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Original Article

Caffeine, lactic acid, or nothing: What effect does expectation have on men's performance and perceived exertion during an upper body muscular endurance task?

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ABSTRACT

Objective: We tested the impact of subjects' belief in an ingested substance's ergogenic or ergolytic properties on muscular endurance performance and perceived exertion.

Methods: Trained men (n = 15, age = 41 ± 4 y; body mass = 82.1 ± 15.8 kg; height = 173 ± 8 cm; experience = 7.4 ± 2.3 y) completed one set to failure at 80% repetition maximum of the bench press under three conditions. In all conditions, subjects ingested capsules of an identical, inert substance (300 mg cellulose), but, in a randomized order, subjects were told that they were either ingesting caffeine (Placebo), lactic acid (Nocebo), or cellulose (Control) and received information on the respective alleged ergogenic/ergolytic/neutral effects of each. Repetitions completed and rating of perceived exertion (RPE) were recorded. The data were analyzed among conditions using a Friedman test with *post hoc* analyses accomplished through Durbin-Conover tests. Spearman correlations were used to compare repetitions performed and RPE between Nocebo and Placebo conditions. Statistical significance was set at $P \leq 0.05$.

Results: Subjects lifted more ($P < 0.001$) repetitions in the Placebo condition (14.1 ± 3.0) versus Control (10.3 ± 2.9) or Nocebo (7.5 ± 2.6), while Control and Nocebo performances were similar ($P = 0.192$). Lower RPE was noted in Placebo versus Control ($P = 0.003$) and Nocebo ($P < 0.001$) and lower in Control versus Nocebo ($P = 0.025$). Subjects who performed more repetitions with Placebo tended to perform fewer repetitions under the Nocebo condition (Spearman's Rho =–0.578).

Conclusion: This study believes that the ergogenic or ergolytic properties of a substance can measurably impact upper-body muscular endurance performance and RPE in trained men.

Keywords: Placebo effect, resistance exercise, strength training

Introduction

Sports nutrition research has often focused on the how consumption of substances may enhance muscular performance through tangible mechanisms, such as increasing muscle glycogen stores,[1] increasing muscle phosphocreatine stores,[2] increasing the speed of mitochondrial fat oxidation,[3] or increasing buffering capacity.[4] However, a growing body of evidence supports the critical role of mental beliefs, independent of measurable physical changes in muscle, on exercise performance.[5] Positive beliefs such as the belief that an ingested performance-enhancing substance may imbue benefits to exercise performance. This may occur regardless of whether said substance is actually exerting a peripheral effect or even whether the substance was truly ingested. Conversely, belief that one has ingested a substance with negative effects may negatively impact exercise performance.[6]

For example, Azevedo *et al*.[7] found that the belief that one had ingested a harmful substance (lactate) caused perception of effort to increase during a 30-min run, although there was no significant effect on the performance itself. In both sessions (Placebo and Nocebo), caffeine was used as a supplement, and subjects were deceived in regard to what they were consuming. The cited study[7] tested performance using 30-min run, likely because most evidence found on the ergogenic effects of caffeine is in long-term efforts.[8,9] However, some studies[10-12] have found positive effects from caffeine ingestion during short-duration and high-intensity efforts.

Caffeine's measurable impacts on exercise are posited to come from its effects on the central nervous system, including its role as an adenosine receptor antagonist.[8] Whether it is ingested or not, belief in caffeine's ergogenic properties is widespread and may contribute to enhanced performance. Conversely, the belief that lactate causes muscle fatigue could hamper performance if one were told that they had ingested it. With this in mind, we sought to test the impact of positive and negative beliefs regarding an ingested pre-exercise substance on a short duration exercise. We hypothesized that muscular endurance exercise performance and rating of perceived exertion (RPE) would differ from a control condition following ingestion of both placebo and nocebo substances.

