ORIGINAL ARTICLE

Nr 2023;13 (4):645-652

# Combined Caffeine-Capsaicin Supplementation does not Enhance the Performance of Trained Men in a Resistance Training Session

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**DOI:**
10.32098/mltj.04.2023.17

**LEVEL OF EVIDENCE: 2**

**SUMMARY**

**Purpose.** This study aimed to verify and compare the potential acute effects of combined and isolated supplementation of caffeine and capsaicin on the performance and the perceived exertion (RPE) in a session of resistance training (RT).

**Methods.** Fourteen trained men participated in the study (5.6 ± 3.5 years of experience in RT and weekly training frequency of 5 ± 0.8 days), aged in average 24.8 ± 3.3 years old, with a mean height of 178.6 ± 4.9 cm, and mean total body mass of 82.4 ± 7.1 kg. We applied a randomized, double-blind, crossover, and placebo-controlled experimental design. The volunteers performed the training protocol after consuming the combined supplementation (CAF+CAP) of capsaicin (12 mg) (CAP) and caffeine (CAF) (5 mg × $kg^{-1}$), in addition consumed them alone. The RT protocol consisted of performing the barbell bench press and incline barbell bench press exercises, with 70% of 1RM until concentric muscle failure. The intervals adopted were 90 and 120 seconds between sets and exercises, respectively. The maximum number of repetitions (MNR), total volume (repetitions × mass lifted), and the RPE in the sessions were registered and compared.

**Results.** One-way ANOVA with repeated measures found no statistically significant difference in the means of MNR ($p = 0.176$), total volume ($p = 0.110$), and RPE ($p = 0.233$) between the experimental conditions.

**Conclusions.** Therefore, combined and isolated caffeine and capsaicin acute supplementation did not improve the upper-body RT performance of trained men. Furthermore, these substances may not attenuate the perception of exertion during RT with maximum repetitions.

**KEY WORDS**

*Multi-ingredients supplementation; nutritional ergogenic resource; sports nutrition; total volume; resistance training.*

## INTRODUCTION

The combination of substances to enhance the ergogenic effect of the supplementation, hence increasing the performance is a nutritional strategy in resistance training (RT) (1, 2). Given the physiological responses and expected results, the combination of caffeine (3) with capsaicin (4) is promising (2).

Studies have shown that caffeine supplementation can enhance RT performance, mainly by increasing the maximum number of repetitions (MNR) and total volume

(MNR × mass lifted in each repetition) (5, 6, 8, 9), in addition to potentially reducing the Rating Perceived Exertion (RPE) (5-7) during RT sessions.

These improvements can be explained by the antagonistic action of caffeine on adenosine receptors, reducing fatigue in RT sessions (3). Another explanation might be related to the increased release and inhibition of calcium reuptake in the sarcoplasm (3). This occurs due to the action of caffeine on ryanodine receptors on the skeletal muscle fibers (10). Such a physiological effect may favor greater production of strength, especially under fatigue (7, 11).

Studies have shown that capsaicin supplementation can also increase MNR and total volume in the RT (12-14), in addition to reducing RPE (12). Such an effect can be explained by the action of capsaicin on Transient Receptor Potential Vanilloid 1 (TRPV1) present in skeletal muscles, increasing the concentration of calcium in the sarcoplasm (4), analogous to caffeine. Another effect is the potential analgesic effect of capsaicin on TRPV1 regulating nociception, which may increase the discomfort threshold, reflecting lower RPE in RT (4).

However, some studies found no significant effect of caffeine or capsaicin supplementation on either MNR or RPE (15, 16). Such differing results might have resulted from the differences in the RT and supplementation protocols used, as well as the responsiveness and trained body segment of individuals (3).

The combination of substances can also influence supplementation results (1). Thus, considering the possible synergistic effect of combining caffeine and capsaicin, since they have similar physiological responses, but through different pathways, the combination of these substances can be a nutritional strategy aimed at increasing performance in RT. Grgic *et al*. (2) reported that the combination of capsaicin and caffeine can generate, or maximize, an ergogenic effect on RT, indicating the need for specific studies on this combination. However, Simões *et al*. (16) found no statistically significant difference in the MNR in four sets of squat exercise resulting from the combined supplementation of caffeine and capsaicin. No other studies investigated such a combination of substances, with other body segments, training protocols, or individuals.

