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Running Title: Caffeine and Maximum Strength test

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Does Caffeine Really improve Maximum Strength Performance?

Abstract

Background: It is recommended that caffeine is not used before repetition maximum strength tests. However, the effect of using caffeine was not tested yet. This article analyzed whether the caffeine supplementation improves bench press one-repetition maximum test (1RM) performance. **Methods:** It is a pre-experimental, single-moment, crossover, counterbalanced, double-blind study. Twenty men (age 23 ± 3 years; body mass 77.72 ± 6.68 kg; height 1.77 ± 0.06 cm; body mass index 24.77 ± 1.57), experienced in resistance training (5.8 ± 2.93 years), performed four visits to the laboratory; baseline assessments and 1RM familiarization composed the first visit. All subjects underwent 1RM in three following conditions: caffeine supplementation (420 mg), placebo intake (420 mg cornstarch), given 45 minutes before the start of the test, and control. According to data analyses, ANOVA One Way was performed, and the level of significance was set at $p \leq 0.05$. **Results:** It was verified there were no significant differences in the maximum strength between the conditions ($F(2,4) = 0.011$; $p = 0.99$), and the average loads obtained in each of them were 96.6 ± 19.55 kg for caffeine supplementation, 96.9 ± 18.46 kg for placebo intake, and 96.00 ± 19.04 kg for control. **Conclusions:** Caffeine intake does not affect maximal strength performance for a scapular girdle and upper limbs in trained men. Thus, it is unnecessary to recommend deprivation of caffeine use before the application of the 1RM test.

Keywords: caffeine, exercise, muscle strength.

Introduction

Caffeine is an alkaloid, pharmacologically active, and central nervous system stimulant substance that has been vastly used to increase sports performance [1]. Although caffeine abstains from any nutritional value, it is considered a natural ergogenic and has been tested in several types of exercises and sports [2].

Specifically, in resistance training (RT), caffeine effects seem to be related to strength endurance, but on maximum strength, caffeine seems to present null results [3]. Although common restrictive actions are linked to caffeine use before maximum strength tests, such as 1-repetition maximum tests (1RM), the literature seems to deny this claim [3].

In the literature, it was found twelve studies that investigated the effect of caffeine supplementation on strength assessed by 1RM. Five of them found an increase of maximum strength [4–8], whereas seven others observed no difference in strength followed caffeine ingestion [8–13]. Besides some differences among the studies, some limitations regarding 1RM such as familiarization, ingestion of substances other than only caffeine, and comparisons with control or placebo groups only make the evidence fragile.

Thereby, it is unclear in the literature whether caffeine could improve performance on the 1RM tests. This information would guide researchers about the need to avoid caffeine before a maximum strength test. Also, coaches of sports modalities that involve maximum strength might improve strategies to attend their athletes better. So, the present study aims to verify if caffeine supplementation improves bench press 1RM performance in men. The theoretical hypothesis is that caffeine does not affect the maximum strength test.

Materials and Methods

Participants

Twenty men (age 23 ± 3 years; body mass 77.72 ± 6.68 kg; height 1.77 ± 0.06 cm; body mass index 24.77 ± 1.57) experienced with resistance training (5.8 ± 2.93 years) volunteered for the study. Participants were healthy and able to perform every assessment without any limitation. Throughout the study, participants were asked to abstain from any ergogenic substance and other exercise programs. Additionally, it was emphasized that participants should abstain from caffeine and any substance that could contain it, such as cocoa, guarana powder, chocolate, and so on, forty-eight hours before the experimental session. To avoid any confusion about the substances, participants received a list of items that contained caffeine. Besides, a food record was used twenty-four hours before the tests. The study was approved by the local Ethics Committee (CAAE: 60965016.1.0000.5203). According to the Helsinki Declaration, all the subjects signed in the informed consent and all the experiments were performed.

Experimental Design

The participants visited the laboratory four times. First, they signed in the informed consent, performed the baseline assessments, and familiarized the 1RM. In the second, third, and fourth ones, the experimental sessions were carried out. One-week of rest between each visit was given. The participants abstained from any product that contained caffeine for at least one month before the study begins.

The 1RM was performed in the bench press in the following conditions: control (ingestion of no capsules), caffeine, and placebo. In the caffeine and placebo conditions, the participants ingested 5 to 6mg of caffeine or cornstarch per body mass kilogram. The substances were made in the form of capsules in a compound pharmacy. All the capsules were administered forty-five minutes before the sessions. The capsules were made in distinct

colors. As the researchers, the participants were not aware of its content, revealed at the end of the study before analyses.

One-repetition maximum Test

The 1RM was carried out in the bench press. The barbell was handed to the participant with extended arms. They remained in the position without any effort until the test has started. The movement consisted of bringing the bar near the chest until the barbell touches a device with approximately 10 cm located on the participant's sternum (to avoid the bar to touch the chest and maintain the movement amplitude of the participants) and returned to the initial position. The position of hands was measured to guarantee the same grip width in each experimental session. Before the test, the participants underwent a warm-up of 2 sets of 50% and 80% of the estimated 1RM, respectively[14]. An interval of 3 minutes was given between the sets. Following the warm-up, the participant performed the first attempt with the estimated 1RM load. Progressive loads determined the 1RM until the participant was unable to perform two repetitions correctly. The maximum load corresponded to the load. The participant performed the first repetition and failed in the second one. If the participant performed a second repetition, 10 to 20% of the current load was increased. Also, if the participant failed to perform one repetition, the load decreased 10 to 20%. Six attempts were carried out with three minutes of rest between them. The participants were not allowed to see the barbell's weight during the test, only at the end of each session. To ensure the participants were blind to the load, a box was attached to the bar to cover the weight. Moreover, verbal encouragement was given throughout the test. The verbal encouragement consisted of “go, go, go!”, “keep it up!”, and “you can do it!”.

