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Both caffeine and placebo improve vertical jump performance as compared to a non-supplement, control condition

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Both caffeine and placebo improve vertical jump performance as compared to a non-supplement, control condition

Abstract

Purpose: To compare the acute effects of caffeine and placebo ingestion with a control condition (i.e., no supplementation) on vertical jump performance.

Methods: The sample for this study consisted of 26 recreationally trained males. Following the familiarization visit, the subjects were randomized in a double-blind fashion to three main conditions: (a) placebo, (b) caffeine, and (c) control. Caffeine was administered in a gelatin capsule in the dose of 6 $mg \cdot kg^{-1}$ of body weight. Placebo was administered in a gelatin capsule containing 6 $mg \cdot kg^{-1}$ of dextrose. Vertical jump performance was assessed using a countermovement jump (CMJ) performed on a force platform. Analyzed outcomes were vertical jump height and maximal power output.

Results: For vertical jump height, we observed significant differences between: (a) placebo and control conditions (g = 0.13, 95% confidence interval [CI]: 0.03, 0.24; +2.5%); (b) caffeine and control conditions (g = 0.31, 95% CI: 0.17, 0.50; +6.6%); and, (c) caffeine and placebo conditions (g = 0.19, 95% CI: 0.06, 0.34; +4.0%). For maximal power output, we did not find a significant main effect of condition (p = 0.638).

Conclusions: Ingesting a placebo or caffeine may enhance CMJ performance as compared to the control condition, with the effects of caffeine vs. control appearing to be greater than the effects of placebo vs. control. Additionally, caffeine was ergogenic for CMJ height as compared to placebo. Even though caffeine and placebo ingestion improved vertical jump height, we did not find any significant effects of condition on maximal power output generated during take-off.

Introduction

The acute ergogenic effects of caffeine supplementation on exercise performance are well-established.[1-3] Traditionally, the effects of caffeine on exercise performance are explored by testing the subjects following the ingestion of caffeine on one occasion and placebo on another. In such a design, it is generally assumed that the placebo condition does not influence exercise performance. However, Beedie and Foad[4] highlighted several instances where placebo administration had a positive effect on exercise outcomes, and they have suggested to researchers to include a baseline or control condition in which exercise performance is evaluated without any supplementation. A comparison of exercise performance following caffeine or placebo ingestion with a control condition may provide findings that inform two different domains, that is, the isolated effects of both caffeine and placebo on exercise performance.[4] These recommendations were echoed in a recent consensus statement on placebo effects in sports and exercise.[5]

A recent meta-analysis by Grgic et al.[1] reported that caffeine ingestion might acutely enhance vertical jump height. This finding was obtained by pooling the results from ten individual studies; however, none of the included studies incorporated a control condition (i.e., studies only compared the effects of caffeine vs. placebo). Similarly, a meta-analysis by Salinero et al.[3] also reported ergogenic effects of caffeine on single and repeated jump height, but again, all studies that provided isolated caffeine included only caffeine and placebo conditions. In this *Brief Report*, we compared the acute effects of caffeine and placebo ingestion with a control condition, on vertical jump performance. We hypothesized that: (a) ingestion of placebo would improve performance as compared to the control condition, and (b) ingesting caffeine would improve performance as compared to both the placebo and control conditions.

Methods

Subjects

A priori power analysis was calculated using G*Power (version 3.1.9.2, University Düsseldorf, Germany). Assuming ANOVA, repeated measures, within factors as the statistical test, 0.15 as the expected effect size (*f*) for vertical jump height, 0.05 as α, the statistical power of 0.80, 1 group, 3 measurements, and correlation of 0.85 (used from a previously published dataset[6]) the power analysis indicated that the required sample size was $n = 23$. To account for possible drop-outs, we recruited 26 recreationally trained males (mean ± SD: age 23 ± 2 years; height 183 ± 7 cm; body mass 83 ± 11 kg; habitual caffeine intake: 0.95 ± 1.16 $mg \cdot kg^{-1}$). All participants were physical education students with resistance training experience, and some had prior experience in different sports (e.g., basketball, handball), but none were current competitive athletes. The Committee for Scientific Research and Ethics of the Faculty of Kinesiology at the University of Zagreb provided ethical approval for the study (20/09/2018); all subjects provided written informed consent.

Design

Randomized, crossover, double-blind study design.

Methodology

The subjects visited our laboratory on four occasions. During the first visit, they filled out the Food Frequency Questionnaire[7] for estimating their habitual caffeine intake and were familiarized with the exercise test. Then, they were randomized in a counterbalanced fashion to three main conditions: (a) placebo, (b) caffeine, and (c) control (i.e., no supplementation).

