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Letter to the Editor

Cutting–edge innovations in caffeine research: Enhancing sports performance

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Dear Editor,

Caffeine is one of the most extensively studied substances in the context of sports performance. Recent research has highlighted numerous mechanisms through which caffeine can enhance both physical and cognitive performance in athletes. These recent innovations are particularly relevant in understanding how caffeine can be optimally used to maximise benefits and minimise risks.[1]

One of the major innovations is the detailed understanding of caffeine pharmacokinetics. It is well known that caffeine is rapidly absorbed in the gastrointestinal tract, reaching its peak concentration in the blood within 45 min of ingestion. This rapid absorption makes caffeine particularly useful for athletes who need a quick boost in alertness and physical performance. In addition, the interindividual variability in caffeine half-life, ranging from 4–6 h, underscores the importance of personalising the dosage and timing of caffeine intake for each athlete.[2]

Another area of innovation is the understanding of the mechanisms of action of caffeine. Research has shown that caffeine exerts its primary effects through the inhibition of adenosine receptors, leading to increased concentrations of excitatory neurotransmitters such as dopamine and norepinephrine. This not only improves alertness and reduces the sensation of fatigue but also significantly impacts muscle contraction and physical endurance. In addition, the inhibition of phosphodiesterase by caffeine leads to increased levels of cyclic adenosine monophosphate, which further stimulates lipolysis and fat oxidation, improving energy efficiency during exercise.[3]

Genetic variability is another significant area of innovation. Recent studies have shown that genes can greatly influence the response to caffeine. For example, the CYP1A2 gene, which encodes the enzyme responsible for caffeine metabolism, has variants that determine whether a person is a slow or fast metaboliser of caffeine.[4] Individuals with the AA genotype (fast metabolisers) tend to derive greater benefits from caffeine compared to slow metabolisers (CC genotype), who may experience more pronounced negative side effects. This implies that caffeine supplementation protocols should be personalised based on the athlete's genetic profile to optimise benefits and reduce risks.

Another innovation involves the use of alternative forms of caffeine administration. Conventionally, caffeine has been consumed mainly in the form of coffee or pills. However, new forms such as gels, bars, chewing gum, and mouth rinses are gaining popularity. These new modes of administration can offer unique advantages, such as faster absorption in the case of chewing gum, which allows caffeine to enter the bloodstream directly through the oral mucosa.[5] This can be particularly

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useful during competitions, where reaction time and speed of absorption can make a significant difference.

The effect of caffeine on sports performance is another field that has seen significant innovations. Caffeine has been shown to be effective in both aerobic and anaerobic exercises. It improves endurance, strength, and muscle power and has positive effects on cognition and mood during exercise. However, the benefits vary based on dosage, timing, mode of administration, and individual characteristics of the athletes. For instance, caffeine has been found particularly effective in enhancing performance in endurance sports such as running, cycling, and swimming. Athletes participating in long-duration competitions can benefit more from caffeine due to its ability to delay fatigue and improve alertness.[6]

Despite the numerous benefits, caffeine is not without side effects. Excessive consumption can cause sleep disturbances, anxiety, tachycardia and, in extreme cases, intoxication. Therefore, it is essential that athletes carefully monitor their caffeine intake and adjust it according to their individual needs and genetic profile.

In conclusion, research on caffeine in sports has made significant progress, providing a deeper understanding of its mechanisms of action, individual variability, and modes of administration. These innovations enable athletes to use caffeine more effectively and safely to enhance their sports performance. However, it is crucial to continue personalising the approach to caffeine supplementation, considering individual characteristics and specific sports needs.

Author's contributions

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