Research paper on caffeine as an ergogenic aid for exercise

Food & Diet, Coffee

Influence of Coffee on Exercise

Caffeine is a pharmacologically active substance that is consumed extensively around the world today. Various dietary sources of caffeine include coffee, tea, chocolate, carbonated drinks and energy beverages (Goldstein et al., " International society" 2010). Among these dietary sources, coffee is the most significant and widely consumed source of caffeine around the world in the present times. Statistics from North America and Europe show that around 90% of the adults consider themselves as regular coffee drinkers and their average caffeine intake adds up to approximately 200mg per day (Pesta et al., 2013).

Chemically, caffeine is 1, 3, 7,-trimethylxanthine i. e. it is a purine alkaloid that belongs to the class of xanthine compounds. Being both water and lipid soluble, this chemical is quickly metabolized, distributed and ejected from the body. Caffeine, when metabolized by the liver is broken down into three separate compounds namely, theobromine, paraxanthin and theophylline via enzymatic action. It is then taken up quickly in the bloodstream such that increased concentrations appear within 15-45 minutes of intake with the level peaking just one hour after consumption. As quickly as caffeine is absorbed, it is also rapidly cleared by the body. Urinary concentrations of caffeine decrease by 50% to 75% within 3-6 hours of intake. Since caffeine is also lipophilic in nature it easily goes across the blood-brain barrier (Goldstein et al., " International society" 2010).

It is these properties of caffeine i. e. its water and lipid solubility and quick metabolism by the body that confer upon it the ability to influence performance during exercise and sports. Over the years, a number of

scientific studies have shown that caffeine does influence endurance, strength, recovery and hydration during exercise. In other words, caffeine confers ergogenic effects on those performing physical activities.

It has always been a common belief that caffeine from the dietary sources enhances physical and mental performance. Generally perceived benefits of caffeine consumption include delayed sense of fatigue, reduced feelings of pain, improved concentration, increased alertness and enhanced energy levels (Wallman et al., 2010). Indeed, it is these benefits of caffeine that render it useful as an ergogenic aid for those desiring improved performance, intensity and duration during exercise.

Researchers have proposed several mechanisms to explain how caffeine acts as an ergogenic aid during intense physical activity. While the primary site of action of caffeine is said to be the central nervous system, investigations have revealed that the compound also affects the muscular system. Indeed, caffeine could act as a neuromuscular agent while exhibiting ergogenic effects on exercise (Goldstein et al., 2010).

The most significant among the mechanisms proposed to explain the ergogenic effect of caffeine is its ability to antagonize the action of adenosine. Adenosine is known to cause vasodilation in local circulations such as that in the forearm and decrease myocardial blood flow thereby inducing sleepiness. As an antagonist to adenosine, caffeine can attenuate these effects and act as a stimulant to speed up neural activity (Daniels et al., 1998). For a person about to perform exercise, this would mean improved alertness.

Some other mechanisms proposed to explain the effects of caffeine on exercise include (Pesta et al., 2013)-

- Enhanced oxidation of fatty acid – Caffeine accelerates lipolysis and prefers using fatty acids as an energy source rather than glycogen. In having such a glycogen sparing effect, caffeine increases the time to exhaustion i. e. it delays fatigue.
- Inhibition of phosphodiesterase enzymes- By inhibiting phosphodiesterase action, caffeine increases cAMP levels which in turn, activates lipolysis.
- Intracellular calcium mobilization- Through this mechanism caffeine is said to increase contractile force in the muscles thus increasing performance and its intensity.
- Increased accumulation of muscle glycogen post exercise- Caffeine increases the rate at which muscle accumulates glycogen after exercise, which helps in faster recovery.

Caffeine and Its Effects during Prolonged Exercise

Endurance becomes a necessity, particularly when performing exercises for prolonged durations. In such cases, ingestion of certain drugs helps individuals to sustain the physical activity levels for longer periods. Caffeine is said to be one such agent. In a double-blind study, nine runners who were aerobically conditioned were asked to perform five runs on the treadmill till exhaustion after consuming 4. 45mg/kg body weight of caffeine. The subjects were asked to run at 85% of maximal oxygen consumption 1 hour after caffeine intake. They were asked to engage in the physical activity till they voluntarily felt exhausted. Results of the study revealed that caffeine significantly increased plasma epinephrine and endurance in the subjects as

compared to placebo. Subjects who had ingested caffeine were able to run 2-3 km longer than placebo. Further, the increase in epinephrine levels suggests that caffeine might have affected the central nervous system, which could have contributed to elevated endurance levels (Graham et al., 1998).

Similarly, caffeine increased endurance during submaximal isometric contractions indicating that this methylxanthine could affect neuromuscular parameters while conferring ergogenic effects. Fifteen subjects tested in a randomized, double-blind experiment, were administered 6mg/kg body weight of caffeine. After 1 hour of caffeine intake they were asked to perform submaximal isometric contractions i. e. 50% of the maximum voluntary contraction of the right quadriceps till the time of exhaustion. Results of the test were compared against placebo. Caffeine consumption by the subjects resulted in approximately 17% increase in the limit of endurance. Additionally, caffeine also decreased force sensation, particularly, during the first 10-20 seconds of contraction, which contributed to a delay in fatigue experienced by the subjects (Plaskett and Caffarelli, 2001).

