

Maximal Jaw Opening as a Method of Producing Concurrent Activation Potentiation

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ABSTRACT

Purpose: The purpose of this study was to examine maximal jaw opening as a strategy to elicit concurrent activation potentiation during countermovement vertical jump performance and bilateral grip strength assessment in both males and females. **Methods:** Twenty-four males (age 21.25 ± 1.45 years; height 177.64 ± 7.67 cm; mass 83.87 ± 9.08 kg) and 24 females (age 21.38 ± 2.12 years; height 165.84 ± 8.96 cm; mass 66.4 ± 13.42 kg) participated in this investigation. Maximal countermovement jump height was recorded using a Just Jump Mat, and dominant and non-dominant handgrip strength was recorded using a digital hand dynamometer under two experimental conditions: jaw relaxed and jaw maximally opened. Paired-sample t-tests were conducted for each dependent variable of interest to determine the differences between the research conditions. **Results:** Maximally opening the jaw led to improvements in vertical jump height ($p = 0.013$, $d = 0.225$), dominant hand ($p = 0.028$, $d = 0.162$), and non-dominant handgrip strength ($p = 0.011$, $d = 0.241$) in males, and although these variables were improved in females under the jaw open condition, that improvement did not reach statistical significance ($p > 0.05$). **Conclusion:** This study supports maximally opening the jaw as an effective strategy for producing concurrent activation potentiation, particularly in males.

Key words: Remote Voluntary Contraction, Vertical Jump, Hand Strength, Ergogenic, Concurrent Activation Potentiation

INTRODUCTION

The use of remote voluntary contractions (RVC) to produce concurrent activation potentiation (CAP) is a performance enhancement strategy to acutely increase force production characteristics during physical exertion (Allen et al., 2016; Allen et al., 2018; Busca et al., 2016; Ebben et al., 2008a; Ebben et al., 2008b; Ebben et al., 2010a; Ebben et al., 2010b; Garceau et al., 2010; Garceau et al., 2012; Hiroshi, 2003). CAP has been defined as the ergogenic advantage of increased prime mover force production characteristics attained through RVC, which is the simultaneous activation of additional musculature not involved in facilitating the movement of interest (Ebben, 2006). Examples of RVC from the literature include maximal jaw clenching, forceful hand gripping, and the Valsalva maneuver.

Research examining the effects of various types and combinations of RVC on force production characteristics has revealed largely positive results during a number of forceful exertion activities. The combination of jaw clenching, bilateral gripping, and the Valsalva maneuver improved isometric (Garceau et al., 2012) and isokinetic knee extensor torque (Ebben et al., 2008b), as well as muscle activation during isokinetic knee flexion and extension (Ebben et al., 2010a). This combination of RVC also improved multiple force variables during back squat and jump squat exercises as well

as improved jump squat height compared to control conditions (Ebben et al., 2010b). Even single RVC strategies, such as maximal jaw clenching, has been shown to augment peak force (PF) and RFD during grip strength assessment (Hiroshi, 2003), RFD and time to peak force (TTPF) during the countermovement vertical jump (CMVJ) (Ebben et al., 2008a), PF and RFD during the isometric clean pull (Allen et al., 2018), and increased muscle activation during CMVJ (Allen et al., 2016).

While single RVC such as jaw clenching is a highly reproducible strategy for eliciting CAP, it has not always yielded ergogenic results (Cherry et al., 2010; Mullane et al., 2015). It appears that a combination of RVC from multiple muscle groups may be most effective at generating CAP during activities requiring forceful exertion. When single versus multiple muscle RVC were compared, the combined RVC from multiple muscles improved average and peak knee extensor torque to a greater degree than single RVC (Ebben et al., 2008b). However, many of the RVC combinations examined in the literature are not practical or convenient for a variety of activities. There remains a need for identification of alternative CAP producing strategies. These unidentified alternative RVC conditions may be more effective at eliciting CAP in groups where previous CAP strategies have been unproductive.

