The effect of caffeinate chewing gum on ice hockey performance after partial sleep deprivation: a double-blind crossover trial

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Project summary

The purpose of this study was to examine the impact of caffeinated chewing gum on the physical performance of elite ice hockey players in a partial sleep deprivation state. Fourteen national-level (Age: 25.2±5.4; height: 176.5±5.3; weight: 78.1±13.4) ice hockey players were tested late at late-night after a full day of partial sleep deprivation. A randomised, double-blind experimental design was employed in which participants either chewed caffeinated gum (CAF) containing 3 mg/kg caffeine or a caffeine-free placebo gum (PLA) for 10 minutes prior to undertaking a series of tests on-ice and off-ice. The off-ice tests include a grip force, counter-movement jump (CMJ) and squat jump (SJ). The in-ice tests include 35 metre sprint, S-Shape agility test and Yo-Yo intermittent recovery test (Yo-Yo IR1 test).

Introduction

Ice hockey is one of the most popular sports in the world and has been an Olympic sport since 1920. Hockey is a high-intensity intermittent team sport. The players engage in periods of high-speed skating, interspersed with periods of passive recovery (1). It has been demonstrated that each skating session typically lasts between 30 and 80 seconds, with a subsequent recovery period of approximately 2 to 5 minutes. Similarly, for those engaged in ice hockey, it is essential to possess the requisite strength, agility, explosive power and aerobic endurance capacity (1). It can be argued that, in addition to their abilities on the ice, the physical capabilities of hockey players are also a significant factor in the sport.

The influence of circadian rhythm on exercise performance has been demonstrated in numerous studies (2). In general, the optimal time for exercise performance is usually in the evening due to the higher core body temperature, which leads to increased energy metabolism, improved muscle compliance, and promotion of actin-myosin cross-bridging (3). In accordance with the sleep model, the human circadian rhythm and the time since the previous period of rest both influence the characteristics of sleep(4). It can be reasonably deduced that modifying sleep schedules and circadian rhythm times may result in enhanced training quality. However, for athletes, student athletes, or when competing abroad, sleep schedules and circadian rhythms may be out of control. Prior to major competitions, 64% of athletes report partial sleep deprivation (5). It can be reasonably deduced that partial sleep deprivation may have an impact on physiological rhythms, which in turn may affect athletic performance.

Caffeine is a beneficial nutrient that has been demonstrated to enhance athletic performance (6). It has been demonstrated that caffeine supplementation prior to exercise has a significant impact on improving endurance performance and reducing fatigue index in athletes. In sports requiring explosive power or agility, the effect size of caffeine was observed to be approximately small to moderate (7). In order to achieve a significant boost in pre-workout strength and explosiveness in explosive sports, a higher dosage of caffeine is required (8). However, supplementation with higher doses of caffeine may cause insomnia or affect sleep quality (9). One potential method for addressing insomnia may be to utilize smaller doses of caffeine prior to exercise, while still achieving a beneficial stimulant effect.

Caffeine gum can be absorbed through the mucous membranes of the mouth, resulting in a faster absorption rate of caffeine (10), which may also have a higher effect size on athletic performance (11). Based on past literature, chewing smaller doses of caffeinate chewing gum has been found to improve lower body strength and explosive performance (12). It may be posited that the use of chewing gum as a caffeine supplement could prove an effective method of enhancing athletic performance without adversely affecting sleep quality. Caffeine supplementation can be effective in improving explosive power and vertical jump height during fatigue after partial sleep deprivation (9). However, there are no published studies investigating the impact of partial sleep deprivation on the physical performance of ice hockey players, whether on-ice or off-ice. The purpose of this study was to examine the impact of ingesting caffeinate chewing gum on the on-ice and off-ice athletic performance of hockey players experiencing partial sleep deprivation.

Methods

Experimental Design

This study used a randomisation crossover design with a single-blind, double-blind experimental design. The participants were randomly assigned to either a caffeinated chewing gum trial (CAF) or a placebo trial (PL). After the first main trial, participants rested and recovered for 7-10 days before proceeding to the next trial. All participants completed all tests within one month. During the study period, all participants maintained their normal training status, with no changes in the training program, and no over-training or extra competitions. This is the out-of-season training period for players.

Participants

Fourteen trained ice hockey players (Age: 25.2±5.4; height: 176.5±5.3; weight: 78.1±13.4) were recruited to participate in this study, including six defensemen, two centres, and six forwards. All participants had more than 6 years of professional hockey training and were familiar with all hockey skills. Inclusion criteria: 1. 6 years of professional ice hockey training, 2. 6 months of continuous training, 3. 3 months of recovery from sports injuries such as strains and sprains. Exclusion criteria: 1. non-specialised ice hockey player. 2. has not trained regularly for the past 6 months. 3. has recovered from an athletic injury. 4. have been recovering from a sports injury for less than 3 months, or have epilepsy, hypertension, hyperlipidemia, heart disease, arthritis, osteoporosis, brain injury, or a history of caffeine allergy. In a past study, the effect of caffeinated chewing gum was found to have an effect size (Cohen's d) = 1.00 on the fatigue index of basketball players (11). The G*POWER statistical software (latest ver. 3.1.9.7; Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) indicated that eight participants were sufficient to interpret the data for the purposes of the study, with a power value of 0.8. In order to achieve a more precise POWER value, the number of participants in this study was set to 14. All participants provided written informed consent after being fully informed about the potential risks involved in the experiment, in accordance with the ethical standards of the relevant academic institution. A signed consent form was obtained from each participant. The order of participants was determined through the use of computerized randomization software (Excel Office 365). This study received approval from the Institutional Review Board of Jen-Ai Hospital - Dali Branch (202300071B0). All the data were performed at the indoor stadium. This study was conducted following the Declaration of Helsinki.

