Concurrent training and caffeine supplementation on resistance training performance - A short research report

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ABSTRACT:
The aim of this study was to examine the influence of caffeine supplementation (4.5 mg·kg⁻¹) on lower body resistance training performance preceded with and without an acute bout of endurance exercise. In a double-blinded crossover study, 10 moderately active males (20.6±2.1 yo) carried out six exercise sessions (2 x 1RM sessions; 2 x resistance sessions; 2 concurrent sessions). Resistance exercise sessions (RES+CAF and RES+PLA) were carried out with 4 maximum sets of leg press, leg extension and leg curl to volitional fatigue at 65% of 1RM for each exercise with 1 min inter-set and inter-session rest interval. Sessions consisted on 4 maximum sets to volitional fatigue at 65% of 1RM for each exercise with 1 min of rest interval between sets and exercises. Concurrent training sessions (CON+CAF and CON+PLA) were identical but were preceded by 30 min of continuous treadmill running at 75-85% HRmax. Physical performance showed a significant main effect for treatment (p < 0.0001), protocol (p < 0.02), exercises (p < 0.0001) and sets (p < 0.0001). Physical performance during RES was reduced after endurance exercise, indicating a cumulative effect of CON. Caffeine supplementation blunted this cumulative effect. We conclude that caffeine supplementation could be used to improve the resistance-training performance when it is done immediately after an aerobic training.

KEY WORDS Ergogenic aid; exercise training; exercise performance; fatigue; exercise testing.

INTRODUCTION
Caffeine is one of the most widely used supplements in the world. It is well founded that caffeine is an ergogenic resource (i.e., a resource to enhance physical performance) for endurance exercise[1–4], but its effect for resistance training performance seem to be unclear[5], depending on the factors as muscle group involved and the regular caffeine ingestion habits[5, 6].

Concurrent training (CON) is a method that combines resistance exercise session (RES) with aerobic exercise in a single program. Public health guidelines by ACSM and AHA[7] recommend 30 min/d of aerobic exercise combined with 2-3 d/wk of whole-body RES. Combining these modes on the same day would seem to be more time efficient and, thus, desirable for the practical reasons. Furthermore, this type of training is commonly used by exercise enthusiasts and athletes[8], but a possible impairment in strength gain after RES, when it is preceded by aerobic training, is one major concern of CON (i.e., concurrent training)[9–12].

The proposed mechanism of caffeine action involve peripheral/metabolic mechanisms, such as the adrenaline-induced enhanced free-fatty acid oxidation and consequent glycogen sparing, and central mechanisms, which suggest a inhibition of adenosine neurotransmission, through antagonist of adenosine receptors, leading to a hypoalgesic effects, reducing the pain perception and perceived exertion during exercise [6]. Both mechanisms of action could collaborate to improve physical performance in resistance-training performance, when this is preceded by aerobic exercises.
Despite caffeine supplementation improve of physical performance in aerobic and anaerobic exercise, when done isolated[3, 13–15], no studies have examined the combination of aerobic and RES in an acute exercise bout with caffeine supplementation.

Therefore, the aim of this study was to examine the influence of caffeine supplementation on lower body resistance-training performance when this exercise method was preceded with and without an acute endurance bout of exercise. We hypothesized that caffeine would improve the resistance-training performance after an acute bout of endurance exercise.

METHODS

Participants

Ten healthy and moderately active males (20.6±2.1 yo; 178±4 cm height; 80.9±9.2 Kg weight; 193±2 bpm HRmax; 261±45 Kg 1RM Leg Press; 65±13 Kg 1RM Leg Extension; 91±15 Kg Leg Curl) volunteered to participate in this study. All procedures were approved by the local Ethics Committee according to the Code of Ethics of the World Medical Association (Declaration of Helsinki). Written informed consent was obtained from the subjects, who were instructed as to the nature and procedures of the study. Because habitual consumption can mediate to caffeine effects[3], we selected subjects who self-reported using less than 90 mg per day.

