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The Effects of Concurrent Activation Potentiation on Bat Swing Velocity of Division II College Softball Athletes

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ABSTRACT

International Journal of Exercise Science 13(1): 1630-1637, 2020. As an ethical and practical ergogenic strategy, concurrent activation potentiation (CAP), achieved by remote voluntary contractions (RVC) such as jaw clenching, has been proposed to acutely enhance muscular and athletic performance characteristics. The effects of CAP on bat swing velocity (BSV), an important component for successful hitting in sports such as baseball and softball has yet to be reported in the literature. The purpose of this research was to examine the effects of maximal jaw clenching on BSV in collegiate division II softball players. Thirteen (n = 13) division II softball athletes volunteered to participate in this study. Subjects completed five maximal effort swings targeting a softball on a tee during two experimental conditions: jaw musculature maximally clenched and relaxed jaw musculature. An inertial measurement unit (Zepp Sensor, Zepp Labs, Inc.) attached to the knob of the bat recorded BSV and all trials for each experimental condition were averaged for analysis. Paired sample t-tests were used to determine differences between the two conditions. Mean BSV was 28.02 m/s (62.68 mph) for the jaw relaxed condition and 29.42 m/s (65.82 mph) for the jaw clenched condition, producing a statistically significant mean difference of 1.4 m/s (3.14 mph) (p = 0.003). Maximal jaw clenching is an effective strategy to improve BSV in division II college softball players.

KEY WORDS: Batting, ergogenic strategy, female, hitting, jaw clenching, performance

INTRODUCTION

A primary focus in the sporting community is the pursuit of ethical and practical approaches to improve athletic performance. Concurrent activation potentiation (CAP) is an ergogenic phenomenon proposed to enhance muscular performance characteristics of prime movers through remote voluntary contractions (RVC) executed during the activity of interest (1, 9, 10). RVC is voluntary activation of musculature not involved in the action facilitated by the prime movers (6).

RVC strategies range from single RVC, where only one muscle group is remotely activated, to aggregate RVC, where multiple muscle groups are remotely activated simultaneously. Maximally activating jaw musculature, through clenching or opening, is the most effective single RVC strategy leading to enhanced muscular performance characteristics (2–4, 10, 12, 16).

Muscular performance characteristics improved by jaw clenching and opening RVC include peak force, time to peak force, rate of force development, mean and peak knee extension torque, rate of torque development, and muscular activation in various performance activities (2-4, 10, 12, 16). When combined with jaw clenching, fist clenching (forceful gripping) and the Valsalva maneuver have been effective as aggregate RVC to improve peak force and rate of force development, mean and peak knee extension torque, and muscular activation (11-13, 16).

Although considerable evidence exists supporting CAP as an efficacious approach to performance improvement, the demonstrated increases in muscular performance characteristics have not always translated to improved athletic performance outcomes. For example, Ebben and colleagues demonstrated that jaw clenching enhanced time to peak force and rate of force development during the vertical jump, but jump height, and possible differences in jump height between conditions, was not reported (10). Other studies examining CAP effects on a variety of performance variables have also failed to demonstrate performance enhancement potentially as the result of methodological differences or proposed gender differences in CAP response (6, 14, 15, 19). Additionally, many of the investigations that have shown performance increases resulting from CAP have done so during isometric and isokinetic assessments (3, 4, 12, 13, 16). This has led some to question the ecological validity of CAP to traditional sport and athletic performance (19). While some studies do demonstrate athletic performance outcome improvement via CAP (mainly jump height during various jumping activities), this lack of consistent results in the literature denotes the need for further CAP investigation with particular regard to its ability to improve athletic performance outcomes as well as to elucidate the most effective RVC implementation strategies (3, 11, 18).

