The Acute Effects of Conventional, Complex, and Contrast Protocols on Lower-Body Power

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Abstract

Talpey, SW, Young, WB, and Saunders, N. The acute effects of conventional, complex, and contrast protocols on lower-body power. *J Strength Cond Res* 28(2): 361–366, 2014—This study compared conventional, complex, and contrast protocols on peak power (PP) output. Static vs. dynamic contractions were also manipulated to determine the effect of these confounding variables. Eighteen recreationally trained men [age, 21.1 ± 3.3 years; body mass, 81.7 ± 15.9 kg; height, 182.8 ± 6.2 cm; 5 repetition maximum (5RM) half back squat, 119.2 ± 25.4 kg; 5RM/BW, 1.5 ± 0.2 kg] involved in sports including Australian Rules football, basketball, soccer, and rugby participated in this investigation. Five protocols were executed in a randomized order, a conventional protocol in which 3 sets of 4 countermovement jumps (CMJs) were performed 2 minutes apart. Contrast protocols using a heavy resistance conditioning action of either 4 repetitions with a 5RM load or a 5-second static back squat were alternated with sets of 4 CMJs. Complex conditions with 3 sets of 4 repetitions of a 5RM back squat or a 5-second static back squat were performed before the 3 sets of CMJs. In all conditions, 4 minutes of rest followed sets of heavy resistance exercises and 2 minutes of rest followed each set of CMJs. Individual set means and a total session mean were calculated from each CMJ performed during the session. Results showed that the conventional protocol produced significantly greater PP than all conditions except for the dynamic complex and the static contrast. Results suggest that the use of the complex and contrast protocols used in this investigation should not be used for acute increases in lower-body PP in recreationally trained individuals.

Key Words postactivation potentiation, contrast training, complex training, CMJ, peak power

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Introduction

Because of the importance of lower-body power production on performance in sport, its development is a primary emphasis in many training programs (2,7). Therefore, strength and conditioning coaches constantly search for ways to elicit gains in the power generating capacity of their athletes. Achieving this goal can be accomplished through both conventional and unconventional training practices (2,7,8,27,30,31). Conventional practice typically involves lighter explosive exercises such as a jump squat being prescribed before heavier strength-based exercises such as back squat (1). This conventional practice is founded on the belief that exercises emphasizing an explosive muscle contraction would be negatively impacted by the fatigue generated during the heavy resistance exercise, in turn leading to reduced force production and ultimately a suboptimum training effect. Conversely, the contrast and complex training methods are examples of unconventional training practices used by strength and conditioning coaches to enhance power output beyond typical gains expected from the conventional method (2,7,8,12,27,31). There has been contention in the literature regarding the definitions of these terms, and for the purpose of clarity, the definitions put forth by Duthie et al. (9) will be used to describe the 2 methods. Contrast training is the method where sets of a heavy resistance exercise are alternated in a set-by-set basis with a lighter explosive-based exercise (9). Complex training is a method in which sets of a heavy resistance exercise are followed by sets of a lighter explosive exercise (9).

Both the complex and contrast methods are underpinned by the theory of postactivation potentiation (PAP). PAP is described as an acute enhancement in the force-generating capacity of skeletal muscle, as the result of a biomechanically similar "conditioning action" (30). It is believed that following the conditioning action, both fatigue and potentiation exist simultaneously, and during the recovery period, fatigue dissipates at a faster rate than the potentiation response. After the recovery period, it is postulated that a brief window of opportunity exists to capitalize on the potentiation effect (27,28,30). Investigating the possible physiological mechanisms of the PAP response is not the purpose of this investigation, and readers are directed to the review by Tillin and Bishop (30) for a more in-depth analysis. However, briefly, possible mechanisms are believed to be an increase in the phosphorylation of myosin regulatory light chain, increased recruitment of higher-order motor units, and changes in the muscles' angle of pennation (30).

Numerous investigations have aimed to discover the optimal rest period (4,17–21,32) and intensity of conditioning actions (19,20,23,24,32) to best exploit skeletal muscle PAP response in contrast to protocols. However, the investigation by Duthie et al. (9) is the only published research that has directly examined the acute influence of both complex and contrast protocols on explosive force production compared with a conventional protocol. Furthermore, static conditioning actions have been shown to be effective in contrast protocols (13,14,22,25); however, no investigations have examined static conditioning actions in a complex protocol. Therefore, the purpose of this investigation was to compare acute response in lower-body peak power (PP) in conventional, complex, and contrast protocols using both static and dynamic conditioning activities.

