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Original Article

Effects of Caffeine on Behavioural Parameters: Analysis of Impulsivity and Character Strengths

Short title: Caffeine and Its Effects on Behaviour

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ABSTRACT

Caffeine is a substance widely used in sports due to its ergogenic effects on physical performance and cognition. However, its impact on socioemotional skills remains underexplored. This study aimed to analyse the effects of acute caffeine intake on impulsivity and character strengths in combat sport athletes. The sample consisted of 19 male athletes, with a mean age of 32.2 ± 12.1 years, distributed across three experimental groups: Placebo (0 mg), CAF250 (250 mg), and CAF450 (450 mg). Participants completed the Character Strengths Scale and the Go/No-Go test. Statistical analysis (one-way ANOVA) did not identify significant differences between groups in terms of impulsivity. However, statistically significant differences were found in the variable social intelligence, one of the character strengths evaluated. Specifically, the group that received 450 mg of caffeine showed significantly lower scores compared to the Placebo and CAF250 groups. These findings suggest that high doses of caffeine may have negative effects on social skills, even if they do not impair inhibitory control.

Keywords: Caffeine, Impulsivity, Character, Combat Sports

INTRODUCTION

Caffeine is one of the most consumed psychoactive substances worldwide and the most popular stimulant used by athletes (Grgic & Del Coso, 2021; Quadra et al., 2020). This substance is found not only in coffee but also in other sources such as tea, yerba mate, energy drinks, certain medications and chocolates (Domínguez et al., 2021; Guest et al., 2021). In sports contexts, including combat sports, caffeine is widely used as an ergogenic aid due to its stimulating effects on the central nervous system and its potential to enhance physical performance (Celi et al., 2022; Del Coso et al., 2013).

The ergogenic effects of caffeine have been extensively investigated, particularly regarding its positive influence on athletic performance in activities requiring anaerobic effort and muscular endurance (Del Coso et al., 2013; Loureiro et al., 2021; McDaniel et al., 2010; Tabassum et al., 2021). Caffeine acts primarily as a non-selective adenosine A1 and A2A receptor antagonist in brain regions involved in mood regulation, motor control, pain perception, and decision-making (Wang et al., 2025; Celi et al., 2022). By blocking adenosine's inhibitory influence, caffeine increases neuronal excitability and facilitates dopaminergic signalling, which in turn contributes to increased alertness and can influence both physical performance and cognitive functioning (Domínguez et al., 2021; Tavares & Sakata, 2012).

From a pharmacokinetic perspective, caffeine is rapidly absorbed after oral ingestion, reaching peak plasma concentrations within 30-60 minutes and readily crosses the blood-brain barrier (Celi et al., 2022). Its metabolism occurs predominantly in the liver via the cytochrome P450 enzyme CYP1A2, resulting in the active metabolites paraxanthine, theobromine and theophylline (Magkos & Kavouras, 2005), with a half-life of approximately

3-5 hours in healthy adults (Celi et al., 2022). These properties allow caffeine to acutely modulate central nervous system activity during the time frame in which many athletes use it before training or competition (López-González et al., 2018).

From a neurobiological standpoint, converging evidence indicates that adenosine plays a fundamental role in regulating inhibitory control and impulsive behaviour, acting as an inhibitory neuromodulator in the central nervous system (Cunha, 2001; Dunwiddie & Masino, 2001; Ferré, 2016). By binding primarily to A1 and A2A receptors, adenosine promotes sedation and reduced neuronal excitability. Animal model studies suggest that blocking these receptors, as occurs with caffeine intake, may reduce the inhibition of automatic or premature responses, thereby favouring impulsive behaviours (Huang et al., 2010; Ferré, 2016). Furthermore, there is a functional interaction between A2A receptors and dopaminergic D2 receptors in regions such as the striatum, indicating that changes in the adenosinergic system may amplify dopaminergic activity associated with impulsivity (Varnäs, Johnström & Jucaite, 2021).

Impulsivity is a multidimensional construct that has been linked to several psychiatric disorders, including antisocial personality disorder, borderline personality disorder, substance dependence, attention-deficit/hyperactivity disorder, conduct disorder and bipolar disorder (Bowyer et al., 1983; Malloy-Diniz et al., 2007; Moeller et al., 2001; Goulardins et al., 2015; Sarmiento et al., 2023). Beyond its clinical relevance, impulsivity plays a critical role in decision-making and performance under pressure and is influenced by both biological and contextual factors. In sport, especially in combat disciplines, the ability to regulate impulsive responses is essential for tactical decision-making, motor control and behavioural regulation during competition. Investigating impulsivity in athletes from multiple dimensions therefore contributes to a broader understanding of its determinants and possible implications for both performance and mental health.

