants such as taurine, glucoronolactone, and B-group vitamins that were not included in the placebo drink.

Recently, Pereira et al.[51] conducted a study to analyse the effect of CAF supplementation on performance of the Yo-Yo Intermittent Recovery Test (YYIRT). Twenty professional soccer players were divided into a CAF (5.5 $mg.kg^{-1}$ BM of CAF, 55 min before the exercise, n=10) and a PLA (n=10) group. The test protocol consisted of a repeated-sprints test (2 series of 6 sets of 10 x 20-m bouts with 10 s of recovery between bouts, 2 min between sets and 15 min between series), followed immediately by the YYIRT until exhaustion. The analysis of YYIRT performance demonstrated that the CAF group ran a distance (~12.5%) when compared to the PLA group ($p < 0.05$). In contrast, Bassini et al.[52] did not find significant differences after CAF ingestion (5 $mg.kg^{-1}$ BM, 60 min before the exercise) for the distance covered in a YYIRT, when compared to PLA ($p > 0.05$). In this study, nineteen professional soccer players were randomly divided into a CAF (n = 11) and a PLA (n = 8) group. On the test day, the athletes performed two sessions of a 45-min variable distance run protocol separated by a 15-min interval, followed immediately by the YYIRT until exhaustion. The authors suggested that the small number of subjects investigated can explain the absence of positive results. However, a limitation of this study is that the athletes received a drink containing electrolytes and glucose *ad* *libitum* throughout the study, which could induce additional benefits on performance. Additionally, in both of these studies,[51,52] the authors did not report the performance in the repeated sprints tests or in the variable distance run protocol performed before YYIRT. Therefore, it is not possible to distinguish whether this difference on the results was affected by the intake of caffeine *per se* or by the combination of CAF with the fatigue produced by the previous exercise protocol.

It is also well known that CAF causes a decrease in muscle pain perception, which can further improve performance during intermittent exercise.[23] Consequently, some studies have evaluated the effects of CAF supplementation on markers of muscle damage in soccer players.[25,50,51,54] However, Machado et al.[50] demonstrated that, despite the repeated-sprint protocol inducing an increased serum concentration in markers of muscle damage (creatine kinase – CK; lactate dehydrogenase – LDH; alanine aminotransferase - ALT and aspartate aminotransferase - AST) 48 hours after the exercise protocol, this was not affected by CAF supplementation (5.5 $mg.kg^{-1}$ BM). Contrarily, Bassini-Cameron et al.[54] found that CAF supplementation (5 $mg.kg^{-1}$ BM, consumed 35 min before the simulated soccer match) had a synergistic effect to the exercise, further increasing serum concentrations of CK and ALT immediately after a simulated soccer match (45 min match in a reduced field of 50 x 50 m followed by a YYIRT until exhaustion) when compared to PLA. However, the authors did not report the performance for the YYIRT, making it impossible distinguish whether the increased concentrations of these injury biomarkers were directly affected by the intake of CAF or due to a CAF-induced increase in performance. Future studies should be conducted to elucidate the possible influence of CAF and increased-performance on biomarkers in soccer players.

Although physical performance is extremely important for success during a soccer match, it is known that the main difference between elite and recreational athletes is the better technical performance of the elite athletes.[55] Hence, a potential benefit of CAF in soccer players may not be physical, but linked to an attenuation of technical, concentration and cognitive performance decrease throughout the game. However, only one study to date has investigated the acute effects of CAF on the technical performance. Foskett et al.[48], using a protocol to measure the passing skills of players (LSPT) every 15 min during the LIST, found that CAF ingestion (6 $mg.kg^{-1}$ BM 60 min before the exercise protocol) improved the passing skills performance (CAF: 51.6 ± 7.7 s and PLA: 53.9 ± 8.5 s, respectively, $p < 0.05$). This increase in performance might be attributed to a significant decrease in the penalty time (which is added to the total time of the test) (9.7 ± 6.6 s and 11.6 ± 7.4 s, respectively, $p < 0.05$). The decrease in the penalty time suggests that caffeine may enhance fine motor skills such as ball control and accuracy.[48]

In summary, ingestion of moderate doses of CAF (from 3 to 8 $mg.kg^{-1}$ BM) seems to produce a significant effect on physical performance, increasing the muscle power and the distance covered at high-intensity running during a soccer match. However, part of this increase may be attributed to other stimulant substances in the caffeined-beverage. Caffeine intake may improve passing skills, but more studies are necessary to support this hypothesis.

Table II. Summary of caffeine supplementation effects on soccer performance. Studies are showed in chronological order.

Study	n	Level (Country)	VO_{2max} ($ml.kg^{-1}.min^{-1}$)§	CAF Dose	CAF Suplementation	Task
Bassini-Cameron et al.[54]	22	Professional (Brazil)	NR	5 $mg.kg^{-1}$ BM 35 min before	Capsule	NR performance results
Foskett et al.[48]	12	Soccer Players (New Zeland)	56.0 ± 4.0	6 $mg.kg^{-1}$ BM 60 min before	Capsule with anhydrous CAF powder	Countermovement jump*
						Mean 15-m sprint
						LSPT movement time
						LSPT penalty time (s)*
						LSPT total time (s)*
Machado et al.[50]	15	Soccer Players (Brazil)	NR	5.5 $mg.kg^{-1}$ BM 45 min before	Capsule	RSA
Del Coso et al.[49]	19	Semiprofessional (Spain)	NR	3 $mg.kg^{-1}$ BM 60 min before	Energy Drink (Sugar-free Red Bull®, which contain taurine, B-group vitamin, glucoronolactone)	Mean jump height (cm)*
						Mean power 15-s jump (kW)*
						Peak running speed (km/h)*
						Total distance

						covered (m)* Distance covered at high-intensity running (m)* Sprints performed (number) *
Pereira et al.[51]	20	Professional (Brazil)	NR	5.5 mg.kg^{-1} BM 55 min before	Capsule	YYIRT*
Bassini et al.[52]	19	Professional (Brazil)	NR	5 mg.kg^{-1} BM 60 min before	Capsule	YYIRT

Legend: VO_{2max} = maximum oxygen uptake; § = values are Mean ± SD; * = $p < 0.05$; NR = not reported; LSPT = Loughborough Soccer Passing Test; RSA = repeated sprint ability; YYIRT = Yo-Yo Intermittent Recovery Test; CAF = caffeine.

4. Combined carbohydrate and caffeine ingestion *and* soccer performance

In the last few years, some evidence has emerged supporting an additive benefit of combining CHO and CAF ingestion (CHO + CAF) on physical and technical performance in soccer (Table III). The results of these studies suggest that CHO + CAF shows a positive effect on jump performance,[27,31] sprint performance,[27] and time to exhaustion,[28] when compared to CHO alone. Controversially, CHO + CAF seem to have no effect [31] on agility performance, compared to CHO alone. Only one study has investigated the effects of CHO + CAF ingestion on technical performance, and observed no significant difference on passing performance.[27]

Guttierres et al.[31] evaluated the effects of CHO + CAF ingestion on jump performance in comparison with CHO alone. The athletes performed a soccer match with regular intake of CHO + CAF (7% CHO + 7.3 $mg.kg^{-1}$ BM of CAF) or CHO (7% CHO). Supplements were taken 20 min before (5 $ml.kg^{-1}$ BM) and every 15 min (3 $ml.kg^{-1}$ BM) during the match. The jump height in CHO + CAF was increased after the match in comparison with baseline ($p < 0.05$), but not in CHO ($p > 0.05$). Moreover, CHO + CAF post-match jump height performance was significantly higher than CHO alone ($p < 0.05$). On the other hand, there was no difference in agility performance between the conditions ($p > 0.05$). The authors suggested that the addition of CAF may have no influence on agility performance because it is dependent on a more complex coordinative process, compared to jump performance.

Similarly, Gant et al.[27] investigated the ingestion of CHO + CAF (6% CHO + 3.7 $mg.kg^{-1}$ BM of CAF) on jump and sprint performance. The players ingested a volume of CHO + CAF or CHO equivalent to 8 $ml.kg^{-1}$ BM 60 min before and 3 $ml.kg^{-1}$ BM every 15 min of the LIST. There was an improved jump performance during and after a LIST protocol, in comparison with CHO alone (6% CHO). Additionally, the mean sprint time for each block of the LIST was significantly lower during CHO + CAF, mainly in the last three blocks ($p < 0.05$). The researchers suggested that CAF had an influence on fatigue perception, allowing these athletes to better maintain voluntary sprinting performance during the final stages of the exercise.