These conditions were separated 3-6 days. Caffeine was administered in a gelatin capsule in the dose of 6 $mg \cdot kg^{-1}$. The placebo was administered in a gelatin capsule containing 6 $mg \cdot kg^{-1}$ of dextrose. To ensure adequate blinding, all administered capsules were of identical appearance and taste. The testing was carried out 60 minutes after capsule ingestion. In the control condition, the participants did not ingest any capsule, but the waiting time, until the exercise session started, was also 60 minutes. Testing sessions were performed between 07:00 and 09:00 am with the subjects in a fasted state (overnight fast). The effectiveness of the blinding was explored as described by Saunders et al.[8]

Fifty minutes after supplement ingestion, the participants performed 10 minutes of self-selected warm-up. The participants were instructed to keep to warm-up consistent in each session. Vertical jump testing was performed on a force platform (BP600600, AMTI, Inc., Watertown, MA, USA), accompanied with a custom-developed software for data acquisition and analysis. In each testing session, the subjects performed three countermovement jumps (CMJ) on this platform, with a detailed procedure explained elsewhere.[9,10] The best jump was used for the analysis. The analyzed outcomes were vertical jump height (cm) calculated from the vertical velocity of the center of mass at take-off data,[11] and maximal power output during take-off ($W \cdot kg^{-1}$). Earlier test-retest reliability assessment in our laboratory yielded the coefficient of variation (CV) of 1.3% for the CMJ height and 1.4% for maximal power output.

Statistical analysis

The differences between the three conditions (i.e., caffeine, placebo, and control) in the analyzed variables (i.e., vertical jump height and maximal power output) were examined by a one-way repeated measures ANOVA. If significant main effects were observed, pairwise comparisons of conditions were explored by a paired t-test. The statistical significance threshold was initially set at $p < 0.05$; however, to account for multiple comparisons, we used the Holm-Bonferroni correction. Effect sizes (Hedges' g; ES) and 95% confidence intervals (95% CI) for repeated measures were calculated, as were the percent differences between the conditions. ESs of <0.20, 0.20–0.49, 0.50–0.79, and ≥0.80 were considered as trivial, small, moderate, and large, respectively. Bang's Blinding Index[12] was used to explore the effectiveness of the blinding. All analyses were performed using the "Statistica" software (version 13.4.0.14; TIBCO Software Inc., Palo Alto, CA, USA). Individual participant data are presented per established recommendations.[13]

Results

Vertical jump performance

The results of the one-way repeated measures ANOVA for vertical jump height indicated a significant main effect of condition, $p < 0.001$. The pairwise comparisons revealed significant differences between: (a) placebo and control conditions ($p = 0.018$; ES = 0.13 [95% CI: 0.03, 0.24]; +2.5%); (b) caffeine and control conditions ($p = 0.0001$; ES = 0.31 [95% CI: 0.17, 0.50]; +6.6%); and, (c) caffeine and placebo conditions ($p = 0.005$; ES = 0.19 [95% CI: 0.06, 0.34]; +4.0%) (Table 1, Table 2). The results of the one-way repeated-measures ANOVA for maximal power output did not indicate a significant main effect of condition ($p = 0.638$), and no post hoc analysis was performed. Within-person variation to the three conditions is presented in Figure 1.

Assessment of blinding

In the pre-exercise evaluation, 23% and 42%, and in the post-exercise evaluation, 31% and 54% of the participants correctly identified the caffeine and placebo conditions beyond random chance, respectively.

Discussion

Our results indicate that: (a) ingesting a placebo or caffeine may acutely increase CMJ height as compared to the control (i.e., no supplementation) condition; and (b) caffeine ingestion may acutely increase CMJ height as compared to placebo. Even though CMJ height increased following caffeine and placebo ingestion, we did not find any significant effects of condition on maximal power output generated during take-off.

Caffeine ingestion, as compared to both placebo and control, was effective in increasing vertical jump height. These results are in line with two recent meta-analyses that reported ergogenic effects of caffeine on vertical jump height, in comparison to placebo.[1,3] Moreover, even the ES of 0.19 observed in this study closely matches the pooled ES in the two meta-analyses[1,3] (ESs of 0.17 and 0.19, respectively). Administering a placebo (as compared to control) was also ergogenic for increasing vertical jump height. These results suggest that providing a placebo when seeking acute improvements in jumping performance may be an option. However, caution is warranted here as providing a placebo may be ethically problematic and may result in issues of trust between the practitioner and client.[4]

In a recent consensus statement on placebo effects in sports and exercise,[5] the authors noted that, in many cases, the placebo effects are of a similar magnitude as the effects of the actual treatment (in this case, caffeine). Given the results of the present study, this may be true to an extent, but only if we compare the effects of caffeine vs. placebo (ES = 0.19: +4.0%) with the effects of placebo vs. control (ES = 0.13; +2.5%). However, the same cannot be stated in the comparison of the effects of caffeine vs. control given that here, the ES magnitude was greater and amounted to 0.31 (+6.6%). While placebo may lead to increased vertical jump height, the effects of caffeine seem to be greater than the effects of placebo, even though it needs to be mentioned that there was a small degree of overlap between the 95% CIs in these comparisons. This is important from a practical perspective if we consider that an individual interested in supplementing with this ergogenic aid will either *ingest* or simply *not ingest* caffeine (i.e., the deliberate use of a placebo is much less likely to occur). From a research perspective, this suggests that studies using a double-blind study design without a control session might underestimate the effect of caffeine given that the actual effect may be greater than that shown in comparison with a placebo condition.

