Comparison of velocity-based and traditional percentage-based loading methods on maximal strength and power adaptations

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ABSTRACT

This study explored the effects of velocity-based training (VBT) on maximal strength and jump height. Sixteen trained males (22.8 ± 4.5 years) completed a countermovement jump test (CMJ), and one repetition maximum (1-RM) assessment on back squat, bench press, strict overhead press, and deadlift, before and after six weeks of resistance training. Participants were assigned to VBT, or percentage-based training (PBT) groups. The VBT group's load was dictated via real-time velocity monitoring, as opposed to pre-testing 1-RM data (PBT). No significant differences were present between groups for pre-testing data ($p > 0.05$). Training resulted in significant increases ($p < 0.05$) in maximal strength for back squat (VBT 9%, PBT 8%), bench press (VBT 8%, PBT 4%), strict overhead press (VBT 6%, PBT 6%), and deadlift (VBT 6%). Significant increases in CMJ were witnessed for the VBT group only (5%). A significant interaction effect was witnessed between training groups for bench press ($p = 0.004$) and CMJ ($p = 0.018$). Furthermore, for back squat (9%), bench press (6%), and strict overhead press (6%), a significant difference was present between the total volume lifted. The VBT intervention induced favorable adaptations in maximal strength and jump height in trained males when compared to a traditional PBT approach. Interestingly the VBT group achieved these positive outcomes despite a significant reduction in total training volume compared to the PBT group. This has potentially positive implications for the management of fatigue during resistance training.

INTRODUCTION

Resistance training is widely recognized as an effective method for improving athletic performance due to documented adaptations in muscular hypertrophy, maximal strength, rate of force development, and power output (28). The specific adaptive response to resistance training has been shown to be directly influenced by the configuration of a number of acute training variables, including loading magnitude, number of sets and repetitions, rest duration, and exercise type (23). While the optimal combination of these training variables remains an area of interest, it appears that relative load, and training volume (sets × repetitions), are the two most critical factors in determining the type and extent of resulting neuro-physiological adaptations (14, 29).

While differing methods for determining training load exist, the most common method, traditionally known as percentage-based training (PBT), prescribes relative sub-maximal loads from a previously established one repetition maximum (1-RM). This method is prevalent within the literature and has been shown to be valid and reliable across a range of populations (24). However, as maximal strength has been shown to fluctuate daily due to fatigue, and significantly increase due to continuous training, the method of prescribing relative load on potentially obsolete 1-RMs has been questioned (11, 15). Other methods, collectively referred to as autoregulatory, rely on an athlete's understanding of their perceived exertion (RPE), and / or 'repetitions in reserve' (16). These methods offer real-time load adjustment, based on an athlete's perceived readiness to train. Whilst considered valid and reliable with trained populations, autoregulatory methods adjust load based on subjective input from the athlete, creating potential inconsistencies between athletes and sessions based on understanding. Furthermore, while these methods facilitate load adaptation within training, they require a minimum number of repetitions to be completed prior to interpretation, potentially fatiguing participants prior to load modification (16). Therefore, an alternative method able to provide instantaneous repetition feedback, enabling objective load modification, could augment adaptations while concurrently limiting training induced fatigue.

A potential alternative, made more accessible with recent advancements in commercially available kinematic measuring devices, exploits the relationship documented between relative load and mean concentric velocity (MCV; (15, 18)). Research has demonstrated that movement velocity, which is dependent on both the magnitude of the load, and the voluntary intent to move it (7), influences neuromuscular stimuli, and thus the adaptations consequent to resistance training. This load-velocity relationship, commonly termed the load-velocity profile (LVP), has been explored across a range of compound movements including bench press, back squat, and prone bench pull (9, 15, 26). Providing maximal concentric effort is applied during movement, an inverse linear relationship is present between load and MCV. Furthermore, as repetitions continue during a consistent range of motion, MCV will decrease as muscular fatigue develops. This understanding has made it possible to determine the relative load during a given movement in relation to an athlete's current daily maximum and their MCV, providing a LVP has been established (15). Such findings have opened up the possibility of real-time monitoring of relative load, enabling specific adaptations to be targeted, factoring in training fatigue and strength fluctuations, as repetitions, sets, and periodization progresses.

