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The Effect of Caffeine on Maximum Oxygen Consumption during Rest, Exercise, and Return to Original State

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Abstract: *Research findings have indicated different influence of caffeine consumption on athletic performance. The purpose of this research was evaluating influence of caffeine consumption on some cardiovascular factors including heart rate and blood pressure during rest, end of exercise and recovery.Subjects of this study were 24 female vollybal athletes with at least one year experience of athletic participation .who participated voluntarily in this study.After recording of some subjects characteristics and assurance of not being sensitive to caffeine, two exercise tests were performed in separate weeks. In first test placebo and in second test caffeine (5 mg/kg) was consumed (one hour before trail) by subjects. heart rate and blood pressure were measured during rest, at the end of exercise testing and during 3rd and 5th minutes of recovery of submaximal test. Maximal oxygen consumption (VO2max) was measured using submaximal cardiorespiratory test on Monark ergometer. T paired test was used for analysis of data. Results: caffeine consumption was effective on Vo2max, hear rate during rest and end of exercise, and end exercise blood pressure ($P>0.05$). caffeine consumption caused increasing heart rate during 3rd and 5th minutes of recovery, blood pressure during rest, 3rd and 5th minutes of recovery in athletes($p\leq o.05$).*

Keywords: *Heart Rate, Blood Pressure, Maximal Oxygen Consumption*

INTRODUCTION

Caffeine is one of the most widely used drugs in the world and it has become a power booster for many athletes in the world (Traves, 2012). Some of the proposed effects of caffeine associated with exercise include increased secretion of catecholamine (Collam, 2005), increased calcium release from Sarcoplasmic network (Golldestin et al., 2015) and improvement of contractility of skeletal muscles (Dolatabadi, 2015). In addition, although more precise mechanisms have not been completely identified, it has been suggested that caffeine can improve force generation by increasing muscles neurotransmissions (Kalman, 2014) and the ability to reach maximum muscle activity (Campbel, 2013).

Caffeine's effects on maximal anaerobic function has not well defined. For example, Bell et al. (2001) reported that recently, very few studies have been conducted on the effects of ergogenic caffeine on the performance of short-term activities with severe instances in which there are short rests between them. It is possible that participants in sports such as football, basketball, hockey, tennis and ... using caffeine supplements before the competition in order to improve their performance. The mechanisms by which they can improve performance include: performing long courses of activity and thus reducing fatigue and increasing levels of blood

catecholamine and increasing neuromuscular transmissions (Whyte, 2013).
In January 2004, the World Anti-Doping Agency (WADA) removed caffeine from its list of banned substances. As a result, athletes can now use caffeine without fear of violating doping rule (Tarnopolski et al., 2005).
There are over 60 studies in journals that by showing evidence, prove the effects of caffeine on various aspects of sport performance. One of the recent studies has confirmed the power booster effect of caffeine on endurance athletes, which have been performed in laboratory environments. In a study conducted by Desbrow and Leveritt in 2007, it was shown that caffeine is very popular among athletes. Athletes before their completions wrote in questionnaires that they intend to use a caffeinated substance during a sports competition (Desbrow and Leveritt, 2007).
Although most athletes consume a lot of protein in their diet in order to meet any increase in the energy they need, those who have a low-energy diet or need to modify their diet for certain reasons during their training, use caffeine as a power booster agent. (Tarnopolski et al., 2005).
The real trend for caffeine as a power booster was increased in the late 1970s, which showed some progress in sport performance. These progresses can be attributed to the increase in the presence of free fatty acids and possible savings of muscle glycogen. Shortly afterwards, researches showed that caffeine increases oxidation and the amount of triglycerides in the muscle during a 30-minute short-term endurance period. Increased oxidation of fats with the reduction of used muscle glycogen has been the dominant theory for the power booster effects of caffeine (Tarnopolski et al., 2005).
It increases the amount of glucose in the body and also its absorption in the intestine improves the body's function by providing glucose to the muscles. Studies have also shown that when caffeine was legally prohibited, the average level of caffeine in the athlete's urine was significantly higher than the permitted amount, which indicates high consumption of caffeine (Poker Yoka et al., 2007).
Desbrow and Leveritt also found that caffeine is a popular and highly consumed supplement among athletes. Some scientists have examined the power booster effects of caffeine on endurance functioning (Tarnopolski et al., 2005; Vakili, 2003; Desbrow and Leveritt, 2007).
Nazem et al. observed that caffeine ingestion before sever intense exercise increases calcium ion and increases the anaerobic power of soccer players during maximal and interval activities (Nazem et al., 2009).
Damerchi and colleagues conducted a study on the effects of caffeine on blood pressure during maximal activity and rest in overweight individuals and found that the mean blood pressure increased with caffeine consumption during rest; however, at the end of the activity, the difference between the blood pressure of caffeine and placebo consumers was not significant (Damerchi et al., 2008).
Regarding these studies and the direct effect of caffeine on the central nervous system (Poker Yoka et al., 2007) and the impact of central nervous system on cardiac respiratory factors, the present study seeks to determine whether caffeine effects the blood pressure and heart rate at rest and recovery for increased exercise and maximum oxygen consumption in athletes?

