THE ACUTE TIME COURSE OF CONCURRENT ACTIVATION POTENTIATION

Luke R. Garceau[1], Erich J. Petushek[2], McKenzie L. Fauth[1], and William P. Ebben[1, 3]

Department of Physical Therapy, Program in Exercise Science, Strength and Conditioning Research Laboratory Marquette University, Milwaukee, WI, USA[1]
Department of Health, Physical Education, and Recreation, Northern Michigan University Marquette, MI, USA[2]
Department of Health, Exercise Science & Sport Management, University of Wisconsin-Parkside, Kenosha, WI, USA[3]

This study evaluated the acute time course of the ergogenic effect of concurrent activation potentiation (CAP). Forty-two men and women, including CAP non-responders and responders, performed a 5 second isometric knee extension on a dynamometer with the use of remote voluntary contractions (RVC). Mean torque was assessed in seven 500 millisecond (ms) time periods. A two-way repeated measures ANOVA revealed significant main effects for time period ($p \leq 0.001$), but no significant interaction between time period and CAP non-responders and responders ($p > 0.05$). The ergogenic effects of CAP are accrued during the first 1000ms. Concurrent activation potentiation responders produce greater initial force than the CAP non-responders, without a concomitant acceleration in force decay throughout the time course.

KEYWORDS: strength, power, latency, Biodex, motor overflow

INTRODUCTION: Sustaining enhanced muscle performance is the primary goal of strength and conditioning programs. Ergogenic strategies have been sought and the phenomenon of concurrent activation potentiation (CAP) has shown promise. Concurrent activation potentiation is believed to increase prime mover muscle activation during the simultaneous contractions of muscles remote from the prime mover via motor overflow (Ebben, 2006). These simultaneous contractions are defined as remote voluntary contractions (RVC). Previous research assessing the effects of CAP have demonstrated increases in torque during isometric testing (Ebben et al., 2008b) and force development during the countermovement jump (Ebben et al., 2008a). To date, the time course of the ergogenic CAP effect has yet to be examined.

Computerized dynamometry is a commonly used and reliable tool to measure muscular performance of the knee (Surakka et al., 2005) producing variables of power, work, rate of torque development (RTD), and peak torque. Research examining the effects of RVC on peak torque have demonstrated an 8.9% increase in isokinetic knee flexion for men, compared to a condition without the use of RVC (Ebben et al., 2010b). Knee extensors have also been examined isokinetically and have shown peak torque increases of 8.4 (Stumbo et al., 2001) and 10.6% (Ebben et al., 2010b) for men and 4.2% (Ebben et al., 2010b) for women during conditions when RVC were used. Additionally, mean and peak torque increases of 14.6 and 14.8%, respectively, were demonstrated during an isometric knee extension with the simultaneous use of RVC (Ebben et al., 2008b). These studies confirm that torque is greater in the presence of RVC but do not explain the duration of this advantage.

Research evaluating the effect of RVC on RTD and rate of force development (RFD) provide some evidence that the ergogenic effect of CAP may occur early during dynamic movements. Various durations of force development have been used to assess CAP's effect: RTD of the first 300ms (Ebben et al., 2010b), RFD of the first 100ms (Ebben et al., 2010a), RFD of the concentric phase (Ebben et al., 2008a), RFD to peak force (Ebben et al., 2010a), and time to peak force during the concentric phase (Ebben et al., 2008a), all resulting in RVC aided performance increases of 14.6, 32.2, 19.5, 8.2, and 20.2%, respectively. Therefore, it can be hypothesized that CAP's ergogenic effect is accrued quickly.

Thus, the purpose of this study was to assess RVC on mean torque during 500ms time periods of isometric knee extension in CAP non-responders and responders, in order to investigate the time course of the ergogenic effect of CAP.

METHODS: Forty-two subjects participated in this study who were previously classified as CAP non-responders (N=11; mean ± SD, age 20.9 ± 1.9 yr; body mass 69.7 ± 9.8 kg) and responders (N=31; mean ± SD, age 21.3 ± 1.6 yr; body mass 75.7 ± 12.0 kg). Inclusion criteria consisted of at least 2 months of biweekly participation in lower body resistance training with exercises that included knee extension. Subjects were excluded if they presented any history of knee pathology that resulted in functional limitation of the right leg. All participants competed in NCAA Division I athletics, club, or intramural sports, and had played high school sports. Participants refrained from resistance training for at least 48 hours prior to testing. All were informed of the risks associated with the study and provided informed written consent. The study was approved by the institution's internal review board and designed in accordance with the ethical standards of the Helsinki Declaration.

