



coffee&health

from the institute for scientific information on coffee

The good things in life:
can coffee and caffeine
enhance sports performance?

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Foreword



Caffeine has been shown to improve endurance performance and this is supported by a Scientific Opinion from the European Food Safety Authority (EFSA).

This report summarises a roundtable discussion, held by The Institute for Scientific Information on Coffee, on the role of coffee and caffeine in sports performance, which seeks to highlight the latest research and proposed mechanisms.

The roundtable, chaired by myself, included contributions from experts in the field of sports performance and nutrition; Dr Javier Gonzalez, member of the Sports, Health, and Exercise Science Group at the University of Bath and Dr Sophie Killer, Performance Nutritionist with British Athletics.



Professor Greg Whyte OBE

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Executive summary

Caffeine has been shown to improve endurance performance in athletes through its role as an adenosine antagonist, leading to an increased production of adrenaline, which stimulates blood flow and increases a feeling of being energised. Caffeine may also reduce the perception of pain, through a role in the central nervous system, further enhancing endurance during sporting activities.

It is suggested that caffeine may benefit short-term high intensity anaerobic exercises, particularly in trained athletes undertaking power based sports who have previously abstained from caffeine, and in team sports.

Relatively low doses of caffeine are known to benefit sports performance (3 – 5mg/kg body weight). Although caffeine has been suggested to cause dehydration, research has concluded that moderate consumption of 3-5 cups of caffeinated coffee per day contributes to overall fluid balance and does not cause dehydration.

The consumption of caffeinated beverages may help to reduce the perception of pain, further enabling endurance and enhancing performance.

Background

It is widely accepted that any effect of coffee consumption on sports performance is linked to the caffeine in coffee, as evidenced by the weight of research focussed on the effect of caffeine, and when caffeinated coffee has been directly compared with decaffeinated coffee.

There is unequivocal evidence that caffeine enhances sports performance at low levels of intake. The European Food Safety Authority (EFSA) stated that a cause and effect relationship has been established for caffeine intake and increased endurance performance (3mg/kg body weight 1 hour before exercise), endurance capacity (3mg/kg bw 1 hour before exercise), and a reduction in perceived exertion (4mg/kg bw 1 hour before exercise).¹

In its Scientific Opinion on the Safety of Caffeine, EFSA concluded that 'single doses of caffeine up to 200mg (about 3mg/kg bw) from all sources do not raise safety concerns for the general adult population, even if consumed less than two hours prior to intense physical exercise under 'normal environmental conditions'.² It further concluded that caffeine intakes from all sources up to 400 mg per day (about 5.7 mg/kg bw) do not raise safety concerns for adults in the general population.²

A plethora of research on caffeine and sports performance is available but to date most has been conducted in Caucasian males. There is a growing evidence base in females, however, which suggests that gender does not influence this effect. The role of ethnicity has not been studied in enough detail to draw conclusions.



