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ORIGINAL ARTICLE

Caffeine-containing energy drink improves physical performance in female soccer players

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Abstract There is little information about the effects of caffeine intake on female team-sport performance. The aim of this study was to investigate the effectiveness of a caffeine-containing energy drink to improve physical performance in female soccer players during a simulated game. A double-blind, placebo controlled and randomized experimental design was used in this investigation. In two different sessions, 18 women soccer players ingested 3 mg of caffeine/kg in the form of an energy drink or an identical drink with no caffeine content (placebo). After 60 min, they performed a countermovement jump (CMJ) and a 7 × 30 m sprint test followed by a simulated soccer match (2 × 40 min). Individual running distance and speed were measured using GPS devices. In comparison to the placebo drink, the ingestion of the caffeinated energy drink increased the CMJ height (26.6 ± 4.0 vs 27.4 ± 3.8 cm; $P < 0.05$) and the average peak running speed during the sprint test (24.2 ± 1.6 vs 24.5 ± 1.7 km/h; $P < 0.05$). During the simulated match, the energy drink increased the total running distance (6,631 ± 1,618 vs 7,087 ± 1,501 m; $P < 0.05$), the number of sprints bouts (16 ± 9 vs 21 ± 13; $P < 0.05$) and the running distance covered at >18 km/h (161 ± 99 vs 216 ± 103 m; $P < 0.05$). The ingestion of the energy drink did not affect the prevalence of negative side effects after the game. An energy drink with a dose equivalent to 3 mg of caffeine/kg might be an effective ergogenic aid to improve physical performance in female soccer players.

Keywords Caffeine · Women · Performance · Exercise · Doping · Sprint

Introduction

Soccer (football) is one of the most popular team-sport worldwide and is played by both men and women. The last Big-Count survey performed in 2006 by the Fédération International de Football Association (FIFA) indicated that there were more than 265 million soccer players and 10 % of these were women (Federation Internationale de Football Association 2006). While the physical and sport-specific skills necessary for male soccer success have been extensively investigated in the last few years (Stolen et al. 2005; Bangsbo et al. 2007), information about the physical demands of female soccer is still limited. Like male soccer matches, female soccer comprises a 2 × 45 min game played on a ≈100 × 60 m soccer field with 11 players per side. Female soccer is also characterized by intermittent high-intensity actions interspersed with periods of recovery and necessitates the use of both oxidative and non-oxidative pathways (Reed et al. 2012). However, women soccer players usually run shorter distances during official games than their male counterparts [10 vs 11 km (Mohr et al.

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2008; Vescovi 2012; Bangsbo 1994)], probably due to the lower VO_{2max} values found in the female population (Ingebrigtsen et al. 2012; Reed et al. 2012).

From the total running distance covered during a match, the distance run at high speed has been identified as the key factor for male team-sport performance (Bishop et al. 2011; Castagna et al. 2003). Specifically in male soccer, an enhanced ability to repeat sprints during a game is related with playing at a higher competitive level (Rampinini et al. 2007; Mohr et al. 2003). In women's soccer, players cover a greater distance at a high running speed and sprinting in international compared with domestic games (Andersson et al. 2010) and these running activities differentiate elite from high level women soccer players (Mohr et al. 2008). Mean sprint distance for female soccer players ranged from 160 to 460 m per match (Andersson et al. 2010; Krustrup et al. 2005; Mohr et al. 2008) although it can reach 530 m when reducing the threshold for sprinting from 25 to 18 km/h, as recently suggested by Vescovi (2012). Thus, increasing the amount of running distance at sprinting velocity during a match might be a crucial strategy to enhance the physical performance of female soccer players.

