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BRIEF REPORT

# Both Caffeine and Placebo Improve Vertical Jump Performance Compared With a Nonsupplemented Control Condition

**Jozo Grgic, Sandro Venier, and Pavle Mikulic**

***Purpose:*** To compare the acute effects of caffeine and placebo ingestion with a control condition (ie, no supplementation) on vertical jump performance. ***Methods:*** The sample for this study consisted of 26 recreationally trained men. Following the familiarization visit, the subjects were randomized in a double-blind manner to 3 main conditions: placebo, caffeine, and control. Caffeine was administered in the form of a gelatin capsule in the dose of 6 mg·kg body weight$^{-1}$. Placebo was also administered in the form of a gelatin capsule containing 6 mg·kg$^{-1}$ of dextrose. Vertical jump performance was assessed using a countermovement jump performed on a force platform. Analyzed outcomes were vertical jump height and maximal power output. ***Results:*** For vertical jump height, significant differences were observed between placebo and control conditions ($g = 0.13$; 95% confidence interval [CI], 0.03–0.24; +2.5%), caffeine and control conditions ($g = 0.31$; 95% CI, 0.17–0.50; +6.6%), and caffeine and placebo conditions ($g = 0.19$; 95% CI, 0.06–0.34; +4.0%). For maximal power output, no significant main effect of condition ($P = .638$) was found. ***Conclusions:*** Ingesting a placebo or caffeine may enhance countermovement jump performance compared with the control condition, with the effects of caffeine versus control appearing to be greater than the effects of placebo versus control. In addition, caffeine was ergogenic for countermovement jump height compared with placebo. Even though caffeine and placebo ingestion improved vertical jump height, no significant effects of condition were found on maximal power output generated during takeoff.

***Keywords:*** supplements, ergogenic effect, performance-enhancing effects

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 after they ingest caffeine on one occasion and placebo on another occasion. 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 suggested to include a baseline or a 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 2 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 10 individual studies; however, none of the included studies incorporated a control condition (ie, 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 ingestion of placebo would improve performance compared with control condition and that ingestion of caffeine would improve performance compared with both placebo and control conditions.

## Methods

### Subjects

A priori power analysis was calculated using G*Power (version 3.1.9.2; University Düsseldorf, Germany). Assuming repeated-measures analysis of variance (ANOVA), within factors as the statistical test, 0.15 as the expected effect size (ES; *f*) for vertical jump height, .05 as $\alpha$, the statistical power of 0.80, 1 group, 3 measurements, and correlation of .85 (used from a previously published data set[6]), the power analysis indicated that the required sample size was n = 23. To account for possible drop-outs, 26 recreationally trained males (mean [SD]: age, 23 [2] y; height, 183 [7] cm; body mass, 83 [11] kg; habitual caffeine intake, 0.95 [1.16] mg·kg$^{-1}$) were recruited. All participants were physical education students with resistance training experience with few participants having prior experience in different sports (eg, basketball and handball), but none of the participants 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 this study (approval number: 48/2019); all subjects provided written informed consent.

### Design

This study was carried out as a randomized, crossover, and double-blind design.

### Methodology

The subjects visited our laboratory on 4 occasions. During their first visit, they filled out the Food Frequency Questionnaire[7] for

Grgic is with the Inst for Health and Sport (IHES), Victoria University, Melbourne, VIC, Australia. Venier and Mikulic are with the Faculty of Kinesiology, University of Zagreb, Zagreb, Croatia. Mikulic (pavle.mikulic@kif.hr) is corresponding author.