Methods

Experimental Approach to the Problem

A within-subject repeated-measures design was used to determine the acute effects of conventional, complex, and contrast protocols on lower-body PP output.

Subjects

Eighteen recreationally trained males [mean ± *SD*; age, 21.1 ± 3.3 years; body mass, 81.7 ± 15.9 kg; height, 182.8 ± 6.2 cm; 5 repetition maximum (5RM) half back squat, 119.2 ± 25.4 kg; 5RM/BW = 1.5 ± 0.2 kg] who were actively involved in sports such as Australian Rules football, basketball, soccer, and rugby participated in this investigation. All participants were in the off-season phase of their training program and had been involved in a resistance training program for a minimum of 1 year. All participants were free from injury during the time of the study and were asked to cease all other resistance training starting 24 hours before the first session through completion of the study. Participants were asked to refrain from caffeine and alcohol intake 24 hours before attending a testing session and to maintain their normal diet throughout the study. Informed consent was obtained from all participants before the start of the study, and approval was granted by the University's Human Research Ethics Committee.

Procedures

A conventional (CONV) protocol served as the control condition, in which 3 sets of 4 countermovement jumps (CMJs), with 2 minutes of rest between sets, were performed without any potential influence from a heavy resistance exercise. Experimental conditions were dynamic contrast (DCONT), dynamic complex (DCOMP), static contrast (SCONT), and static complex (SCOMP). Figure 1 presents a schematic diagram of the control and experimental conditions.

Peak power, measured in watts (W), was obtained from each CMJ performed during the session, the mean PP from each jump performed in a set was used to represent the set mean, and the mean of the 12 jumps performed in a session was used to represent the total session PP output. PP was independently examined from the CMJ assessment because it is commonly assessed when investigating lower-body explosive force production (33) and is believed to be fundamental to success in many sports (7).

Although participants regularly participated in resistance training, a 4-week familiarization program to reinforce participants on correct half-squat and CMJ technique occurred before data collection. During the familiarization period, participants were instructed to maintain their normal exercise habits. During the testing period, participants attended a total of 7 sessions over a 4-week period. The first 2 sessions were to establish test-retest reliability and determine the participants' 5RM half back squat. Over the remaining 3-week period, participants completed the 5 experimental conditions in a randomized order. Sessions were separated by a minimum of 72 hours and occurred at the same time of day to account for diurnal fluctuations in the explosive force-generating capacity of muscle (29).

Each session commenced with a standardized warm-up that consisted of 5 minutes of cycling on a stationary ergometer at a self-selected intensity to induce a light sweat, and participants were asked to repeat this intensity for all subsequent sessions. If participants were scheduled to execute a dynamic protocol, they then performed 1 set of 10 half-squats at 50% of 5RM followed by a minute of rest, a set of 4 half-squats at 70% of 5RM followed by 1 minute of rest, and finally a set of 2 half-squats at 80% of 5RM followed by 2-minute rest. For static protocols, participants performed one 5-second static back squat at approximately 50% of maximum effort, another at approximately 70%, and finally another 5-second contraction at "near-maximal" intensity. For static contractions, participants followed a simple 5-second countdown, followed by "go, 1, 2, 3, 4, stop." Participants began the static contraction on the word "go" with an aim to be at maximal intensity by the count of "2". The 2-second buildup of force during static protocols was implemented to decrease the injury risk associated with maximal force production in a static position and has been shown to be effective when used as a high-intensity conditioning activity during a warm-up (11). Static contractions were executed in a Smith machine that allowed the bar to be locked into place and prohibited any movement of the bar. Foot position was recorded based on the numbered boxes marked on the floor to ensure that positioning was consistent between conditions. For static contractions, a 110° knee angle was measured with a goniometer during the familiarization sessions and bar positioning was recorded for consistency between conditions.

Measurements

Countermovement Jumps. All CMJs were performed on a commercially available force plate (400 Series Force Plate; Fitness Technology, Adelaide, Australia) with a linear position transducer (LPT) (PT5A; Fitness Technology, Adelaide,

