The Effects of Eccentric, Velocity-Based Training on Strength and Power in Collegiate Athletes

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ABSTRACT

International Journal of Exercise Science 9(5): 657-666, 2016. The purpose of this study was to determine if combining velocity-based training with eccentric focus (VEB) and velocity-based training (VBT) results in power and strength gains. Nineteen men and women collegiate track and field athletes participated in this study. The subjects completed a 12-week intervention with either a VEB program or a VBT program. To determine the effectiveness of each program, the subjects completed four exercise tests before and after the training period: vertical jump, medicine ball put test, 1RM projected bench press and 1RM projected squat. There were no significant differences between the VBT results and the VEB results. However, there were significant improvements between the pre-test and post-test measures for each group. There were increases in 1RM projected squat for VEB men, VBT men, and VBT women. There were also significant improvements in the VEB male vertical jump and medicine ball put test pre- to post-intervention. For track and field athletes, both programs may result in strength and power gains, however, the results cannot be used to conclude that one resistance training program is superior.

KEY WORDS: Track and field, resistance training, projected one-rep max, eccentric training, velocity training

INTRODUCTION

Standard strength and conditioning typically aims to improve slow speed strength, while plyometrics and agility training focus on power development (12). When velocity-based training (VBT) was introduced, it combined the strength and power phases to improve power development in the weight room with high-velocity movements using loads that compare to those used to improve strength (12). Research showed the positive effects of VBT and its effectiveness in improving overall power production (9). Since the introduction of VBT, coaches and athletes of many anaerobic-based sports have implemented VBT into their strength regiments as a way to maintain strength and increase power, while preventing muscular fatigue for the upcoming competition.
Another popular style of strength training is eccentric training, as larger forces can be developed eccentrically (10). Wirth, et al. reported that if an athlete can effectively use concentric and eccentric types of contractions, it is superior in building strength compared to a concentric contraction-based program (16). One particular study was able to show that after eleven weeks of eccentric training, explosiveness increased by 44% eccentrically and 77% concentrically (11). Also, many injuries occur during eccentric loading movements, and therefore training eccentrically may develop muscle that is more resistant to injury (3).

Taken together, it is possible that a combined program, including both velocity and eccentric training (VEB), may produce gains of both strength and power. Both VBT and eccentric training have been found to improve vertical jump (7, 13). Further, no matter the contraction type or load, power output is increased by training at maximal velocity (9).

To combine the styles of eccentric training and VBT, the resistance should be at a moderate load, the eccentric contraction speed slow, and the concentric speed explosive. Moderate loads and low repetitions have been used in a study for VBT, along with sprint and jump training to enhance performance (7).

To date, a study that has combined these two training programs in athletes could not be found. Lesczak, et al. did combine VBT and eccentric training, but in older adults (11). There, they reported positive results of increased 1RM in leg curl, leg press, and leg extension, supporting the combination of VBT and eccentric training.

The purpose of this study was to determine whether eccentric training and VBT could be used together (VEB) in a strength training program in track and field athletes to develop two critical characteristics of athletics: strength and power. We hypothesized that by training the two programs of eccentric contraction and VBT together in one program (VEB), larger gains in both strength and power production would be made compared to a VBT program alone. Our null hypothesis was that there would be no differences in performance between the VEB and VBT training groups.

METHODS

Participants
Twenty Division III men and women Track and Field athletes were randomly placed into one of two training groups: VBT or VEB (Table 1.0). Within each group (throwers, jumpers, sprinters), each participant was randomly assigned to either the VEB or VBT training program. Both training groups completed their program on Legend Fitness training equipment (Knoxville, TN). All athletes had completed a physical prior to participating in this study with the NWU Athletic Training staff indicating they were healthy and eligible for training and competition. The Nebraska Wesleyan University Institutional Review Board approved this study. All participants were informed of the risks involved and benefits associated with the
study before they signed the informed consent form. Parental consent was gained if the subject was a minor.

