Effect of Caffeine on Upper-Body Anaerobic Performance in Wrestlers in Simulated Competition-Day Conditions

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Purpose: Peak power (PP) and mean power (MP) attained in upper body sprint performance test are considered important factors for competitive success in wrestling. This study aimed to determine whether acute caffeine ingestion would better maintain PP and MP across a simulated competition day in wrestling. Methods: In a double-blind, counterbalanced, crossover study, 14 trained wrestlers ingested either placebo or 5 mg/kg caffeine and completed four 6-min upper body intermittent sprint performance tests with 30-min recovery periods between consecutive tests. PP and MP were recorded during and blood lactate concentration was measured before and after each test. Ratings of perceived fatigue (RPF) and exertion (RPE) were recorded before and after each test, respectively. Heart rate (HR) was monitored across the whole testing period. Results: Mean power decreased across four tests in both trials (p < .05), but the reduction in PP (from 277.2 ± 34.6 W to 257.3 ± 45.1 W; p < .05) only occurred in caffeine trial. Both pretest blood lactate concentration and HR were higher in caffeine than in placebo trial (p < .05) in the third and fourth tests. No between-trial differences occurred in RPF or RPE. Conclusions: Under simulated competition day conditions mimicking four consecutive wrestling matches, acute caffeine ingestion has a partially detrimental effect on upper body intermittent sprint performance in trained wrestlers. Elevated HR and blood lactate levels observed between tests after caffeine ingestion suggest that caffeine may impair recovery between consecutive maximal efforts.

Keywords: brazilian jiujitsu, submission wrestling, ergogenic aid

Resulting from intensive research over decades, there is an ample body of evidence supporting caffeine’s potential to enhance performance over a wide range of physical activities and sports (Astorino & Roberson, 2010; Burke, 2008; Davis & Green, 2009; Goldstein et al., 2010; Warren, Park, Maresca, McKibans, & Millard-Stafford, 2010). Recent studies reported a high prevalence (on average 74%) of caffeine use during competitions in elite athletes in different sports (Del Coso, Muñoz, & Muñoz-Guerra, 2011).

Data on caffeine use among wrestlers is scarce. Del Coso et al. (2011) compared mean urinary caffeine concentrations in frequently tested sports and reported the highest levels in triathletes, cyclists and rowers, and the lowest values in gymnasts, tennis players and wrestlers. However, in college athletes, Froiland, Koszevski, Hingst, & Kopecky (2004) observed a significantly higher frequency of caffeine use in wrestlers than in the representatives of the other sports investigated. Furthermore, some handbooks for wrestling coaches and wrestlers (e.g., Kimpel, 2010) recommend caffeine as a potentially useful dietary supplement. There is also anecdotal evidence about caffeine use in the competitive environment among wrestlers.

In recent studies, improvements in some performance characteristics that may be important for achieving success in wrestling have been demonstrated with caffeine administration. Caffeine increased upper body muscular endurance in moderately trained men and in highly trained male athletes (Duncan & Oxford, 2011; Woolf, Bidwell, & Carlson, 2008). Furthermore, Stuart, Hopkins, Cook, and Cairns (2005) observed multiple beneficial effects of caffeine on activities requiring high levels of force, speed, and motor skills in a 90-min test simulating a rugby game in well-trained rugby players. Caffeine exerted beneficial effects by causing reductions in fatigue during repeated high-intensity efforts. Similarly, Gant, Ali, and Foskett (2010) reported improved explosive leg power and a smaller decline in sprinting performance over 90 min of intermittent exercise with caffeine ingestion in soccer players, and Paton, Lowe, and Irwine (2010) found that caffeine attenuated fatigue in competitive cyclists in intermittent high-intensity sprints performed during 50 min. In wrestling, a tournament may last for hours and it would be a substantial advantage for a wrestler, if he or she could better maintain the ability to perform powerful actions in the latest matches.

