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The effect of caffeine consumption on the time to reach fatigue and oxygen consumption index in active men

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Original Research

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Abstract

Purpose: Caffeine is a widely used and available physiological stimulant that is effective in sports performance. The purpose of this study was to investigate the effect of caffeine consumption and exercise on fatigue and cardiovascular responses in active men. **Methods:** The statistical population of this research was made up of all male students of physical education in the age range of 19 to 27 years with at least three activity sessions per week. 15 of them were selected as subjects and they performed the exercise protocol in two stages (the first stage by eating placebo and the second stage by eating coffee). The exercise protocol was the Bruce test, which was performed separately on two days with a 5-day interval. Subjects consumed 5 mg/kg of coffee in the first session under placebo conditions, and in the second session, subjects consumed 5 mg/kg of coffee one hour before the test. Blood samples were collected before taking placebo or caffeine and after the test. The descriptive statistics method was used to describe the data, determine the mean and standard deviation of the data, and the correlated t-test was used in the statistical inference section to analyze the data. Statistical analysis was used with SPSS version 26 software with a significance level of less than 5 percent. **Results:** The results of the correlated t-test showed that the consumption of caffeine supplements significantly increased the time to reach fatigue (p=0.023) and the index of oxygen consumption after exercise (p=0.041). **Conclusion:** In general, it can be said that active men can use 6 mg/kg of caffeine supplement one hour before sports activity to improve the time to reach fatigue.

Keywords: caffeine, fatigue, active men, oxygen consumption index.

Introduction

Today, under the shadow of research and advancement of science and scientific communication, the quality of sports officials is also increasing, and the level of sports competitions is approaching (Acquah-Sam, 2021). Meanwhile, athletes can achieve better results if they pay more attention to more subtle and important factors (Jokar, Behpoor, Fasihi, Fasihi, & Ebrahimi Torkamani, 2021). The research shows that increasing VO2 max by 22% increases the distance traveled by 14% in game conditions. One of these factors is caffeine supplement consumption (7,3,1 trimethylxanthine) (Khcharem, Souissi, Masmoudi, & Sahnoun, 2022; Siahkouhian, Fasihi, Valizadeh, & Naghizadeh, 2018). Alkaloid caffeine is a stimulant and is considered one of the most commonly consumed supplements in the world (Domaciuk, Wójcik, Zarzeczna, Kanatek, & Jędrocha, 2022). It is a quasi-crystal, white, and bitter-tasting substance that is found in tea, coffee, Nescafé, cola drinks, and chocolates containing cocoa (Fasihi, Tartibian, & Eslami, 2021). Due to the effect of caffeine on the central nervous system and the subsequent improvement in alertness and concentration, as well as its low cost and easy consumption, it has become very popular among male and female athletes in order to improve sports performance (Gharakhanlou & Fasihi, 2023).

Some research conducted on the energy-boosting effects of caffeine during exercise shows that during aerobic activity, caffeine increases reliance on fat in energy catabolism and can save muscle glycogen consumption by increasing fatty acid oxidation (Naeini & Taghian, 2018). It has also been shown that the consumption of caffeine in the amount of 5 mg per kilogram of body weight causes a decrease in the respiratory exchange ratio (Bauer, Maier, Linderkamp, & Hentschel, 2001), This refers to the consumption of more fat as an energy source during exercise. In a study by Bridge et al. (2006), they investigated the effect of consuming five milligrams of caffeine per kilogram of body weight on endurance performance in untrained and recreational runners (Bridge & Jones, 2006). Their results showed that the consumption of caffeine significantly improved the performance in two groups (Bridge