Importantly, while LVPs have been shown to be reliable across repeat visits with trained athletes (5), limited research has explored the use of integrating LVPs into periodised resistance training as a method of adjusting training load. Previous literature exploring VBT has utilized the LVP as a means to prescribe load at a given concentric velocity, with participants instructed to complete all repetitions maximally. This maximal concentric method has been compared to various training modalities, with results generally supporting its use as a means to elicit adaptations in strength and power performance (12, 13, 20, 22). Despite these prospective improvements, methodological discrepancies between the research designs limit the confidence surrounding the proposed conclusions. Issues such as lack of training variable control, participants training experience, use of a Smith Machine as opposed to free-weight movements, undisclosed maturation status of youth participants, and / or unreliable velocity collection methods are present throughout. Furthermore, to date, no research has explored the effect of VBT when compared to traditional PBT methods.

Despite the perceived and demonstrated importance of lifting velocity and its relationship with optimal load prescription, no research currently exists comparing the effects of manipulating load based on a pre-established LVP. Therefore, the aim of the present research was to investigate the effects VBT has on the strength and power adaptations within resistance trained males when compared to a traditional PBT approach. This aim was achieved via the implementation of MCV monitoring into a periodized resistance training program over a six-week mesocycle. Addressing this will provide further insight to researchers and practitioners in making informed decisions about the use of velocity as a performance variable within athletic program design and monitoring.

METHODS

Experimental approach to the problem

A randomized controlled research design was employed to explore the effects of manipulating load, based on MCV, within a resistance training program. Following familiarization and pre-testing, participants were randomly assigned to either a VBT or PBT training intervention. All participants completed two training sessions each week, over a six-week mesocycle, before repeating the testing battery post-intervention. Testing consisted of a series of free-weight, 1-RM strength tests, including back squat, bench press, overhead press, and conventional deadlift, and a CMJ protocol. All tests were carried out at least 96 hours before / after the most recent training session. All testing and training took place at the same venue, under the direct supervision of the lead investigator, at the same time of the day (±1 hour) for each subject, and under constant environmental conditions (~20 °C).

Subjects

Thirty males originally volunteered to take part in the research study, however, due to injury (n = 3), and failure to meet the inclusion criteria (n = 11), sixteen resistance trained males were recruited and completed the training intervention (mean ± SD, age: 22.8 ± 4.5 years, stature: 180.2 ± 6.4 cm, body mass: 89.3 ± 13.3 kg). Participants 1-RM for the back squat, bench press, strict overhead press, and deadlift were 140.2 ± 26.0 kg, 107.7 ± 18.2 kg, 61.3 ± 8.7 kg, and 176.6 ± 27.2 kg, respectively (i.e. 1.54 ± 0.29, 1.13 ± 0.20, 0.68 ± 0.10, and 1.95 ± 0.30, respectively, when normalized to body mass). It was required that all subjects had at least two years resistance training experience and had been engaged in continuous resistance training for at least six months prior to the program start date. Following medical screening and experimental outline, written informed consent was obtained from each participant, with prior approval from the institutional ethics committee, in line with the Helsinki Declarations for research with human volunteers.

Procedures

Prior to all testing and training sessions, participants were supervised during a standardized warm-up, consisting of five min of stationary cycling (Wattbike; UK; 60 rpm, 60 W), followed by an additional five min of self-prescribed dynamic stretching, and barbell mobility work.

Countermovement jump

Jumps were calculated at the nearest 0.1 cm, using a Just Jump mat (Probiotics; AL, USA), with the subject holding a 0.4 kg dowel behind their head (back squat position; (10)). The dowel was required to remain in contact with the participant's trapezius throughout the full trial. During each attempt, at a self-selected pace, participants would squat to their perceived optimum depth before immediately driving upwards, with the aim of attaining maximum vertical height. Participants were instructed to keep legs straight throughout the airborne phase, with any deviation from this resulting in a void trial. A total of three trials were completed, interspaced with three min rest.

