Caffeine supplementation improves the cognitive abilities and shooting performance of trained e-sports players

Project summary

We explored the effect of 3 mg/kg of caffeine supplementation on the cognitive ability and shooting performance of trained e-sports players. We recruited nine e-sports players who had received professional training in e-sports and had won at least eighth place in national-level e-sports shooting competitions. After performing three to five familiarization tests, we employed a randomized crossover design to divide participants into a caffeine trial (CAF) and a placebo trial (PL). The CAF group took capsules with 3 mg/kg of caffeine, whereas the PL group took a placebo capsule. After a 1-h rest, the Stroop task, visual search ability test, and the shooting ability test were conducted.

Introduction

Owing to the popularity of e-sports, numerous countries have recognized e-sports as a formal sport. E-sports were also included as a demonstration event at the 2018 Asian Games in Jakarta. Professional e-sports leagues have been founded in several countries. E-sports include multiplayer online battle field arena games (e.g., *League of Legends*), first-person shooter games (e.g., *Counter-Strike: Global Offensive*, and *Valorant*), real-time strategy games, and sports games (1). Studies on first-person shooters have revealed that players with experience in competitions had shorter reaction times in a Stroop test (2) and stronger visual search abilities (3). Therefore, improving cognitive abilities that relate to e-sports competitions may be critical for participants in first-person shooter competitions, and external nutrients that enhance cognitive abilities may be crucial to their success.

Caffeine is a popular and effective ergogenic supplementation for athletes of all levels (4, 5). It is typically consumed through food and drink, and the mechanism through which low-dose caffeine acts as a psychostimulant is based on central antagonism at the A_1 and A_{2A} adenosine receptors. The capacity of caffeine to bind adenosine receptors facilitates the inhibition of the brake that endogenous adenosine imposes on the ascending dopamine and arousal systems,which facilitates cholinergic and dopaminergic transmission (6, 7). Therefore, caffeine consumption may improve energy, mood, cognitive function, attention, simple reaction time, choice reaction time, and memory and alleviate fatigue (8, 9). The consumption of caffeine 1 hour before playing a first-person shooter can improve players' visual search ability and speed in a state of alertness (10). A dosage of 3 mg/kg of caffeine before a game can increase players' typing speed (11), shorten their reaction times, and increase their shooting accuracy (12). However, few studies have explored this.

Because visual search ability and the presence of decoys, which can distract players, can both affect play performance in first-person shooters, reaction time alone is insufficient as an index for cognitive ability in research on the effect of caffeine on shooting accuracy. We explored the effect of caffeine ingested 1 hour before a first-person shooter on players' performance by using a Stroop task and testing the players' visual search and shooting abilities.

Methods

Participants

We recruited nine healthy male adults (with the desired age and training). All participants had experience with national competitions and regularly underwent training in first-person shooters. They consumed less than 80 mg of caffeine a day and did not have any diseases affecting the heart, bones, and joints or diseases that preclude exercise. Before the experiment, all participants were fully informed of the experimental procedures and the possible risks, and they provided informed consent. This study received approval from the Institutional Review Board of Jen-Ai Hospital – Dali Branch (110-06). This study was conducted in accordance with the Declaration of Helsinki.

Design

We adopted a randomized crossover design and divided the participants into a caffeine trial (CAF) and placebo trial (PL). The order of the trails in a test was randomized, and tests were separated by 7 days to avoid interference. At least 1 week before the formal experiment, all participants participated in three to five familiarization tests, such as cognitive function tests and shooting tests. The primary outcome was cognitive function, and the secondary outcome was shooting performance.

Experimental procedure

All tests were conducted in a professional e-sports classroom, and the indoor ambient temperature was set at 26°C. Participants' diet and meal times were recorded for the 3 days before the first experiment, and the participants were required to follow the same diet 3 days before the subsequent experiment. They were also required to avoid food and beverages with caffeine (e.g., coffee, energy drinks, chocolate, and tea) during this period.

On the day of the formal experiment, participants had breakfast and lunch at 8:00 a.m. and 12:00 p.m., respectively, and arrived at the classroom at approximately 3:00 p.m. for the experiment. The participants took capsules with 3 mg/kg of caffeine (the CAFtrial) or a placebo capsule (the PLtrial) with 200 mL of water. The placebo capsule contained flour. Each participant had a computer with a frame rate of at least 240 Hz and a mouse of scrolling speed of 1 ms. After the participants remained in the room for 1 hour, during which they were required to take a rest in any form of their choosing except engaging in esports, the Stroop task, visual search test, and shooting ability test were conducted.