Therefore, this study aimed to verify and compare the possible acute effects of combined and isolated supplementation of caffeine and capsaicin on performance and RPE in a session of RT, using multiple sets and exercises for the upper body. Hypothetically, combined caffeine and capsaicin supplementation will result in a higher increase in performance and lower RPE.

# METHODS

## Experimental design

We applied a randomized, double-blind, crossover, and placebo-controlled experimental design. Each volunteer participated in eight experimental sessions, with an interval of seven days.

The first session was conducted to introduce the research. In the second session, the volunteers were familiarized with the training place, exercises, equipment, test of 1-maximum repetition (1RM), tables, and questionnaires. In the third and fourth sessions, the 1RM test was performed, respectively, in the bench press and the incline bench press exercises. In the fifth to eighth sessions, the volunteers performed an RT session under the supplementation conditions.

In addition, in the second session, we recorded total body mass, height, and usual caffeine consumption carried out a 24-hour dietary recall, which was also applied in the last experimental session. An experienced nutritionist researcher performed the 24-hour food recall, the registration of the meal before the experimental sessions, and the application of the questionnaire on habitual caffeine consumption.

The MNR, RPE, and heart rate (HR) were registered during the RT protocol. In addition, for the analysis of lactate concentration [LAC], blood samples were collected immediately after supplementation (pre-training) and immediately after performing the RT protocol (post-training). Moreover, 30 minutes after the RT session, the RPE was recorded to determine the perceived exertion concerning the session (RPE session).

## Subjects

Fourteen trained men participated in the study (5.6 ± 3.5 years of experience in RT and weekly training frequency of 5 ± 0.8 days), aged in average 24.8 ± 3.3 years, with a mean height of 178.6 ± 4.9 cm, and mean total body mass of 82.4 ± 7.1 kg. The volunteers had experience in performing certain exercises to concentric failure.

As exclusion criteria, the volunteers could not present joint, muscle, and/or bone lesions in the trunk and upper limbs, in addition to gastrointestinal and cardiovascular diseases, food allergies, smoking, or any other conditions that could interfere with the protocol training. In addition, the volunteers should not have consumed any type of nutritional ergogenic resource for at least six months.

## Ethical care

All volunteers were fully informed on the research and signed the Informed Consent Form, agreeing to participate in the study. This project complied with all the norms established by the National Health Council (Res 466/2012), being approved by the Research Ethics Committee of the Federal University of Minas Gerais (32570820.6.0000.5149 – Date of approval: August 24, 2020).

## Procedures

### *Anthropometric measurements*

The volunteers were characterized by total body mass and height. A digital scale (Welmy, model W200) with a precision of 100 g and 0.5 cm was used for measuring total body mass and a stadiometer attached to the scale was used to measure height.

## Supplementation

The volunteers were subjected to the following four experimental conditions: placebo (PLA), caffeine (CAF), capsaicin (CAP), and the combination of caffeine and capsaicin (CAF+CAP). Six identical capsules were consumed by each volunteer before the RT protocol: six of placebo (50 mg of starch) in the PLA condition; one of placebo and five of caffeine (5 mg × $kg^{-1}$) in the CAF condition; five of placebo and one of capsaicin (12 mg) in the CAP condition; and five of CAF (5 mg × $kg^{-1}$) and one of CAP (12 mg) in the CAF +CAP condition.

Previous studies have demonstrated that the capsaicin dose of 12 mg enhanced RT performance (12, 13) and was well tolerated by the individuals (12, 16). Each volunteer received the caffeine dose of 5 mg × $kg^{-1}$ due to its safety and potential ergogenic effects on RT (17).

The supplement capsules were consumed by each volunteer 45 minutes before the RT protocol since caffeine and capsaicin can reach peak blood concentrations during this period (3, 4).

