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Original article

A Study of Acute Effects of Caffeine Supplementation on Strength and Agility of Strength Trained Athletes

Dr. Ravneet Sandhu[1], Tanya Arora[2]

[1*]Assistant Professor, MYAS-GNDU, Department of Sports Sciences and Medicine

[2]Student in MSc. Sports Nutrition, MYAS-GNDU, Department of Sports Sciences and Medicine

Name: Dr. Ravneet Sandhu

Address: H.no.4, Lane No. 2, Labh Nagar, Ram Tirath Road, Amritsar, Punjab, 143002

Phone Number: +919781624266

E-mail- ravneet86nutrition@gmail.com

Abstract

The capacity to create large amounts of force is one of the most important aspects influencing success in a wide range of sporting activities. As the most extensively used psychoactive drug in the world, caffeine is widely utilized by athletes before competitions to improve their physical and mental performance. Due to the high number of athletes who regularly use caffeine, it is vital to study the effects of acute caffeine administration in caffeine-dependent athletes. Caffeine has been shown to increase strength, repeatability, and work volume in strength trained athletes. A total of 18 strength trained athletes were selected in the age group of 18 to 25 years who were undergoing strength training for at least past 6 months. The subjects were administered caffeine and placebo in two separate sessions. The subjects performed agility test, bench press and leg press. Baseline and post intervention values were recorded. To examine the difference between the effects of caffeine and placebo, t-test was used. The results showed that caffeine causes significant improvement in agility ($p<0.05$) in strength trained athletes as compared to placebo but no significant differences were observed in percentage improvements in leg press and bench press in caffeine and placebo effect.

Key words- Psychoactive drug, Caffeine, Strength, Repeatability, Work Volume, Agility, Legpress, Benchpress

Introduction

Athletes are always looking for legal ergogenic aids to enhance their performance. Substances, techniques, or sports equipment that improve sports performance are termed as ergogenic aids. Diverse range of dietary supplements is available to ameliorate physiological responses to enhance athletic performance and increasing adaptation of the training. Variety of combinations and substances such as protein and carbohydrates supplements, vitamins, minerals, phosphate, sodium bicarbonate, alcohol and caffeine are available as supplements.

Caffeine is one of the supplements that have attracted the attention of many athletes and coaches, in last few years to improve cognitive and physical performance[1-3]**.** The most common form of caffeine that forms almost 54 percent of the caffeine consumption in the world is coffee (8 cups of coffee may contain 50-200 mg caffeine), followed by tea which constitutes 43 percent and other substances containing caffeine like chocolate, sports beverages, drugs, etc make only 3 percent of the caffeine[4].

Removal of caffeine (1,3,7-trimethylxanthine), from the prohibited list by the World Anti-Doping Committee (WADA) in 2004 enhanced the consumption of caffeine to augment athletic performance[5].

Characteristics and Mechanism of Action of Caffeine

Caffeine is promptly absorbed by the gastrointestinal tract and it is adequately hydrophobic to transit through many biological membranes to be widely distributed throughout all tissues of the body[6]**.** Caffeine might have the potential to increase fat oxidation and, thus, spare glycogen utilization and thereby alter substrate utilization[7].

It usually takes between 15 and 120 mins to achieve peak concentrations of caffeine in plasma after oral ingestion, although dosage might affect peak values and the time for peak concentration[8]**.** It generally takes around four to six hours to attain caffeine's half-life (the time required for the quantity to reduce to half its concentration in the body[9]**.**

Caffeine induced escalated secretion of catecholamines accentuated calcium release from the sarcoplasmic reticulum[10]**,** and an enhancement in skeletal muscle contractility[11] contribute to the exercise related effects of caffeine**.** It has been proposed that caffeine may bring surge in force production by enhancing neuromuscular transmission and improving the ability to achieve maximal muscle activation

The hypoalgesic effect of caffeine decreases the perception of pain and effort during exercise and therefore might also be considered as a supplementary mechanism of action, at least for exercise situations that induce pain[12-13]**.** Lower pain perception could maintain or increase the firing rates of the motor units and possibly produce a more sustainable and forceful muscle contraction, and consequently, allow greater strength production[14].

Agility is defined as the capacity to controllably move and change the direction and position of one's body. It demands rapid reactions, coordination, balance, quickness, and the ability to respond appropriately to changing circumstances. Caffeine has been proven to improve sprint speed, anaerobic power, and response time, all of which are important characteristics of agility. Illinois agility test is a valid measure of agility that uniquely assesses movement in different planes, thus providing a comprehensive assessment of high-level mobility[15].

