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ACUTE CAPSAICIN SUPPLEMENTATION ENHANCES ISOMETRIC CONTRACTION AND ENDURANCE IN BRAZILIAN JIU-JITSU ATHLETES: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Background: Dietary supplements such as capsaicin have gained increasing attention for their potential to enhance sports performance. Brazilian Jiu-Jitsu (BJJ), a grappling-based martial art, demands high levels of muscular strength and endurance. Capsaicin (CAP), a bioactive compound found in chili peppers, has demonstrated ergogenic effects. However, its acute impact on strength and endurance in BJJ athletes remains unclear. This study aimed to evaluate the acute effects of CAP supplementation on upper-limb strength, endurance performance, and rating of perceived exertion (RPE) in BJJ athletes.

Materials and methods: Eighteen athletes participated in a randomized, crossover, triple-blind clinical trial. In two separate sessions, participants ingested either 12 mg of CAP or a placebo 45 minutes before performing physical tests, including handgrip strength (HS), isometric pull-up (IP), and dynamic pull-up (DP), all conducted while wearing a gi. RPE was recorded after each test. Normally distributed variables (IP and DP) were analyzed using the paired t-test, while non-normally distributed variables (RPE and HS) were analyzed using the Wilcoxon test. A significance level of $p < 0.05$ was adopted.

Results: CAP supplementation significantly increased isometric pull-up duration ($\Delta = +2.83$ s; $p = 0.040$; $d = 0.52$). No statistical differences were found for HS, DP, or RPE; however, RPE showed a moderate effect size ($r = 0.37$). No significant differences in adverse events were observed between conditions.

Conclusion: Acute supplementation with 12 mg of capsaicin improved isometric upper-limb endurance in BJJ athletes, as evidenced by increased isometric pull-up duration.

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KEYWORDS
Dietary supplements, isometric contraction, martial arts, muscle strength, physical endurance

INTRODUCTION

Brazilian Jiu-Jitsu (BJJ) is a combat sport based on grappling techniques and body control[1]. Matches last between five and ten minutes and can be decided by points, submission, or disqualification[2]. During combat, intermittent movements predominate, consisting of isometric and dynamic actions performed with sudden variations in intensity and no defined pattern[3]. Among the factors influencing competitive success, the athlete's ability to sustain offensive and defensive actions with technical efficiency stands out[4].

Upper-limb strength and endurance are key performance components in BJJ, especially for grip fighting, opponent control, technique execution, and maintenance of dominant positions[5]. These physical capacities have been assessed using tests such as handgrip strength (HS), which measures maximal grip force[6]. The pull-up test performed with a gi is used to evaluate upper-limb muscular endurance—either isometrically (IP) through time sustained, or dynamically (DP) by the maximum number of repetitions[7]. Both tests are sensitive for estimating grip strength and endurance of the upper limbs[8]. HS has shown strong correlations with body composition[9] and positive associations with competitive rankings across various combat sports[10]. The gi pull-up test has demonstrated high reliability, with intraclass correlation coefficients (ICC) of 0.96 for the isometric version and 0.95 for the dynamic version[11] and is also employed as an exercise for strength and endurance training of the upper limbs[8].

The ability to sustain force in repeated upper-limb actions is considered fundamental in BJJ and is associated with maintaining technical efficiency throughout the match[12]. Additionally, small improvements in physical performance may directly influence competitive success[13]. In this context, strategies aimed at preserving or enhancing performance have been increasingly investigated[14]. Among these, the use of dietary supplements, considering regulated nutritional resources, has gained prominence for its ergogenic potential and widespread adoption across various sports disciplines[15,16]. In combat sports, such nutritional resources have been explored as complementary interventions to physical training[17], with the goal of optimizing force production, prolonging muscular endurance, and reducing the rating of perceived exertion (RPE)[14].

