Comparison of individual and group-based load-velocity profiling as a means to dictate training load over a six-week strength and power intervention

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Original Investigation

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ABSTRACT

This study compared the effects of dictating load using individual (ILVP) or group (GLVP) load-velocity profiles on lower-body strength and power. Nineteen trained males (23.6 ± 3.7 years) completed a back squat one-repetition maximum (1-RM), load-velocity profiling (LVP), and countermovement (CMJ), static-squat (SSJ) and standing-broad (SBJ) jump tests before and after six-weeks of resistance training. Participants were randomly assigned to an ILVP, or GLVP intervention with intra-session load dictated through real-time velocity monitoring and prediction of current relative performance using either the participant's LVP (ILVP) or a LVP based on all participant data (GLVP). Training resulted in significant increases in back squat 1-RM for the ILVP and GLVP group ($p < 0.01$; 9.7% and 7.2%, respectively), with no group-by-time interaction identified between training groups ($p = 0.06$). All jump performance significantly increased for the ILVP group ($p < 0.01$; CMJ: 6.6%; SSJ: 4.6%; SBJ: 6.7%), with only CMJ and SSJ improving for the GLVP group ($p < 0.05$; 4.3%). Despite no significant group-by-time interaction across all variables, the ILVP intervention induced greater magnitude of adaptation when compared to a GLVP approach. Additionally, an individualised approach may lead to greater positive transfer to power-based movements, specifically vertical and horizontal jumps.

KEY WORDS: Velocity-based training; Load velocity relationship, Resistance training; Load prescription; Autoregulation

INTRODUCTION

Due to the many factors that contribute to resistance training programming, determining the optimal dose and combination of acute training variables for targeted adaptations can be challenging (Ahtiainen, Pakarinen, Alen, Kraemer, & Häkkinen, 2005; Kraemer & Ratamess, 2004). Research has demonstrated that specifically, the number of sets, repetitions, and prescribed relative load are key determinants to the adaptations witnessed (Kraemer & Ratamess, 2004). As such, one of the main problems encountered by strength and conditioning practitioners revolves around the prescription of these variables over prolonged training cycles, where fluctuations in strength and fatigue will alter an athlete’s daily training capabilities.

The external load applied during a given movement has the capacity to directly impact upon the physical adaptations witnessed, the fatigue induced, achievable sets and repetitions, and the required recovery time between training bouts (Drew & Finch, 2016; Halson, 2014). As such, relative training load is often regarded as a primary variable within programme design. While numerous forms of dictating and manipulating load exist, no one method is without limitations. Traditional approaches utilise percentages of pre-training maximal strength assessments to target specific adaptations. Standardised load increments are often employed to facilitate overload and account for any assumed muscular progression. However, ensuring the prescribed absolute load reflects the targeted relative load is challenging, as acute strength may fluctuate between training bouts and practitioners are unable to directly measure these changes (Jovanović & Flanagan, 2014). Alternate approaches such as auto-regulatory methods employ ratings of perceived exertion (RPE) or repetitions in reserve (RIR) to alter load on an individual basis, potentially alleviating these concerns

(Helms, Cronin, Storey, & Zourdos, 2016). These methods allow practitioners to progress or regress resistance training programmes potentially increasing their efficacy based on athlete perception. Despite their widespread practice (Helms et al., 2016; 2018), the use of subjective measures of athlete awareness have associated limitations (Banyard et al., 2019).

To address these concerns, contemporary literature has focused on alternative methods, such as velocity-based training (VBT), proposed to provide coaches with objective data allowing informed choices to be made both within and between sessions (Banyard et al., 2019; Dorrell et al., 2020; García-Ramos, Pestaña-Melero, Pérez-Castilla, Rojas, & Haff, 2018a; Pareja-Blanco et al., 2017; Sánchez-Medina, Pallarés, Pérez, Morán-Navarro, & González-Badillo, 2017). One application of VBT utilises the load-velocity profile (LVP), an equation that is suggested to predict the relative load based on the mean concentric velocity (MCV) of a lift (González-Badillo & Sánchez-Medina, 2010; Sánchez-Medina et al., 2017). Following collection of an athlete’s LVP and 1-RM, an estimation of relative performance can be calculated by inputting absolute load and MCV into the LVP equation. This information has then been proposed to allow the manipulation of absolute load for each set to match the desired relative load (Banyard et al., 2019; Dorrell et al., 2020; González-Badillo & Sánchez-Medina, 2010). It is proposed that such methods are sensitive enough to allow coaches to make informed decisions on a set-by-set basis (Banyard et al., 2019; Dorrell et al., 2020). While limited research exists exploring these approaches, such methods have demonstrated significant increases in strength and power, despite significant reductions in accrued volume, when compared to traditional percentage-based approaches (Dorrell et al., 2020).

