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Research paper

Velocity-Based Training; A Contemporary Method of Resistance Training: A Mini Review

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Abstract

Velocity-based training (VBT) can help all people who participate in resistance training (RT) programs to improve/maintain health and physical fitness levels. VBT is a RT intervention that uses velocity feedback to prescribe and/or manipulate training load. Two new variables are adopted for prescribing the training load in VBT, one is the initial fastest repetition velocity in sets to set the load instead of %1RM, the other is the velocity loss threshold (VL) to terminate the set instead of the traditional fixed repetitions. VBT sessions relatively have lower volume and lower post-exercise fatigue and this reason may encourage people to use it as a training method. In addition, VBT devices help coaches to predict optimal load and volume before each training session; so modified training variables result in a better adaptation. On the other hand, VBT devices are expensive and the dose-response relationship between velocity loss and neuromuscular adaptation is still not clear.

Keywords: Resistance Training, Muscular Endurance, Muscular Strength, Velocity Based Training, Velocity Loss

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Introduction

Previous findings underlined the positive effects of RT on health (Feigenbaum & Pollock, 1999; Stamatakis et al., 2018). RT diminishes the age-related decrease in muscle mass and strength (Distefano & Goodpaster, 2018; Woo, 2017), enhances health related quality of life (Hart & Buck, 2019), and there is an opposite association of muscular strength and fitness with all-cause mortality, even after adjusting with cardiorespiratory fitness or proven risk factors (Abramowitz et al., 2018; Jochem et al., 2019; Kim et al., 2018; Volaklis et al., 2015). However, the mode of exercise training seems to be crucial for achieving demanded effects, which is why optimal training prescription is essential (Sjøgaard et al., 2016).

RT practitioners typically prescribe specific loads relative to an individual's maximal personal best in specific movement (e.g., 80% of bench press one repetition maximum (1RM)) (Baechle & Earle, 2008; Weakley et al., 2017). Furthermore, athletes are commonly appointed to complete a fixed number of sets and repetitions (e.g., 3 sets of 8 repetitions) based on the training goal (Banyard et al., 2019). However, using an athlete's previous maximal ability to prescribe training loads cannot be accurate if the athlete's 1RM changes as a consequence of training because the prescribed load may not match the percentage of 1RM calculated for the single session (J. Weakley, S. McLaren, et al., 2020). Additionally, it is known that the number of repetitions that can be performed with a certain % of 1RM differs between athletes and, for that reason, assigning the same number of sets and repetitions for all athletes may bring on different levels of effort and fatigue (Richens & Cleather, 2014; J. Weakley, S. McLaren, et al., 2020). Therefore, different methods such as velocity-based training (VBT) have been developed to provide accurate and objective data to develop RT programs (Banyard et al., 2017; Banyard et al., 2018; Banyard et al., 2019).

Methodology

For this mini-review literature search was conducted from October 26, 2022 to November 1, 2022 for the following databases: PubMed, Google Scholar and Research Gate. The keywords used in the search were as follows: "velocity based training," or "resistance training," or "velocity based resistance training," or "velocity loss". Searches were limited to human participants and English language publications. Two reviewers harmoniously performed the identification and screening of titles and abstracts (if necessary, full texts), with disagreement settled by consensus. Records from the literature search were examined by title and abstract to exclude irrelevant records. Studies were selected following the eligibility criteria. Additional records were identified through articles reference lists.

Studies were included in the present study based on the following criteria: (1) published in English, (2) included youth or adult trained and non-trained participants, (3) provided documentation of the resistance training programs related to VBT (4) quantified the resistance training and VBT. By removing duplicate or irrelevant data, 83 independent studies were selected.

Literature Review

It is well known that maximizing the RT adaptations largely depends on the manipulation of the program variables such as the intensity, volume, rest interval, movement tempo, etc. (Kraemer & Ratamess, 2004). Among them, intensity and volume are the key variables in prescribing the RT program (Kraemer & Ratamess, 2004). Traditional 1RM-based resistance training (TRT) has been criticized for the inherent limitations such as the complex process, risk of injury during the maximum strength test (González-Badillo et al., 2017), and possible attenuation of type II muscle fiber adaptation owing to the sets to failure (Andersen & Aagaard, 2000; Izquierdo, Ibañez, et al., 2006), which may result in suboptimal training adaptation (Liao et al., 2021).