Caffeine and Its Effects during High Intensity Exercise

As compared to prolonged exercises where endurance holds the key, the high intensity physical activities require quick bursts of energy to maximize performance. Research has shown that caffeine can enhance performance during high intensity exercises, particularly in trained athletes. For example, caffeine, at a small dose, increased the speed during a high intensity run on the treadmill. In this study, 10 subjects, all regional athletes of varying

levels, were administered 3g of caffeinated coffee (~15-200mg caffeine) one hour before exercising. The participants were then asked to run on the treadmill for 1100 m at a speed 1km/h less than their maximum speed. They were also required to complete the last minute of the run as fast as possible so as to simulate a ‘ finishing burst’ of around 400m. All the ten subjects recorded faster speeds after consuming caffeinated coffee than after ingesting decaffeinated coffee. Additionally, their VO2 was also higher corresponding to their increased running speeds (Wiles et al., 1992).

Caffeine and Its Effects on Strength-Power Performance

Caffeine can not only enhance endurance during prolonged exercises and performance during high-intensity activities, it can also improve strength and power. Caffeine supplementation at acute levels improved strength performance as was shown in fifteen resistance-trained women. The participants of this double-blind, cross-over, placebo-controlled study were given 6mg/kg body weight of anhydrous caffeine with 16. 9 ounces of water 1 hour before exercise. They were then asked to perform the barbell bench press exercise to determine the ‘ repetitions to failure’ at 60% of the standardized bench press as well as to arrive at the ‘ one maximum repetition’. Participants were also asked to lift weights which were increased gradually till they failed to finish a lift. Analysis of the data thus collected revealed that participants showed a markedly higher ‘ bench press maximum’ after consuming caffeine than without intake indicating improved muscular endurance and strength (Goldstein et al., “ Caffeine enhances” 2010).

Caffeine and Its Effects on Recovery after Exercise

In addition to improving performance during exercise, whether prolonged or intense, caffeine also aids faster recovery post exercise. The idea that caffeine could aid recovery post exercise stems from the fact that this compound is known to increase the rate of glycogen synthesis after a round of physical activity. In a study on trained cyclists and triathletes, caffeine enhanced glycogen synthesis in the subjects. The seven participants of the study, of a double-blind, cross-over and randomized design, were asked to fast overnight, following which they performed the cycle ergometer exercise at 70% VO2 peak till exhaustion. Each of the subjects was given 8mg/kg body weight of caffeine along with 4g carbohydrate/kg body weight or only carbohydrate of the same quantity in two doses. After a 4-hour period of recovery, it was clear that glycogen synthesis following caffeine and carbohydrate treatment was 66% higher than with only carbohydrate supplementation (Pedersen et al., 2008).

Caffeine and Hydration

If an individual is to sustain intense or long periods of physical activity, how well he/she keeps themselves hydrated is of great importance. With respect to caffeine, it is a common notion that its consumption can induce acute dehydration. However, research states that whether caffeine affects the hydration status of a person depends to a large extent on how hydrated he/she is during exercise (Goldstein et al., “ International society” 2010). On the whole, caffeine has not been reported to affect the fluid-electrolyte balance in the body. No significant difference in the fluid balance was found

in the participants of a study, with and without caffeine intake, when they exercised moderately or were at rest. In this study, the six subjects were asked to complete 180 minutes of cycling at 60% VO2 max at a moderate intensity preceded by 4h or 1h of rest. The caffeine quantity administered to them was 8. 7mg/kg body weight in the form of a drink. Although urine volume was found to be higher in participants after caffeine consumption during rest, the fluid balance was not significantly different during exercise (Wemple et al., 1997). Scientific literature on this subject also indicates that caffeine neither affects the rate at which sweat is produced during exercise nor does it negatively impact dissipation of heat from the body (Goldstein et al., " International society" 2010). Thus, it can be said that caffeine does not cause any adverse effects on a person's hydration status and hence does not affect performance during prolonged exercises or the rate of recovery

Based on the body of the research conducted on the effects of caffeine on exercise, it can be said that this xanthine compound, even at low to moderate physiological doses of 3-6mg/kg body weight, acts as an effective ergogenic aid. Through this, it improves the endurance, intensity, strength and performance, both during prolonged exercise as well as during high-intensity workouts. In addition, it also aids recovery and does not seem to have any adverse effects on the hydration status of the individual.

Since it has been firmly established that caffeine, in its anhydrous form, with water or in coffee, is a potent ergogenic aid for trained athletes, its use in various world sports competitions has come under the scanner. As a result, the International Olympic Committee has limited its intake to 9-13mg/kg body weight around one hour before performance. There is also a limit set

for the urinary levels of caffeine with 12-15 micrograms/ml of urine being allowed. Additionally, while the Word Anti Doping Agency has not banned caffeine use altogether, it has included the substance under its monitoring program as a means to curbing its misuse during competitions. In fact, caffeine has featured on the Prohibited List of the World Anti-Doping Agency (Pesta et al., 2013).

However, it is to be noted that most of the studies on caffeine and exercise have been done on trained athletes who are already conditioned for higher levels of physical activity. Also, the number of studies conducted on women is far and few. In this regard, it would be interesting to note if caffeine has the same effects when untrained individuals perform exercises as it has on the trained sportspersons. This is of particular significance since caffeine is one ergogenic aid that is present in many regularly consumed dietary sources and hence is ingested by one and all daily.

Nevertheless, given the fact coffee acts as an ergogenic aid during exercise, as has been proven by several researches, it must be said that whoever called the coffee a ‘ pick-me-up’ cup was absolutely right in saying so.

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