International Journal of EXERCISE SCIENCE

Original Research

Beyond the Buzz: Do Energy Drinks Offer More Than Caffeine for Mental and Physical Tasks?

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ABSTRACT

International Journal of Exercise Science 17(2): 1208-1218, 2024. Energy drinks are marketed for enhancing mental and physical performance, often containing ingredients beyond caffeine. This study investigated whether an energy drink (ED), Gorilla Mind, exerted greater effects on sustained attention, mood, handgrip strength, and push-up performance than a caffeine-matched control drink (CAF) in exercise-trained individuals (n = 21, age: 22 ± 5.9 years). In a randomized, counterbalanced, crossover design, participants first completed tests assessing mood (Profile of Mood States; POMS), sustained attention (Psychomotor Vigilance Test; PVT), handgrip strength (HG), and 1-minute maximum push-up performance (PU). They then consumed either an ED or CAF drink (200mg caffeine) in a randomized order. After 45 minutes, the tests were repeated. Following a 1-week washout period, participants returned to consume the other drink and completed the same protocol. While the ED group improved reaction time (PVT), the Delta score between ED and CAF was not statistically significant ($p = 0.3391$). No significant differences were found between ED and CAF groups for other measures (POMS: $p = 0.152$, HG: $p = 0.499$, PU: $p = 0.209$). These findings suggest that the additional ingredients in the ED may not offer substantial benefits beyond caffeine for these measures in active individuals. It is important to note that the caffeine dose was, on average, less than 3.0 mg/kg body mass, which may have influenced the outcomes.

KEY WORDS: Cognitive function, physical performance, psychomotor vigilance, energy, alertness

INTRODUCTION

Caffeine is one of the most widely consumed psychoactive substances in the world, and it is a primary ingredient in many commercially available energy drinks (22). The ergogenic effects of caffeine on exercise performance have been extensively studied, with evidence indicating that it can enhance endurance, high-intensity exercise, and cognitive performance (15, 13).

Energy drinks are widely consumed beverages marketed for their ability to enhance mental focus, physical performance and reduce fatigue (22). Several investigations have sought to elucidate the effects of energy drinks on cognitive performance, with mixed results. Some studies have reported improvements in reaction time, attention, and vigilance, (1, 5-10) while others have found no significant effects (2, 12, 33). Similarly, the impact of energy drinks on muscular strength and endurance has been inconsistent across studies (14, 7, 9, 25). However, the potential benefits of energy drinks beyond those provided by caffeine alone are less clear. While some studies have reported positive effects of energy drinks on exercise performance (29, 18), others have found no significant differences compared to placebo or caffeine alone (13). However, the effectiveness of these additional ingredients beyond caffeine's established effects remains unclear. These discrepancies may be due to variations in the specific formulations of the energy drinks used, the caffeine doses, or the exercise protocols and outcome measures employed.

The ED used in this study contained various ingredients beyond caffeine. These included B vitamins, L-tyrosine (a precursor for neurotransmitters potentially enhancing focus and alertness at high doses), (16) and L-theanine, an amino acid found in tea, possibly working synergistically with caffeine to improve cognitive function (17). It is important to note that the effectiveness of these additional ingredients, particularly at the specific dosages used in the ED, requires further investigation. To our knowledge, there has been no prior research specifically investigating the effects of the Gorilla Mind energy drink in mental and physical tasks.

Given the widespread consumption of energy drinks, particularly among young adults and athletes, it is important to clarify their potential benefits and risks compared to caffeine alone (22). The present study aimed to investigate the effects of a commercially available energy drink on mental and physical performance tasks, including sustained attention, mood, upper body muscular endurance, and handgrip strength, in comparison to a positive control drink containing an equivalent amount of caffeine. By directly comparing the energy drink to a caffeine-matched control, this study sought to elucidate whether the additional ingredients in the energy drink confer any advantages beyond those provided by caffeine alone.