Experimental design

The study was a within-subjects, double-blind, and crossover design. Treatment trials were counter-balanced to account for ordering effects. Each workout was repeated within 1 week of the last workout.

One repetition maximum test

Two sessions were conducted to determine one repetition maximum (1RM) loads for the leg press (LP), leg extension (LE), and prone leg curl (LC) (Righetto, São Paulo, Brazil). These exercises were chosen owing to the evidence of positive effect of caffeine supplementation on strength of lower limb muscles, especially, knee extensors[15]. A major consideration in choosing these exercises was the relative ease with which testers could ensure that subjects were performing them with a consistent range of motion. Given the repeated measures nature of the experiment, we felt it was important to ensure that all sessions were performed with consistent exercise technique, so that there were no differences in work completed between each session.

To increase the reliability of 1RM testing, the following strategies were employed: (a) the 1RM for each exercise was measured on 2 nonconsecutive days that were separated by 72 hours, (b) exercise testing proceeded in the same sequence as listed above, (c) exercise technique was monitored and corrected as needed, (d) all subjects received verbal encouragement, and (e) the exercise sequence (i.e., leg press, leg extension and leg curl) was maintained in the two 1 RM testing sessions[16, 17].

Experimental sessions

Four testing sessions were performed (Caffeine vs Placebo and Resistance vs Concurrent). Participants did not maintain their strength and conditioning routine and abstained from alcohol and caffeine for 48 hours prior to each lab session. The testing sessions were conducted the same time of day for all participants in order to minimize effects of circadian rhythms.

Before each testing session, subjects ingested the caffeine or placebo 60 min prior to the beginning of exercise, and then completed a 10-min warm-up. The warm-up consisted of light static stretching plus 2 x 15 repetitions with 40% of 1-RM Leg Press. Resistance exercise sessions (RES+CAF and RES+PLA) consisted of 4 maximum sets to volitional fatigue at 65% of 1RM for each exercise with 1 min of rest interval between sets and exercises. The sequence of resistance exercises was the same from the 1 RM testing session (i.e., leg press, leg extension and leg curl). Concurrent sessions (CON+CAF and CON+PLA) is identical but preceded for 30 min of continuous treadmill running at 75-85% of HRmax predicted according to Tanaka et al.[18] with 5 minutes of rest before RES.

Supplementation protocol

Each subject was given a comprehensive list of caffeine containing foods and drinks and was asked to abstain from these products during the 48 h before the experimental sessions. In randomized order, caffeine or a placebo was ingested in the form of indistinguishable capsules, so that the subjects were not aware of which substance was ingested. The caffeine (Purifarma, China) was administered at 4.5 mg.kg−1 and the placebo consisted of 500 mg of cellulose to fill the capsule (Gujarat Microwax, India).

Statistical analysis

A 2 treatment x 2 protocols x 3 exercises x 3 sets ANOVA with repeated measures was used to compare the physical performance (i.e., number of repetitions). When appropriate, least significant difference post hoc analyses were used to identify any significant differences among dependent variables. A Bonferroni test was used to evaluate all dependent variables utilizing Statistical Package for Social Sciences (SPSS, Inc., Chicago, IL). All data are reported as mean ± standard error (SE). Alpha level of < 0.05 was considered significant. Only the significant main effects and interactions are presented, unless otherwise noted.
RESULTS

The physical performance, evaluated through number of repetitions along sets of exercises, showed a significant main effect for treatment (F1,324 = 17.02; p < 0.0001), protocol (F1,324 = 5.16; p < 0.02), exercises (F2,324 = 303.04; p < 0.0001) and sets (F2,324 = 66.44; p < 0.0001). Additionally, it was observed a significant treatment x protocol (F1,324 = 8.63; p = 0.004) and treatment x exercise (F2,324 = 3.24; p = 0.04) interactions were observed. Physical performance during resistance exercise was dramatically reduced after endurance exercise (see Figure 1), indicating a cumulative effect of concurrent training.