Caffeine and sports performance

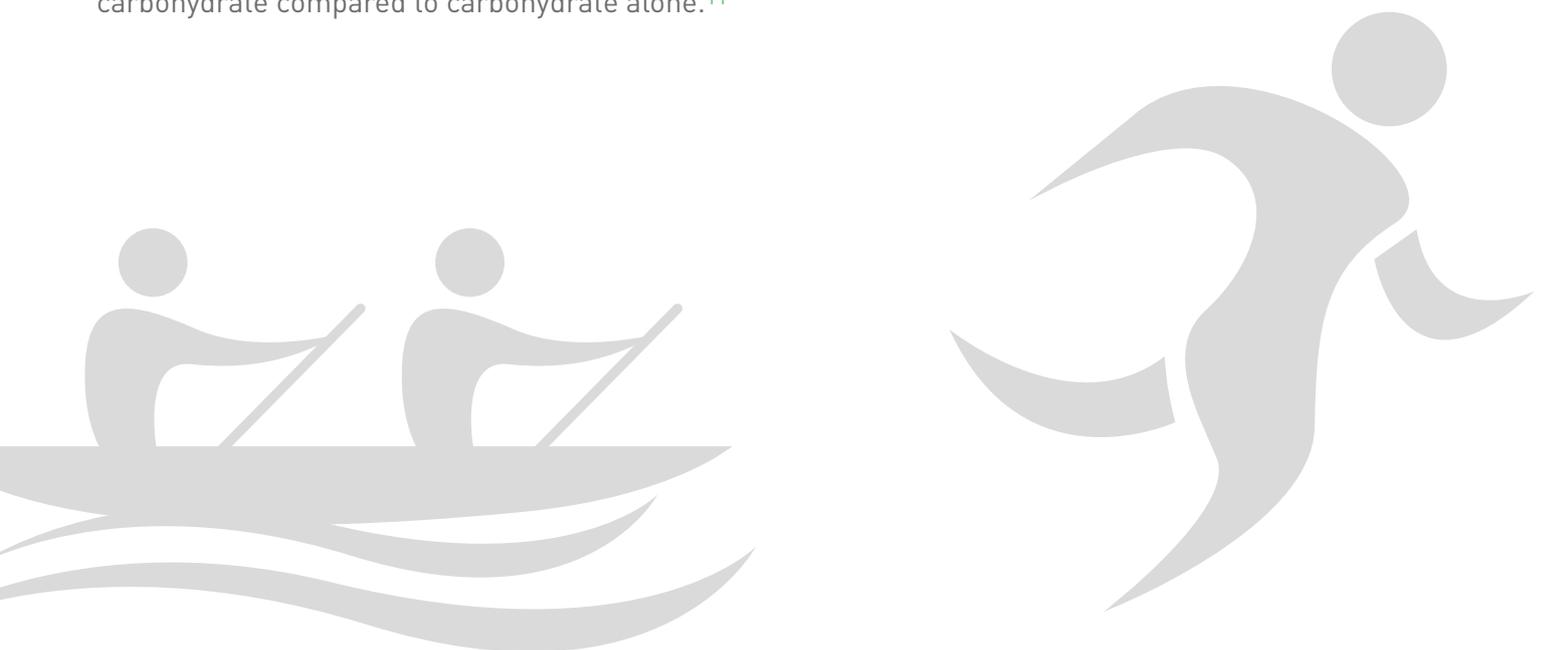
Research suggests that caffeine improves physical performance. Caffeine increases time to physical exhaustion, improving endurance and time trial performance. Data on doses from 1mg/kg body weight through to 9mg/kg suggests that performance enhancement occurs at around 3mg/kg with no added benefit beyond 5mg/kg, with some adverse effects being seen at intakes above 5mg/kg body weight.³

The effect of caffeine on sports performance is particularly notable in aerobic endurance sports lasting more than five minutes, such as rowing, cycling and running, where studies have shown an improvement in time trial performance and a reduction in muscle pain.⁴

During high intensity anaerobic exercise, such as in team sports and high intensity exercises, caffeine may also be beneficial. A review concluded that caffeine can benefit short-term high intensity anaerobic exercises, particularly in trained athletes undertaking power based sports who had previously abstained from caffeine, and in team sports.⁵ Caffeine may also reduce feelings of pain associated with intense exercise as studies have shown a reduction in perceptions of leg muscle pain during moderate intensity cycling^{6,7} and reductions in muscle soreness after high intensity muscle strengthening exercises^{8,9}.

Recreational athletes are physiologically similar to elite athletes. Much of the research on sports performance has been undertaken in both elite and recreational groups confirming that caffeine can reduce perception of pain in both groups, helping improve the enjoyment of exercise for both general sports people and endurance in trained athletes. Consuming a caffeinated coffee beverage between 30 and 60 minutes prior to exercise can enhance both performance and enjoyment.¹⁰

Caffeine may also play a role during the recovery period since caffeine consumption may encourage better renewal of muscle energy stores (glycogen). Athletes who exercised to exhaustion showed better glycogen storage during recovery when taking caffeine and carbohydrate compared to carbohydrate alone.¹¹





Proposed mechanisms

Caffeine is rapidly absorbed and can be detected 5 – 15 minutes after intake. Levels in the blood peak between 30 and 60 minutes after ingestion and can remain elevated in the blood for 5 – 15 hours post intake.¹⁰

Early research suggested that at high doses caffeine may increase fat breakdown, increasing levels of free fatty acids in the blood providing a fuel for activity and potentially sparing muscle glycogen. However, more recent research has shown that low doses of 3mg/kg bw provide a performance benefit but do not increase free fatty acid availability; at this level of intake the potential side effects of high doses (diuresis and gastro-intestinal distress) are also avoided.³

