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The effect of different doses of caffeine on cardiovascular variables and shooting performance

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Summary

Study aim: the purpose of this study was to assess the effect of 3 mg and 5 mg per kg of body weight of caffeine on heart rate, blood pressure and shooting performance among elite shooters.

Material and methods: sStudy participants comprised 8 male shooters among athletes at the national level with at least 2 years of experience, with the mean age (26.50±13.08 years), weight (73.02 ± 12.2 kg), height (174.62 ± 8.97 cm) and BMI (23.93 ± 2.88 kg/m^2). The blood pressure and heart rate of all participants were measured at rest. Participants then randomly took caffeine (3 mg and 5 mg per kg of body weight) or placebo for 3 different days, 2 days apart. One hour after ingestion, they shot with rifle and air pistol. Statistical analysis was performed using the ANOVA with repeated measures and the Bonferroni test.

Results: the results of the survey showed that taking 5 mg/kg of caffeine caused a significant increase in systolic blood pressure ($p < 0.001$), diastolic blood pressure ($p < 0.05$) and also caused a significant increase in heart rate ($p < 0.05$) and a significant decrease in shooting performance ($p < 0.05$). Moreover, taking 3 mg/kg of caffeine caused a significant increase in systolic blood pressure ($p < 0.05$). But this amount of caffeine had no significant effect on the heart rate, diastolic blood pressure or shooting performance ($p < 0.05$).

Conclusions: the results of this study suggest that taking 5 mg/kg of caffeine can increase the blood pressure and heart rate of the shooters that leads to a decrease in shooting performance.

Key words: Caffeine – Heart rate – Blood pressure – Shooting

Introduction

Caffeine, (1, 3, 7-trimethylxanthine), a bitter alkaloid, is odourless, crystalline and white. Its chemical formula is $C_8H_{10}N_4O_2$, which is found in tea, coffee and cola drinks. After caffeine intake, the amount of its metabolites usually increases in the blood within 15–45 minutes, and its concentration in the blood reaches the maximum level after an hour. Furthermore, its effect appears less than an hour after taking a moderate dose of caffeine, and it disappears after 5 hours [7]. In January 2004, caffeine was removed from the list of banned substances and doping of the World Anti-Doping Agency (WADA). The agency allowed its ordinary use by the athletes. After that, the athletes could take caffeine, and they could have no fear of doping. The benefits of caffeine as a performance-enhancing substance have been extensively investigated, especially in endurance sports. The results of previous studies have shown that caffeine can cause increased alertness, focus and mental performance, decreased reaction time, increased time to fatigue, and increased endurance ability [2, 6, 13]. According to the report of the Committee on Military Nutrition Research and Food and Nutrition Board, United States Institute of Medicine in 2001 entitled "caffeine to maintain the mental performance in military operations", taking 150 mg of caffeine can increase endurance and physical performance among military forces [18]. Another study showed that taking 75 mg of caffeine can improve the reaction time, alertness, focus, precision in responding and ability to remember the order of numbers [8, 9]. In one study, compared with a placebo, taking 200 mg of caffeine enabled trainees in the United States Navy, despite 72 hours of continuous sleep deprivation, to point their guns precisely and quickly [22]. On the other hand, only a few studies have investigated the effect of caffeine on exercise performance in which athletic success requires long-term mental alertness, focus and good motor skills, e.g. shooting. Of the few studies done, Share and et al. (2009) reported that the doses of 2 mg and 4 mg

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of caffeine have no effect on the performance and reaction time of shooters of clay targets [20]. Also, Ahmadi and et al. (2012) examined the effect of caffeine intake on arousal and performance in dart-throwing at different times of day. They reported that caffeine can increase the motivation of athletes but that it has no significant effect on the performance of dart-throwing players [1].

On the other hand, many studies have investigated the relationship between caffeine intake and blood pressure and reported that caffeine increases systolic and diastolic blood pressure [3, 23].

According to the previous studies, on one hand, caffeine improves the shooting performance of military forces after 48 hours of sleep deprivation; on the other hand, it increases the heart rate and blood pressure, which increases tremors or shaking in shooters' hands [12]. Obviously, body sway can worsen shooting performance [15]. Very few studies have investigated performance in rifle and air pistol shooting after caffeine intake. A question then arises of whether taking doses of 3 mg and 5 mg of caffeine per kg of body weight influence heart rate, blood pressure and shooting performance among competitive shooters?

