

# **Effects of caffeinated gum on a Batting and Pitching Performance of Female Softball Players: a crossover trial**

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## **Project summary**

The purpose of this study was to investigate the effects of caffeinated chewing gum on female softball pitching and hitting performance. 24 trained female softball players (10 pitchers and 14 fielders) were divided into a caffeine chewing gum trial (CAF) or a placebo trial (PLA) in a single-blind, randomized, crossover experimental design. Two pieces of gum containing 100 mg of caffeine (CAF) or without caffeine (PLA) were chewed for 10 minutes and then spit out, followed by a 15-minute warm-up. The physical tests included grip strength and countermovement jump. The softball-specific tests included pitching (fast ball speed) or hitting (exit speed). The two trials were separated by seven days.

## **Introduction**

Women's softball is one of the most popular sports in the world and a summer Olympic sport. For softball performance, pitching and hitting performance are important factors that affect the game. Pitching velocity is an essential factor in evaluating pitching performance. Factors affecting ball velocity include upper extremity muscle strength and lower extremity explosive power (1, 2). Muscle strength and explosive power not only improve ball velocity but also improve ball control (3). For hitting performance, bat-swing speed and exit speed are essential indicators of batting ability. Faster bat speeds allow for more reaction time and quicker exit speeds (4), which in turn allows the ball to be hit farther and makes it more difficult for the defense to handle the ball (5), resulting in an increased chance of scoring runs. In

addition to bat selection (6), factors affecting bat speed include lower body strength (6, 7) and trunk rotation (8) (9) (10). Therefore, enhancing muscle strength or explosive power may significantly affect the specialized performance of women's softball pitchers and batters.

Caffeine (1, 3, 7-trimethylxanthine) is a plant-derived chemical commonly found in the daily diet, including coffee, tea, and energy drinks. Caffeine acts on the central nervous system, antagonizing adenosine and increasing the concentration of neurotransmitters, including serotonin, dopamine, and acetylcholine, which have a stimulating effect (11, 12). In addition, caffeine improves the ability of the sarcoplasmic reticulum to release calcium ions and increases the availability of calcium in myofibers, improving muscle strength (13, 14). Caffeine supplementation before exercise has been confirmed effective in increasing maximal muscle strength and explosive performance (15). The increase in strength and explosiveness may have enhanced women's softball specialized performance.

Caffeine chewing gum is a convenient and effective way to get caffeine because of its fast absorption and bioavailability advantage. In a previous study, the relationship between the duration of chewing, the percentage of caffeine released, and the concentration of caffeine in plasma was investigated. It was found that chewing gum containing 100mg of caffeine for 5 minutes released 76% of the caffeine, and 96.2%

was released when chewing for 10 minutes. On the other hand, the caffeine concentration in blood plasma peaked at 10 minutes and 45 minutes. This means that caffeine is efficiently delivered and absorbed through the capillary in the oral mucosa. Some caffeine is swallowed through saliva and reabsorbed through the gastrointestinal tract (16). Ingesting chewing gum containing 100mg-300mg of caffeine 5-15 minutes before exercise has also been shown to improve exercise performance, such as vertical jump height, repetitive sprinting ability, power output, cycling time trial (17).

Whether ingesting caffeine chewing gum effectively enhances sport-specific performance in women's softball remains unclear. To accurately quantify the pitching ability of women's softball pitchers and the hitting ability of batters, we used a device with Doppler Radar and a high-speed camera [18] to investigate the effects of ingesting caffeinated chewing gum on the women's softball pitchers' and batters' performance. We hypothesize that ingesting caffeinated chewing gum can improve pitching and hitting performance.

## **Materials and methods**

### **Experimental design**

This study utilized a randomized, crossover, single-blind experimental design. At least two familiarization tests were conducted one week before the formal trial to ensure

each participant was familiar with the experimental procedures. Before the first formal trial, participants were randomly assigned to either the caffeinated chewing gum trial (CAF) with 200 mg of caffeine or the placebo trial (PLA) without caffeine, seven days apart (Figure 1). The primary outcome was the pitching and hitting performance, and the secondary outcomes were hand grip strength and height of countermovement jump.

## **Participants**

Twenty-four trained female softball players without the habit of caffeine intake were recruited in this study as participants. The participants included fourteen fielders (age  $20.3 \pm 1.3$  years; height  $159.5 \pm 5.2$  cm; body mass  $58.1 \pm 6.9$  kg; habitual caffeine intake  $37.4 \pm 10.2$  mg/day) and ten pitchers (age  $20.5 \pm 1.3$  years; height  $163.9 \pm 4.6$  cm; body mass  $68.0 \pm 6.7$  kg; habitual caffeine intake:  $26.3 \pm 6.5$  mg/day). Inclusion criteria are 1. adult female; 2. at least six years of professional softball training and familiarity with all softball skills; 3. caffeine intake of less than 80 mg daily. Exclusion criteria were: 1. not professionally trained; 2. having a medical condition for which exercise is not recommended, such as hypertension, hyperlipidemia, or heart disease; 3. having any musculoskeletal injuries within the last six months or not being able to complete a full trial; 4. having a history of caffeine allergy.