The basis for jaw clenching as RVC stems from research demonstrating the Jendrassik maneuver's effectiveness at increasing muscular H-reflex activity (Zehr & Stein, 1999). The Jendrassik maneuver involves clenching the jaw, hooking and interlocking the fingers, then attempting to pull the hands apart while the tendon reflex is invoked. However, Takahashi et al. (2001) demonstrated that there was no difference between jaw clenching and jaw opening in regards to soleus H-reflex modulation. Therefore, maximally opening the jaw may be a viable RVC strategy to produce CAP and enhance muscular force production characteristics. Anecdotal evidence from the sport of weightlifting supports this notion. Many athletes, just prior to and during the initiation of the snatch or clean, will open their mouths and jaws wide, possibly for performance purposes. Maximal jaw opening, however, has yet to be investigated as an ergogenic strategy. Therefore, the purpose of this study was to examine maximal jaw opening as a strategy to elicit CAP during CMVJ performance and bilateral grip strength assessment in both males and females. It was hypothesized that maximally opening the jaw would improve vertical jump and grip strength performance when compared to maintaining relaxed jaw musculature in both genders.

METHODS

Participants and Design

Twenty-four males (age 21.25 ± 1.45 years; height 177.64 ± 7.67 cm; mass 83.87 ± 9.08 kg) and 24 females (age 21.38 ± 2.12 years; height 165.84 ± 8.96 cm; mass 66.4 ± 13.42 kg) participated in this investigation. All participants were involved in intercollegiate or recreational athletics as well as resistance training exercise at a frequency of three sessions per week for at least three months. All participants self-reported as illness and injury free at the time of testing, and all signed University approved Institutional Review Board informed consent documents.

This study examined the effects of maximal jaw opening on CMVJ and bilateral grip strength performance. Each participant performed CMVJ and grip strength assessment of dominant and non-dominant hands under the experimental and control conditions during a single data collection session. The two conditions, maximal jaw opening (experimental) and jaw relaxed (control), were counterbalanced between participants to negate any potential order effect. Participants were instructed to breathe as normally as possible throughout all assessments during both experimental conditions to prevent holding the breath (Valsalva maneuver) from confounding the results. To control for jaw musculature activation during the jaw relaxed condition, participants were instructed to breathe through pursed lips for the duration of each vertical jump and grip strength assessment trial. Pursed lip breathing is believed to limit jaw musculature activation and is consistent with previously published research (Allen et al., 2016; Allen et al., 2018; Ebben et al., 2010a; Garceau et al., 2012). Following the completion of each assessment trial, participants were asked whether they maintained the required breathing pattern and whether their jaw musculature

activation was maximal or remained relaxed. If the participant indicated a violation, the trial was repeated.

Procedures

The data collection session began with the participant providing written informed consent. Basic anthropometric measurements including age, height, and weight were recorded. Subjects then completed a brief dynamic warm-up followed by CMVJ and grip strength assessment demonstration and submaximal practice. Participants then completed the maximal CMVJ and grip strength assessments under the first experimental condition. A ten minute period of quiet rest was provided for each participant to ensure complete recovery from the initial bout of assessments. Following this rest period, the participants repeated the assessments under the remaining experimental condition.

Vertical jump assessment consisted of three maximal effort, countermovement vertical jump trials. All trials were performed on the Just-Jump mat (Probotics, Inc.; Huntsville, AL, USA). Participants were instructed to complete each jump trial without moving the feet prior to take off, to keep hands located on the outside of the waist, and to ensure they landed safely back on the mat. Approximately thirty seconds of rest between jump trials was afforded each participant. The trial producing the highest jump was selected for analysis.

