CONVENTIONAL vs COMPLEX TRAINING: A SET BY SET AND SESSIONAL COMPARISON OF KINETIC AND KINEMATIC VARIABLES

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The purpose of this study was to investigate the effects of complex sets on kinetic and kinematic variables in a countermovement jump (CMJ) compared to a conventional training session. Twenty-three recreationally trained males completed two familiarisation and two experimental conditions. No significant differences ($p < 0.05$) occurred in the CMJ peak jump height, peak force, peak power and peak velocity obtained from three sets of four CMJ's which either preceded (conventional training) or followed (complex training) three sets of four back squats with a five repetition maximal load.

KEYWORDS: Post-activation potentiation, power, countermovement jump.

INTRODUCTION: When designing a resistance training session it is often recommended that explosive strength exercises such as a jump squat are performed prior to strength-based exercises which require the production of relatively large amounts of force (Baechle & Earle, 2008). The prescription of explosive exercises prior to strength exercises is often recommended, because it is believed that the force production needed to execute the strength based exercises will lead to fatigue and a diminished capacity to execute the explosive exercises with the optimal combination of force and velocity to achieve the desired training effect.
Complex training is the prescription of various sets of groups / complexes of exercises performed in a manner in which multiple sets of a heavy resistance exercise are followed by sets of a biomechanically similar lighter exercise (Duthie, Young & Aitken, 2002). Complex training is underpinned by the phenomenon of skeletal muscles post-activation potentiation response (PAP), which is an acute enhancement in the force generating capacity of skeletal muscle as a result of its contractile history (Tillin & Bishop, 2009). Complex training is an intriguing option for coaches to implement when aiming to enhance skeletal muscle's explosive force producing capability. Research has shown that the force generating capacities which underlie jumping performance can be enhanced following a single contrasting set where a heavy load high force movement is alternated with a low load high power movement (Gullich & Schmidtbliecher, 1996; Young, Jenner, & Griffiths,1998). However, less is understood about how the complex method can influence the kinetic and kinematic variables during jumps involved with several sets of complexes comprising a training session designed to enhance the explosive capacity of skeletal muscle. The purpose of this study was to compare the changes in kinetic and kinematic variables (peak power, peak force, peak velocity and peak displacement) during jumps between the conventional method of training where explosive exercises are performed prior to strength-based exercises, and the complex method where sets of strength-based exercises precede sets of explosive exercises.

METHODS: Twenty-three recreationally trained participants (age: 22.0 ±3.8y; weight: 84.5 ±18.4kg; 5RM: 122 ±25.4kg) attended two familiarisation and two experimental sessions separated by a minimum of 48 hours. The first familiarisation session consisted of a four minute cycle warm-up, two sets of 10 body weight squats followed by the execution of three sets of four CMJ's using Ballistic Measurement System software (BMS) (Fitness Technology, South Australia) to measure jump height (displacement),force, velocity and power output. A 5RM back squat strength test was administered following sets of CMJ's. The second familiarisation session consisted of the same warm-up as session one followed by three sets of four jump squats. A rest period of two minutes occurred between all sets of jump squats during both familiarisation and experimental sessions. During experimental sessions participants performed a warm-up consisting of a four minute cycle followed by two sets of 10 body weight squats, a set of squats at 50% of 5RM, and a set of two repetitions at 90% of 5RM. The testing session order was randomly assigned as to eliminate any order bias, and at least 48 hours separated testing sessions. During the conventional session participants performed three sets of four CMJ's for maximum height with two minutes of rest between sets, followed by three sets of four back squats at a 5RM load with four minutes of recovery between sets. During the complex session participants performed the sets of squats prior to the sets of jumps. All jumps were performed on a force platform with a linear position transducer (BMS) attached to an aluminium bar of negligible weight placed across the participants back. Participants were required to keep the bar in contact with each jump, and instructed to jump for maximal height.

Measures of peak jump height, peak force, peak velocity and peak power for each individual jump were determined from the lowest point on the displacement – time curve as described by Hansen et al. (2011). All results were then transferred to Microsoft Excel. Means for each set of jumps and the entire session for each condition were then analysed utilising SPSS version19. Conditions were paired and analysed using paired T-tests to determine significant differences ($p < 0.05$) between sets 1, 2 and 3, and for the whole session. Paired T-tests were also used to determine significant differences ($p < 0.05$) in the same variables between conditions. An independent T-test was performed to determine if the group which obtained a greater performance with the complex method were significantly stronger ($p < 0.05$).