METHODS

Participants

A total of 21 exercise-trained volunteers (9 men and 12 women) participated (mean ± SD: age 22 ± 6 years; height: 170.8 ± 10.8 cm; weight: 71.9 ± 14.8 kg; body fat percentage: 20.2 ± 9.4; average years of training: 9.5 ± 5.9 years; average daily caffeine intake: 200.5 ± 140.2 mg). Individuals considered physically active, between the ages of 18-60, were eligible to participate. Individuals were considered "physically active" if they had consistently exercised at least three times a week, incorporating activities such as resistance training or aerobic exercise, over the past year. A sample size of 21 participants was chosen based on power analysis to ensure sufficient power to detect the hypothesized effect sizes (5). The University's Institutional Review Board (IRB# 2023_118 Concordia University) approved all procedures involving human subjects, and written informed consent was obtained from each participant prior to participation. This research was

carried out fully in accordance with the ethical standards of the International Journal of Exercise Science (27).

Protocol

The study employed a randomized, counterbalanced, crossover design. During the first visit, participants completed a battery of baseline tests, including the Profile of Mood States (POMS), Psychomotor Vigilance Test (PVT), handgrip strength (HG), and a 1-minute maximum push-up test (PU). Subsequently, they were randomized to consume either an energy drink (ED; Gorilla Mind, Gorilla Mind LLC, Boise, ID, USA, see figure 1) or a positive control drink containing 200 mg of caffeine (CAF). The CAF drink consisted of 8 oz of water, 1 packet of Crystal Light's sugar-free concord grape flavor (10 calories, citric acid, maltodextrin, malic acid, aspartame, potassium citrate, sodium citrate, calcium phosphate, less than 2% of natural flavors) in addition to the 200 mg of caffeine. After a 45-minute waiting period, the entire battery of tests was repeated. Following a one-week washout period, participants returned for a second visit, where they crossed over to consume the other drink and completed the same testing protocol. Testing sessions were scheduled at the same time of day for each visit to control for diurnal variations in performance. Participants were instructed not to change their dietary and exercise habits during the study timeframe.

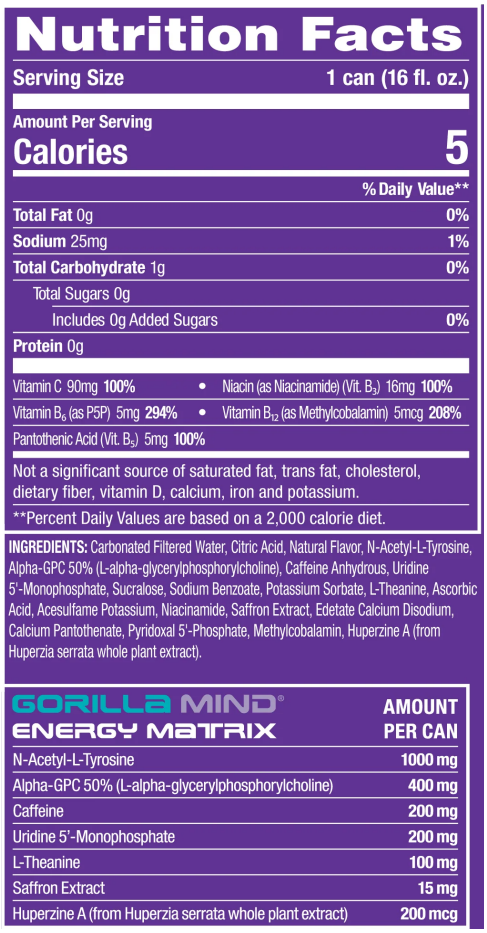

Figure 1. Supplement Facts Panel of the Energy Drink (Gorilla Mind).

Body Composition Assessment: Prior to participation, body composition (weight, fat mass, lean body mass, total body water, and percentage fat) was assessed using a multi-frequency bioelectrical impedance device (InBody 270). Participants were instructed to arrive at the laboratory after a 3-hour fast for body composition assessment. Standing on the device's platform with bare feet on the electrodes, participants held handles equipped with additional electrodes on their thumb and fingers, maintaining straight arms and horizontally abducted at approximately 30 degrees. This assessment lasted approximately one minute.

