Caffeinated chewing gum improves sympathetic nerve activity and simulates wrestling performance: a double-blind crossover trial

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Project summary

The purpose of this study was to investigated whether caffeine intake is effective in improving the performance of wrestlers in a simulated competition. The study was designed to involve 16 healthy adult male athletes who had been trained in professional wrestling and were divided into caffeine trial (CAF trial) and placebo trial (PL trial) in a randomized crossover double-blind study design. After three days of dietary control, participants arrived at the laboratory in the afternoon of the day of the trial to collect saliva samples in a quiet state and were fitted with a heart rate monitor. Participants chewed either caffeine-containing gum at 3 mg/kg body weight (CAF trial) or placebo-containing gum without caffeine (PL trial) for 10 minutes and then spit it out. Participants then underwent a 15-minute dynamic warm-up. At the end of the warm-up, participants performed 2 rounds of 3-minute wrestling-specific simulated matches, and the number of falls in the simulated matches was recorded. After the simulation match, saliva samples were collected from the participants again. The saliva samples were analyzed for caffeine alpha-amylase concentration. Differences between the two trials were analyzed using a paired sample t-test and significance was set at $\alpha<0.05$.

Introduction

At the Olympic Games and the World Athletics Championships, wrestling is one of the most popular event. In addition to specialized skills, the key to winning a wrestling match is muscle strength and anaerobic power (1, 2). In a previous study, 92 male wrestlers were divided into elite and non-elite groups according to their performance, and it was found that absolute muscular strength and anaerobic power were the key factors that differentiated elite wrestlers from non-elite wrestlers(2). From these studies, it appears that improving strength as well as anaerobic power of a wrestler is an important factor in winning a competition.

Many studies have suggested that caffeine (1,3,7-trimethylxanthine) supplementation prior to exercise is effective in improving maximal muscle strength and anaerobic capacity, with approximately small to moderate improvements (3). It has been established that the mechanisms in question consist of antagonised adenosine receptors.

The resulting effect of this is a reduction in the level of fatigue experienced during periods of physical exertion. Furthermore, it has been demonstrated that the release of calcium ions from the sarcoplasmic reticulum is increased, while at the same time the activity of sodium-potassium ATPase (Na+/K±ATPase) is maintained. In addition to the abovementioned effects, it has been observed that the aforementioned mechanisms stimulate glycolysis (4, 5). A dose of 3-6 milligrams of caffeine per kilogram of body weight is recommended before exercise. This can be achieved through energy drinks or capsules(3).

Another physiological mechanism that may affect maximal muscle strength and anaerobic power may be related to the activation of sympathetic nerves. Recent studies have demonstrated that enhanced sympathetic activation during exercise can be an effective strategy for reducing fatigue and increasing energy output at maximum intensity (6, 7). In order to comprehend the status of sympathetic nerve activation, it is possible to quantify the electrocardiographic signal from the heart, the α-amylase levels in saliva, or the plasma catecholamine concentration (8). Caffeine supplementation has been demonstrated in previous studies to enhance sympathetic nerve activity(9). In addition to the ingestion of capsules, the chewing of caffeinated gum has been observed to enhance sympathetic nerve activity and significantly reduce fatigue during maximal sprinting(7).

It has been demonstrated that chewing caffeinated gum can enhance the rate of caffeine absorption, leading to a more expeditious attainment of the maximum blood concentration of caffeine(10). The absorption of caffeine from chewing caffeine gum is a process that occurs through the mucous membrane of the oral cavity. The rate of absorption is such that the highest concentrations of caffeine in the blood can be reached within approximately fifteen minutes after chewing (11). With regard to the effects of caffeine on exercise performance, studies based on systematic reviews and meta-analyses have found that the ingestion of caffeine chewing gum at a dose greater than 3 mg/kg of body weight prior to exercise can effectively improve maximal muscular strength and anaerobic power (12). In the case of weight classes being required for events such as wrestling, the caffeinated chewing gum has been demonstrated to reduce water intake and may decrease the risk of being overweight. This may serve as an additional effective method of supplementing caffeine intake. The purpose of this study was to investigate the effect of caffeinated chewing gum on sympathetic nerve activity on wrestling simulation match.

Methods

Study design

In this study, a double-blind crossover experimental design was used, in which participants were randomised to either the caffeinated chewing gum trial (CAF) or the placebo chewing gum trial (PL). After a seven-day washout period, the participants were switched to another trial of experiments (Figure 1). All tests were conducted after a regular 6-day training period with a day off to ensure that participants were in a similar physiological state prior to the experiment. Prior to the experiment, participants were asked to perform at least 2 simulated matches to familiarise with the simulated matches before the main experiment. The primary outcome measure was the number of falls in the simulated match, while the secondary outcome was α-amylase concentration in saliva, as an indicators of sympathetic nerve activity. The study commenced on 11 June 2024 and concluded on 23 December 2024.