& Jones, 2006). Greer et al. (1998) reported that the consumption of caffeine supplement in the amount of 6 mg/kg increased peak power consumption and average power consumption in the phases At the end of the repeated Wingate test (Greer, McLean, & Graham, 1998), Virk (1994) investigated the effect of consuming 5-10 mg of caffeine per kilogram of body weight on excess oxygen consumption in non-exercised women Oxygen consumption and fat mobilization showed submaximal recovery after 90 minutes of exercise (Virk, 1994). In contrast, some researchers observed no effect of caffeine consumption on respiratory exchange ratio (RER) or consumption of free fatty acids by muscles (Hoffman et al., 2007; Leelarungrayub, Sallepan, & Charoenwattana, 2011; Tartibian, Fasihi, & Eslami, 2022). In a study, Piene et al. (2012) investigated the effect of consuming 5 mg of caffeine per kilogram of body weight on the complete fatty acid curve in untrained men during 30 minutes of stationary cycling. with an intensity of 75% of VO2max (Piene, 2012). Their results showed that caffeine consumption does not produce any specific metabolic advantage, and there is no significant difference between the caffeine and placebo groups in RER (Piene, 2012). Also, Westerterp-Plantenga et al. (2005) investigated the effect of consuming 6 mg of caffeine per kilogram of body weight on additional oxygen consumption after exercise in resistance-trained men (Westerterp-Plantenga, Lejeune, & Kovacs, 2005). They concluded that the additional oxygen consumption after exercise increases after performing resistance exercises with an intensity of 70-80% of a maximum repetition until exhaustion (Westerterp-Plantenga et al., 2005). In this research, the training intensity was high, and there was a time delay of 7 minutes from the time of the last repetition of resistance training to the assessment of respiratory gases, which prevented accurate results from being obtained.

Many studies have been conducted on the energy-enhancing effects of caffeine on fatigue and oxygen consumption during exercise, but there are still many uncertainties in this field (Fasihi, Shahrbanian, & Jahangiri, 2025). Therefore, the aim of this study was to investigate the effect of caffeine consumption on the time to reach fatigue and oxygen consumption index in active men.

Methods

The current research method was applied, semi-experimental and pre-test-post-test. The statistical sample consisted of fifteen male students in the field of physical education, who were selected voluntarily due to having at least one year of regular sports activity (three sessions per week). The subjects participated in the research in a cross-sectional manner and were placed in two states of placebo (p) and caffeine consumption (caf) for three consecutive days. All the volunteers were healthy, and the general health of the people was evaluated through the medical history questionnaire and the questionnaire of readiness to start physical activity. Also, all subjects completed a written consent form regarding participation in the research program.

Sports protocol

The exercise protocol was the Bruce test, which was performed separately on two days with a 5-day interval. Subjects consumed 5 mg/kg of coffee in the first session under placebo conditions and in the second session one hour before the test. The subjects were asked to refrain from vigorous physical activity 24 hours before the test and from eating or drinking any substance containing caffeine 48 hours before the test. Substances containing caffeine were presented to the subjects in the form of a list. The first session of the test was performed after at least 4 hours of eating. First, they did the warming up, and then they did the Bruce test on the turntable. The test started at 1 mile per hour and increased by 2/ (seven three-minute stages) with a ten percent incline and a 7 percent incline speed with every 3 minutes until the end. Systolic and diastolic blood pressure indices (DBP and SBP) were measured using an Aneroid blood pressure device (BPAGI-20 model) in the control state and immediately after reaching the resting state. Myocardial oxygen consumption index from the formula was calculated below (Siahkohian, Fasihi, & Ebrahimi Torkamani, 2023). RPP = (HR*SBP)/100

Blood sampling and statistical method:

A blood sample (5 ml) was taken from the forearm vein using a syringe. The samples were kept on ice until they were transferred to the laboratory and allowed to coagulate. After being transferred to the laboratory, the samples were centrifuged at 3000 rpm for 10 minutes. The separated serum was kept frozen at 20 - 20 until analysis. To describe the data, the method of descriptive statistics, determining the mean and standard deviation, and the correlated and independent t-test were used to analyze the data. Statistical analysis was done with SPSS version 26 software at a significance level of 0.05.

Results

The characteristics of the subjects (age, height, weight, and body mass index) are presented in Table No. 1. All values are expressed as average and standard deviation and are related to the measurements taken before the start of the test.

Table 1: Anthropometric characteristics of subjects

Variables	Exercise Mean + SD
Age (Year)	23.56±3.11
Weight (kg)	55.14±6.4
Height (cm)	162.11±4.5
BMD (kg/m^2)	21.60±2.14

First, the assumption of normality of the distribution of the variables was investigated using the Shapiro-Wilk test, and the significance levels obtained were more than 5 percent ($P<0.50$). The results of the correlated t-test regarding the effect of caffeine on the time to reach fatigue showed that caffeine supplementation increased the time to reach fatigue ($p=0.023$). (Figure 1).