Material and methods

Participants

Study participants comprised 8 male shooters (2 rifle and 6 pistol) among national athletes, with the mean age (26.50 ± 13.08 years), weight (73.02 ± 12.2 kg), height (174.62 ± 8.97 cm) and BMI (23.93 ± 2.88 kg/m2). They were at the national level with at least 2 years of experience. Per research criteria, participants who consumed more than 300 mg of caffeine per day (assessed via a caffeine consumption questionnaire) were excluded from the study [3].

Preparation and Consumption of Supplements

The caffeine supplement was prepared with the brand name of SIGMA-ALDRICH. Capsules contained 3 mg/kg and 5 mg/kg of caffeine and the same amount of placebo (starch). Each capsule was administered to the participants with 200 ml water via the double-blind method.

Procedure

Using the double-blind method, this study was performed 3 days, with a time interval of 48 hours between days. All of participants experienced 3 situations (placebo, 3 mg/kg, and 5 mg/kg caffeine) in 3 separated days. Priority of situations for each participant was randomly assigned. After ingestion, they rested for 1 hour in order to achieve maximum caffeine concentration in the blood. The initial 15 minutes following the 1 hour of passive rest was assigned to warm-up exercise. After 5 minutes of light exercise, they warmed up by shooting for 10 minutes and adjusted their own guns during this time. Afterwards, shooters fired their 10 main shots. They shot in the standing position. It took almost 30 minutes of shooting time. Each participant shot with a professional gun (2 rifle and 6 pistol). Five minutes after shooting, participants' blood pressure and heart rate were measured.

Statistical analysis

The Kolmogorov-Smirnov test was used to assess normality of data distribution for each variable. Also, ANOVA for repeated measures and the Bonferroni test at significance level $\alpha=0.05$ were applied to analyse the data. Data analysis was performed using the SPSS v. 20 software.

Results

Repeated measures ANOVA revealed significant differences between 3 situations in systolic ($p < 0.001$) and diastolic ($p < 0.001$) blood pressure. Pair comparison via the Bonferroni test showed that there was significant difference in systolic pressure between placebo and caffeine (3 mg/kg, $p = 0.016$, 5 mg/kg, $p < 0.001$), and 3 mg/kg and 5 mg/kg of caffeine ($p < 0.05$) ingestion (Fig. 1). Also, there was significant difference in the diastolic blood pressure between placebo and 5 mg/kg of caffeine ($p < 0.05$), but there was no significant difference between placebo and 3 mg/kg of caffeine ($p = 0.055$) or between 3 mg/kg and 5 mg/kg of caffeine ($p = 0.106$) ingestion (Fig. 2).

Mauchlly's test of sphericity of heart rate was significant ($p < 0.05$); therefore, we used the Greenhouse-Geisser method for epsilon correction. Accordingly, repeated measures ANOVA showed significant differences between 3 situations in heart rate ($p < 0.05$). Pair comparison via the Bonferroni test demonstrated that there was significant difference in heart rate between placebo and 5 mg/kg of caffeine ($p < 0.05$) and between 3 mg/kg and 5 mg/kg of caffeine ($p < 0.05$) ingestion (Fig. 3). Also, there was significant difference in shooting performance between 3 situations ($p < 0.001$). Bonferroni pair comparison showed that there were significant differences between placebo and 5 mg/kg of caffeine ($p < 0.05$) and between 3 mg/kg and 5 mg/kg of caffeine ($p < 0.05$) ingestion. But there was no significant difference between placebo and 3 mg/kg of caffeine ($p = 0.757$) ingestion (Fig. 4).