Elite athletes typically use diverse nutritional strategies to increase sport-specific performance (Burke et al. 2006) and caffeine is one of the most consumed ergogenic aids because of its effectiveness in a wide range of sports specialties (Bishop 2010). In fact, caffeine or its metabolites are present in 74 % of post-competition urine samples of elite athletes from a large number of sports (Coso et al. 2011). The use of caffeine pills (3–6 mg/kg of body mass) has been repeatedly proven as effective to increase the ability to repeat sprints during simulated team-sport activities in male athletes (Glaister et al. 2008; Stuart et al. 2005; Pontifex et al. 2010; Carr et al. 2008; Schneiker et al. 2006). However, the manner in which athletes consume caffeine is diverse and nowadays energy drinks have become the most popular caffeine-containing products (Hoffman 2010).

Energy drinks contain moderate amounts of caffeine (32 mg × 100/mL of beverage) in addition to carbohydrates, taurine, glucuronolactone and B-group vitamins (Clauson et al. 2008). Initially, Alford et al. (2001) determined that energy drinks may improve aerobic endurance (maintaining 65–75 % max. heart rate) and anaerobic performance (maintaining max. speed) on cycle ergometers. More recently, energy drinks with a dose of 3 mg of caffeine per kg of body mass have been proven as an effective aid to increase the distance covered at sprint speed in male soccer (Del Coso et al. 2012a) and rugby players (Del Coso et al. 2013b). In women team-sport players, the results are contradictory. The ingestion of 1 mg/kg of caffeine in the form of an energy drink did not alter repeated sprint performance during a simulated sport-specific test (Astorino et al. 2012) but 3 mg/kg of caffeine via an energy drink increased sprint performance during official games in an international rugby sevens competition (Del Coso et al. 2013a). Thus, it seems that caffeine dosage is a key factor for obtaining physical benefits derived from energy drink ingestion, as previously found for maximal muscle performance (Del Coso et al. 2012b).

The aim of the present investigation was to determine the effectiveness of a caffeine-containing energy drink to improve the women soccer players' physical performance. We tested the ability to sprint repeatedly during soccer-specific tests and during a simulated soccer game in addition to other physical variables. We hypothesized that 3 mg of caffeine per kg of body weight in the form of an energy drink would increase maximal running speed and the distance covered at sprint velocity during a simulated match.

Methods

Subjects

Eighteen female soccer players from the same team volunteered to participate in the study. They had a mean ± SD age of 21 ± 2 years, body mass of 57.8 ± 7.7 kg and height of 161 ± 6 cm. All participants had previous soccer experience of at least 3 years and had trained for ~2 h/day, 3–4 days/week (including a weekly competition) during the previous year. All participants were light caffeine consumers (not more than one coffee or one serving of energy drink per day). Initially, 22 players were recruited (to complete the simulated game), but two soccer players sustained injuries during the experimental trials and their data have been excluded from this investigation. Furthermore, data from the two goalkeepers were not included in the analysis. Participants were fully informed of any risks and discomforts associated with the experiments before giving their informed written consent to participate. The study was approved by the University Ethics Committee in accordance with the latest version of the Declaration of Helsinki.

Experimental design

A double-blind, placebo controlled and randomized experimental design was used in this study. Each player performed two experimental trials under the same environmental conditions (7 ± 1 °C; 87 ± 5 % of relative humidity) and separated by 1 week. On one occasion, players ingested a commercially available powdered caffeine-containing energy drink (Fure®, ProEnergetics, Spain) dissolved in 250 mL of tap water. The amount of energy drink was individually set to provide a dose of 3 mg of caffeine per kg of body mass. On another occasion, players ingested an identical drink with no caffeine content

(0 mg/kg; placebo). The placebo drink was provided by the energy drink manufacturer and had the identical appearance and similar taste to the caffeine-containing energy drink. The energy drink formulae included taurine (18.7 mg/kg), sodium bicarbonate (4.7 mg/kg) and of L-carnitine (1.9 mg/kg) but these substances were ingested in identical proportions in the two experimental trials. Thus, the experimental trials differed only in the amount of caffeine ingested (0 mg with placebo vs 173 ± 23 mg with the energy drink). The beverages were prepared in opaque plastic bottles to avoid identification and ingested 60 min before the onset of the experimental trials. An alphanumeric code was assigned to each trial to blind participants and investigators to the drink tested.