Among the most studied nutritional ergogenic aids currently is capsaicin (CAP), a bioactive phytochemical compound derived from plants of the Capsicum genus, family Solanaceae[18,19]. The primary mechanism of action of CAP involves the selective activation of the transient receptor potential vanilloid 1 (TRPV1), an ion channel expressed in various tissues with distinct and complementary physiological functions[20]. In sensory neurons, it can influence pain and temperature perception[21]; in the vascular endothelium, it is associated with vasodilation and regulation of blood flow[22]; in adipose tissue, it modulates lipid metabolism[23]; and in skeletal muscle, it contributes to sarcoplasmic calcium release, affecting contractile function[24]. This multiorgan expression of TRPV1 allows CAP to exert integrated systemic effects that converge to enhance various aspects of physical performance[19].

Evidence indicates that acute ingestion of 12 mg of CAP, 45 minutes prior to activity[25], has demonstrated significant ergogenic effects, such as increased repetitions in strength exercises[26], improved running performance[27], and reduced RPE[28], without causing gastrointestinal discomfort. These effects support the interest in using CAP in combat sports, where studies have shown positive outcomes[29,30]. In kickboxing athletes, acute CAP supplementation increased the number of strikes during simulated fights[29]. In BJJ practitioners, an increase in peak power and peak velocity was observed during the bench press exercise[30]. However, the effects of CAP on performance in specific tests such as HS, IP, and DP have not yet been explored. Considering CAP's ergogenic potential and its systemic and integrated physiological effects, which can influence different aspects of physical performance, the aim of this study was to investigate the acute effects of this supplementation on specific strength and endurance tests in BJJ athletes. We hypothesized that acute supplementation with 12 mg of CAP would significantly increase the time sustained in the IP test and the number of repetitions in the DP test, while producing minimal or no changes in HS and RPE.

MATERIALS AND METHODS

Ethical considerations

The study was approved by the Research Ethics Committee of the Federal University of Minas Gerais under CAAE 92956325.9.0000.5149 and opinion number 8.501.808, in accordance with Resolution No. 466/2012 of the Brazilian National Health Council and the Declaration of Helsinki. All participants signed an informed consent form after being informed about the study's objectives, potential benefits, risks, and procedures.

Experimental design

The study followed a randomized, crossover, triple-blind,

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placebo-controlled design. Four in-person sessions were conducted: two for familiarization and test reliability verification, and two experimental sessions involving capsaicin and placebo conditions, with a minimum interval of seven days between them. All sessions were held at the same time of day for each participant, with a maximum variation of 30 minutes, in a natural environment with an average air temperature of 30.3°C and relative humidity of 66.3%, according to the National Institute of Meteorology (2025).

Sample size calculation

The sample size was calculated using G*Power software (version 3.1.9.4), based on a paired t-test, considering an effect size of d = 0.8 (large)[26], a significance level of α = 0.05, and a statistical power of 80%. A minimum of 15 participants was estimated to ensure adequate statistical sensitivity.

Participants

Eighteen BJJ athletes participated in the study, with a mean age of 31.7 ± 6.0 years and a mean training experience of 12.8 ± 3.4 years. Belt ranks were distributed as follows: black belt (n = 8), brown (n = 5), purple (n = 3), and blue (n = 2). Among them, 66.7% (n = 12) competed at the national level and 33.3% (n = 6) at the international level. Height was measured using a Filizola® stadiometer (São Paulo, Brazil) integrated with a scale, with a precision of 0.1 cm. Body composition was assessed using the Ironman BC-1500® multifrequency bioelectrical impedance analyzer (Tanita Corporation, Tokyo, Japan), with the following results: total body mass (79.9 ± 5.8 kg), fat mass (11.5 ± 1.4 kg), lean mass (68.4 ± 4.4 kg), and body fat percentage (14.4 ± 1.8%)[31].