Table 1. Characteristics of subjects (Mean ± SD)

|                  | Men (n = 11)   | Women (n = 9) |
|------------------|---------------|---------------|
| Age (years)      | 20.25 ± 1.13  | 19.75 ± 1.03  |
| Height (cm)      | 185.84 ± 7.25 | 172.72 ± 4.70 |
| Weight (kg)      | 94.21 ± 19.50 | 82.78 ± 19.65 |

Protocol
The effectiveness of both VEB and VBT were measured by testing projected 1RM squat, projected 1 RM bench press, vertical jump, and medicine ball put test. Resistance training programs for 20 Track and Field athletes were designed for a 12-week training period where the content of the programs was similar, only the method of execution of core lifts differed. Subjects were instructed on technique of all testing and program lifts. Details about the content and periodization of the programs are given below, as well as detailed procedures for the exercise tests.

A projected 1RM squat was performed by each individual to measure lower body strength. To perform the squat, each individual performed parallel to the floor squats until they reach a repetition between three and six. From there, they increased the weight and perform three to six repetitions until they could no longer reach parallel or couldn’t perform a single repetition. While the protocol is stated three to six repetitions, athletes were coached to perform three repetitions due to greater accuracy of conversion of one-rep max. Experienced spotters were in proximity to assist and reduce the risk involved.

A projected 1RM bench press was calculated to determine each participant’s upper body strength. To perform the bench press, each individual was supine on a bench. Similar to squat, the subject unracked the barbell, lowered the bar to their chest until their arms formed a 90-degree angle or until the barbell touched their chest. The subject then extended their arms until the barbell was back in its starting position. They completed this motion between three to six times and then moved up in weight. While the protocol is stated three to six repetitions, athletes were coached to perform three repetitions due to greater accuracy of conversion of one-rep max. They completed the bench press when they could no longer return the barbell to its starting position with arms fully extended, or they couldn’t complete more than one repetition. Experienced spotters were in the proximity to assist the subject.

Each subject completed the vertical jump test to determine their lower body power, and to begin, one subject stood under the Vertec Jump training system and with his or her dominant arm up, reached for the highest peg possible. This creates a baseline for the subject. Then, the subject was instructed to stand under the Vertec, was allowed one rock step, and then jumped as high as possible off of both feet and push away more of the pegs on the Vertec. Each subject jumped three attempts, and the best jump was recorded. Each subject completed a short warmup before it was their turn to jump to reduce the risk of injury.
The subject was seated on a bench at an incline angle with a medicine ball, 8 pounds for females and 12 pounds for males. The medicine ball was placed in both hands, with elbows out to the sides of body. A chest toss for distance was performed, with the subject explosively extending their arms without having their back leave the seat of the bench. The toss was measured, and the best of three attempts was recorded.

Resistance training programs for the Track and Field athletes consisted of core lifts, power lifts, and accessory exercises 3-4 times per week, rotating upper and lower body exercises to allow for adequate rest and recovery for 12 weeks. The first 6 of the weeks resistance training was performed 4 times/week, and the final 6 of the weeks of the program, resistance training was performed 3 times/week. During the resistance training, power lifts were performed first, followed by core lifts, and finally accessory exercises.

Core lifts that were performed in both training programs include: squat, bench press, shoulder press, leg press, and incline bench press. These 5 lifts were assigned as either VBT or VEB for their respective subjects. Those in the VEB group were coached to performing the lifts with a
slow and controlled eccentric phase (approximately three seconds) and an explosive concentric phase, whereas the VBT group was coached to performed both the eccentric and concentric phases explosively. Power lifts and accessory lifts were also included in both programs, and the way in which they were performed did not differ between groups. Power lifts included: snatch, hang clean, power clean, and high pull. Approximately 4-6 accessory exercises, such as body weight lunges, pushups and pull-ups, were performed at the end of each resistance training session.

Baseline measurements were completed over the course of a Monday and Tuesday, and the training programs began the following Monday. Periodization for the 12-week program included three 3-week cycles, with one deload week after the first two cycles, and ending the programs with two weeks of tapering for peak. Details of the core and power lifts periodization include: Cycle 1: 4-5 sets x 6-8 repetitions at 50-60% of projected 1RM, Cycle 2: 3-5 sets x 4-6 repetitions at 60-70% of projected 1RM, Deload week: 3 x 4-5 at 70% of projected 1RM, Cycle 3: 4-5 sets x 2-4 repetitions at 70-80% of projected 1RM, Final Two Weeks: 4-6 sets x 2-5 repetitions at 55-65% of projected 1RM. The post-testing data was collected during the week following the end of the intervention.