Dorrell et al. (2020) compared the effects of dictating load through VBT and percentage-based approaches (PBT) over a six-week training programme. Traditional percentage-based methods based on pre-training maximal strength assessments were used for the PBT group, where systematic load increases were applied throughout the programme length. Within the VBT group, reported MCV was compared to previously established LVP data of the whole training group. This facilitated subsequent loads being increased or decreased based on current performance in relation to the athletes acute estimated relative performance. Participants completed six weeks of training focusing on upper- and lower-body strength and power. The VBT method resulted in the same, or significantly greater adaptations in maximal strength and vertical jump height, despite a significantly lower total volume accumulation. The authors concluded that by using methods that can estimate an athlete's acute maximal strength, relative load can be auto-regulated to increase the effectiveness of the prescribed programme to achieve the desired outcomes. Despite these promising findings, the use of generalised group profiles may result in greater error when estimating absolute strength due to not accounting for between athlete differences.

Previous literature has explored the potential use of individualised LVP as opposed to the previously explored generalised group LVP (Banyard, Nosaka, Vernon, & Haff, 2018; García-Ramos, Pestaña-Melero, Pérez-Castilla, Rojas, & Haff, 2018b). Within these studies, following acute measurement of the individual LVP, the authors suggest that due to noteworthy individual differences, and high levels of reliability over repeat visits, the individual LVP may offer a more accurate representation of an athlete's current readiness to train. Furthermore, it is suggested that because of this, group-based profiling may fail to account for athletes whose profile is above or below the group mean (Banyard et al., 2018). While the presented findings are noteworthy in an acute setting, to date no research has explored the applicability of these findings into an applied longitudinal study; exploring the effects of both individual and group-based approaches on training adaptations.

Despite the apparent importance of MCV and its relationship with relative load prescription, to date limited research exists exploring the concept of using MCV as a means to dictate relative load in real-time. Furthermore, currently no literature has explored the idea of individualising load prescription based on an individual LVP over a training cycle. Within such a study, participant’s load would be altered based on their performance in relation to their own previously established LVP, potentially removing the error previously proposed when grouping data sets. Therefore, the aim of the present investigation was to explore the effects of an individual load-velocity (ILVP) and group load-velocity profiling (GLVP) intervention, over a six-week lower body strength and power phase. Such a study would provide a greater understanding surrounding the utilisation of MCV as a training variable, and further the knowledge on the best way to successfully implement it.

MATERIALS AND METHODS

Experimental approach to the problem

A randomised controlled design was employed to explore the effects of manipulating load, based on two MCV monitoring protocols. Following familiarisation and pre-testing, participants were randomly assigned to either an ILVP or GLVP training intervention. All participants completed two training sessions each week, over a six-week mesocycle focusing on lower-body strength and power, before repeating the testing battery post-intervention. Testing consisted of a free weight full back squat 1-RM, and three jumping protocols including countermovement (CMJ), static-squat (SSJ), and standing-broad jumps (SBJ). All tests were carried out at least 96 hours before or 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 participant, and under consistent environmental conditions (~20 °C).

Participants

Twenty-four males originally volunteered to take part in the research study, however, due to withdrawal pre-data collection (n = 5), nineteen resistance trained males completed the training intervention (mean±SD, age: 23.6±3.7 years, stature: 182.7±5.1 cm, body mass: 92.2±8.7 kg). Participant's pre-training 1-RM for the free-weight back squat was 150.7±23.7 kg, (normalised to body mass: 1.64±0.19). All participants had at least two years resistance training experience and had been engaged in continuous resistance training for at least six months prior to the programme start date. 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 standardised warm-up, consisting of five minutes of stationary cycling (Wattbike; UK;

60 rpm, 60 W), followed by an additional five minutes of self-prescribed dynamic mobility work.