There is a lack of methods for reliable assessment of the potential effect of caffeine ingestion directly on wrestling performance. However, anaerobic peak power (PP) and mean power (MP) attained in high-intensity arm-cranking exercise are considered important success
factors for wrestling (Garcia-Pallarés, López-Gullón, Muriel, Díaz, & Izquierdo, 2011; Hübner-Woźniak, Lutoslawska, Kosmol, & Zuziak, 2006). To the best of our knowledge, no study has assessed the potential impact of caffeine on anaerobic performance in any wrestling-specific performance test in wrestlers. Therefore, our purpose was to determine the effects of acute caffeine ingestion on upper body anaerobic performance in trained wrestlers employing a wrestling-specific arm cranking test protocol in simulated competition day conditions. We hypothesized that PP and MP attained in an upper body intermittent sprint performance (UBISP) test would be better maintained across four consecutive tests with caffeine ingestion compared with placebo. In conducting this study, we attempted to gain an understanding of performance effects of caffeine, which could be of practical importance in improving the quality of preparation of trained wrestlers for a tournament.

Methods

Participants

Fourteen healthy, nonsmoking, trained Brazilian jiu-jitsu (BJJ) and submission wrestling (SW) practitioners volunteered to participate in this study the protocol of which was approved by the Research Ethics Committee of the University of Tartu, Estonia. The participants were informed of the nature and possible risks of the experimental procedures before providing written consent. All participants had a minimum of four years of regular wrestling training and competition experience and their conventional training volume was 8 hr per week. Participants’ (mean ± SD) age, body mass and height were 25.3 ± 4.9 years, 77.8 ± 6.1 kg and 178.9 ± 5.4 cm, respectively. Ten participants’ habitual caffeine intake was less than 70 mg · d⁻¹ and four were light-to-moderate caffeine consumers (80–200 mg · d⁻¹).

Study Design

The participants visited the laboratory three times with 5–7 days between consecutive visits. During their first visit, the participants were familiarized with the testing devices and procedures. On the 2nd and 3rd visit, the participants completed a series of UBISP tests in a manner that simulated an ordinary competition day in BJJ and SW. In these sports, during a competition 6-min matches take place with relatively short (approximately 30 min) recovery periods and to win a competition, an average of four matches are fought. Therefore, our wrestlers accomplished four 6-min UBISP tests with 30-min recovery periods between the consecutive tests. Caffeine (CAF) or placebo (glucose; PLC) were administered in a double-blind, counterbalanced, crossover manner before the first UBISP test of each simulated competition day.

Upper-Body Intermittent Sprint Performance Test

The UBISP test protocol employed in the current study was similar to that developed specifically for assessing anaerobic performance in wrestlers (Hickner et al., 1991). Cycle ergometer (Monark Ergomedic 894 E, Monark, Sweden) was mounted on a stable table with pedals replaced by handgrips. The wrestlers were secured on an adjustable chair in a seated position with their hips and legs strapped to the seat to isolate the use of arms during the test. The resistance on the ergometer was individually adjusted to 0.04 kg · kg⁻¹ initial body mass and resistance remained constant for each participant throughout the study. The wrestlers warmed up before each UBISP test with light unloaded cranking for 3 min. The test began with 40 s of unloaded easy cranking at volitional pace. This light effort was followed by 5 s of unloaded cranking to reach maximum cadence and the participants were verbally stimulated to maintain maximal handgrip speed throughout the following 15-s period once the appropriate resistance was applied. The 15-s maximal effort was followed by unloaded easy cranking at volitional pace for 40 s again. This sequence was repeated 6 times during each UBISP test. The ergometer was interfaced with a computer that was used to record power output data. PP and MP for each 15-s interval of maximal effort was calculated by the means of the standard software provided by the manufacturer of the ergometer. Test-retest reliability data collected in our laboratory showed intraclass correlation coefficients of 0.94 for PP and 0.95 for MP (n = 16).