Included participants were male athletes with at least five years of continuous BJJ experience, in full training condition, and with participation in official competitions within the last 12 months. Participants were excluded if they used dietary supplements or anabolic steroids within the previous 60 days. Additional exclusion criteria included the use of supplements or stimulants on test days, upper-limb injuries, medical conditions that could prevent participation, absence from any of the experimental sessions, or failure to comply with the previously agreed-upon instructions.

Familiarization and reliability sessions

The first two sessions were designated for participant familiarization with the test protocols and for evaluating the reliability of the instruments used, with a 72-hour interval between them. The handgrip strength test (HS) showed excellent reliability (ICC(3,1) = 0.98), as did the isometric pull-up (IP) (ICC(3,1) = 0.87), dynamic pull-up (DP) (ICC(3,2) = 0.97), and rating of perceived exertion (RPE) (ICC(3,2) = 0.97). Despite greater absolute variability in the IP test, the values were considered acceptable[32]. The inclusion of test–retest reliability assessment is consistent with methodological recommendations in sports performance research[33].

Randomization and blinding

The randomization of the order of experimental conditions was performed in R, using the RStudio platform by an external researcher, generating balanced combinations (A–B or B–A). The sequences were printed and sealed in opaque, numbered envelopes, which were individually drawn by participants at the time of data collection. The capsules, indistinguishable in size, color, and packaging, were individually stored in sealed containers labeled only with the letters A or B, ensuring triple blinding among participants, administrators, and evaluators.

Supplementation

The intervention consisted of ingesting a capsule containing either 12 mg of purified CAP or 12 mg of corn starch placebo (PLA). Intake was supervised, and the physical tests began 45 minutes after ingestion[26].

Dietary control

Before the start of the experimental protocol, an experienced nutritionist instructed participants to maintain their usual diet. To monitor dietary intake, a 24-hour dietary recall was applied before each experimental session. This procedure allowed for the analysis of total caloric value (TCV) and the distribution of macronutrients—carbohydrates, proteins, and lipids—adjusted for body mass. Data were recorded and analyzed by the nutritionist using the DietBox application (version 7.8.1, Dietbox Ltda., Porto Alegre, Brazil), with reference to the TACO, IBGE, and Sônia Tucunduva Philippi food composition tables.

The perception of the ingested capsule and the occurrence of adverse events were assessed using a questionnaire previously applied in capsaicin-related studies[34]. Blinding efficacy was assessed by the proportion of participants who correctly identified the treatment received in each session, using the exact binomial test with a null hypothesis of 50% accuracy.

Test procedures

Physical tests were conducted in gyms and training locations previously arranged with the participants, always at the same time of day for each individual. All sessions took place in their usual training environment. Following a general warm-up lasting five to ten minutes, the tests were administered.

Handgrip strength (HS) was measured using a digital dynamometer, model Instrutherm DM-90 (Instrutherm, Brazil), with a maximum capacity of 90 kgf (kilogram-force) and a precision of 0.1 kgf. This equipment is widely used in clinical and sports settings in Brazil. In a pilot test with 10 Jiu-Jitsu athletes, an intraclass correlation coefficient (ICC(3,1)) of 0.98 was obtained (95% CI: 0.87–0.98; p <0.01), with a standard error of measurement (SEM) of

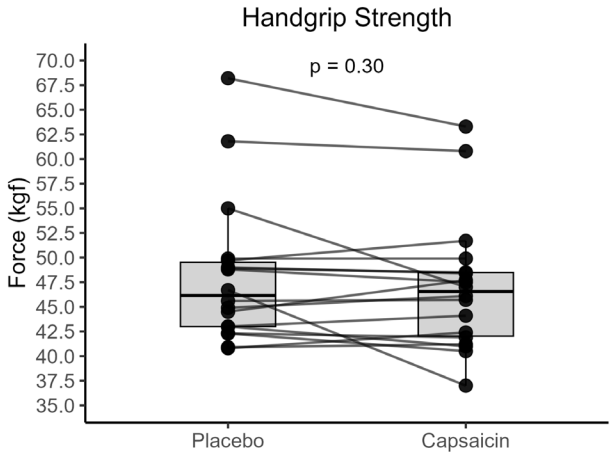


Figure 1. *Handgrip strength under PLA and CAP conditions. Legend: Dots represent individual participants, with lines connecting paired values. Boxplots display quartiles and the median. No statistically significant difference was observed (p = 0.30).*