Jump protocols

All jump variables were calculated using a force plate (Kistler, Winterthur, Switzerland; 1500 Hz) logged via Cortex software (Motion Analysis Corporation, CA, USA) and analysed using a custom MatLab script (MathWorks, MA, USA). Vertical jump height (CMJ, SSJ) and horizontal jump distance (SBJ) were calculated using take-off velocity of the centre of mass (COM) that was determined using the impulse-momentum relationship. Jump height was defined as the maximum estimated vertical displacement of the COM from take-off, and distance as the estimated horizontal displacement of the COM between take-off and when vertical displacement of the COM was zero on the jump descent. This approach removed the effect of landing technique on jump performance.

For all jumps, participants began in a standing position with feet parallel, and hands placed on their hips. Hand position was required to remain constant throughout the full jumping movement. For both the CMJ and SBJ participants completed each trial at a self-selected pace, squatting to their perceived optimal depth and immediately exploding upwards or forwards with the aim of attaining maximal vertical or horizontal distance, respectively. For the SSJ, participants were instructed to squat to achieve a 90° angle at the knees (verified by a goniometer before each trial), while maintaining full foot to floor contact. Following a three second pause, participants were instructed to explosively rise upwards into a vertical jump, aiming for maximum height. It was required that no downward motion was recorded prior to jumping following the pause.

For all jumps three trials were completed, interspaced with 3 minutes rest. The mean data were used for subsequent analysis.

One repetition maximum and velocity profiling

For the back squat, 1-RM and velocity profiling were established following an innovative progressive loading assessment, completed twice prior to the initiation of training (95% limits of agreement [LOA], coefficient of variation [CV], and intraclass correlation coefficient [$ICC_{2,1}$] between visits; 30% 1-RM: LOA = -0.003 ± 0.072 $m\cdot s^{-1}$,CV = 2.6%, $ICC_{2,1}$ = 0.74; 50% 1-RM: LOA = -0.014 ± 0.083 $m\cdot s^{-1}$, CV = 2.6%, $ICC_{2,1}$ = 0.85; 70% 1-RM: LOA = -0.017 ± 0.068 $m\cdot s^{-1}$, CV = 3.1%, $ICC_{2,1}$ = 0.84; 100% 1-RM: LOA = -0.010 ± 0.069 $m\cdot s^{-1}$, CV = 7.7%, $ICC_{2,1}$ = 0.57; Bland & Altman, 1986). Initial load was set at ~30% estimated 1-RM, or 20 kg, with incremental increases of ~5% estimated 1-RM at each set. For loads $\leq$50% estimated 1-RM, participants completed three repetitions, decreasing to two repetitions for loads between 51-75% estimated 1-RM, and a single repetition for loads $>$75% estimated 1-RM. For sets where more than one repetition was collected, the mean was used for analyses. For all repetitions, participants were instructed to complete the eccentric portion of the lift at a self-selected pace, before generating maximal velocity during the concentric phase. Verbal encouragement and velocity feedback were provided to motivate participants 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. During each incremental load the GymAware Power Tool (GPT; Kinetic Performance Technology, Canberra, Australia) was attached to the barbell, allowing calculation of MCV. Furthermore, the GPT was utilised to monitor depth during the back squat, ensuring participants maintained a consistent barbell displacement throughout.

Following collection of all load-velocity data, relative load was plotted against attained MCV before fitting a second-order polynomial for each individual participant (ILVP). Calculated standard error of the estimate (SEE) was used to represent the participant specific error between trials, with this subsequently used to determine both upper and lower boundaries of the individualised velocity zones. All participant data within the GLVP intervention were combined before following the same data processing procedure.

Resistance training programme

Participants completed two resistance training sessions per week, for six continuous weeks. For both training groups, the base programme (Table 1) followed a wave-like periodisation structure (Baker, 2007, 2013). In addition to the back squat, supplementary exercises were included within the training intervention. To ensure consistency between the two 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; Helms et al., 2016; Zourdos et al., 2016). For all movements, a RIR of 2-3 repetitions was detailed to the participants (excluding back squat and box jump).

Table 1. Descriptive characteristics of the base training programme completed by both ILVP and GLVP training interventions.

