Caffeine and Athletic Performance: Advantages and Disadvantages

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Abstract

Caffeine, a psychoactive substance that is widely consumed, has gained significant attention in the fields of sports and exercise science due to its potential to amplify athletic performances. The point of this article is to comprehensively audit the existing writing to supply an adjusted understanding of the points of interest and drawbacks of caffeine utilization on athletic execution. The article assesses the instruments through which caffeine influences the body, the potential benefits it offers to competitors, and the related disadvantages. By basically looking at accessible studies, this article looks to supply evidence-based bits of knowledge into the part of caffeine in optimizing sports execution.

Keywords: Caffeine/ Doping/ Performance

1. Introduction

Caffeine, a stimulant found in coffee, tea, and different vitality items, has pulled in intrigued for its potential to impact physical performance. This article explains the multifaceted relationship between caffeine and athletic endeavors by analyzing both its profitable and hindering impacts.

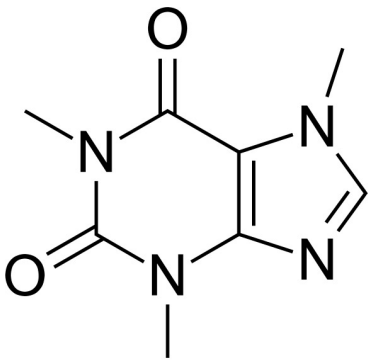
2. Mechanisms of Action

Caffeine's effect on athletic execution is fundamentally credited to its interaction with adenosine receptors, driving expanded readiness and diminished discernment of exertion. The consequent discharge of neurotransmitters such as dopamine and norepinephrine contributes to moving forward and perseverance amid a workout.

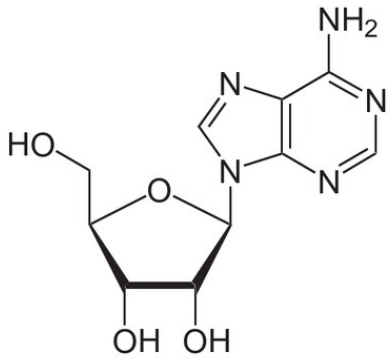
3. Effects of Caffeine on Humans

Caffeine is similar in chemical structure to adenosine, a substance with a sedative effect on the nerves, and binds to the places in the human body where adenosine must bind to exert its effect. As a result, adenosine is unable to bind to its receptors, which inhibits its action and excites the nerves.

Excessive intake of caffeine and overstimulation of the central nervous system can cause dizziness, increased heart rate, excitement, anxiety, trembling, and insomnia. Stimulation of the gastrointestinal tract may cause diarrhea, nausea, and vomiting.



（Caffeine)



(Adenosine)

In addition, the New Zealand Ministry of Primary Industries (MPI) notes that long-term effects may include an increased risk of hypertension associated with coffee consumption in some people with impaired liver function. They also state that caffeine consumption, particularly in people with low calcium intake, may increase the rate of calcium elimination from the body, potentially leading to the development of osteoporosis. It also warns that caffeine consumption by pregnant women may impair the development of the fetus.

It points out that there is no set acceptable daily intake (ADI) for caffeine, although individual sensitivity to caffeine varies widely, making it difficult to assess health effects accurately.

Furthermore, the US Centers for Disease Control and Prevention (CDC) notes that caffeine may mask the functional impairment caused by alcohol, leading to excessive intake and making alcohol more likely to harm health.

4. Advantages of Caffeine Consumption

In the world of sports, caffeine is reported to be particularly beneficial for improving performance in endurance sports, as it inhibits the action of a substance including adenosine, which has a soothing effect on the nerves and has an arousing effect, reducing fatigue during exercise, which is said to be advantageous for improving endurance.

1, In many, but not all, studies, caffeine intake has been shown to enhance sports performance. The benefits of caffeine have been seen in a wide range of aerobic and anaerobic exercises, including endurance, speed, strength, jumping, and throwing.

2, Caffeine may improve cognitive and physical performance in some people under conditions of sleep deprivation.

3, Caffeinated chewing gum, mouthwashes (Gargle. mouth rinses), energy gels, and other alternative sources have been shown to improve performance, primarily in aerobic exercise.
Caffeinated energy drinks and pre-workout supplements (supplements taken before training) have been demonstrated to improve both anaerobic and aerobic performance.