Experimental protocol

Two days before the first experimental trial, women soccer players were nude-weighed to calculate the energy drink dosage. Furthermore, participants were encouraged to refrain from all dietary sources of caffeine (coffee, cola drinks, chocolate, etc.) and alcohol for 48 h before testing. The day before each experimental trial, participants refrained from strenuous exercise and adopted a similar diet and fluid intake regimen. Food and fluid diaries were obtained to ensure compliance. At the day of the experimental trials, participants were encouraged to have a pre-competition meal 3 h before the start of the tests.

At 19.00 h, participants arrived at their habitual training stadium and voided in a sterilized container. After that, participants were nude-weighed (Radwag, Poland) and the experimental drink was individually provided. The exchange of bottles among players was not allowed and investigators encouraged players to drink the beverage in its entirety. Then, players dressed in their competition clothes and wore a GPS/HR device inserted in a purpose built back-pack (GPS, SPI PRO X, GPSports, Australia) and a heart rate belt (Polar® T34, Finland) attached to their chest. Participants then performed a standardized warm-up and began the performance tests just 60 min after the end of beverage intake. The performance tests included a maximal countermovement jump test (CMJ), measured by means of a force platform (Kistler, QuattroJump, Switzerland) and a 7 × 30 m maximal running speed test with 30 s of active recovery between repetitions [measured using the GPS devices (Barbero-Álvarez et al. 2009)].

Fifteen minutes after soccer-specific testing, players completed a 2 × 40 min simulated soccer game (without extra time at the end of each half), including a 15-min half time. The game was played on a regular artificial turf soccer field (90 × 60 m) with 11 players per side. The game followed the rules of the FIFA and the team's coach acted as a referee to make decisions on play disputes during the game. Participants were divided into two soccer teams according to their habitual outfield positions. In each team, a similar number of field players received the energy drink or placebo. During the game, the GPS device and heart rate belt continuously monitored the data on running distance, running speed and heart rate. Analyses of soccer players' movements during the game were categorized based on a previous study by Castagna et al. (2003). Each episode of running at a speed higher than 18 km/h was considered a sprint bout, as suggested by Vescovi (2012). All the data analyses were performed with a specific software package (Team AMS software V R1.2011.6, GPSports).

After testing, post-exercise nude body weight was recorded within 10 min of the end of the match. Thirty to sixty minutes after the end of testing, participants voided again and a urine sample was obtained. The urine will be used for future analysis. During each experimental trial, players drank water ad libitum only from their own individually labeled bottles. Fluid intake rate was measured from the change in bottle weight using a scale (Delicia, Tefal, France). Sweat rate was estimated from body mass change, total fluid intake and experimental trials duration.

Just after the game, players were required to fill out a questionnaire about their sensations of power, endurance and perceived exertion (RPE) during the soccer game. This questionnaire included a 1–10 point scale to assess each item, and participants were previously informed that 1 point meant minimal amount of that item and 10 points meant maximal amount of the item. In addition, participants were provided with a survey to be filled out in the following morning about sleep quality, nervousness, gastrointestinal problems and other discomforts. This survey included seven items on a yes/no scale and has been previously used to assess side effects derived from energy drink ingestion (Del Coso et al. 2012b).

Statistical analysis

The results are presented as mean ± SD. Data from the 7 × 30 m tests were analyzed using a two-way ANOVA (beverage × repetition) with repeated measures. After a significant F test, differences between means were identified using Bonferroni adjustment. Differences in the CMJ variables, the total running distance, the running distance at different speeds and the number of sprints during the simulated game were analyzed using paired t tests. Differences in sweat rate, the urinary concentrations of caffeine and its metabolites and perceived fitness during the game were also examined using paired t tests. Differences on side effects were analyzed using the McNemar test. The data were analyzed with the statistical package SPSS v20.0 (SPSS Inc., Chicago, IL, USA). The significance level was set at $P < 0.05$.