	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**
Box Jump ***	5,5,5	BM	4,4,4	BM	3,3,3	BM	5,5,5	BM	4,4,4	BM	3,3,3	BM
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
RDL	8,8,8	****	8,8,8	****	8,8,8	****	8,8,8	****	8,8,8	****	8,8,8	****
Walking lunge	8,8,8	*****	8,8,8	*****	8,8,8	*****	8,8,8	*****	8,8,8	*****	8,8,8	*****
	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**
Box Jump **	5,5,5	BM	4,4,4	BM	3,3,3	BM	5,5,5	BM	4,4,4	BM	3,3,3	BM
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
Nordic curl	5,5,5	BM	5,5,5	BM	5,5,5	BM	5,5,5	BM	5,5,5	BM	3,3,3	BM
BB step-up	8,8,8	******	8,8,8	******	8,8,8	******	8,8,8	******	8,8,8	******	8,8,8	******

* RDL: Romanian deadlift; BB: barbell; BM: body mass; ILVP: individual load-velocity profile; GLVP: group load-velocity profile; 1-RM: one repetition maximum

** Only the back squat load was dictated using concentric velocity

*** Box jump height was initially set at mid-thigh, however increased/decreased based on performance each session and number of jumps in set

**** RDL load calculated at 50% 1-RM back squat

***** Walking lunge load calculated (11): 0.6 (*6-RM squat [kg; 0.52] + 14.82 kg)*

****** BB step-up load calculated at 30% 1-RM back squat, with step up so knee at knee at 90°

For both training groups, relative training load (% 1-RM), the number of sets and repetitions, and inter-set rest time (3 min) were equated throughout the six-week intervention. However, due to the individual nature of the programming, participants could deviate from this volume based on their velocity output. For all repetitions within both intervention groups, participants were instructed to maintain eccentric control, before generating maximal velocity throughout the concentric phase. Verbal encouragement was provided to all participants to motivate them to give maximal effort throughout the sessions with both groups receiving an additional auditory tone to signal they were completing repetitions within the target velocity zone.

Training regulation utilising velocity

Load velocity profiles and MCV were used to dictate absolute load for the back squat on a set-by-set basis for both intervention groups. For the ILVP group, load was dictated based on individual data collected during the initial load-velocity profiling collections. This meant that load alterations were specific to the participant. For the GLVP intervention, all data were combined from the pre-testing sessions and used to create a mean data line and associated range. This encompassed all participants load-velocity data within the group, and therefore load was modified in relation to group averages.

To achieve set-by-set load adjustment, MCV was measured using the GPT for the first one or two repetitions in line with the profiling methodology (relative load ≤75% 1-RM: two repetitions; relative load ≥76% 1-RM: one repetition). Using velocity data from the preceding warm up or working set the relative load of those lifts was estimated using the upper boundary of the load-velocity profile equation. The upper boundary of the profile was used due to the unfatigued state the participant would have completed these repetitions in and the effect this likely had on attained MCV. As the equation describes the relationship between MCV and relative load, a participant's acute 1-RM could be estimated prior to each set, and therefore the absolute load required for the programmed relative load calculated. It should be noted that this approach is not intended to provide a valid approach to athlete testing, instead produce an estimate of strength to allow a more effective approach to auto-regulation of training load. A worked example is presented in Table 2 and these steps were completed using a custom written MatLab application for each back squat set during the intervention. In addition to dictating load, the total attempted repetitions were dictated based on the velocity of each preceding repetition. If achieved repetition MCV was below the velocity zone determined as the upper and lower boundaries of the load velocity profile, the set was stopped, and the rest period initiated.

Table 2. Mathematical example of how the equation of the load velocity profile and lift velocity (MCV) was used to estimate the lifted relative load and subsequently required absolute load.

Known data	
Equation of the line (LVP):	$y = -0.0001x^2 - 0.0035x + 1.2656$
Standard error (SEE):	0.031 $\text{m}\cdot\text{s}^{-1}$
Previous load:	84 kg
Mean MCV of selected repetitions:	0.870 $\text{m}\cdot\text{s}^{-1}$
Subsequent target load	
Target load (TL) %:	70% 1-RM
Estimate based of traditional pre-intervention 1-RM:	98 kg
Calculation of subsequent target load	
Process:	**Input data:**
$\text{Mean MCV} - \text{SEE} = \text{Vel}_e$	$0.870 - 0.031 = 0.839$
Velocity predicted relative load (%) =	**Velocity predicted relative load (%) =**
$\frac{-b \pm \sqrt{b^2 - 4a(c - \text{Vel}_e)}}{2a}$	$\frac{-0.0035 \pm \sqrt{0.0035^2 - 4 \times -0.0001 \times (1.2656 - 0.839)}}{2 \times -0.0001}$ = 58.1%
Subsequent load =	**Subsequent load =**
$\frac{\text{Load lifted}}{\text{Actual \% 1RM}} \times \text{TL \%}$	$\frac{84}{58.1} \times 70$ = 101.4 kg