Velocity-based training is a contemporary method of RT that enables accurate and objective prescription of resistance training loads variables like intensity and volume (J. Weakley, S. McLaren, et al., 2020). VBT covers a wide array of training topics and approaches (J. Weakley, S. McLaren, et al., 2020). The integration of VBT depends on a continuum and can be used with varying emphasis (J. Weakley, S. McLaren, et al., 2020). At its most basic level, velocity can be used as an accessory to TRT (J. Weakley, S. McLaren, et al., 2020). For example, studies show that velocity feedback can enhance performance and improve motivation and competitiveness during RT (Argus et al., 2011; J. Weakley et al., 2019; J Weakley et al., 2019; J. J. S. Weakley et al., 2021; J. J. S. Weakley et al., 2019). On the other hand, VBT can be implemented across all types of a RT programming and support the prescription of load, sets, number of repetitions, and the programming method applied (Banyard et al., 2019; de Hoyo et al., 2021; Jovanović & Flanagan, 2014; Weakley et al., 2017). Therefore, VBT should be defined as a method that "uses velocity to monitor or enhance training practice." This definition accounts for the wide execution of training methods that use velocity and assist the practitioner in achieving their training goals (J. Weakley, S. McLaren, et al., 2020). Compared with TRT, VBT has several convincing features. Firstly, velocity can be used to estimate the 1RM and adjust the intensity in real time to match the actual intention for the particular session regardless of the fluctuation of personal 1RM due to the life load or training load (González-Badillo & Sánchez-Medina, 2010). Secondly, monitoring the velocity loss in training set can assist to control the levels of efforts and fatigue in a certain range and make the lifted repetitions correspond well with the training specific adaptation (González-Badillo et al., 2017; J. Weakley, C. Ramirez-Lopez, et al., 2020). Thirdly, instant augmented feedback of velocity following each repetition could motivate the athletes to enhance acute physical performance and improve adaptation after that (J. Weakley et al., 2019; J. J. S. Weakley et al., 2019). Therefore, based on these features, it could be argued that the VBT would be more effective in improving performance than TRT (Liao et al., 2021).

The muscle fast fibers could be specifically recruited more when performing faster repetition with the similar load by maximum voluntary efforts (Liao et al., 2021). On the whole, it might be inferred that VBT and TRT improve strength and hypertrophy through different mechanism (Liao et al., 2021). VBT should produce a better stimulus for neural adaptations by higher velocity of the concentric part of movement and lower training stress, while it seems, TRT produce better adaptation in muscle morphology by higher mechanical and metabolic stress (Liao et al., 2021). These influencing factors might be mutually resulting in the similar effects on improving squat 1RM between VBT and TRT (Liao et al., 2021). Several studies show that muscle failure with heavy load RT might not be essential for greater improvements in muscle strength and hypertrophy in comparison with lower RT volumes (Galiano et al., 2022; Izquierdo, Ibañez, et al., 2006). Conversely, training to muscle failure might even reduce myosin heavy chain IIX percentage (Martinez-Canton et al., 2021) that mostly express in fast, type 2B muscle fibers (Smerdu et al., 1994). Furthermore, evidences indicated that exercise repetitions performance at maximum voluntary velocity could result in greater improvements in muscle strength and power in comparison with the submaximal velocities by enhancing motor unit firing rate and stimulating type II fiber which have a greater relative hypertrophy than type I fiber (González-Badillo et al., 2014; Pareja-Blanco et al., 2014; Schuenke et al., 2012; Van Cutsem et al., 1998). In Sarcopenia, age related muscle atrophy, the size of type I muscle fibers is almost maintained, but the size of type II fibers diminishes (Lexell et al., 1988; Nilwik et al., 2013). Evidences showed the decline in muscle fiber number, mostly in type II fibers, remains the main reason for the reduced muscle mass and strength with aging (Strasser et al., 2021). This is supported by a study that found that mRNA and protein expression of IIA myosin heavy chain, that mostly exist in type I muscle fibers, decreased 14% and IIX myosin heavy chain, that mostly exist in type II muscle fibers, decreased 10% in human skeletal muscle per decade (Short et al., 2005). Therefore, it seems type I mRNA remained constant with age (Short et al., 2005). Type II fibers seem to be especially prone to loss of nerve supply with increasing age. However, fiber loss is at least partly prevented by the age-related remodeling of motor units that results in loss of nerve supply in fast fibers with collateral re-innervation of slow fibers (Vandervoort, 2002). While type I fibers are more susceptible to inactivity and loss of nerve supply induced atrophy with a slow-to-fast fiber type collateral re-innervation, type II fibers are more affected with diseases (e.g., cancer, type 2 diabetes, chronic heart failure) aging with a fast-to-slow fiber type collateral re-innervation (Wang & Pessin, 2013). Despite the fact that traditional slow-velocity RT in the first place is associated with improvements in muscle strength, also muscle power training with higher-velocity and lower-intensity (30–60% of 1RM or the use of body mass resistance) is recommended to enhance neuromuscular functional abilities (i.e., sit-to-stand, walking ability, stairs climbing) in elderly individuals (Cadore & Izquierdo, 2018). By the high capacity of VBT on type II fibers hypertrophy, it could be a piece of puzzle of Sarcopenia patients training program to maintain their muscle mass. Collectively, regardless of the difference in volume, almost similar load and higher velocity is a specific stimulation in neuromuscular adaptation (Liao et al., 2021). Studies reported that VBT had lower training volume compared with TRT with load range 59% to 95% of 1RM. For example, Liao et al. reported that the total repetitions of TRT group were 77% higher than VBT group (Liao et al., 2021). In parallel, some studies showed VBT produced lower training stress (Banyard et al., 2019; Held et al., 2021; Orange et al., 2019). It could be explained by the reason that the mean time under tension of VBT was significantly less than TRT, which might decrease mechanical stress (Banyard et al., 2019; Orange et al., 2019). It is plausible that the lower volume and lower training stress also lead to the higher repetition velocity owing to participants' less fatigue and need for recovery (Liao et al., 2021). Liao et al. indicated that the overall recovery and stress after 24 and 48 hours in VBT were higher than TRT via a validated daily questionnaire (Liao et al., 2021). This review aimed to compare the training effects of VBT vs. TRT to determine real features of VBT rather than TRT on training programs that want to improve muscular fitness.