## Resistance training protocol

The same procedures of Drummond *et al.* (18) were adopted for the 1RM test, both in the familiarization and the test sessions. Initially, the 1RM value estimated at familiarization (19) was used for each volunteer. The volunteers were instructed not to perform vigorous physical efforts 72 hours before the test sessions.

Ten series were performed (20), five sets in the bench press and five sets in the incline bench press (Konnen – Olympic, Apple line), both with a barbell (Olympic: 20 kg; weights: Supersport washers), with 70% of 1RM (9, 12), until concentric muscle failure. Rests of 90 and 120 seconds were adopted between sets and exercises, respectively (19). Both exercises were performed using the same technique adopted by Bergstrom *et al.* (1). The volunteer performed a warm-up before starting the RT protocol (9).

MNR and displaced mass were registered for performance analysis. Therefore, the total volume (maximum repetitions × lifted mass) (21) was used as a performance parameter. Volunteers were verbally encouraged while performing the exercises.

## Assessment of food consumption

This nutritional research tool is aimed at detecting potential changes in the dietary profile of the volunteers' diet concerning the average consumption of calories and macronutrients that may interfere with the study results (16).

The pre-exercise meal was individually standardized to minimize potential interference from other nutrients in the experimental sessions. The usual meal ingested by the volunteers was maintained and should be consumed one hour before each experimental session (16). In addition, during the study period, the volunteers were instructed not to change their regular diets and exercise routine neither to use any other supplement or ergogenic substance nor consume peppers or spicy foods, coffee, teas, energy drinks, and alcoholic beverages 24 hours before the test and RT session (3). We recorded the 24-hour dietary recalls and calculated the energy and macronutrient intake on the Dietbox software (version 6.8.3, Brazil) (16).

The registration for estimating the volunteers' usual caffeine consumption followed Buhler *et al.* (22). Thus, the volunteers were classified according to the values (mg × $kg^{-1}$) of usual caffeine consumption (23).

## Rating Perceived Exertion (RPE), RPE session, Heat Rate (HR), and lactate concentration [LAC]

The RPE and HR were checked and registered 10-15 seconds after the end of each set during the RT protocol (24). As to RPE and RPE session, we used the scale and equation of Foster *et al.* (25) to record the volunteer perception of exertion to the effort and the entire session, in rest, respectively. For HR analysis and recording, the volunteer used a transmitter belt (brand: Polar; model: T-31 Coded – Embu das Artes, São Paulo – Brazil) compatible with a specific application (Polar Beat, version 3.4.6 – IOS App Store Brazil).

For the [LAC], a blood sample was collected through one of the volunteers fingers using a disposable lancet (Accu-Chek Safe-T-Pro Uno, 28 g/0.36 mm – Roche). Immediately after, two microliters of blood were transferred to a reagent strip (Lactate Detect Test Strip – model: TD-4261; ECO Diagnóstica LTDA) for analysis in a portable lactate analyzer (Lactate Detect – model: TD-4261 - ECO Diagnóstica LTD) (26).

## Statistical analysis

The data normality and data sphericity were verified by the Shapiro-Wilk test the Mauchly test, respectively. The one-way ANOVA with repeated measures was used to compare the means of the variables that presented normal distribution. If necessary, the Bonferroni *post-hoc* was applied. The Friedman test was used to compare the means of variables without normal distribution. The significance level adopted was $\alpha = 0.05$. The effect size (d) was calculated and classified following Rhea (27). The paired t-test was used to compare the means of kilocalories (kcal) and grams (g) of macronutrients, referring to the dietary profile at the beginning and end of the experimental intervention. The Wilcoxon test was used to compare means that did not show normal distribution. All statistical analyses were performed on the SPSS software (version 22.0).

## RESULTS

The variables total volume, NMR, RPE, and energy (kcal) at the two moments of the food recall and lipid intake at the two moments of the food recall and pre-exercise meal showed normal distribution ($p > 0.05$). The variables RPE session, HR, pre- and post-training lactate, energy (kcal) at the two moments of the pre-exercise meal, carbohydrates, and proteins in the two moments of the food recall and pre-exercise meal did not present normal distribution ($p < 0.05$). The total volume and RPE variances presented homogeneity ($p > 0.05$).