Statistical analysis

For all variables, values are presented as means ± SD. Data analyses were completed using SPSS 22.0 (Chicago, IL, USA), with the alpha level for significance set at $\alpha = 0.05$. Appropriate statistical assumptions of normality and sphericity were confirmed prior to running any analyses on the data.

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) ANOVA, with Bonferroni post-hoc comparisons, using one inter-factor (ILVP vs. GLVP) and one intra-factor (pre- vs. post-training), were conducted to examine the differences across the back squat and all jump protocols between groups. In addition, effect sizes (ES) were calculated according to Hedge's *g,* accounting for sample size (Ellis, 2010; Hedges & Olkin, 1985; Lakens, 2013). ES were classified as small ($g = 0.21\text{-}0.59$), moderate ($g = 0.60\text{-}1.19$), large ($g = 1.20\text{-}1.99$), and very large ($g \geq 2.0$) (Hopkins 2010).

RESULTS

All scheduled sessions were completed by all participants across both intervention groups, with no significant difference reported for training volume accumulation between interventions (average difference: 0.87%; $p = 0.632$). Descriptive characteristics and ES (± 95% confidence intervals) are presented within Table 3 for both groups and all assessments.

Table 3. Descriptive characteristics (mean ± SD) and effect sizes of the individual (ILVP) and group (GLVP) load velocity training groups, pre- to post-training.

	ILVP			**GLVP**		
	Pre	**Post**	**ES ****	**Pre**	**Post**	**ES ****
Back squat (kg)	150.3 ± 24.7	164.8 ± 26.0	0.47 ± 0.89	150.6 ± 24.3	161.4 ± 25.2	0.41 ± 0.93
CMJ (cm)	38.7 ± 7.5	41.2 ± 8.0	0.30 ± 0.88	36.2 ± 5.1	37.8 ± 5.1	0.30 ± 0.93
SSJ (cm)	36.4 ± 6.6	38.1 ± 6.6	0.25 ± 0.88	32.8 ± 5.7	34.2 ± 6.7	0.17 ± 0.93
SBJ (cm)	97.2 ± 19.9	103.7 ± 20.5	0.31 ± 0.88	87.8 ± 15.4	90.7 ± 15.4	0.18 ± 0.92

* ILVP: individual load-velocity profile; GLVP: group load-velocity profile; CMJ: countermovement jump; SSJ: static squat jump; SBJ: standing broad jump; ES: effect size (Hedge’s *g*)