RESULTS: During experimental conditions measures of mean peak displacement (cm), peak velocity (m/s), peak force (N) and peak power (W) were calculated from the set of four CMJ's, session averages for each variable were determined from the mean of each set. These variables were shown to be reliable between sessions separated by at least 48hrs (Displacement = .917; Velocity = .945; Force = .958; Power = .967). No significant differences ($p < 0.05$) occurred within any variables in the same set number between conditions or between total session means each condition (Table 1). During analysis participants were separated into two groups based upon their individual responses to the protocols, a participant was determined to be a responder to the complex protocol if their power output during the complex session was increased beyond the typical error of the test. An Independent samples T-test showed a non-significant trend ($p = .199$) for those participants who produced greater power output with the complex training session ($n = 11$) to posses greater relative strength than those who performed better in the conventional training session ($n = 12$) (Table 2)

DISCUSSION: This investigation compared the changes in the kinetic and kinematic variables between a single training session using either the complex or conventional structure. Data analysis revealed that there were no significant differences in any of the dependent variables. This finding conflicts with conventional training practice, which state that power based exercises should be performed prior to strength based exercises in a training session, due to possible fatigue negatively impacting power output in subsequent exercises. Interestingly, when the group was separated by participants who demonstrated a greater mean peak power in the complex session compared to the conventional there was a trend for these participants to have a greater relative strength. This trend is consistent with previous findings, who have reported that participants with greater levels of strength maybe better able to capitalise on the PAP phenomenon (Duthie et al., 2002, French, Kraemer, & Cooke, 2003; Batista, Roschel, Borroso, Ugrinowitsch, & Tricoli, 2011). A possible explanation for the trend is that the fatigue generated from the sets of heavy load exercises may have generated too great a level of fatigue, which could have masked the possible potentiating affect in the sets of CMJ's.

CONCLUSION: The order in which exercises are prescribed during a training session is an important variable to consider when designing a training session. Conventional theory states explosive exercises aimed at enhancing power output should precede heavy-load strength-based exercises due to the accumulation of fatigue, which is viewed as a negative influence on the development explosive force production. Complex training may be an effective unconventional method of structuring training sessions if trying to enhance the explosive capacity of skeletal muscle, however, an individual's strength level and training history may impact his ability to capitalise on this training method. Results from this investigation demonstrate that sets of heavy-load exercises did not negatively affect the kinematic and kinetic characteristics of a CMJ, and that stronger individuals may receive a somewhat greater training effect when the heavy exercises precedes the lighter exercise. These findings will help provide more options for strength and conditioning coaches when adding variety to a resistance training session focused on the development of strength and power. The utilisation of contrasting sets to capitalise on the PAP response has been a major focus of research and practice, however the findings of this investigation may warrant further research to investigate the impact complex sets may have on acute and chronic explosive force production responses. The manipulation of training variables such as volume, intensity and recovery in complex or contrasting sets and their effects on sport movements such as jumping and sprinting has also been a research focus (Chaouachi et al. 2011). However, further research should focus on the variability in the individual responses to the various complex and contrast set protocols, and if training with an acutely successful protocol will lead to a significantly greater training effect compared to conventional training.

Table 1

Set by set and session means and differences in dependent variables between experimental conditions.

	Set 1			**Set2**			**Set 3**			**Session**		
	Mean (SD)	**% diff.**	**P**	**Mean (SD)**	**% diff.**	**P**	**Mean (SD)**	**% diff.**	**P**	**Mean (SD)**	**% diff.**	**P**
							Displacement (cm)					
Conv.	45.1 (0.089)			44.9 (0.089)			45.5 (0.093)			45.2 (0.09)		
Comp.	44.6 (0.078)	1.1	0.416	44.6 (0.089)	0.6	0.646	44.5 (0.086)	2.1	0.126	44.6 (0.083)	1.3	0.254
							Velocity (m/s)					
Conv.	2.55 (0.34)			2.56 (0.35)			2.59 (0.36)			2.57 (0.35)		
Comp.	2.52 (0.32)	1.1	0.218	2.55 (0.35)	0.3	0.782	2.55 (0.35)	1.5	0.146	2.54 (0.33)	1.1	0.229
							Force (N)					
Conv.	1127.1 (261.8)			1120.5 (277.2)			1088.4 (270.2)			1112 (265.2)		
Comp.	1103.6 (215.4)	2.0	0.401	1082.2 (209.3)	3.4	0.22	1077.8 (197.1)	0.97	0.402	1087.9 (205.5)	2.1	0.359
							Power (W)					
Conv	2480.9 (680.7)			2465.4 (646.9)			2443.3 (663.7)			2463.2 (661.1)		
Comp.	2439.6 (607.8)	1.6	0.404	2466.7 (651.9)	0.005	0.978	2439.6 (637.7)	0.15	0.402	2436.5 (629.9)	1.0	0.552

Table 2
Comparison of strength levels between participants who demonstrated improvement in the complex compared to the conventional method. PP= Peak Power.

	PP (W) Conventional (±SD)	**PP (W) Complex (±SD)**	**Relative Strength (5RM/BW)**	
Better with Complex (N = 11)	2222.3 ±578.6	2372.7 ±649.3	1.52 ±0.26	8.6% difference
Not better with Complex (N = 12)	2684.1 ±677.2	2495.1 ±634.6	1.40 ±0.16	

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