estimating their habitual caffeine intake and were familiarized with the exercise test. Then, they were randomized in a counterbalanced manner to 3 main conditions: (1) placebo, (2) caffeine, and (3) control (ie, no supplementation). These conditions were separated from 3 to 6 days. In the caffeine condition, the subjects were administered gelatin capsules containing caffeine (6 $mg \cdot kg^{-1}$), and in the placebo condition, the subjects were administered gelatin capsule containing dextrose (6 $mg \cdot kg^{-1}$). To ensure adequate blinding, all administered capsules were of identical appearance and taste. The testing was done 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 9:00 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, participants performed 10 minutes of self-selected warm-up. The participants were instructed to keep the warm-up consistent in each session. Vertical jump testing was performed on a force platform (BP600600; AMTI, Inc., Watertown, MA), accompanied with a custom-developed software for data acquisition and analysis. In each testing session, the subjects performed 3 countermovement jumps (CMJs) 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 (in centimeters) calculated from the vertical velocity of the center of mass at take-off data[11] and maximal power output during take-off (in watt per kilogram). Earlier test–retest reliability assessment in our laboratory yielded the coefficient of variation of 1.3% for CMJ height and 1.4% for maximal power output.

### Statistical Analysis

The differences between the 3 conditions (ie, caffeine, placebo, and control) in the analyzed variables (ie, vertical jump height and maximal power output) were examined by 1-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 $P < .05$; however, to account for multiple comparisons, the Holm–Bonferroni correction was used. ESs (Hedges' *g*) and 95% confidence interval (95% CI) for repeated measures were calculated, as were the percent differences between the conditions. ESs of <0.20, 0.20 to 0.49, 0.50 to 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 Statistica software (version 13.4.0.14; TIBCO Software Inc., Palo Alto, CA). Individual participant data are presented per established recommendations.[13]

## Results

### Vertical Jump Performance

The results of the 1-way repeated-measures ANOVA for vertical jump height indicated a significant main effect of condition ($P < .001$). The pairwise comparisons revealed significant differences between: (1) placebo and control conditions ($P = .018$; ES = 0.13; 95% CI, 0.03–0.24; +2.5%), (2) caffeine and control conditions ($P = .0001$; ES = 0.31; 95% CI, 0.17–0.50; +6.6%), and (3) caffeine and placebo conditions ($P = .005$; ES = 0.19; 95% CI, 0.06–0.34; +4.0%) (Tables 1 and 2). The results of the 1-way repeated-measures ANOVA for maximal power output did not indicate a significant main effect of condition ($P = .638$), and no post hoc analysis was performed. Within-person variation in responses to the 3 conditions is presented in Figure 1.

### Assessment of Blinding

In the preexercise evaluation, 23% and 42% of the participants, and in the postexercise evaluation, 31% and 54% of the participants correctly identified the caffeine and placebo conditions beyond random chance, respectively.

## Discussion

Our results indicate that (1) ingesting a placebo or caffeine may acutely increase CMJ height compared with the control (ie, no supplementation) condition and (2) caffeine ingestion may acutely increase CMJ height compared with placebo. Even though CMJ height increased following caffeine and placebo ingestion, no significant effects of condition were found on maximal power output generated during take-off.

Caffeine ingestion, compared with both placebo and control, was effective in increasing vertical jump height. These results are in-line with 2 recent meta-analyses that reported ergogenic effects of caffeine on vertical jump height, in comparison with placebo.[1,3] Moreover, even the ES of 0.19 observed in this study closely matches the pooled ES in the 2 meta-analyses[1,3] (ESs of 0.17 and 0.19, respectively). Administering a placebo (compared with 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 this study, this may be true to an extent, but only if we compare the effects of

**Table 1 Vertical Jump Data in the 3 Conditions**

| Variable | Caffeine | Placebo | Control |
|---|---|---|---|
| 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 Adjusted *P* Values Using Holm–Bonferroni Correction for Vertical Jump Height**

| Pairwise comparison | Paired *t* test *P* value | Rank | Adjusted statistical significance threshold |
|---|---|---|---|
| Placebo vs control | .018 | 3 | .05 |
| Caffeine vs placebo | .005 | 2 | .025 |
| Caffeine vs control | .0001 | 1 | .017 |

