THREE WEEKS OF ECCENTRIC TRAINING COMBINED WITH OVERSPEED EXERCISES ENHANCES POWER AND RUNNING SPEED PERFORMANCE GAINS IN TRAINED ATHLETES

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ABSTRACT

Cook, CJ, Beaven, CM, and Kilduff, LP. Three weeks of eccentric training combined with overspeed exercises enhances power and running speed performance gains in trained athletes. *J Strength Cond Res* 27(5): 1280–1286, 2013—Eccentric and overspeed training modalities are effective in improving components of muscular power. Eccentric training induces specific training adaptations relating to muscular force, whereas overspeed stimuli target the velocity component of power expression. We aimed to compare the effects of traditional or eccentric training with volume-matched training that incorporated overspeed exercises. Twenty team-sport athletes performed 4 counterbalanced 3-week training blocks consecutively as part of a preseason training period: (1) traditional resistance training; (2) eccentric-only resistance training; (3) traditional resistance training with overspeed exercises; and (4) eccentric resistance training with overspeed exercises. The overspeed exercises performed were assisted countermovement jumps and downhill running. Improvements in bench press (15.0 ± 5.1 kg; effect size [ES]: 1.52), squat (19.5 ± 9.1 kg; ES: 1.12), and peak power in the countermovement jump (447 ± 248 W; ES: 0.94) were observed following the 12-week training period. Greater strength increases were observed as a result of the eccentric training modalities (ES: 0.72–1.09) with no effect of the overspeed stimuli on these measures ($p > 0.05$). Eccentric training with overspeed stimuli was more effective than traditional resistance training in increasing peak power in the countermovement jump (94 ± 55 W; ES: 0.95). Eccentric training induced no beneficial training response in maximal running speed ($p > 0.05$); however, the addition of overspeed exercises salvaged this relatively negative effect when compared with eccentric training alone (0.03 ± 0.01 seconds; ES: 1.33). These training results achieved in 3-week training blocks suggest that it is important to target-specific aspects of both force and movement velocity to enhance functional measures of power expression.

KEY WORDS eccentric, concentric, negative loading, sprint, rugby

INTRODUCTION

Speed and power are requisite for success in a range of sporting activities (8,21,30). Consequently, athletes perform resistance training programs to improve specific aspects of strength and power, and it is generally accepted that training to specifically target both force and the velocity components of power is effective in enhancing lower-body power output (4,15,17,30,34). As power is the product of force and velocity (or work divided by time), resistance training programs should attempt to maximize gains in both force and velocity to elicit positive power adaptations (30).

Previous research suggests that the velocity component of power production in the lower body can be specifically trained through negative loading, using elastic bands to assist the concentric action and accentuate the adaptive stimulus (1,24,37). Methods of overspeed training where supramaximal muscular movements are performed have previously been applied to sprint training with positive effects observed in kinematics and running velocity (5,10,31). Additionally, training studies have reported improvements in sprint times and stride rate after exposure to a downhill running training (23,32).

Because of the force component of power expression, maximum muscular strength will contribute to explosive power (30). A meta-analysis that compared the effectiveness of exercise modalities at eliciting muscular adaptations

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27(5)/1280–1286

Journal of Strength and Conditioning Research

concluded that high-intensity eccentric training was associated with greater muscular adaptations than concentric training (35). It has been demonstrated that the peak force produced during eccentric muscle actions is significantly greater than that produced during concentric muscle contractions (7,11). Enoka (13) reported that the increased forces associated with eccentric contractions are due to specific activation strategies employed by the nervous system. Furthermore, longitudinal studies have demonstrated that eccentric cycling can enhance lower-body strength (22,36) and power expression (12,16).

It is apparent that both overspeed and eccentric training modalities are effective in improving the 2 components of muscular performance and have the potential to positively modulate power output. However, no research has assessed the effectiveness of the combination of these training modalities to improve strength, lower-body power, and maximal running speed compared with traditional resistance training. In many team sports, such as rugby, there is an onus on short-term training blocks to enhance aspects of both strength and power concurrently as trainers and athletes often only have short training phases with limited opportunities to significantly enhance multiple aspects of physical conditioning (2). Thus, it is crucial that the programming during such blocks is as effective as possible.