The inclusion of character strengths as a variable in this research broadens the understanding of how positive psychological traits can influence behavioural and psychomotor responses to caffeine in combat athletes. Character strengths such as self-control, prudence, perseverance, and teamwork are central components of positive psychology and are associated with emotional regulation, resilience, and decision-making under pressure (Park, Peterson & Seligman, 2004). In sports contexts, these traits may act as moderating factors of caffeine's effects on impulsivity and psychomotor performance by supporting focus, the inhibition of impulsive responses, and emotional regulation in high-pressure competitive situations (Sheard, 2012; Stadler, Wolff & Schüler, 2020; Vaughan et al., 2021).

Despite the extensive literature on caffeine’s ergogenic properties, there is still a shortage of behavioural research on this widely used substance, especially in athletic populations (Grgic & Del Coso, 2021; Quadra et al., 2020). Combat sports are particularly suitable for investigation due to their inherent motor and behavioural demands. These sports require a high degree of motor control, rapid decision-making and behavioural self-regulation, making them promising contexts for examining how caffeine influences variables such as impulsivity and socioemotional functioning (López-González et al., 2018; Calvo et al., 2021; Coswig et al., 2018).

Although the acute effects of caffeine on physical performance and simple cognitive tasks are well established, gaps remain regarding its impact on behavioural domains, which are crucial for combat sport (López-González et al., 201; Diaz-Lara et al., 2022). In particular, there is a lack of studies examining how acute caffeine ingestion affects character strengths, socioemotional functions and impulsivity in trained combat athletes. To our knowledge, no previous research has specifically investigated character strengths under acute caffeine administration in this population.

Therefore, the main objective of the present study was to investigate the acute effects of caffeine on cognitive and behavioural aspects of combat sports athletes, with particular emphasis on impulsivity and character strengths. More specifically, we examined the effects of two doses of caffeine (225 mg and 450 mg) on psychomotor performance, impulsivity as assessed by a Go/No-Go task, and character strengths. Given the scarcity of prior work on socioemotional outcomes and character strengths, analyses involving these results were considered exploratory.

METHOD

This research can be characterised as a quantitative experimental study with a double-blind design, in which both the participant and the researcher responsible for data collection were unaware of the dosage being administered. The participants were randomly allocated to one of three experimental conditions: placebo, 250 mg caffeine, or 450 mg caffeine. Each received a single oral dose according to their group, in identically appearing capsules separated by an independent researcher not involved in testing or analysis. A schematic of the experimental design is presented in Figure 1.

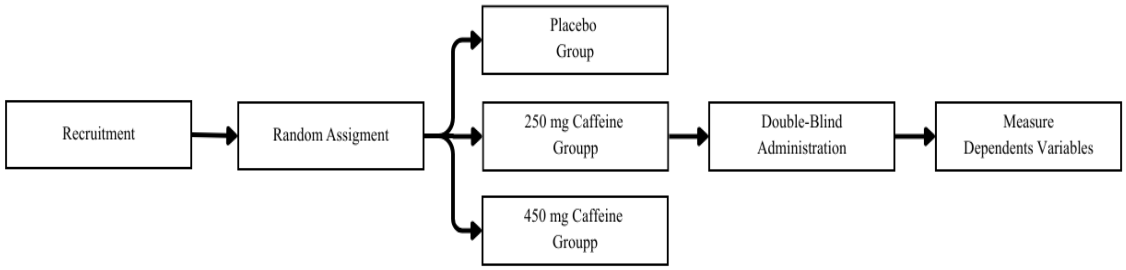

Figure 1. Experimental design and assessment timeline across caffeine conditions.

Sample

The sample consisted of 19 male participants, all healthy, with a mean age of 32.2 ± 12.1 years and an average training experience of 12.4 ± 9.58 years, including competitive experience. Participants were randomly assigned to three experimental groups: placebo, CAF 250 mg, and CAF 450 mg.