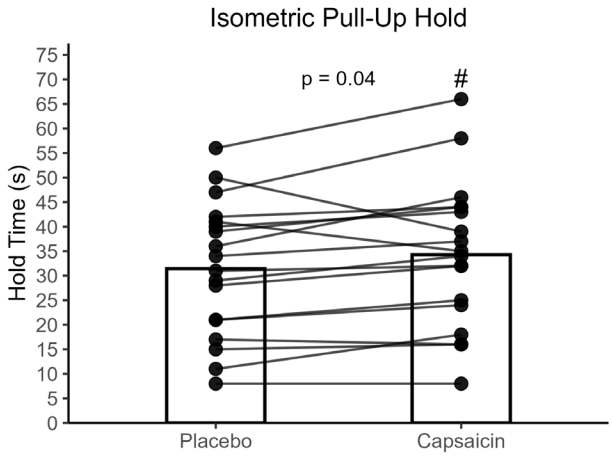


Figure 2. *Isometric pull-up test (hang time) under PLA and CAP conditions.*
Legend: Bars represent mean ± standard deviation (SD). Dots indicate individual participants, with lines connecting paired values. A statistically significant difference was observed between conditions (p = 0.04). # indicates statistical significance.

0.226 kgf and a minimal detectable change (MDC) of 0.63 kgf. The test protocol was performed with athletes in a standing position, shoulder adducted, elbow flexed at 90°, forearm in a neutral position, and wrist between 0° and 30° of extension[6]. Participants were instructed to perform a maximal isometric contraction sustained for 5 seconds. Three attempts were performed with the dominant hand, with a 180-second rest interval; the average of the values obtained was used for analysis.

The IP test was performed on a horizontal bar positioned at a height of 2.40 m, with a gi attached. Athletes used a direct grip on the lapels of the gi[7]. They remained suspended with elbows flexed (~90°) and torso upright, without foot support. Total hang time was recorded over three attempts, with 180-second intervals.

In the DP test, participants used the same lapel grip and performed full range elbow flexions consecutively until voluntary exhaustion, and the total number of valid repetitions was counted[35]. RPE was recorded 2 minutes after test completion using the adapted Borg CR-10 scale[36]. A recovery period of 5 minutes was provided at the end of each test.

Statistical analysis

The normality of data distribution was assessed using the Shapiro–Wilk test. For variables with approximately normal distribution ($p > 0.05$), the paired t-test was applied, and effect size was calculated using Cohen's d (small: 0.2; moderate: 0.5; large: 0.8). For variables without normal distribution ($p < 0.05$), the paired Wilcoxon test was used, with effect size estimated by the coefficient r (small: 0.1; moderate: 0.3; large: 0.5). Variables were presented as mean ± standard deviation for normally distributed data, or as median and interquartile range (IQR: Q1–Q3) for data that did not follow a normal distribution. The significance level was set at $p < 0.05$. All analyses were performed using R software (version 4.4.2), via the RStudio platform. The incidence of adverse events was evaluated using a 2×2 contingency table ("yes"/"no") responses between PLA and CAP), analyzed with Fisher's exact test, adopting a significance level of $p < 0.05$.

RESULTS

Nutritional control

Macronutrient intake and total caloric value (TCV) were similar between the PLA and CAP conditions: carbohydrates (228.3 ± 35.9 g vs 220.1 ± 73.9 g; p = 0.74; d = 0.107), proteins (151.8 ± 23.9 g vs 145.6 ± 26.0 g; p = 0.61; d = 0.163), lipids (70.5 ± 17.7 g vs 70.5 ± 13.6 g; p = 0.99; d = 0.001), and TCV (2157.0 ± 325.9 kcal vs 2091.5 ± 404.8 kcal; p = 0.66; d = 0.143). Despite minor variations, no significant differences were observed.

