Effect of different velocity loss thresholds during a power-oriented resistance training program on the mechanical capacities of lower-body muscles

Alejandro Pérez-Castilla, Amador García-Ramos, Paulino Padial, Antonio J. Morales-Artacho and Belén Feriche

Department of Physical Education and Sport, Faculty of Sport Sciences, University of Granada, Granada, Spain; Facultad de Educación, Universidad Católica de la Santísima Concepción, Concepción, Chile

ABSTRACT
This study compared the effects of two velocity loss thresholds during a power-oriented resistance training program on the mechanical capacities of lower-body muscles. Twenty men were counter-balanced in two groups (VL10 and VL20) based on their maximum power capacity. Both groups used the same exercises, relative intensity and repetition volume, only differing in the velocity loss threshold of each set (VL10: 10% vs. VL20: 20%). Pre- and post-training assessments included an incremental loading test and a 15-m linear sprint to assess the force- and load-velocity relationships and athletic performance variables, respectively. No significant between-group differences (P > 0.05) were observed for the force-velocity relationship parameters (ES range = 0.15–0.42), the MPV attained against different external loads (ES range = 0.02–0.18) or the 15-m sprint time (ES = 0.09). A high between-participants variability was reported for the number of repetitions completed in each training set (CV = 30.3% for VL10 and 29.4% for VL20). These results suggest that both velocity loss thresholds induce similar changes on the lower-body function. The high and variable number of repetitions completed may compromise the velocity-based approach for prescribing and monitoring the repetition volume during a power-oriented resistance training program conducted with the countermovement jump exercise.

Introduction
A key physical performance factor in numerous sport activities is the ability to produce a high amount of force in the shortest time possible (Haff & Nimphius, 2012). Success in such actions (e.g., jumping, sprinting, change of direction, etc.) has been closely related to high muscle power outputs, that is, to the ability to produce high levels of force at high muscle contraction velocities (Crónin & Hansen, 2005; Swinton, Lloyd, Keogh, Agouris, & Stewart, 2014). Ballistic exercises, which are characterized by accelerating the body mass or an implement through the whole range of motion, are commonly included in resistance training (RT) programs aiming to enhance maximal power production (Cormie, McGuigan, & Newton, 2011; Haff & Nimphius, 2012). Therefore, of particular interest for coaches, strength and conditioning professionals and sport scientists would be to identify the most appropriate approaches for prescribing and monitoring RT programs aiming to maximize power performance that typically include ballistic exercises (e.g., vertical jumps).

Velocity-based training (VBT) has been proposed as an objective and practical method of prescribing both the intensity and volume of RT programs (González-Badillo & Sánchez-Medina, 2010), which are considered the two acute RT variables with most influence in the training response (Kraemer & Ratamess, 2004; Scott, Duthie, Thornton, & Dascombe, 2016). Exercise intensity has been traditionally prescribed as a percentage of the one-repetition maximum (%1RM) (González-Badillo & Sánchez-Medina, 2010; Kraemer & Ratamess, 2004). However, the strong and stable relationship observed between movement velocity and %1RM supports the use of movement velocity to prescribe the relative load (Conceiçã, Fernandes, Lewis, González-Badillo, & Jimenéz-Reyes, 2016; González-Badillo & Sánchez-Medina, 2010; Sánchez-Moreno, Rodríguez-Rosell, Pareja-Blanco, Morac-Custodio, & González-Badillo, 2017). More recently, the velocity loss incurred during a training set has been proposed as a criteria to decide when each set should be stopped (Pareja-Blanco et al., 2016; Pareja-Blanco, Sánchez-Medina, Suárez-Arrones, & González-Badillo, 2016). This approach is justified by the significant associations observed between the magnitude of velocity loss and the degree of fatigue (Sánchez-Medina & González-Badillo, 2011). Accordingly, it would be expected that the degree of velocity loss experienced during the training sets influence the RT effect. However, there is scarce evidence regarding the effect of different velocity loss thresholds (e.g., 10% vs. 20%) on the neuromuscular adaptations following a power-oriented RT program.