Participants were recruited from local academies by direct contact with coaches. The inclusion criteria were as follows: a minimum age of 18 years, a systematic training routine of at least twice a week, and good self-reported health. Participants would be excluded from the study if they self-reported regular use of caffeine-containing supplements or medications that could affect attention and wakefulness during the test procedures.

From an ethical standpoint, the present study complied with the Research Ethics Committee for Human Subjects of the Núcleo de Medicina Tropical – UFPA, under CAEE number 72236323.4.0000.5172, and approval number 6.947.863. Participation in the study was only confirmed after reading and signing a Free and Informed Consent Form specifically prepared for this purpose.

Instruments

Character Strengths

To measure the athletes' character strength profiles, we used the Character Strengths Scale (EFC), adapted and validated for the Brazilian context by Noronha and Barbosa (2016), and based on the model developed by Peterson and Seligman (2004). The final version of this scale consisted of 71 Likert-type items (ranging from 0 for "does not describe me at all" to 4 for "describes me completely").

Impulsivity – Go/No-Go Test

To assess impulsiveness, the Go/No-Go test was used. In this paradigm, participants are presented with a rapid sequence of visual stimuli and are instructed to respond as quickly and accurately as possible to the target (GO) stimuli by pressing a specific key, while withholding their response when non-target (NO GO) stimuli are presented. The sequence of stimuli was standardised and identical for all athletes. The task comprised 72 trials in total, of which 56 (≈78%) were GO trials and 16 (≈22%) were NO GO trials. GO trials occurred with higher frequency than NO GO trials in order to establish a prepotent response tendency and thereby increase the demand for inhibitory control during NO GO trials (Vale et al., 2025).

Task performance was quantified using two error indices. Commission errors corresponded to incorrect responses to NO GO stimuli and were interpreted as failures of response inhibition. Omission errors corresponded to failures to respond to GO stimuli and were interpreted as lapses of attention or reduced vigilance.

Procedures

For the experimental procedure, the gelatin capsules were produced by a compounding pharmacy. The capsules had the same weight and appearance, differing only in content: 450 mg of caffeine in its anhydrous form, 250 mg of caffeine in its anhydrous form, or a placebo substance (excipient). The anhydrous form was chosen due to its ease of ingestion and dosage control (Sökmen et al., 2008).

For the supplementation distribution, individuals were randomly assigned by a third blinded researcher who handled the capsule distribution. Participants were divided into three groups: CAF450 group (n=7), which received a dose of 450 mg of caffeine; CAF250 group (n=6), which received a dose of 250 mg of caffeine; and Placebo group (n=5), which received capsules containing placebo substances. In the present study, the control group was the placebo group.

All data collection sessions were scheduled in advance with each participant. Additionally, all participants were instructed to eat two hours prior to the session. Participants were also asked to complete a set of questionnaires to collect information, including an anamnesis form and the free and informed consent form.

Next, the previously assigned groups (CAF250, CAF450, and Placebo) ingested a gelatin capsule containing doses of 250 mg of caffeine, 450 mg of caffeine, and placebo, respectively, along with 250 mL of water, and remained seated at rest for 40 minutes until the beginning of the behavioural tests. After this period, participants proceeded to the behavioural assessments.

Statistical Analysis

The data were tabulated and organised, then analysed using the Jamovi statistical software (version 2.3). Initially, exploratory data analysis allowed for the calculation of means and standard deviations. The normality of the data was assessed using the Shapiro-Wilk test, and the homogeneity of variances was examined with Levene's test. For variables that met the assumptions of normality and homoscedasticity, an ANOVA was applied to compare the experimental conditions. Tukey's test was employed when a post-hoc analysis was required. For variables that violated these assumptions, the nonparametric Kruskal-Wallis test was employed and, when appropriate, pairwise comparisons with adjusted p-values were conducted. In addition to the p-value, the effect size was calculated to complement the interpretation of the results. The significance level adopted for this study was $p < 0.05$. No a priori sample size calculation or power analysis was performed; therefore, the study should be considered exploratory and the results interpreted with caution.

RESULTS

Preliminary data analysis indicated that character strength variables did not show significant deviations from normality in any condition when using the Shapiro-Wilk test ($p > 0.05$), while variables derived from the Go/No-Go task showed deviations from normality in at least one group ($p < 0.05$). Consequently, one-way ANOVA was used to analyse character strengths, while the non-parametric Kruskal-Wallis test was applied to performance measures in the Go/No-Go task. Table 1 presents the descriptive characteristics of the participants, relating to the frequency of habitual caffeine consumption in each group.