Bat swing velocity (BSV) is an important component for successful hitting in baseball and softball (7, 8, 22, 25). Ideally, bat-ball impact will occur when the bat reaches its peak rotational velocity because greater BSV would result in greater batted ball exit speed. In addition to increasing batted-ball velocity, increasing BSV decreases swing time allowing the batter more time to decide whether or not to swing (25). Collectively, these factors optimize the batter’s chance of a successful hitting outcome. Therefore, assuming a batter maintains proper swing mechanics, increasing BSV is an effective strategy to pursue in attempt to improve hitting performance.

Various warm-up equipment for the purposes of improving BSV, such as weighted donut rings for bats or weighted gloves, are commercially available, and athletes across multiple levels of the game employ such products. However, research demonstrates that such equipment is largely ineffective at improving BSV beyond warming up with a standard game bat (23, 24, 26). The authors of these studies suggest that individuals use the specific equipment they most prefer given that results were not significantly different (23, 24, 26).

Since previous research has been unable to determine clear and effective methods to improve BSV through implementation of various weighted equipment, additional research is necessary to elucidate effective BSV improvement strategies. It is possible that RVC utilized during hitting performance could improve BSV lending credence to the ecological validity of CAP and providing an effective strategy to improve BSV. Therefore, the purpose of this study was to examine the effects of CAP through maximal jaw clenching on BSV in division II collegiate softball players. The authors hypothesized that BSV would be improved through maximal jaw clenching.

METHODS

Participants

Participants were female, division II softball athletes at a small private college in the southeast. The 2019 team roster consisted of 19 athletes. Of those athletes, 16 were players who regularly had in-game at-bats and/or participated in regular batting practice. Thirteen of those players volunteered to participate in this research. Participant demographics are presented in Table 1. All were injury free at the time of data collection, which occurred late in the fall semester, during the team's off-season. Participants provided written informed consent prior to participation and the Institutional Review Board at Florida Southern College approved the research protocol. This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (20).

Table 1. Participant Demographics

Age	19.79 ± 1.31 years
Height	167.69 ± 6.91 cm
Mass	68.23 ± 8.68 kg

Protocol

A stadiometer was used to measure participant height and mass, and participant age was self-reported. Following a brief dynamic warmup, researchers instructed participants to complete their typical on deck warmup routines as if preparing for a competition at-bat, and a self-determined number of practice swings were completed. When ready, participants completed ten maximal effort swings targeting a softball on a tee. Tee height, tee placement, and bat used were determined by player preference and although they varied between participants, they remained consistent for all individual swing attempts. Participants performed five swings while maximally clenching the jaw (RVC condition) and five swings with relaxed jaw musculature (control condition). Researchers instructed participants to breathe through pursed lips during the control condition. Pursed lip breathing has been effectively utilized in previous research to limit participant ability to clench the jaw musculature (2, 10, 11, 19). A 30-second rest period was provided between swing attempts. Experimental conditions were counterbalanced between participants to minimize possible order effects.

BSV was recorded using an inertial measurement unit (Zepp Sensor, Zepp Labs, Inc.) attached to the knob of the bat. Researchers recalibrated the sensor prior to each new participant's swing attempts. This device was previously demonstrated to produce excellent within and between session reliability measurements (5).

Upon completion of each swing attempt, the researchers asked participants to confirm whether the experimental condition was completed correctly. If participants reported a sub-maximal effort swing, jaw clenching during the relaxed jaw musculature condition, or failure to execute maximal jaw clenching during the experimental condition, the trial was repeated. Another trial was also conducted if the Zepp Sensor failed to register the BSV of a swing attempt. Recorded BSVs for each condition were averaged for analysis. One participant repeated one swing trial during the control condition due to self-reporting uncertainty of maintaining a relaxed jaw during the swing trial. Two additional participants repeated one swing trial each, and another participant repeated several swing trials as the result of the Zepp Sensor not recording a BSV. These repeated trials occurred following 30-seconds of rest and were included in data analysis.

Statistical Analysis

An a priori significance level of $p \leq 0.05$ was determined. The Shapiro-Wilk normality test was applied to data from each experimental condition to determine distribution normality. Paired sample t-tests were employed to determine the differences between the jaw clenched and jaw relaxed conditions. Effect size was calculated and expressed as Cohen's *d*. These statistical procedures were conducted using IBM statistics package software, version 21.0 (IBM SPSS Software; Armonk, NY, USA). A post-hoc power analysis was conducted using G*Power software version 3.1 (Universitat Kiel, Germany).

