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Review Article

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Ergogenic Supplementation: Caffeine and Physical Exercise

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Abstract

This review aims to highlight the ergogenic potential of caffeine for physical exercise. The promise of rapid results has popularized the use of dietary supplements worldwide. It is known that although caffeine is not considered a micronutrient, it is proven to be an ergogenic substance whose natural presence in various foods and beverages has caused it to be ingested from remote periods and is currently one of the most consumed substances in the world. By blocking the adenosine receptors, caffeine causes physiological effects in the most different organic tissues, decreasing the perception of fatigue and prolonging the intensity of aerobic and anaerobic exercises for a longer time.

Keywords: *Ergogenic Supplementation; Caffeine and Physical Exercise*

Introduction

Supplementation and Ergogenic Resource

The application of dietary changes and supplementation with specific nutrients originated in ancient Greece, in which athletes made use of certain foods to prepare themselves for the competitions of the Olympic Games of Antiquity [1].

The Renaissance rediscovered classical art along with the Hellenic beauty pattern, making the choice of the academy, concern for appearance, body exercise, and specific dietary pursuits since then, habits inherited from ancient Greece and desired by many people [2]. With the beauty standard imposed, the use of nutritional supplements with the intention of improving aesthetics and physical performance has contributed to the fact that athletes and physically active people are their biggest consumers, who for the desire to achieve fast results have made use of these supplements very attractive, and are now readily available worldwide [1].

Supplementation of specific nutrients with the intention of improving human physical performance gave rise to ergogenic supplementation [3]. The ergogenic word is derived from the Greek origin ergo (work) and gen (production of), usually having the meaning of improvement of the potential for work production [4,5]. Thus, in order for a substance to be legitimately classified as ergogenic, it must be demonstrated to improve performance [6].

Justification

The review is justified by the fact that caffeine, together with creatine, sodium bicarbonate, beta alanine and nitrate, is one of the substances with proven ergogenic action [7], in addition to being classified as an apparently effective and generally safe food supplement for weight loss [8]. It is added to this, the ease with which it is found in beverages, foods and some medicines, causing the majority of the general population to make or have already made use of this substance [9].

Hypothesis and Objectives

Considering that caffeine supplementation may increase performance in physical exercises, this review aims to highlight the ergogenic potential of the substance in aerobic and anaerobic exercises, as well as to identify the current dose of the substance recommended for performance improvement.

Methodology

The literature review was based on articles hosted in the PubMed, Google Academic and Portal Capes databases, in Portuguese or English, as long as they related caffeine as an ergogenic resource in physical exercises. Complementary literature such as books and specific resolutions were sought from the need to deepen the points cited in the articles, taking due care to select more updated sources on the subject.

Literature Review

Introduction to Caffeine

Caffeine is chemically called 1,3,7-trimethylxanthine, belonging to the group of xanthines, which in turn are not considered micronutrients, and are mainly used for therapeutic and pharmacological purposes [10], this group also includes theophylline, theine, guarana and theobromine, and are chemically closely related alkaloids that are differentiated by potency in the stimulating action on the central nervous system [11].

The use of caffeine refers to the Paleolithic period, emphasizing that it is currently easily found in beverages, foods and some medications such as analgesics and anti-flu; it is not an exaggeration to say that about 80% to 90% of the general population makes or has already made use of this substance [9].

The presence of caffeine (in milligrams) is quantified in various beverages and foods [12]:

• Coffee (150ml cup): machine between 110 and 150mg, strainer between 64 and 124mg, instantaneous between 40 and 108mg and instant decaffeination between 2 and 5mg;
• Tea (bulk or sachets - 150 ml cup): infused from one minute between 9 and 33mg, three minutes between 20 and 46mg and five minutes between 20 and 50mg;
• Soft drinks (350ml): 46mg in Coke and Diet Coke, 38.4 in Pepsi Cola and 36mg in Diet Pepsi, Pepsi Light and Melo Yello;
• Products with tea: 12 to 28mg in instant tea (150ml cup) and between 22 and 36mg in iced tea (350ml cup);
• Chocolates: made from the mixture and the milk (28g) around 6mg, while in confectioner chocolate (28g) around 35g of the substance;
• Energy (250ml) around 80mg (Flash Power, Flying Horse, Dynamite, Red Bull, On Line and Blue Energy Xtreme).

The popularization of the consumption of caffeine was through coffee, which was heavily introduced in Europe in the sixteenth century by the Spanish and Dutch, but the substance, even in a restricted way, was already consumed by means of tea and the noble drink at the time [13].

