THE EFFECT OF ANTAGONIST CONDITIONING CONTRACTIONS ON LOWER AND UPPER BODY POWER TESTS

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This study assessed the effect of antagonist conditioning contractions (ACC) on lower and upper body power tests. Six subjects performed the bilateral countermovement jump and the supine medicine ball chest throw on a force platform in baseline conditions and after ACC. A repeated measures ANOVA was used to compare performance between the baseline conditions and the ACC condition. Analysis demonstrated no significant main effects for GRF (p = 0.41) or RFD (p = 0.55) for the countermovement jump. Additionally, there were no significant main effects for GRF (p = 0.85) or RFD (p = 0.95) for the medicine ball throw. This study demonstrated that maximal short term ACC do not enhance multi-joint power tests such as the countermovement jump and medicine ball throw.

KEYWORDS: reversal of antagonists, successive induction, Golgi tendon organ, superset

INTRODUCTION: The activation of the antagonist in order to potentiate the agonist muscle group has been thought to stimulate the Golgi tendon organ (GTO) (Kroll, 1972). Golgi tendon organ activation may inhibit the antagonist and activate the agonist. This process has been termed successive induction, the reversal of antagonists, and is typified by the rapid transitions between antagonist and agonist muscle groups during movements such as walking, running, and rowing (Voss et al., 1985). Additionally, skilled athletes appear to be able to reduce antagonist co-activation as an adaptation that allows them to produce greater agonist force (Bazzucchi et al., 2008).

A small body of literature also defines phenomena such as successive induction and the reversal of antagonists, as antagonist conditioning contractions (ACC). Research examining the role of ACC on agonist force demonstrates higher rates of force development (RFD) but neither higher peak force, nor increased muscle activation (Gabriel et al., 2001; Grabiner et al., 1994; Kamimura et al., 2009) during single joint strength tasks. Furthermore, some evidence demonstrates that stimulating a muscle with a maximal or near maximal activation may potentiate rather than inhibit it (Hodgson et al., 2005) and efforts to reduce the activation of the antagonist, via a fatiguing stimulus, resulted in its potentiation and subsequent impairment of agonist functioning (Maynard and Ebben, 2003). Thus, the challenge seems to be to activate the antagonist enough to stimulate the GTO, while not potentiating it, and to take advantage of the antagonist inhibition before it decays.

Furthermore, if this process has ergogenic value and external validity it would need to translate to functional movements. Therefore, the purpose of this study was to assess the effect of ACC on lower body power during the countermovement jump and upper body power during supine medicine ball chest throws.

METHODS: Six men (mean ± SD: age = 21.50 ± 1.05 years; height = 174.78 ± 7.56 cm; body mass = 79.54 ± 13.72 kg; countermovement jump height = 67.75 ± 7.24 cm; seated 6 kg medicine ball throw = 427.83 ± 43.85cm) volunteered to serve as subjects for the study. Inclusion criteria required subjects who were 18-27 years old and participated in upper and lower body resistance training for at least 8 weeks prior to testing. Exclusion criteria included any orthopedic upper or lower limb or cardiovascular pathology preventing maximal effort. Subjects signed an informed consent form prior to participating in the study which was approved by the Institutional Review Board.

Subjects warmed up and then participated in a single 60 minute testing session. The warm up consisting of 3 minutes on a rowing ergometer followed by a 10 yard forward walking lunge, 10 yard backward walking lunge, 10 yard walking hamstring stretch, 10 yard walking quadriceps stretch, 5 slow bodyweight squats, 5 fast bodyweight squats, 5 small arm circles forward, 5 small arm circles backward, 5 large arm circles forward, and 5 large arm circles backward. Five medicine ball chest throws and 5 countermovement jumps were performed at 75% of the subject's self-assessed maximal effort. Then, two maximal repetitions of each were performed and the average was recorded. These medicine ball chest throws and countermovement jumps were performed in order to evaluate and demonstrate subject characteristics. The vertical jump was assessed with a Vertec. The medicine ball chest throw was performed from a seated position with the subject's back against a wall using a 6 kg medicine ball. Subjects then rested for 4 minutes.

During the test, subjects performed 6 sets including 3 sets of 3 repetitions of countermovement jumps and supine medicine ball chest throws. The 3 test sets of each exercise were performed in the following order, including a pre ACC baseline condition with no preceding ACC, an ACC condition with a preceding ACC, and a post ACC baseline condition without a preceding ACC. The order of the test exercises (countermovement jump or medicine ball chest throw) was randomized and kept consistent throughout all 3 test sets. Four minutes of rest was used between the pre ACC baseline condition and the ACC condition. Fifteen minutes of rest was provided between ACC and post ACC baseline test in order to reduce the potential potentiation of the antagonist from the previous set since the potentiation effect is believed to be brief (Chalmers, 2004). Thus, testing included 2 non ACC baseline conditions with one before and one after the ACC condition in order to minimize potential order effects. Merely randomizing the ACC and non ACC conditions might have resulted in residual ACC potentiation in the non ACC conditions when randomization resulted in the non ACC conditioning occurring after the ACC condition.