Protocol

All participants were required to perform the exercise-specific tests at least 2 times prior to the formal trial to familiarise themselves with the process of the formal trial. Participants were asked to record their diet 3 days before the first formal trial and were asked to repeat the same diet before the next trial. The following experiments were scheduled to start at 11 p.m. Upon arrival at the designated Ice hockey arena, the participants were granted a 10-minute rest.

All participants remained awake (CAF: 11.5±2.2 hours; PL: 11.8±2.2 hours) for a full day after adequate sleep (CAF: 7.4±1.4 hours; PL: 7.1±1.2 hours), with no nap allowed in between. After 10 minutes of breath, participants chewed either caffeinate chewing gum (CAF) containing 3 mg/kg of caffeine or caffeine-free chewing gum (PL) for 10 minutes each time. After spitting out the chewing gum, participants performed dynamic stretching and warm-up. After the warm-up, a 1-minute break was taken, followed by an off-ice test and an in-ice test. The measures employed in this study can be classified into two principal categories: off-ice tests and in-ice tests. In previous studies, a significant positive correlation has been identified between the off-ice tests and in-ice tests (13) Accordingly, the present study distinguished between off-ice and in-ice tests. The off-ice test includes grip force, counter-movement jump and squat jump (13). The in-ice test includes 35 metre sprint (13), S-Shape agility test (14) and Yo-Yo intermittent recovery test in ice (15). Participants were first tested on land, then after a 10-minute break and wearing ice equipment, they were tested on ice.

Outcome measure

The counter-movement jump was measured using Gymaware (GymAware, KineticPerformance, Australia). The device strap should be secured to the participant's waistband. The participant is instructed to remain as still as possible and place their hands on their waist. They are then required to squat down to the ground in a parallel position with their thighs, and then jump up as quickly as possible. The experimental procedure was conducted twice, with a one-minute interval between trials. The mean value of the two trials was calculated as the final result.

The squat jump was measured using Gymaware. The device strap should be secured to the participant's waistband. The participant is instructed to remain as still as possible and place their hands on their waist. They are then required to squat down to the ground in a parallel position with their thighs for 2-3 seconds, and then jump up. The experimental procedure was conducted twice, with a one-minute interval between trials. The mean value of the two trials was calculated as the final result. The same vertical jump test has been employed in previous study (11).

In the grip force test, the participant stood in a standing position holding a grip dynamometer (Smedlay's Hand Grip Dynamometer TTM, Japan) (16) with the grip adjusted to the second knuckle and the arm at about 10-15 degrees to the trunk, and continuously pressed the grip for about 3 seconds at maximum force. Both hands were tested twice with a one-minute rest in between. The average strength of both hands was taken as the result.

The 35 metre sprint on ice (13) was measured using a timing grating (Witty, Microgate, Bolzano, Italy) with an accuracy of 0.01 seconds. The first timing grate was placed at the starting position and the second timing grate was placed at the 35m position. Participants dressed in official ice hockey equipment, ready to remain stationary, holding the stick and retreated behind the starting line, began to complete the 35-metre sprint with maximum effort, during the process of the stick close to the ice surface, each experiment performed twice, with a three-minute break in the middle of the experiment, to adopt the best results.

The Ice S-Agility test is conducted using the timing grating (Witty, Microgate, Bolzano, Italy). The participant, wearing official hockey equipment and holding a stick, stands behind the half-ice goal and circles the two scrimmage circles in the half-ice, then sprints in a straight line across the blue line of the rink without touching the scrimmage circles and with the stick close to the ice surface. This approach has been used in the literature in the past (14). Each experiment was performed twice with a three-minute break and the best score was taken.

The on-ice Yo-Yo IR test measures the aerobic endurance of hockey players (15). Place the cone at the start point, the finish point (20m), and the buffer zone (5m after the start point). Participants stand on the ice wearing official hockey equipment and holding a stick. A 20-metre sprint is performed after hearing an instruction tone, with a 10-second rest period after every 2 sprints. During the test, the indicator tone will speed up with the longer time, during the process, if two consecutive times can not reach the opposite cone before the indicator tone, it will be judged as a failure, and the results of the previous stage will be recorded.

Caffeine and placebo gum

The caffeinated chewing gum used in this study, specifically Military Energy Gum (Arctic Mint flavor; Stay Alert, Chicago, USA), has been previously utilized in other studies (12, 17). Each piece contained 100 mg of caffeine, with a 5 g gum base. The gum was provided in various weights, according to the relative dosage. A commercially available blue mint gum was used as the placebo. To achieve a target dose of 3 mg caffeine per kilogram of body weight and maintain a double-blind design, all chewing gums were mashed, ground, homogenised, and reshaped after incorporating 0.3 g of peppermint flavouring powder. This ensured that the colour, appearance, taste, weight, and size of the gum types were indistinguishable. All chewing gums were prepared by specialized individual and given to the on-site testers after numbering.

Statistical Analysis

All data are presented as means ± standard deviations. The normality of the data distribution was assessed using the Shapiro–Wilk test. The grip force, CMJ, SJ, 35 metre sprint, S-Shape agility test and Yo-Yo intermittent recovery test were employed to analyses the through paired t-tests. The magnitude of the observed effects was quantified using Cohen's d, a measure of effect size. The power value of each data was conducted using G*Power 3.1.9.6 software (18). All data were calculated using SPSS (version 20, Chicago, IL, USA), and the significance level was $p < 0.05$.

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