Outcome measure

The color–word Stroop task and visual search test were conducted using Psych/Lab for Windows. Measures used in the literature with satisfactory reliability and validity were adopted. The Stroop task involved four base colors, namely red, green, blue, and yellow, and the names of the base colors were presented in Chinese characters and in various colors to confuse the participants. The participants were required to press a key corresponding to the base color name they saw on screen (“R” for red, “G” for green, “B” for blue, and “Y” for yellow). In each test, 80 trials lasting 5 min each were conducted. The test results comprised a congruent condition, in which the key pressed corresponded correctly to the color on screen, and an incongruent condition, in which the key pressed corresponded incorrectly to the color name on screen.

In the visual search test, participants identified orange “T”s on the screen from upside-down orange “T”s, blue “T”s, and upside-down blue “T”s. When an orange “T” would appear, the participants were required to press the space bar as quickly as possible. If no orange “T” appeared, the participants were required to not react. A total of 80 search displays were presented in 5 min. In each display, 5, 10, 15, or 20 -Ts were presented.

The shooting ability test involved a three-dimensional aim trainer, which was proposed in a previous study [12]. Participants used the mouse to shoot the electronic targets on the computer screen. The test comprised 60 targets and could be completed in 2 min. It was performed on a static map with medium difficulty. In each round, three targets appeared at once, and participants were required to shoot them within 2 s, ideally eliminating each target with a one-shot kill. Participants’ kill ratio (number of targets hit/60), hit accuracy (60/number of shooting), and average time to target were noted.

Statistics

All data are presented as averages ± standard deviations. The Shapiro–Wilk test was used to examine the normality of the data. Cognitive performance, accuracy, and hit reaction time were analyzed through a paired sample t test. We used G*power 3 software24 to achieve an alpha value of 5% and a power of 0.8; a sample of six was considered sufficient for this study. All data were calculated using SPSS (version 20, Chicago, IL, USA), and the significance level was $\alpha < 0.05$.

Reference

1. Thiel A, John JM. Is eSport a 'real'sport? Reflections on the spread of virtual competitions. Taylor & Francis; 2018. p. 311-5.
2. Kowal M, Toth AJ, Exton C, Campbell MJ. Different cognitive abilities displayed by action video gamers and non-gamers. Computers in Human Behavior. 2018;88:255-62.
3. Wu S, Spence I. Playing shooter and driving videogames improves top-down guidance in visual search. Attention, Perception, & Psychophysics. 2013;75(4):673-86.
4. Ganio MS, Klau JF, Casa DJ, Armstrong LE, Maresh CM. Effect of caffeine on sport-specific endurance performance: a systematic review. J Strength Cond Res. 2009;23(1):315-24.
5. Gomez-Bruton A, Marin-Puyalto J, Muñiz-Pardos B, Matute-Llorente A, Del Coso J, Gomez-Cabello A, et al. Does Acute Caffeine Supplementation Improve Physical Performance in Female Team-Sport Athletes? Evidence from a Systematic Review and Meta-Analysis. Nutrients. 2021;13(10).
6. Fredholm BB, Yang J, Wang Y. Low, but not high, dose caffeine is a readily available probe for adenosine actions. Molecular Aspects of Medicine. 2017;55:20-5.
7. Camfield DA, Stough C, Farrimond J, Scholey AB. Acute effects of tea constituents L-theanine, caffeine, and epigallocatechin gallate on cognitive function and mood: a systematic review and meta-analysis. Nutr Rev. 2014;72(8):507-22.
8. Lorenzo Calvo J, Fei X, Domínguez R, Pareja-Galeano H. Caffeine and Cognitive Functions in Sports: A Systematic Review and Meta-Analysis. Nutrients. 2021;13(3).
9. Chen JQA, Scheltens P, Groot C, Ossenkoppele R. Associations Between Caffeine Consumption, Cognitive Decline, and Dementia: A Systematic Review. J Alzheimers Dis. 2020;78(4):1519-46.
10. Gillingham RL, Keefe AA, Tikuisis P. Acute caffeine intake before and after fatiguing exercise improves target shooting engagement time. Aviation, space, and environmental medicine. 2004;75(10):865-71.
11. Rogers PJ, Heatherley SV, Mullings EL, Smith JE. Faster but not smarter: effects of caffeine and caffeine withdrawal on alertness and performance. Psychopharmacology. 2013;226(2):229-40.
12. Sainz I, Collado-Mateo D, Del Coso J. Effect of acute caffeine intake on hit accuracy and reaction time in professional e-sports players. Physiology & Behavior. 2020;224:113031.