Although both of these studies[27,31] have presented some evidence for the benefits of combined CHO + CAF on physical performance, there is a lack of knowledge regarding technical performance. Gant et al.[27] investigated the effect of CHO + CAF on passing skill. Soccer passing skill was not significantly different between CHO + CAF and CHO alone, although the total time taken to complete the passing protocol (LSPT) increased 13% during the CHO trial, but only 3% during the CHO + CAF trial; this difference was not statistically significant ($p = 0.26$). The authors attributed their results to the fact that the caffeine dose (3.7 $mg.kg^{-1}$ BM) was almost two times lower compared to another study where caffeine increased passing performance.[48] This suggests that certain aspects of cognitive performance are affected only at higher concentration doses of caffeine, while other motor tasks (sprinting and jumping) could be sensitive to lower doses. Alternatively, it would be suggested that isolated CHO ingestion offsets the decline in passing performance during the 90 min period,[32] and adding CAF would not have additive effects over that produced by CHO. However, the absence of an experimental session with isolated CAF or PLA trials limits the exploration of this claim.

More recently, Taylor et al.[28] conducted a study to test the hypothesis that coingestion of CHO + CAF during a 4-h recovery period after glycogen-depleting exercise augments subsequent high-intensity, interval-running capacity compared with CHO alone. The athletes performed a morning session consisting of treadmill running aiming for depletion of MG, followed by a 4-h passive recovery period in which they ingested: 1) 1.2 $g.kg^{-1}$ $BM.h^{-1}$ BM of 15% CHO (CHO); 2) the same amount and type of CHO added to 8 $mg.kg^{-1}$ BM of CAF (CHO + CAF); or 3) PLA. Following 4 h, the players performed a LIST. Participants had a significant ($p < 0.05$) increase in time to exhaustion in CHO + CAF (48 ± 15 min) compared to CHO and PLA (32 ± 15 and 19 ± 6 min, respectively). Differences in high-intensity, interval-running capacity between CHO and PLA trials approached significance ($p = 0.06$). Confirming the authors' hypothesis, this study demonstrated that CAF + CHO co-ingestion during recovery between training sessions increases performance in the subsequent training session. Although the precise mechanisms for these effects are currently only speculative, it has an important practical application. However, the absence of isolated CAF trial is still a limitation.

Despite the fact that the mechanism of enhance performance by CHO and CAF co-ingestion are not fully understood, it has been speculated that it exerts an influence on both central and peripheral events. Firstly, CAF *per se* is a nonselective adenosine inhibitor leading to modified pain perception while sustaining motor unit firing rates and neuromuscular excitability.[20] Additionally, CAF may increase motivational drive in the brain, which in turn results in a lowered rating of perceived exertion.[56] Peripherally, CAF also increases plasma epinephrine concentrations,[57] and this increased hormonal release influences the activity of the glycogen phosphorylase increasing glycogenolysis.[58] A part of these isolated effect of CAF, CAF + CHO co-ingestion result in higher intestinal glucose absorption and increase exogenous CHO oxidation, when compared to CHO alone. These findings have been attributed to CAF inhibiting the enzyme phosphodiesterase which enables cAMP to remain active longer at the cell membrane. The cAMP has been shown to acutely increase glucose absorption via activation of sodium-glucose-linked transporter 1 (SGLT1[59]), increasing the glucose flux through SGLT1 into the enterocyte. A second transporter, GLUT-2, is responsible for glucose transport from the enterocity to the blood, which could potentially lead to a higher availability of CHO for oxidation.[29,30] It is interesting to note that studies have concentrated on comparison between CHO against CAF + CHO, making impossible to identify if a positive effect of combined supplementation comes from the combination or CAF alone.

In summary, recent evidence suggest that combining CHO + CAF ingestion increases jump and sprint performances, and time to exhaustion in a training session performed subsequently to a strenuous training session. Nevertheless, a misleading factor influencing the definitive conclusion is the fact there is no comparison between CHO+CAF with CAF alone, what in turn makes impossible to determine if either is the combination of CHO+CAF or CAF *per se* that improves the performance. In this regard, future studies should be performed to elucidate the mechanisms responsible for these effects, and to analyze the effects of combined CHO + CAF intake on technical performance of soccer players.

Table III. Summary of carbohydrate combined with caffeine supplementation effects on soccer performance. Studies are showed in chronological order.

Study	n	Level (Country)	VO_{2max} (ml.kg^{-1}.min^{-1})§	CHO+CAF Supplementation and concentration	Task
Guttierres et al.[31]	18	Under-17 (Brazil)	50.1 ± 3.2	5 ml.kg^{-1} BM 20 min before and 3 ml.kg^{-1} BM every 15 min (7% CHO) + 7.3 mg.kg^{-1} BM of CAF	Sargent Test∗ Illinois Agility Test
Gant et al.[27]	15	Soccer Players (New Zeland)	56.0 ± 4.0	8 ml.kg^{-1} BM 60min before and 3 ml.kg^{-1} BM every 15 min (6% CHO) + 3.7 mg.kg^{-1} BM of CAF	Countermovement jump∗ Mean 15-m sprint∗ LSPT
Taylor et al.[28]	6	Recreational Players (England)	56.0 ± 1.0	1.2 g.kg^{-1} BM.h^{-1} (15% CHO) 1-4 h before and 8 mg.kg^{-1} BM of CAF 3 h and 1 h before	Time to exhaustion LSIT∗

Legend: VO_{2max} = maximum oxygen uptake; § = values are Mean ± SD; ∗ = $p < 0.05$ compared to CHO alone; LSPT = Loughborough Soccer Passing Test; LIST = Loughborough Intermittent Soccer Test; CHO = carbohydrate; CAF = caffeine.

5. Conclusions

A body of evidence has shown that isolated CHO ingestion has positive effects on soccer shooting performance, mainly towards the end of the game. However, results regarding the effects of CHO intake on sprint, agility, and passing performance remain controversial. The physiological mechanisms governing these discrepancies are not completely understood, but this may be linked with level of MG before the experimental exercise. Therefore, further studies should investigate the effects of CHO supplementation on physical and passing performance using a more-controlled pre-exercise MG stores. Nonetheless, beneficial effects of CHO supplementation on soccer-related performance have predominantly been observed in conditions of reduced MG availability, which could be interesting especially in the actual competitive soccer calendar or World Cup tournament, where the repetitive number of training/games, and reduced time to recovery between them, could lead to a potential decrease in MG stores.

The results from recent studies suggested that CAF ingestion has a positive effect on jump, peak running speed, and sprint performance, increasing the muscle power and the distance covered at a high-intensity during a simulated soccer match. However, part of this beneficial effect may be attributed to other stimulant substances in caffeined-beverages. Additionally, CAF intake may improve passing skills, but more studies are necessary to support this hypothesis.

Recent evidence also suggests that the combined ingestion of CHO and CAF is able to increase jump and sprint performances, and time to exhaustion of soccer players, more than CHO alone. However, the lack of studies comparing CHO+CAF with CAF alone precludes a definitive conclusion about the additive effect of combine CAF with CHO on performance.

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2º artigo: artigo de resultados

ANDRADE-SOUZA, VA; LIMA-SILVA, AE. Effects of isolated or combined carbohydrate and caffeine supplementation between two daily training sessions on soccer performance

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ABSTRACT

The aim of this study was to investigate whether isolated or combined carbohydrate (CHO) and caffeine (CAF) supplementation administrated during a 4-h recovery period following a first training session would have positive effects on subsequent soccer performance tests performed in a second session. Thirteen male soccer players completed four experimental trials in a randomized, double-blinded, and crossover design. In the morning, participants performed a 90-min Loughborough Intermittent Shuttle Test (LIST). Then, participants ingested: 1) 1.2 g . kg^{-1} body mass . h^{-1} CHO of a 20% CHO solution immediately after and 1, 2, and 3 h post the LIST; 2) a dose of CAF (6 mg . kg^{-1} body mass) 3 h post the LIST; 3) CHO combined with CAF (CHO + CAF); 4) distilled water combined with cellulose capsule (PLA). After this 4-h recovery, participants performed in a second session a countermovement jump test, a Loughborough Soccer Passing test and a repeated-sprint test (5 x 30 m). CAF tended to improve jump performance compared to control (34.9 ± 1.3 vs. 32.9 ± 1.0 cm, effect size = 0.56, $p = 0.07$), and significantly improved passing performance (40.9 ± 3.9 vs. control 45.8 ± 3.5 s, effect size = 0.42, $p < 0.05$). Both CHO and CHO + CAF ingestion promoted negative effects on rating of perceived effort and pleasure-displeasure. In conclusion, the isolated ingestion of CAF during the recovery seems to improve jump and passing performance, while there is no benefit when combined with CHO.

Keywords: Recovery, fatigue, supplementation, soccer, nutrition, athletic performance

Introduction

It is common practice for soccer players to train twice per day (Taylor et al. 2011). During these training sessions, soccer players commonly perform both physical and technical skill such as jumping, sprinting, agility, heading, passing, and shooting drills. However, a partial recovery (3 to 6 h) between sessions leads the athletes to initiate the second one with lower endogenous carbohydrate (CHO) stores, which could impair the athletic performance (Kirkendall 1993). In this regard, it was suggested that acute ingestion of a CHO beverage (1.2 g . kg^{-1} body mass (BM)) might be an optimal strategy to improve soccer-specific sprint and shooting performance, especially when the exercise starts with already reduced muscle glycogen stores (Taylor et al 2011; Ali et al. 2007b; Russell et al. 2012).