One repetition maximum

For both the back squat and bench press, 1-RM were established following the same procedures. Participants completed an initial set of 8-10 repetitions with the empty bar; followed by 5-6 repetitions at ~50% estimated 1-RM. This was increased to ~70% estimated 1-RM for 3-5 repetitions, and finally ~90% estimated 1-RM for a single repetition. At this stage the researcher dictated incremental load increases, until 1-RM was achieved using correct technique, through a full range of motion. For all repetitions, subjects were instructed to maintained eccentric control, before generating maximal force during the concentric phase. Achievable load increases were selected, with the aim of attaining a true repetition maximum within three to five attempts. If an attempt was failed, the load was decreased until a single repetition was completed. Each series of repetitions throughout the full protocol was interspaced with 3-5 min rest. During each incremental load a linear positional transducer (GymAware PowerTool; Kinetic Performance Technology, Canberra, Australia) was attached to the barbell, allowing calculation of MCV. Furthermore, the GymAware PowerTool was utilized to monitor depth during the back squat, ensuring participants maintained a consistent depth during all repetitions during the protocol.

For both the strict overhead press and deadlift, 1-RM and velocity profiling were established following procedures similar to those described by Sánchez-Medina, González-Badillo, Perez and Pallarés (26). For both exercises, initial load was set at ~30% estimated 1-RM, or 20 kg (empty bar), with incremental increases of ~5% estimated 1-RM following completion of successful repetitions. For light loads (≤50% estimated 1-RM) participants completed three repetitions, decreasing to two repetitions for medium loads (55-75% estimated 1-RM), and a single repetition for high loads (≥80% estimated 1-RM). For all repetitions, subjects were instructed to maintain eccentric control, before generating maximal force during the concentric phase. Strong verbal encouragement and velocity feedback were provided to motivate subjects to give maximal effort throughout. If participants continued to successfully complete repetitions after achieving their estimated 1-RM, incremental load increases were applied until a true 1-RM was achieved. For all repetitions, MCV was calculated and recorded via use of the GymAware PowerTool.

Resistance training program

All participants completed two resistance training sessions per week, for six continuous weeks. For both training groups, the base program (Table 1) was devised based on methods previously described by Baker (2-4), following a wave-like periodization structure. Relative training loads (% 1-RM), number of sets, and inter-set rest time were equal between groups throughout the six-week intervention. In addition to the assessed compound movements (back squat, bench press, strict overhead press, and deadlift), supplementary exercises were included within the training intervention. To ensure consistency between groups, sets and repetitions were equated, with load dictated via specific equations, using body mass, or through use of a repetitions in reserve approach (Table 1; (16)). All participants were given strong verbal encouragement throughout repetitions to motivate them to give maximal effort throughout.

Table 1. Descriptive characteristics of the base training program

Session 1												
	Week 1		**Week 2**		**Week 3**		**Week 4**		**Week 5**		**Week 6**	
Exercise	**Reps**	**% 1-RM**	**Reps**	**% 1-RM**	**Reps**	**% 1-RM**	**Reps**	**% 1-RM**	**Reps**	**% 1-RM**	**Reps**	**% 1-RM**
Back squat	8,8,8	70,70,70	8,6,5	70,75,80	6,5,3	75,80,85	8,6,5	70,75,80	6,5,3	78,85,90	5,3,2+	85,90,95
Bench press	8,8,8	70,70,70	8,6,5	70,75,80	6,5,3	75,80,85	8,6,5	70,75,80	6,5,3	78,85,90	5,3,2+	85,90,95
BB squat jump	2(3),2(3)	BW	2(3),2(3)	BW	2(3),2(3)	BW	2(3),2(3)	BW	2(3),2(3)	BW		
Strict OHP	8,8,8	70,70,70	8,6,5	70,75,80	6,5,3	75,80,85	8,6,5	70,75,80	6,5,3	78,85,90	5,3,2+	85,90,95
Deadlift											5,3,2+	85,90,95
Seated row	6,6,6	2 RIR	6,6,6	2 RIR	6,6,6	2 RIR	6,6,6	2 RIR	6,6,6	2 RIR		
Walking lunge	10,10,10		10,10,10		10,10,10		10,10,10		10,10,10			