Simulated Competition Day

The participants were instructed not to perform any training sessions and to refrain from foods containing caffeine for 24 and 48 hr, respectively, before the 2nd and 3rd visit to the laboratory. On both simulated competition days, the participants reported to the laboratory approximately 2 hr after breakfast. They accomplished four 6-min UBISP tests (hereinafter: T1, T2, T3 and T4) with 30-min recovery periods between the consecutive tests. CAF (anhydrous caffeine; Oriola OY, Espoo, Finland) or PLC (glucose; Ceresar Deutchland GmbH, Krefeld, Germany) was administered in a gelatin capsule as a single dose of 5 mg · kg⁻¹ body mass 30 min before T1. A moderate caffeine dose was used considering that supplementation in the range of 4–6 mg · kg⁻¹ can be advantageous to intermittent-prolonged duration high intensity performance in trained athletes (Goldstein et al. 2010) and that caffeine doses exceeding 6 mg · kg⁻¹ increase the probability of occurrence of negative side effects (Burke, 2008). It was also considered that plasma caffeine level reaches maximal value approximately 60 min after ingestion (Graham, 2001) and that performance effects of a single caffeine dose of 5 mg · kg⁻¹ body mass may be maintained for three to six hours (Bell, & McLellan, 2002). By timing CAF ingestion 30 min before T1, we intended to favor the occurrence of the potential
ergogenic effect of caffeine mainly during the second half of the simulated competition day when the wrestlers are likely to feel more fatigued compared with the first half.

Each 30-min recovery period was divided into 5 phases. Firstly, for the initial 5 min the participants remained seated on the chair behind the ergometer. The rating of perceived exertion (RPE) was asked immediately after each UBISP test. The posttest blood sample was taken and early recovery heart rate (HRER) was recorded at the end of the 4th min of recovery. Secondly, during the following 10 min, the participants could walk around in the laboratory, visit the toilet or rest in a self-selected position. Thirdly, the participants spent the next 10 min resting quietly in a supine position on a couch. Late recovery heart rate (HRLR) was recorded during the last 5 min of this phase. Fourthly, the participants took a seat on the chair behind the ergometer and performed a 3 min warm-up by unloaded arm-cranking at a self-selected pace. Fifthly, the participants remained seated and rested for the last 2 min of the recovery period. The pretest blood sample was taken and the rating of perceived fatigue (RPF) was recorded 2 min after warm-up, immediately before each UBISP test. Both RPF and RPE were measured using Borg’s 10-point scale (Borg, 1998).

After T2, during the 2nd recovery phase, the participants ate a small meal rich in carbohydrates, which consisted of a 0.5 L sports drink (Arctic Sport, A Le Coq, Estonia) and a weighed banana. During all the recovery periods, the participants could drink water ad libitum and the individual quantities were recorded. When visiting the toilet, the participants were asked to collect all urine into a container.

Measurement of Blood Lactate Concentration

Lactate concentration was measured in a 10 μl capillary blood sample taken from a fingertip (Dr. Lange cuvette tests LKM 140; miniphotometer LP 20 Plus, Dr. Lange, Düsseldorf, Germany).

Heart Rate (HR) Monitoring

HR was monitored using a standard Suunto HR belt (Suunto Oy, Finland) and recorded in real time to a desktop computer using Suunto Monitor software (version 1.1.2 Suunto Oy, Finland). HRpeak was the highest HR value during the UBISP test. Early recovery heart rate (HRER) was recorded at the end of the 4th min of recovery. Late recovery heart rate (HRLR) was measured as the last 5 min average of the 10 min supine position resting phase.

Assessment of Hydration Status

Two urine samples for the assessment of hydration status were collected from the participants on both simulated competition days: at their arrival in the laboratory and after T4. Urine specific gravity and osmolality were measured using a digital clinical refractometer PDX-CL (VEE GEE Scientific, Inc., Kirkland, WA) and a freezing point depression osmometer Model 3250 (Advanced Instruments Inc., USA), respectively. After donating urine samples, nude body mass of each participant was recorded with 1g accuracy (Scale CH3G-150I Combics; Sartorius, Germany). In addition, the volume of urine passed throughout the simulated competition day was measured. Sweat loss was calculated based on the change in body mass considering urine volume, water intake and the weight of the small meal.