Guidelines for Caffeine Ingestion

Current guidelines recommend the ingestion of low-to-moderate doses of caffeine, ranging from 3 to 6mg/kg, approximately 60 min prior to exercise to get these improvements.

Higher doses of caffeine (9–13 mg/kg) do not present any additional enhancement in physical performance but increase the incidence and magnitude of main caffeine-related side effects[16]. Caffeine is excreted in the urine and its peak concentration in urine is 1 to 3 hours after consumption[17]. The threshold of caffeine toxicity appears to be around 400 mg/day in healthy adults (19 years or older), 100 mg in healthy adolescents (12-18 years old) and 1.5 mg/kg/day in healthy children (less than 12 years). In addition, high doses of caffeine might end in urine caffeine concentrations greater than 15 µg/ml, which is prohibited by the National Collegiate Athletic Association (NCAA).

According to Medical Council of International Olympic Committee (IOC), caffeine is allowed in sports as long as its urinary excretion level is below 12µg/ml. Caffeine's ubiquity raises the possibility that regular, repeated exposure may blunt the subsequent physiological effects of supplementation. In animal studies, chronic caffeine intake increases adenosine receptor concentration attenuating caffeine's stimulatory effects[18].

Caffeine's stimulation of the nervous system and breathing, paired with an increase in energy, has long been known to affect sports performance in a variety of ways. In fact, the effects of caffeine on performance have been shown to be strong enough to warrant some caffeine restriction.

The main aim of the study is to determine the effect of caffeine on strength and agility of resistance trained athletes and compare the effect of caffeine with placebo.

Materials and methods

Subjects

The research was undertaken in MYAS-GNDU, Department of Sports Sciences and Medicine Amritsar with 18 male athletes aged 18 to 25 who are involved in strength training. This criteria excludes athletes with cardiovascular or respiratory issues. The independent variables include Agility, bench press, and leg press, whereas the dependent variables are caffeine and placebo, which are used to observe the experiment.

Table 1. Subject Characteristics

Variables	Mean±SD
Age(years)	21.16±2.31
Height(cm)	177.22±5.32
Weight(Kg)	69.94±7.82
BMI(Kg/m^2)	22.15±1.50

Procedure

After obtaining consent form, subjects were asked to avoid performing strenuous activity and eating food containing caffeine 24 hours before the test. In two separate sessions, the subjects after 12 hours of fasting, consumed caffeine (capsules containing 5mg/kg) and placebo (biotin) with 200 ml of water. The test material was consumed an hour before the test by the subjects to achieve plateau concentrations of caffeine in the blood. Subjects performed

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special warm-up activities for 15 minutes. Then, they did one repetition maximum test (1RM) in bench press (as especial upper body exercise) and leg press (as original lower body exercise) with 3-minute rest intervals in the range of 3 to 5 attempts. After 5 minutes of rest, subjects carried out bench press and leg press 3 times with 80% of one repetition maximum with maximum possible repeat until exhaustion with 3 minutes' rest between sets. The subjects also performed Illinois Agility Test and time (seconds) taken is noted to complete the test. The agility test was conducted and rated according to the below table:

Rating	Male (seconds)	Female (seconds)
Excellent	<15.2	<17
Above average	15.2-16.1	17-17.9
Average	16.2-18.1	18.0-21.7
Below average	18.2-19.3	21.8-23.0
Poor	>19.3	>23.0

Statistical analysis

Statistical analysis like mean, standard deviation, standard error and t-test were evaluated for the data to get a significant result. The data was first put into an excel file and transferred into SPSS 24.0 version. Thus, using SPSS software the present study results analysed.

Results & Discussion

Average muscle strength in the bench press and leg press and agility in caffeine and placebo conditions are presented in Table 2. And Table 3 According to the t-test results, bench press and leg press values significantly increased in caffeine and placebo ($p<0.05$) from the baseline values.

Table 2: Difference in means of baseline and placebo

		Mean	SD	Mean Difference	t value	p value
Agility (Second)	**Baseline**	16.83	2.23	1.278	4.808	0.000
	Placebo	15.56	2.09			
Bench press (KG)	**Baseline**	44.44	12.706	-3.056	-3.051	0.007
	Placebo	47.50	12.035			
Leg press (KG)	**Baseline**	114.72	66.365	-15.556	-3.654	0.002
	Placebo	130.28	67.963			

Table 3 : Difference in means of baseline and Caffeine

		Mean	SD	Mean Difference	t value	p value
Agility (Second)	Baseline	16.83	2.098	2.89	10.363	0.000
	Caffeine	13.94	1.421			
Bench press (KG)	Baseline	44.44	13.108	-8.06	-5.720	0.001
	Caffeine	52.50	12.523			
leg press (KG)	Baseline	114.72	66.365	-40.28	-10.418	0.001
	Caffeine	155.00	71.229			

Table 4 shows that bench press and leg press muscle strength did not show any significant increase after caffeine ingestion compared to placebo but significant ($p<0.005$) improvement in agility was observed in case of caffeine ingestion as compared to placebo with a mean difference of 2.89 seconds. Significant differences were observed in the upper and lower body strength improvements as depicted by the values of bench press and leg press in athletes of the given age groups after caffeine ingestion. Most substantial improvements in leg press and bench were observed in the age group of 20 to 22 years as shown in table 5.