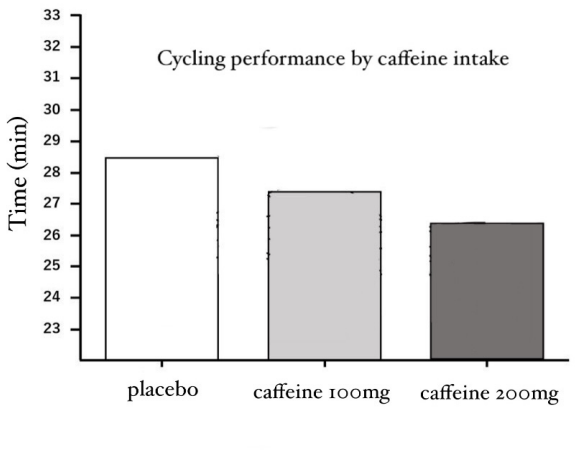
4, Coffee tends to make people more insensitive to muscle pain, as the caffeine reduces the adenosine that causes pain in muscles, slowing down its response and reducing muscle soreness by 10 percent.

5, Caffeine stimulates the central nervous system and increases attention and alertness. This allows for greater concentration and reduced reaction times during competitions. It is particularly useful during long periods of competition or training when fatigue can set in.

6, Caffeine intake increases fatty acid oxidation and assists the body to utilize fat more efficiently during aerobic exercise. This helps increase fat as a source of energy in endurance sports and may enhance endurance.

Several studies have examined the effects on actual competitive performance. For example, it has been reported that caffeine consumption significantly improved time trial results in 15 cyclists4 (Figure A). Another study reported that caffeine consumption

extended the time to exhaustion in running, demonstrating its performance-enhancing effects.



(Figure A)

Typically, 3-6 mg/kg of caffeine is ingested to induce acute ergogenic effects. However, some athletes consume higher doses in anticipation of higher effects. However, there is no evidence of an add-on effect when consuming more than 3-6 mg/kg.

Several studies have examined the acute effects of caffeine intake of 9 mg/kg or more in habitual caffeine consumers, but the results have been inconsistent. Those studies have also reported a dose-dependent increase in adverse events.

Based on this background, some experiments have investigated the effects of high doses of caffeine on performance in athletes who consume caffeine daily.

Comparison of bench press raising speeds in male athletes after high-dose caffeine consumption

The study design was a placebo-controlled, double-blind, randomized crossover method.

The eligibility criteria for study participation are as follows.

1, No neuromusculoskeletal disorders.
2, Having been strength training for at least two years and being able to lift at least 120% of body weight.
3, Must be habitually consuming caffeine.

Exclusion criteria, on the other hand, are as follows
1, Smokers.
2, Must not be allergic to caffeine.
3, Consuming drugs, dietary supplements, or ergogenic aids that may affect the results.

A preliminary statistical review calculated that 10 participants were required to show a significant difference, and 12 male athletes were recruited in anticipation of drop-out. Age 25.2 ± 1.3 years, body weight 85.4 ± 13.2 kg, body fat percentage 12.1 ± 3.0%, training history 4.1 ± 1.3 years, 1RM 121.1 ± 30.5 kg (140.4 ± 15.2% of body weight), daily caffeine intake of 5.2 ± 1.4 mg/kg/day (463.3 ± 171.3 m/day) and energy intake of 3,341.7 ± 568.8 kcal/day, with energy intake ratios for key nutrients of 19.5 ± 3.9% protein, 28.3 ± 2.3% fat and 52.3 ± 4.0% carbohydrate.

The ergogenic effect of caffeine intake was determined by bar raising velocity at 30% 1RM in the bench press. All participants were tested in three conditions: placebo, 9 mg/kg of caffeine, and 12 mg/kg of caffeine. Caffeine or placebo was provided in capsules so that neither participants nor researchers could distinguish between them.

The three-condition trial included a one-week washout period, and all three conditions were tested at the same time of day (10-11 a.m.). The last meal was consumed at least three hours before the test and caffeine or placebo was consumed 60 minutes before the test. They also consumed caffeine as usual during the study period but were asked to refrain from caffeine intake and strenuous exercise 24 hours before the test trial in each condition.