It is proposed that caffeine may enhance the central nervous system through binding to the adenosine receptor. Adenosine normally binds to this receptor leading to a series of events including a reduction in stimulating neurotransmitters such as dopamine, which can lead to feelings of tiredness. Since caffeine and adenosine have similar structures, caffeine can also bind to the adenosine receptor, blocking the actions of adenoside, increasing the presence of stimulatory neurotransmitters, leading to feelings of alertness and arousal, in turn enhancing performance. Caffeine can also stimulate the production of adrenaline, increasing attention and giving an energy burst.^{12,13}

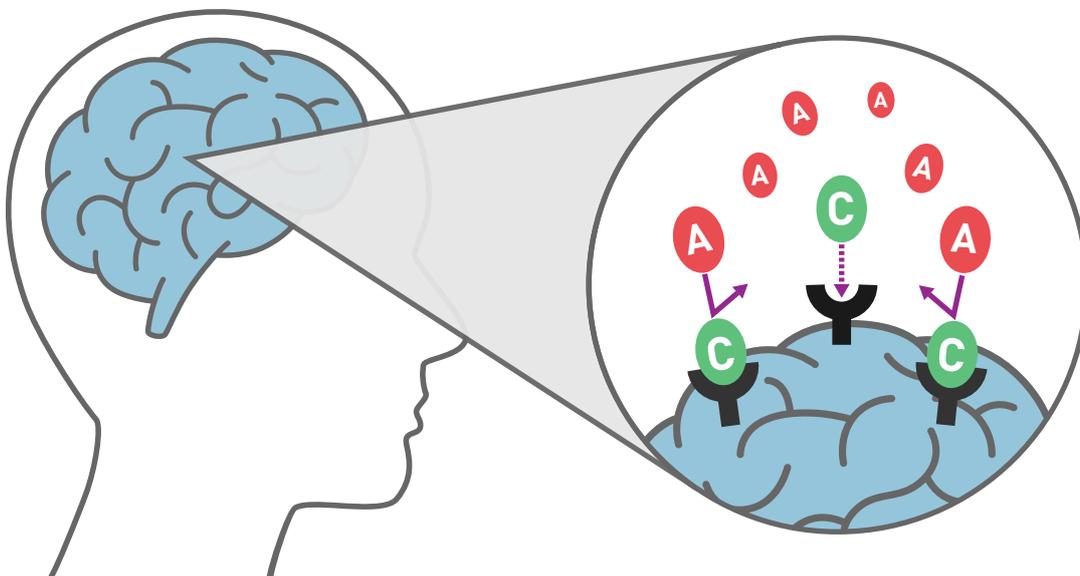


Fig. 1 Caffeine binding to the adenosine receptor



The mechanisms for caffeine in anaerobic exercise are unknown, but its role as an adenosine antagonist may be important. There is significant variability in the results of studies on caffeine in anaerobic exercise, but this could be related to a number of differences such as different dosing regimes or study of trained and untrained athletes. Further more specific studies are required to draw conclusions.

A debatable difficulty in studying the effect of caffeine on sports performance is that results may be affected by a participant's expectation that caffeine will have an effect.¹⁴ However, one 2013 study incorporated a 4-way design which arguably disguised caffeine ingestion. Participants consumed a flavoured drink consisting of either caffeine (5 mg/kg bw), no caffeine (placebo), caffeinated instant coffee (5 mg/kg bw) or decaffeinated instant coffee one hour prior to exercise. The study concluded that both the caffeinated coffee and the caffeine drink improved performance, whereas the decaffeinated coffee and placebo drink showed no significant difference.¹⁵

Caffeine and fluid balance

Fluid balance is critical to athletic performance and understanding the role of caffeine in hydration is key. Physiologically, high doses of caffeine can result in inhibition of sodium re-absorption in the kidneys, thus preventing water re-absorption and causing diuresis. Until recently, it was not understood how a caffeinated beverage, such as coffee would impact hydration status.

Research in a group of males who were regular coffee drinkers confirmed that a moderate intake of coffee contributed to overall fluid balance and did not cause dehydration.¹⁶ Levels of total body water were no different when drinking coffee compared to the control phase when drinking equal amounts of water (Fig. 2), confirming that drinking caffeinated coffee did not disrupt fluid balance levels. Therefore, a moderate consumption of coffee in a group of males who were regular coffee drinkers contributed to overall fluid requirement. The authors concluded that a moderate amount of coffee (4 cups per day in this study) contributes to the daily fluid requirements of those who are habitual coffee drinkers and is not likely to cause chronic low-level dehydration, therefore abstinence before and during exercise is unnecessary.