Participants

Seventeen professionally wrestling male athletes were recruited for this study. After one participants withdrew due to personal reasons, the final results of 16 participants (age: 21.8 ± 1.0 years; height: 168.4 ± 4.5 cm; mass: 68.2 ± 8.7 kg) were analyzed. The inclusion criteria for this study were: (i) more than 6years of professional wrestling training; (ii) more than 6 months of continuous training; (iii) recovering from sports injuries such as strains and contusions for at least 3 months. The exclusion criteria were: (i) non-professionally wrestling athlete; (ii) none regular training in the past 6 months; (iii) less than 3 months of recovery from a sports injury, or present epilepsy, hypertension, hyperlipidemia, heart disease, arthritis, osteoporosis, or brain injury; (iv) a history of caffeine allergy. The consent form is completed after the participant has given consent. This study was conducted following the Declaration of Helsinki.

Sample size calculation

In this study, the number of participants in request was analysed using the G*Power software (version 3.1.9.4, Universität Düsseldorf, Germany) (13). In a previous study, 12 wrestling athletes were given the Pittsburgh Wrestling Performance Test (PWPT) after a caffeine intake and found that supplementation with a high dose of caffeine significantly reduced the completion time (56.8 ± 2.0 vs. 52.9 ± 1.8 s; $p < .05$) of the PWPT. Based on this data, we calculated that the effect size of this study reaches 2. The calculation was based on an alpha level of 0.05and a correlation coefficient of 0.80, it was calculated that 6 participants would be sufficient to meet the requirement of participants.

Protocol

Prior to the first official test, the participant must record the diet and training for the 3 days prior to the test, and consume the same diet and training before the next test. On the day of the test, the same breakfast and lunch will be provided to the participant to ensure the same energy intake before the test.

All the experiments were conducted at 3pm. Upon arrival at the laboratory, the participants were required to undergo saliva collection. Three milliliters of saliva were spat into a saliva tube for later analysis. After the participants putted on heart rate monitor, participants were instructed to chew either caffeine-containing gum (3 mg/kg body weight) or a caffeine-free placebo gum for a period of 10 minutes. Thereafter, the gum was to be expectorated. Following this, the participants underwent a dynamic warm-up for a period of 15 minutes. It has been established that the highest blood concentration of caffeine is achieved 15 minutes after the chewing of the gum and subsequent expulsion(11). After warming up, participants are permitted to engage in any form of self-stimulation they deem appropriate, including yelling, punching the dummy, and other similar actions. The present action has been meticulously designed to enhance sympathetic nerve activity. This finding serves to corroborate the hypothesis that caffeine supplementation exerts a stimulant effect on sympathetic nerve activity.

After warming up, the grip strength of the participant's hands was measured with a grip strength meter (Smedlay's Hand Grip Dynamometer TTM, Tokyo, Japan). Subsequently, participants engaged in a 3-minute, 2-round simulated wrestling match. This simulation has been shown to have good reliability and validity(14). In each 3-minute round of the simulation, one dummy fall was performed in the first 30 seconds, with an interval of 10 seconds each time. The participants then try to complete the maximum number of falls in 20 seconds. After the fall, the participants were given a 10-second break for a total of 1 minute. The same pattern was followed in the 2nd and 3rd minutes. During the 3rd minute, the duration of continuous wrestling was extended to 30 seconds. After a 30-second break, the participant repeated the same simulation and record the total number of falls. After the simulation competition, saliva was collected again and caffeine concentration and α-amylase concentration were measured.

Caffeine and placebo gum

The caffeinated chewing gum employed in the present study (Military Energy Gum, Arctic Mint flavour; Stay Alert, Chicago, USA) has been utilised in previous studies(7, 10). It is estimated that a single piece of gum contains approximately 5 grams and 100 milligrams of caffeine. The placebo gum was a commercially available blue mint gum

(Lotte Gum Mint., Ltd., Tokyo,Japan). In order to administer a dose of 3 mg/kg of caffeine per unit of body weight, it was necessary to crush, grind, blend, reshape and flavor all chewing gums with 0.3 g of peppermint-flavored powder. The process was designed to ensure that the new chewing gums were comparable to the original in terms of appearance, color, flavor, weight and size. Previous studies have demonstrated that this method renders it impossible for the participant to distinguish the type of gum (7, 15).

Saliva sample collection and analysis

Saliva samples were stored in a refrigerator at -80 degrees immediately after collection. For analysis, samples were thawed and centrifuged at 4000 rpm for 5 min. 500 μL of saliva samples were transferred to glass tubes for mass spectrometry analysis and Enzyme-linked immunosorbent assay (ELISA) analysis respectivelyThe analysis of saliva α-amylase concentration was conducted utilising an enzyme-linked immunosorbent assay (ELISA) with commercially available reagents (Neogen Corporation, Kentucky, USA; Salimetrics LLC, State College, PA, USA).

Statistical analysis

All data are presented as means ± standard deviations. The Shapiro–Wilk test was utilised to evaluate the normality of the data. The grip strength and number of fall on each rounds between the two trials were analyzed using paired t-tests. The saliva caffeine and α-amylase concentration and RPE were analyzed using two-way ANOVA with repeated measures. If the interaction effect (trial × time) were significant, the Bonferroni method was used to perform post hoc comparisons. Effect sizes were calculated using Cohen's d to quantify the magnitude of observed ef-fects and defined as trivial (<0.20), small (0.20–0.40), moderate (0.40–0.80), and large (>0.8), respectively. The power value of each data was conducted using G*Power 3.1.9.6 software (13)

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