Statistical Analysis

The Statistica 10 software was used for performing statistical analysis. Data are expressed as mean ± SD. Normality of all data sets was examined using the Kolmogorov-Smirnov test. The effect of caffeine ingestion on performance, heart rate, RPE and RPF was assessed using repeated-measures ANOVA (trial and test as factors with 2 and 4 levels, respectively). The blood data were analyzed with 3-way analysis of variance (trial, test, and pre- and postperformance test as factors). In all analyses, a Tukey’s HSD post hoc was used to identify specific differences within and between the trials. Significant deviations from sphericity were tested with the Mauchly sphericity test. When a violation of sphericity was observed, the Greenhouse-Geisser correction was employed. Statistical significance was set at p < .05.

Results

Upper-Body Intermittent Sprint Performance

There was no statistically significant main effect of trial for either PP (F = 2.327, p = .151) or MP (F = .579, p = .460). The main effect of test was significant for both PP (F = 8.344, p = .0002) and MP (F = 22.95, p < .0001). A significant reduction in PP (7.2%; p = .001) was observed in T4 in the CAF trial, whereas a much smaller (3.1%) and nonsignificant (p = .480) decline of this performance parameter occurred across the four tests in the PLC trial (Figure 1A). More detailed analysis of the data revealed that PP reduction in T4 compared with T1 was mainly due to significantly (p < .001) lower PP in sprint bouts 1 and 2 in the CAF trial (Figure 2). MP decreased significantly (10.1%; p < .0001) across the four tests in both trials (Figure 1B).

Blood Lactate Concentration

There was a significant main effect of trial (F = 13.69, p = .003) and test (F = 76.25, p < .0001) on blood lactate concentration. Pretest blood lactate concentration in T2, T3, and T4 was higher than in T1 in both trials and in T3 and T4, it was higher in the CAF compared with the PLC trial (Figure 3).
Figure 1  Peak power (A) and mean power (B) achieved during upper body intermittent sprint performance tests (T1–T4). a: $p < .05$ from T1.

Figure 2  Peak power achieved during each 15-s maximal effort in upper body intermittent sprint performance tests T1–T4 in placebo and caffeine trial. a: $p < .05$ from T1.

Figure 3  Blood lactate concentration. a: $p < .05$ from Pretest; b: $p < .05$ from Test 1; c: $p < .05$ from placebo.
Heart Rate (HR)
There was a significant main effect of trial on HR\textsubscript{PEAK} (F = 13.67, p = .003), HR\textsubscript{ER} (F = 7.12, p = .019), and HR\textsubscript{LR} (F = 9.7, p = .008). The main effect of test on these parameters was not significant: F = 1.44, p = .248 for HR\textsubscript{PEAK}, F = 1.96, p = .136 for HR\textsubscript{ER}, and F = 1.68, p = .206 for HR\textsubscript{LR}. HR\textsubscript{PEAK} in T2, T3, and T4 was higher in the CAF compared with the PLC trial (Table 1). HR\textsubscript{LR} in T1, T2, and T3 was higher in the CAF compared with the PLC trial.

Ratings of Perceived Fatigue (RPF) and Exertion (RPE)
The main effect of trial on RPF (F = .047, p = .831) and RPE (F = .63, p = .441) was not statistically significant. However, there was a significant main effect of test on both RPF (F = 35.37, p < .001) and RPE (F = 13.68, p < .001). In both trials, RPF in T2, T3 and T4 was higher than in T1 and RPE in T3 and T4 was higher than in T1 (Table 2).

Body Mass and Hydration Status
Body mass and indices of hydration status did not differ between the two trials and remained unchanged across the four UBISP tests (Table 3).

Discussion
The main finding of this study was that ingestion of a moderate dose of caffeine did not improve PP or MP attained by trained wrestlers during four consecutive UBISP tests completed within 144 min with 30 min

Table 1 Heart Rate (bpm)

<table>
<thead>
<tr>
<th>Test</th>
<th>Placebo</th>
<th>Caffeine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR\textsubscript{PEAK}</td>
<td>HR\textsubscript{ER}</td>
</tr>
<tr>
<td>T1</td>
<td>170 ± 10</td>
<td>101 ± 17</td>
</tr>
<tr>
<td>T2</td>
<td>170 ± 8</td>
<td>103 ± 16</td>
</tr>
<tr>
<td>T3</td>
<td>169 ± 7</td>
<td>103 ± 13</td>
</tr>
<tr>
<td>T4</td>
<td>170 ± 8</td>
<td>103 ± 12</td>
</tr>
</tbody>
</table>

Note. HR\textsubscript{PEAK} = peak heart rate; HR\textsubscript{ER} = early recovery heart rate; HR\textsubscript{LR} = late recovery heart rate.