RESULTS

Experimental data sets were normally distributed. Achieved statistical power was 0.94. Mean swing velocity for the relaxed jaw musculature condition was 28.02 m/s (62.68 mph) and 29.42 m/s (65.82 mph) for the jaw clenched condition. This produced a statistically significant mean difference of 1.4 m/s (3.14 mph) ($p = 0.003$; $d = 1.05$). Individually, ten of the 13 participants had higher BSV under the jaw-clenched condition than the control (Figure 1).

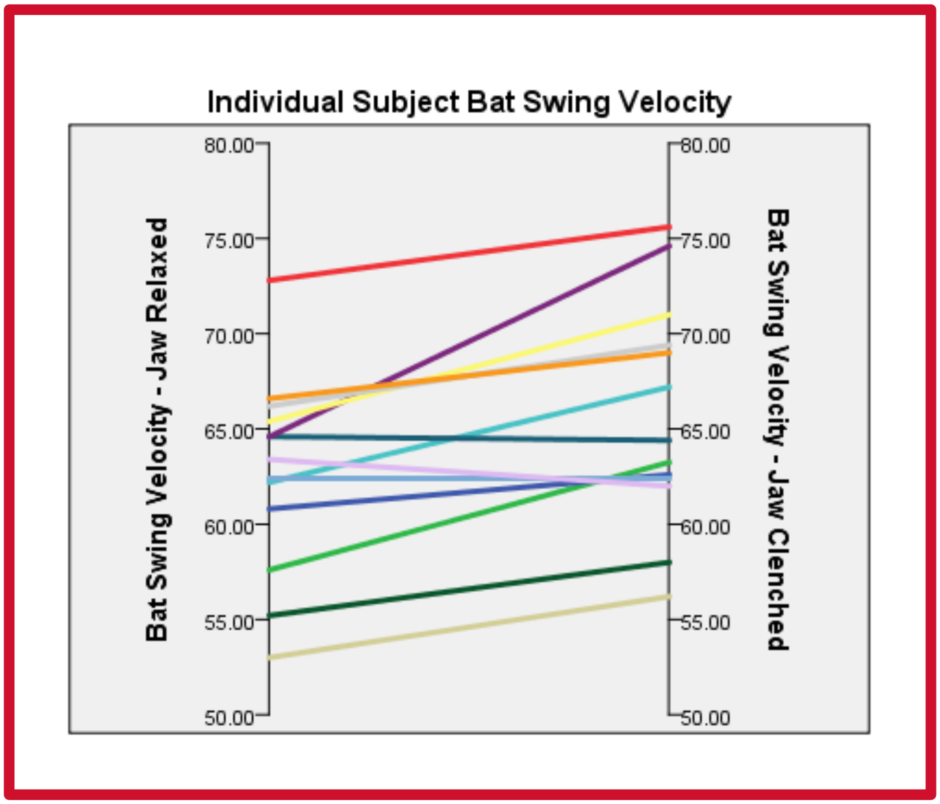

Figure 1. Individual participant bat swing velocity.

DISCUSSION

The results of this research demonstrate that maximal jaw clenching is an effective ergogenic tactic to improve BSV in female Division II college softball athletes. This improvement is presumably achieved through enhancement of muscular performance characteristics. These results support the use of maximal jaw clenching as a single RVC strategy to produce CAP and enhance specific athletic performance outcomes.

The present research adds to the literature supporting CAP as a practical ergogenic approach to improve athletic performance outcomes. Allen demonstrated a statistically significant enhancement in vertical jump height as the result of maximally opening the jaw in male subjects (3). Ebben and colleagues observed a 26% increase in jump squat height resulting from a combination of RVC including jaw clenching, hand gripping, and the Valsalva maneuver (11). Issurin and Verbitsky saw an improvement in swimming race start efficiency of 0.08 s over the initial 15-m of a race, which the authors suggest is the result of increased rate of force development in takeoff and greater flight distance (i.e. better jumping performance) (18). The current study revealed increased BSV resulting from CAP, broadening the potential sporting and athletic activities in which RVC implementation may benefit performance.