Discussion

Studies showed that both VBT and TRT were effective and beneficial to improve physical fitness aspects like muscular strength/endurance and muscular hypertrophy that can modify body composition (Liao et al., 2021). Nevertheless, the key point of VBT is cost-benefit relationship of this method. Velocity is commonly used over other kinetic or kinematic outputs (e.g., power) during RT for three reasons. First, as an external mass is increased, lifting velocity decreases (Izquierdo, González-Badillo, et al., 2006; J. Weakley, D. Chalkley, et al., 2020).

This loss of velocity continues until a 1RM load is achieved which corresponds with the minimum velocity threshold that called V1RM (Izquierdo, González-Badillo, et al., 2006). Second, there is a linear relationship between velocity and load as a percentage of maximum ability (i.e., % of 1RM). This has been observed consistently across a range of exercises with submaximal loads (Conceição et al., 2016; García-Ramos, Pestaña-Melero, et al., 2018). Third, a common element of many definitions of exercise-induced fatigue is that as fatigue increases, there is a short-term decline in muscle fiber shortening speed, force generating capacity and relaxation times that altogether cause reductions in voluntary exercise velocity (González-Badillo et al., 2017; Sánchez-Medina & González-Badillo, 2011). Simply speaking, as fatigue increase, decline in exercise velocity occurs (J. Weakley, S. McLaren, et al., 2020). Therefore, movement velocity can be used as accurate and objective prescribing method of external loads and training volumes for each RT session, irrespective of daily fluctuations in fatigue and athlete readiness (J. Weakley, S. McLaren, et al., 2020). Therefore, variables which are used to prescribe the training load in VBT, one is the initial fastest repetition velocity in sets to set the load equal to %1RM in TRT, and the other is the percentage of velocity loss threshold (%VL) to terminate the set instead of the traditional fixed repetitions in sets in TRT (Liao et al., 2021).

Reliability of testing method and measurement tool that has been used by VBT practitioners is important for training prescription and training monitoring. The reliability of test performance is influenced by measurement error and normal fluctuation within the participant’s biological systems (J. Weakley, S. McLaren, et al., 2020). Cava et al. observed the linear velocity transducer stands as the most accurate technology for VBT, showing the finest readings among the other devices (Martínez-Cava et al., 2020). The linear position transducer mobile apps and camera-based systems were found as acceptable alternatives to monitoring movements against medium to heavy loads (Martínez-Cava et al., 2020).