More recently, Taylor et al. (2011) demonstrated that adding caffeine ingestion (CAF, 8 mg . kg^{-1} BM) to CHO feeding (1.2 g . kg^{-1} BM . h^{-1}, 15% CHO), after a muscle-glycogen depletion protocol, improves subsequent high-intensity interval running capacity, compared with CHO feeding alone. However, an important concern when investigating the combined effect of CHO and CAF is that the results have not been compared with CAF alone. In this regard, it is not known if the positive effect of CHO + CAF is derived from a combination of these two supplements or is just an isolated effect derived from acute CAF alone.

The benefits of isolated CAF administration after a full-rest period (24-48 h) on parameters involved with soccer performance such as vertical jump height, total distance covered during a simulated soccer game, and number of sprint bouts during the game has been demonstrated (Schneiker et al. 2006; Foskett et al. 2009; Del Coso et al. 2012). Additionally, acute CAF ingestion reduces perceived exertion and increases both pleasure and perceived activation during the exercise, indicating that the main effect of CAF could be by stimulating the CNS (Doherty and Smith 2005; Astorino et al. 2012; Sawyer et al. 1982). A recent study from our laboratory supports the notion that isolated CAF ingestion is able to counteract the negative effects of an exercise-induced reduction in CHO stores on cycle time-trial performance (Silva-Cavalcante et al. 2013). This results suggest that isolated acute CAF supplementation, without any CHO ingestion, might have a benefit during the second training session following a first training session.

Therefore, considering the lack of studies with a randomized, double-blind, crossover design investigating the effects of isolated or combined CHO and CAF supplementation administrated before a second training session, this study was design to investigate whether isolated and combined CHO and CAF supplementation administrated between two training sessions would have effect on subsequent soccer-related performance parameters. We hypothesized that the co-ingestion of CHO + CAF would improve soccer-related performance when compared with isolated CHO ingestion, although the main benefits might be attributable to CAF alone.

Materials and methods

Participants

Thirteen male soccer players (age 25.4 ± 2.3 years; height 1.79 ± 0.08 m; body mass 83.7 ± 14.6 kg; body fat 16.7 ± 3.9 %; peak oxygen uptake 43.9 ± 2.3 ml . kg-1 . min-1) volunteered to participate in this study. All players were members of the University soccer team. However, two of them were excluded from the experimental analysis due muscle injuries before the experimental tests (n = 11), but their data were maintained in the reliability analysis (n = 13). The sample size required was estimated to be at least 9 participants from the equation n = 8e2/d2, where n, e, and d denote predicted sample size, coefficient of variation, and the magnitude of the treatment effect, respectively (Hopkins 2000). Coefficient of variation and treatment effect were assumed to be 3% for tests applied in this study (Nuzzo et al. 2011; Ali et al. 2007b). This study was performed during the pre-season training period. Participants were instructed to refrain from exercise and consuming alcohol and caffeine-containing substances during the 24 h prior to each trial. This study was submitted and approved by the Local Ethics Committee and a written informed consent was obtained from all participants.

Preliminary measurements

Participants reported to the laboratory on three separate occasions for preliminary and reliability measurements. During the first visit, an anthropometric assessment and a Yo-Yo Intermittent Recovery Test Level 1 (YYIRT1) to estimate peak oxygen uptake (VO2peak) were performed, as described elsewhere (Krustrup et al. 2003). Following ten minutes of passive recovery, participants were familiarized with the Soccer Field-Test Battery consisting of countermovement jump (CMJ), a passing accuracy test (Loughborough Soccer Passing Test, LSPT) and a 30-m repeated-sprint test (RST), interspersed by a 5 min of recovery between each test. In the next two sessions, seven days apart, participants performed Soccer Field-Test Battery to determine both baseline (control) values, and test and retest reliability. Athletes were asked to record their food and drink consumption during the 24 h prior the first control trial and to replicate this 24 h prior to each subsequent trial.

Experimental procedures

Participants completed four experimental trials (7 days apart), with the first beginning seven days after the last control trial. The experimental trials were performed using a randomized, double-blinded, and crossover design (figure 1).

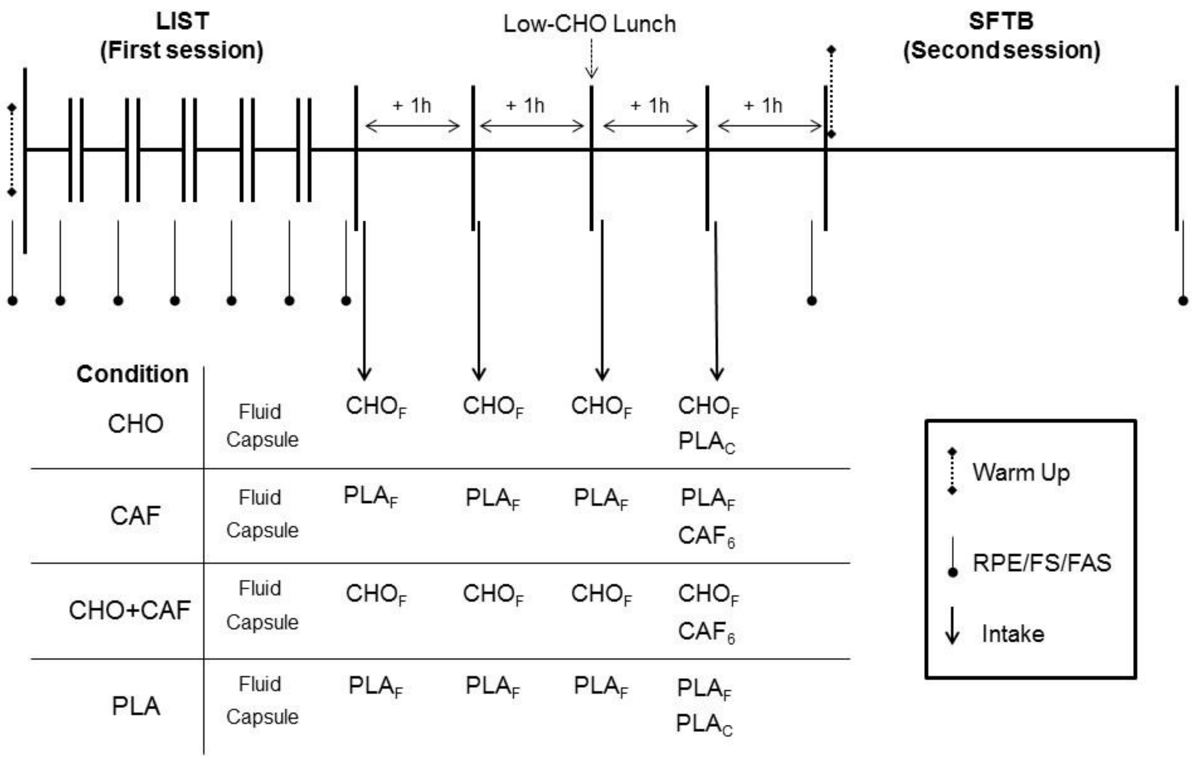

Figure 1. Timeline of experimental protocol. CHO = Carbohydrate; CAF = Caffeine; PLA = Placebo; LIST = Loughborough Intermittent Soccer Test; SFTB = Soccer field-test battery; CHOF = 1.2 g . kg^{-1} . h^{-1} BM of maltodextrin, CAF6 = 6 mg . kg^{-1} BM of caffeine, PLAF = distilled water corresponding to CHO placebo, PLAc = cellulose capsule corresponding to CAF placebo; RPE = Rating of Perceived Exertion Scale; FS = Feeling Scale; FAS = Felt Arousal Scale.

In a given experimental day, players arrived at the laboratory at 6:30 AM and consumed a standardized breakfast (532 kcal: 56.4% CHO, 27.4% fat, 16.1%

protein). One hour later, participants performed a 90-min Loughborough Intermittent Shuttle Test (LIST). Then, participants ingested either: 1) 1.2 g . kg^{-1} BM . h^{-1} CHO (maltodextrin tasteless and odorless, diluted in distilled water, 20%) immediately after and 1, 2, and 3 h post the LIST (CHO condition); 2) 6 mg . kg^{-1} BM of CAF 3 h post the LIST (CAF condition); 3) CHO combined with CAF (CHO + CAF condition); 4) distilled water immediately after and 1, 2, and 3 h post LIST, with the addition of a cellulose capsule after 3 h (PLA condition). Corresponding placebo intake was offered at the same time during CHO, CAF and CHO+CAF conditions to keep participants blinded from the supplementation schedule. At the midpoint of this supplementation schedule (~ 11:30 AM), participants consumed a standardized low-CHO lunch containing ~ 7.6 g of CHO (527 kcal: 5.3% CHO, 85.8% fat, 8.7% protein) to avoid interference of long fasting on performance. It has been demonstrated that this low-CHO lunch results in non-significant muscle glycogen resynthesis until the second exercise training session (Morton et al. 2009). An hour after the last supplementation intake, participants performed a Soccer Field-Test Battery (~ 1:30 PM).