The countermovement jump was performed from a standing position on a force platform whereas the supine medicine ball chest throw was performed on a flat utility bench on the force platform. During the supine medicine ball chest throw subjects were positioned with shoulders flexed to 90°, elbows extended, and their head, upper and lower back, buttocks, and both feet on the utility bench. A 9 kg medicine ball was placed in the hands of the subject. Following a verbal cue, the subject performed a countermovement and then explosively threw the medicine ball vertically. Researchers caught the ball and re-administered the medicine ball to the subject for the next repetition. The pre and post ACC baseline conditions were performed without an ACC. The ACC condition consisted of a brief 6 second isometric contraction for the hamstrings and the shoulder retractors for the bilateral countermovement jump and supine medicine ball chest throw, respectively. Following the cessation of the 6 second ACC of each exercise, subjects were allotted 10 seconds to reposition themselves for the respective test set.

The test exercises were assessed with a 60 x 120 cm force platform (BP6001200, Advanced Mechanical Technologies Incorporated, Watertown, MA, USA) which was bolted to the laboratory floor and mounted flush in the center of a 122 x 244 cm weightlifting platform. 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, Inc., Watertown, MA USA) for later analysis.

Vertical ground reaction force data were acquired and reduced with manufacturer software Peak vertical ground reaction force (GRF) and RFD was calculated from the force-time records for the concentric phase. Peak GRF was defined as the highest value attained from the force time record. The RFD was defined as the peak GRF minus the GRF value 100 ms prior to the peak divided by 100 ms, consistent with methods previously used (Ebben et al., 2008). Three repetition averages were then calculated. Data were evaluated with SPSS

18.0 for Windows (Microsoft Corporation, Redmond, WA, USA) using a repeated measures ANOVA to determine statistical differences in GRF and RFD between the test conditions. Assumptions for linearity of statistics were tested and met. All data are expressed as means ± SD.

RESULTS: Analysis demonstrated no significant main effects for GRF (p = 0.41) or RFD (p = 0.55) for the countermovement jump. Additionally, there were no significant main effects for GRF (p = 0.85) or RFD (p = 0.95) for the supine medicine ball chest throw. Mean data are presented in Table 1-4.

Table 1. Mean (± SD) concentric peak vertical ground reaction force (GRF) and rate of force development (RFD), during the countermovement jump (CMJ) in the pre and post antagonist conditioning contraction (ACC) baseline conditions, and during the ACC condition.

	PRE	ACC	POST
CMJ GRF (N)	1246.95 ± 429.79	1406.88 ± 295.47	1368.17 ± 270.43
CMJ RFD (N·sec^{-1})	4335.36 ± 1729.90	4800.94 ± 1356.92	4301.57 ± 1467.15

Table 2. Mean (± SD) concentric peak vertical ground reaction force (GRF) and rate of force development (RFD) during the medicine ball (MB) chest throws in the pre and post antagonist conditioning contraction (ACC) baseline conditions, and during the ACC condition.

	PRE	ACC	POST
MB GRF (N)	661.58 ± 107.47	686.88 ± 163.06	692.82 ± 208.98
MB RFD (N·sec^{-1})	6003.61 ± 1223.85	6166.00 ± 1578.38	5912.94 ± 2586.80

DISCUSSION: This study shows that ACC do not significantly increase performance in lower or upper body power exercises, despite using brief and maximal ACC based on previous recommendations (Grabiner et al., 1994; Holt et al., 1969; Kamimura et al., 2009). These results raise questions about the effectiveness of activating the antagonist in order to augment performance of a subsequently activated agonist during multi-joint movements.

Results of the present study differ from previous research examining the effect of ACC which demonstrated increased RFD (Gabriel et al., 2001; Grabiner et al., 1994; Kamimura et al., 2009), but not force (Grabiner et al., 1994; Kamimura et al., 2009) or work (Grabiner et al., 1994) during single joint and less dynamic tasks.

Most studies assessing ACC failed to find any increase in electromyography of the agonist (Gabriel et al., 2001; Holt et al., 1969; Kamimura et al., 2009) demonstrating that either EMG was unable to detect, or another mechanism was responsible for, the increase rate of force development demonstrated in these studies. This absence of statistically significant differences in the present study may be due to the fact that the ACC mediated inhibition may only last one second (Chalmers, 2004). Thus, it is possible that the transition from the ACC to medicine ball chest throw or countermovement jump may not have occurred within the 1 second time interval. While ACC may not work well for strength and power tasks, a functional benefit may still be present during the reversal of antagonists for a variety of functional movements that quickly transition between antagonist and agonist such as walking or running (Voss et al., 1985) or as a potential for chronic adaptation in skilled performers (Bazzucchi et al., 2008).

In the present study, for the countermovement jump, the ACC was performed for the hamstring muscle group. While the hamstring muscle group is a knee extensor antagonist, it is a hip extensor agonist which is used during the countermovement jump.

It should be noted that, despite no statistically significant differences between the baseline and the ACC conditions, the mean countermovement jump RFD and GRF is at least 10.7% and 2.77% higher, respectively, during the ACC compared to the baseline condition. For the medicine ball chest throw, the mean RFD is 2.72% higher. These mean data are consistent with previous reports that ACC may have a larger effect on RFD than peak force production (Gabriel et al., 2001; Grabiner et al., 1994; Kamimura et al., 2009). In the present study, large subject variability, manifested as large standard deviations, and a small number of subjects may have precluded a finding of significance. Thus, the use of ACC during dynamic multi-joint tasks should be further investigated.

CONCLUSION: This study demonstrated that maximal short term ACC do not enhance multi-joint power tests such as the countermovement jump and medicine ball throw.

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Acknowledgement

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