Comparisons between tests

The comparative results for HS, IP, DP, and RPE under the PLA and CAP conditions are presented in *Table 1*. A statistically significant difference was observed for IP ($p < 0.05$), whereas no significant differences were found for the other variables.

Handgrip strength

The data for the HS variable were analyzed using the paired Wilcoxon test. The median values were 46.55 kgf for CAP and 46.15 kgf for PLA, with no statistically significant difference between conditions (V = 98.5; p = 0.30). The effect size, calculated using the r coefficient, was 0.24, indicating a small effect magnitude in favor of the PLA group. *Figure 1* displays the distribution of individual values and central tendency measures for both conditions.

Isometric pull-up

Regarding the IP test, the paired t-test revealed a

Variable	PLA	CAP	p value	Effect size
HS (kgf)	46.15 (Q1 43.0; Q3 49.5)	46.55 (Q1 42.0; Q3 48.4)	0.30	r = 0.24
IP (seconds)	31.44 ± 13.78	34.27 ± 15.00	0.04*	d = 0.52
DP (repetitions)	13.22 ± 6.11	13.78 ± 5.37	0.37	d = 0.22
RPE	7 (Q1 7; Q3 8)	7 (Q1 6, Q3 8)	0.11	r = 0.37

Table 1. *Comparison of outcomes between PLA and CAP conditions with statistical analysis and effect size.*
*Legend: HS, handgrip strength (kgf); IP, isometric pull-up (seconds); DP, dynamic pull-up (repetitions); RPE, rating of perceived exertion (CR-10 scale). Data are expressed as mean ± standard deviation (SD) or median and interquartile range (Q1–Q3), according to the distribution of the variables. *Statistically significant difference (p <0.05).*

statistically significant difference between conditions (t(17) = –2.22; p = 0.040), with a mean difference of 2.83 seconds (95% CI: –5.53 to –0.14), indicating superior performance in the CAP condition. On average, hang time was 31.44 ± 13.78 seconds in the PLA condition and 34.27 ± 15.00 seconds in the CAP condition. The effect size was classified as moderate (d = 0.52). *Figure 2* shows the distribution of individual values and the mean differences between conditions.

Dynamic pull-up

In the DP test, the paired t-test did not reveal a statistically significant difference between conditions (t(17) = –0.92; p = 0.368). On average, the number of repetitions was 13.22 ± 6.11 for PLA and 13.78 ± 5.37 for CAP, with a small effect size (d = 0.22). *Figure 3* illustrates the individual and mean values for repetitions across conditions.

Rating of perceived exertion

For RPE, the Wilcoxon test indicated a median of 7 CR-10 units in both conditions, with an interquartile range of 7 to 8 in the PLA group and 6 to 8 in the CAP group. No significant difference was observed between conditions (p = 0.11), and the observed effect size was moderate (r = 0.37).

Adverse events and blinding assessment

The number of adverse events was low in both groups, with an incidence of 11.1% in PLA and 5.6% in CAP, with no statistically significant difference (p = 1.00). The proportion of correct responses was 50% in the PLA session (9 of 18 participants) and 47.1% in the CAP session (8 of 17 participants), not differing significantly from what would be expected by chance (Placebo: p = 1.00; Capsaicin: p = 1.00). The 95% confidence intervals ranged from 26.0 to 73.9% for PLA and from 22.9 to 72.2% for CAP, suggesting that blinding was maintained in both conditions.

DISCUSSION

The results of the present study indicated that acute supplementation with 12 mg of CAP, administered 45 minutes before physical testing, significantly improved performance in the IP test, partially confirming the proposed hypotheses.