First training Session

After a 5-min warm up (jogging at 8 km . h^{-1}), participants performed the LIST (see Nicholas et al. 2000 for more specific details). Briefly, the protocol consisted of a fixed period of variable-intensity shuttle running over 20 m. The participants completed six 15-min blocks consisting of approximately 11 repeated cycles of walking, maximal sprinting, jogging, and running, interspersed by 3 min of rest.

Second session (Soccer Field-Test Battery)

The participants carried out a 5-min warm up (jogging at 8 km . h^{-1}), followed by the Soccer Field-Test Battery. Tests into the Soccer Field-Test Battery were separated by 5 minutes to recovery:

Vertical Jump test

Athletes performed a CMJ on the pitch starting from an erect standing position. The athletes were instructed to maintain their hands on their hips and to takeoff and land on the pitch at the same place. A digital camera (60 Hz) recorded the jumps and height was estimated as suggested by Bosco et al. (1995). The players performed three CMJ and the best CMJ was considered for analysis.

Loughborough Soccer Passing Test (LSPT)

The LSPT was described in details elsewhere (see Ali et al. 2007a). Briefly, players performed sixteen passes against colored targets, whilst maneuvering around a grid of cones and lines, as quickly as possible. Performance comprised time to complete the passes plus any additional penalty time for inaccurate passing or poor control of the ball (figure 2).

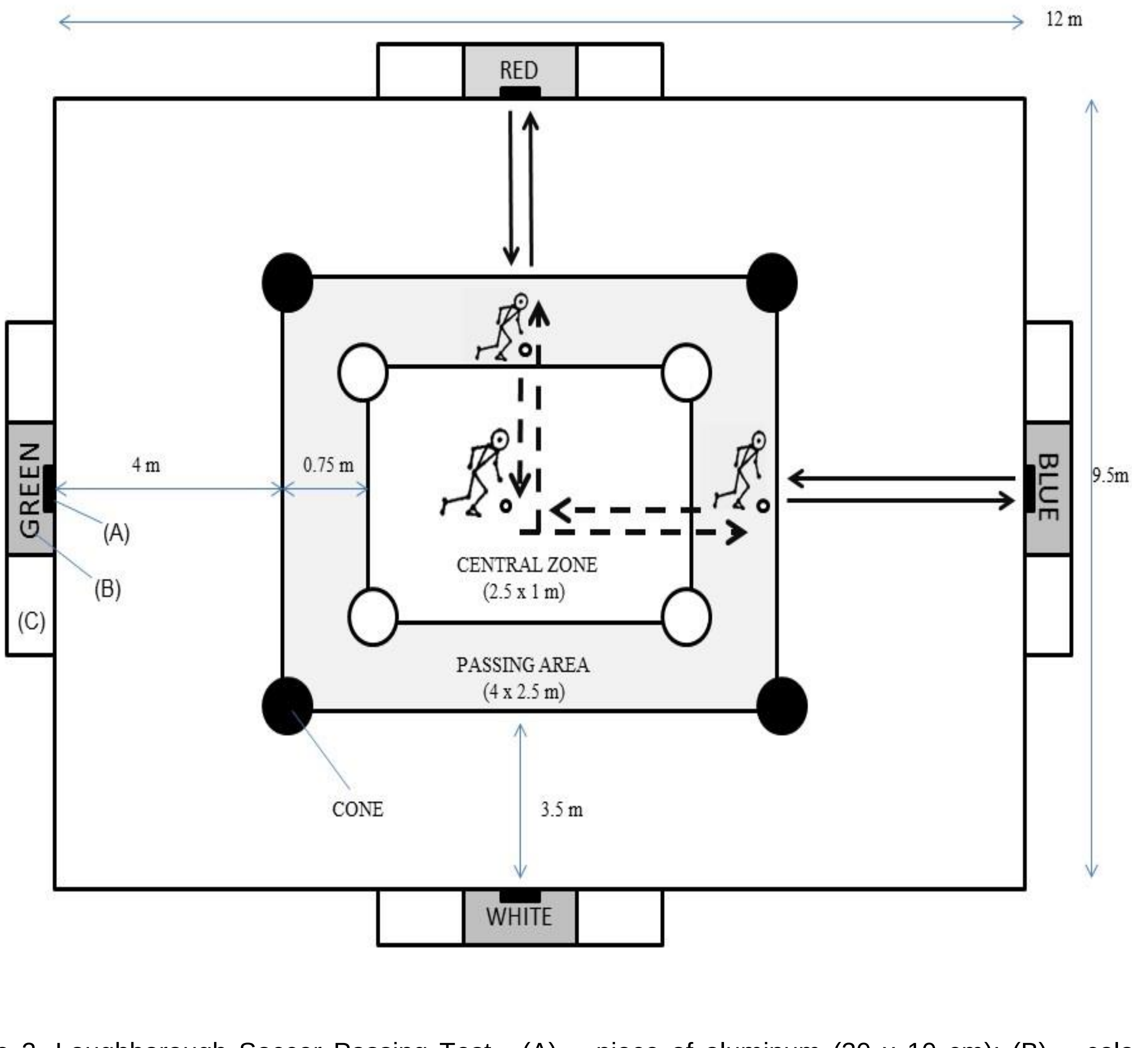

Figure 2. Loughborough Soccer Passing Test. (A) = piece of aluminum (30 x 10 cm); (B) = color target area (red, blue, white and green; 60 x 30 cm); (C) = wooden bench (250 x 30 cm); - -> = displacement of the player controlling the ball; → = displacement of the ball after pass execution; note that the order of the passes is clockwise.

30-m Repeated-Sprint test

Five, 30-m sprints, separated by 25 s of active recovery were performed to measure repeated sprint performance (Krustrup et al. 2006; Bishop et al. 2001). The sprint times were recorded by a digital camera (60 Hz) and then best sprint time, total time and percentage of decrement were calculated.

Measurements

Capillary blood samples (50 µL), heart rate, pleasure-displeasure, perceived activation, and perceived exertion were assessed immediately prior to and after the test battery. Plasma lactate concentration ([La]) was determined by a spectrophotometer using commercial kits (Biotecnica®, Varginha, Brazil). HR was recorded using a heart rate monitor (Polar S810i®, Polar Electro OY, Kempele, Finland). Pleasure-displeasure was assessed using an 11-point, single-item, bipolar FS scale (Hardy and Rejeski 1989). Perceived activation/arousal was estimated from a 6-point, single-item, polar FAS scale (Svebak and Murgatroyd 1985). The rating of perceived exertion scale (15-point RPE) was used to access perceived effort (Borg 1998).

Statistical Analysis

All data are expressed as mean ± SEM. Data distribution was analyzed using the Kolmogorov-Smirnov test and homogeneity by Levene’s test. Test-retest reliability was examined using paired t tests, interclass correlation coefficients, and typical error of measurement. Differences between [La], HR, RPE, FS, and FAS were analyzed using a two-way repeated-measures general linear model with time (pre and post exercise) and condition (control, CHO, CAF, CHO+CAF, and PLA) as factors. Differences in performance between conditions were analyzed using repeated measures general linear model. A Bonferroni correction for multiple comparisons was employed for post hoc analysis when necessary. The effect size was calculated to evaluate performance differences between conditions, using 0.2, 0.5 and 1.0 as small, moderate and large effect thresholds, respectively (Betterham and Hopkins 2006). The level of significance was established at $p \leq .05$. All analysis were performed in SPSS (version 17 for Windows, SPSS Inc., Chicago, IL).

Results

Test-retest Reliability

There were no significant differences between test and retest values for all performance measurements (Table 1; all $p > .05$). All outcomes presented a moderate to highly reliability, except for the fatigue index in RST. Based on this, percentage of decrement was not used in the posterior comparisons.

Table 1. Mean (±SD) for measurements of the Soccer Field Test Battery for test and retest, as well interclass correlation coefficient (ICC) and typical error of measurement (TEM).

	Test	Retest	ICC	TEM (%)
CMJ (cm)	32.3 ± 4.2	32.6 ± 3.3	0.85	1.9 (1.4 – 3.2)
LPST (s)	48.5 ± 14.9	49.4 ± 13.1	0.84	7.6 (5.4 – 12.8)
RST				
Best sprint (s)	5.3 ± 0.3	5.4 ± 0.3	0.68	0.2 (0.2 – 0.4)
Total time (s)	28.0 ± 1.6	28.5 ± 1.6	0.83	0.9 (0.6 – 1.4)
Decrement (%)	4.3 ± 2.3	4.3 ± 3.6	0.18	2.9 (2.1 – 4.8)

CMJ = countermovement jump; LSPT = Loughborough Soccer Passing Test; RST = repeated sprint test.