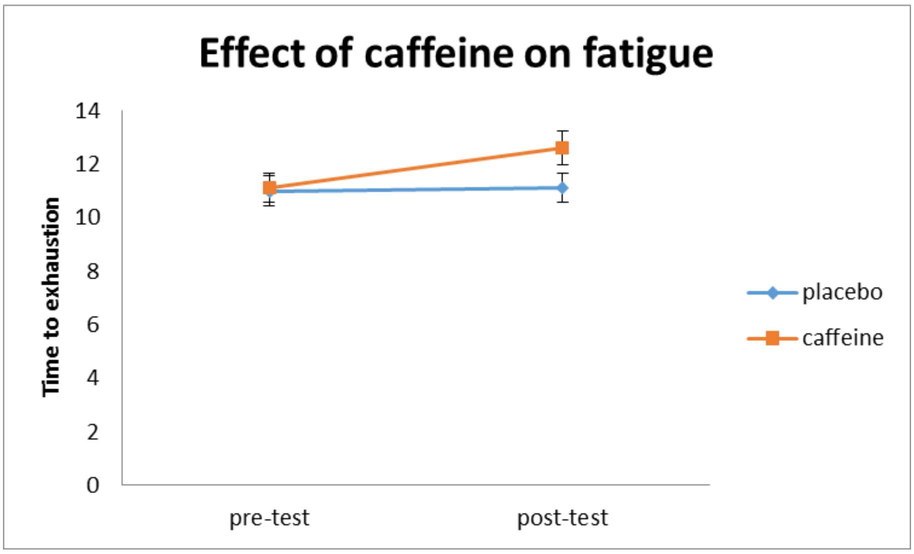

Figure 1: The effect of caffeine supplementation on the time to reach fatigue in active men

Regarding the effect of caffeine supplement consumption on the oxygen consumption index, hockey results showed a significant increase in this index after Bruce's test and caffeine supplement consumption compared to the placebo condition (p=0.041). (Figure 2)

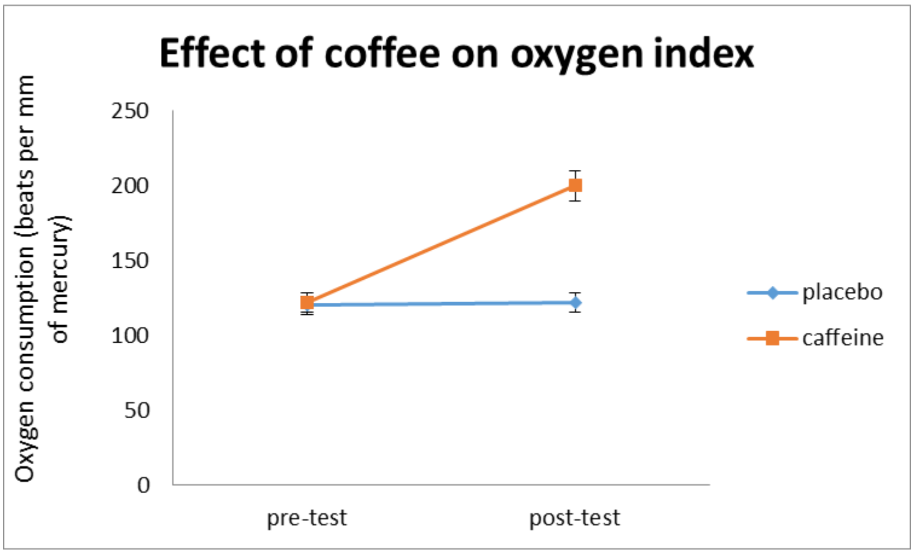

Figure 2: The effect of caffeine supplementation on myocardial oxygen consumption index in active men

Discussion

In this research, the researcher investigated the effects of caffeine and placebo for one session. The findings of this research were confirmed in the inter-group comparison test of a significant increase in the time to reach fatigue and the amount of myocardial oxygen consumption index after caffeine supplementation in active men (Figure 1 and 2).