Outcome of the Experiment

Peak velocity was 2.16 ± 0.19 m/sec in the placebo condition, 2.24 ± 0.20 m/sec in the 9 mg/kg caffeine condition, and 2.23 ± 0.17 m/sec in the 12 mg/kg condition, with the two conditions with caffeine having a significantly faster rate of raising than the placebo condition ($p < 0.01$). However, the two caffeine-fuelled conditions were equivalent ($p=0.92$).

The mean velocity was 1.37 ± 0.10 m/sec in the placebo condition, 1.41 ± 0.09 m/sec in the 9 mg/kg caffeine condition, and 1.41 ± 0.09 m/sec in the 12 mg/kg condition, with the two conditions with caffeine having significantly faster raising velocity than the placebo condition ($p < 0.01$). However, the two caffeine-fuelled conditions were equivalent ($p=0.96$).

Bar-raising velocities have been examined in terms of peak and mean velocities.

Association between caffeine intake and adverse events shown in the experiment

In the immediate post-test assessment, significant associations were found between caffeine intake and anxiety/nervousness ($p = 0.001$) and headache ($p = 0.032$). In addition, a significant association was found between increased vitality and activity ($p = 0.028$).

At the 24-hour post-test assessment, significant associations were found between caffeine intake and tachycardia/palpitations ($p < 0.001$), anxiety/nervousness ($p = 0.001$), headache ($p < 0.001$), and insomnia ($p = 0.009$). Other significant associations were found with increased vitality and activity ($p=0.006$).

5. Disadvantages and Considerations

While caffeine offers potential benefits to athletes, its use is not without drawbacks. Possible advantages include enhanced endurance and improved cognitive function. However, adverse effects like restlessness, insomnia, and gastrointestinal discomfort can occur, particularly with excessive consumption.

1, Individual differences in the effects on sports performance, and adverse effects such as sleep and anxiety following caffeine consumption, may be due to genetic variations related to caffeine metabolism and physical and psychological responses. Other factors, such as habitual caffeine intake, may also influence these responses.

2, Caffeine can cause gastrointestinal discomfort for some people. This can be particularly problematic during exercise and can cause abdominal pain, diarrhea, and vomiting.

3, Excessive consumption of caffeine can lead to caffeine intoxication syndrome. This includes irregular heartbeat, hand tremors, dizziness, headache, and nausea. It is important to consume appropriate amounts of caffeine before exercise.

4, Caffeine is generally not banned by sports regulatory bodies, although some athletic organizations may have restrictions. Athletes should consider the use of caffeine in the context of competition rules and ethics.

5, There is a risk of caffeine dependence if high doses of caffeine are consumed over a prolonged period. Dependence may result in a need for caffeine and withdrawal symptoms. The body can build up a tolerance to caffeine if it is consumed continuously. This may lead to the need for more caffeine to achieve the same effect.

6. History of Caffeine and Sports

Scientific research into the effects of caffeine began in the 20th century. During the 1960s and 1970s, research on the effects of caffeine on exercise performance increased. It has been suggested to increase endurance, delay fatigue, and improve alertness.

1, Caffeine has gained general acceptance in the sports community, with many athletes commonly consuming caffeine before training or competition. Caffeine use is particularly common in endurance sports such as cycling, running, and triathlon.

2, Caffeine is found in many sports and energy drinks, and these products are widely used by athletes and

fitness enthusiasts before and during training and competition. These drinks provide an easy way to consume caffeine, helping to provide energy and improve alertness.

3, Some sporting organisations have introduced regulations on the use of caffeine. For example, the International Olympic Committee (IOC) had caffeine restrictions in the past, which were later withdrawn. However, restrictions on caffeine use may still exist for some sports and organizations.

4, In the modern era, research on caffeine and sports performance is ongoing and there is a growing understanding of individual differences in the response of individual athletes and optimal ingestion strategies. There is also a growing market for energy drinks and caffeine supplements, offering a diverse range of options.