Studies that reported increases in vertical jump height following caffeine ingestion commonly interpret these results as improvements in ‘power’.[1] However, as we demonstrate in this study, vertical jump height might change following caffeine ingestion even though maximal power output remains relatively similar across all conditions. This finding is in line with a recent paper suggesting that vertical jump height might not be a good indicator of lower limb power/maximal power output capability.[14] Therefore, we further reinforce the notion that changes in vertical jump height might not mirror those observed for muscular power.[14] For a more detailed insight on the issue, readers are referred to the paper by Morin et al.[14]

The strengths of this study are the use of a double-blind study design, the addition of a control condition, relatively effective blinding of the participants, and the inclusion of a large sample size (allowing for detection of small, but potentially meaningful differences between conditions). The limitation is that subjects’ expectancy of caffeine, that is, their belief in the caffeine's ergogenic effects,[5] was not explored. This needs to be acknowledged, given that individual expectancy is one of the possible reasons that might explain the placebo effect on exercise performance.[5]

Practical applications

When seeking acute improvements in vertical jump performance, both caffeine and placebo provided in isolation may be ergogenic; however, the effects of caffeine seem to be greater than the effects of placebo.

Conclusions

Ingesting a placebo may improve vertical jump height as compared to no supplementation, and ingesting caffeine may improve vertical jump height as compared to both the placebo and no supplementation. Interpreting any changes in vertical jump height following caffeine ingestion as changes in 'power' should be done with caution. As we show herein, vertical jump height following caffeine ingestion may change without any evident changes in generated maximal power.

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Figure 1 — Within-person variation in responses to the 3 conditions (caffeine, placebo, and control) for (A) vertical jump height and (B) maximal power output during take-off.

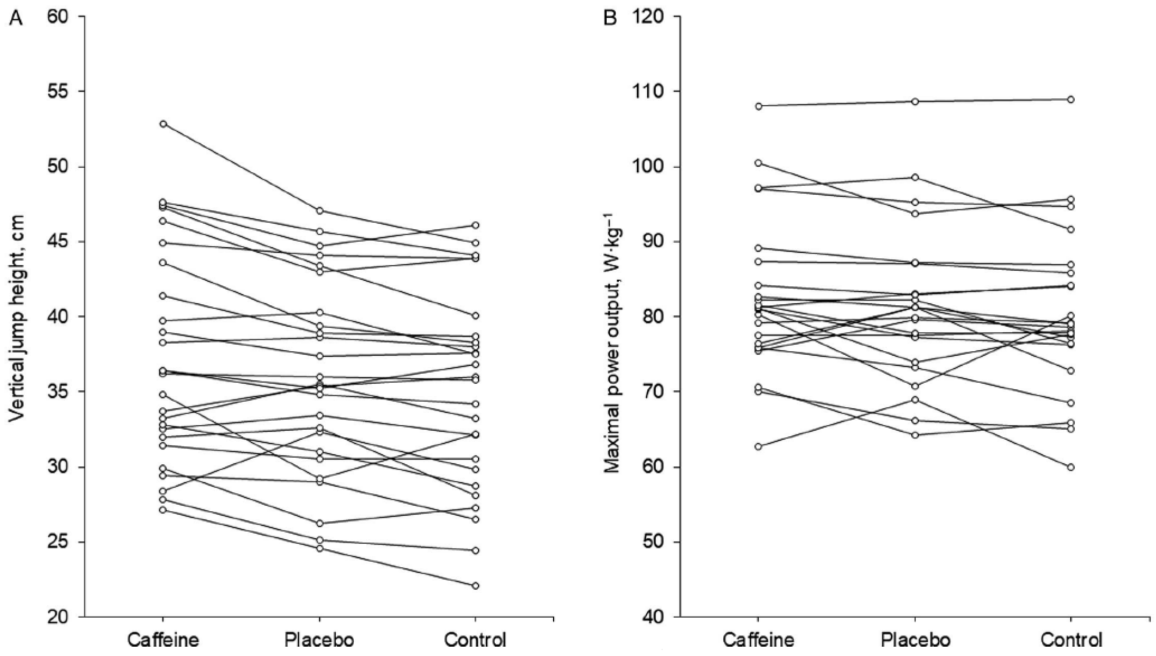

Table 1. Vertical Jump Data in the 3 Conditions

Variable	Caffeine condition	Placebo condition	Control condition
Vertical jump height, cm	37.3 (7.2)	35.9 (6.4)	35.0 (6.6)
Maximal power output, $W \cdot kg^{-1}$	79.7 (12.6)	81.2 (11.8)	81.5 (10.9)
Note. Data are reported as mean (SD).			

Table 2. Pairwise Comparisons and the Adjusted P Values Using the Holm–Bonferroni Correction

Variable	Pairwise comparison	Paired t test P value	Rank	Adjusted statistical significance threshold
Vertical jump height	Placebo vs control	0.018	3	0.05
	Caffeine vs placebo	0.005	2	0.025
	Caffeine vs control	0.0001	1	0.017