\textsuperscript{a}p < .05 from placebo.

Table 2 Ratings of Perceived Fatigue (RPF) and Perceived Exertion (RPE)

<table>
<thead>
<tr>
<th>Test</th>
<th>Placebo</th>
<th>Caffeine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RPF</td>
<td>RPE</td>
</tr>
<tr>
<td>T1</td>
<td>1.0 ± 1.2</td>
<td>7.4 ± 1.7</td>
</tr>
<tr>
<td>T2</td>
<td>2.4 ± 1.6\textsuperscript{a}</td>
<td>8.1 ± 1.5</td>
</tr>
<tr>
<td>T3</td>
<td>3.1 ± 1.5\textsuperscript{a}</td>
<td>8.5 ± 1.3\textsuperscript{a}</td>
</tr>
<tr>
<td>T4</td>
<td>3.3 ± 1.5\textsuperscript{a}</td>
<td>8.6 ± 1.1\textsuperscript{a}</td>
</tr>
</tbody>
</table>

\textsuperscript{a}p < .05 from T1.

Table 3 Body Mass and Hydration Indices

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Placebo</th>
<th>Caffeine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before Test 1</td>
<td>After Test 4</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>77.72 ± 6.03</td>
<td>77.81 ± 6.06</td>
</tr>
<tr>
<td>USG</td>
<td>1.0143 ± 0.0073</td>
<td>1.0140 ± 0.0053</td>
</tr>
<tr>
<td>Uosm (mOsm · kg\textsuperscript{-1})</td>
<td>629 ± 291</td>
<td>585 ± 193</td>
</tr>
<tr>
<td>Urine volume (ml)</td>
<td>393 ± 151</td>
<td>421 ± 131</td>
</tr>
<tr>
<td>Water intake (ml)</td>
<td>1010 ± 255</td>
<td>958 ± 290</td>
</tr>
<tr>
<td>Sweat loss (ml)</td>
<td>675 ± 145</td>
<td>709 ± 133</td>
</tr>
</tbody>
</table>

Note. USG = urine specific gravity; U\textsubscript{osm} = urine osmolality.
recovery periods between the tests. Furthermore, caffeine ingestion in comparison with placebo had a partially detrimental effect on UBISP, which was revealed in a significant reduction (7.2%) in PP across the four tests in the CAF but not in the PLC trial.

This study is unique among others that have investigated the effect of acute caffeine ingestion on physical working ability, because the wrestling-specific UBISP test protocol was employed in a manner that mimicked a competition day in BJJ and SW. However, repeated measurement of intermittent high-intensity exercise performance during a comparatively prolonged time interval is an apparent common feature of some previous studies (Gant et al., 2010; Paton et al., 2010; Schneiker, Bishop, Dawson, & Hackett, 2006; Stuart et al., 2005) and the current one. The abovementioned studies revealed that caffeine ingestion may reduce a fatigue-induced decline in intermittent high-intensity exercise performance occurring over a prolonged activity period of 50–100 min. Therefore, we hypothesized that PP and MP would be better maintained across four consecutive UBISP tests with caffeine ingestion compared with placebo, but our results did not confirm this hypothesis.

The impact of acute caffeine ingestion on intermittent sprint performance may differ depending on the muscle groups predominantly activated during exercise. Indeed, caffeine improved intermittent sprint performance in team sport athletes and cyclists during activities which loaded lower limbs (Gant et al., 2010; Paton et al., 2010; Schneiker et al., 2006; Stuart et al., 2005), but not in our wrestlers who performed an arm-cranking exercise. These findings agree with the conclusion of Warren et al. (2010) that caffeine exclusively improves maximal voluntary contraction strength in knee extensors but not in other muscle groups. The authors considered plausible that caffeine-induced gains in knee extensor strength may also translate into performance improvements in short-term high-intensity exercise. Thus, the lack of strength gain in upper body muscles may explain the absence of any positive impact of caffeine on UBISP in our wrestlers.