Table 1. Descriptive characteristics of the participants by group (mean ± SD).

Group		Frequencies	%
0mg	Once a day	0	0
	Twice a day	2	40
	Three times a day	1	20
	More than three times a day	2	40
250mg	Once a day	3	42.9
	Twice a day	1	14.3
	Three times a day	1	14.3
	More than three times a day	2	28.6
450mg	Once a day	1	14.3
	Twice a day	2	28.6
	Three times a day	1	14.3
	More than three times a day	3	42.9

Regarding impulsivity, the analysis of the Go/No-Go test results, examined using the Kruskal-Wallis test, indicated that acute caffeine intake had no significant effect on participants' impulsivity, $H(2) = 0.39$, $p = 0.822$, with a negligible effect size ($\eta^2 = 0.020$). The statistical analysis did not show significant differences between the groups in terms of accuracy or error rates. Specifically, the mean accuracy scores (± standard deviation) were 69.72 ± 27.60 for the 0mg group, 76.97 ± 23.31 for the 250mg group, and 77.57 ± 26.42 for the 450mg group. Therefore, the data suggest that acute caffeine intake did not meaningfully influence response inhibition ability under the present experimental conditions.

Descriptive statistics for all character strengths are presented in Table 2. The one-way ANOVA test revealed a significant difference in social intelligence between the caffeine groups, $F(2,16) = 7.10$, $p = 0.009$. The effect size measured was $\eta^2 = 0.470$, suggesting that 47% of the variance in social intelligence can be explained by caffeine dosage.

Table 2. Descriptive statistics (mean ± SD) for character strengths scores by group.

	0 mg		250 mg		450 mg	
	mean	**SD**	**mean**	**SD**	**mean**	**SD**
Creativity	10.75	1.26	11.0	2.58	11.17	6.18
Curiosity	9.75	3.3	8.71	3.25	10.33	1.51
Critical thinking	16.5	5.92	14.0	6.08	14.33	5.82
Love of learning	13.5	4.44	16.43	9.81	14.5	10.56
Wisdom	15.0	3.6	16	6.51	12.33	7.23
Bravery	6.0	6.93	4.57	5.77	6.17	4.83
Perseverance	8.75	6.65	4.14	5.31	6.33	4.97
Authenticity	10.0	1.16	8.57	3.6	7.0	1.79
Zest	13.25	2.63	12.29	6.85	8.17	5.15
Love	7.5	5.45	7.14	3.93	4.66	4.03
Kindness	9.25	3.78	11.29	0.95	12.33	5.24
Social intelligence	13.25	2.63	13.57	3.91	6.83	3.66
Citizenship	5.75	6.65	4.57	5.74	6.0	4.69
Fairness	10.5	1.92	10.14	1.57	9.5	1.97
Leadership	7.5	4.8	6.86	2.67	8.5	3.78
Forgiveness	4.5	5.45	3.0	3.87	2.5	2.07
Humility	10.25	1.71	10.71	1.11	9,0	2.0
Prudence	4.75	5.5	3.86	4.85	4.5	3.56
Self-regulation	6.0	1.41	8.71	3.86	7.0	6.63
Appreciation of beauty	3.75	4.35	2.29	3.35	3.67	2.94
Gratitude	13.0	2.71	14.71	4.86	12.17	5.98
Humor	9.71	1.5	9.71	1.5	9.17	2.32
Hope	10.25	2.22	9.29	2.22	8.17	2.56
Spirituality	9.75	3.3	8.43	3.05	7.17	3.43

Tukey's post-hoc test showed that the 450 mg group had significantly lower scores compared to the 0 mg and 250 mg groups. No statistically significant difference was found between the 0 mg and 250 mg groups ($p = 0.877$). No significant differences were observed for the other character strengths evaluated. Figure 2. Post hoc comparisons of social intelligence scores across caffeine conditions.