A survey on the usage of caffeine in sports

Many athletes use caffeine, and analyses of urine samples for doping tests have shown that three out of four elite athletes use caffeine. However, the actual use of caffeine in football players has so far been unclear.

When footballers use caffeine inappropriately, e.g. at doses higher than 9 mg/kg, the risk of side effects such as nausea, anxiety, insomnia, and restlessness increases, while the performance benefits do not increase. Evidence-based practical guidance for safe and effective caffeine intake is therefore needed.

Based on this, caffeine use at elite football clubs in England was investigated.

The survey covered the top 91 teams in the English professional football league.

Outcome of the survey

Out of the 36 teams that provided the answer, thirty-five of the 36 clubs, or 97%, said they provide caffeine to their players as a means of improving performance.

The timing of when caffeine was offered to players was 94% before the match and 48% during the match. The time of day when the match took place was not as much of a consideration. On non-match training occasions, 37% (n = 13) indicated that they had offered caffeine before training.

The timing of pre-match caffeine intake was distributed over a range of 15-90 minutes, with the most common time of intake being 30-45 minutes before kick-off (n = 14, 40%).

The most common forms of administration were energy shots (n = 24, 68%) and caffeine gum (n = 20, 57%), with 27 clubs (77%) using two forms together and a further 17 (49%) using three or more forms.

The recognition of the use from the team

Only eight clubs (23%) monitored whether players were consuming more caffeine than prescribed. Thirty-one clubs (89%) stated that not all players followed the same caffeine intake strategy and 11 clubs (31%) stated that the amount of caffeine being used was not consistent.

On the other hand, eight clubs stated that caffeine consumption was voluntary for players and not compulsory. Three clubs (9%) stated that players were educated or advised on the amount of caffeine contained in supplements.

Over 70% of responding clubs (over 25 clubs) reported a moderate or greater effect on aspects of performance.

Over 50% also recognized that caffeine had a moderate or greater effect on muscle strength, endurance, and sleep. A further 80% (n = 29) perceived caffeine to have a moderate or greater effect on vitality and 44% (n = 16) perceived it to have a moderate or greater effect on playing confidence.

A further 22% (n = 8) reported that mental malaise and sleep were very much affected by caffeine consumption.

7. Main items containing caffeine

It is recommended to drink 60 minutes before the caffeine starts to act, as the effects of any nutrients will last for at least an hour after they are absorbed.

The list below shows the type of drink and food and the amount of caffeine it contains.

Drink/Food	Amount of Caffeine (mg/100ml)
Instant coffee	80mg
Drip coffee	90mg
Matcha	45mg
Brown rice tea	15mg
Milk chocolate	20mg
Green tea	30mg
Coke	24.5mg
Energy drinks	80mg
Black tea	30mg
Espresso	75mg
Roasted green tea	20mg
Oolong tea	20mg

8. Effects of caffeine in sports

An athlete's competitive performance is composed of many elements. It is made up of several Athletic performances based on physique and muscle composition, basic fitness, basic athletic performance, and specialized athletic performance. In addition, athletic performance can be quantified for some sports, such as athletics and swimming, where competition results can be quantified in terms of times. On the other hand, some sports, such as football, basketball, and rugby, require competencies that are specific to the nature of the sport, with tactics influencing the outcome. However, it is also true that factors such as sleep, inoculation nutrition, and motivation also play a role in athletes' performance. The table below shows the effects of caffeine in each sport.

Effects of caffeine in sports:

Sports	Performance with Observed Effectiveness
Soccer	15 m repeated running time, vertical jump
Golf	Distance, Shot accuracy, Total score
Swimming	50m swimming time
Running	1500m running time
Basketball	Vertical jump
Judo	Judo-specific Fitness Testing
Rugby	Mileage, jumps, exercise intensity
Cycling	Time trial
Tennis	Serving speed, running pace

9. Ethical and Regulatory Considerations

Sport is a culture of negotiated agreements. That is why it is unacceptable to intentionally break the agreement by using drugs to gain an advantage only for oneself. It is also unacceptable to deliberately commit foul play in a match to gain an advantage. The win-at-all-costs mentality, in which anything is acceptable to win, can destroy the sport itself. For sports to be fair, individual ethics are required above all.