Therefore, the purpose of this investigation was to compare the functional effects of traditional or eccentric exercises training blocks that incorporated downhill running and assisted countermovement jumps in trained athletes. It was hypothesized that (a) eccentric training would elicit greater strength gains than traditional training modalities and (b) the incorporation of overspeed exercises into a training block would result in enhanced increases in maximal running speed and lower-body power expression by specifically targeting the velocity aspect of power production.

METHODS

Experimental Approach to the Problem

Twenty trained semiprofessional team-sport athletes were divided into 4 groups and performed 4 different training modalities: (1) traditional resistance training alone, where both concentric and eccentric actions were performed with the loading during the concentric phase; (2) eccentric training alone; (3) traditional concentric training combined with overspeed exercises; or (4) eccentric training combined with overspeed exercises. Within a 12-week preseason period, each group performed each of the 4 training modalities during a 3-week training block that involved 10 treatment sessions and 2 testing sessions. Such short-term blocks are common in athletic training programs and time constraints often necessitate the concurrent training of multiple aspects of physical conditioning. We assessed how the incorporation of overspeed training into traditional and eccentrically focused resistance training affected specific attributes commonly associated with improved performance. Specifically, the dependent variables of interest were changes in strength, countermovement jump peak power, and 40 m maximal running speed. Between-athlete variability in these variables was used to quantify meaningful differences between treatments.

Subjects

Twenty male semiprofessional rugby union players (mean ± *SD*, age: 19.7 ± 0.7 years; height: 1.85 ± 0.04 m; body mass: 94.8 ± 7.1 kg) from the same club that played a range of positions were voluntarily recruited. All players had a minimum of 2 years of resisted training experience and were currently in the preseason phase of their training program. The athletes were divided into groups with a similar spread of age, body mass, height, and existing strength and speed performance (Table 1). All the subjects provided written informed consent, and the study was approved by the ethics committee of the university. The study was tailored to form a 12-week resistance training block for the athletes to achieve functional strength and power gains that they would normally focus on during preseason resistance training.

Procedures

Testing. Before commencing training, all athletes attended 2 consecutive days of testing to determine initial strength, power, and speed. All athletes were familiar with the testing protocols from their prior training.

TABLE 1. Physical characteristics of the athletes (mean ± *SD*).*

	Group 1	Group 2	Group 3	Group 4
Age (y)	19.4 ± 0.5	19.8 ± 0.8	19.6 ± 0.89	19.8 ± 0.4
Height (m)	1.85 ± 0.03	1.87 ± 0.05	1.85 ± 0.04	1.83 ± 0.05
Body mass (kg)	93.8 ± 7.0	96.6 ± 9.3	95.8 ± 7.7	92.8 ± 6.0
BP 1RM (kg)	128.0 ± 7.6	135.0 ± 10.6	134.0 ± 9.6	131.0 ± 12.8
Squat 1RM (kg)	150.5 ± 21.2	156.0 ± 18.9	155.5 ± 18.2	151.0 ± 20.2
CMJ PP (W)	4,641 ± 607	4,708 ± 612	4,751 ± 376	4,665 ± 450
40 m time (s)	5.30 ± 0.33	5.28 ± 0.38	5.22 ± 0.26	5.31 ± 0.32

*$n = 5$ for each group. BP = bench press; 1RM = 1 repetition maximum; CMJ PP = countermovement jump peak power.

Strength. On day 1 of testing, athletes assembled at 1100 hours having consumed breakfast and a minimum of 750 ml fluid and having been encouraged to get at least 7.5 hours sleep. A standard warm-up of 5 minutes on a rowing ergometer, 5 minutes on a cycling ergometer (both at target heart rates of 120–130 $b \cdot min^{-1}$ measured by heart rate monitors; Polar S810i, Polar, Auckland, New Zealand), and 5 minutes of mixed calisthenics was performed.

Athletes then performed back squats to just below parallel in a controlled manner under the supervision of a trained strength conditioning coach. Using historical records of individual performance, athletes did the following squats: 5 × 50% of 1 repetition maximum (1RM), 3 × 60%, 2 × 80% and then 1 × 90%, 1 × 95%, and 1 × 100%. If successful, they continued to increase the weight in increments of 2.5 kg until failure. The best lift was recorded as the athlete's 1RM. Athletes were allowed 5 minutes recovery between attempts. After a further 5 minutes rest, this routine was repeated to determine each individual's bench press 1RM. One average, athletes performed 3 maximum attempts.