Session 2												
	Week 1		**Week 2**		**Week 3**		**Week 4**		**Week 5**		**Week 6**	
Exercise	**Reps**	**% 1-RM**	**Reps**	**% 1-RM**	**Reps**	**% 1-RM**	**Reps**	**% 1-RM**	**Reps**	**% 1-RM**	**Reps**	**% 1-RM**
Back squat	8,8,8	70,70,70	8,6,5	70,75,82	6,5,3+	75,83,88	8,6,5	70,75,82	6,4,2	78,88,92	4,4,4	70,70,70
Bench press	8,8,8	70,70,70	8,6,5	70,75,82	6,5,3+	75,83,88	8,6,5	70,75,82	6,4,2	78,88,92	4,4,4	70,70,70
BB squat jump	2(3),2(3)	BW	2(3),2(3)	BW	2(3),2(3)	BW	2(3),2(3)	BW	2(3),2(3)	BW		
Strict OHP											4,4,4	70,70,70
Deadlift	8,8,8	70,70,70	8,6,5	70,75,80	6,5,3	75,80,85	8,6,5	70,75,80	6,5,3	78,85,90	4,4,4	70,70,70
Plyo push-up	2(3),2(3)	BW	2(3),2(3)	BW	2(3),2(3)	BW	2(3),2(3)	BW	2(3),2(3)	BW		
BB hip thrust	8,8,8	+ BW	8,8,8	+ BW	8,8,8	+ BW	8,8,8	+ BW	8,8,8	+ BW		

* BB: barbell; OHP: overhead press; Plyo: plyometric; BW: bodyweight; 2(3): cluster set, 2 x 3 repetitions; RIR: repetitions in reserve; + BW: completed with body weight on the barbell.

** Walking lunge load calculated (Ebben *et al*., 2008): 0.6 (*6-RM squat [kg; 0.52] + 14.82 kg)*

In order to successfully integrate velocity monitoring into the base resistance training program for the VBT group, a combination of velocity zones, and velocity stops were used (19, 23). For the key movements (back squat, bench press, strict overhead press, and deadlift), MCV monitoring was utilized to dictate changes in load lifted, and number of repetitions completed, on a real-time, set-by-set basis. Group zones for each movement were created using a combination of previously published data (15, 21, 26, 27), and data collected within the pre-testing 1-RM assessments. From this consolidation of data, specific group velocity zones were calculated for each movement, for each relative load (i.e. 70% 1-RM, back squat: 0.74 – 0.88 $m \cdot s^{-1}$; bench press: 0.58 – 0.69 $m \cdot s^{-1}$; strict overhead press: 0.77 – 0.91 $m \cdot s^{-1}$; deadlift: 0.51 – 0.65 $m \cdot s^{-1}$). Velocity stops were integrated into each set at 20% below the target velocity of each specific zone (23).

During each repetition, VBT participants were provided with real-time auditory feedback based on the MCV of each repetition in relation to the predetermined zone. The MCV of the completed repetitions (relative load <80% 1-RM: two repetitions; relative load >80% 1-RM: one repetition) was then reviewed in comparison to the relative velocity zone data. If the velocity was within the zone, the sets continued as programed, if the velocity was above or below the zone, the subsequent load was adjusted based on the load-velocity relationship profiles. This meant that load increments/decrements were not standardized and instead specific to the athlete's current performance in comparison to the group load-velocity profile.

Statistical analysis

For all variables, values are presented as means ± standard deviation (SD). Data analysis were completed using SPSS 22.0 (Chicago, IL, USA), with the alpha level for significance set at α = *0.*05. Independent sample *t*-tests were completed to examine the pre-training inter-group differences, as well as post-training total volume relationship. Paired-samples *t*-tests were completed to examine the intra-group percentage difference pre- to post-training. Two-way mixed (between-within) analysis of variance (ANOVA), with Bonferroni *post-hoc* comparisons, using one inter-factor (VBT vs. PBT) and one intra-factor (pre- vs. post-training), were conducted to examine the differences across all compound movements and jump protocols between groups. In addition, effect sizes (ES) were calculated according to the Cohen scale (8). Calculating ES allows the inter-group differences to be quantified irrespective of sample size. According to Cohen (8), ES can be classified as small (d = 0.2), medium (d = 0.5), and large (d = 0.8), thus inferring that when group means don't differ by greater than 0.2 standard deviations, the difference is trivial.

RESULTS

Pre-testing

No significant differences between the VBT and PBT groups were reported pre-training for any variables analyzed, including body mass, 1-RM strength, and CMJ height.

Strength assessments

For both training groups, compliance within the program was 100% of all scheduled sessions. Descriptive characteristics and ES are presented within Table 2. Training resulted in significant increases in maximal strength for back squat (VBT 9%, PBT 8%), bench press (VBT 8%, PBT 4%), strict overhead press (VBT 6%, PBT 6%), and deadlift (VBT 6%; Figure 1). No significant group by time interaction effects were witnessed between training groups for the back squat, strict overhead press, or deadlift. A significant group by time effect ($F_{(1,14)}$ = 11.50, p = 0.004) was recorded between groups for the bench press, indicating a significantly greater increase in maximal strength following the VBT intervention when compared to the PBT intervention.

