Caffeine in Sport

**MECHANISMS OF ACTION**

Caffeine consumption can affect the body in a number of ways, principally through the inhibition (competitive blockade) of adenosine receptors (2). Due to the complex biochemistry and interacting responses, the underlying mechanisms behind the ergogenic effect of caffeine remain unclear. One suggested mechanism is through the modulation of the hormones involved in fat metabolism which may result in glycogen sparing (1). Recent findings, however, do not support the theory and furthermore fat oxidation is not important in some situations when caffeine has been shown to be ergogenic, such as in short term, high intensity activity.

It is well established that caffeine can stimulate the central nervous system altering sympathetic activity, motor recruitment and perception of effort and pain (3). It may be this later mechanism which may account for the ability of caffeine to enhance sporting performance.

**CAFFEINE INGESTION ON PHYSIOLOGICAL PERFORMANCE**

**Short and Long Term Endurance**

Endurance is best described as the ability of an athlete to sustain a set or chosen intensity for as long as possible and can be measured in two ways: time trial (performance test) or exercise to exhaustion (capacity test). Caffeine has been shown to be ergogenic during both protocols with durations ranging between 3-minutes and 120-minutes (1,4,5,6,7,8). The magnitude of performance benefit has been recorded between 1.0% and 33%, depending on study design. Currently, only a few studies report no ergogenic benefits of caffeine (9), with no studies reporting a negative effect. These results appear to be independent of individual fitness level, caffeine dose, habituation and abstinence (5).

**Short Term High Intensity Intermittent Exercise**

Stuart *et al.* (10) and Scheiker *et al.* (11) have...
investigated the impact of caffeine on the short term high intensity intermittent sprinting demands similar to those of team sports. Despite different research designs, both reported the ingestion of 6 mg/kg body mass caffeine 60-minutes prior to exercise improved the amount of work done (sprints) compared to placebo in both the first and second half by 6-10%. It was concluded that caffeine can improve performance in an intermittent high intensity team sport by delaying the onset of fatigue. Currently, the effect of caffeine on single sprints lasting less than one minute remains unclear.

**Caffeine taken in combination with Carbohydrate**

Recent research has suggested that the ingestion of caffeine in combination with carbohydrate may have synergistic effects on performance. In 2000, Van Nieuwenhoven et al. (12) reported that intestinal glucose absorption was increased by 23% when caffeine was ingested with carbohydrate (1.4 mg/kg and 0.5 g/min respectively). As intestinal absorption is one of the limiting factors for exogenous carbohydrate oxidation, Yeo et al. (13) investigated whether the ingestion of caffeine with carbohydrate would increase the availability of ingested carbohydrate and thus exogenous carbohydrate oxidation during prolonged endurance exercise. In 8 well trained cyclists a 26% increase in exogenous carbohydrate oxidation was found. As carbohydrate feeding during prolonged exercise can postpone fatigue and enhance endurance capacity, the potential application to the endurance performer is significant.

**CAFFEINE INGESTION ON COGNITIVE PERFORMANCE**

There is a long history of scientific interest into the effects of caffeine on cognitive functions. Research has clearly demonstrated that caffeine through its effects on the central nervous system, can significantly improve alertness (14), concentration (15,16), memory (7,14) and reaction time (14,16). Such results have been shown to occur at caffeine doses as low as 12.5 mg to doses as high as 350 mg, with the ingestion of caffeine in isolation (16) or in combination with carbohydrate (7,15). Whilst further sport and exercise specific research is required in this area, Hogervorst et al. (7) did report the ingestion of 150 and 225 mg caffeine following a 60-minute cycling time trial improved attention, complex psychomotor speed and recognition memory compared with placebo. Similar results have also been observed within the military, with the beneficial effects of caffeine ingestion on reaction time and sustained attention, or vigilance, tasks reported (15).

One of the most consistently reported outcomes of caffeine ingestion during exercise testing, regardless of mode, intensity or duration of exercise is an alteration in participant's perceptual response. In 2004, Doherty and Smith (3) completed a meta-analysis on the impact of caffeine on Rating of Perceived Exertion (RPE) and reported that in comparison to placebo caffeine represents a 6% reduction in the RPE, independent of subject withdrawal, caffeine dose and interval time between ingestion and exercise. In many sporting environments, a reduction of perceived effort at a given exercise intensity may result in improved concentration, reaction times, precision and motor co-ordination.

**PRACTICAL CONSIDERATIONS OF CAFFEINE INGESTION**

**Dose**

Well controlled studies demonstrate that the ingestion of 3-13 mg/kg body mass caffeine improves endurance performance (i.e. 210 – 910 mg caffeine for a 70 kg athlete). Of those studies investigating varying doses of caffeine it would appear that a caffeine intake of 3 mg/kg body mass improves performance, but higher intakes will not always result in an increased benefit (6,8,17). Interestingly, the work of Cox et al. (4) reported improvements in performance with caffeine ingestion at doses as low 1 mg/kg body mass in cyclists with no dose response following a time trial performance. Currently data investigating the comparison of single and repeated doses of caffeine has found that caffeine divided between before and during exercise provides no ergogenic effect on endurance performance over a bolus dose before exercise (18).
As it is commonly reported that the maximum concentration of caffeine in the body is typically attained within one hour (1), it is general practice for athletes to consume caffeine 60-minutes prior to exercise.

**Diuretic effect of caffeine**

Caffeine under sedentary conditions may have a diuretic action (19), and athletes are often advised to avoid beverages containing caffeine in situations where fluid balance may be compromised. Studies specific to exercise that have quantified body weight loss, sweat rates, plasma volume electrolytes and core temperature did not find any impact of caffeine ingestion (6,20). Thus, caffeine is a diuretic in resting conditions but not during exercise and therefore it would appear there is no clear reason to refrain from caffeine containing drinks in such situations (19,21).

**WADA**

Caffeine is mainly excreted from the body in the urine; the time to clear half of ingested caffeine is 3-5 hours. This however, is subject to considerable individual variation with several factors including genetics, prior ingestion of caffeine, gender, exercise, diet and use of certain drugs shown to affect the metabolism and thus half life of caffeine (2). It is for this reason that the World Anti-Doping Agency (WADA) have struggled to find a consolidated position on caffeine and why caffeine currently remains off the list of prohibited substances.

**Possible Adverse Effects**

Caffeine use in sport can have side effects, particularly when ingesting high doses (greater than 500 mg per day) or when taken by those individuals not consuming caffeine on a regular basis. Side effects may include gastrointestinal distress, headaches, tachycardia, restlessness, irritability, tremor, elevated blood pressure, psychomotor agitations, and premature left ventricular contractions. Whilst these symptoms are caused by the effect of caffeine on the CNS, they are individual in nature and therefore caffeine ingestion should be trialled in training prior to use in competition. If side effects occur an athlete should consult their physician.

**References**