Materials and Methods

Participants

Fifteen men (41 ± 4 y.o.; 82.1 ± 15.8 kg; 173 ± 8 cm) experienced in resistance training (7.4 ± 2.3 years) were recruited as subjects. Sample size calculations, based on the data from Azevedo *et al*.,[7] indicated that a minimum sample size of 12 subjects would be sufficient to reach a statistical power (1-β) of 80%. All subjects were free of any musculoskeletal injuries that could impact bench press performance. Throughout the experimental period, they were instructed not to change their habitual diet or physical activity routine. All procedures were approved by the local ethics committee (protocol nº 313.934) according to the Declaration of Helsinki, and the study was approved by the Research Ethics Board (REBEC) at the University of Itaperuna, REBEC trial registry number = RBR-3h5hffm. The purpose and procedures of the experiment were explained, and consent was obtained before the commencement of the experiment. Each subject underwent experimental procedures under the same instructions and conditions.

Protocol

Subjects voluntarily made 5 laboratory visits. In the first two visits, they performed anthropometric measurements, answered a questionnaire, and performed a one-repetition maximum test (1RM) bench press. These two visits were separated by an interval of 72 h. During these initial visits, they also received education about the nature of the supplements (caffeine and lactate); they were supposed to take. During one morning of each of the following 3 weeks, subjects arrived at the laboratory and received a capsule containing 300 mg of cellulose. Although given cellulose at each visit, participants were randomly given a short talk about which supplement they would be using, employing deception. One trial, caffeine was reported (positive effect; Placebo), a second trial lactic acid (harmful effect; Nocebo), and in third cellulose (would have no effect; Control). The lectures were shown on video so that everyone received the same information individually on their cellphone with audio narration provided through headsets. The order of these trials was randomized.

50 min after ingesting the capsule, subjects warmed up with two sets of fifteen (fixed) repetitions bench press at 40% 1RM with 1-min rest. After 3 min, they performed one 80% 1RM maximal set (until concentric failure) and at the end, they indicated on an image the level of effort performed.[13] The exercises were standardized[14] for counting valid repetitions.

Statistical analysis

The number of repetitions and the rating of perceived exertion (RPE) were tested for normality (Shapiro-Wilk) and homogeneity (Levene). As both presented non-normal curves, we used the Friedman test (non-parametric) to compare the treatments. The *post hoc* test used was Durbin-Conover. We used Spearman's correlation test for the association between Placebo and Nocebo conditions for both repetitions performed and RPE.[15] Statistical significance was set at the $P \leq 0.05$ level of confidence.

Results

Our results showed that there was a significant difference in the performance of the participants according to the type of stimulus given (nocebo=control<placebo; $P < 0.001$; $\eta^2 = 0.491$) as can be seen in [Table 1]. In addition, we found significant differences in RPE (nocebo>control >placebo; $P < 0.001$; $\eta^2 = 0.344$) [Table 1]. Effect sizes for each comparison were as follows: Placebo versus nocebo = 1.17272, placebo versus control = 1.0476, and control versus nocebo = 0.000.

We also performed a correlational study to verify the association between belief in the described effects and performance in the number of repetitions (we compared placebo and nocebo treatments). A moderate negative and significant correlation was found between performance in the number of repetitions [Figure 1, Spearman's Rho −0.578; $P = 0.024$]. On the other hand, RPE showed no significant association between treatments (Spearman's Rho 0.344; $P = 0.209$) [Table 3].

Discussion

The Placebo/Nocebo effects observed in this study were quite large: Ingestion of Placebo resulted in 37% greater performance in repetitions and a significantly lower RPE when compared to Control. Ingestion of Nocebo resulted in no difference in the performance of repetitions compared to Control, but a higher RPE.