Power and Speed. On the second day of testing, the athletes again assembled at 1100 hours and performed the same standard warm-up. They then performed 3 maximal effort unloaded countermovement jumps, without an arm swing, on a force plate (Kistler Instrument Corporation, Amherst, NY, USA) with the best jump being recorded. One minute of rest was allowed between jump attempts.

After the conclusion of jump testing, athletes undertook three 40-m warm-up sprints at 50, 65, and 80% of a self-perceived maximum pace. Recovery between sprints consisted of walking the distance back to the start. After a further 1-minute rest period, the athletes performed 3 × 40 m maximal sprints, and speed was assessed via electronic timing light gates (Brower Timing System, Salt Lake City, UT, USA). Three minutes of recovery was allowed between sprint efforts, and the fastest time was recorded.

Training Blocks

Athletes were divided into 4 groups ($n = 5$). Groups were then randomized across all 4 training blocks in a counterbalanced crossover fashion. Each training block was 3 weeks long. All training sessions were performed at 0900 hours.

Traditional. The traditional training block consisted of 2 lower-body sessions (Monday and Thursday) and 2 upper-body sessions (Tuesday and Friday). After warm-up sets, lower-body sessions consisted of 4 sets of squats, 4 sets of mid-thigh pulls and 4 sets of Romanian dead lifts, with each set consisting of 5 repetitions to momentary muscular failure. In the upper-body sessions, after warm-up sets, athletes performed 4 sets of bench press, 4 sets of weighted pull-ups, and 4 sets of single-arm dumbbell bent-over rows, with each set consisting of 5 repetitions. All exercises were set at a load of approximately 80% of the predetermined 1RM for the individual but adjusted to ensure repetition completion. Progressive increments of added weight were encouraged within this constraint.

Eccentric. The eccentric training block also consisted of 2 lower-body sessions (Monday and Thursday) and 2 upper-body sessions (Tuesday and Friday). The exercises were identical to those of the traditional training block, except only the eccentric phase of the movement was performed with the weight returned to the starting position by spotters after each repetition. The exception was dumbbell rows where a spotter assisted the movement upward (so some concentric action was included in this particular exercise). The resistance load was initially set at 120% of the predetermined 1RM for the individual (3). Again, progressive increments of added weight were encouraged.

After the completion of both the traditional and eccentric lower-body training sessions, the athletes performed 7 maximal unloaded countermovement jumps 1 minute apart. They then completed 2 warm-up sprints at ~60 and ~80% of a self-perceived maximal pace before undertaking 5 × 40 m sprints from a standing start on a flat dry grass area. Each of the five maximal sprints were separated by 1 minute.

Overspeed Treatments. For the eccentric and traditional training blocks described above, the countermovement jumps and sprints were replaced with band-assisted (Iron Woody LLC, Olney, MT, USA) vertical jumps and overspeed sprints. For the band-assisted jumps, the athletes performed 2 maximal unloaded countermovement jumps, 4 maximal countermovement jumps with vertical bands assisting lift, and then 1 more unloaded jump. The band-assisted jumps were performed inside a squat cage while wearing a climber's harness (Black Diamond, Salt Lake City, UT, USA), with one end of an elastic band attached to either side of the harness at hip level and the other end attached to the squat cage above the subject. The harness straps were adjusted (tightened or loosened) so that the elastic bands provided upward vertical tension, which reduced the body mass of each subject by 20% when in a standing position on the force platform with hip and knee fully extended (1). For the overspeed sprints, the athletes started running for 5 m on a flat dry grass area, which then continued to a 25 m stretch down a 2° slope with the final 10 m moving back onto a flat plane. Athletes performed 2 warm-up sprints at ~60% and ~80% of a self-perceived maximal pace before completing 5 × 40 m maximal sprints, each separated by 1 minute. Maximum downhill 40-m running time was typically 0.05–0.25 seconds faster than those performed on a solely flat plane.