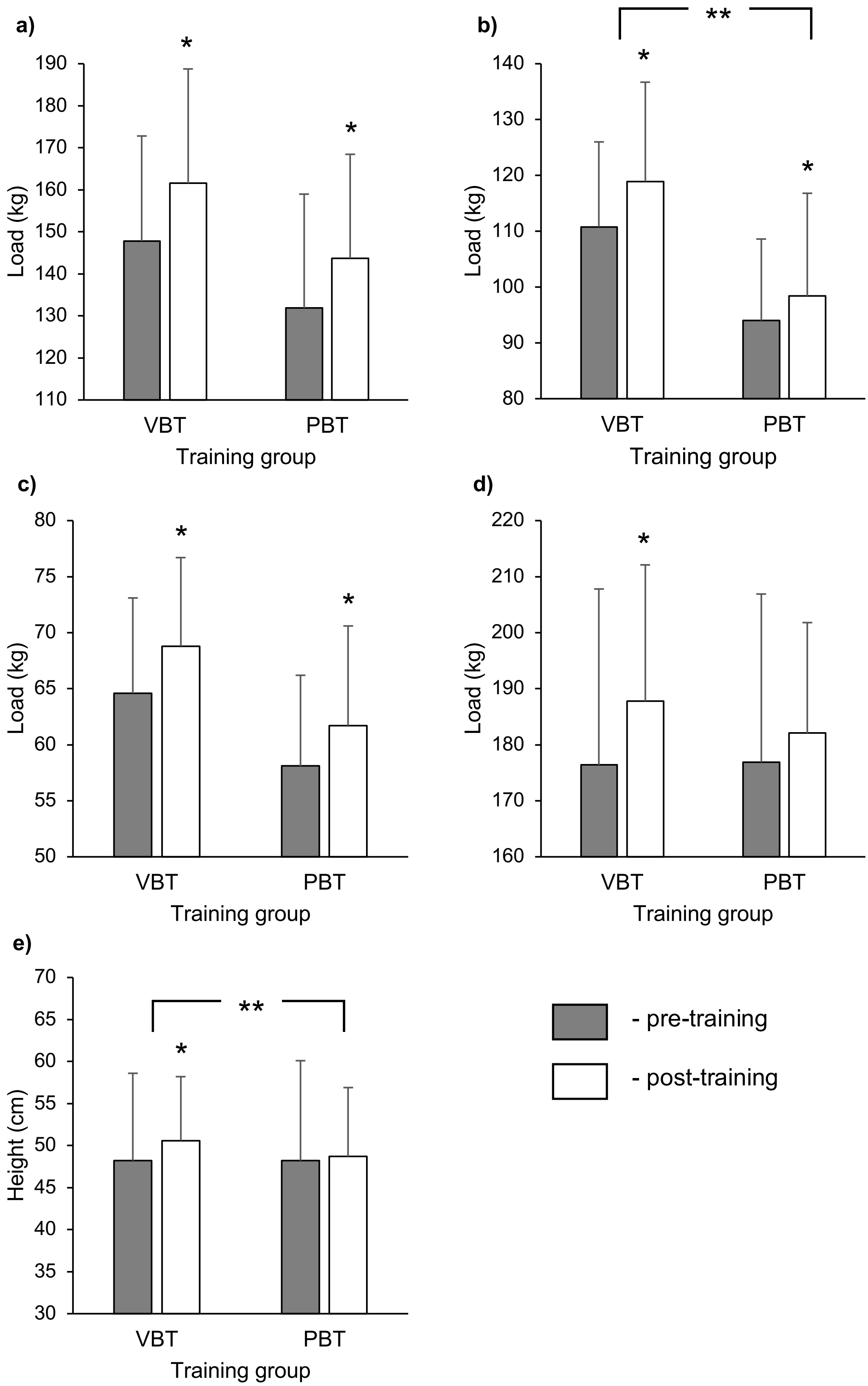
Table 2. Descriptive characteristics (mean ± SD) and effect sizes of VBT and PBT training groups, pre- to post-training.