Grip strength was assessed using a Takei 5401 Grip-D digital hand dynamometer (Creative Health Products, Inc.; Ann Arbor, MI, USA). Dominant handgrip strength was assessed first, followed by non-dominant hand assessment. While standing with the wrist in neutral position, arms at sides but not touching the torso, and the elbow flexed to approximately 90 degrees, the participants gripped the dynamometer and completed each trial. Participants were instructed to apply consistent force to the handle for up to three seconds or until no additional force could be applied. A thirty second rest period between each trial was provided. If the difference in measures between any two trials was greater than 3kg, a fourth trial for that respective hand was provided. Participants' trials with the greatest force were selected for further analysis.

Statistical Analyses

Data for each gender and experimental condition were tested for distribution normality using the Shapiro-Wilk statistic. Paired-sample t-tests were implemented for each dependent variable of interest to determine the differences between the relaxed jaw and maximally opened jaw conditions. Independent samples t-tests were utilized to test gender differences for each measured variable under both experimental conditions. A significance level of $p \leq 0.05$ was set *a priori*, and effect size was calculated and expressed as Cohen's *d*. Sample size was also determined *a priori* using G*Power 3.1 software (Faul et al., 2009). All other statistical processes were conducted using IBM statistics package software, version 21.0 (IBM SPSS Software; Armonk, NY, USA).

RESULTS

All data were normally distributed. For all variables and experimental conditions, male performance was different (greater) than females. Those differences were all statistically significant ($p < 0.001$). Mean vertical jump height and bilateral grip strength values for males and females are presented in Table 1 below. Maximally opening the jaw led to statistically significant improvements in vertical jump height ($p = 0.013$, $d = 0.225$), dominant hand ($p = 0.028$, $d = 0.162$), and non-dominant handgrip strength ($p = 0.011$, $d = 0.241$) in males. Jump height, dominant hand, and non-dominant handgrip strength was improved in females under the jaw open condition, but that improvement did not reach statistical significance ($p > 0.05$). Mean assessment results for males and females are presented in Table 1.

DISCUSSION

This is the first study to test maximal jaw opening as a strategy to induce CAP. Results indicate that opening the jaw maximally is a viable strategy to augment CMVJ as well as grip strength performance, particularly in males. These grip strength assessment results are consistent with the findings of several previous investigations of the effects of CAP on isometric muscular performance, and the CMVJ assessment results add to the evidence that RVCs can be effective at eliciting CAP during dynamic activity.

Handgrip

Hiroshi (2003) demonstrated that peak force and rate of force development were significantly improved when jaw clenching was employed just before and during dominant handgrip strength assessment in male participants. Peak force and rate of force development were also improved during maximal isometric clean pull performance (Allen et al., 2018). Additionally, Busca et al. (2016), while investigating the effects of jaw clenching and bite-aligning mouthpieces on strength, reported a significant improvement in dominant handgrip strength performance when male participants maximally clenched the jaw compared to not clenching. In the current investigation, maximal jaw opening led to significant increases in both dominant and non-dominant handgrip strength in male participants.

Vertical Jump

Likewise, some previous investigations have demonstrated increased performance characteristics as the result of CAP during jumping activities (Ebben et al., 2008a; Ebben et al.,

2010b). One investigation demonstrated improved jump squat height under RVC compared to no RVC conditions (Ebben et al., 2010b). Another showed enhanced RFD and time to peak force during the CMVJ (Ebben et al., 2008a). Conversely, other investigators have reported no significant impact of CAP strategies on CMVJ performance (Mullane et al., 2015). The current investigation revealed a significant increase in CMVJ height for males when maximal jaw opening was employed. The discrepancy between the outcomes of these investigations may be explained by a difference in research procedures, specifically with the timing of RVC implementation relative to the jump initiation. Previous research has demonstrated that the time course of action of CAP ergogenic effects occurs within the first 1000ms of RVC initiation (Garceau et al., 2010), meaning that initiating RVC strategies too soon would lead to the ergogenic effects of CAP dissipating prior to the initiation of the performance activity. The investigation reporting no CMVJ performance improvements as the result of CAP had participants initiate RVC conditions three seconds prior to CMVJ initiation (Mullane et al., 2015). It is possible that this methodological choice led to the CAP benefits not being realized and demonstrated. The current investigation, as well as the investigations by Ebben et al. (2008a; 2010b), required participants to initiate RVC conditions simultaneously with performance activities.

