The Effect of Caffeine on Athletic Performance

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Abstract

Hypothesis: The intake of caffeine can increase physical performance during athletic activity

Methods: A search for primary sources was done using PubMed with MeSH terms. The search was limited to randomized controlled trials that were published between 2015 and 2020. After application of inclusion and exclusion criteria, seven articles were selected for this literature review.

Results: Of the seven randomized controlled trials selected, six demonstrated caffeine ingestion led to a statistically significant increase in physical performance. One of the randomized controlled trials found no statistically significant relationship between caffeine and run timings. Major findings and results of the studies were stated and contrasted against each other.

Conclusion: With regards to the results of the selected studies, caffeine was shown to have ergogenic activity and was able to increase physical performance during exercise and sporting competition through multiple mechanisms.

Introduction

- Caffeine is the most widely utilized psychoactive substance in the world
- Caffeine has an ability to induce alertness, increase ability to sustain intellectual activity and enhance body reactivity to stimulus
- Caffeine emerges as a potential performance enhancer due to its stimulatory effect on the nervous system with direct and hormonal effects on skeletal muscle function
- Acts as an adenosine receptor antagonist to decrease the impairment of attentional processes and counteract the consequences sleep deprivation, to improve focus and reduce fatigue
- Non-selective antagonist to both the A1 and A2 adenosine receptors and indirectly effects the release of other neurotransmitters such dopamine, GABA and acetylcholine
- Caffeine reduces myocyte glycogen consumption by increasing lipolysis of triglycerides leading to reduced lactic acid production
- Caffeine has a methylxanthine function, which allows it to inhibit phosphodiesterase to increases cAMP concentration causing to norepinephrine and epinephrine release to stimulates the cardiovascular system leading to increased coronary and skeletal blood flow
- Caffeine is readily absorbed in the digestive tract within an hour of ingestion and redistributes throughout the body by its lipophilic nature
- Half-life ranges from 2.5 to 10 hours allowing its effects to last through the entire competition

Methodology

- Major source of information for both the results and introduction of this study was PubMed which served as a database providing meta-analyses and systemic reviews for general information and randomized controlled trials for the results
- Medical Subject Headings (MeSH), a wide-ranging search was conducted on caffeine and its relation to athletic performance using terms, ("Caffeine"[Mesh]) AND "Athletic Performance"[Mesh] which yielded 464 results
- To narrow the search further, search term "AND "Exercise"[Mesh]" was added to locate studied using exercises in a quantitative manner to measure the effect of caffeine, which minimized the search to 219 results
- search was limited to studies published within 5 years from the initiation of this literature review results generated 45 possible articles
- Articles were screened based on their methods and abstract sections to determine if they most clearly displayed the effect caffeine on performance in a sport, sports related exercise, general exercise or sport-specific training techniques

Figure 1. PRISMA (Moher, 2009) flow diagram displaying exclusion and selection of articles

Results

Table 1. Evidence table of primary sources used in results

First Author	Date of publication	Study Design	Level of Evidence	Study Population	Interventions	Outcomes/Results
1. Puente, Carlos et al.	June 2017	RCT	1	Twenty professional and semi-professional male and female basketball players	3mg/kg body mass anhydrous caffeine or a placebo	Caffeine supplementation increased average Abalakov jump height, number of body impacts, and basketball performance index rating
2. Marques, Alexandre et al.	April 2018	RCT	1	Twelve males with amateur running experience that had fasted overnight (8 -12 hours)	5.5 mg /kg caffeine ingested as coffee or a decaffeinated coffee placebo	No differences were found between the caffeine and placebo group in time to complete the 800m race and no changes in rating of perceived exertion, blood glucose or blood lactate levels
3. Grgic, Jozo et al.	May 2017	RCT	1	Seventeen male participants with supplementation over one year of 6mg/kg body mass resistance training and had been training atleast 3 time a week for the last six months	Caffeine or a placebo one hour before testing	The caffeinated group had increased one repetition maximum for back squat strength, increased power in the seated medicine ball throw, increased overall lower body strength, and reduction in perceived exertion and pain perception
4. Cheng, Ching-Feng, et al.	January 2016	RCT	1	Fifteen Division 1 college male basketball players	6mg/kg body mass of either caffeine or a placebo	It was found caffeine increased work above end-power (WEP) and power output between 60 to 150 seconds
5. Zbiden-Foncea, Hermann, et al.	May 2017	RCT	1	Ten male volleyball players from the Chilean national team	5mg/kg anhydrous caffeine or a placebo	Caffeine intake increased countermovement-jump peak concentric force, peak power and increased the maximum height, velocity, power and acceleration achieved during the jump
6. Potgieter, Sunita, et al.	December 2017	RCT	1	Twenty-six male and female triathlon athletes	6mg/ kg body mass caffeine or a placebo	Caffeine led to a mean 3.7% decrease in swimming times and mean 1.3% decrease in total time to complete the triathlon.
7. Fett, Carlos, et al.	April 2017	RCT	1	Eight women between ages 20 to 30 years old and BMI between 20-25 with atleast one year of continuous resistance training	6mg/kg body mass of caffeine or a placebo 30 minutes before performance tests	Caffeine increased hack squat strength and for the second caffeine trial, there was an increase to bench press strength, and increased time until exhaustion

Discussion

- Caffeine was able to enhance athletic performance through physiological and neuromuscular effects by acting as an ergogenic agent
- Caffeine was able to increase height reached in Abalakov jumps, amount of body impacts during a game, number of free throws attempted and made, total assists, total rebounds and offensive rebounds
 - Improved positioning, increased coordination, and increased focus of players which led to improved sport-specific skills by improving physical performance and decision-making abilities
- Caffeine led to increased physicality which gives players advantages by drawing fouls and overpowering opponents
- Caffeine improved strength by reducing self-perceived exertion
 - Achieved by CNS stimulation to decrease pain sensitivity and increasing motor unit recruitment
 - Increased calcium released to enhance contractility
- Endurance is enhanced by caffeine by reduction of fatigue accumulation in muscle and the CNS
- Caffeine to cause insomnia if the interval between bedtime and ingestion was less than 6 hours
- Polymorphisms in the CYP1A2 and ADORA2A adenosine receptor gene play role in caffeine effects
 - CYP1A2 genotype AA are faster caffeine metabolisers and have greater effects of caffeine when compared to genotypes AC and CC
- Caffeine has been shown to increased the anaerobic capacities by increasing the accumulated oxygen deficit
- Caffeine can improve focus and concentration and reduce pain through its antagonism of adenosine receptors
 - Increased Na⁺/K⁺ ATP induced by caffeine reduces serum potassium concentration to maintain membrane potential and enhance rapid muscle stimulation

Conclusion

- Six out of the seven found caffeine to have a statistically significant impact on improving the physical performance of athletes
- Two of the studies tested caffeine in a realistic sporting setting, and found a statistically significantly improvement in both for sport-specific performance
- The author declares there were no conflicts of interest or funding in regard to this paper