Performance

The CMJ height tended to be higher in CAF than in control ($p = 0.07$), reaching a moderate effect size (0.56), but there were no differences across the other conditions (Figure 3A; all $p > 0.05$). CAF decreased the total time to complete the LSPT compared to control ($p < 0.05$; effect size = 0.42; Figure 3B). There were no differences for best sprint and total sprints time between the conditions (Figure 3C; all $p > 0.05$).

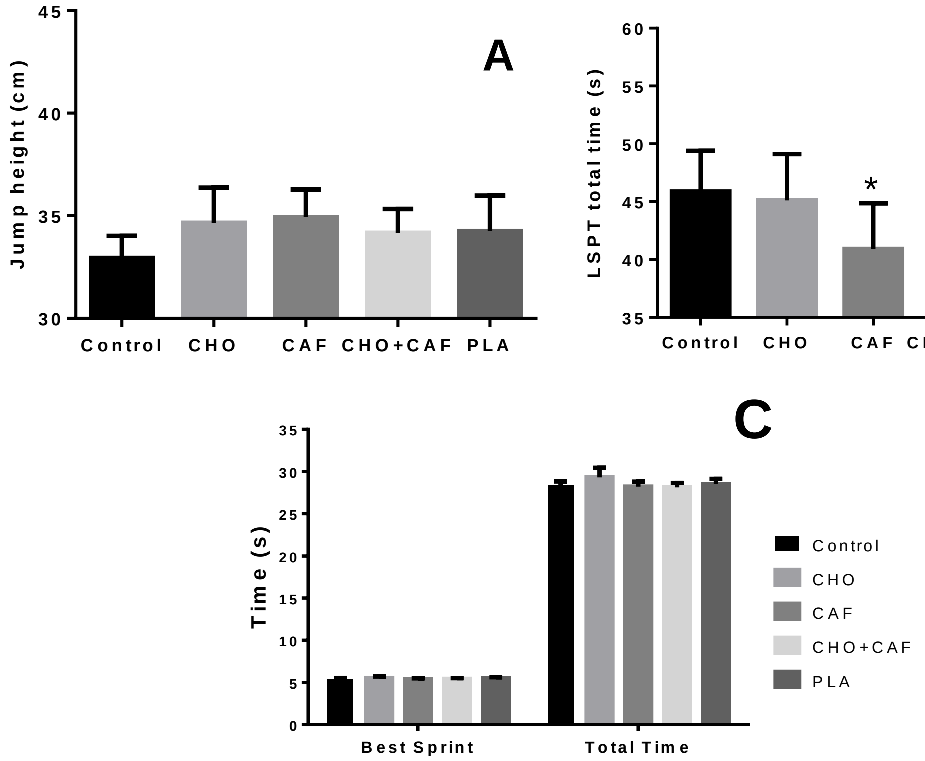

Figure 3. Countermovement jump height (A), Loughborough Soccer Passing Test (B), and 30-m Repeated Sprint test (C) results for control, CHO, CAF, CHO+CAF, and PLA trials (mean ± SEM). Carbohydrate; CAF = Caffeine; CHO+CAF = Carbohydrate + caffeine; PLA = Placebo. *Significantly different from control test ($p \leq 0.05$).

Physiological and perceptual responses

The [La] increased with the exercise similarly between the conditions ($p \leq 0.05$, figure 4A). Nevertheless, [La] for CAF and PLA was lower in both pre- and post-tests compared to control ($p \leq 0.05$). Additionally, post-test [La] in CHO was lower than control ($p \leq 0.05$).

For all conditions, the RPE and FAS increased, whereas FS declined from pre to post tests ($p \leq 0.05$; Figure 4B, 4C and 4D). The CHO and CHO+CAF exhibited higher RPE and lower FS values compared to control in pretest ($p \leq 0.05$), but these differences disappeared posttest ($p > 0.05$; Figure 4B and 4C, respectively). HR increased with the exercise, but there were no differences between the conditions ($p > 0.05$).

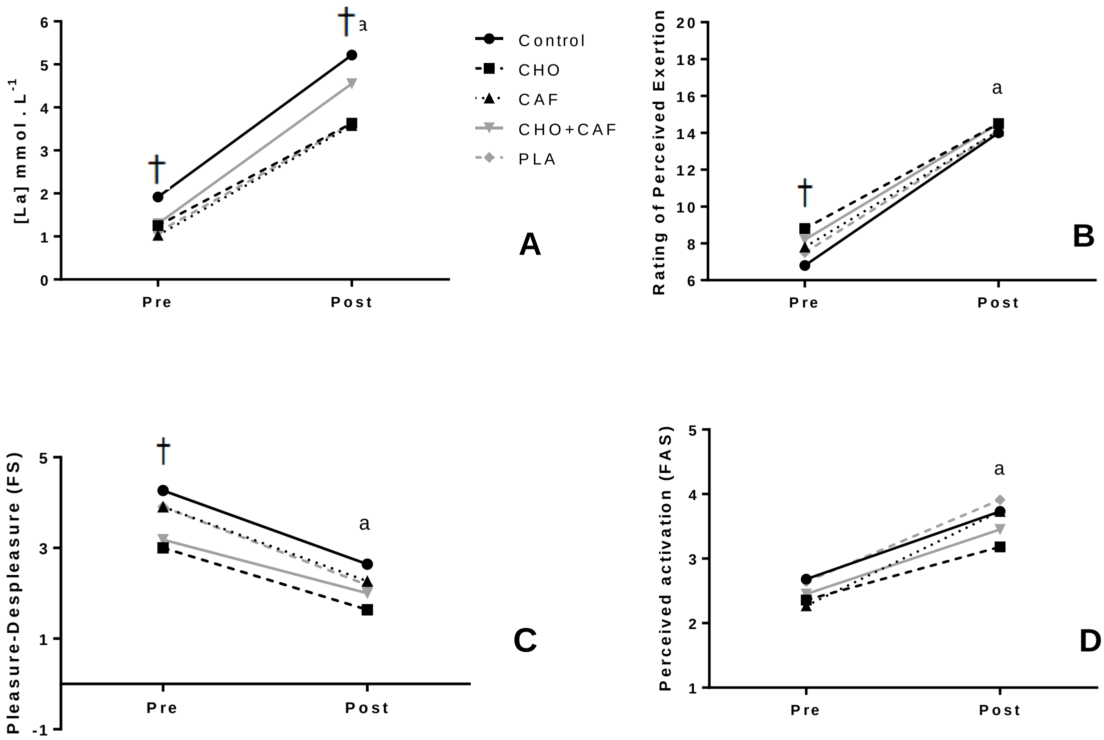

Figure 4. Mean of plasma lactate concentration (A), rating of perceived exertion (B), pleasure–displeasure (C) and perceived activation (D) before and after tests for control, CHO, CAF, CHO+CAF, and PLA trials. CHO = Carbohydrate; CAF = Caffeine; CHO+CAF = Carbohydrate + caffeine; PLA = Placebo. †Control different from CAF and PLA at pre test, and different from CHO, CAF and PLA at post test in (A). †Control different from CHO and CHO+CAF at test in (B and C) (all $p < 0.05$); a Significantly different from pre test in all conditions ($p < 0.05$).

Discussion

The aim of this study was to investigate whether isolated or combined CHO and CAF supplementation, administrated after a first training session, would affect subsequent performance during tests associated with soccer skills. The main finding of this study was that the isolated ingestion of CAF, but not associated with CHO, tended to improve CMJ and increase passing accuracy.

The CMJ performance did not decrease in the second session compared to the control for all conditions, suggesting there was no effect of residual fatigue. This suggests that a 4-h recovery after the LIST was sufficient to restore CMJ performance. Foskett et al. (2009) observed that CMJ performance was not impaired immediately after a 90-min LIST, suggesting that this protocol does not induce an acute negative effect on jump performance. On the other hand, we found that CAF ingestion produces a moderate improvement in CMJ performance (effect size = 0.56) in comparison with control, but this effect was not evident when combined with CHO. This is consistent with other studies showing that caffeine improves CMJ performance before and after an exercising protocol (Foskett et al. 2009; Del Coso et al. 2012). The mechanism by which CAF enhances CMJ performance is not completely understood, but it could be that CAF induces a more favorable intracellular ionic environment in the active muscle, resulting in an increased force production by the motor units (Kalmar and Cafarelli 1999; Graham 2001).

Passing skills are central to success in soccer (Gant et al. 2010). It was reported that isolated CAF enhanced passing accuracy (Foskett et al. 2009), while CHO ingestion reduced the decline in passing accuracy during a simulated match play (Ali et al. 2007b; Ali and Williams 2009). In the present study, the co-ingestion of CHO and CAF did not promote positive effects on passing skills, corroborating with Gant et al. (2010) who observed no improvement in soccer passing accuracy when combining both supplements. However, we observed that isolated ingestion of CAF improved the performance in LSPT compared to control.

