# Effects of concurrent activiation potentation induced by customized mouth guard on baseball and softball performance

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**Project summary**
This study recruited 45 baseball and softball players, including 30 fielders and 15 pitchers. Using a randomized crossover experimental design, the study was divided into randomised divided into customised mouthguards trial (MG) and control trial (CON) without temporal positioning. After the participants wore the mouthguard, they performed the vertical jump and grip strength tests sequentially. At the end of the test, depending on the pitcher or fielder, a baseball pitching ability test or a hitting ability test was conducted using a radar baseball tracking system. It is expected to analyze the vertical jump height, grip strength, pitchers' straight and changeup ball speeds, rotation speeds, degree of displacement, on-base and off-base locations. Hitting ability was expected to be documented with respect to initial velocity, elevation, and consistency of elevation.

**Key word:** concurrent activation potentiation, athletic performance, bite force

## Introduction

Concurrent Activation Potentiation (CAP) is a strategy that synchronizes voluntary contraction of remote and target muscles through remote voluntary contraction (RVC), resulting in an increase in contractile capacity of the target muscles, which in turn facilitates exercise performance (1). Possible physiological mechanisms contributing to CAP include increased alpha motor neuron activity, stimulation of myoclonic changes, motor cortical overflow theory, and inhibition of presynaptic inhibition. The most widely recognised theories are motor cortical overflow and inhibition of presynaptic inhibition (2). CAP can be achieved by using either single or multiple RVC muscle groups. The most commonly used muscle group is jaw clenching. The activation of the motor cortex area responsible for controlling the musculature of the jaw is known to trigger the activation or strengthening of the motor cortex area of the arms and legs, consequently leading to enhanced muscle contraction in these extremities (2).

Recent studies have indicated that the utilization of customized mouthguards may serve as an effective strategy to enhance the contraction of temporomandibular joint muscles, thereby improving the CAP effect (3). The use of customised mouthguards improves the CAP effect and enhances maximum isometric grip strength (4, 5), the force and height of vertical jump (4, 6-8), increases explosive power, muscle strength (3) and improves sprinting ability over short distances (8). It appears that the use of customised mouthguards may have an effect on improving the performance indexes of the explosive type of sports. However, there was no study that have examined the effects of using customised mouthguards on the performance of baseball pitcher.

For baseball pitchers, the fastball velocity and the sharpness of breaking ball are important indicators of pitching performance. For indicators of muscular strength and physical performance, excellent pitchers (e.g., MLB) generally have better indicators of these pitches, as well as better lower extremity explosive strength and upper extremity strength (9). However, the extent to which increasing the bite force through customized mouthguards can enhance the muscle strength and athletic performance of baseball pitchers remains to be investigated. The purpose of this study is to investigate whether the use of customised mouthguards is effective in improving the athletic performance of baseball and softball performance.

## Methods

### Study design

This study used a randomised crossover experimental design in which participants were randomised to complete a customised mouthguards trial (MG) and a control trial (CON)

without mouthguards. Participants were tested for grip strength, counter movement jump, and baseball pitching ability with (MG) or without mouthguards (CON). During the study, the participants maintained a training schedule of 6 days and 1 day of rest. The study was conducted on the next day after the seventh day off to avoid training or fatigue factors affecting the accuracy of the experiment.

**Participants**

25 professional baseball and softball players were recruited for this study. The inclusion criteria for this study were: (i) has won the top 8 national level baseball of softball championships in the last three years. (ii) no cardiovascular and joint diseases. (iii) aged 20 or above who are adults. (iv) continuing to train professionally more than 5 days a week for the past year. The exclusion criteria for this study were: (i) have not won the top 8 national baseball or softball championships in the past three years. (ii) have a cardiovascular or joint disease, or any injuries that may be impaired by exercise. (iii) participants who are underage or not in regular baseball or softball training. (iv) have injury to the temporomandibular joint. Prior to involvement in the study, participants are provided with a participant consent form to sign after receiving comprehensive information regarding the study and its potential risks. This study received approval from the Institutional Review Board of Jen-Ai Hospital - Dali Branch (202300083B0). All experiments were carried out in a covered playground stadium. This study was conducted following the Declaration of Helsinki.