Table 4: Difference in means of Placebo and Caffeine

		Mean	SD	Mean Difference	t value	p value
Agility (Second)	Placebo	15.56	2.092	1.61	2.647	0.012
	Caffeine	13.94	1.514			
Bench press (KG)	Placebo	47.50	12.035	-4.772	-1.021	0.324
	Caffeine	52.27	12.523			
Leg press (KG)	Placebo	130.28	67.963	-24.72	-1.065	0.294
	Caffeine	155.45	71.229			

Table 5: Mean and Standard Deviation of Percentage Improvements in Leg Press, Bench Press and Agility after Caffeine ingestion according to age

Variables	Age	Mean	SD	F value	P value
%age Improvement in Leg-press (KG) after caffeine ingestion	Less than 19 years	72.50	27.523	7.675	0.005
	20 to 22 years	175.56	66.165		
	Above 22 years	110.00	0.000		
%age Improvement in Bench press (KG) after caffeine ingestion	Less than 19 years	42.50	9.324	4.182	0.057
	20 to 22 years	62.50	9.574		
	Above 22 years	51.67	10.408		

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%age Improvement inAgility (sec) after caffeine ingestion	**Less than 19 years**	14.50	1.915	0.87	0.917
	20 to 22 years	14.75	1.500		
	Above 22 years	15.00	1.000		

Discussion

The results demonstrated a significant increase in upper and lower body strength after ingestion of caffeine. Improvements in agility were also presented after the ingestion of caffeine. This conclusion might be explained by the fact that the individuals in this study had prior resistance training experience, namely bench press training, and that the ergogenic benefits of caffeine per day, 2.5-7mg per kg of body weight, are best for endurance, short, and intense exercise. It usually takes between 15 and 120 minutes for caffeine to reach its peak concentration in plasma, although peak values and the time for peak concentration might be affected by the dose[8]. Caffeine was shown to substantially boost the maximum power of the upper and lower extremities, repetition sustainability, and training volume in both upper and lower extremities in this study. Caffeine boosts fatty acid oxidation and muscle glycogen storage, which might help athletes perform better during endurance exercise. However, it is claimed that glucose availability does not play a role in quick and intensive activities, such as those performed in this study[2,17]. As a consequence, it seems that caffeine's effect through this channel has little impact on these actions. Increased calcium release from the sarcoplasmic reticulum is one of the proposed reasons for caffeine's ergogenic advantages on athletic performance[19,20]. Of course, these effects occur at larger concentrations than physiological values, thus the dangers of caffeine in these amounts are unsurprising. As a consequence, given the dosages used in this study, it's unlikely that this mechanism plays a substantial role in improving performance. Caffeine, on the other hand, is thought to work as a competitive antagonism of adenosine in short-term and intense activities, which is the main and possibly influencing caffeine mechanism. Due to linkage of caffeine to adenosine receptors in the CNS more motor units are activated and also neuronal discharge increases which leads to increased voluntary contraction and force production advantages of caffeine on athletic performance in intense and short-term activities like those used in this study.

Conclusion

This research examined at how caffeine affects upper and lower body strength and agility in strength-trained athletes. Significant improvement in leg press, bench press and agility were observed from the baseline values in both caffeine and placebo group. Agility was the parameter that presented significant improvements after caffeine ingestion as compared to placebo with appreciable reduction in time (2.89secs) taken to complete the Illinois agility test. In view of, effect of caffeine ingestion according to age group highest percentage improvements in leg press and bench press were observed in the age group of 20-22 years. In brief, taking into consideration beneficial effects presented by moderate consumption of caffeine on strength performance and muscle endurance in resistance trained athletes and minimal side effects of this supplement, it can be prescribed along with taking into considerations for resistance trained athletes. But, to ensure these findings further studies are necessary