Statistical Analysis
Data is presented as mean ± standard deviation. Changes in performance between training groups were compared using an independent t-test using Microsoft Excel. Within-group analysis was also done using a dependent t-test. A value of p < 0.05 was used to determine the significance of the results within the experiment.

RESULTS

Nineteen track and field athletes completed either the VBT or VEB within the 12-week off-season (fall). One subject did not complete the training program due to injury. When comparing the pre-to-post changes in performance, there were no significant differences between the VBT and VEB training groups.

However, there were significant differences from pre-to-post-intervention within each training group. Within the VEB training group, there were significant increases in men’s 1RM squat (166.55 ± 35.74 to 177.73 ± 34.80 kg; Figure 2A), men’s vertical jump (73.63 ± 12.67 to 75.83 ± 12.37 cm; Figure 3A), and men’s medicine ball put test (4.12 ± 0.52 to 4.54 ± 0.46 m; Figure 3B).

Within the VBT training group, there were significant improvements in men’s 1RM squat (154.55 ± 9.46 to 176.71 ± 15.89 kg; Figure 2A), and women’s 1RM squat (104.63 ± 23.76 to 123.89 ± 24.80 kg; Figure 2B). All other group performances did not improve significantly, including no improvements in 1RM bench press in either training group.
Figure 2. The effects of VBT and VEB training on projected 1RM squat in (A) Men and (B) Women track and field athletes. *P ≤ 0.05 from pre- to post- intervention. Data are presented as means ± SD.
Figure 3. The effects of VBT and VEB training on (A) Men’s vertical jump and (B) Men’s medicine ball put test. *P ≤ 0.05 from pre- to post-intervention. Data are presented as means ± SD.
DISCUSSION

The main findings of this study suggest that VBT with or without eccentric focus will increase strength and power output, particularly seen in squat. A recent study by Janovic, et al. reported results and proposed that no matter the contraction type or load, the subject is able to increase power output by training with the intent to move the load at maximal velocity for the individual (9). In this study, power output and strength both increased, which is likely due to their interconnection to each other (14, 17). Strength and power are interrelated in the force development of power output, and be should trained as such to maximize potential in any given athletic event (4, 14, 15). Using a program such as VBT, as shown in this study, will develop the athlete’s strength and ability to create force quickly. There were very few pre- to post-intervention performances that were negative numbers, demonstrating that on average, using any velocity-based training program can result in strength and power gains for the athlete.

We hypothesized that VEB would increase both strength and power output. As seen in this study, VBT does increase both strength and power output, with or without eccentric focus, and this could be due to the fact that working at high velocities regardless of contraction type increases strength gains (1, 2, 6). Our study does contradict with a couple reports, showing that after eccentric training, explosiveness increased by 44% eccentrically and 77% concentrically (11). It is important to note that this study did not have VBT, but rather compared a high-velocity program without the heavy lifting concept to the eccentric training. Others have reported that eccentric contraction training results in improved jumping ability (5), which we only noted in the men’s VEB training group. Another study using moderate loads and low repetitions, which is a similar training strategy as velocity-based training, reported enhanced vertical jump and strength performance (7).

Athletes began competitive training halfway through this study, and therefore, this could have influenced the performance in our study. It is possible that the athletes were fatigued or over-trained, which could have affected their performance. Unfortunately, there was much variety in the pool of athletes recruited for this study. Athletes were of different ages, had varying experience with resistance training, and competed in different types of events. These confounding factors could not be controlled in this study. Future studies involving a variety of athletes should be done to further investigate the effectiveness of a combination strength training program involving both eccentric and velocity components to determine if specific groups would benefit more from one type of training over another. As only performance measures were taken here, it is not known how lean mass changed within the athletes during the training program. It may be of interest for future studies to investigate changes in lean mass between the different types of programs to determine if hypertrophy or neuromuscular changes are involved in the performance improvements seen in VBT.

While the findings of this study show that both the VBT and VEB training programs were effective in improving strength and power, neither was superior. In examining the cost-benefit analysis of performing a VEB program, it may not be worth the time and effort it takes to
perform the eccentric motion. Athletes who participated in the VEB program took much longer to finish their workout, but overall the gains were similar compared to the VBT group. Additionally, the moderate-to-low-intensity loads in VBT allows for less fatigue and quicker recovery, all-the-while- performance is still improving. Therefore, this type of training would be best implemented during the final weeks leading up to competition or a peak in training.

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