Results

In comparison to the placebo, the pre-exercise ingestion of the caffeinated energy drink increased mean jump height (26.6 ± 4.0 vs 27.4 ± 3.8 cm, respectively; $P = 0.05$) and tended to increase peak power (42.2 ± 4.5 vs 43.0 ± 5.2 W/kg; $P = 0.08$) during the CMJ test. In addition, the caffeinated energy drink increased the average peak speed (24.2 ± 1.6 vs 24.5 ± 1.7 km/h; $P < 0.05$) and the maximal speed (25.0 ± 1.4 vs 25.6 ± 1.4 km/h; $P < 0.05$) obtained during the 7 × 30 m test.

During the 2 × 40 min game, the total distance covered was 6,631 ± 1,618 m with the placebo drink and 7,087 ± 1,501 m with the caffeinated energy drink ($P < 0.05$). Figure 1 depicts the distance covered at different speeds, ranging from standing (zone 1) to sprinting (zone 6). In comparison to the placebo drink, the utilization of the caffeinated energy drink produced a significant rise in distance covered at standing (zone 1; $P < 0.05$), at low-intensity running (zone 3; $P < 0.05$), at medium-intensity running (zone 4; $P < 0.05$) and at sprint velocity (zone 6; $P < 0.05$). In addition, the number of sprint bouts during the game was increased with the ingestion of the caffeine drink (16 ± 9 vs 21 ± 13; $P < 0.05$). Yet, the maximal speed attained during the game was unaffected by the caffeine ingestion (23.8 ± 2.5 vs 24.2 ± 2.4 for placebo and energy drink, respectively; $P = 0.25$).

Maximal (182 ± 6 vs 186 ± 5 bpm for placebo and energy drink, respectively; $P = 0.16$) and average heart rate during the game (152 ± 13 vs 158 ± 12 bpm; $P = 0.10$) tended to be higher with the ingestion of the energy drink although the differences did not reach statistical significance. Dehydration level (0.2 ± 0.8 vs 0.2 ± 0.8 %; $P = 0.86$), sweat rate (0.6 ± 0.1 vs 0.5 ± 0.1 L/h; $P = 0.47$) and fluid intake rate (0.3 ± 0.3 vs 0.3 ± 0.3 L/h; $P = 0.94$) during the game were similar with the ingestion of the two experimental beverages.

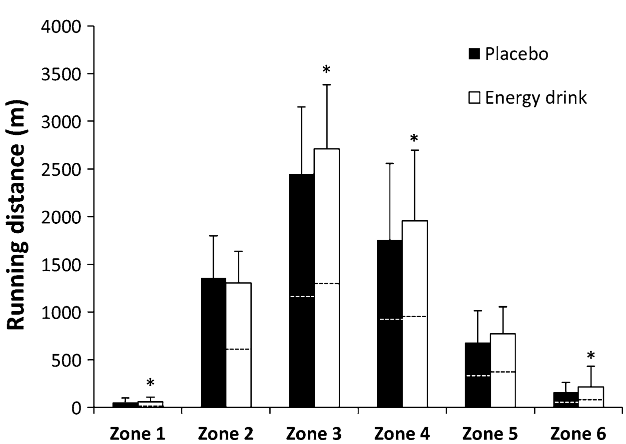

Fig. 1 Running distance covered at different speeds during a simulated soccer game with the ingestion of a caffeinated energy drink (3 mg of caffeine/kg of body weight) or a decaffeinated control drink. Data are mean ± SD for 19 soccer players. *Asterisk* different from control ($P < 0.05$). *Dashed lines* indicate the half time. Zone 1 (standing) = 0–0.4 km/h; Zone 2 (walking) = 0.5–3.0 km/h; Zone 3 (low-intensity running) = 3.1–8.0 km/h; Zone 4 (medium-intensity running) = 8.1–13.0 km/h; Zone 5 (high-intensity running) = 13.1–18.0 km/h; Zone 6 (sprinting) = speed higher than 18.0 km/h