Foskett et al. (2009) attributed an improved passing after CAF ingestion to a decrement in the penalty time, which is added negatively in the test score. In the current study, CAF ingestion produced a moderate, negative effect on penalty time in comparison with control (effect size = 0.44, data did not shown). Together, these results suggest that CAF may enhance fine motor skills such as ball control and passing accuracy (Foskett et al. 2009). The blockade of adenosine receptors by CAF increasing neuronal excitability and synapse transmissions may explain the improvement in the fine motor skills (Davis et al. 2003). Because CAF had no effect when combined with CHO, it seems reasonable to speculate that the co-ingestion of CHO and CAF might have concurrent effect on acute exercise. Acute CAF ingestion stimulates sympathetic nervous system and inhibits phosphodiesterase activity increasing muscle glycogen breakdown, while CHO promote the opposite (Davis et al. 2003; Lima-Silva et al. 2010; Spriet et al. 1992; Saltiel and Kahn 2001). Therefore, these concurrent effects of CHO and CAF co-ingestion might offset the ergogenic effect of CAF ingestion alone.

There were no differences in repeated-sprint performance between the conditions. Only two studies directly analyzed the effects of isolated CAF ingestion on RST performed by soccer players and produced conflicting results (Del Coso et al. 2012; Machado et al. 2009). Machado et al. (2009) found no significant differences during multiple-sprints between CAF supplemented and non-supplemented athletes. In contrast, Del Coso et al. (2012) found that a caffeinated energy drink increased the mean peak running speed during repeated sprints. This discrepancy may be due the presence of other stimulants such as taurine, glucoronolactone, and B-group vitamins in the energy drink. However, no research to date has directly compared the effects of isolated CHO and combined CHO + CAF on RST in soccer players. Thus, our results suggest that the acute ingestion of both CHO and CAF, either isolated or combined, has no effect on subsequent RST performance.

Plasma lactate concentrations were lower in all conditions when compared to control, but were significantly lower in CAF and PLA in pretest, and in CHO, CAF and PLA in posttest. Compared to the control test, the presence of a first training session in the other four conditions probably promoted a reduction in the initial muscle glycogen levels, which may have reduced plasma lactate concentrations during exercise (Gollnick et al. 1973). It has previously been reported that LIST was able to cause a reduction in the muscle glycogen stores (Nicholas et al. 1999). Our results are therefore in agreement with other studies demonstrating that blood lactate concentration is reduced after a muscle glycogen depletion protocol (Gollnick et al. 1973; Lima-Silva et al. 2009; Lima-Silva et al. 2013).

In the current study, isolated CHO and combined CHO + CAF promoted an increase in RPE and a decrease in pleasure before the tests, compared to control. On the other hand, this adverse effect was not observed after the tests. The reason for this increased RPE and reduced pleasure pre trial with CHO is not clear. The use of a high-concentrated CHO beverage (20% CHO) may have induced some gastrointestinal discomfort. However, although we did not measure it formally, there were no systematic complaints from participants linked with supplementation. In addition, similar high-concentrated CHO beverages have been described in the literature without gastrointestinal discomfort (McConell et al. 1996; Taylor et al. 2011). The option to use a high-CHO concentrated beverage was an attempt to reduce total volume of liquid ingested, avoiding thus any gastrointestinal discomfort caused by large liquid volumes.

A limitation of the current study is the absence of muscle glycogen measurement before and after the first training session. However, Nicholas et al. (1999) reported that the LIST was able to cause a reduction in muscle glycogen, suggesting that a reduction in muscle glycogen must have happened in the present study after the first training session. In addition, a reduced sample size (n = 11) may have precluded the confirmation of differences between some conditions. Nevertheless, considering the complexity of the experimental design, and the number of manipulated and controlled variables, and the fact that calculated sample size required at least nine participants, we argue that we recruited an appropriately-power sample size.

In summary, the isolated ingestion of CAF, but not when combined with CHO, after a first training session tended to improve jump performance and improved passing accuracy during a subsequent session. Within a real training situation, this would indicate that the ingestion of CAF before the second training session would allow the player to make more accurate passes. Furthermore, the positive effects of CAF alone suggest that any effect of CHO + CAF may not be derived from a potentiation of these two supplements, but rather an isolated effect of CAF alone.

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3 CONSIDERAÇÕES FINAIS

Uma aplicação prática dos nossos resultados seria o uso da CAF durante os intervalos entre as sessões de treinamentos, uma vez que atletas frequentemente realizam duas sessões de treinamento em períodos diferentes do dia, o que pode resultar na redução da reserva de glicogênio muscular e prejudicar a manutenção da intensidade da segunda sessão de treinamento. Em conclusão, o presente estudo demonstrou que a ingestão isolada de CAF, diferentemente do uso combinado com CHO, durante um período de recuperação de 4 horas entre as sessões de treino da manhã e da tarde, melhorou a altura de salto vertical e a precisão de passe na sessão de treino da tarde. Em uma situação real de treinamento, esses resultados indicam que a ingestão de CAF antes da segunda sessão de treinamento permitiria ao jogador saltar mais alto durante a realização do cabeceio e realizar passes com maior precisão. Adicionalmente, os efeitos positivos da suplementação de CAF sugerem que qualquer efeito da ingestão combinada de CHO e CAF não é derivado de uma potencialização desses dois suplementos, mas pode ser um efeito isolado da CAF.

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5 APÊNDICES

APÊNDICE A

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (T.C.L.E.)

(Em 2 vias, firmado por cada participante voluntário(a) da pesquisa e pelo responsável)

"O respeito devido à dignidade humana exige que toda pesquisa se processe após o consentimento livre e esclarecido dos sujeitos, indivíduos ou grupos que por si e/ou por seus representantes legais manifestem a sua anuência à participação na pesquisa"

Eu,..,.......................

tendo sido convidado(a) a participar como voluntário(a) do estudo "O efeito da suplementação de cafeína sobre o desempenho em tarefas intermitentes de alta intensidade", que será realizada no Laboratório de Nutrição Experimental, Faculdade de Nutrição – FANUT - UFAL recebi do Sr Adriano Eduardo Lima da Silva*,* Professor Adjunto II da Faculdade de Nutrição da Universidade Federal de Alagoas, responsável por sua execução, as seguintes informações que me fizeram entender sem dificuldades e sem dúvidas os seguintes aspectos:

1) Que o estudo se destina a avaliar o efeito da suplementação de cafeína sobre o desempenho em exercícios intermitentes;

2) Que a importância deste estudo é quais os efeitos da suplementação de cafeína sobre o desempenho específico do futebol;

3) Que os resultados que se desejam alcançar são a melhoria do desempenho no Loughborough Soccer Passing Test (LSPT);

4) Que este estudo começará em 04 de fevereiro de 2013 e terminará em 30 de abril de 2013;

5) Que eu participarei do estudo da seguinte maneira: Irei até o laboratório sete vezes e realizarei uma avaliação antropométrica, duas sessões de familiarização com os protocolos de testes, e quatro testes para a depleção dos estoques de glicogênio muscular seguidos da realização dos testes experimentais, com duração aproximada de 40 minutos. Antes de cada um dos testes, eu deverei realizar a administração de conteúdos diferentes de cafeína;

6) Que os possíveis riscos à minha saúde física e mental são complicações cardíacas que possam ocorrer durante o teste;

7) Que os pesquisadores adotarão as seguintes medidas para minimizar os riscos: verificar se estou livre de fatores de riscos associados a doenças cardiovasculares, pulmonares ou metabólicas; se terei disponibilidade e aptidão para iniciar o programa de testes estabelecidos no presentes estudo e durante a realização dos testes serei monitorado por meio de um monitor cardíaco;

8) Que poderei contar com a assistência do Professor Dr. Adriano Eduardo Lima da Silva e caso eu tenha algum problema, eu serei transportado de ambulância pública ou de automóvel particular para o hospital mais próximo da Universidade, o Hospital Universitário (HU);

9) Que os benefícios que deverei esperar com a minha participação são: eu terei acesso a qualquer resultado referente ao meu teste e que poderei, a qualquer momento, esclarecer minhas dúvidas com o pesquisador responsável;

10) Que, sempre que desejar, serão fornecidos esclarecimentos sobre cada uma das etapas do estudo;

11) Que, a qualquer momento, eu poderei recusar a continuar participando do estudo e, também, que eu poderei retirar este meu consentimento, sem que isso me traga qualquer penalidade ou prejuízo;

12) Que as informações conseguidas através de minha participação não permitirão a identificação da minha pessoa, exceto aos responsáveis pelo estudo, e que a divulgação das mencionadas informações só será feita entre os profissionais estudiosos do assunto;

13) Que eu deverei ser ressarcido por qualquer despesa que venha a ter com a minha participação nesse estudo e, também, indenizado por todos os danos que venha a sofrer pela mesma razão, sendo que, para estas despesas foi-me garantida a existência de recursos.

Finalmente, tendo eu compreendido perfeitamente tudo o que me foi informado sobre a minha participação no mencionado estudo e, estando consciente dos meus direitos, das minhas responsabilidades, dos riscos e dos benefícios que a minha participação implica, concordo em dela participar e, para tanto eu DOU O MEU CONSENTIMENTO SEM QUE PARA ISSO EU TENHA SIDO FORÇADO OU OBRIGADO.