Participants were asked to avoid excessive training or vigorous exercise for 72

hours before each formal trial and avoid caffeine or alcohol for 24 hours before each test. At the time of recruitment, the purpose of the experiment, the complete procedure, and the potential risks were explained. Participants will read and sign the consent form to ensure they understand the entire process and their rights before the experiment. This study was approved by the Institutional Review Board of Jen-Ai Hospital - Dali Branch (111-22). This study follows the principles of the Declaration of Helsinki and the recommendations proposed by the CONSORT Statement.

### **Experimental protocol**

All participants are required to take a familiarization test at least two times before the official experiment to ensure that they are familiar with the experimental protocol. The formal trial includes grip strength, vertical jump, pitching, and batting tests. Before the first trial, the participants' diets for the previous two days were recorded, and the participants were asked to consume the same food before the next test, especially breakfast and lunch on the day of the trial. On the day of the experiment, participants were asked to fast for at least 3 hours and arrive at the lab at 3:30 p.m. All experiments were conducted at the same time each week.

When participants arrived at the laboratory, the first formal experiment collected basic information, including age, height, weight, and habitual caffeine intake. Then,

they were randomly assigned to either the CAF or PLA trials. During the formal experiment, a 5-minute break was taken upon arrival at the laboratory, followed by administering caffeinated chewing gum containing 200 mg of caffeine or the placebo gum without caffeine, which was chewed for 10 min and then spit out. 15-min standardized dynamic warm-up exercises were performed after the gum spat out, and the warm-up was conducted the same manner as during the daily training. Grip strength, vertical jump, and softball specialized tests were measured after the warm-up. After the first test, a second test was conducted at the same time one week apart, and the groups were switched to follow the same experimental protocol.

### **Caffeinated chewing gum and Placebo**

In this study, the CAF group used two mint-flavored gums containing 100 mg of caffeine each (Military Energy Gum, Arctic Mint Flavor, Stay Alert, Chicago, USA), and the PLA group used two mint-flavored gums of similar appearance and taste without caffeine (Xylitol, Fresh Mint, Lotte Vietnam CO., LTD). Fresh Mint, Lotte Vietnam CO., LTD). The caffeine gum used in this study has been shown to have good absorption and bioavailability (18) and to be effective in improving repetitive sprint performance (19, 20), vertical jump height (20, 21), and upper and lower extremity strength (21). Therefore, the caffeinated chewing gum used in this study was the

product with the supplemental effect. After the participants spit out the gum, verbal questioning was used to confirm whether the participants could differentiate between caffeine gum and placebo. 4 of 14 (29%) fielders and 4 of 10 (40%) pitchers correctly determined the type of gum intervention.

## **Outcome Measure**

### **Grip Strength**

In the grip strength test, the participant stood in a standing position with a customary hand-held grip dynamometer (Smedley's Hand Grip Dynamometer TTM, Japan) and adjusted the grip to the second knuckle, with the arm at about 10-15 degrees to the trunk, and pressed the grip continuously for about 3 seconds with maximum strength, keeping the trunk stable during the process, performing the procedure three times, with one minute's rest in the middle of each time, and calculating the data averages (22).

### **Countermovement Jump**

The vertical jump test collected data using a Gymaware (Gymaware, KineticPerformance, Australia) device. The participant wore a belt and attached a lanyard to the belt. During the jumping process, the participant jumped upward as far

as possible after squatting with arms folded at the waist, without interruption of movement, and without flexion of the hip and knee joints when leaving the ground. The jumps were performed three times in total, with a one-minute rest in the middle of each jump, and the data average was calculated (23).

### **Pitching Performance**

The windmill pitching method was used in the pitching performance test. Using the adult women's fastpitch rules, the pitching plate is placed 13.11 meters from the home plate. A green screen is placed behind the home plate, and the location of the tape is marked. The player is asked to throw each ball to the target location. Each set consisted of 10 fastballs, three sets in total. Pitching data were collected and analyzed using Rapsodo Pitching 2.0 (Rapsodo Baseball System, Rapsodo Inc, Fisher, IN). This device has been used in the literature and has been found to have high reliability for both hitting and pitching measurements (24, 25). During the test, the device was placed 15.6 feet from the front edge of the home plate according to the manual to ensure data accuracy. The pitching test evaluates average and maximum fastball velocity and average fastball spin rate.

### **Hitting Performance**



Hit off Tee was used in the hitting performance test. The T-base is placed on the front edge of the center of the home plate, adjusted to the height of the participant's navel, and set up the stance consistently. A target is set 10 meters in front of the home plate at a height angle of 10 degrees, requiring the participant to hit each ball to the target position. There were five sets of 5 swings per set. Hitting data were collected and analyzed using Rapsodo Hitting 2.0 (Rapsodo Baseball System, Rapsodo Inc, Fisher, IN). During the test, the device was placed 14 feet from the front edge of the home plate according to the instruction manual to ensure data accuracy. The batting test evaluates average exit speed and maximum exit speed.

### **Statistical analysis**

Data from this study were presented as mean  $\pm$  standard deviation and analyzed using SPSS 23.0 statistical software. The Shapiro–Wilk test was conducted to test the normality of the data. Paired samples t-tests were used to compare hand grip strength, countermovement jump, average exit speed, max exit speed, average fastball speed, max fastball speed, and average fastball spin rate. The significance level was set at  $\alpha < 0.05$ .

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