Energy Drink and Control Drink: The energy drink and the caffeine control drink (200 mg caffeine) were provided to participants in black, opaque containers. The caffeine content of the energy drink was not disclosed to participants conducting the tests.

Profile of Mood States (POMS): The Profile of Mood States (POMS) is a psychological rating scale used to assess transient, distinct mood states (26). Participants completed the POMS

questionnaire to evaluate their mood before and after consuming the drinks. The POMS consists of 65 adjectives rated on a 5-point scale, where participants indicate how they feel right now, from "Not at all" to "Extremely." The total mood disturbance score (TMDS) was calculated by summing the negative subscale scores (Tension, Depression, Anger, Fatigue, and Confusion) and subtracting the positive subscale score (Vigor).
Psychomotor Vigilance Test (PVT)

The PVT (Vigilance Buddy software) was administered using a standard electronic tablet to assess reaction time and behavioral alertness (4). Participants were instructed to respond as quickly as possible to the sudden appearance of a stimulus within a box on the screen by tapping the box. The iPads were positioned flat on a table, ensuring consistent testing conditions across participants. The test lasted 5 minutes. Premature responses (false starts) were also recorded.

Handgrip Strength: Handgrip strength was measured using a standard dynamometer (Digital Hand Dynamometer, 300 lb. gauge, functional model 12-0072) (7). Participants performed three maximal isometric contractions with their dominant hand, standing up straight, arms by their side, elbow, and wrist extended, with the highest value recorded as their maximum handgrip strength.

Push-up Test: For the 1-minute maximum push-up test, participants were instructed to perform as many consecutive push-ups as possible within 1 minute. Participants were instructed to start in the "up" position with their elbows fully extended and their torso straight, then lower their body until their elbow formed a 90-degree angle and their upper arm was parallel to the floor (18). They then returned to the "up" position by fully extending their elbows. The push-up test was used to assess upper-body muscular endurance (18). The total number of push-ups completed was recorded.

Statistical Analysis
Appropriate statistical analyses were conducted using Intellectus 360 software to compare the effects of the energy drink and caffeine-positive control drink on the outcome measures (PVT, POMS, HG, and PU). Paired t-tests were employed to assess within-subject differences. Normality of the data was assessed using Shapiro-Wilk tests. If normality assumptions were violated, non-parametric tests (i.e., Wilcoxon signed-rank) were used as alternatives. The Delta scores (change from baseline) between the CAF and ED conditions were compared via a paired t-test. Statistical significance was set at $p \leq 0.05$.

RESULTS

The participants' characteristics are shown in Table 1.

PVT: A paired t-test revealed no significant difference in PVT improvement (delta scores) between the energy drink (ED) and caffeine control (CAF) groups (Figure 3). Cohen's d (0.21) suggests a small effect size, indicating a limited practical difference in PVT performance between the groups. However, the within-group analysis showed the ED group significantly

improved PVT compared to the baseline (p = .005), while the CAF group did not (p = .395, Table 3, Figures 1 and 2).

Table 1. Subject Characteristics.

	Mean ± SD
Age (years)	22.0 ± 5.9
Height (cm)	170.8 ± 10.8
Weight (kg)	71.9 ± 14.8
LBM (kg)	57.2 ± 12.5
Fat Mass (kg)	14.7 ± 6.9
% Fat	20.2 ± 9.4
Total Body Water (liters)	41.9 ± 9.1
Total Years Training	9.5 ± 5.9
Avg Hours Cardio/week	4.4 ± 4.0
Avg Hours Weight Training/week	5.2 ± 3.4
Other Exercise/week	1.3 ± 2.9
Average Caffeine Consumed Daily (mg)	200.5 ± 140.2

