THE EFFECT OF REMOTE VOLUNTARY CONTRACTIONS DURING FAST STRETCH SHORTENING CYCLE ACTIVITY

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This study evaluated the effect of remote voluntary contractions (RVC) on depth jump performance. Subjects performed the depth jump in a RVC condition and a condition without RVC (NO-RVC). Ground reaction force (GRF), impulse (I), and reactive strength index (RSI) were assessed with a force platform. Data were analyzed using a two way ANOVA. Analysis of GRF showed no significant main effects for RVC condition (p = 0.46) and no interaction for RVC condition and gender (p = 0.11). Analysis of I showed no significant main effects for RVC condition (p = 0.99) and no interaction for RVC condition and gender (p = 0.61). Analysis of RSI showed no significant main effects for RVC condition (p = 0.78) and no interaction for RVC condition and gender (p = 0.20). Remote voluntary contractions appear to offer no performance benefits for exercises such as the depth jump.

KEYWORDS: Concurrent activation potentiation, plyometrics, depth jump

INTRODUCTION: The contractions of muscles remote from a prime mover have been described as remote voluntary contractions (RVC) and have been shown to increase lower body reflexes in clinical populations (Delwaide & Toulouse, 1980; Hortobagyi et al., 2003; Pereon et al., 1995).

Additionally, RVC have been recommended to improve muscle performance and this phenomenon has been described as concurrent activation potentiation (CAP) (Ebben, 2006). Researchers studying the effect of RVC determined that a combination of jaw clenching, hand gripping, and the Valsalva maneuver was more effective than jaw clenching or hand gripping alone for enhancing knee extension performance (Ebben et al., 2008a). Remote voluntary contractions have been demonstrated to be effective during isometric (Ebben et al., 2008a; Sasaki et al., 1998), but not during some dynamic tasks (Sasaki et al., 1998). On the other hand, only one published study examined the effect of RVC's during dynamic athletic movements such as jumping (Ebben et al., 2008b). In this study, subjects produced 19.5% higher rate of force development (RFD) and 20.2% faster time to peak force during the countermovement jump while jaw clenching, compared to a non-jaw clenching condition (Ebben et al., 2008b). However, these subjects did not produce greater peak ground reaction force (GRF) in the jaw clenching condition. Thus, the potential of RVC as a potentiation phenomenon for dynamic athletic tasks remains uncertain as does its potential application during slow and fast stretch shortening cycle activities.

Schmidtbleicher (1992) defined fast and slow stretch shortening cycle activities as those lasting approximately 100 ms and more than 250 ms, respectively. Countermovement jumps, which demonstrate RVC mediated improvement in performance, are thought to be slow stretch shortening cycle activities whereas the depth jump typically has been defined as a fast stretch shortening cycle activity (Schmidtbleicher, 1992). At present, it is not known if the mechanisms associated with CAP is present and potentially ergogenic during fast stretch shortening cycle activities such as the depth jump.

Therefore, the purpose of this study was to compare conditions that included RVC and a condition that did not (NO-RVC) and the effect on kinetic parameters of depth jump performance.

METHODS: Subjects included 13 men (mean ± SD, age = 21.3 ± 1.6 yr; body mass = 87.1 ± 15.7 kg; vertical jump = 62.62 ± 8.61 cm) and 10 women (mean ± SD, age 20.9 ± 1.1 yr; body mass 65.7 ± 4.35 kg; vertical jump = 45.46 ± 4.93 cm). All subjects participated in intercollegiate or recreational athletics as well as lower body resistance training and plyometrics for at least 2 months. Exclusion criteria included any history of lower limb pathology that resulted in functional limitation of the exercises to be assessed in this study. The subjects 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.

Subjects performed a pre-test habituation and test session. Prior to each, subjects warmed up for 5 minutes with light exercise on a rowing ergometer followed by dynamic stretching. A pre-test habituation session was conducted to teach and allow the subject to correctly perform the depth jump with a subsequent vertical jump (DJ) to be used during the test session. Subjects' countermovement jump height was also assessed using a Vertec (Sports Imports, Columbus, OH, USA).

During the test session, subjects performed 2 repetitions of the DJ in the RVC and NO-RVC conditions. In the RVC condition, subjects were instructed to maximally clench their jaw on a dental vinyl mouth guard (Cramer Products Inc., Gardner, KS), clench their fists forcefully and perform a brief Valsalva maneuver during the contact phase of the DJ landing prior to the subsequent vertical jump. The NO-RVC condition included the subjects performing the DJ with an open mouth and pursed lips to limit the likelihood of jaw clenching, and cycling between inspiratory and expiratory flow in order to reduce the Valsalva effect. These methods were similar to those previously used (Ebben et al., 2008a). Depth jumps were performed from a box height that was normalized to the subjects' countermovement height assessed during the habituation session. The order of the RVC and NO-RVC conditions was counterbalanced. Five minutes of rest was provided between each condition to reduce fatigue effects. Subjects were instructed to perform maximally and were encouraged equally for all test exercises.