Table 1: Comparison of bench press repetitions completed and rating of perceived exertion after ingestion of a believed control, placebo, or nocebo. Data presented in Mean±SD (CI 95%)

Treatment	Number of repetitions	Rating of perceived exertion
Control	10.3±2.9 (8.9–11.8)	7.4±1.1 (6.9–8.0)
Placebo	14.1±3.0 (12.5–15.6)	6.4±1.0 (5.9–6.9)
Nocebo	7.5 ± 2.6 (6.1–8.8)	8.3 ± 1.2 (7.7–8.9)

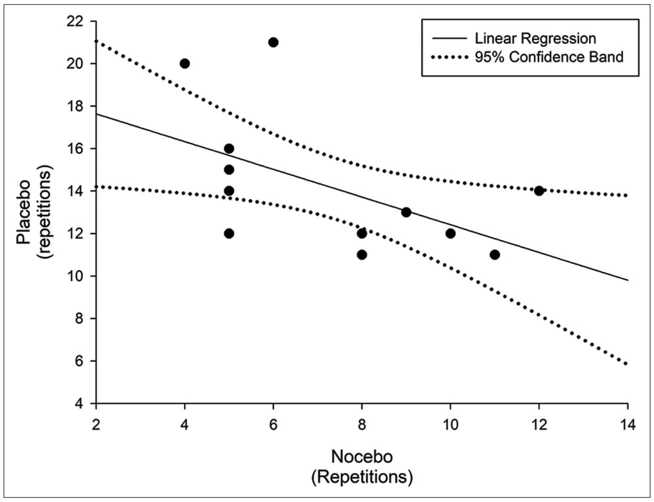

Figure 1: Relationship between number of repetitions performed at 80% 1 rm bench press under placebo and nocebo conditions ($n = 15$).

Table 2: *Post hoc* analyses using Durbin-Conover tests between conditions

Comparisons	Number of repetitions	Rating of perceived exertion
Control versus Placebo	<0.001	0.003
Control versus Nocebo	0.192	0.025
Placebo versus Nocebo	<0.001	<0.001

In regard to RPE, our results corroborate those obtained by Azevedo *et al*.[7] When imagining they were using an ergogenic supplement (caffeine), subjects perceived a lower level of effort, and they perceived the opposite when they thought that they were using something harmful (lactate). Unlike the aforementioned study, we found positive results in terms of performance in a number of repetitions when comparing placebo versus nocebo, while there was no difference between control and nocebo. The positive benefits to performance seen in the present study versus the no measureable impact on performance reported by Azevedo *et al*.[7] may be ascribed to differences in the exercise bout performed, including the shorter duration of the bout completed (single set to fatigue in ~30 s vs. 30 min run) and the lower volume of muscle mass exercised (bench press vs. running). This contrast leads us to speculate that briefer exercise stress focused on a smaller area of muscle mass may be more subject to measureable placebo/nocebo effects.

The moderately strong[15] Spearman correlation [Figure 1] indicated a negative relationship between repetitions performed under placebo versus nocebo. This allows us to speculate that one's belief in the success of a placebo is equally detrimental to the performance of a nocebo. In other words, beliefs seem to be more ingrained in some individuals than others, modifying their behavior in the practice of exercises. There is some evidence[16] supporting this notion, though was not our primary objective to discuss the matter.

In conclusion, in this experiment, the belief in the ergogenic or ergolytic effects of a supplement affected both performance and perceived exertion. Furthermore, it seems that individuals who most strongly believe in positive effects will also believe in the negative.

Authors' Declaration Statements

Ethics approval and consent to participate

The study was approved by the Research Ethics Board at the University Iguaçu at Itaperuna and is in accordance with the code of ethics of the World Medical Association (Declaration of Helsinki). Participants were informed about the general characteristics of the task; they would perform before written consent was obtained.

Competing interests

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

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The financial resources were obtained from the Iguaçu University through the institution's scientific research incentive program.

Authors' contributions

DC and MM designed the experiment and collected data. MM and AJK analyzed the data. DC, AJK and MM contributed to the interpretation of the results. DC and MM wrote the initial draft. AJK and MM wrote the final version. DC, AJK, and MM approved the final version of the manuscript.

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