**Protocol**

Approximately one month prior to the commencement of the experiment, participants were referred to a dentist for a dental diagnosis. A customized mouthguard was subsequently fabricated. All participants were required to perform the same test at least 2 times before the formal test to familiarize themselves with the content of the formal test. Participants were examined by a dental professional to check the alignment of the teeth, obtain the distribution of occlusal forces using a special occlusal plate, and make dental molds. After the customized mouthguards are completed, the test begins.

All tests began at 3:00 p.m., which is the baseball team's daily practice time. Participants recorded the first warm-up, including all dynamic stretches, sprints, and number of pitches, and performed the same warm-up in the next experiment. After a personalized warm-up, participants were randomly fitted with customized mouthguards (MG trial) or without mouthguards (CON trial), and tested for bite force, grip strength, counter movement jump and pitching test in sequence.

**Outcome measure**

Bite force was measured using a pressure-sensitive occlusion plate (GC Dental Prescale II) and subsequently scanned with a Bite Force Analyzer. Prior to the experimental phase, the subjects were familiarized with the protocol by first handling the plastic wrapping within the bag of the bite plate. They were then instructed to bite down with maximum force for a duration of ten seconds, thereby replicating the instructed scenario. The operator then selected the appropriate bite plate size (S, M, or L) and positioned it within the subject's oral cavity, replicating the initial procedure. The scanning process was conducted within approximately ten minutes with the bite plates stored in their original packaging to prevent light exposure during preparation and scanning. GC Prescale II bite plates were maintained in environments with controlled light and temperature (5°C) to ensure material stability.

In the grip strength test, the participant should stand with their feet separated to the width of their shoulders, their hands in a natural and unstretched position, and the grip strength meter (Smedlay's Hand Grip Dynamometer TTM, Japan) (10) held at the second knuckle. The researchers verbally reminded the participants to clench their jaws with all their strength while gripping the grip strength meter with all their strength. Participants were then performed two maximal grip strength tests with the dominant hand and the non-dominant hand, with a 1-minute break in between each test. The value is presented as the average of two sums of hands.

Jump height of counter movement jump was measured in this study using the SmartJump contact mat (Smartjump, Fusion Sport, Sumner Park, Queensland, Australia) measurement monitoring system (11). The participant assumes a standing posture on a mat with arms crossed, and is verbally prompted to clench their jaws and propel themselves upward with maximal force while simultaneously descending until their thighs are in a parallel position with the ground. Vertical jumps were performed three times, each time with a one-minute rest, and the average value of the three times was analyzed.

In this study, pitching ability was analyzed using Rapsodo pitching 2.0 (Rapsodo Baseball System, Rapsodo Inc, Fishers, IN) (12). After a full warm-up, participants were given a pitching test of 10 fastballs and 5 sliders. According to statistics data from Statcast Search website (https://baseballsavant.mlb.com/statcast_search), major league pitchers throw about 15 pitches per inning, including 61% fastballs and 39% breaking ball. Based on this data, the pitcher was asked to throw 15 pitches, including 10 fastballs and 5 sliders, with 15 seconds of rest between each pitch. Recorded ball speeds and

spin rates of fastballs and sliders for subsequent analysis.

**Fabriction of mouthguards for participants**

The customized mouthguard in this study was made by a professionally trained dentist. The impressions were made with alginate (GC Aroma Fine Plus Normal Set Alginate), following the manufacturer's guidelines to the best of our ability. The pouring was executed immediately after the impression was made with dental stone (GC Fujirock EP Type 4 Dental Stone) in accordance with the manufacturer's instructions and using a dental laboratory vibrator. The vibrator was utilized to eliminate air pockets within the dental stone, as these pockets have the potential to induce imperfections in the cast model.

The customized mouthguard was vacuum formed using a dental stone model as a mold. A thermoformed mouthguard material, copolyester (Keystone Pro-Form vacuum forming materials, 0.5 mm), was utilized to overlay the dental stone. The fabrication of MG in maximum intercuspation involves the utilization of a dental stone cast derived from alginate, which is subsequently overlaid on top of the thermoformed material following a heating process (Figure 1).

**Statistical Analysis**

All data are presented as means ± standard deviations. The Shapiro–Wilk test was employed to evaluate the normality of the data distribution. The bite force, grip strength, counter movement jump and pitching test were employed to analyses the through paired t-tests. Effect sizes were calculated using Cohen's d to quantify the magnitude of observed effects 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). All data were calculated using SPSS (version 20, Chicago, IL, USA), and the significance level was $p < 0.05$.

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