	VBT			PBT		
	Pre	Post	ES	Pre	Post	ES
Back squat (kg)	147.8 ± 25.0	161.6 ± 27.1	0.59	131.9 ± 27.2	143.8 ± 24.7	0.44
Bench press (kg)	110.8 ± 15.2	118.9 ± 14.6	0.61	94.0 ± 17.8	98.4 ± 18.4	0.24
Strict OHP (kg)	64.6 ± 8.5	68.8 ± 7.9	0.52	58.1 ± 8.1	61.7 ± 8.9	0.41
Deadlift (kg)	176.4 ± 31.4	187.6 ± 30.0	0.38	176.9 ± 19.7	182.1 ± 19.7	0.22
CMJ (cm)	48.2 ± 10.2	50.6 ± 11.9	0.23	48.2 ± 7.6	48.7 ± 8.2	0.06

* VBT: velocity-based training; PBT: percentage-based training; OHP: overhead press; CMJ: countermovement jump; ES: effect size

Vertical jump assessment

A significant group by time effect ($F_{(1,14)}$ = 7.14, p = 0.018) was present between training groups for CMJ (Figure 1). Training resulted in a significant increase in CMJ performance for the VBT group (5%), but not the PBT group (1%).



* : significant difference pre vs. post; ** : significant group by time effect.

Figure 1. Mean changes in back squat, bench press, strict overhead press, and deadlift 1-RM (a, b, c, d, respectively), and CMJ (e) following six weeks training.

Intended vs. actual total volume

The VBT group completed significantly less volume for the back squat (9%), bench press (6%), and strict overhead press (6%) when compared to the PBT group (Table 3).

Table 3. Mean total volume completed for individual exercises and programme, created using relative load percentage in relation to pre-testing 1-RM data.

	VBT	PBT	Difference (%)	*p* value
Back squat	114896	125010	8.80	0.033
Bench press	117457	123982	5.56	0.019
Strict OHP	65742	69593	5.86	0.049
Deadlift	66827	67735	1.36	0.398
Mean volume	91231	96580	5.86	0.005

* VBT: velocity-based training; PBT: percentage-based training; OHP: overhead press

DISCUSSION

The aim of the present research was to investigate the impact of two different load prescription methods over a six-week resistance training intervention on strength and power in trained males. The data presented provides sufficient evidence to support the use of velocity-based loading methods within a resistance trained population for eliciting favourable adaptations in maximal strength and vertical jump height when compared to traditional percentage-based loading methods. This finding is furthered when considering the significant reduction in volume completed by the VBT group over the intervention compared to the PBT group, specifically across the back squat, bench press, and strict overhead press exercises.

Findings from this research revealed training induced adaptations in maximal strength and jump height following six weeks of VBT. While no direct comparative research is currently available, the results of this study are in agreement with previous investigations that reported increases in strength and / or vertical jump performance following similar VBT interventions. Pareja-Blanco, Rodríguez-Rosell, Sánchez-Medina, Gorostiaga and González-Badillo (22) demonstrated the importance of velocity within resistance training, comparing maximal velocity to deliberate “half-velocity” training. Following a six-week intervention, back squat 1-RM significantly improved in both groups (maximal velocity: 18.0%; half-velocity: 9.7%), with a group by time trend approaching significance. Furthermore, significant adaptations were recorded for CMJ in the maximal velocity group only (+8.9%), producing a significant group by time interaction. In a similar context, González-Badillo, Rodríguez-Rosell, Sánchez-Medina, Gorostiaga and Pareja-Blanco (13) reported significant increases in bench press 1-RM following six weeks of maximal velocity resistance training when compared to “half-velocity” training. Both groups (recreationally trained males; n = 20) saw significant improvements (maximal velocity: 18.2%; half-velocity: 9.7%) pre- to post-training, with the maximal velocity group producing significantly greater adaptations. Further research (23) explored the outcome of eight weeks VBT, comparing the effects of velocity loss on 1-RM back squat and CMJ performance. Participants (healthy males; n = 22) completed identical training programs, only differing in velocity stop cut-off for each exercise (20% vs. 40%), and thus potential total repetitions. Significant maximal strength adaptations were recorded in both the 20%, and 40% group (18.0% vs. 13.4%, respectively), with no group by time effect recorded. Further significant adaptations were witnessed in the 20% group for CMJ (9.5%), with negligible improvement witnessed in the 40% group (3.5%), resulting in a significant group by time effect.