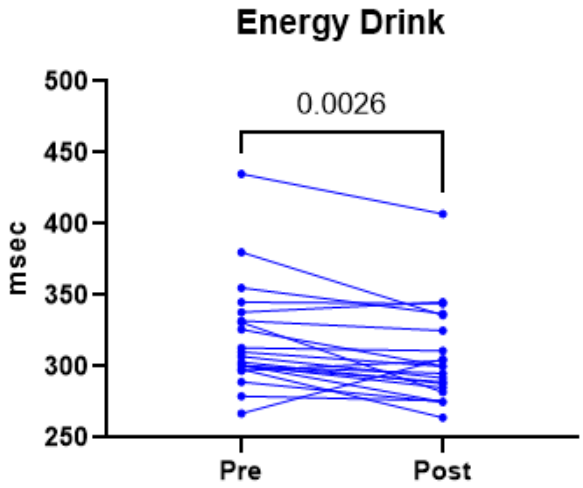

Figure 1. Psychomotor vigilance. The energy drink treatment significantly improved reaction time pre to post (p=0.0026).

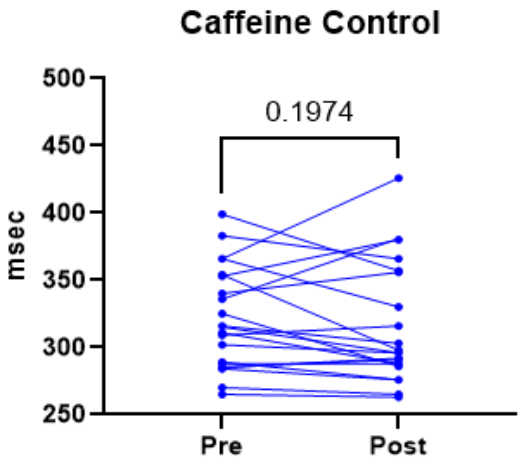

Figure 2. Psychomotor vigilance. The caffeine control group did not significantly change reaction time pre to post (p= 0.1974)

Mood State (POMS): A paired-sample t-test revealed no significant difference in mood changes between the energy drink (ED) and caffeine control (CAF) delta scores (Table 2, p = .152). The small to medium effect size (Cohen's *d* = 0.32) suggests a possible but statistically non-significant difference in mood between the groups. However, normality assumptions were violated. Therefore, a non-parametric Wilcoxon signed-rank test supported the null hypothesis (p = .590). Interestingly, the caffeine control group exhibited improved mood scores after consumption (p = .014) compared to the energy drink group (p = .065).

Table 2. Mental and Physical Performance– Delta Score.

Measure	Delta Energy	Delta CAF	P-value	Cohen's *d*
Psychomotor vigilance (msec)	-13±19	-5.3 ± 27.9	0.339	0.21
Mood (POMS)	-4.5±10.6	-13.1±22.2	0.152	0.32
Handgrip Strength (kg)	-2.2±13.5	0.0±3.3	0.499	0.15
Push-ups (number of repetitions)	2.0±5.0	0.0±4.0	0.209	0.28

Data are expressed as the mean ± SD. Legend: msec—millisecond; POMS—Profile of Mood State.

Table 3. Pre and Post-Performance Data.

Measure	Pre ED	Post ED	P-value	Pre CAF	Post CAF	P-value
Psychomotor vigilance (msec)	319.4±33.2	306.4±33.2	0.005	321 ± 38.2	315.7 ± 44.7	0.395
Mood (POMS; TDMS)	10.9±23.6	6.4±23.6	0.065	25.3±37.3	12.2±23.4	0.014
Peak handgrip strength (kg)	41.9±20.3	39.7±14.1	0.471	39.9±12.4	39.9±13.2	0.954
Push-ups (number of repetitions)	35±16	37±18	0.122	34±19	34±21	0.843

Data are expressed as the mean ± SD. Legend: msec—millisecond; PVT—psychomotor vigilance test; POMS—Profile of mood states; TMDS—Total Mood Disturbance Score.