Discussion

The purpose of this study was to examine the effect of two doses of caffeine on systolic and diastolic blood pressure, heart rate and shooting performance with rifle and air pistol among elite shooters. It concluded that taking

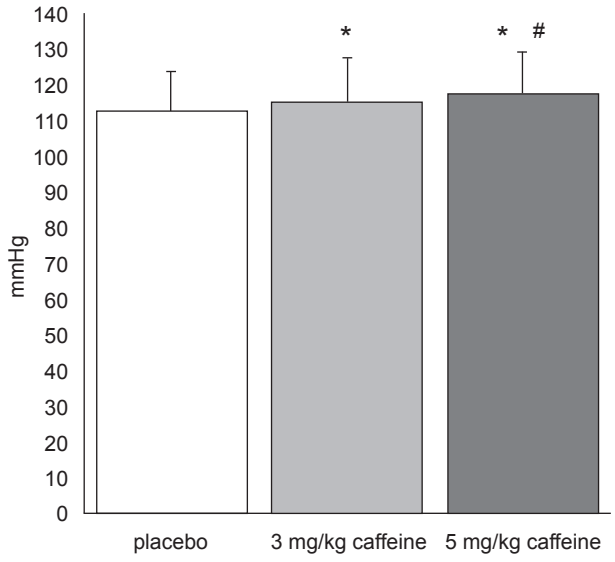


Fig. 1. Systolic blood pressure

* – significant differences with placebo; # – significant differences with 3 mg/kg caffeine

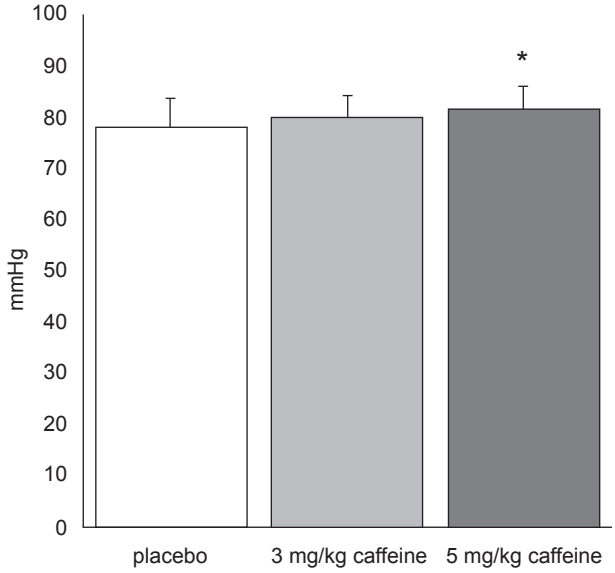


Fig. 2. Diastolic blood pressure

* – significant differences with placebo

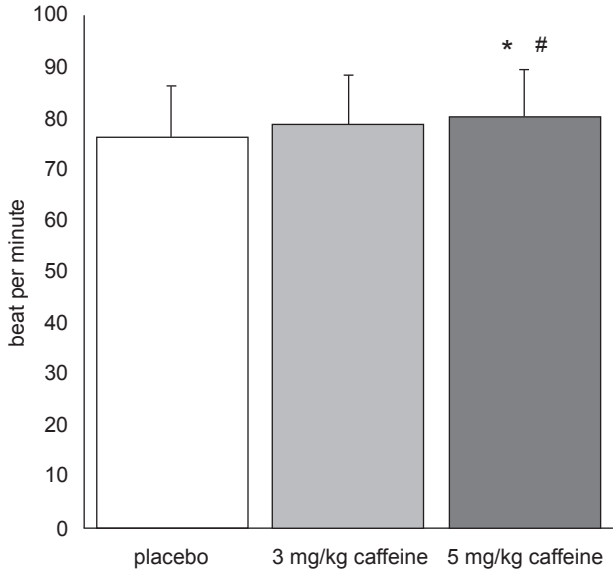


Fig. 3. Diastolic blood pressure

* – significant differences with placebo; # – significant differences with 3 mg/kg caffeine