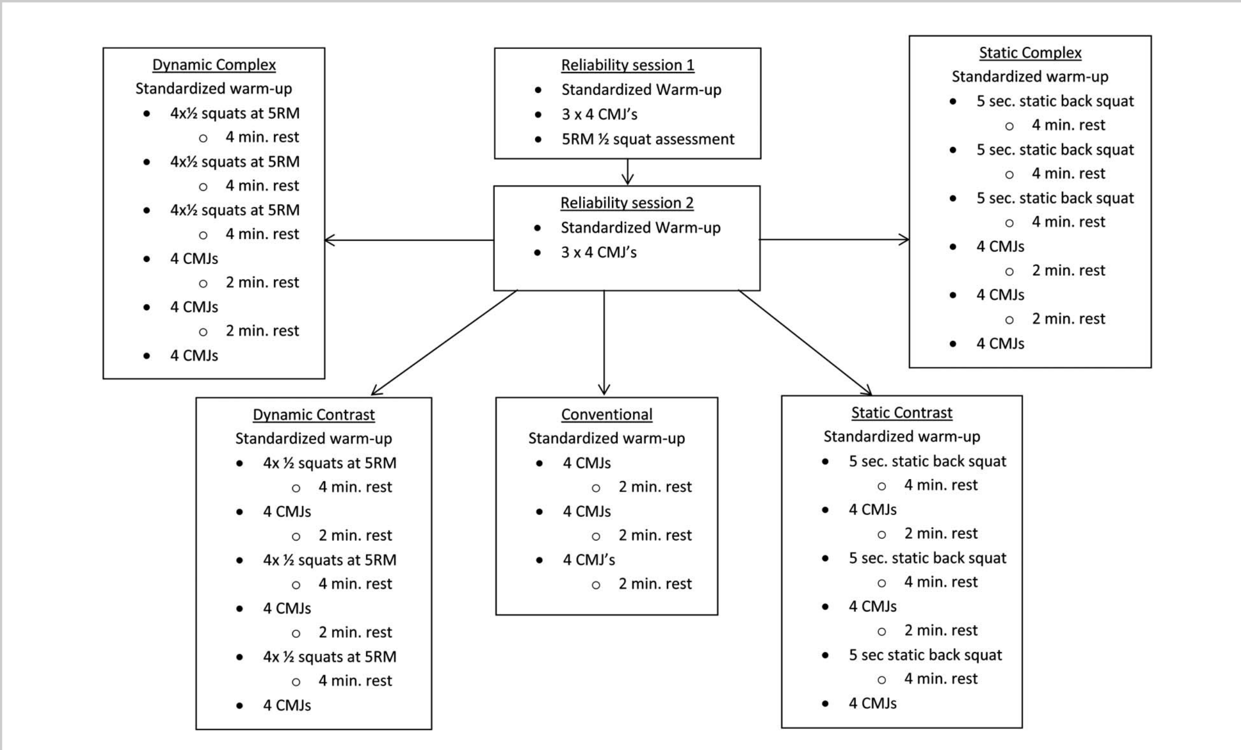

Figure 1. Schematic diagram visually presenting the 2 familiarization sessions and the 5 experimental conditions.

Australia) tethered to the right side of an aluminium bar of negligible weight placed across the participant's shoulders. Both force plate and LPT were sampled at 500 Hz, which has been shown to be an acceptable sampling frequency (17). Force plate and LPT were interfaced with computer software (Ballistic Measurement System; Fitness Technology, Adelaide, Australia). Before each set of CMJs, participants were instructed to dip to a self-selected depth and "jump for maximal height." From each CMJ, PP output was calculated as the instantaneous product of the vertical ground reaction force and bar velocity. PP was obtained from each individual jump performed over the course of the 3 sets to determine individual set means. A total session mean was also determined from each jump executed during the session. Calibration of the force plate and LPT was to a known weight and distance, respectively, and occurred before the start of each data collection session. PP output was obtained during the concentric phase of the jump, which was determined from the lowest point on the displacement-time curve and concluded after peak displacement was achieved (15).

5RM Half-squat. A 5RM half-squat was determined as this was the load used in the dynamic back squat conditions. 5RM testing occurred during the first familiarization session using a modified Smith machine. Participants performed 3 warm-up sets, 10 repetitions at an estimated 50% of 1RM, 4 repetitions at an estimated 70% of 1RM, and 2 repetitions at an estimated 80% of 1RM. Three minutes after the final warm-up set, participants attempted their first 5RM. A 90° knee angle was measured with a goniometer, and a bungee cord was stretched between the tracking poles of the Smith machine as a reference point for the bottom position of the movement. If optimal depth was not obtained, feedback was provided to either increase or decrease the squat depth. If participants failed to reach the desired squat depth on 3 repetitions, the attempt was considered a failure. If participants were successful, the weight was increased to the nearest 2.5 kg until the participant could not lift the weight through the required range of motion. A 5-minute rest was provided between each attempt, and each participant reached their 5RM within 5 attempts.