All athletes undertook all 4 treatments across the 12 weeks in a randomized counterbalanced fashion. Strength, power, and speed testing took place on the last Thursday and Friday of each treatment, thus each block consisted of 10 treatment sessions and 2 testing sessions. For each testing day, the athletes assembled at 1100 hours having consumed breakfast

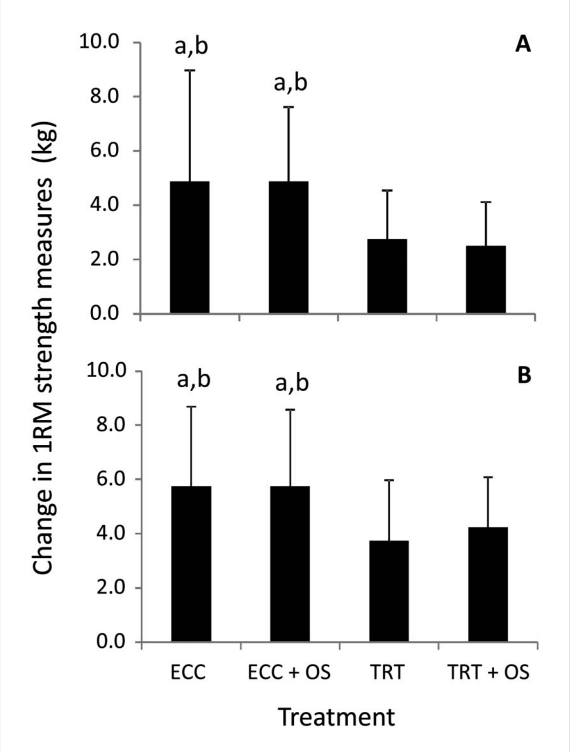

Figure 1. Mean change in strength measures across 4 × 3-week treatment blocks (*n* = 20). A) Bench press; B) Squat. a: substantially enhanced compared with TRT; b: substantially enhanced compared with TRT + OS. 1RM = 1 repetition maximum; ECC = eccentric training modality; ECC + OS = eccentric training modality with overspeed training component; TRT = traditional training modality; TRT + OS: traditional training modality with overspeed training component.

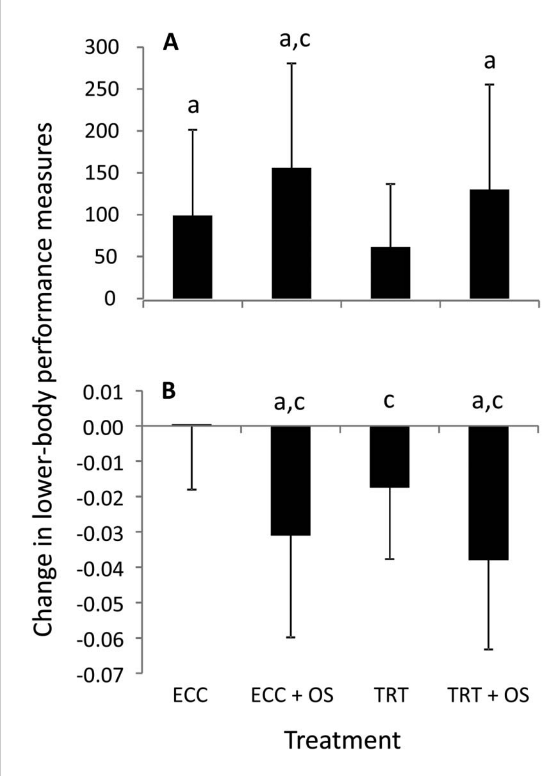

Figure 2. Mean change in lower-body power and performance across 4 × 3-week treatment blocks (*n* = 20). A) Unloaded countermovement jump peak power (in W); B) 40-m sprint time (in seconds). a: substantially enhanced compared with TRT; b: substantially enhanced compared with TRT + OS; c: substantially enhanced compared with ECC. ECC = eccentric training modality; ECC + OS = eccentric training modality with overspeed training component; TRT = traditional training modality; TRT + OS = traditional training modality with overspeed training component.

and a minimum of 750 ml fluid and having been encouraged to get at least 7.5 hours sleep. In addition to weight training, all athletes were prescribed 1 separate speed session (Tuesday afternoon), 1 additional skill session incorporating a game of touch rugby (Wednesday afternoon), and 1 endurance session (Thursday afternoon). These sessions were equivalent across all groups. Saturday and Sunday were always scheduled rest days.