The total volume means were statistically similar ($p = 0.110$) between the experimental conditions (PLA: 7257.0 ± 1644.6; CAF: 7024.6 ± 1448.2; CAP: 7332.7 ± 1866.2; CAF+CAP: 6827.3 ± 1494.0). **Figure 1** present the individual total volume values. A trivial effect size on the total volume occurred in the experimental conditions (CAF: d = 0.14; CAP: d = 0.05; CAF+CAP: d = 0.26) compared with the placebo.

No statistically significant difference ($p = 0.176$) was found for MNR between the means of the experimental conditions (PLA: 54.5 ± 8.4; CAF: 53.2 ± 9,7; CAP: 55.0 ± 10.0; CAF+-CAP: 51.3 ± 7.5).

There was no statistically significant difference between the means of the RPE ($p = 0.233$) and RPE session ($p = 0.694$) in the experimental conditions. **Table I** present the means and standard deviations of the RPE and RPE session. The effect size was trivial for the RPE (CAF: d = 0.09; CAP: d = 0.13; CAF+CAP: d = 0.27) and RPE session (CAF: d = 0.24; CAP: d = 0.08; CAF+CAP: d = 0.25) in the experimental conditions, compared with the placebo.

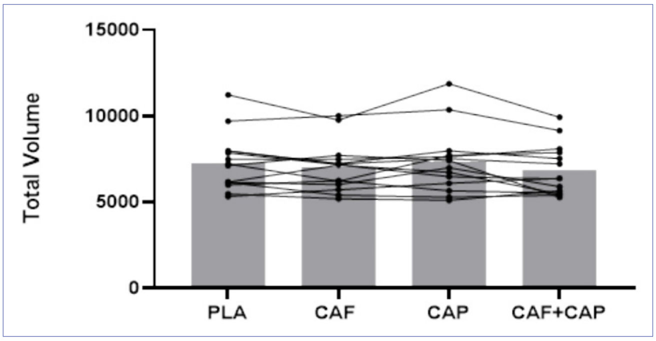


**Figure 1.** Mean and individual total volumes in the experimental conditions.

PLA: placebo; CAF: caffeine; CAP: capsaicin; CAF+CAP: caffeine + capsaicin.

In addition, the [LAC] means of the experimental conditions were statistically similar in the pre-session ($p = 0.331$) (PLA: 2.4 ± 0.9 mmol/L; CAF: 2.1 ± 0. 5 mmol/L; CAP: 1.8 ± 0.4 mmol/L; CAF+CAP: 2.1 ± 0.5 mmol/L) and post-session ($p = 0.350$) (PLA: 10.4 ± 2.6 mmol/L; CAF: 10.2 ± 2.4 mmol/L; CAP: 9.7 ± 2.1 mmol/L; CAF+CAP: 9.6 ± 2.3 mmol/L) situations. In the post-session, [LAC] was trivial in the experimental conditions (CAF: d = 0.07; CAP: d = 0.27; CAF+CAP: d = 0.30) compared with the placebo.

The HR means were statistically similar between the experimental conditions ($p = 0.405$) (PLA: 114.7 ± 15.8 bpm; CAF: 119.0 ± 18.6 bpm; CAP: 117.2 ± 14.1 bpm; CAF+ CAP: 119.4 ± 22.1 bpm).

In the habitual caffeine consumption, the daily average relative consumption was 1.1 ± 0.9 mg × $kg^{-1}$ and the absolute consumption was 92.9 ± 77.4 mg. Therefore, the volunteers of this study were classified as light consumers of caffeine.