Endereço do(a) participante voluntário(a):

Domicílio: (rua, conjunto)..Bloco: ....

Nº: ...., complemento: ....Bairro: ....

Cidade: ....CEP.:.....................................Telefone: ....

Ponto de referência: ....

Contato de urgência (participante): Sr(a): ....

Nome e Endereço do Pesquisador Responsável:

Adriano Eduardo Lima da Silva

Endereço: Rua Marechal Álvaro Alvin Câmara. Bloco: /Nº: /Complemento: 48/apto 803.

Bairro: /CEP/Cidade: Jatiúca/57035-530/Maceió Telefones p/contato: 82 96156579

Instituição: **Universidade Federal de Alagoas. Endereço (Rua, nº): Avenida Lorival Melo Mota, S/N – Campus A.C. Simões – BR 104 Norte Km 14, CEP: 57072-970, Maceió, Alagoas.**

ATENÇÃO: Para informar ocorrências irregulares ou danosas, dirija-se ao Comitê de Ética em Pesquisa e Ensino (COEPE), pertencente ao Centro Universitário Cesmac – FEJAL: Rua Cônego Machado, 918. Farol, CEP.: 57021-060. Telefone: 3215-5062. Correio eletrônico: cepcesmac@gmail.com

Maceió, _________ de ______________________ de _________

____

Assinatura ou impressão datiloscópica do(a) voluntário(a) ou responsável legal
(rubricar as demais folhas)

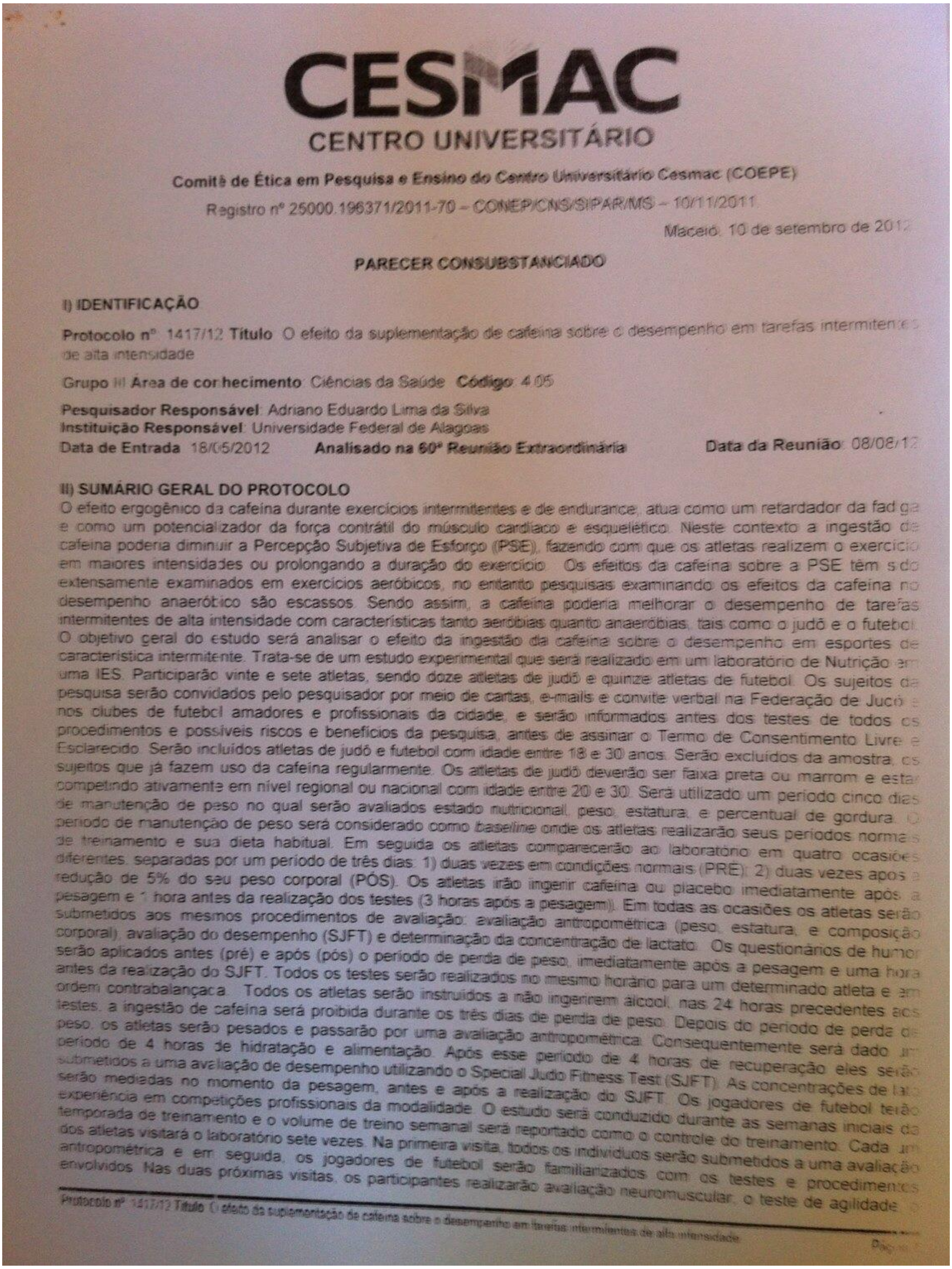
____

Assinatura do responsável pelo Estudo
(rubricar as demais folhas)

6 ANEXOS

ANEXO A

PARECER DO COMITÊ DE ÉTICA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Comitê de Ética em Pesquisa e Ensino do Centro Universitário Cesmac (COEPE)

Registro nº 25000.196371/2011-70 – CONEP/CNS/SIPAR/MS – 10/11/2011

Maceió, 10 de setembro de 2012

PARECER CONSUBSTANCIADO

I) IDENTIFICAÇÃO

Protocolo nº: 1417/12 **Título**: O efeito da suplementação de cafeína sobre o desempenho em tarefas intermitentes de alta intensidade

Grupo III **Área de conhecimento**: Ciências da Saúde **Código**: 4.05

Pesquisador Responsável: Adriano Eduardo Lima da Silva
Instituição Responsável: Universidade Federal de Alagoas
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II) SUMÁRIO GERAL DO PROTOCOLO

O efeito ergogênico da cafeína durante exercícios intermitentes e de endurance, atua como um retardador da fadiga
e como um potencializador da força contrátil do músculo cardíaco e esquelético. Neste contexto a ingestão de
cafeína poderia diminuir a Percepção Subjetiva de Esforço (PSE), fazendo com que os atletas realizem o exercício
em maiores intensidades ou prolongando a duração do exercício. Os efeitos da cafeína sobre a PSE têm sido
extensamente examinados em exercícios aeróbicos, no entanto pesquisas examinando os efeitos da cafeína no
desempenho anaeróbico são escassos. Sendo assim, a cafeína poderia melhorar o desempenho de tarefas
intermitentes de alta intensidade com características tanto aeróbias quanto anaeróbias, tais como o judô e o futebol.
O objetivo geral do estudo será analisar o efeito da ingestão da cafeína sobre o desempenho em esportes de
característica intermitente. Trata-se de um estudo experimental que será realizado em um laboratório de Nutrição em
uma IES. Participarão vinte e sete atletas, sendo doze atletas de judô e quinze atletas de futebol. Os sujeitos da
pesquisa serão convidados pelo pesquisador por meio de cartas, e-mails e convite verbal na Federação de Judô e
nos clubes de futebol amadores e profissionais da cidade, e serão informados antes dos testes de todos os
procedimentos e possíveis riscos e benefícios da pesquisa, antes de assinar o Termo de Consentimento Livre e
Esclarecido. Serão incluídos atletas de judô e futebol com idade entre 18 e 30 anos. Serão excluídos da amostra, os
sujeitos que já fazem uso da cafeína regularmente. Os atletas de judô deverão ser faixa preta ou marrom e estar
competindo ativamente em nível regional ou nacional com idade entre 20 e 30. Será utilizado um período cinco dias
de manutenção de peso no qual serão avaliados estado nutricional, peso, estatura, e percentual de gordura. O
período de manutenção de peso será considerado como *baseline* onde os atletas realizarão seus períodos normais
de treinamento e sua dieta habitual. Em seguida os atletas comparecerão ao laboratório em quatro ocasiões
diferentes, separadas por um período de três dias: 1) duas vezes em condições normais (PRÉ); 2) duas vezes após a
redução de 5% do seu peso corporal (PÓS). Os atletas irão ingerir cafeína ou placebo imediatamente após a
pesagem e 1 hora antes da realização dos testes (3 horas após a pesagem)). Em todas as ocasiões os atletas serão
submetidos aos mesmos procedimentos de avaliação: avaliação antropométrica (peso, estatura, e composição
corporal), avaliação do desempenho (SJFT) e determinação da concentração de lactato. Os questionários de humor
serão aplicados antes (pré) e após (pós) o período de perda de peso, imediatamente após a pesagem e uma hora
antes da realização do SJFT. Todos os testes serão realizados no mesmo horário para um determinado atleta e em
ordem contrabalançada. Todos os atletas serão instruídos a não ingerirem álcool, nas 24 horas precedentes aos
testes, a ingestão de cafeína será proibida durante os três dias de perda de peso. Depois do período de perda de
peso, os atletas serão pesados e passarão por uma avaliação antropométrica. Consequentemente será dado um
período de 4 horas de hidratação e alimentação. Após esse período de 4 horas de recuperação eles serão
submetidos a uma avaliação de desempenho utilizando o Special Judo Fitness Test (SJFT). As concentrações de lac
serão mediadas no momento da pesagem, antes e após a realização do SJFT. Os jogadores de futebol terão
experiência em competições profissionais da modalidade. O estudo será conduzido durante as semanas iniciais da
temporada de treinamento e o volume de treino semanal será reportado como o controle do treinamento. Cada um
dos atletas visitará o laboratório sete vezes. Na primeira visita, todos os indivíduos serão submetidos a uma avaliação
antropométrica e em seguida, os jogadores de futebol serão familiarizados com os testes e procedimentos
envolvidos. Nas duas próximas visitas, os participantes realizarão avaliação neuromuscular, o teste de agilidade