While this is the first study to examine the effects of CAP on BSV, it is not the first to examine the impact of CAP on velocity performance. Gallegos and colleagues investigated the effects of maximal jaw clenching on soccer kick and throw-in velocity in 14 females with recent competitive soccer experience (15). There were no differences in kick or throw-in velocity between RVC and control conditions. Authors suggested that CAP has only led to performance improvements in "simple" tasks, and the chosen soccer kick and throw-in assessments were too complex for CAP realization. Additionally, it was suggested that implementation of RVC from a combination of musculature, rather than jaw clenching alone, may have led to positive changes in velocity performance. The results of the present study contradict those of Gallegos and colleagues. Hitting is a complex, multi-joint, rotational movement, where BSV improved approximately 5% on average by maximally clenching the jaw while executing the swing. Unlike the soccer kick and throw-in, which generally involve a run-up approach, softball athletes are generally stationary before swinging a bat with the exception of slap hitters. Even though the soccer kick and throw-in velocity was unchanged as the result of jaw clenching, muscular characteristics such as peak force or muscular activation might have been positively affected, but these variables were not measured (15). This occurrence has been observed in other studies where muscular characteristics were improved through RVC, but performance of the assessment activity remained unchanged (2, 10). Still other investigations have reported that the CAP phenomenon has no discernable benefit, but methodological inconsistencies in RVC implementation have been proposed to explain the lack of changes in performance (1, 6, 19, 21).

Another interesting finding from the current study is that CAP was an effective ergogenic strategy for females. This is the first investigation of CAP yielding positive, statistically significant results in an all-female sample (14, 15). Previous research on mixed gender participants has revealed differences in response to CAP with males benefiting more than females (3, 13, 16). These gender differences have been attributed to differing levels of RVC muscular activation in males compared to females, supporting the notion that the magnitude of CAP achieved is a result of the quantity of RVC muscular activation (13, 16). Although muscular activation was not measured in the current investigation, the improved BSV suggests that adequate RVC muscular activation levels were achieved for CAP to benefit performance.

The concept of responders and non-responders to CAP has also been suggested in the literature, and provides an alternative explanation to individual response differences to CAP (17). Mullane and colleagues examined single and combination RVC strategies and their effects on muscular performance variables during vertical jump assessment (19). Although there were no statistically significant differences between conditions, 17 of the 24 male participants had greater peak force during the combination RVC (jaw and fist clenching) condition compared to the control condition. In the present study, 10 of the 13 participants responded positively to CAP while three participants experienced little to no change while jaw clenching. This individual variability in CAP response demonstrates the need for coaches and athletes to assess performance under various RVC conditions to determine if CAP is an appropriate ergogenic approach to pursue, and which RVC strategies work best, if at all, for each athlete.

BSV is only one component of hitting. Reaction time, hand-eye coordination, swing mechanics such as bat angle at impact and attack angle as well as pitch velocity and location are just a few of many factors that can impact hitting performance. This study examined the jaw clenching RVC effect on BSV, demonstrating an ergogenic effect of increased BSV, therefore increasing a batter's chance of a successful at-bat (25). As previously stated, not all individuals respond in the same manner to RVC strategies, but coaches can encourage their athletes to incorporate RVC strategies into their hitting approach and assess whether there is a positive effect on each individual's BSV. Due to parallels between hitting in softball and baseball, baseball players are also likely to experience an increase in BSV by utilizing the jaw clenching RVC strategy. Athletes in sports such as golf, cricket, tennis, and other sports may also benefit from the appropriate incorporation of RVCs such as jaw clenching while swinging their respective sporting implements. Additional research is necessary to confirm these inferences.

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