Handgrip (HG): A two-tailed paired-sample t-test was used to examine the difference in delta handgrip strength scores. While the t-test result in Table 2 was not statistically significant (t(20) = -0.69, p = .499), we acknowledge the normality assumption violation. Therefore, a non-parametric Wilcoxon signed-rank test was conducted as a more robust alternative. The Wilcoxon signed-rank test results (also in Table 2) supported the findings of the t-test, revealing no significant difference in delta handgrip strength between the ED and CAF conditions (V = 112.00, z = -0.26, p = .794). The small effect size (Cohen's *d* = 0.15) suggests a minimal difference in handgrip strength between the groups. A paired-sample t-test compared pre-consumption (Pre) and post-consumption (Post) peak handgrip strength measurements for each group. The results in Table 3 revealed no statistically significant changes in handgrip strength for either the ED group (p = 0.471) or the CAF group (p = 0.954).

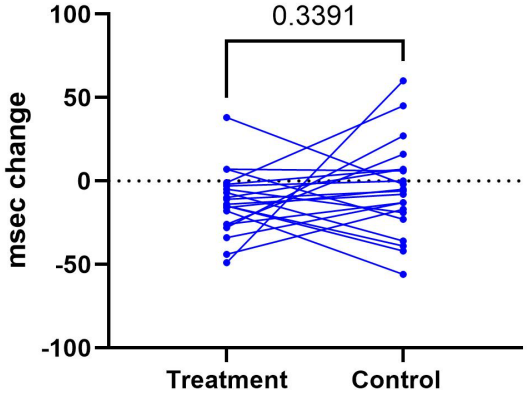

Figure 3. Psychomotor vigilance. There was no difference in reaction time delta score between the groups (p = 0.3391).

Push-ups (PU): Similar to the other outcome measures, we employed paired-sample t-tests to examine the difference in delta push-up scores between the ED and CAF groups (Table 2). No statistically significant differences were found between groups (t(20) = 1.30, p = .209). The small effect size (Cohen's d = 0.28) suggests a limited practical difference in delta push-up scores between the groups. Secondly, no statistical difference was found (ED, p = 0.122, CAF, p = 0.843)

when comparing the average number of push-ups completed before (Pre) and after (Post) consuming each drink (Table 3).

DISCUSSION

This study investigated the effects of a commercially available energy drink on exercise-trained individuals' cognitive and physical performance measures. The major findings of the current investigation are that the ED, compared to a positive (caffeine-matched) control drink, resulted in a non-significant improvement on a sustained attention test (PVT) when comparing delta scores between the groups. No significant differences were observed between the groups for handgrip strength, mood or push-up performance. Interestingly, there were significant differences between pre and post sustained attention within the ED group and mood within the CAF group. The CAF group showed a significant improvement in mood scores post-consumption compared to baseline, whereas the ED group did not exhibit a statistically significant change. This suggests that while both drinks contain caffeine, the additional ingredients in the ED might not contribute to mood enhancement as effectively as caffeine alone. In addition to caffeine, the blend of ingredients in the ED might not offer significant advantages for the measured performance metrics. Beyond caffeine (200mg), the ED included several ingredients purported to enhance cognitive function and performance. One such ingredient is L-tyrosine (1000mg), a precursor to neurotransmitters like dopamine, epinephrine, and norepinephrine, which influence focus, alertness, and motivation (22,16). While limited research suggests potential benefits of L-tyrosine supplementation at high doses (2g-12g) for cognitive function during demanding tasks, (28, 23) the optimal dosage and effectiveness within the context of an energy drink remain unclear. The ED also contained 100mg of L-theanine, an amino acid found in tea that may improve cognitive function, potentially through synergistic effects with caffeine at specific dose ranges (100-250 mg theanine and 40-160mg caffeine) (17, 23). However, the prevalence of these specific dosages within commercially available energy drinks is often unclear due to limited ingredient disclosure (21). Future research investigating these ingredients' individual and combined effects at the dosages present in the ED is necessary to determine their actual impact on cognitive function and physical performance.

Wesnes et al. observed improvements in vigilance, alertness, and attentional focus following an ED containing caffeine, taurine, citicoline, malic acid, and glucuronolactone compared to a placebo (35). Giles et al. also highlighted the influence of individual ingredients and their interactions (14). Their study found that caffeine alone improved reaction time, executive control, and working memory, while taurine's effects were less consistent (14). This suggests that specific combinations of ingredients beyond caffeine might enhance cognitive function.