Another factor that could have prevented us from observing any ergogenic effect of caffeine ingestion may be the active recovery to high intensity work ratio 3:1 during each UBISP test. Davis and Green (2009) suggest that the rest to work ratio between 2:1 and 3:1 may be inappropriate and that for the appearance of any positive effect of caffeine on intermittent sprint performance at least 4.5:1 ratio may be needed. Recently Lee, Cheng, Lin, and Huang (2012) found that with caffeine ingestion, repeated sprint cycling performance is likely enhanced if the rest to work ratio is at least 5:5:1. Nevertheless, it is important to note that all previous studies which revealed the significance of rest to work ratio in respect of performance improvements employed lower body exercise protocols.

An average 7.2% decline in PP across the four consecutive tests in the CAF trial was statistically significant and 2.3 times greater than that observed in the PLC trial. Considering the randomized crossover design of the study and high reliability of the test protocol, we consider it unlikely that the decline observed in PP in CAF trial was just a random event. However, caffeine’s detrimental effect on physical performance is a very rare finding in the literature. To the best of our knowledge, this has only been observed in high-intensity intermittent cycle exercise (Greer et al., 1998; Crowe et al., 2006; Lee et al., 2012) and the exact mechanism of caffeine’s partially negative impact on performance remains obscure. In our subjects, a significant decline in PP across the four UBISP tests in the CAF trial may be associated with impaired recovery between the consecutive tests. This notion is supported by higher HR_{LR} recorded in T1, T2, and T3 as well as by higher pretest blood lactate concentrations in the CAF trial than in the PLC trial observed in T3 and T4.

Regarding HR, the results showed not only higher HR_{LR} but also elevated HR_{PEAK} and HR_{ER} in CAF trial. The between trial difference in HR_{PEAK} was 2–4 bpm, whereas HR_{LR} in CAF trial exceeded that observed in PLC trial by 4–8 bpm, suggesting that elevated HR_{LR} in CAF trial was not merely a consequence of higher HR_{PEAK} achieved during the UBISP test but a reflection of impaired recovery. According to the current understanding, a posttest decrease in HR is initially caused by a rise in parasympathetic activity, which is later followed by sympathetic withdrawal (Javorka, Zila, Balhárek, & Javorka, 2002). To the best of our knowledge, the impact of caffeine ingestion on HR during posttest recovery has previously only been assessed by Yeragani, Krishnan, Engels, and Gretebeck (2005). Considering their findings, the occurrence of higher recovery HR in our wrestlers in CAF trial may be associated with exaggerated vagal withdrawal.

Overall, elevated blood lactate values observed in CAF trial are in agreement with the findings of other studies (Duncan & Oxford, 2011; Glaister et al., 2008; Schneiker et al. 2006), which have employed anaerobic exercise protocols. In previous studies, blood lactate measures were taken before, during and shortly after exercise, but not during extended recovery periods following several consecutive bouts of high-intensity intermittent exercise. Nevertheless, Graham, Helge, Maclean, Kiens, and Richter (2000) found that caffeine inhibited blood lactate clearance during exercise. In light of these data, similar posttest blood lactate concentrations in T3 in both trials and an elevated pretest lactate level in T4 in CAF compared with PLC trial suggest that caffeine inhibited blood lactate clearance during recovery after T3. Improved blood lactate clearance during recovery after a high-intensity exercise was associated with greater anaerobic power output during the following high-intensity exercise bout (Ahmadi et al., 1996). Furthermore, Hübner-Woźniak et al. (2006) found that elite Polish wrestlers (national team members), who surpassed their less experienced counterparts in peak and mean power attained in intermittent high-intensity arm-cranking exercise, also exhibited significantly faster blood lactate clearance. Hence, less efficient blood lactate clearance
after T3 might contribute to decreased PP observed in T4 in CAF trial.