Protocolo nº 1417/12 Título: O efeito da suplementação de cafeína sobre o desempenho em tarefas intermitentes de alta intensidade

Loughborough Soccer Passing Test (LSPT), e o teste de *sprint* repetido em duas ocasiões, separados por uma semana (PRE1 e PRE2). Posteriormente, nas visitas quatro, cinco, seis e sete, uma semana após o período controle, os sujeitos realizarão quatro sessões experimentais, sendo cada separada por pelo menos sete dias. A ordem das sessões experimentais será randomizada com o objetivo de cancelar um possível efeito da ordem. Cada sessão experimental será dividida em duas fases. Na Fase 1, os sujeitos chegarão ao laboratório e realizarão um período prolongado de corrida em esteira motorizada para reduzir os estoques de glicogênio muscular usando um procedimento sugerido por Taylor et al. (2011). Durante as três horas seguintes ao protocolo de depleção de glicogênio (Fase 2), os participantes irão ingerir: 1) 1,2 g · kg peso corporal -1 · RS-1 de CHO, imediatamente após e 1, 2 e 3hs pós-depleção (DEP-CHO); 2) moderada dose de cafeína (6 MG · kg peso corporal-1), somente 3hs após o protocolo de depleção (DEP-CAF); 3) mesmas quantidades de carboidratos e cafeína de forma combinada, sendo a cafeína administrada em duas doses iguais (3 MG · kg peso corporal-1) somente imediatamente após e 2hs pós-depleção (DEP-CHO+CAF); 4) uma quantidade equivalente em cápsulas de celulose (DEP-PLA), administrada imediatamente após e 1, 2 e 3hs pós-depleção. Todas as soluções serão administradas por técnicos de laboratório independentes, sem conhecimento dos objetivos do estudo. Uma hora após a administração de cada solução, os sujeitos irão para o laboratório para a execução dos testes neuromusculares, do Square Test, do LSPT e do teste de 40m Shuttle Sprint. Para ambos os estudos (judô e futebol), serão aplicados testes para averiguar se atendem aos pressupostos paramétricos (normalidade, homogeneidade e independência da variância dos resíduos). Uma vez atendidos, as variáveis serão comparados utilizando ANOVA de medidas repetidas de dois fatores. Para todos os tratamentos será adotado um nível de significância inferior a 5% (P<0,05). Os possíveis riscos a saúde física e mental do sujeito envolvem complicações cardíacas, que possam ocorrer durante os testes experimentais, decorrentes da ingestão de cafeína. Serão adotadas medidas de minimização dos riscos envolvidos na participação da pesquisa, mediante uma verificação prévia de possíveis fatores de risco associados a doenças cardiovasculares (eletrocardiograma) e disponibilidade e aptidão para iniciar o programa de testes estabelecidos no presente estudo (questionário PARq). Durante os testes será realizado um monitoramento cardíaco por meio de um cardiofrequencimetro. Os benefícios do estudo para os sujeitos serão o acesso a qualquer resultado referente aos testes com a liberdade de buscar e resolver quaisquer dúvidas com o pesquisador responsável que fará a assistência caso os atletas tenham algum problema, sendo transportados de ambulância pública ou de automóvel particular para o hospital mais próximo da universidade, onde os sujeitos serão assistidos por médicos e enfermeiros de plantão. A pesquisa será interrompida quando o pesquisador perceber algum risco ou dano à saúde do sujeito participante da pesquisa, como consta no TCLE.

III) TCLE (linguagem adequada, descrição dos procedimentos, identificação dos riscos e desconfortos esperados, endereço do responsável, ressarcimento, sigilo, liberdade de recusar ou retirar o consentimento, entre outros):
Apresentado com identificação das diretrizes definidas na Resolução 196/96 CNS/MS.

IV) CONCLUSÃO DO PARECER

APROVADO

V) CONSIDERAÇÕES
Ilmo. Prof. Dr. **Adriano Eduardo Lima da Silva**, lembre-se que, segundo a res. CNS 196/96:

- Sujeito da pesquisa tem a liberdade de recusar-se a participar ou de retirar seu consentimento em qualquer fase da pesquisa, sem penalização alguma e sem prejuízo ao seu cuidado e deve receber cópia do TCLE, na íntegra, por ele assinado, a não ser em estudo com autorização de declínio;
- V.S^a deve desenvolver a pesquisa conforme delineada no protocolo aprovado e descontinuar o estudo somente após análise das razões da descontinuidade por este CEP, exceto quando perceber risco ou dano não previsto ao sujeito participante ou quando constatar a superioridade de regime oferecido a um dos grupos da pesquisa que requeiram ação imediata;
- O CEP deve ser imediatamente informado de todos os fatos relevantes que alterem o curso normal do estudo. É responsabilidade do pesquisador, assegurar medidas imediatas adequadas a evento adverso ocorrido e enviar notificação a este CEP;
- Eventuais modificações ou emendas ao protocolo devem ser apresentadas ao CEP de forma clara e sucinta, identificando a parte do protocolo a ser modificada e suas justificativas;
- Seus relatórios parciais e final devem ser apresentados a este CEP, inicialmente em 20/11/2012 e ao término do estudo. A falta de envio de, pelo menos, o relatório final da pesquisa implicará em não recebimento de um próximo protocolo de pesquisa de vossa autoria.

Atenciosamente

Profa. Niédja Figueiredo Dantas
Sec. Exec. do COEPE/COEPE

ANEXO B

ESCALAS DE PERCEPEÇÃO DE ESFORÇO, PRAZER-DESPRAZER E ATIVAÇÃO

Grupo de Pesquisa em Ciências do Esporte **PSE/FS/FAS**

Percepção Subjetiva de Esforço/PSE

Durante a sessão de exercícios, nós queremos que você preste muita atenção para o quão difícil você sente que o ritmo de trabalho é. Este sentimento deve refletir o seu valor total de esforço e fadiga, combinando todas as sensações e sentimentos de estresse físico, esforço e fadiga. Não se preocupem com qualquer um dos fatores, tais como dor nas pernas, falta de ar ou a intensidade do exercício, mas tente se concentrar em seu sentimento interior, do total de esforço. Tente não subestimar ou superestimar a sua sensação de esforço; seja tão preciso quanto possível.

6	
7	Extremamente leve
8	
9	Muito leve
10	
11	Razoavelmente leve
12	
13	Pouco intenso
14	
15	intenso
16	
17	Muito intenso
18	
19	Extremamente intenso
20	

Escala Prazer-Desprazer/FS

Enquanto está participando de exercícios, é comum a experiência de mudanças de humor. Algumas pessoas acham exercício prazeroso, enquanto outras acham que ele seja desagradável.

Além disso, a sensação pode variar ao longo do tempo. Ou seja, pode se sentir bem ou mal várias vezes durante o exercício. Os cientistas desenvolveram esta escala para medir tais respostas.

+5	Muito bom
+4	
+3	Bom
+2	
+1	Razoavelmente bom
0	Neutro
-1	Razoavelmente ruim
-2	
-3	Ruim
-4	
-5	Muito ruim

Percepção de Ativação/FAS

Estima-se aqui quanto excitado você realmente se sente. Por "excitação" aqui se entende quão "emocionado" você se sente.

Você pode experimentar a "Alta Excitação" de uma variedade de maneiras, por exemplo, como excitação ou ansiedade ou raiva.

"Baixa Excitação" pode também ser experimentados por uma série de maneiras diferentes, por exemplo, como o relaxamento ou tédio ou calma.

1	Baixa excitação
2	
3	
4	
5	
6	Alta excitação