Table 1 Rates of perceived fitness during a simulated soccer game and the prevalence of side effects during the hour following the game with the ingestion of a caffeinated energy drink (3 mg of caffeine/kg of body weight) or the same drink without caffeine

Item	Placebo	Energy drink
Power	6 ± 2	7 ± 2
Endurance	6 ± 2	7 ± 2
Exertion	5 ± 2	4 ± 2
Headache (%)	22	0
Abdominal/gut discomfort (%)	11	0
Muscle soreness (%)	50	22
Increased vigor/activeness (%)	11	11
Tachycardia and heart palpitations (%)	0	0
Insomnia (%)	0	33

Data mean ± SD from 19 women soccer players

In comparison to the placebo, the pre-exercise energy drink intake tended to increase perceived power ($P = 0.10$; Table 1) during the soccer game, although the differences did not reach statistical significance. The energy drink intake also tended to increase insomnia in the following hours after the soccer game ($P = 0.09$). Nonetheless, the remaining side effects were unaffected by the ingestion of the caffeine-containing energy drink.

Discussion

The aim of the present investigation was to determine the effects of ingesting a caffeine-containing energy drink before a women's soccer-simulated competition on players' physical performance. The most important finding was that several key variables for the success of female soccer were significantly increased by ingesting a commercially available energy drink. In comparison to a decaffeinated drink, the caffeine-containing energy drink with 3 mg/kg of caffeine improved: (a) jump height by 2.9 ± 7.3 % and power output by 1.7 ± 5.4 % during a CMJ test; (b) mean running speed during a 7 × 30 m maximal running test by 2.4 ± 2.0 %; (c) the total running distance during a simulated soccer match by 6.9 ± 3.1 %; (d) total distance at sprint velocity by 34.0 ± 10.3 % and the number of sprint bouts during a simulated game by 31.0 ± 7.6 %; (e) side effects reported by the soccer players in the following hours after the intake of the caffeinated energy drink were similar to the placebo drink (Table 1). Thus, the ingestion of an energy drink (with a dose of 3 mg/kg of caffeine) is a potent ergogenic aid for women soccer players' performance and the side effects derived from its intake are minor.

Several studies have investigated the benefits of pre-exercise caffeine ingestion on the ability to repeat running sprints. Most of these investigations tested the effectiveness of moderate amounts of caffeine (3–6 mg/kg) on several series of sprint bouts with short distances (20–40 m) and short recovery times (20–60 s), attempting to replicate team-sport physical performance. Briefly, the ingestion of caffeine enhanced the running velocity during repeated sprint tests in soccer (Del Coso et al. 2012a) and rugby players (Stuart et al. 2005), and trained (Pontifex et al. 2010) and physically active men (Glaister et al. 2008; Carr et al. 2008). Furthermore, the ingestion of caffeine has been shown to be effective to augment the benefits of carbohydrate intake (Gant et al. 2010; Roberts et al. 2010) and creatine supplementation (Lee et al. 2011) on repeated sprint tests.

The use of GPS devices has allowed investigators to measure instantaneous running speed during real or simulated games without hindering game actions. Instead of using specific tests to imitate the physical demands of a team sport, GPS permits assessing running actions of team-sport players while performing their habitual performance routines, that is, in a more ecologically valid context. Using this methodology, it has been tested the efficacy of ingesting 3 mg/kg of caffeine in the form of energy drinks during simulated soccer (Del Coso et al. 2012a) and rugby (Del Coso et al. 2013b) games. These authors found that the caffeinated energy drinks increased the running distance covered at sprint velocity (e.g. >18 km/h) by 30.0 % in male soccer players and by 20.8 % in male rugby players. In addition, caffeinated energy drinks also increased the number of sprint actions during the simulated games. However, these investigations have been performed on male team-sport players.