The two velocity variables most commonly used in studies are mean velocity (MV) (i.e., the concentric phase average velocity) and peak velocity (PV) (i.e., the concentric phase maximum instantaneous velocity) (Pérez-Castilla et al., 2019; Tomasevicz et al., 2020). In addition, mean propulsive velocity (MPV) (i.e., portion of the concentric phase during which movement acceleration is greater than acceleration due to gravity) has also been used as an alternative variable (Sanchez-Medina et al., 2010). The difference between the MPV and MV is that the MPV removes the braking portion of the concentric movement and can provide greater reliability of velocity outcomes (Newton et al., 1997; Pérez-Castilla et al., 2018). Studies recommended to use the MV compared with MPV to estimate the 1RM because of its higher reliability against light loads (García-

Ramos, Haff, Jiménez-Reyes, et al., 2018; Pérez-Castilla, Jiménez-Reyes, et al., 2021). Neuromuscular function can be evaluated by measuring the velocity value attained against a given load using traditional (e.g., lat pull down or dead lift) or ballistic (e.g., medicine ball throw or squat jump) exercises (Cormie et al., 2010; Pérez-Castilla et al., 2018). When testing with light or moderate loads, it is recommended that ballistic exercises are used rather than traditional exercises (J. Weakley, S. McLaren, et al., 2020). Using MV and MPV to measure ballistic performance seems unacceptable because both of these variables include the movement flight phase (J. Weakley, S. McLaren, et al., 2020). Beside, due to difficulties in tracing the exact moment of take-off, MPV values could be even more problematic (J. Weakley, S. McLaren, et al., 2020).

VBT needs optimal level of motivation. Feedback variables could modify neuromuscular performance during VBT. Nagata et al. found giving feedback after each repetition has been shown to have greater effects on lifting performance compared with after each set (Nagata et al., 2020). They have also found, giving quantitative feedback of velocity improve performance greater than observing video recording of previous exercise (Nagata et al., 2020). However, when visual feedback of kinematic outputs are provided, improvements are observed in both males and females (J. Weakley, K. Wilson, et al., 2020; J Weakley et al., 2019; J. J. S. Weakley et al., 2019; Wilson et al., 2018; Wilson et al., 2017). Verbally encouraging can enhance movement velocity and power output (J. Weakley, K. Wilson, et al., 2020). Extrinsically motivated may prefer to verbal feedback, while intrinsically motivated individuals may prefer to visual feedback (J. Weakley, K. Wilson, et al., 2020).

Banyard et al. present four steps for the development of an individualized L-V profile (Banyard et al., 2018). First, the athlete performs a 1RM assessment in the relevant exercise to determine their 1RM and V1RM (J. Weakley, S. McLaren, et al., 2020). After at least 24 hours recovery, in second step, athlete perform 1 to 3 repetitions with 20, 40, and 60%, and a single repetition with 80 and 90% of 1RM, by 2 minutes rest between sets (Banyard et al., 2018; Banyard et al., 2019) García-Ramos et al. present 2-point method with repetitions performed at 2 approximate loads of 45% of 1RM and 85% of 1RM (García-Ramos, Haff, Pestaña-Melero, et al., 2018). The validity of the 2-point method has been confirmed for upper-body exercises (García-Ramos et al., 2019; Jiménez-Alonso et al., 2022; Pérez-Castilla, Suzovic, et al., 2021), but its validity during lower-body exercises is not explored yet (J. Weakley, S. McLaren, et al., 2020). In third step, the MV data of the fastest repetition from each load are plotted against the corresponding percentage of 1RM, and then, a linear line of best fit is applied to extrapolate the regression equation (J. Weakley, S. McLaren, et al., 2020). The final step is to create a velocity table from the regression equation (J. Weakley, S. McLaren, et al., 2020). Velocity monitoring can serve as a useful tool for VBT practitioners to know about athlete's fitness/fatigue status (J. Weakley, S. McLaren, et al., 2020). For instance, when lifting a fixed external load, changes in MV or PV indicate altered neuromuscular qualities (J. J. S. Weakley et al., 2021). Reductions in MV or PV may be symptomatic of fatigue, overreaching, overtraining, or detraining, and maladaptation, while higher velocities could signify improvements in neuromuscular function or acute potentiation (Cunanan et al., 2018).