Statistical Analyses

Data were analyzed using the Statistical Package for the Social Sciences (SPSS for Windows, version 18.0; SPSS, Inc., Chicago, IL, USA). Four individual 1-way ANOVAs with repeated measures were performed for the session and the 3 individual set means from each protocol to determine if there were significant effects on PP output. When a significant effect was observed, simple contrasts were used to determine which protocols were significantly different from the conventional. Statistical significance was set at $p \leq 0.05$ for all data analyses.

Table 1. Comparison of session and set peak power ($n = 18$).*

	Mean ± *SD*	% Difference to conventional	Effect size
Session (conventional: 2,400.8 ± 632.6 W)			
DCONT (W)	2,267.8 ± 540.4	−5.50†	−0.23 (small)
DCOMP (W)	2,393.0 ± 638.8	−0.32	−0.01 (trivial)
SCONT (W)	2,340.6 ± 626.2	−2.50	−0.01 (trivial)
SCOMP (W)	2,303.3 ± 583.6	−4.06†	−0.16 (trivial)
Set 1 (conventional: 2,412.5 ± 643.0 W)			
DCONT (W)	2,320.8 ± 544.9	−3.80	−0.15 (trivial)
DCOMP (W)	2,402.8 ± 616.3	−0.40	−0.02 (trivial)
SCONT (W)	2,375.2 ± 636.8	−1.15	−0.04 (trivial)
SCOMP (W)	2,308.5 ± 593.6	−3.92†	−0.16 (trivial)
Set 2 (conventional: 2,404.6 ± 621.8 W)			
DCONT (W)	2,242.9 ± 561.2	−6.72†	−0.27(small)
DCOMP (W)	2,416.0 ± 661.4	0.47	0.02 (trivial)
SCONT (W)	2,324.2 ± 623.4	−3.34	−0.13 (trivial)
SCOMP (W)	2,303.0 ± 590.6	−4.23†	−0.17 (trivial)
Set 3 (conventional: 2,385.3 ± 642.0 W)			
DCONT (W)	2,239.7 ± 529.6	−6.10	−0.25 (small)
DCOMP (W)	2,360.3 ± 646.2	−1.05	−0.04 (trivial)
SCONT (W)	2,322.5 ± 624.1	−2.63	−0.10 (trivial)
SCOMP (W)	2,298.5 ± 572.3	−3.64	−0.14 (trivial)

*CONV = conventional method; DCONT = dynamic contrast; DCOMP = dynamic complex; SCONT = static contrast; SCOMP = static complex.
†Significantly different from the conventional method ($p < 0.05$).

Calculations of effect sizes were performed to determine the magnitude of differences between means using a publicly available spreadsheet (16). Hopkins descriptive terms for differences in means were used to classify the effect sizes: trivial (0.0–0.19), small (0.2–0.59), moderate (0.6–1.19), large (1.2–1.9), and very large (>2.0) (3).

The difference in PP in the conventional and unconventional protocol was thought to be an indicator of potential PAP. Because a PAP response has been associated with strength levels, a Pearson's correlation was performed between the difference score (PP unconventional − PP conventional) and the leg strength. To determine the test-retest reliability of PP from the CMJ assessment, the typical error of measurement (TEM) and the intraclass correlation coefficient (ICC) were calculated using a publicly available spreadsheet (16).

Results

Conventional vs. Unconventional Protocols

The 1-way ANOVAs with repeated measures revealed significant effects for the total session mean ($p = 0.035$) and for the individual set means for set 1 ($p = 0.026$) and set 2 ($p = 0.016$). A nonsignificant effect for set 3 was observed ($p = 0.160$). Simple contrasts revealed that the conventional method was significantly greater than the DCONT ($p = 0.026$) and the SCOMP ($p = 0.021$) for session PP output. The SCOMP was the only protocol that produced a significantly lower PP output than the convention during the first set of CMJs ($p = 0.020$). However, in the second set of CMJs, DCONT ($p = 0.044$), SCONT ($p = 0.044$), and SCOMP ($p = 0.021$) all produced a PP output significantly lower than the conventional. Mean (±*SD*), p values, effect sizes, and percentage differences for each condition compared with the conventional are presented in Table 1.

Influence of Strength

There were no significant correlations between absolute (5RM) and relative (5RM/body weight) leg strength and the ability to enhance PP in any of the unconventional protocols

Table 2. Correlations between gains in session peak power in unconventional protocols over the conventional protocol and leg strength.*

	Absolute strength		Relative strength	
	r	*p*	*r*	*p*
DCONT–CONV	0.073	0.733	0.235	0.348
DCOMP–CONV	−0.117	0.643	−0.106	0.675
SCONT–CONV	0.069	0.786	0.284	0.254
SCOMP–CONV	−0.174	0.490	0.213	0.396

*CONV = conventional method; DCONT = dynamic contrast; DCOMP = dynamic complex; SCONT = static contrast; SCOMP = static complex.

over the conventional protocol. Table 2 presents the correlations between leg strength and changes in PP in unconventional protocols to the conventional protocol.