On the other hand, in the sports world, the use of caffeine became evident from the middle of the nineteenth century, more specifically during the first edition of the "six-day race" in 1879, when participants of different nationalities were used of several stimulant products, among which were the caffeinated compounds, in order to withstand the great effort required [14].

Metabolism

The liver is the main responsible for the metabolism of caffeine, but other tissues indirectly participate in this process, such as the kidney and brain [9].

The oral caffeine as a rapidly and efficiently absorbed substance from the gastrointestinal tract with approximately 100% bioavailability, reaching a peak concentration in the bloodstream after 15 to 120 minutes of ingestion, however a possible variation in the rate of absorption can be determined mainly by the gastric occupation [15]. Oral caffeine absorption levels are similar for both beverages and for capsules or chocolate bars [16].

Mechanism of action

The caffeine enhances the action of the Sympathetic Nervous System by blocking adenosine receptors [17,18]. This neuromodulator acts in the opposite way to caffeine, acting in the decrease of the cellular activity, and once the caffeine blocking its action, accelerates these cellular activities at the neural level. Adenosine receptors are present in various tissues, including the brain, heart, skeletal muscle and adipocytes [17,18].

Thus, caffeine may have effects on several tissues, such as the Central Nervous System, skeletal muscle, cardiac muscle, renal function, bronchial smooth muscle and gastrointestinal tract, differing depending on the target cell [10].

Physiological Effects and Ergogenic Action

Due to the action at the level of the Central Nervous System, there are proven effects, such as increased mental attention; increased concentration; mood improvement; decreased reaction time; increased release of catecholamines, increased mobilization of free fatty acids; and increased use of muscle triglycerides [19].

In skeletal muscle, caffeine can act directly not through the action of catecholamines as many other authors report, but because of increased permeability of the sarcoplasmic reticulum to ions calcium, increasing the activity of the sodium and potassium pump and optimizing muscle contraction [19,20]. According to the same authors, caffeine could also influence the sensitivity of the contractile proteins through calcium ions in order to increase excitation-contraction coupling, improving muscle contraction and increasing contraction force. Although older studies, even though they did not know the mechanism of action, have already indicated an increase in muscle strength accompanied by a greater resistance to the installation of the muscle fatigue process after caffeine intake [21-24].

By stimulating the Sympathetic Nervous System, caffeine interferes with the functioning of the adrenal medulla, increasing the release of catecholamines, which are responsible for effects such as vasodilation, glycogenolysis and bronchodilation [25,26].

In the Respiratory System, this bronchodilatation of the alveoli, as well as the vasodilatation is able to increase the speed of the filtration of the blood [17].

On the Cardiovascular System, caffeine exerts a direct stimulation on the myocardium, causing an increase in cardiac output, contraction force and frequency [10].

The evidence of the many physiological effects of caffeine shows its ergogenic power, in which the Academy of Nutrition and Dietetics, Dietitians of Canada & American College of Sports Medicine, based on evidence from other studies, concludes that in reducing the perception of fatigue, allowing the exercise to be maintained at a higher intensity for longer, being both indicated for the improvement of aerobic and anaerobic exercise yields [7].

Side Effects

Intake of high doses of caffeine (10 to 15 mg/kg body weight) is not recommended because plasma caffeine levels can reach toxic values up to 200 mm [27]. Therefore, the side effects caused by caffeine intake occur in a greater proportion in susceptible people who use this substance in excess [28].

High doses caffeine causes several unwanted side effects that may limit its use in some sports, such as: insomnia, headaches, irritation, anxiety, memory impairment, in some cases gastrointestinal discomfort and even bleeding, in addition of cardiac arrhythmias and stimulation of diuresis due to the inhibition of the antidiuretic hormone (ADH) and due to this diuretic action, the athlete's good performance in hot and humid situations may be impaired [9].

As for stomach problems, there may be aggravation in individuals who are already prone to gastritis or ulcer, especially when caffeine is ingested in the fasted state [28].

Also, physically caffeine can impair the stability of the upper limbs inducing them to tremor and tremor, a result of chronic muscular tension [12].

Some authors even suspect that high levels of caffeine intake may increase the risk of bladder cancer [25,29]; while others show that there is evidence of the production of delusions and hallucinations [30].

Dose and Habituation

Conlee [31] showed that caffeine, when consumed at low dosages (2mg/kg), was able to cause an increase in wakefulness, decrease in sleepiness, relief of fatigue, increased respiration, increased catecholamine release, increased heart rate, increased metabolism and diuresis; as well as at high dosages (15mg/kg), it was able to generate nervousness, insomnia, tremors and dehydration.