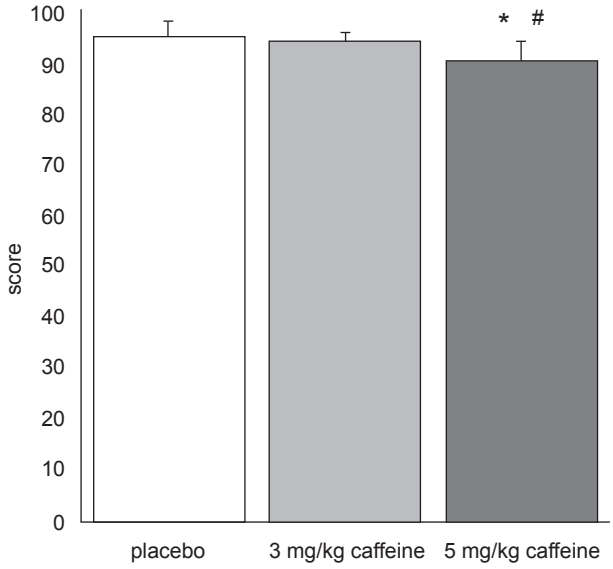


Fig. 4. Shooting performance

* – significant differences with placebo

3 mg/kg of caffeine can cause significant increase in the systolic blood pressure but that it has no significant effect on the diastolic blood pressure, heart rate and shooting performance of the shooters. However, taking 5 mg/kg of caffeine can cause significant decreases in the shooting performance, in addition to significant increases in the systolic and diastolic blood pressure and heart rate, among elite shooters.

The results of this study on the effect of caffeine on blood pressure and heart arte are consistent with most previous studies [3, 16]. Sung and et al. (1990) suggested that taking 3.3 mg/kg of caffeine can increase systolic and diastolic blood pressure while pedalling on a bicycle ergometer at maximum and sub-maximum intensities [21]. Daniels and et al. (1998) showed that taking 6 mg/kg of caffeine can cause significant increases in systolic blood pressure by 17% and mean arterial pressure by 11% [4]. Damirchi and et al. (2009) indicated that taking 5 mg/kg of caffeine can increase the systolic blood pressure after 30 minutes of treadmill running at 60% vo_2max in both

obese and lean people [3]. Most researchers agree that the mechanism of the effect of caffeine is more likely related to the vasoconstriction caused by sympathetic nerve stimulation [5, 17].

Our results indicated that taking 3 mg/kg of caffeine had no significant effect on the shooting performance but that the 5 mg/kg of caffeine caused significant decrease in the shooting performance of the shooters. Also, there are similar results concerning heart rate. Heart rate increased with 5 mg/kg of caffeine but not with 3 mg/kg of caffeine. It seems that decreased shooting performance is probably due to increased heart rate [11]. As heart rate increases, anxiety, agitation and tremors in the organs, and especially in the hands of shooters, causes them to lose their ability to focus and keep their guns on target, so they likely fire a pendulum shot that increases the shooting error. In addition, the effects of caffeine on the nervous system and body temperature as effector factors cannot be ignored [12]. Because taking both doses of caffeine can increase shooters' blood pressure, then, it can be concluded that increases in heart rate can decrease the shooting performance and that increases in blood pressure have no effect on the shooting performance among shooters.

Share and et al. (2009) reported in the only research on shooting athletes that the doses of 2 mg/kg and 4 mg/kg of caffeine have no effect on the shooting performance, reaction time or tracking of clay targets [20]. But more research has been done on military personnel after sleep restriction, which has demonstrated that taking caffeine has a positive effect on the accuracy of shooting. For example, Tharion and et al. (2003) suggested that taking 200 mg of caffeine enabled trainees in the U.S. Navy to point their guns more accurately and faster after 72 hours of sleep deprivation [22]. Also, McLellan et al. (2005) observed that taking caffeine can improve participants' shooting performance under conditions of sleep deprivation [14]. On the other hand, Johnson and Merullo (2000) stated that taking 200 mg of caffeine has no significant effect on shooting performance among military personnel [10]. A simple review of these results suggested that caffeine can probably improve shooting performance only in situations involving sleep deprivation; during situations of normal sleep, a low dose of caffeine have no effect on shooting performance. However, a medium dose of caffeine can worsen shooting performance. Nevertheless, the style of shooting, shooting conditions, and many other differences between the military and sports shooting (in this case rifle and pistol) should not be ignored.

According to the results of this study, it can be concluded that taking low doses of caffeine has no effect on heart rate, diastolic blood pressure or shooting performance of shooters but that taking medium doses of caffeine can increase systolic and diastolic blood pressure and heart rate, and decrease the shooting performance of professional shooters. Also, with regards to the results of this study and previous studies, it can be stated that caffeine cannot improve the shooting performance under normal conditions but that it can improve the shooting performance of participants under conditions of sleep deprivation.

However, the low sample size is a limitation of this study. Also, if measurement of blood pressure and heart rate were performed during shooting, we could have a better view of the effects of caffeine while shooting.

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