THE EFFECT OF THE DIFFERENCE IN RESISTANCE TRAINING VELOCITY LOSS ON MUSCULAR STRENGTH AND EXPLOSIVE PERFORMANCE

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The present study aimed to compare the effects of mixed-training with different proportions of concentric velocity loss (10% vs. 30%) on muscular strength and explosive performance. Twenty healthy trained men were recruited and randomly assigned to the velocity loss of 10% (VL10) and velocity loss of 30% (VL30) for eight weeks of mixed-training. The participants performed 1RM in back squat, countermovement jump (CMJ), 10-m (T10) and 20-m (T20) sprint running before and after mixed-training. Both groups showed similar improvement in the 1RM strength (9.6% vs 9.3%). However, only the VL10 group significantly improved CMJ (6.2%), T10 (-1.7%), and T20 (-1.3%) after training. In this study, controlling the velocity loss at a lower percentage (10%) was more advantageous for explosive performance.

KEYWORDS: training velocity, load-velocity relationship, movement velocity, barbell velocity, fatigue monitoring

INTRODUCTION: Mixed-training consists of high-intensity resistance training and ballistic exercise. Such exercise sequencing stimulates the post-activation potentiation, a phenomenon that stimulates the performance of subsequent ballistic exercise through the post-activation potentiation after high-intensity resistance training, which can improve muscular strength and explosive performance in the long term (Cormier et al., 2022).
Wearable devices, such as the linear position transducer (LPT) and inertial measurement unit (IMU), have commonly been employed to monitor motion quality during resistance training (Pareja-Blanco et al., 2017). These devices measure the kinematic parameters of the barbell, including its velocity. The velocity of the barbell movement is then utilized to prescribe the intensity of the training, and this method is referred to as velocity-based training (VBT). LPT and IMU analyzed the mean concentric velocity (MCV) and mean propulsive velocity (MPV) during the concentric phase of resistance training, establishing a load-velocity profile (LVP) (Sánchez-Medina et al., 2017). In the classic study conducted by Sánchez-Medina et al. (2017), it was demonstrated that a high degree of predictive power exists between changes in MCV and % of one repetition maximum (%1RM) (R^2 = 0.955). In addition, when prescribing resistance training, movement velocity is a crucial consideration, especially the MCV in the concentric phase, which can reduce or aggravate fatigue, increase motivation, and monitor changes in physical performance. By controlling the magnitude of changes in movement velocity during resistance exercise, it is possible to control the fatigue response accurately. VBT used the LVP to control fatigue during training by prescribing the proportion of velocity loss for each set of resistance exercise (Weakley et al., 2021). Previous studies have indicated a strong positive correlation between the velocity loss of the back squat and blood lactate as well as the effort index (indicating that the more velocity loss, the higher the levels of blood lactate and effort index) (Rodríguez-Rosell et al., 2018). In addition, the proportion of velocity loss has been found to be highly predictive of the proportion of repetitions completed in a single set of back squats (R2 = 0.93). A 10% and 20% decrease in the MPV of the back squat is approximately equivalent to completing 36% and 50% of the maximal repetitions (Rodríguez-Rosell et al., 2020). Therefore, the literature suggests that VBT can effectively replace the traditional 1RM method in monitoring the intensity and volume of each training session. However, the effect of VBT applied to mixed-training is still unclear. Therefore, this study aimed to compare the effects of different velocity loss percentages (10%, 30%) on muscle strength and explosive performance after eight weeks of mixed-training.