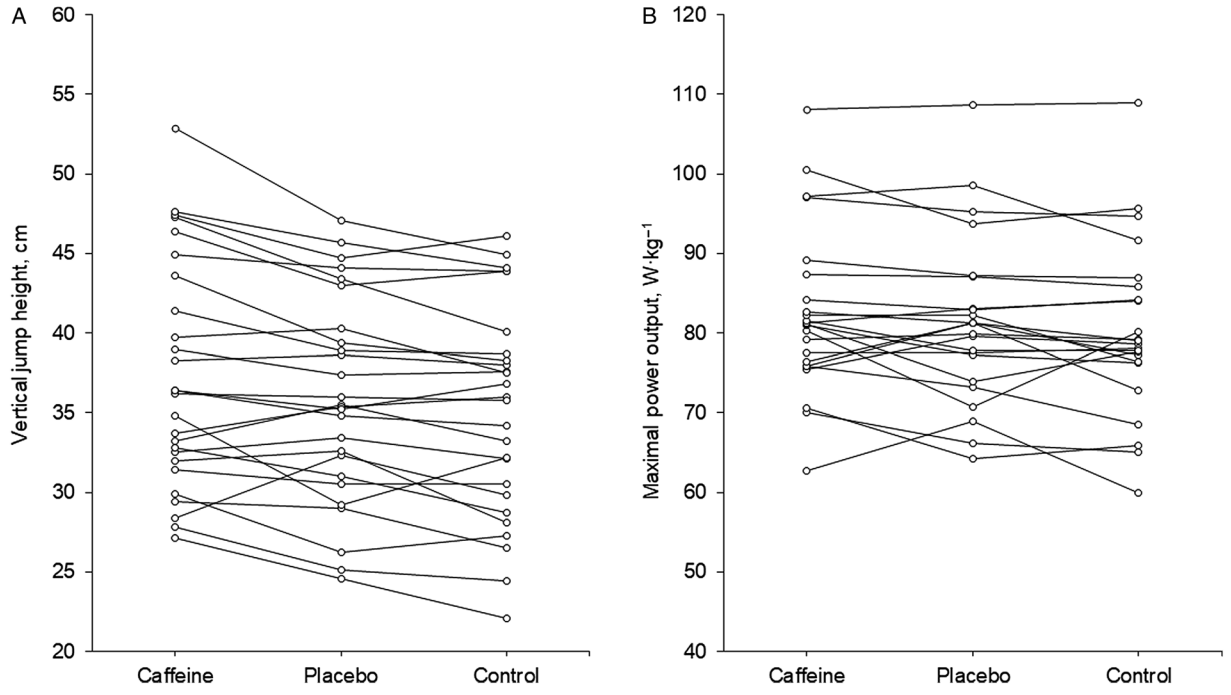


**Figure 1** — Within-person variation in responses to the 3 conditions (caffeine, placebo, and control) for (A) vertical jump height and (B) maximal power output during takeoff.

caffeine versus placebo (ES = 0.19; +4.0%) with the effects of placebo versus control (ES = 0.13; +2.5%). However, the same cannot be stated in the comparison of the effects of caffeine versus control given that here, the ES was greater and amounted to 0.31 (+6.6%). Although 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 (ie, 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 study 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 study by Morin et al.[14]

The strengths of this study are the use of a double-blind study design, addition of a control condition, relatively effective blinding of the participants, and 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. As shown in Figure 1, the response to caffeine and placebo ingestion can vary between individuals. Those interested in supplementing or prescribing caffeine or placebo should consider these findings as a starting point and then experiment with different protocols to optimize the response for their own circumstances.

## Conclusions

Ingesting a placebo may improve vertical jump height compared with no supplementation, and ingesting caffeine may improve vertical jump height compared with placebo and no supplementation. Interpreting any changes in vertical jump height following caffeine ingestion as changes in "power" should be done with caution. As shown in this study, vertical jump height after caffeine ingestion may change without any evident changes in generated maximal power.

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