According to traditional understanding, a high lactate level is concomitant with increased concentration of H+ ions (low pH) and especially the latter may depress muscle function through multiple mechanisms, including suppression of energy supply by glycolysis/glycogenolysis (Gladden, 2008). On the other hand, the results of experiments on isolated muscles suggest that H+ ions and lactate are merely of limited importance in the development of fatigue (Allen et al., 2008). Nevertheless, the fact that ingestion of substances which increase the capacity of extracellular (Requena et al., 2005) or intracellular (Van Thielen et al., 2009) H+ buffers also has potential to improve physical performance in high-intensity exercise suggests that in conditions where large acid-base disturbances occur, proton accumulation may still play an important role in fatigue development. Cairns (2006) proposed a hypothesis according to which a severe plasma acidosis in humans may impair exercise performance by causing a reduced central nervous system drive to muscle. Our previous study (Timpmann et al., 2012) revealed that exceptionally high blood lactate levels induced by the UBISP test protocol occurred in conjunction with extensive reduction in blood pH. According to Robergs, Ghiasvand, and Parker (2004) lactate production retards, not causes acidosis, but muscle or blood lactate accumulation are still good indirect indicators of increased proton release and potential for decreased cellular and blood pH. Therefore, in the current study higher lactate levels found in CAF trial compared with PLC trial may be considered to indirectly indicate more severe acidosis.

Although HR and blood lactate data suggest impaired recovery between the consecutive UBISP tests in CAF trial, similar RPF values recorded before the beginning of each test reveal that subjectively our wrestlers felt equally recovered from the preceding effort in both trials. Similar RPE values observed in the two trials are in accordance with the findings of other researchers who have employed intermittent high-intensity exercise protocols (Gant et al., 2010; Glaister et al., 2008; Schneiker et al., 2006). Considering RPE was registered immediately after each UBISP test, our results support the suggestion of Doherty and Smith (2005) that effort sense experienced following all-out exercise is essentially the same regardless of preceding caffeine or placebo ingestion. Thus, subjective feelings of fatigue and perception of effort is apparently not associated with a partially detrimental effect of caffeine on UBISP in our wrestlers.

Body mass, water intake, sweat loss and urine data all confirm that caffeine had no impact on hydration status in our wrestlers. Acute caffeine ingestion generally does not stimulate diuresis or sweat loss during exercise (Armstrong, 2002; Goldstein et al., 2010). However, the diuretic effect of caffeine may occur in resting conditions (Wemple, Lamb, & McKeever, 1997), and dehydration has been shown to be associated with decreased UBISP in trained wrestlers (Timpmann et al., 2012). As the design of this study was unique (the wrestlers mostly rested and only exercised episodically during 144 min of a simulated competition day), we considered it important to assess their hydration status. The results clearly indicate that a partially detrimental effect of caffeine on UBISP was not induced by changes in body hydration status.

The current study has two important limitations. First, our performance data cannot be directly generalized to tournament wrestling performance. Although PP attained in high-intensity arm-cranking exercise is considered an important success factor in wrestling (Garca-Pallarés et al., 2011; Hübner-Woźniak et al., 2006), it is not known whether a 7.2% decrease in PP translates into impaired performance in a real wrestling match. Second, elevated HR and blood lactate levels observed in CAF trial suggest impaired recovery between consecutive high-intensity arm-cranking exercise bouts, but these data alone remain too scarce to elucidate the exact mechanism through which caffeine may have a partially detrimental effect on performance in this type of exercise. Future studies would certainly benefit from collecting additional data (muscle and blood metabolic parameters, heart rate variability) for developing a more comprehensive understanding of recovery processes between consecutive high-intensity upper body exercise bouts completed with and without acute caffeine ingestion.

Results of this study indicate that in trained wrestlers under simulated competition day conditions mimicking four consecutive wrestling matches, acute caffeine ingestion reduces the ability of upper body musculature to generate PP. Elevated HR and blood lactate levels concomitant with caffeine ingestion suggest that caffeine may impair postexercise recovery processes. Further research should elucidate whether caffeine induces abnormalities in parasympathetic and sympathetic activities during limited recovery periods between consecutive maximal anaerobic efforts and whether these potential abnormalities are related to decreased performance.

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References