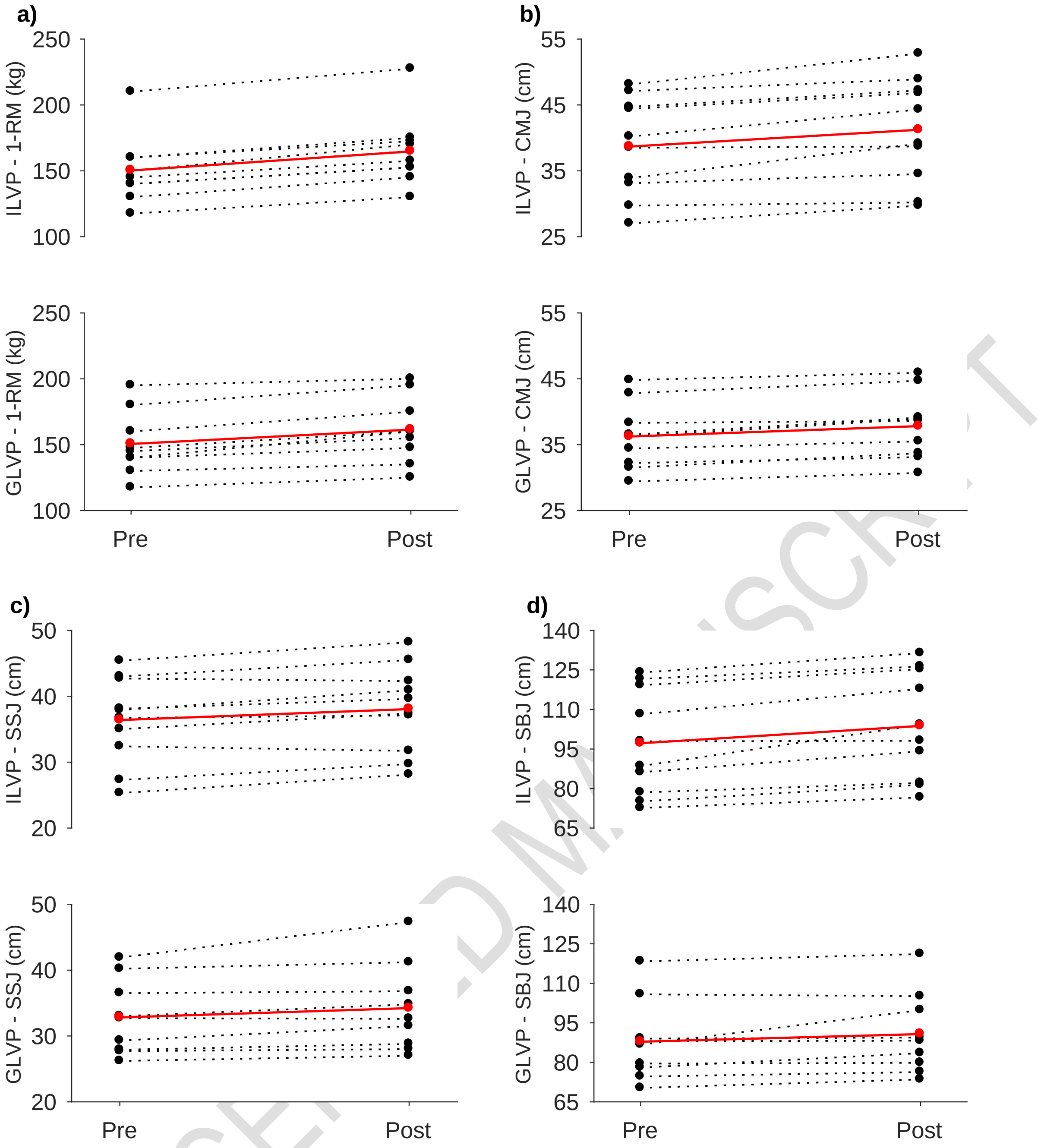
** Effect sizes are presented ± 95% confidence intervals

Pre-testing

No significant pre-training differences between groups were reported for any variables analysed, including body mass, 1-RM strength, and jump performance ($p > 0.05$).

Strength assessments

Training resulted in significant increases in back squat 1-RM for the ILVP and GLVP group ($p < 0.01$; 9.7% and 7.2%, respectively; Figure 1). No significant group by time interaction effect was witnessed between training groups ($F_{(1,17)} = 3.97$ $p = 0.06$).



* ILVP: individual load-velocity profile; GLVP: group load-velocity profile; 1-RM: one repetition maximum; CMJ: countermovement jump; SSJ: static squat jump; SBJ: standing broad jump;

Figure 1. Individual (dotted) and mean (red) changes for back squat 1-RM, CMJ, SSJ, and SBJ performance (a, b, c, and d, respectively) following six weeks training intervention. All mean improvements are statistically significant (*p* < *0.05*) for both groups excluding the SBJ for the GLVP intervention.

Jump assessments

Significant increases in CMJ, SSJ, and SBJ performance were noted for the ILVP group (p < 0.01; % increase: CMJ: 6.6%; SSJ: 4.6%; SBJ: 6.7%), and CMJ and SSJ only for the GLVP group (p < 0.05; both 4.3%; Figure 1). No significant group by time interactions were reported between the groups (CMJ: $F_{(1,17)} = 2.50$ $p = 0.13$; SSJ: $F_{(1,17)} = 0.15$ $p = 0.71$; SBJ: $F_{(1,17)} = 3.49$ $p = 0.08$).

DISCUSSION

The aim of the present investigation was to explore the impact of two different velocity-based load prescription methods over a six-week resistance training programme. The presented data provides sufficient evidence to support the use of velocity-based loading methods within a resistance trained population for eliciting favourable improvements in maximal strength and jump performance. Furthermore, while no group by time interactions were reported between groups, the ILVP intervention did result in larger percentage increases and greater or equal ES across all variables assessed, indicating the potential worth of such an approach.