The greater control over training outcomes is an exciting prospect for the strength and conditioning coaches, understanding the different methods of training prescriptions that are available through VBT is essential for designing productive training programs. The velocity associated with a given percentage of 1RM is consistent across training sessions (Balsalobre-Fernández et al., 2018; Banyard et al., 2018; Curran-Everett, 2009; García-Ramos, Haff, Pestaña-Melero, et al., 2018). However, it has been shown that fatigue (Vernon et al., 2020) or adaptation with a short-term RT program to improve power (Pérez-Castilla & García-Ramos, 2020) alter the velocity at a given percentage of 1RM. For that reason, it is advised to develop individualized L-V profile for accurate prescription of RT intensity (J. Weakley, S. McLaren, et al., 2020). On the other hand, Weakly et al. suggested that, relative losses in exercise velocity cause consistent internal and external responses at a given relative load (Jonathon Weakley et al., 2020; J. Weakley, C. Ramirez-Lopez, et al., 2020). Consequently, in some of VBT approaches, practitioners use repetitions velocity loss (VL) as indicator of in-set repetition instead fixed repetition during set (J. Weakley, S. McLaren, et al., 2020). Although, previously training methods and their periodization models can still be applied (Jonathon Weakley et al., 2020) but, using velocity as an accessory for RT prescription and monitoring, can improve individualization and control of training and subsequent adaptation (Dorrell et al., 2020; J. Weakley, C. Ramirez-Lopez, et al., 2020). Due to changes in strength during the training period, one issue with percentage-based load prescription is that the relative load prescribed may not equal to the relative load that is completed by athlete (Jonathon Weakley et al., 2020). For example, 1RM test data from four weeks earlier will not enable accurate prescription of load (Jonathon Weakley et al., 2020). Therefore, it seems RT loads that are prescribed by coaches are often lower or higher than athletes ability (Jonathon Weakley et al., 2020). Established VBT approaches can be considered for these fluctuations by monitoring velocity during the warm-up and main training (J. Weakley, C. Ramirez-Lopez, et al., 2020). Two of the most common VBT methods use either: 1) a targeted training velocity (e.g., an athlete finds an external load within a given range that is being targeted that day (e.g., 0.70 to 0.60 ± 0.05 $m.s^{1}$) (Dorrell et al., 2020; J. Weakley, C. Ramirez-Lopez, et al., 2020), or 2) a targeted load (as a percentage of 1RM) that perform with relative velocity from a previously assessed L-V profile (Dorrell et al., 2020). Both these VBT approaches are useful for long-term planning. As mentioned above, the percentage of VL is highly correlated with selective muscle hypertrophy (Held et al., 2021; J. Weakley, S. McLaren, et al., 2020). A greater VL could reduce and then inhibit demanded neuromuscular adoption (J. Weakley et al., 2021). This reduction may negatively impact related explosive athletic performance, such as sprint, because MHC-IIX , that contributes to generating the highest contractile speed (Bottinelli et al., 1999), with very high percentage of VL. 20 to 40% VL may be effective to obtain greater adaptations in athletic preparation, lean body mass, and muscular endurance (Pareja-Blanco et al., 2017). On the other hand, in-season, lower VL (e.g., 20%) may be beneficial in reducing fatigue and preventing considerable reductions in performance (Jonathon Weakley et al., 2020; J. Weakley, C. Ramirez-Lopez, et al., 2020). The amount of VL experienced during RT does not seem to affect muscular endurance and strength adaptations while greater VL may be superior when the aim is to induce hypertrophy (Jukic et al., 2022). As it was mentioned, only low to moderate VL experienced during VBT seems to be a feasible dosage for optimizing jumping, sprinting, and lifting velocity against submaximal loads (Jukic et al., 2022).

Conclusion

In conclusion, VBT is a rising auto-regulation method that dynamically regulates training loads to assist RT. However, the role of VBT in improving various health related factors of physical activity was not reported in previous studies. However, what is clear is that VBT can supply power that is a critical demand of athletes and generally VBT sessions relatively have lower volume and post-exercise fatigue and this reason may encourage people to use it as a popular training method. Additionally, VBT devices help coaches to predict optimal load and volume before each training session; so modified training variables result produce better adaptations. On the other hand, VBT devices are expensive and the dose-response relationship between velocity loss and neuromuscular adaptation is not very clear yet, so we call for more focus on the role of velocity loss manipulating on different muscular adoptions. Besides, daily diet may affect athletes' responses to VBT, which should be highlighted and controlled in future controlled trials.

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