On the other hand, as sport has become a focus of attention in society and generates significant economic benefits, more and more people consider sport as a means of pursuing profit. However, attempting to use sport solely for economic gain can harm the healthy development of sport. To enhance the value of sport and promote its further development, society as a whole needs an ethical perspective.

We must use our human wisdom and strength to build a culture of sport. A sporting ethic is required that considers what is acceptable and what is not acceptable in sport.

In competitive sports, doping has become a frequent occurrence due to the huge prize money and prestige offered. In recent years, as testing regimes have been strengthened, the offenders have become more sophisticated, and various methods of doping have emerged. It is said that the day will soon come when doping is done by manipulating human genes. Doping is not only detrimental to the health of athletes, but it is also a despicable act that goes against the spirit of sport, which is supposed to be fair. If drugs are allowed to spread in the world of sport, the value of sport is undermined. Furthermore, if young people become less resistant to drug-taking, it will harm society as a whole.

The use of caffeine in sports is subject to regulations and ethical considerations. While caffeine is not prohibited by most sports organizations, its potential to enhance performance raises questions about fairness and integrity. Athletes and coaches must navigate the fine line between legitimate use and potential abuse.

10. Future Perspectives

Future research opportunities are presented by the caffeine research landscape, which is changing. Individual differences in reaction, long-term consequences on health and performance, and potential combinations with other drugs are also areas of research. Further research on caffeine's effects on other sports disciplines may yield insightful results.

11. Conclusion

The effects of caffeine on sports performance span the physical, cognitive, and psychological domains. Caffeine can benefit your attention and endurance, but you should use caution while consuming it to avoid any negative side effects. To maximize the positive effects of caffeine while limiting negative consequences, athletes, coaches, and practitioners should take individual variances into account.

This study emphasizes the complex connection between caffeine use and athletic performance. The study offers insights into caffeine's mechanisms of action, benefits, drawbacks, and considerations for its usage in the context of athletics by a thorough analysis of the current research.

References

[1] Acquas, E., Tanda, G. and Di Chiara, G. (2002): Differential effects of caffeine on dopamine and acetylcholine transmission in brain areas of drug-naive and caffeine-pretreated rats.

[2] Adan. A., Solé-Casals, J., Xavier Caldú, X. et al. (2010): Effects of caffeine and glucose, alone and combined, on cognitive performance.

[3] American Psychiatric Association (2013): Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5).

[4] Astorino, T.A., Tamp, P., Rietschel, J.C. et al. (2010): Effect of two doses of caffeine on muscular function during isokinetic exercise.

[5] Burke LM (2008) Caffeine and sports performance.

[6] Chen HY, Chen YC, Tung K, Chao HH, Wang HS (2019a) Effects of caffeine and sex on muscle performance and delayed-onset muscle soreness after exercise-induced muscle damage: a double-blind randomized trial.

[7] Dawkins, L., Shahzad, F.-Z., Ahmed, S.C., et al. (2011): Expectation of having consumed caffeine can improve performance and mood.

[8] Drake, C., Roehrs, T., Shambroom, J., et al. (2013): Caffeine effects on sleep taken 0, 3, or 6 hours before going to bed.

[9] Gant, N., Al, A., Foskett, A., et al. (2010): The influence of caffeine and carbohydrate ingestion on simulated soccer performance.

[10] Goldstein, E.R., Ziegenfuss, T., Kalman, D., et al. (2010): Caffeine enhanced upper body strength in resistance-trained women. J. Internat. Soc.

[11] Hurley CF, Hatfield DL, Riebe DA (2013) The effect of caffeine ingestion on delayed onset muscle soreness.

[12] Ker, K., Edwards, P.J., Felic, L.M. et al. (2010): Caffeine for the prevention of injuries and errors in shift workers.

[13] Liguori, A. and Robinson, J.H. (2001): Caffeine antagonism of alcohol-induced driving impairment. Drug. Alcohol Depend. 63, 123-129.

[14] Philip, P., Taillard, J., Moore, N. et al. (2006): The effects of coffee and napping on nighttime highway driving: A randomized trial. Ann. Intern.

[15] Tallis J, Duncan MJ, James RS (2015) What can isolated skeletal muscle experiments tell us about the effects of caffeine on exercise performance?