To date, only two studies have analysed the effect of different velocity loss thresholds during RT on the neuromuscular adaptations (Pareja-Blanco et al., 2016, 2016). Both studies used the full-squat exercise and high intensity oriented loads (i.e. 50–85%1RM). While similar increases in maximal strength were observed for the different velocity loss thresholds, there was no difference in the force-velocity relationship parameters.
thresholds, ballistic performance (i.e. unloaded countermovement jump [CMJ] height) further improved in the groups that used lower velocity loss thresholds (i.e., minimizing fatigue). It should be noted that in both studies the groups that used a high-velocity loss threshold (30% and 40%) performed a significantly higher training volume (i.e., higher number of repetitions) than the groups that used a low velocity loss threshold (15% and 20%). Therefore, since RT muscle responses are markedly influenced by the training volume (González-Badillo, Izquierdo, & Gorostiaga, 2006; Schoenfeld, Ogborn, & Krieger, 2017), it could be interesting to explore the effect of different velocity loss thresholds when the total training volume is equalised between groups. It is also unknown whether VBT can be a suitable approach for prescribing and monitoring a power-oriented RT program with lower relative intensities (<50%1RM) and using ballistic exercises (e.g., the loaded CMJ), which are commonly recommended to develop maximum power and high-velocity explosive actions performance. In this regard, since ballistic exercises are commonly performed with minimal fatigue (Cormie et al., 2011), it seems reasonable to explore in these exercises the effects of lower velocity loss thresholds than the typically used in previous studies.

To address the existing gaps in the literature, the objective of the present study was to compare the effect of two velocity loss thresholds (10% vs. 20%) during a power-oriented RT program with the same exercise intensity and repetition volume on the mechanical capacities of lower-body muscles. We hypothesized that the RT program allowing a 10% velocity loss would result in greater short-term power performance improvements than a 20% velocity loss due to the greater number of repetitions performed at higher velocity. The expected findings should contribute to refining the VBT approach to prescribe intensity and volume of power-oriented RT programs.

**Method**

**Participants**

Twenty men volunteered to participate in this study. Participants were physically active sports science students with at least two years of recreational RT experience. They were instructed to avoid any strenuous exercise over the course of the study and were also required to complete the specific RT programs without missing any session. None of them reported physical limitations, health problems or musculoskeletal injuries that could compromise tested performance. All participants were also informed of the procedures to be utilized and signed a written informed consent form prior to initiating the study. The study protocol adhered to the tenets of the Declaration of Helsinki and was approved by the Institutional Review Board.

**Experimental design**

A longitudinal pre-post design was employed to compare the effects of two power-oriented RT programs with different velocity loss threshold on the mechanical capacities of the lower-body muscles. Participants were matched according to their theoretical maximum power (Samozino, Rejc, Di Prampero, Belli, & Morin, 2012) and then randomly assigned to one of the two groups: VL10 (n = 10, age 22.2 ± 2.5 years, body mass 73.9 ± 17.1 kg, height 174.6 ± 5.9 cm) or VL20 (n = 10, age 21.9 ± 1.7 years, body mass 80.1 ± 15.2 kg, height 176.7 ± 6.0 cm). Prior to the power-oriented RT program, all participants took part of six preliminary sessions (twice a week) with the purpose of ensuring a proper technique and increasing strength levels. Thereafter, they undertook two different RT programs over a four-week period (eight sessions). Both training groups performed the same exercise (loaded CMJ) at the same relative intensity (mean propulsive velocity [MPV] = 1.20 m·s⁻¹) and training volume (36 repetitions). The only difference between the groups was the velocity loss allowed during the training sets (VL10 = 10% vs. VL20 = 20%). Participants were assessed before and after the RT program through a 15 m linear sprint and an incremental loading test in the CMJ exercise. The incremental loading test was performed 5 min after completing the linear sprint test. All sessions were conducted in the laboratory with at least 48–72 h of rest, at a consistent time of the day for each participant (±1 h) and under similar environmental conditions (~22°C and ~60% humidity).

**Testing procedures**

**Sprint test**

Three maximal 15 m indoor sprints were performed with 3 min of rest between them. The starting position was standardized with the lead-off foot placed 1 m behind the first time gate (Microgate, Bolzano, Italy). Participants were instructed to run as fast as possible and only the shortest time was selected for the subsequent analysis. The standardized warm-up consisted of jogging at a self-selected easy pace, dynamic stretching and lower-body joint mobilization exercises, followed by two sets of 15 m running progressive accelerations. The coefficient of variation (CV) and intraclass correlation coefficient (ICC) for sprint times were 2.22% (95% confidence interval [CI]: 1.68%-3.24%) and 0.71 (95% CI: 0.40–0.88).

**CMJ incremental loading test**

The CMJ technique involved participants standing with the knees and hips fully extended, feet approximately shoulder-width apart, and the barbell held across the top of the shoulders and upper back. Thereafter, participants initiated a downward movement until reaching 90° knee flexion, followed immediately by a jump for maximum height. To ensure the 90° knee angle, participants descended until touching an adjustable rod on a tripod with their glutei (Morales-Artacho, Padial, García-Ramos, Pérez-Castilla, & Feriche, 2017). The 90° knee angle was individually measured with a manual goniometer and the height of the tripod was maintained for all testing and training sessions. Participants were instructed to apply constant downward pressure on the barbell and to touch down the ground with extended leg in foot plantar flexion (Jiménez-Reyes et al., 2017). If any of these criteria were not met, the trial was repeated.