METHODS: Twenty healthy trained men were recruited and randomly assigned to the velocity loss of 10% (VL10, n = 10, age: 22.8 ± 3.2 years, height: 176.7 ± 8.9 cm, body mass: 76.0 ± 12.2 kg) and velocity loss of 30% (VL30, age: 26.1 ± 4.9 years, height: 174.3 ± 6.8 cm, body mass: 71.6 ± 9.2 kg). Both groups trained twice a week (48-72 hours apart) during 8-week for a total of sessions, which consisted of high-intensity back squat (70~85%1RM), load squat jumps (30~60%1RM), and hurdle jumps. All participants have engaged in regular resistance training for at least one year (2 sessions/week). The participants performed back squat 1RM test, countermovement jump (CMJ), 10-m (T10) and 20-m (T20) sprint running before and after mixed-training.
Back squat 1RM was tested using a 20kg barbell and a linear position transducer (GymAware Power Tool, Kinetic Performance Technologies, Canberra, Australia). Participants performed 20% (3 reps), 40% (3 reps), 60% (3 reps), 80% (1 rep), and 90% (1 rep) of the predicted 1RM, with a 2-minute rest between sets. They then performed a 1RM test, taking the last successful repetition as the 1RM. The 1RM test should be completed within 5 sets, with a 3-minute rest between 1RM measurements. After the 1RM test, the MCV of each load was obtained. Converting each load to a relative strength (%1RM) and its corresponding MCV results in a regression equation: MCV = a × (%1RM) + b, which can be utilized to obtain the velocity required to achieve %1RM (Weakley, 2021; figure 1).
During mixed training, the load for each set of the back squat was adjusted according to the LVP from the 1RM test. For instance, if 90% of the 1RM corresponds to an MCV of 0.5 m/s, then, in the next set of back squats, either increase or decrease the load by 5% of the 1RM in order to return the velocity to that of 90% of the 1RM (Weakley et al., 2021). The Back Squat is performed at a set percentage of velocity loss and then stopped (10% or 30%). Each training session consists of 3 sets of back squats, and the training intensity progresses from week 1 to week 8 as follows: 75% 1RM → 80% → 85% → 70% → 75% → 80% → 85% → 70%. A total of 3 sets of load squat jumps and hurdle jumps were performed in each training session. For load squat jumps, the training intensity was set at 30% 1RM for weeks 1-3 (6 reps), 45% 1RM for weeks 4-6 (5 reps), and 60% 1RM for weeks 7-8 (4 reps). As for hurdle jumps, the intensity involved one's body weight without any additional load, with 4 repetitions for weeks 1-3, 6 repetitions for weeks 4-6, and 8 repetitions for weeks 7-8. A mixed design of two-way ANOVA was used to compare the group factor (VL10 vs. VL30) and the time factor (pre-training vs. post-training), with the significance level set at α = .05.

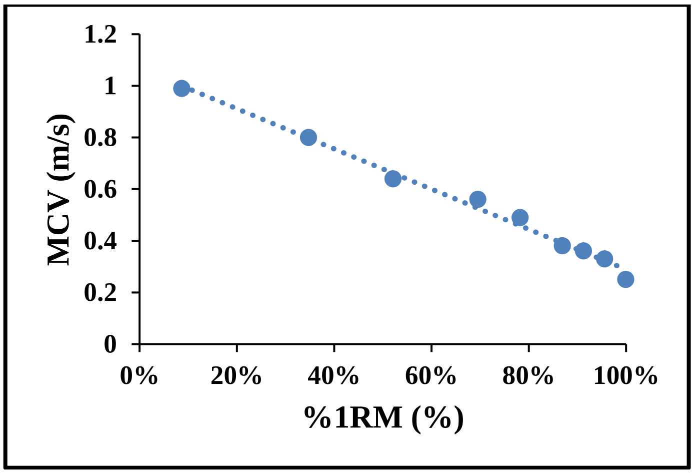

Figure 1: Schematic diagram of back squat of Load-Velocity Profile

RESULTS: During the 8-week mixed training, the actual velocity loss achieved was 14.0 ± 1.5% for the VL10 group and 32.5 ± 1.2% for the VL30 group. The total number of repetitions for the back squat was significantly greater in the VL30 group than in the VL10 group (348.9 ± 60.1 vs. 185.7 ± 18.59, $p < 0.001$). Regarding the overall back squat training velocity, the mean velocity of the VL10 group was significantly higher than that of the VL30 group (0.58 ± 0.07 vs. 0.53 ± 0.06 m/s, $p = 0.026$). There was no significant difference in the fastest velocity per set

between the VL10 group (0.62 ± 0.07 m/s) and the VL30 group (0.61 ± 0.06 m/s) (p = 0.66). Concerning the slowest velocity during each set of training, the VL30 group was significantly lower than the VL10 group (0.41 ± 0.04 vs. 0.53 ± 0.07 m/s, $p < 0.001$)
There was no significant interaction for back squat 1RM (p = .845). Following the training intervention, statistically significant increases were observed in 1RM strength (VL10: +9.6%; VL30: +9.3%, p = .001). A significant interaction was found for CMJ height (p = .022), indicating a 6.24% increase in the VL10 group (p = .037), whereas there was no significant change in the VL30 group (-2.81%, p = .286). The 10-m sprint showed nearly significant interaction (p = .058). There was a significant improvement in the 10-m sprint in the VL10 group (-1.72%, p = .027) and no significant change in the VL30 group (+0.005%, p = .621). A significant interaction was observed for the 20-m sprint (p = .008). There was a significant improvement in sprint performance in the VL10 group (-1.32%, p = .022), while no significant change was observed in the VL30 group (+0.009%, p = .168).