The main findings from this investigation were that a significant increase in back squat maximal strength and jumping performance was observed following six weeks of VBT. Both the ILVP and GLVP interventions led to similar increases in back squat and CMJ performance as previously published data following a similar training design (9.3% and 5.0%, respectively; Dorrell et al., 2020). While neither group led to significantly greater outcomes when compared between, the ILVP intervention did result in larger percentage increases across all assessments (back squat: 9.7% vs. 7.2%; CMJ: 6.6% vs. 4.3%; SSJ: 4.6% vs. 4.3%; SBJ: 6.7% vs. 3.4%), and greater or equal ES (Table

3). These marginal improvements were observed despite no significant difference and trivial effect sizes reported for overall total volume (*p* = 0.63; ES: 0.09±0.46) between intervention groups.

The concept of individualisation is paramount to consider in the design of resistance training protocols to continually stimulate optimal adaptation over prolonged time periods (Borresen & Lambert, 2009; Helms et al., 2018; Kiely, 2012). Research has demonstrated improvements in training adaptation when individualised training programmes are employed over non-individualised approaches (Hermassi et al., 2018; Jones et al., 2016; Mann, Thyfault, Ivey, & Sayers, 2010). Despite such findings, and the demonstrated importance of individualisation within resistance training, training load is still commonly prescribed based on pre-training 1-RM assessment (Fleck & Kraemer, 2014). As previously discussed, such methods offer minimal individualisation both within and between athletes and are open to error based on atypical performance during assessment (Ben, Latiri, Dogui, & Ben, 2017; Knowles, Drinkwater, Urwin, Lamon, & Aisbett, 2018; Perkins, Wilson, & Kerr, 2001). Therefore, the method of prescribing load from such assessments may lead to non-optimal loading, ultimately reducing the physical improvements witnessed.

The novelty of this study is within the use of individualised LVPs as a method of dictating training load adjustments on a set-by-set basis over a training cycle. Consequently, there is a lack of direct comparative research available from which the significant improvements can be cross-examined. However, as the foundation of such a method is developed based on the individualisation of training load, the results of this study will be compared to other individualised loading methods such as RPE and

RIR (Helms et al., 2016; Zourdos et al., 2016). While direct comparisons cannot be made due to vastly different research designs, it will provide a greater understanding surrounding the efficacy of such an approach when compared to an individualised alternative.

To date, limited research has implemented an RPE / RIR based loading approach into resistance training when compared to traditional percentage-based methods (Helms et al., 2018; Graham & Cleather, 2019). Helms et al (2018) explored the impact of eight weeks training on free weight back squat 1RM, with load dictated via percentage-based methods or through utilisation of individual athlete perceptions (RPE scale; Zourdos et al., 2016). Following 24 training sessions both groups displayed significant increases in strength ($p < 0.001$), with 1-RM increasing by 13.9±5.9 kg and 17.1±5.4 kg for the percentage- and RPE-based loading methods, respectively. Additionally, small between-group ES and greater probability of change were noted for 1RM (0.50; 79%, respectively), favouring the RPE-based approach. Despite no apparent significant difference between loading methods, the authors concluded that the greater absolute change, stronger ES, and higher probability of change witnessed following the RPE-based loading approach demonstrate the worth of such loading methods. Further research by Graham and Cleather (2019) explored the impact of a similar RIR protocol over a 12 week training programme on back squat 1RM when compared to a fixed loading (percentage-based) method. A reported increase of 15.2 kg compared to 9.1 kg was reported for the RIR and fixed loading approaches, respectively. Additionally, this result displayed a significant time by group interaction ($p = 0.006$). The authors suggested that as the participants within the RIR-based approach were able to autoregulate load, they were able to accommodate perceived increases in strength by increasing loading intensity. This was demonstrated through a significant increase in weekly training intensity between groups, favouring the RIR approach (p = 0.006).