Subjects warmed up and performed 15 seconds of lower body dynamic stretching for each major muscle group. Subjects were then positioned and secured in a dynamometer (System 4, Biodex Inc., Shirley, NY, USA) according to manufacturer specifications. Straps across the chest, waist, right thigh, and right ankle reduced extraneous movement during the exercise. The right knee joint was positioned goniometrically at 90 degrees and calibrated with the system software and the mass of the limb was measured. Knee joint angle was then adjusted until the software indicated the knee was at 60 degrees of flexion. Test specific warm up sets of two 5 second isometric knee extension exercises at 75 and 90% of their self-perceived maximum ability were then performed. During the exercise, subjects simultaneously used RVC including maximal jaw clenching on a dental vinyl mouth guard (Cramer Products Inc., Gardner, KS, USA), maximal bilateral hand griping using hand dynamometers (model 78010, Lafayette Industries, Lafayette, IN, USA), and the performance of the Valsalva maneuver.

Five minutes of rest were provided between warm up and test sets. Testing consisted of one maximal isometric right knee extension for 5 seconds on the dynamometer with the simultaneous use of the aforementioned RVC. Subjects were instructed to perform maximally.

Isometric torque curves for each subject were analyzed using manufacturer's software. Mean torque was calculated for each of seven 500ms time periods: 0-500, 500-1000, 1000-1500, 1500-2000, 2000-2500, 2500-3000, and 3000-3500, totaling 3.5 seconds. The onset of the 0-500ms time period was identified by the first positive torque value in the torque curve.

All data were analyzed using SPSS 18.0. A two-way repeated measures ANOVA was used to evaluate mean torque, expressed as a percentage of body weight, for the time period and the interaction between the time period for CAP non-responders and responders. Bonferroni adjusted pairwise comparisons were used to assess the specific differences between time periods and CAP non-responders and responders. Statistical power (d) and effect size (η_p^2) are reported and all data are expressed as means ± SD. The *a priori* alpha level was set at $p \leq 0.05$.

RESULTS: The analysis of mean torque, expressed as a percentage of body weight, revealed significant main effects for time course ($p \leq 0.001$, $\eta_p^2 = 0.79$, $d = 1.00$) but no significant interaction between the time course for non-responders and responders ($p = 0.844$). Results of the pairwise comparison are demonstrated in Table 1 and Table 2 in order to provide descriptive data for CAP non-responders and responders, respectively.

Table 1. Mean isometric right knee extension torque as a percentage of body weight (mean ± SD) during 500 millisecond time periods for CAP non-responders (N=11).

0 – 500ms	500 – 1000ms	1000 – 1500ms	1500 – 2000ms	2000 – 2500ms	2500 – 3000ms	3000 – 3500ms
95.38 ± 32.31 [a]	141.16 ± 27.09	147.71 ± 26.21	149.31 ± 25.26	151.49 ± 27.40	153.86 ± 26.71	152.82 ± 25.13

ms = millisecond
[a] Significantly different ($p \leq 0.001$) than all other time periods.

Table 2. Mean isometric right knee extension torque as a percentage of body weight (mean ± SD) during 500 millisecond time periods for CAP responders (N=31).

0 – 500ms	500 – 1000ms	1000 – 1500ms	1500 – 2000ms	2000 – 2500ms	2500 – 3000ms	3000 – 3500ms
105.52 ± 28.77 [a]	154.43 ± 32.14 [a]	163.26 ± 33.27	166.46 ± 33.39	168.41 ± 32.58	169.37 ± 31.38	170.67 ± 30.58

ms = millisecond
[a] Significantly different ($p \leq 0.001$) than all other time periods.