Statistical Analyses

A repeated-measures analysis of variance was used to compare dependent variables among the 4 treatments. Pairwise comparisons were made among the 4 treatments conditions where interaction effects were identified, and differences were interpreted in relation to the likelihood of exceeding the smallest worthwhile change with individual change thresholds for each variable. Changes in the mean of each measure were used to assess the size of effects (ES) by dividing the changes by the appropriate among-athlete *SDs*. Magnitudes of the standardized effects were interpreted using thresholds of 0.2, 0.6, and 1.2 for small, moderate, and large, respectively (19). Standardized effects of between −0.19 and 0.19 were termed trivial. To make inferences about the large-sample value of an effect, the uncertainty in the effect was expressed as a 90% confidence limit. An effect was deemed unclear if the confidence interval overlapped the thresholds for both small positive and negative effects. The alpha level was set at $p \leq 0.05$. An intraclass correlation (ICC) of 0.90 for peak power in a resisted squat jump in a cohort with a similar training background has been reported previously (1). Similarly, high reliability for the 40-m sprint (ICC = 0.91) and strength measures (ICC ≥ 0.96) has been reported in well-trained rugby athletes (6).

RESULTS

Over the 12-week preseason period, mean improvements (±90% confidence limits) were observed in bench press (15.0 ± 5.1 kg; ES: 1.52), squat (19.5 ± 9.1 kg; ES: 1.12), and peak power in the countermovement jump (446.5 ± 248.0 W; ES: 0.94). When the 4 exercise modalities were compared, eccentric training elicited greater strength gains when compared with traditional training in the bench press and squat exercises (Figure 1). The overspeed stimulus did not affect strength gains achieved across the 3-week blocks ($p > 0.05$). As a result, strength data for the eccentric and traditional training treatments was pooled from the first 2 blocks, and large clear differences were observed between the increases in bench press (5.5 ± 3.6 kg; ES: 2.17) and squat strength (3.0 ± 2.8 kg; ES: 1.46).

The changes in lower-body peak power produced in unloaded countermovement jumps are presented in Figure 2A. All treatments effectively increased this measure of lower-body power ($p \leq 0.0017$); however, all treatments produced greater improvements than traditional training (ES: 0.42–0.95). The eccentric training modality with an overspeed training component produced the largest peak power enhancement (156 ± 124 W; ES: 1.32).

No change in 40-m sprint time was observed when eccentric training was performed ($p = 0.9050$, Figure 2A) and slower running times were observed in 12 out of 20 athletes. However, the incorporation of overspeed stimuli to the 3-week eccentric training block was sufficient to enhance maximal running speed when compared with eccentric training alone (0.03 ± 0.01 seconds; ES: 1.33) and more so than traditional training alone (0.01 ± 0.01 seconds; ES: 0.55). Sprint speed only worsened in one athlete who performed the eccentric training combined with overspeed actions. The traditional training modality, when combined with downhill running and negatively loaded countermovement jumps, produced the largest enhancement in 40-m running performance (0.04 ± 0.03 seconds; ES: 2.04).

DISCUSSION

Our data demonstrate that eccentric training elicited greater improvements in upper- and lower-body strength than traditional resistance training and that the addition of overspeed training stimuli to eccentric training produced improvements in measures of functional lower-body power. The current findings, which occurred in short-term training blocks in athletes with a solid training history, support a recent meta-analysis and systematic review (35), which concluded that eccentric training can enhance strength gains and muscle mass to a greater extent than concentrically focused actions because of the higher absolute forces experienced by the muscle.

Indeed, earlier research has demonstrated that maximal eccentric contractions are more effective than maximal concentric actions in stimulating protein synthesis and hypertrophy (11,14,22). Interestingly, when compared with concentric actions, eccentric actions have been reported to exhibit selective recruitment of type II motor units (29), and this reversal of Henneman's size principle (18) may contribute to the propensity of eccentric actions to elicit hypertrophic adaptations via enhanced protein synthesis signaling (33). Thus, in agreement with the summation of this earlier research, our data demonstrates that eccentric training, with or without the addition of overspeed stimuli, was more effective than traditional resistance training in increasing both upper- and lower-body strength measures.