Caffeine supplementation diminished or eliminated the effect of prior exercise on RES performance (see Figure 1).

As expected, LE exercise exhibited a lower performance when compared to LP and LC exercises, since it was preceded by LP, which also had quadriceps muscles as a main muscle group exercised. Interestingly, caffeine supplementation blunted the performance decline during LC exercise, the last exercise, independent of protocol training employed (i.e., Concurrent or resistance training) (see Figure 1).

DISCUSSION

The main finding of this study was that caffeine supplementation enhanced concurrent training compared to resistance training alone. As shown previously, acute endurance training induces performance reduction on resistance training[8]. In the current study results showed that caffeine could inhibit this cumulative effect.

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Our results corroborate previous studies, showing that caffeine supplementation does not improve resistance training performance until failure[13]. Previous studies examining lower body resistance training have shown no effect on performance[19] with Davis et al.[13] showing a 3.9% decrease in performance on the leg press. Despite of this, we found that caffeine supplementation may improve the physical performance of resistance training, when preceded by aerobic exercise.
There is evidence that aerobic exercise performed prior to resistance exercises may have detrimental effects, such as impairment of acute RES performance on the second[20, 21]. A metabolic hypothesis has been suggested to explain the decline of physical performance during resistance training preceded by aerobic training[20, 22]. Interestingly, the caffeine's action hypothesis related to an adrenaline-induced increase of the free-fatty acid oxidation with consequent glycogen-sparing effect seem to be unlikely when applied to resistance exercises, since an enhanced fatty acid oxidation would not affect the performance of an exercise dominated by oxygen-independent metabolic pathways. However, it could be plausible if a resistance exercise were preceded by an aerobic exercise, but carbohydrate supplementation failed to revert the deleterious effects of endurance exercise upon subsequent strength performance[20].

In addition, Gomes and Aoki[22] showed that creatine supplementation blinded the cumulative effect of concurrent training, suggesting that this ergogenic supplement could improve the resistance training performance after an aerobic training.

Together, the cited studies indicated that it is possible that metabolic changes after an aerobic training were not the single mechanism that explains the performance decline on resistance training after an aerobic bout, especially when the resistance training is performed until volitional failure. We hypothesize that central mechanisms (e.g., neural control of task and/or a hypoalgesic effect) may play an important role in addition to peripheral mechanism (e.g., metabolic changes). In this context, a greater perceived exertion may lead to a volitional failure and caffeine supplementation is known to reduce the perceived exertion during both aerobic and resistance exercises[21, 23, 24]. Therefore, it is possible that quicker reduced perceived exertion induced by caffeine supplementation explain the observed blinding effect.

Perceived exertion was not evaluated in our study owing to the limitations of this measure when exercise is conducted until to volitional failure. It is possible that the measure of perceived exertion at the end of sets or session of resistance exercises did not differ from supplemented and placebo groups. However, we suggest that further research include the measure of perceived exertion, especially after aerobic bouts of exercise.

Astorino and Roberson[5] reviewed the literature and found that physical performance improvements were more common in elite athletes who do not regularly ingest caffeine. Despite our sample were not elite athletes, they were low caffeine consumer, what could contribute to explain the observed positive results on physical performance.

**PRACTICAL APPLICATIONS**

Concurrent training is a popular method employed by many fitness enthusiasts. Considering caffeine has not collectively shown enhanced performance with lower body resistance training this study brings novel insight into the ergogenic effects of caffeine on concurrent training. Since caffeine seems to maintain lower-body RES performance when preceded by aerobic exercise, individuals employing concurrent training into their workout regimen may experience enhanced performance with caffeine supplementation.

**CONCLUSIONS**

Based on our findings, we conclude that caffeine supplementation may blunt the cumulative effect of concurrent training, suggesting that this ergogenic supplement could be used to improve resistance-training performance when it is preceded by aerobic exercise.

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**CONFLICT OF INTEREST**

The Authors declares that there is no conflict of interest.
REFERENCES