The test exercises were assessed with a 60 x 120 cm force platform (BP6001200, Advanced Mechanical Technologies Incorporated, Watertown, MA USA). The force platform was calibrated with known loads to the voltage recorded prior to the testing session. Kinetic data were collected at 1000 Hz, real time displayed and saved with the use of computer software (BioAnalysis 3.1, Advanced Mechanical Technologies, Incorporated, Watertown, MA USA) for later analysis. Peak vertical GRF, impulse (I), and reactive strength index (RSI) were calculated from the concentric phase of the force-time records consistent with methods previously used (Flanagan et al., 2008; Jensen & Ebben, 2007; Jensen et al., 2008). All values were determined as the average of 2 trials for each exercise. Peak GRF was defined as the highest vertical GRF value attained during the contact phase of the DJ, minus body mass (Jensen & Ebben, 2007). Impulse was calculated as the force multiplied by the time it took to develop it based on the area under the curve of the contact phase of the force time record (Jensen et al., 2008). Reactive strength index was calculated as jump height divided by the contact time (Flanagan et al., 2008).

All data were analyzed with SPSS 16.0 using a two way ANOVA to evaluate the differences between the RVC conditions and the interaction between RVC conditions and gender. The *a priori* alpha level was set at $p \leq 0.05$. The trial to trial reliability of each dependent variable was assessed using single and average measures intraclass correlation coefficients (ICC). In addition, a repeated measures ANOVA was used to confirm that there was no significant difference ($p > 0.05$) between the trials for each dependent variable.

RESULTS: Analysis of GRF showed no significant main effects for RVC condition ($p = 0.46$) and no interaction between RVC condition and gender ($p = 0.11$). Analysis of I showed no significant main effects for RVC condition ($p = 0.99$) and no interaction between RVC condition and gender ($p = 0.61$). Analysis of RSI showed no significant main effects for RVC condition ($p = 0.78$) and no interaction between RVC condition and gender ($p = 0.20$). Data are presented in Table 1. Single and average measures ICC are presented in Table 2.

Table 1. Data are presented as mean ± SD for the depth jump peak vertical ground reaction force (GRF), impulse (I), and reactive strength index (RSI) in the RVC and NO-RVC conditions.

	Men (N=13)			Women (N=10)		
	RVC	NO-RVC	%	RVC	NO-RVC	%
GRF (N)	2303.29±436.88	2495.97±585.44	7.7	1706.72±339.13	1634.47±204.82	4.2
I (N·sec)	729.19±135.74	735.71±144.38	1.0	467.68±86.50	461.03±69.38	1.3
RSI	0.83±0.23	0.82±0.30	1.3	0.60±0.19	0.57±0.13	5.0

% = percent difference between RVC and NO-RVC condition

Table 2. Intraclass correlation coefficients (ICC) for the depth jump peak vertical ground reaction force (GRF), impulse (I), and reactive strength index (RSI) in the RVC and NO-RVC conditions.

	Single Measures ICC	Average Measures ICC
RVC depth jump GRF	0.82	0.90
NO-RVC depth jump GRF	0.92	0.96
RVC depth jump I	0.87	0.93
NO-RVC depth jump I	0.93	0.96
RVC depth jump RSI	0.90	0.95
NO-RVC depth jump RSI	0.94	0.97

DISCUSSION: This is the first study to investigate the effects of CAP during a fast stretch shortening cycle activity such as the DJ. Results demonstrate that no ergogenic advantage was accrued for any of the outcome variables assessed in the RVC compared to the NO-RVC condition. Furthermore, no gender differences were found for any of the variables.

The results of this study stand in contrast to previous research that demonstrated 15.8% increases in the rate of force development during an isometric hand grip task (Hiroshi, 2003) and 14.8% increase in isometric knee extensor torque (Ebben et al., 2008a), while using RVC. Additionally, the findings of the present study are dissimilar to those that demonstrated 19.5% higher rate of force development during the countermovement jump (Ebben et al., 2008b). Thus, RVC appear to offer an ergogenic advantage during countermovement jumps, but not depth jumps. This finding indicates that RVC may work for slow but not fast stretch shortening cycle activities as defined by Schmidtbleicher (1992).

The stretch shortening cycle is known to include both passive mechanical and active neurophysiological force producing components. Previous research has demonstrated that DJ produce lower levels of muscle activation compared to many other plyometric exercise variations including the countermovement jump (Ebben et al., 2008c). This finding is thought to be due to a disproportionate reliance on passive, and not active, force producing mechanisms during the DJ (Ebben et al., 2008c). Previous reports have indicated that RVC may function due to motor overflow and a concomitant increase in muscle activation of the prime mover (Ebben 2006). Thus, fast stretch shortening cycle activities such as the DJ may occur too quickly to take advantage of RVC mediated increases in muscle activation. Based on the results of this study, this effect appears to be similar for men and women.

CONCLUSION: Results of this study demonstrate that no performance augmentation is experienced during the RVC compared to the NO-RVC condition during DJ. Remote voluntary contractions may not work during fast stretch shortening cycle activities that may preferentially rely on passive force production more than active force producing phenomena such as muscle activation.

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