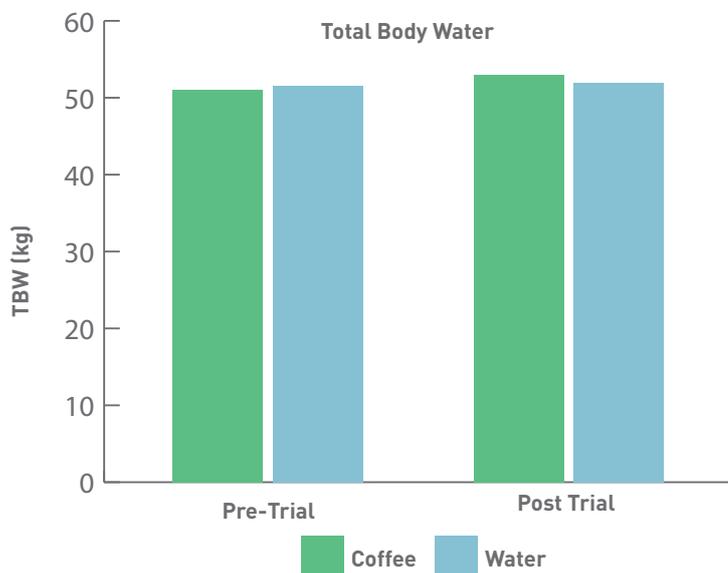


Fig. 2 Mean total body water estimates from Day 1–Day 3.¹⁶



Caffeine intake levels

A moderate intake of caffeine (3-5mg/kg body weight) can improve endurance performance, and benefit short term high intensity exercise.¹

Individuals who regularly drink coffee can become tolerant to the effects of caffeine and may require a greater dose of caffeine to achieve a similar effect on performance, when compared to those who avoid coffee and caffeine (known as 'caffeine naïve'). To date, studies have not controlled the caffeine dose to take account of habitual intakes of caffeine, but it is suggested that in those who are caffeine naïve, a stimulatory effect will be seen at a lower dose than those who regularly drink coffee.

Sports nutritionists do not advocate mega-dosing with caffeine as there is a potential to develop adverse effects including a racing heartbeat, anxiety and the 'shakes' at very high intakes. 3mg/kg body weight is generally an effective dose in athletes but higher levels up to 5mg/kg body weight may be considered in some individuals.³

Conclusion

The research presented at ISIC's roundtable on coffee, caffeine and sports performance confirms that caffeine can help to improve performance in endurance sports such as rowing, cycling and running and in short term high intensity anaerobic exercise such as sprinting and teams sports.

For most individuals an intake of caffeine at levels of 3-5mg/kg body weight is associated with improved performance and is not associated with any adverse effects.

Caffeine may also help by reducing perceptions of pain and improving muscle energy storage during the recovery phase and importantly for athletes, a moderate consumption of caffeinated coffee can contribute to fluid balance and does not cause dehydration. The benefits of consuming caffeine are not only important for trained athletes but can also improve performance and reduce feelings of pain in recreational sports people.



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ISIC's Roundtable on Coffee, Caffeine and Sports Performance featured contributions from:



Professor Greg Whyte OBE

Former Olympian and Professor in Applied Sport & Exercise Science at Liverpool John Moores University, UK.



Dr. Javier Gonzalez

Lecturer in Human and Applied Physiology at the University of Bath, UK.



Dr. Sophie Killer

Performance Nutritionist at British Athletics.

About ISIC

The Institute for Scientific information on Coffee (ISIC) is a not-for-profit organization founded in 1990, devoted to the study and disclosure of science related to coffee and health. ISIC's activities are focused on:-

- the study of scientific matters related to coffee and health
- the collection and evaluation of studies and scientific information about coffee and health
- the support of independent scientific research on coffee and health
- active dissemination of balanced coffee and health scientific evidence and knowledge to a broad range of stakeholders.

ISIC respects scientific research ethics in all its activities. ISIC's communications are based on sound science and rely on evidence and scientific studies derived from peer-reviewed scientific journals and other publications.

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