The results of the present study showed that the consumption of caffeine supplement (5 mg/kg) significantly increased the time to reach the resistance, and the subjects ran for a longer time in comparison with the control and placebo conditions. In line with the results of this research, Rourke et al. (2007) investigated the effect of consuming five milligrams of caffeine per kilogram of body weight on endurance performance in fifteen trained and recreational runners (O'Rourke, O'Brien, Knez, & Paton, 2008). One hour after consuming caffeine, people started to run a distance of five kilometers. At the end of their research, they reported that caffeine consumption significantly improved performance in two groups, but the trained group was able to register a better time. Bridge et al. (2006) investigated the effect of consuming five milligrams of caffeine per kilogram of body weight on endurance performance in eight trained male runners. People in three conditions, control, placebo, and caffeine, performed the 8 km running test. The results showed a significant increase in endurance performance in runners due to caffeine consumption (Bridge & Jones, 2006). Also, Bell and Mclellan (2003) investigated the effect of caffeine consumption on endurance performance with an intensity of 80% of the maximum oxygen consumption on a two-wheel carmeter in two times in the morning and in the evening in 9 men. The results showed that the consumption of caffeine before the morning test caused a significant increase in the delay time (Bell & McLellan, 2003). This increase was also observed in the evening shift. Although the caffeine concentrations observed in the evening shift in the group that consumed five milligrams of caffeine per kilogram of body weight were lower than the groups that consumed the same five milligrams in the morning. Also, the results of the current research are in line with the results of the research of Greer et al. (2000). They compared the effect of caffeine (6 mg/kg) and theophylline (4.5 mg/kg) on endurance performance metabolism in eight healthy men. The result indicated that reaching the delay time was increased in both caffeine and theophylline groups compared to placebo. Researchers considered the significant increase in performance after caffeine consumption as a result of the reduction of adenosine receptor activity (Greer, Friars, & Graham, 2000). It seems that the reduction of pressure perception and fatigue caused by the suppression of adenosine receptors can be seen in activities that last longer. Therefore, considering that in the present research, the activity continued for a long time, this factor can be effective in significantly improving the performance.

The results of the present study are inconsistent with the results of Graham and colleagues (1995). They investigated the effect of 6 and 9 mg of caffeine per kilogram of body weight on endurance performance and catecholamines, consumption of 3 in eight trained men. The results showed that the group that consumed 3 and 6 mg of caffeine per kilogram of body weight experienced a significant increase in endurance performance, but their findings showed that the group that consumed 9 mg of caffeine per kilogram of body weight improved performance. did not show. The researchers admitted that the use of a high dose in the latter group is the reason for the lack of a significant increase in performance (Graham & Spriet, 1995). Taking a high dose of caffeine (6 to 9 mg) may be associated with side effects such as aggression, increased heart rate, and decreased performance (Burke, 2008). Therefore, taking the optimal dose of caffeine can be an effective factor in significantly improving performance in our study.

In general, the ergogenic effects of caffeine on sports performance are influenced by several factors. The proposed mechanism of the researchers is to increase the activity of the central nervous system, increase the extracellular potassium, and decrease the perception of pressure. Caffeine in the CNS and adipose tissue increases the intracellular concentration of cyclic ANP by binding to adenosine receptors. This action increases alertness, concentration, and freshness and increases the call of motor units. Also, increasing the concentration of cyclic AMP in adipose tissue increases liposis. As a result, caffeine increases sports performance by saving muscle glycogen consumption and increasing the call of free fatty acids during sports activities with greater or longer intensities. Also, having more muscle mass and the effect of caffeine on muscle fibers, as well as having more central effects of caffeine in reducing the perception of pressure in athletes, due to their greater mental preparation than non-athletes and the consumption of moderate doses of caffeine, have been mentioned (Bridge & Jones, 2006).

Conclusion

Based on the studies, most of the results obtained from the research support the energy-boosting effect of caffeine on aerobic exercise, so caffeine consumption is recommended to improve the performance of endurance exercise. According to the results of the present study, the effective mechanism seems to be the increase of carbohydrate oxidation and the suppression of adenosine receptors by reducing fatigue and pressure perception.

Conflict of interest

The authors declare that there is no conflict of interest.

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