When comparing the magnitude of change following both discussed interventions to that of the present study, similar percentage improvements can be seen between studies. Within the current data collection, participants within the ILVP group improved free weight back squat performance by 9.7% after 12 sessions, as opposed to 8.6% within the RPE-based loading group (Helms et al., 2018), and 10.7% following a RIR approach (Graham & Cleather, 2019). One reason for the trivial reported difference between interventions may be due to combination of discrepancies between initial starting strength values, and total training volume completed. Within the current study, participants within the ILVP group attained a 1-RM to body mass ratio of 1.63 and completed a total of 12 training sessions. Participants within Helms et al (2018) and Graham and Cleather (2019) RPE / RIR approaches had higher starting strength values (1.82 and 1.70, respectively), and also completed notably more training sessions (both 24). Despite this, the presence of comparable percentage increases following the ILVP intervention, despite only completing six weeks of training (as opposed to eight: Helms et al., 2018, and twelve: Graham & Cleather, 2019), support the concept of such loading approaches potentially offering greater optimisation of load than alternative individualised methods.

While no group by time interactions were present for any of the assessed variables pre- to post-intervention within the current data collection, the magnitude of the improvements, specifically within the ILVP group, should not be overlooked. When compared to traditional percentage-based loading methods completed with similarly trained athletes (1-RM to body mass ratio), the magnitude of the documented improvements is better appreciated. For example, Hoffman et al. (2009) conducted research exploring the impact of 15 weeks periodised strength training on the 1-RM back squat and jump performance of resistance trained athletes. Within this study, the participants attained a 1-RM to body mass ratio of 1.56 pre-intervention. At the end of the training intervention 1-RM back squat had significantly improved by an average of 11.1% ($p < 0.05$). While the improvements in maximal strength witnessed are greater than those displayed within the current study (11.1% vs. 9.7%, respectively), it is important to highlight that the participants training programme accrued over twice the training weeks, and thus 2.5 times the training sessions. Despite this greater exposure to a training stimulus, and a similar initial training status (1.56 vs. 1.63), the ILVP group within the current study achieved comparable strength improvements. Such findings demonstrate the potential of velocity-based loading approaches to augment the strength improvements witnessed in considerably shorter time periods, with individualised approaches potentially offering the most effective method. However, as this research did not explore the longitudinal influence of such methods (i.e. > 6 weeks), such things can only be hypothesised.

It is well established that the optimisation of resistance training is largely dependent on the optimal configuration of the acute training variables over time (Kraemer, 1983a). Specifically, a periodic alteration in training intensity is advocated to be of paramount importance when seeking to optimise physiological strain, ultimately inducing positive alterations in muscular strength (Jenkins et al., 2015). It is widely acknowledged that the force applied during a contraction impacts upon the recruitment of motor units, with said force influenced by both the external load, and velocity of the contraction (Jenkins et al., 2015). Whilst no data were collected on the mechanisms by which VBT appears to achieve favourable adaptations, in a similar way to that of previous literature (Dorrell et al., 2020), the manipulation of load may ensure the athlete is lifting the most suitable load for the desired adaptations. Lifting a correct load may positively impact upon the recruitment of higher threshold motor units by maximising the muscle force and velocity output throughout a training intervention (Desmedt & Godaux, 1977; Nardone, Romano, & Schieppati, 1989). While both training interventions within the current study utilised a velocity-based approach, the ILVP groups loading was specific to their individual LVP. This may have positively impacted upon the specificity of the load, allowing a better adjustment of training intensity both within and between sessions. In comparison, while the GLVP load dictation method may lead to greater specificity than more traditional percentage-based methods (Dorrell et al., 2020), it may not be as sensitive as ILVP, explaining the variance in improvement rate (Table 3). As such, the method of individualising load based on ILVPs may increase the ability of athletes to maintain higher velocities with higher loads, ultimately increasing force output over repeated repetitions, and thus positively influencing motor unit recruitment.

In summary, the data presented within this study demonstrates the potential impact of utilising a velocity-based loading approach on measures of maximal strength and power. Specifically, the results suggest that use of individualised velocity-based loading may result in a greater magnitude of change for athletes when compared to a group-based approach. As previous research has already eluded to the fact that such group-based approaches may lead to significantly greater adaptations than percentage-based approaches (Dorrell et al., 2020), it could be theorised that the same significance would be present for individual-based approaches. Furthermore, the data suggest that adopting an individualised approach may lead to a greater positive transfer to power-based movements, specifically vertical and horizontal jumps. It should however be noted that due to potential inaccuracies related to predicting athlete strength using a LVP (Ruf, Chéry, & Taylor, 2018), the findings of this study only support the described approach as a method of autoregulation and not for athlete testing.

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