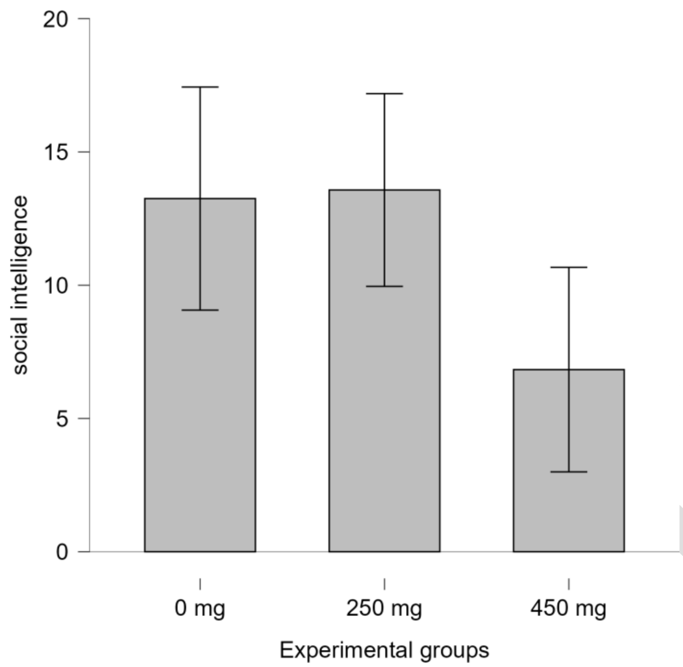

Figure 2. Post hoc comparisons of social intelligence scores across caffeine conditions.

DISCUSSION

This study aimed to investigate the acute effects of caffeine on impulsivity and character strengths in combat sports athletes. Ingestion of the highest dose of caffeine (450 mg) was associated with a reduction in character strengths compared to the placebo group and the group that ingested 250 mg. However, no significant effects of caffeine on impulsivity were observed. These results suggest that high doses of caffeine may impact specific socio-emotional competencies without producing effects on indicators of impulsivity in the evaluated consciousnesses.

The effect found on character strengths is reflected in the significant reduction of social intelligence scores in the group that ingested 450 mg compared to the placebo and 250 mg groups. It is important to note the absence of a difference between the placebo and 250 mg groups, establishing a pattern more compatible with a threshold effect than a dose-dependent effect. Therefore, social intelligence appears to be preserved at lower doses of caffeine.

From a neurobiological perspective, caffeine acts as a non-selective antagonist of adenosine A1 and A2A receptors, enhancing dopamine transmission in the prefrontal cortex and striatum, regions associated with attention, inhibition, and social behaviour (Chen & Cunha, 2023; Fredholm et al., 2022). Although moderate doses may optimise focus and motor readiness, higher doses can dysregulate prefrontal control and emotional modulation, potentially explaining the observed reduction in social intelligence at 450 mg. This suggests that excessive arousal may interfere with interpersonal judgment and emotional self-regulation, key components of this strength.

To our knowledge, no previous study has examined social intelligence under the effect of acute caffeine ingestion in athletes; some evidence from non-athlete samples points in a similar direction. Experimental studies have shown that higher doses of caffeine can increase anxiety and irritability, as well as modify mood in social or evaluative contexts, and alter the processing of emotional stimuli (Liu et al. 2024; Kosecka et al. 2025; Smith, Lawrence & Diukova, 2012). These findings corroborate the hypothesis that as physiological arousal increases, socio-emotional processes may be compromised. Therefore, the observed reduction in social intelligence is consistent with previous evidence.

It is plausible that the higher dose of caffeine increased physiological arousal and anxiety, thereby reducing their sensitivity to social cues and impairing their performance in tasks requiring attentiveness and interpersonal interaction. Social intelligence is closely related to sustained attention, emotional recognition, and social information processing (Cotter et al., 2018; Mayer et al., 2008). When physiological arousal and stress levels are heightened, as can occur following high caffeine consumption, individuals may experience diminished capacity to interpret emotional expressions and respond appropriately, potentially undermining social performance in competitive environments.

Character strengths, such as social intelligence, self-regulation, and bravery, are central to psychological functioning and performance under pressure Park, Peterson & Seligman, 2004). In sports settings, these traits influence teamwork, resilience, and ethical behaviour. The finding that high caffeine intake may impair social intelligence points to potential unintended consequences of supplementation strategies, particularly in disciplines requiring strategic interaction and behavioural control (Kapellou, Pilic & Mavrommatis, 2025; Smith et al., 2012). From a practical standpoint, this pattern suggests that high absolute doses of caffeine should be used with caution in combat sports, especially immediately before competition, as potential socioemotional costs may offset or even outweigh expected ergogenic benefits.