Evaluated at the beginning and end of the intervention, the means of caloric intake in the food recall (2213.8 ± 440.7 and 2186.2 ± 653.4, $p = 0.874$) and in the pre-exercise meal (566.8 ± 267.1 and 627.3 ± 294.3, $p = 0.345$) were statistically similar. The grams of macronutrients showed no statistically significant difference in the food recall (carbohydrate:

**Table I.** Means of RPE, RPE session under experimental conditions.

| Condition | RPE | RPE session |
|---|---|---|
| PLA | 15.4 ± 2.2 | 80.5 ± 38.8 |
| CAF | 15.6 ± 2.5 | 89.9 ± 39.6 |
| CAP | 15.1 ± 2.4 | 77.1 ± 41.9 |
| CAF+CAP | 14.8 ± 2.7 | 90.3 ± 34.4 |

Data are presented as means ± standard deviation; RPE: perceived exertion; RPE session: perceived exertion of the session; PLA: placebo; CAF: caffeine; CAP: capsaicin; CAF+CAP: caffeine + capsaicin.

248.1 ± 71.0 and 249.6 ± 93.0, p = 0.917; proteins: 141.0 ± 53.5 and 119.5 ± 32.2, p = 0.345; lipids: 74.5 ± 23.3 and 78.4 ± 31.0, p = 0.700) and pre-exercise meal (carbohydrate: 66.0 ± 35.1 and 56.0 ± 36.2, p = 0.208; proteins: 44.3 ± 28.4 and 46.0 ± 26.0, p = 0.600; lipids: 20.0 ± 10.0 and 26.0 ± 15.4, p = 0.101), at the beginning and end of the intervention.

## DISCUSSION

This study verified the acute combined and isolated supplementation of caffeine and capsaicin, in an RT session, with multiple sets in the barbell bench press and inclined barbell bench press exercises. Hypothetically, the supplementation will increase the performance and reduce the RPE, with a greater effect on the combination of the substances. However, no statistically significant difference was found either for total volume, NMR, RPE or RPE session between the experimental conditions or for the mean concentrations of lactate and HR. Therefore, our hypothesis was not confirmed.
As to total volume, our results are similar to the results of Simões *et al.* (16), who also found no significant difference between the conditions of a placebo, capsaicin, caffeine, and a combination of both substances in an RT protocol for lower limbs. The authors speculate that individual responsiveness to non-individualized doses, especially capsaicin, might explain the results. Still, our results suggest that the combination of caffeine and capsaicin doses was not enough to exert a synergistic effect, not mitigating the cumulative effects of fatigue caused by the RT protocol with multiple sets and exercises. It is worth pointing out that Simões *et al.* (16) used the same doses in caffeine supplementation, capsaicin, and the combination of both substances. No other studies were found that investigated such a combination, which limits the discussion. Thus, further studies should address the combined supplementation of these substances, with different doses and strength training protocols (2).
Regarding the supplementation of isolated substances, other studies contradict our results and found a significant difference in total volume and NRM in the caffeine (5, 6, 9) and capsaicin (12, 13) conditions compared with the placebo condition. The difference in the results of the studies might have resulted from individual variation in response to supplements, substance doses, and different muscle activation between different body segments.
Concerning the individual response variability, the literature reports that not all individuals respond positively to capsaicin supplementation in the RT (16). Such an individual variation can be explained by a potential genetic variation in TRPV1 (28, 29). However, further studies are needed to verify whether a possible genetic polymorphism related to TRPV1 influences the variability of response to capsaicin supplementation.
The literature also reports that individual response variability to caffeine supplementation may occur in RT (3); however, the possible causes are not very well understood (30). Nonetheless, the levels of conditioning and habitual consumption of this substance, with possible up-regulation in the concentration of adenosine receptors, are mentioned as potential factors that may influence the response to caffeine (30). Such variations in individual responses may have influenced our results concerning the combined CAF+CAP, like Simões *et al.* (16).
Another potential cause such differing results is the dose of the substances. No human studies were found classifying capsaicin doses as low, moderate, or high based on the pharmacokinetics of this substance. However, Oh and Ohta (31) carried out a study with rats that indicate a potential dose dependence between capsaicin and performance. Nonetheless, Moura *et al.* (14) demonstrated that 6 mg of capsiate enhanced the MNR performed in RT compared with a 12 mg dose and placebo. Therefore, further studies should address different doses, especially those referent to body weight with capsaicin supplementation in the RT.
Furthermore, different doses of caffeine are associated with the magnitude of effects on strength manifestations, such as maximum strength, power (30), and strength resistance (32). Salatto *et al.* (8) showed that a high dose of caffeine (9 mg × $kg^{-1}$) was effective in increasing the performance of RT. Thus, the lower dose of caffeine adopted in this study may explain the difference in the results.
Wilk *et al.* (15) reported that the absence of caffeine ergogenic effect on RT might have resulted from individual tolerance. In their study, the volunteers had an average daily consumption of 4.9 mg × $kg^{-1}$ of caffeine, which is considered a moderate consumption (23). In turn, in our study, the average daily consumption of volunteers was 1.1 ± 0.9 mg × $kg^{-1}$, which is considered light consumption (23). Thus, tolerance to caffeine ergogenicity may not explain our results. Therefore, further specific studies should address the influence of habitual caffeine consumption on supplementation response in the RT (30).
A possible explanation for such differing results is a difference in activation that might occurred between muscle groups of different body segments when supplemented with caffeine, capsaicin, and the combination of these substances. Since the literature reports a potential genetic polymorphism referring to this receptor (28, 29), there may be a difference in the concentration of the TRPV1 receptor between the muscle groups of different body segments. Through caffeine supplementation, is suggested that this substance may increase the activation of lower limb