It is important to mention that the effect of caffeine varies from person to person, depending on their weight and regularity with which they ingest it [8]. In addition, the effects of caffeine on the metabolism of the body and its effects on the metabolism of caffeine and its effects on the metabolism of carbohydrates and the metabolism of carbohydrates have been studied. The effects of caffeine on the daily intake of caffeine may lead to a decrease in the metabolic responses induced by the ingestion of the substance, causing individuals who regularly drink caffeinated beverages to experience less ergogenic benefits [8].

Individuals are classified as non-users with caffeine intake of less 20mg / day, an habitual user between 30 and 100mg/day, a habitual user between 120 and 150mg/day, a moderate user between 450 and 720mg / day and as a user intentional intake greater than 720mg [12]. The possibility of habituation is reached from a daily intake of more than 100mg, that is, corresponding to approximately 2½ cups of common coffee [9,12,32].

Individuals who maintain intakes of less than 50mg/day, classified as unused, would experience better ergogenic effects in the sports environment [33].

Some authors suggest that after habituation to re-observe the effects, individuals should have abstinence for four to seven days, followed by ingestion between 3h and 4h before exercise [29,32,34].

Thus, habituation to caffeine has been shown to be of great relevance and concern when one thinks about the use of the substance as a resource for improving physical performance [33].

The recommended dosage for aerobic activities is approximately 5 mg / kg body weight, and 3 to 6 mg/kg for anaerobic activities [15,35], between 60 and 90 minutes before exercise , representing a safe time interval for obtaining the peak of the substance in the blood plasma. Other studies indicate that caffeine intake (eg 3 to 9 mg/kg taken 30-90 minutes before exercise) can save carbohydrate use during exercise and thus improve endurance of exercise [36,37].

Supplementation

Several methods of caffeine supplementation have been reported, but it is suggested that their ingestion in anhydrous form (capsules) rather than drink intake may exert more interesting effects on exercise time until exhaustion in trained athletes [38].

In Brazil, caffeine supplements for athletes are only allowed when it is alone in the product ready for consumption. In addition, caffeine with a minimum content of 98.5% of 1,3,7-trimethylxanthine, calculated on the anhydrous basis, should be used in the formulation of the product. Brazilian legislation still provides that the product should provide between 210 and 420mg of caffeine in the portion [39].

Caffeine and Doping

Authors report that during the early 1980s, the indiscriminate use of caffeine by athletes to improve performance led to the inclusion of caffeine in the banned substances list of the International Olympic Committee (IOC), which stipulated borderline value of 15µg/mL caffeine in the urine for positive doping [41,42].

However, the use of caffeine became evident only after the Los Angeles Olympic Games (1984), when some members of the United States cycling team publicly stated that they had used this alkaloid as a stimulant during competitions, the IOC changed the borderline value to 12µg/mL of caffeine in the urine for positive doping [15,18,42].

The caffeine was included in the list of substances banned by the World Anti-Doping Agency (WADA) in the stimulant class (A) until the end of 2003, and the threshold for positive doping was also 12 µg/mL in the urine [40]. This amount would be detected with consumption of approximately 800-1000mg of caffeine (+ or - 8 cups of coffee) [43].

However, due to the difficulties of establishing a borderline value, from 2004 caffeine was included in WADA's monitoring program and was no longer considered a banned substance [44].

Studies have shown that even though no longer a substance banned by WADA, no significant increase in caffeine consumption in the sports environment has been observed [45,46].

It should be noted that although only a small amount of caffeine is excreted (0.5 to 3%), without alteration in its chemical composition, its detection in the urine is relatively easy [47]. And that for women, the proportion of caffeine excretion is particularly important, since during intense exercise they have a greater elimination of the substance than men [48].

Results

It was found that caffeine supplementation increases performance for both aerobic and anaerobic exercise, with an approximate dose of 5 mg/kg body weight for aerobic exercise and 3 to 6 mg/kg for anaerobes indicated [15,35], between 60 and 90 minutes before exercise.

Conclusion

Through this review, it is evident that caffeine supplementation provokes physiological effects that demonstrate its

potential ergogenic effect, both for aerobic and anaerobic exercises when ingested prior to the practice, but to enjoy this ergogenic potential requires attention to dosage and non-habituation of the by the substance. When ingested at high doses (above 10 mg/kg), in addition to causing side effects that impair performance in physical exercises, they can also result in positive urine detection by doping control agencies (above 12 μg/mL). Thus, the safety and efficacy of the substance require the prescription and follow-up of a multiprofessional team that fully understands all the nutritional and physiological aspects involved in improving performance in physical exercises.

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