CAP and Females

The lack of statistically significant force variable improvements from RVC in females has led some researchers to suggest that the use of RVC to elicit CAP and subsequently improve performance is only an effective strategy for males. There is some supporting evidence to this notion. Garceau et al. (2012) demonstrated that the CAP present as the result of RVC is proportionate to the amount of muscle activation involved in RVC generation. Several studies have shown that aggregate RVC from multiple muscle groups led to greater levels of CAP compared to single site RVC (Ebben et al., 2008b; Ebben et al., 2010a; Ebben et al., 2010b; Garceau et al., 2012). Gender differences in muscle activation of both prime mover musculature as well as musculature involved in generating RVC has been reported (Garceau et al., 2012). The CAP dependence upon the amount of remote muscle activation and the fact that males have demonstrated greater muscle activation of both prime mover and RVC musculature, may explain the lack of statistically significant ergogenic improvement in female participants.

Another explanation, at least in part, for the lack of significant performance improvement in female participants

Table 1. Jump height and grip strength

	Jump height (cm)		Dominant hand grip strength (kg)		Non-dominant hand grip strength (kg)	
	Jaw open	Jaw relaxed	Jaw open	Jaw relaxed	Jaw open	Jaw relaxed
Males (n=24)	52.95±5.91*	51.66±5.85	41.76±7.50*	40.56±7.65	41.52±7.38*	39.75±7.64
Females (n=24)	39.88±4.41	39.04±5.04	28.45±4.64	28.24±4.19	28.40±4.56	27.83±4.58

Data are expressed as mean±standard deviation. An asterisk (*) indicates a significant difference ($p < 0.05$) between jaw conditions

in this study may be related to the motor control concepts of attention as a limited resource, focus of attention, and automaticity. When an individual attempts to perform two tasks simultaneously, both tasks draw on the participant's attention, particularly when one or both of those tasks are novel. In such cases, performance of either one or both tasks is deleteriously affected (Kahneman, 1973). While it has been stated that maximal jaw clenching is fairly common during physical exertion requiring high levels of force production (Ebben, 2006; Ebben et al., 2008a), maximal jaw opening is a decidedly novel task for most individuals to perform during sport and physical activity performance. This task novelty (lack of automaticity) requires greater focus of attention for execution, which can undesirably affect performance of the primary task. It is possible that the attention required to maximally open the jaw while maximally jumping or gripping impacted performance enough to preclude CAP benefits. Conversely, if participants focused more on jumping and gripping performance, maximal jaw muscle activation may not have been achieved, preventing CAP manifestation. This proposed explanation for the observed outcome differences is not gender specific, which makes the results of the current investigation perplexing. However, it is possible that CAP from maximal jaw opening was sufficient to overcome these potential motor control issues in males but not females, due to the previously discussed gender differences in prime mover and remote muscle activation (Garceau et al., 2012). Future investigations should account for the novelty of RVC strategies through purposeful familiarization and measurement of RVC musculature activation when possible.

It should be noted that although maximal jaw opening did not lead to performance improvements in female participants, it did not negatively influence performance either. Future research should compare maximal jaw opening to other established RVC strategies such as maximal jaw clenching to determine if one strategy more effectively develops CAP than another.

CONCLUSIONS

For males, maximally opening the jaw is an effective RVC strategy for producing CAP during the CMVJ and grip strength assessments. Therefore, it may be an effective strategy during other explosive and high force activities as well. Coaches can encourage their athletes to employ maximal jaw opening as an ergogenic strategy as this technique does not appear to negatively impact performance, although consideration of individual variability is warranted. Depending upon athlete comfort and familiarity, maximal jaw opening may be an effective alternative for athletes with sensitive teeth who may wish to avoid jaw clenching.

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