muscles, higher than the trunk and upper limbs muscles (32). The likely higher concentration of adenosine receptors in the muscles of the lower limbs (33), may partially justify the results of our study. However, Simões *et al*. (16) found results that contradict such a premise by investigating the same supplements adopted in our study in the performance of RT of lower limbs, with similar results.

Our study found no significant difference for RPE and RPE session between the experimental conditions. In contrast to our findings, other studies have found a significant reduction in RPE with caffeine (5-7) and capsaicin (12) acute supplementation. Such differing results may be due to the difference in perceived exertion between exercises for different body segments and RT protocols. Salatto *et al*. (8) reported that exercises for the trunk and upper limbs may be less strenuous than exercises for the lower limb. Thus, RPE will be less affected by acute supplementation in upper limbs in RT.

Corroborating our findings, Simões *et al*. (16) found no reduction in RPE through capsaicin, caffeine, and a combination of substances, compared with a placebo. In addition, other studies have also found no significant difference between caffeine (8, 34) and capsaicin conditions (14). Supplements do not seem to attenuate RPE in RT protocols performed until muscle failure (34). Therefore, the need to perform the series until failure may have influenced the results.

Regarding the lactate concentration, our study found no significant difference between the experimental conditions, like the results for caffeine (6) and capsaicin (12, 14) from other studies. Caffeine (30) and capsaicin (4) are reported to have a sparing effect on muscle glycogen due to the potential increase in mobilization and oxidation of fatty acids. This physiological effect is considered a potential mechanism that can influence performance improvement in exercises (4, 30). However, the lack of significant difference in lactate concentration between the experimental conditions presented here indicates that caffeine and capsaicin supplements, as well as the combination of these substances, may not have muscle glycogen-sparing effect on RT.

Regarding energy and macronutrient intakes, there was neither a significant change in food consumption nor in nutrition at the pre-exercise moment. Thus, such a finding indicates that the dietary profile may not have influenced performance (16).

Among others previously pointed out and discussed, a possible limitation of this study is the number of participants, which was defined by convenience, recruiting all volunteers obtained through disclosure, and meeting the inclusion criteria. In addition, the usual consumption of peppers and spicy foods was not estimated.

## CONCLUSIONS

Combined and isolated caffeine and capsaicin acute supplementation did not improve the upper-body RT performance of trained men. Furthermore, these substances may not attenuate the perception of exertion during RT with maximum repetitions.

## FUNDINGS

This study was financed in part by Coordination for the Improvement of Higher Education Personnel - Brazil (CAPES) - funding code 001.

## DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

## CONTRIBUTIONS

VC, MD: data analysis, results interpretation, writing – original draft. RS, MM, IF, RN, YP: writing – review & editing. All authors: final version approval.

## ACKNOWLEDGMENTS

The authors thank the volunteers for their effort and dedication while engaging in this study.

## CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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