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References

1. McArdle, W. D., Katch, F. I., & Katch, V. L. (2005). *Essentials of exercise physiology*. Lippincott Williams & Wilkins.
2. Wong, K., Martin, B., Volland, L., Rohmann, R., & Astorino, T. (2008). Effect of caffeine ingestion on resistance training performance. In *Southwest ACSM Meeting* (Vol. 7).
3. Hoffman, J. R., Ratamess, N. A., Ross, R., Shanklin, M., Kang, J., & Faigenbaum, A. D. (2008). Effect of a pre-exercise energy supplement on the acute hormonal response to resistance exercise. *The Journal of Strength & Conditioning Research*, *22*(3), 874-882.
4. Gilbert, R. M. (1984). Caffeine consumption. The Methylxanthine Beverages and Foods: Chemistry, Consumption, and Health Effects (Spiller GA ed) pp 185–213, Alan R. Liss. *Inc., New York*.
5. Mohr, M., Nielsen, J. J., & Bangsbo, J. (2011). Caffeine intake improves intense intermittent exercise performance and reduces muscle interstitial potassium accumulation. *Journal of applied physiology*, *111*(5), 1372-1379.
6. Magkos, F., & Kavouras, S. A. (2005). Caffeine use in sports, pharmacokinetics in man, and cellular mechanisms of action. *Critical reviews in food science and nutrition*, *45*(7-8), 535-562.
7. Costill, D. L., Dalsky, G. P., & Fink, W. J. (1978). Effects of caffeine ingestion on metabolism and exercise performance. *Medicine and science in sports*, *10*(3), 155-158.
8. Kamimori, G. H., Karyekar, C. S., Otterstetter, R., Cox, D. S., Balkin, T. J., Belenky, G. L., & Eddington, N. D. (2002). The rate of absorption and relative bioavailability of caffeine administered in chewing gum versus capsules to normal healthy volunteers. *International journal of pharmaceutics*, *234*(1-2), 159-167.
9. Graham, T. E. (2001). Caffeine and exercise. *Sports medicine*, *31*(11), 785-807.
10. Lopes, J. M., Aubier, M., Jardim, J., Aranda, J. V., & Macklem, P. T. (1983). Effect of caffeine on skeletal muscle function before and after fatigue. *Journal of Applied Physiology*, *54*(5), 1303-1305.
11. Smith, A. P., Rusted, J. M., Savory, M., Eaton-Williams, P., & Hall, S. R. (1991). The effects of caffeine, impulsivity and time of day on performance, mood and cardiovascular function. *Journal of Psychopharmacology*, *5*(2), 120-128.
12. Davis, J. K., & Green, J. M. (2009). Caffeine and anaerobic performance. *Sports medicine*, *39*(10), 813-832.
13. Tallis, J., Duncan, M. J., & James, R. S. (2015). What can isolated skeletal muscle experiments tell us about the effects of caffeine on exercise performance?. *British Journal of Pharmacology*, *172*(15), 3703-3713.

14. Stojanović, E., Stojiljković, N., Scanlan, A. T., Dalbo, V. J., Stanković, R., Antić, V., & Milanović, Z. (2019). Acute caffeine supplementation promotes small to moderate improvements in performance tests indicative of in-game success in professional female basketball players. *Applied Physiology, Nutrition, and Metabolism*, *44*(8), 849-856.
15. Raya, M. A., Gailey, R. S., Gaunaurd, I. A., Jayne, D. M., Campbell, S. M., Gagne, E., ... & Tucker, C. (2013). Comparison of three agility tests with male servicemembers: Edgren Side Step Test, T-Test, and Illinois Agility Test. *Journal of Rehabilitation Research & Development*, *50*(7).
16. Pickering, C., & Kiely, J. (2018). Are the current guidelines on caffeine use in sport optimal for everyone? Inter-individual variation in caffeine ergogenicity, and a move towards personalised sports nutrition. *Sports Medicine*, *48*(1), 7-16.
17. Woolf, K., Bidwell, W. K., & Carlson, A. G. (2009). Effect of caffeine as an ergogenic aid during anaerobic exercise performance in caffeine naive collegiate football players. *The Journal of Strength & Conditioning Research*, *23*(5), 1363-1369.
18. Fredholm, B. B., Bättig, K., Holmén, J., Nehlig, A., & Zvartau, E. E. (1999). Actions of caffeine in the brain with special reference to factors that contribute to its widespread use. *Pharmacological reviews*, *51*(1), 83-133.
19. Pasternak, H. (2000). *The effect of ingesting caffeine, ephedrine, and their combination on repeated strength performance* (Doctoral dissertation).
20. Russell, M. D. (2008). *The effect of caffeine gum administration on blood glucose and blood lactate during cycling to exhaustion* (Doctoral dissertation, University of Akron).