The improvement observed in the IP test may be explained by well-established physiological mechanisms described in the scientific literature, particularly the activation of TRPV1 receptors located in the sarcoplasmic reticulum of skeletal muscle fibers[20]. TRPV1 activation by capsaicin triggers a cation influx—mainly Ca^{2+}—that depolarizes the cell membrane and activates voltage-dependent calcium channels[37]. This process amplifies intracellular calcium signaling, promoting additional Ca^{2+} release from the sarcoplasmic reticulum via ryanodine receptors (RyR)[24]. The resulting increase in cytoplasmic Ca^{2+} concentration enhances actin–myosin interaction, favoring the maintenance of contractile force during prolonged efforts[38]. In addition, recent findings indicate that genetic polymorphisms of TRPV1 can alter receptor sensitivity to capsaicin, which may contribute to the substantial interindividual variability often observed in supplementation responses[39].

In this context, other studies have also reported improved physical performance, such as increased maximum

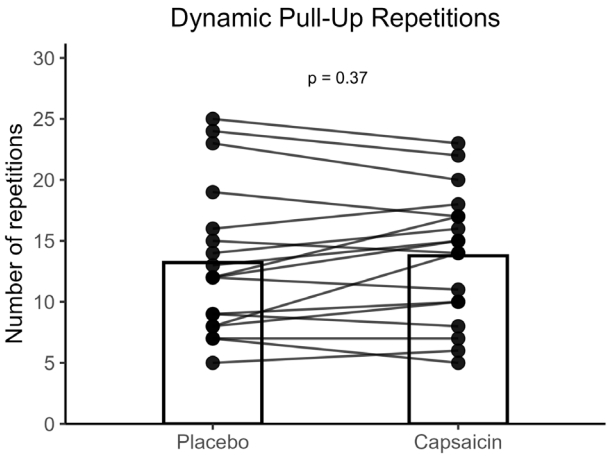


Figure 3. *Dynamic pull-up test (number of repetitions) under PLA and CAP conditions.*
Legend: Bars represent mean ± standard deviation (SD). Dots indicate individual participants, with lines connecting paired values. No statistically significant difference was observed (p = 0.37).

repetitions in squat[26,27], bench press[40], and leg extension exercises[41], as well as in running events such as 400 m, 1500 m, and 3000 m[42,43]. Thus, it would be plausible to expect an increase in DP performance as well; however, the variability of this test, combined with the fact that the task was performed using body weight, may have limited the number of repetitions and hindered the manifestation of CAP's ergogenic effect—unlike previous studies in which performance improvements occurred under submaximal loads of approximately 70% of 1RM[26,40]. In the present study, body mass may have represented a relatively higher load for some individuals, limiting potential performance gains.

Specifically, in the context of combat sports, the study by Cruz et al. (2024)[29] also reported an increase in the number of strikes performed by Kickboxing athletes following a sport-specific physical test. Among BJJ practitioners, an increase in peak power and peak velocity during the bench press exercise was observed[30]. These findings suggest that the effects of CAP may occur across different types of muscle actions but appear to be more evident in tasks where muscular endurance is predominant[18].

Although both HS and IP tests involve isometric muscle actions, they assess distinct manifestations of muscular strength[8]. The dissociation between CAP's effects on isometric endurance and maximal strength may be explained by the different physiological mechanisms involved in each test. HS reflects the maximal force produced during an isometric contraction[9] and, as a maximal strength test, also reflects neural recruitment capacity, as well as inter- and intramuscular coordination[44]. On the other hand, the gi pull-up tests—IP and DP—assess strength endurance under different demands[35]. IP involves a submaximal isometric action with a simpler motor pattern, while DP requires high intra- and intermuscular coordination to perform full repetitions[7].

Thus, the improvement observed only in the IP test suggests that CAP's effects are more closely related to sustaining contraction, benefiting tasks limited by peripheral mechanisms[44]. TRPV1 activation increases intracellular calcium release, which may prolong the ability to generate force during continuous efforts[24]. This could explain the absence of effects in HS and DP, whose complexity and specific neuromuscular recruitment patterns may not be positively influenced by CAP's action.