To the author's knowledge, only two studies have been geared to determining the effects of caffeine intake on women's sprint performance. Astorino et al. (2012) tested the effectiveness of 1.3 mg/kg of caffeine in the form of a commercially available energy drink on women's soccer performance during a 3 × 8 "all out" sprint test. They found that caffeine did not modify sprint velocity or the rate of perceived exertion during the test. Del Coso et al. (2013a) provided 3 mg/kg of caffeine via an energy drink or a decaffeinated placebo drink to women rugby players before an international competition. The pre-exercise ingestion of caffeine increased running distance covered at >18 km/h during a real game by 32 % although it was ineffective to increase the sprint velocity during a 6 × 30 m sprint test performed after the competition. Thus, to the date, it was inconclusive whether caffeine increases sprint performance in women team-sport players, as it has been found in their male counterparts.

As previously indicated, pre-exercise caffeine ingestion via energy drink increased the total running distance during the simulated soccer match from 6,631 ± 1,618 to 7,087 ± 1,501 m. However, out of all the running actions performed during soccer games, the actions performed at high-intensity running are the most important for success as they are related with scoring or defending (Barbero-Álvarez et al. 2009). For this reason, Castagna et al. (2003) proposed classifying soccer players' locomotor activities into six speed zones, from walking to sprinting. Under this classification, high-intensity running was considered when soccer players moved between 13 and 18 km/h while sprints were categorized as actions with a velocity higher than 18 km/h. Figure 1 depicts the distance covered at each speed zones during the women's soccer game. When the players ingested the placebo drink they ran 680 ± 334 m in zone 5 (high-intensity running) and 161 ± 99 m in zone 6 (sprint running). These values for high-intensity running and sprinting are lower than previously found in elite and professional women soccer players (Andersson et al. 2010; Krustrup et al. 2005; Mohr et al. 2008; Vescovi 2012) likely due to the lower level of our players (e.g., amateur players). Nevertheless, the ingestion of the caffeine-containing energy drink tended to increase high-intensity running to 773 ± 281 m ($P = 0.10$) and sprint running to 216 ± 103 m ($P < 0.05$). In addition, the energy drink intake also increased the distances covered at low-intensity running ($P < 0.05$) and at medium-intensity running ($P < 0.05$) while the movement patterns at walking were unaltered (Fig. 1). These results indicate that caffeine strongly modified the locomotor patterns of women soccer players; they increased the movements performed at high-intensity or sprint velocity which probably represent a significant physical advantage for obtaining victory during the game. In addition, these data support the notion that women's sprint performance can be significantly increased by ingesting caffeine.

Jumping is a very characteristic exercise action in soccer and the height reached during jumping actions influences the achievement of a defensive or offensive soccer actions. The effects of caffeine ingestion on lower body strength and power production are unclear. Several investigations have found that caffeine (3–6 mg/kg) was ineffective to increase power production during a test that included leg press repetitions to failure with 60 % of 1 RM (Beck et al. 2006; Astorino et al. 2012; Green et al. 2007; Duncan et al. 2009). On the other hand, Hudson et al. (2008) found that

6 mg/kg of caffeine resulted in significantly greater number of repetitions for leg extensions at 100 % of individuals' 12 RM. Del Coso et al. (2012a) found that a caffeinated energy drink with 3 mg/kg increased the mean jump height and the muscle power generated during a 15-s jump test in male semiprofessional soccer players and female international rugby sevens players (Del Coso et al. 2013a). In the present investigation, we have found that 3 mg/kg increased height and leg muscle power during a single countermovement jump. This information indicates that caffeine-containing energy drinks are effective to increase jump height in female soccer players and may represent a meaningful improvement either for headers or when players are competing for a ball. These data reinforce the effectiveness of the caffeine as an ergogenic aid for team-sport players.