The eccentric training block in this study also resulted in greater improvements in countermovement jump peak power when compared with traditional training. Similar results have been reported in a 7-week training study, which showed that eccentric cycling training improved leg stiffness and maximum jump power when compared with concentric cycling (12). Furthermore, in our study when countermovement jumps and flat plane sprints were replaced with assisted jumps and downhill running within training sessions in the eccentric training block, a substantial improvement in countermovement jump peak power were observed. Indeed, superior gains in countermovement jump height have previously been reported when an overspeed stimuli has been compared with bodyweight jump training in athletic populations (1,37).

Whereas the eccentric training treatment performed in the current trial was effective in producing strength and countermovement jump power gains when compared with traditional training, it is worth noting that these improvements did not manifest as improvements in 40-m running performance. This relatively negative response may have been because of the adaptive specificity of eccentric training. Adaptations to eccentric training have been reported to be more specific to the mode (20) and speed (36) than concentric training. Indeed, Seger et al. (36) demonstrated that, while eccentric training produced significant increases in both eccentric and concentric strength at the training velocity; strength gains with concentric training occurred at all velocities equal to, and lower than, the training velocity.

Importantly, the incorporation of overspeed training stimuli within the eccentric training block was effective in producing improvements in 40-m sprint running times that were similar to the most effective training treatment (traditional training with additional overspeed stimuli) and superior to the traditional training treatment. Assisted and downhill running training have previously been reported to improve running sprint speed (23,32), and these improvements have been associated with changes in running kinematics (5,31) and neural activation (26). We used a 2° gradient for practical reasons, and this gradient is similar to that used in the study by Paradisis and Cooke (32) that demonstrated performance benefits across a 6-week training study. It is apparent that an optimal downhill gradient for sprint running enhancement has not yet been established as one report suggests that gradients of less than 2.6° should be used (28), whereas others suggest that a gradient of approximately 5.8° should be used (9). It should be noted, however, that Ebben (9) does not present longitudinal data to support the transference of maximal speed increases to horizontal sprint running performance.

Complex training, where a heavy resistance exercise is combined with a biomechanically similar plyometric exercise within an exercise session, has been reported to improve muscular function to a greater extent than training these aspects individually (15,17,34). It should be noted that both the eccentric and traditional training treatments incorporated plyometric exercises after each training session and that these additional exercises were matched by volume with the overspeed treatment. Thus, the beneficial effects of the overspeed stimuli on maximal running times can be attributed to these specific overspeed interventions and not to complex training per se.

It is worth noting that kinematic differences distinguish the overspeed jumping and running stimuli that were applied in this study. The overspeed running stimulus will accentuate the eccentric loading on the lower body. Previous research has demonstrated elongated strides during overspeed running are associated with greater braking forces (5,27). In contrast, the overspeed jump stimulus is associated with an unloading during the eccentric (landing) phase during a countermovement jump because of the stretch in the elastic bands. Decreases in eccentric phase muscle activity, such as would occur in our overspeed countermovement jump exercise, have been demonstrated to have negative effects on muscle activity, force output, and subsequent concentric performance (25).

Irrespective of mechanisms, the incorporation of overspeed exercises was effective in enhancing the transference of strength into functional power measures. The long-term effects were not assessed, but the use of overspeed stimuli to a preseason training block facilitated a meaningful contribution in the short term to performance adaptations of trained athletes.

PRACTICAL APPLICATIONS

Eccentric training was more effective in improving upper- and lower-body strength measures when compared with traditional concentrically focused training. Though eccentric training alone did not improve 40-m sprint times, replacing countermovement jumps and flat plane sprints with assisted jumps and downhill running within training sessions improved the transference of strength into maximal running speed. These improvements were seen in already well-trained male athletes and are likely to assist any athlete requiring explosive power. Indeed, athletes will likely benefit from individualized training prescriptions based on prior assessment of limitations in the specific components of power production. It is apparent that in short-term training blocks with multiple training goals, which are common in a range of sports, eccentric training with an overspeed component can be used by coaches and trainers to improve lower-body strength, power, and running speed.

ACKNOWLEDGMENTS

Partial funding for this project was received from the United Kingdom Sports Council.

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