RPE did not show a statistically significant difference between conditions, a result consistent with previous studies[34,45,46]. However, the observed moderate effect size (r = 0.37) suggests that CAP supplementation may have reduced RPE to a degree that could be meaningful in practice, even though the confidence interval still included the null. In competitive contexts, moderate reductions in perceived exertion may help athletes sustain performance for longer periods, particularly in efforts that involve repeated or prolonged actions. Previous studies have also demonstrated decreases in RPE following CAP supplementation[26,27,43], an effect attributed to the desensitization of TRPV1 receptors located on afferent nerve terminals, which may attenuate discomfort and effort perception[26]. In addition, the complexity of measuring perceived exertion in combat sports should be considered, since RPE integrates multiple physiological and psychological components. This was highlighted in another study, which demonstrated the construct validity of session-RPE in young karate athletes, supporting both the usefulness of RPE and the challenges of interpreting its variability in combat-sport contexts[47]. Thus, although our findings were not statistically significant, they indicate a possible practical benefit of CAP supplementation for modulating RPE during high-intensity activities.

In other sports, such as CrossFit, findings have also been inconsistent. While Piconi et al. (2022)[28] observed a reduction in RPE in trained men, Piconi et al. (2019)[45] found no significant effects in women under the same protocol. Furthermore, it has been hypothesized that the response to CAP may be modulated by genetic variations in TRPV1 receptors, leading to differences in both sensitivity and the magnitude of the physiological responses induced by supplementation[22]. This interindividual variability may help explain the different response patterns observed among participants[40].

An important aspect of CAP supplementation concerns its low bioavailability, due to rapid hepatic and intestinal metabolism, which may limit the duration of its systemic availability[25,48]. Moreover, since both bioavailability and physiological response to CAP can vary widely among individuals, a fixed absolute dose may not achieve effective physiological concentrations in all cases. As such, individualizing the dose based on body mass may be a useful alternative to mitigate this limitation.

Athletes' dietary intake was similar across testing days, with no significant differences in macronutrient intake or total caloric value (TCV). All participants completed the tests within three hours after their last meal, ensuring similar conditions between sessions. Participants were unable to correctly identify whether they had ingested CAP or placebo, indicating the effectiveness of the blinding protocol. No relevant adverse effects were reported, which aligns with other studies that also used a single 12 mg dose of CAP[34,49].

This study has some limitations that should be acknowledged. First, only male athletes with a high competitive level were included, which restricts the generalizability of the findings to female athletes and to practitioners of different training backgrounds or competitive standards. Second, a fixed absolute dose of 12 mg of CAP was administered to all participants. Given the variability in body mass within our sample, it is possible that individualized, body mass-adjusted dosing strategies could have produced stronger or more consistent ergogenic responses.

Third, we did not include biochemical or physiological markers, such as blood lactate or hormonal responses, which could have provided additional information into the effects of supplementation. Fourth, testing was conducted in controlled physical assessments rather than in real-match conditions. Although this approach allowed for standardization, it does not fully replicate the complex and multifactorial demands of competitive BJJ. Finally, in the DP test, body weight itself may have represented a limiting factor for some participants, potentially creating a ceiling effect and reducing the sensitivity of this outcome. Future studies should therefore include female athletes, consider dose adjustments according to body mass, incorporate biochemical and physiological markers, examine supplementation effects under real combat situations, and use weighted or assisted DP variations to better individualize task demands. These improvements would allow a more complete understanding of CAP's ergogenic potential in combat sports.

CONCLUSION

Acute supplementation with 12 mg of capsaicin increased hang time in the isometric pull-up test, suggesting improved upper-limb endurance in BJJ athletes. These results support the potential use of capsaicin as an ergogenic aid, with possible applications in the context of combat sports.

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