Another factor influencing the results might be the caffeine dosage in the ED. While previous research suggests that caffeine in energy drinks (EDs) can enhance mood, reaction time, and alertness (6, 20, 31), the specific dosage might influence its effectiveness on various performance measures. In our study, the ED contained a 200mg caffeine dose. This dosage might not have been sufficient to produce significant effects across all performance measures compared to studies utilizing higher caffeine levels (3, 30). Antonio et al. demonstrated faster reaction times

in exercise-trained individuals following an ED with a higher caffeine dose (300mg) (9). Similarly, another study reported improved performance (i.e., sprint time) for both caffeine and ED groups following a moderate dose of caffeine (3 mg/kg body mass) (30). Evans et al. reported that acute consumption of an ED containing 300mg of caffeine enhanced processing speed and reduced PVT false starts in active individuals (11).

The current study found no significant differences between the ED and CAF groups for muscular endurance (push-up performance). The effects of energy drinks (EDs) on muscular endurance appear mixed in the literature. While some studies report benefits, the specific ingredients and study designs seem to influence the outcomes. Duncan et al. observed improved resistance exercise performance (repetitions to failure) in resistance-trained males following an ED containing 179 mg caffeine alongside B vitamins, tyrosine, taurine, and other ingredients compared to a placebo (10). Notably, their study design compared an ED to a placebo, allowing for a clearer isolation of the combined effects of the ingredients. Dawes et al. also observed increased push-up repetitions to failure in healthy males following an ED containing 175 mg caffeine, N-Acetyl-L-Tyrosine (125mg), and other ingredients compared to a placebo (8). Like Duncan et al. (2012), their study design using a placebo control allows a more precise attribution of the observed benefits to the full ingredient list within the ED. This study highlights the complexity of ingredient interactions in energy drinks and underscores the need for further research to determine optimal dosages and combinations for performance enhancement. The findings suggest that the additional ingredients in the ED may not provide significant benefits beyond those of caffeine alone under the conditions tested.

Our study has limitations to consider. We did not explore the effects of individual ingredients within the ED, and the caffeine dose might not have been optimal for all participants. Additionally, our sample's average daily caffeine intake (200.5mg/day) could be relevant. Individuals might have a blunted response to the 200mg dose in both drinks, making it difficult to detect additional effects from the ED. Previous research suggests that higher caffeine doses, such as 300 mg or 3 mg/kg body mass, may be more effective in enhancing mood, reaction time, and physical performance (3, 11, 30). Future research could address these limitations by investigating the specific ingredients within the ED used and optimizing the caffeine dosage.

This study investigated whether the additional ingredients in a commercially available energy drink (Gorilla Mind) offered any cognitive or physical benefits beyond those of caffeine alone in exercise-trained individuals. We compared the effects of an ED to a positive (caffeine-matched) control drink (CAF) on various performance measures. Our findings suggest that, for the measures assessed in this study (i.e., sustained attention, mood, handgrip strength, and push-ups), the additional ingredients in the ED did not provide any substantial benefits beyond the effects of caffeine in our sample of active men and women. We posit that the primary differences in outcomes between our study and others showing positive effects of energy drinks are due to the specific blend of ingredients beyond caffeine and the caffeine content (200mg).

It is important to note that the caffeine dose in the ED was, on average, less than 3.0 mg/kg body mass, which is generally considered a moderately low dose. The PVT results showed some

inconsistency. While there was no significant difference between the ED and caffeine control groups when directly compared, the ED group showed improvement from baseline, unlike the CAF group. Further research is needed to explore this finding and understand why a between-group difference was not observed despite the within-group improvement for the ED.

ACKNOWLEDGEMENTS

This study was unfunded. Jose Antonio is the CEO of the ISSN. The ISSN occasionally receives grant support from companies that manufacture, market and sell caffeine-containing dietary supplements.

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