Table1 Changes in neuromuscular performance from pre- to post-training for each group

	VL10 (n = 10)			VL30 (n = 10)		
	Pre	Post	Δ (%)	Pre	Post	Δ (%)
Back squat 1RM (kg)	124.7 ± 19.4	136.3 ± 21.4 #	9.6	125.0 ± 19.5	135.5 ± 16.0 #	9.3
CMJ height (cm)	45.1 ± 7.0	47.8 ± 7.5 #	6.2*	43.2 ± 4.5	41.9 ± 4.8	-2.8
T10 (s)	1.77 ± 0.07	1.73 ± 0.06 #	-1.7*	1.78 ± 0.08	1.79 ± 0.07	0.005
T20 (s)	3.06 ± 0.11	3.02 ± 0.12 #	-1.3*	3.09 ± 0.15	3.12 ± 0.13	0.009

Note: * = significant difference between VL10 and VL30 groups, # = intra-group differences from Pre- to Post-training

DISCUSSION: This study is the first to investigate the effects of mixed-training with different velocity losses (10% vs. 30%) on muscle strength and explosive performance. Although both groups used the same number of sets and intensity for each training session, the different velocity loss resulted in a significantly lower total volume of back squat training in the VL10 group than in the VL30 group (185 vs 348). Despite the lower total training volume in the VL10 group, both groups showed similar improvements in the 1RM of the back squat (VL10: 9.6%; VL30: 9.3%). Regarding explosive performance, the VL10 group increased their CMJ height (6.2%). It significantly improved their 10-m sprint (-1.7%) and 20-m sprint (-1.3%), while the VL30 group showed no significant changes in the explosive performance after training.
With a fixed training volume for the plyometric exercises (load squat jumps, hurdle jumps), the total number of repetitions for the back squat in the VL10 group was approximately 53% of that in the VL30 group (185 vs. 348). However, the magnitude of improvement in maximal muscle strength was similar in the two groups (VL10: 9.6%; VL30: 9.3%). This finding aligns with previous studies (Pareja-Blanco et al., 2017; Rodríguez-Rosell et al., 2020; Rodríguez-Rosell et al., 2020), where low velocity loss (10-20%, low training volume) resulted in the same muscle strength gains as high velocity loss (30-40%, high training volume). In contrast, some studies suggest that training volume is a critical factor in improving muscle strength (Robbins et al., 2012). Robbins et al. (2012) propose that the benefits of maximal muscular strength gains begin to increase significantly at sets higher than 4 in a single session. However, in the present study, the number of sets for the single back squat was fixed at 3, which could explain why there was no difference in muscle strength gains between the VL10 and VL30 groups.
In this study, we found that mixed training combined with a 10% velocity loss effectively improved CMJ height and sprinting times (T10, T20). However, when the velocity loss was increased to 30%, no significant improvement in explosive performance was observed after training. This aligns with findings from previous studies, where lower velocity loss (10~20%) has been shown to be beneficial in improving explosive performance (Rodríguez-Rosell et al., 2020; Pareja-Blanco et al., 2017).

When the intention is to perform the movement at maximum velocity, it is beneficial to improve explosive performance. Although there was no significant difference in the fastest concentric velocity between the two groups during the eight-week back squat (VL10: 0.62 m/s; VL30: 0.61 m/s), the slowest velocity during the concentric phase was significantly lower in VL30 (0.41 m/s) compared to VL10 (0.53 m/s), suggesting that more low-velocity repetitions were performed in the VL30 group. This may not be beneficial for the improvement of explosive performance.

CONCLUSION: Mixed-training combines high-intensity resistance training with low-intensity explosive training to improve muscle strength and explosive performance. The main findings of this study were that eight weeks of mixed-training with different velocity loss (10%, 30%) were effective in increasing muscular strength (back squat 1RM); however, only a 10% velocity loss was effective in increasing explosive performance (CMJ heights, 10- and 20-meter sprints). By monitoring the proportion of concentric velocity loss during resistance training, the training volume can be controlled to prevent excessive fatigue, which, in turn, affects the long-term adaptive effects of training. When the goal of training is to improve explosive performance, the mixed-training prescription should consider controlling velocity loss.

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