While the training induced effects, and levels of percentage change reported in the aforementioned research are greater than those witnessed in the current investigation, this can be attributed to a number of methodological disparities. Firstly, all the investigations discussed used recreationally trained males (back squat 1-RM: 92.1 ± 10.4 kg (22); 106.2 ± 13.0 kg (23); bench press 1-RM: 74.9 ± 13.8 kg (13)) as opposed to the current study, where resistance trained males were used (back squat 1-RM: 140.2 ± 26.0 kg; bench press 1-RM: 107.7 ± 18.2 kg). The training status of individuals is known to have a significant effect on the resultant adaptations witnessed following a training intervention (1, 25, 28). Lesser trained participants have been shown to generate significantly greater adaptations when compared to trained individuals, directly impacting upon this comparison of data. This has been linked to increased neural alterations occurring at an accelerated rate in lesser trained participants, such as greater synchronization and recruitment of motor units, improved rate coding, and greater reflex potentiation (6). As participants in the current study were already resistance trained, these neural mechanistic changes are not witnessed to the same extent, impacting on the overall post-training adaptations. Furthermore, in two of the comparative investigations (13, 22), control participants were instructed to deliberately slow their repetitions to that of ~50% maximal MCV, which has been shown to have a significant effect on the adaptations witnessed (23). In the current study, both groups were instructed to maintain eccentric control before immediately lifting the load, utilizing a three second eccentric phase, minimal pause, followed by an immediate concentric phase. The only differing factor was the use of MCV to dictate load and repetitions within the VBT group.

The data presented further suggests that utilizing MCV as a means to determine load and repetitions results in a significant reduction in required training volume to produce favorable adaptations in maximal strength and jump performance. Recent literature (23) established how continued repetitions, and thus a decrease in lifting velocity, can alter the adaptations witnessed when compared to a higher velocity program, with lower total volume. Following completion of a VBT program, with either low (20%; V20), or high (40%; V40) velocity stop cut-off, participants completed a 1-RM squat protocol. While within-subject pre- to post-training statistical differences were present (V20: 18.0% vs. V40: 13.4%), no group by time interaction was recorded. However, a significant difference was present between the total repetitions completed by each group (V20: 185.9 ± 22.2 vs. V40: 310.5 ± 42.0), and the total work completed (V20: 127.5 ± 15.2 kJ vs. V40: 200.6 ± 47.1 kJ), highlighting the importance of concentric mean velocity monitoring within resistance training. While the V20 group did not significantly improve over the V40 group, the lower volume, higher velocity training, elicited favorable adaptations while reducing the likeliness of training induced fatigue (17). Within the present data collection, the VBT group lifted significantly less volume than the PBT group, for back squat (9%), bench press (6%), strict overhead press (6%), and consequently, overall (6%), however produced similar (back squat, strict overhead press), or statistically greater (bench press) adaptations. It is worth noting that training programs were initially designed with equated total volume (sets × repetitions × relative load), however, as the VBT groups load and repetitions were dictated via real-time MCV monitoring, deviations from this equated volume occurred. This variance of total lifting volume was allowed to occur, as it was deemed a true representation of VBT, and how MCV impacts other training variables.

In summary, the data presented within this investigation suggests that utilizing velocity as a performance variable and means of dictating load, may provide greater maximal strength adaptations than traditional percentage-based loading methods. The combination of velocity zones and stops employed, provided a favorable environment for strength and power adaptations within a resistance trained population. Furthermore, the results suggest that providing movements are completed with an optimal load (dictated via MCV), fewer repetitions, and thus a lower total training volume is necessary to significantly improve maximal strength, and, more pertinent to sporting performance, allow a positive transfer effect to movements including vertical jump.

PRACTICAL APPLICATIONS

The results of this study contribute to the awareness surrounding VBT interventions within a resistance trained population, and specifically the use of MCV as a means to alter training load. The data presented increases confidence surrounding the practical use of velocity zones and stops within a periodized resistance training program, and how these can be utilized to improve muscular strength and power. Furthermore, prescribing and monitoring training intensity via MCV provides greater control over the prescribed training load and the participants current state of fatigue, without the need to perform multiple repetition maximum protocols.

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