Statistical population and research sample

The statistical population of the current research consisted of female volleyball athletes of Zarghan city, with at least 1 year of regular sports experience and participation in the tournaments. The statistical sample of this study included 24 of these athletes aged 14-17 years who volunteered to participate in the research. Before choosing subjects, those who consumed daily caffeine more than 300 mg per day were excluded from the study.

Procedure

To determine the amount of daily caffeine intake, the caffeine consumption registration form (Appendix 1) and the daily mean of caffeine consumption by subjects were measured and recorded (Appendix 2) (Nutrition Information Center, 2008).
Two separate tests were conducted at an interval of one week, so that on the first day subjects were given placebo (an empty gelatin capsule) and on the second day, capsules containing caffeine (5 mg / kg of body weight) With 200 ml of water had been given to the participants. Because it takes 45 to 60 minutes for caffeine to reach

the maximum concentration in the blood (Damirchi et al., 2008), the capsule was given to the subjects 60 minutes before the test, and during this time they were asked to Sit down on a chair and begin to warm up 5 minutes before the test.

Note: The subjects were asked to avoid using caffeine for at least one week and avoid any intense activity one day before the test.

The factors that were measured in subjects are:

1- Calculating Maximum Oxygen Consumption (Vo_2max) by performing a Fox Test on a Monarque Bicycle
2- Measuring blood pressure and heart rate of recovery of subjects 3 minutes after test
3- Measuring blood pressure and heart rate of recovery of subjects 5 minutes after the test

Description of test execution

The subjects peddle for 5 minutes on a fixed bicycle with 150 watts (900 kg / min) at a steady speed. At the end of the fifth minute, their heart rates were measured. After that, we put the obtained heart rates in the following formula to determine the maximum oxygen consumption of the subjects:

0.0193 x Heart rate per minute - 6.3 = Maximum absolute oxygen consumption (liters per minute)

Note: Because heart rates decreased rapidly after exercise, first measurements should be completed immediately after the interruption of the exercise; second, heart rates should be counted in ten seconds and multiplying it by 6 (Sharifi et al., 2007).

Results

Table 1: Comparison of Maximum Oxygen Consumption after Placebo and Caffeine consumption

Statistic Variable	Number	Mean	Standard Deviation	Degree of Freedom	t-statistic	Level of Significance	Result
Placebo	24	3.431	0.326	23	0.460	0.52	NS
Caffeine	24	3.981	0.560				

As the table above shows that t-value with a degree of freedom of 23 is 0.460 and its significant level is greater than 0.05, therefore, there is a significant difference between the maximum oxygen consumption after taking placebo and caffeine.

Discussion and Conclusion

Maximum Oxygen Consumption

The results of this study showed that the mean of maximum oxygen consumption by placebo in the athletes was 3.431 ± 0.326, which increased to 3.981 ± 0.560 after caffeine consumption. This increase was statistically significant. In other words, the consumption of caffeine affects the maximum oxygen consumption. Ebrahimi et al. (2008) in their study showed that caffeine increases the intake of oxygen (VO_{2max}). The maximum oxygen consumed are measured by different tests. In this study, the maximum oxygen consumption (VO_{2max}) was calculated using sub-maximal Fox test and calculating the maximum heart rate at the end of the test. For example, theobromine (which is obtained from the decomposition of caffeine) is an artery opener that increases the flow of oxygen and food to brain and muscles. Theophylline (a component of caffeine) increases cardiac efficiency and paraxanthine increases the amount of glycerin and fatty acids in the blood. Obviously, these two substances are consumed as fuel in the muscle (Mahani, 2014); also caffeine facilitates the release of calcium, which both converts and secretes glycogen phosphorylase B-enzyme (glycogenic adrenaline). Therefore, it seems that one of the implications of activating these systems by caffeine is the increased production of Octets. Also, in 1996, Jackman and colleagues concluded that the power booster effects of caffeine during short-term intense exercises is not related to glycogen consumption, but rather it can be due to a direct effect of Muscle. increased CNS muscle strength changes performance as a result of Caffeine consumption is probably due to the release of calcium from the endoprosthetic system or the increased sensitivity of myofibrils to calcium. It seems that the increased formation of transverse bridges leads to and stimulates glycolysis and the increased ATP, increases the demand for intracellular calcium and stimulates glycogenosis. This is due to increased power of high lactate in blood as a result of intense exercise. (Highland, 2014). Regarding this matter, and considering the fact that the maximum heart rate at the end of the test showed a significant difference in the two groups, the maximum oxygen consumption in the two groups also had a significant difference.

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