In contrast to the robust effect for social intelligence, caffeine did not significantly affect impulsivity or Go/No-Go task performance. No significant differences between the placebo, 225 mg and 450 mg groups were found for accuracy, and the effect sizes for these comparisons were negligible. Under the present experimental conditions, acute caffeine ingestion therefore did not appear to meaningfully modulate inhibitory control in this sample of combat athletes.

The results of the Go/No-Go task, which assesses impulsivity and inhibitory control, did not reveal significant differences between the administered caffeine doses. To date, there is a lack of studies specifically evaluating this behavioural variable in response to caffeine intake among combat athletes (Chen & Dessel, 2024; Vale et al., 2025). Therefore, the absence of significant effects highlights the importance of further research to better understand how caffeine might modulate impulsivity in sports contexts.

The Go/No-Go task has been widely employed in cognitive neuroscience to evaluate impulsive behaviour, particularly in populations with attention deficit hyperactivity disorder (ADHD), substance use disorders, and athletes under cognitive stress (Eagle, Bari & Robbins, 2008; Smith et al., 2014). Although these studies did not explore the effects of caffeine, they reinforce the Go/No-Go task's utility as a sensitive measure of inhibitory processes and executive function. Despite its widespread use and recognised sensitivity to changes in inhibitory control, the present findings suggest that, at least in this specific protocol and sample, Go/No-Go performance was not substantially altered by acute caffeine ingestion.

One possible explanation for the lack of caffeine effects on Go/No-Go performance is that trained combat athletes may already exhibit relatively high levels of inhibitory control, leaving limited room for further improvement through acute pharmacological stimulation. In addition, the specific version of the Go/No-Go task used in this study may not have been sufficiently demanding, potentially leading to ceiling effects and masking subtle differences between groups (Tyburski et al., 2021). It is also conceivable that caffeine exerts more pronounced effects on other cognitive domains than on the particular inhibitory processes captured by the present task (Tyburski et al., 2021)

Despite the significant findings concerning social intelligence, no other significant correlations were found between caffeine and the remaining behavioural parameters. This suggests that the behavioural response to caffeine may be influenced by individual factors such as neurobiological variability, personal stress coping strategies, and previous caffeine consumption history (Nehlig, 2018). These factors could significantly affect how athletes react, highlighting the need for a personalised approach in caffeine-related research to better understand its effects on social behaviour in combat athletes.

This study is not free from limitations, and they should be acknowledged. The small sample size and the absence of a prior sample size calculation or statistical power analysis mean that these results should be regarded as exploratory and limit the ability to detect effects of small magnitude, particularly in the case of null findings. This limitation is related to the reduced number of athletes willing to comply with all stages of the protocol, reflecting the logistical challenges of recruiting competitive populations. Even so, the use of trained athletes enhances the ecological validity of the findings in contrast with part of the literature on caffeine.

Caffeine was administered in absolute quantities rather than doses adjusted for body mass. This choice prevents an accurate estimation of the relative dose ingested by each athlete and may have increased interindividual variability in responses to caffeine. Nevertheless, the use of fixed doses reflects how caffeine is frequently consumed in sports practice, which brings the findings closer to real-world situations of athlete supplementation (Guest et al. 2018).

Habitual caffeine consumption was not systematically assessed, which precludes a more precise evaluation of the impact of prior tolerance or deprivation on responses to the experimental intake. On the other hand, conducting assessments under conditions close to the athletes' usual training routines brings the experimental conditions closer to those in which caffeine is consumed in competitive contexts. The inclusion of only male athletes may limit the generalisation of the findings to females. Conversely, the homogeneity of the sample in terms of sex and age range allowed for a more focused analysis of the effects in this specific group of athletes.

Conclusions

Although caffeine intake did not produce significant effects on impulsivity, the findings regarding social intelligence suggest that higher doses of caffeine may have implications for athletes' social and emotional functioning. Specifically, a significant decrease in social intelligence scores was observed at the 450 mg dose, indicating that acute ingestion of a high absolute dose of caffeine may interfere with athletes' ability to perceive, interpret and manage social cues effectively.

From a practical standpoint, this pattern suggests that high absolute doses of caffeine should be used with caution in combat sports, particularly immediately before competition, as potential socioemotional costs may offset or even outweigh expected ergogenic benefits. Given that the analyses involving social intelligence and other character strengths were exploratory and based on a specific sample of male combat sport athletes, these results should be interpreted cautiously and replicated in future studies with larger and more diverse samples.

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