The mechanisms responsible for the effects of caffeine ingestion on exercise performance have been the source of a scientific debate during several decades. In the 1970s, the effects of caffeine were primarily tested on long-term exercise and it was believed that caffeine's ergogenicity was related to increased lipolysis and enhanced muscle glycogen spare (Costill et al. 1978). However, the effectiveness of caffeine intake to increase fat oxidation during exercise has been questioned in the 2,000 s (Graham et al. 2000). In addition, several recent investigations have found that caffeine increases short-term high-intensity exercise (e.g., sprint actions or jumps) while these actions are not primarily associated with carbohydrate and/or fat metabolism. It has also been proposed that caffeine benefits human muscle contraction via enhanced Ca^{++} release from the sarcoplasmic reticulum (Tarnopolsky and Cupido 2000) although this outcome has been primarily obtained with supraphysiological plasma caffeine concentration (Magkos and Kavouras 2005). Caffeine also enhances motor unit recruitment by acting as an adenosine antagonist on the central nervous system (Davis et al. 2003). In previous studies with humans, it has been found that caffeine ingestion improves maximal muscle strength due to a higher voluntary activation of the central nervous system (Coso et al. 2008) while it decreases the time to obtain maximal muscle performance (Del Coso et al. 2012b). These effects indicate a better intra- and inter-muscular coordination during muscle contractions. In the present investigation, we did not assess the source of the benefits found with the caffeine-containing energy drink. However, we speculate that caffeine's ergogenicity on physical match performance of female soccer players was related to an enhanced motor unit recruitment.

The outcomes of caffeine ingestion on physical performance have been mainly tested using pure anhydrous caffeine supplied to experimental subjects in pills (Burke 2008; Coso et al. 2008, 2009; Doherty and Smith 2004). However, the current use of caffeine in sports mainly comes from the ingestion of commercially available energy drinks (Hoffman 2010). These beverages have become the most popular supplement in the sports population, with a prevalence of 73 % in American college athletes (Froiland et al. 2004), 75 % in Canadian Varsity athletes (Kristiansen et al. 2005) and 42 % in British elite athletes (Hoffman 2010). In an attempt to improve the applicability of the results of this study to the sports population, we have used a commercially available energy drink vs a placebo drink that only differed in the amount of caffeine. Although the influence of caffeine contained in the energy drinks has been the topic of the present investigation, more information is required to elucidate any synergies of the remaining components of the energy drinks (taurine, glucuronolactone, B-group vitamins, etc.) on sports performance.

One research topic related to energy drinks in sports is related to the side effects derived from the consumption of these beverages (Alsunni and Badar 2011). Some concerns have been raised about the safety of caffeine-containing energy drinks because of the excessive caffeine intake from consuming several energy drinks per day. In fact, the International Society of Sport Nutrition has recently suggested that the intake of more than one energy drink serving (typically 250 mL or 1–2 mg/kg of caffeine) per day may lead to adverse events and harmful side effects (Campbell et al. 2013). In the sport setting, 3 mg/kg of caffeine in the form of an energy drink increased vigor/activeness in physically active participants, basketball players (Del Coso et al. 2012b) and insomnia in female rugby players (Del Coso et al. 2013a) while other side effects as headache, gastrointestinal discomforts and muscle soreness were similar to placebo energy drinks. In the present investigation, there was a tendency for increased insomnia (0 vs 33 % of prevalence) with the caffeinated energy drink, but it did not increase the remaining side effects in the following hours after the soccer game. These data indicate that a single (e.g. 3 mg/kg) dose of caffeine in the form of an energy drink does not intensify the prevalence of post-exercise side effects in young athletes, although it is necessary to investigate the side effects derived from long-term energy drink intake.

In summary, the present study demonstrated that 3 mg/kg of caffeine in the form of an energy drink enhanced women soccer players' jump height, the ability to perform repeated sprints, the total running distance and the distance covered at high intensity and sprint velocity during a simulated game. Thus, caffeinated energy drinks might be an effective ergogenic aid to improve physical performance in female football players.

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Conflict of interest The authors declare that they have no conflict of interest.

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