DISCUSSION: This is the first study to investigate the time course of the ergogenic advantage of CAP during isometric knee extension. Non-responders and responders of CAP demonstrated similar torque maintenance during the time course even though the CAP responders mean torque was greater, as shown in previous studies (Ebben et al., 2008a; Ebben et al., 2008b; Ebben et al., 2010a; Ebben et al., 2010b). Practitioners can use this knowledge to prescribe RVC without concern of a higher than usual acute performance decay. This study is the first to demonstrate that the use of RVC do not present a performance decreasing cost to motor resources.

Evaluation of the CAP responder's mean torque throughout the time course demonstrates the first two 500ms time periods are significantly different than the rest. In the first time period, 0-500ms, the CAP responders demonstrated a 10.1% greater mean torque/ body weight percentage than the CAP non-responders. Collectively, these data potentially explain the performance enhancements in RTD (Ebben et al., 2010b), RFD (Ebben et al., 2008a; Ebben et al., 2010b), and time to peak force (Ebben et al., 2008a; Ebben et al., 2010b). The performance variables assessed in the present, as well as the aforementioned studies, all evaluated force production within the first 500ms or less. The CAP responder's non-significantly greater mean torque value within the first 500ms of the exercise, compared to the CAP non-responders, is consistent with results from previous research (Ebben et al., 2008a; Ebben et al., 2008b; Ebben et al., 2010a; Ebben et al., 2010b), and together, these data suggest the ergogenic effect of CAP may only occur during the first 1000ms in strength and power tasks.

The present study demonstrates no significant difference in force maintenance between CAP non-responders and responders, with both showing nearly identical percent differences in mean torque values throughout the duration of the time course. Mean torque increased 45.8 and 48.9% from the 0-500ms to the 500-1000ms time period for CAP non-responders and responders, respectively. CAP non-responders and responders again demonstrated similar mean torque increases of 6.6 and 8.8%, respectively, from the 500-1000ms to the 1000-1500ms time period. The comparatively similar linear performance enhancement of the CAP non-responders and responders is consistent throughout the duration of the exercise, suggesting the knee extensor's performance is not eventually hindered during the use of RVC. Consistent with the present study, previous literature assessing the effect of RVC on isokinetic knee flexor and extensor strength has demonstrated increases in the kinetic knee performance of CAP responders but not CAP non-responders (Ebben et al., 2010b). Therefore concluding, the use of RVC may improve, but do not eventually impede muscular performance.

CONCLUSION: Results of the present study demonstrate CAP's ergogenic effect occurs within the first 1000ms. Concurrent activation potentiation non-responders and responders present no differences in force maintenance, thus the use of RVC do not continually impede muscular performance regardless of the individual's response to CAP. Thus, regardless of an individual's response to CAP, the use of RVC will not adversely affect performance.

REFERENCES:

Ebben, W.P. (2006). A brief review of concurrent activation potentiation: theoretical and practical constructs. *Journal of Strength and Conditioning Research*, 20, 985-991.

Ebben, W.P., Flanagan, E.P., & Jensen, R.L. (2008a). Jaw clenching results in concurrent activation potentiation during the countermovement jump. *Journal of Strength and Conditioning Research*, 22, 1850-1854.

Ebben, W.P., Leigh, D.H., & Geiser, C.F. (2008b). The effect of remote voluntary contractions on knee extensor torque. *Medicine and Science of Sports and Exercise*, 40, 1805-1809.

Ebben, W.P. and Petushek, E.J. (2010a). Kinetic analysis of concurrent activation potentiation during back squats and jump squats. *Journal of Strength and Conditioning Research*, In press.

Ebben, W.P., Petushek, E.J., Fauth, M.L., & Garceau, L.R. (2010b). Electromyographical analysis of concurrent activation potentiation. *Medicine and Science of Sports and Exercise*, (ePub ahead of print).

Surakka, J., Virtanen, A., Aunola, S., Maentaka, K., & Pekkarinen, H. (2005). Reliability of knee muscle strength and fatigue measurements. *Biology of Sport*, 22, 301-313.

Stumbo, T.A., Merriam, S., Nies, K., Smith, A., Spurgeon, D., & Weir, J. (2001). The effect of handgrip stabilization on isokinetic torque at the knee. *Journal of Strength and Conditioning Research*, 15, 372-377.

Acknowledgement

Travel to present this study was funded by a Green Bay Packers Foundation Grant.