Test-Retest Reliability

Results of the reliability testing demonstrated that PP for individual sets was reliable between training sessions. From data gathered during the pretesting reliability sessions, PP demonstrated excellent test-retest reliability for individual sets (ICC = 0.967–0.970; TEM = 112.8–120.3) and the total session mean (ICC = 0.973; TEM = 113.9 W).

Discussion

The 1-way ANOVAs demonstrated that no unconventional training protocol produced greater PP output than the conventional. In regard to the total session mean, the PP output in 2 of the 4 unconventional protocols (DCONT and SCOMP) was significantly ($p < 0.05$) lower than the conventional; however, only the difference between the conventional and the DCONT had an effect size greater than the "trivial." This finding is surprising as contrast protocols are often researched and put into practice and have been recommended by coaches for enhanced explosive force production (3,7,8,12). These results are also in contrast with findings from Duthie et al. (9) who reported that complex protocols resulted in the lowest PP outputs over the course of 3 sets compared with contrast and conventional protocols. In this investigation, the PP output in the DCOMP increased slightly from the first to second set when all other protocols resulted in a decrease in PP output. The conflicting results from this investigation and those reported by Duthie et al. may be because of the different training status of the participants. Participants in the investigation by Duthie et al. (10) were national-level softball and hockey athletes who were involved in a comprehensive power training program, whereas participants in this investigation were actively involved in sport and resistance training but had not been in a structured program specifically designed to enhance power output. The conditioning activities may have been too fatiguing for recreationally trained participants, causing each set of jumps to be performed in a physiological state dominated by fatigue. This is supported by findings from Chiu et al. (6) who found that highly trained power athletes were better able to capitalize on a PAP response than recreationally trained participants.

It has been established in previous research that when attempting to capitalize on potentiation protocols, there is an intricate interplay between muscles' potentiation and fatigue responses (5,27,28,30). During the unconventional protocols performed in this investigation, there may have been accumulated fatigue throughout the sets, leading to a decrease in muscles' power capacity. The other side of the interplay is that there may not have been enough residual potentiation after the recovery period to elicit an acute increase in the muscle power capacity. At the time of performing the power activity, if the residual potentiation is greater than the fatigue, power performance can be enhanced. Conversely, if fatigue is greater than the residual potentiation, performance may be hampered. Finally, if potentiation and fatigue are similar (whether high, medium, or low), power performance will be stable.

There are several variables that influence the balance between fatigue and potentiation. The 4-minute rest period used during the conditioning activities was not optimal for the load (intensity × volume) causing the window of opportunity to be missed. This is supported by recent findings from Wilson et al. (32) who found that >4 minutes of recovery is needed when recreationally trained subjects perform potentiation protocols with similar loads, and the authors recommend a 7–10-minute recovery period.

It is believed that a participant's capacity to recruit the necessary fast-twitch muscle fibers and generate a substantial amount of force is a physical characteristic influencing the ability to capitalize on complex and contrast protocols (6,26,30). The finding is that there were no significant correlations between leg strength and an increased PP output in unconventional protocols over the conventional, conflicts with previous research. Several investigations have reported that stronger participants are able to elicit greater PP outputs in unconventional training protocols (5,6,9,34). It is possible that participants in this study were not of a high enough strength training level to recruit the necessary fast-twitch muscle fibers to produce a significant potentiation response. Alternatively, the participants may not have had the physiological capacity to successfully manage the fatigue from the conditioning activities causing decreased force-generating capacity during the subsequent CMJs.

Practical Applications

The most significant finding from this investigation is that none of the unconventional protocols resulted in greater PP output than the conventional method. Therefore, it is not recommended that coaches implement the complex or contrast protocols investigated in this study for recreationally trained athletes. However, manipulation of training variables (i.e., volume, intensity, and rest) within these protocols may yield different results. Future investigations may look to determine how manipulation of these variables affects lower-body power output. It is recommended that coaches assess the efficacy of any complex or contrast set protocols before implementing them into practice. However, the finding that the DCOMP protocol was the closest unconventional protocol to the conventional and was significantly greater than DCONT was interesting because of the considerable attention paid to the contrast protocols in research and practice.

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