Statistical Analysis

Shapiro-Wilk test was carried out to analyze data normality. The mean obtained in each experimental session was analyzed using repeated measures one-way ANOVA, and if necessary, a Bonferroni post-hoc was applied. The significance level adopted was established by 5%. The software SPSS v. 20.0 was used to perform the analyses, and the significance level adopted was 5%.

Results

According to the results presented in Figure 1, no significant difference was verified between the conditions ($F_{(2.4)} = 0.011$; $p= 0.99$). The means obtained in each condition were 96.6 ± 19.55 kg for the caffeine supplementation, 96.9 ± 18.46 kg for the placebo, and 96.00 ± 19.04 kg for the control.

Insert Figure 1 here

Discussion

We hypothesized that caffeine would not affect maximum strength in the 1RM. Thus, our hypothesis was confirmed. Thereby, any recommendation about caffeine withdrawal seems unnecessary for maximum strength tests. The study's results indicate that participants can ingest caffeine before 1RM tests without affecting the final maximum strength scores. Also, coaches should be aware that caffeine might be an ineffective ergogenic in sports that mainly require maximum strength. Thus, a focus on strength training might be desirable than using caffeine as a strategy to increase maximum strength in trained individuals.

In fact, the results found in the literature are controversial [4,6,7,11,12]. The different methodologies possibly explain the results among the studies, such as caffeine dosage,

caffeine abstention before sessions, type of exercise, placebo, intensity of exercise, experience, and training status. Additionally, some limitations of the previous studies deserve some attention: lack of familiarization with maximum strength test, heterogeneity of participants (different level of training and experience in RT), ergogenic substances other than caffeine as well as lack of studies that compare distinct experimental conditions (caffeine vs. placebo; caffeine vs. control; placebo vs. control).

In the present study, participants performed familiarization for the 1RM. It is understandable that 1RM presents a strict method for strength assessment [15], and the learning effect might improve the results in the test, the familiarization turns out as a powerful instrument to avoid such interferences [16]. However, some studies lack familiarization, and that factor might explain the differences among them [4,6,9]. Thus, summed to that, the randomized crossover design with three groups comprised of experimental condition, control, and placebo groups allow us to conclude with greater confidence that caffeine is ineffective to increase maximum strength.

According to the literature, only Fett et al. [6] conducted the study in three experimental conditions, similar to our study. The strength of eight women was tested in different exercises, using 1RM. The authors observed higher strength scores only when compared with the control group (without using any capsule). Another possible explanation for the differences between our results and Fett et al. [6] might be the number of participants. Whereas the present study analyzed twenty participants, only eight were analyzed by Fett et al. [6], which may have influenced the results. Also, as happened in other studies, Fett et al. [6] lacked familiarization for the 1RM.

Moreover, according to the literature, it is necessary for two to four familiarization sessions for elderlies, children, and women [17]. Thus, it is possible to speculate that Fett et al. [6] findings might have occurred due to the test's neural adaptations. Moreover, the experimental

conditions were not randomized. In the first session, all the participants carried out the test without taking caffeine, and the last one was performed with caffeine ingestion, strengthening the supposition that neural adaptation has occurred [18].

Noteworthy, caffeine absence during all the study and the use of food record twenty-four hours before the session might have minimized possible ergogenic interferences on the results. Despite the procedure adopted in the present study diminish the possibility of any undesirable ingestion, only five studies used this strategy [7,9,11,12].

Another main point of our study is the absence of any ergogenic substance other than caffeine. In other studies, the ingestion of another ergogenic might have influenced the results [7,8,10,13]. Thereby, it is debatable to affirm that the increase in strength was originated by the caffeine only. Otherwise, it is noteworthy that our study did not standardize the diet, presenting a significant limitation.

Conclusions

The results showed that caffeine ingestion does not affect maximum strength in trained men's upper body. Thus, it is unnecessary the caffeine privation during maximum strength tests for the upper body. Also, strength training should be prioritized as the primary pathway to achieve better performance, and the several quantities of caffeine that are common among athletes should be avoided, mainly in sports predominantly dependent on maximum strength. It is essential to highlight that those results must not be extrapolated to other populations or exercises.

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Notes

Conflicts of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions

André L T PIRAUÁ gave substantial contributions to the conception or the design of the manuscript; Thâmara R M MATHIAS, Leylanne S R de MELO, Heber A A de LIRA to acquisition; Dalton de LIMA-JUNIOR, Luciano M F T de OLIVEIRA and Breno Q FARAH contributed to analysis and interpretation of the data. All authors have participated to drafting the manuscript, Gustavo VASCONCELOS and Natália B BELTRÃO revised it critically. All authors read and approved the final version of the manuscript.

Figure title

Figure 1. Strength performance in the 1-Repetition maximum test (1RM)