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REVIEW ARTICLE **OPEN ACCESS**

Velocity-Based Training: Unveiling Optimal Strategies for Peak Athletic Performance, Injury Minimization, and Recovery: A Comprehensive Review

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Abstract

The primary challenge faced by any strength and conditioning (S&C) practioner or performance coach is to devise, determine, and implement an ideal training regimen that is exclusively focused on maximizing peak athletic performance. This can be achieved by combining ballistic exercises, like weightlifting, with plyometric exercises, which are typically chosen based on their biomechanical resemblance to the sport being played. To maximize outcomes, nutrition and recuperation techniques are also included. Because of this, most S&C coaches prescribe the appropriate workout intensity to athletes using velocity-based training (VBT) as opposed to more conventional percentage-based training (PBT) techniques. While VBT is a useful tool for athletes to maximize their performance, there aren't many academic studies about its optimal use for better strength adaptations; hence, the study aims to unveil this. Electronic searches of computerized databases were performed using specific keywords. The following six databases were searched: Google Scholar, PubMed, MEDLINE, EBSCO, SCOPUS, and Web of Science. A total of forty-seven studies were selected for this comprehensive review. Seventeen papers were found to be pertinent for additional study after duplicates and articles rejected based on title and abstract reviews were eliminated. After that, a consensus was formed over which studies to include in the comprehensive review so that conclusions can be drawn. Further analysis revealed that optimizing VBRT for maximal benefit requires consideration of specific variables like individual height, time, gender, upper- and lower-body strength ratios, psychology, and a personalized approach focused on targeted velocity. Hence, further research is warranted.

Key words: *Velocity-Based Training, Percentage-Based Training, peak athletic performance, weightlifting, plyometric.*

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INTRODUCTION

The global sports industry has seen a surge in the demand for skilled coaches, leading to significant investments and incentives. Strength and conditioning (S&C) coaches work in various entities, including government-funded organizations, educational institutions, professional sports clubs, and individual athletes [1]. Traditionally, S&C coaches have prescribed resistance training (RT) based on an individual's one repetition maximum (1RM). However, traditional RT relies on percentage-based training (PBT) to estimate an athlete's 1RM, which can be impractical and time-consuming [2]. Velocity-based training (VBT) is a promising alternative to percentage-based training (PBT), which is traditionally used to optimize athletic performance, injury mitigation, and athlete recovery [3]. VBT has the potential to facilitate the implementation of training methodologies reliant on velocity, aiding strength and conditioning practitioners in achieving specific training objectives. It aligns with a fundamental principle of sports biomechanics, demonstrating a strong correlation between external mass and lifting velocity. Traditional resistance training (RT) methods, such as percentage-based training (PBT), overlook physiological variations within athletes, potentially leading to inappropriate training intensities and compromised performance [4]. However, some studies have failed to yield significant outcomes, warranting further investigation for conclusive results. The current review focuses on recent research incorporating state-of-the-art VBT methodologies employed in elite training settings, emphasizing performance optimization, injury prevention, and recovery among athletes. The primary objective is to facilitate ongoing research endeavors in identifying optimal VBT strategies to elevate peak athletic performance, mitigate injury risks, and enhance recovery modalities. The manuscript aims to provide guidelines for the effective application of these contemporary training practices, fostering improved outcomes in athletic conditioning.

MATERIAL AND METHODS

The present comprehensive review was carried out using the guidelines provided by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) [5].

Search Strategy

We conducted electronic searches across multiple databases using particular keywords to gather relevant studies. An extensive investigation was conducted across six databases, specifically Google Scholar, PubMed, MEDLINE, EBSCO, SCOPUS, and Web of Science. We found forty-seven studies that met the specified criteria and were included in this review. The search method utilized several combinations of terms related to velocity-based training (VBT) and its effects on performance in elite athletes, as outlined in **Figure 1.**

Figure 1 Searching strategy for the study inclusion.

The evaluation criteria for the papers were as follows: they had to be original studies that were published as full-text manuscripts by February 2023, and they had to look at how velocity-based resistance training affects athlete performance, reduces injuries, and helps determine the best ways to use it. Participants in the research had to be at least 17 years old, and assessments were done both before and after.

The current comprehensive review adheres to the **PICOS** concept when determining which papers to include and exclude.

P (population): Individuals comprising students, sportspersons, and elite athletes who possess a minimum of one to three years of resistance training (RT) experience.

I (intervention): To determine the most effective utilization of VBT technology for improving performance, minimizing injuries, and expediting recovery.

C (comparison): Optimal uses of different velocity metrics and thresholds.

O (outcomes): VBT plays a crucial role in forecasting an athlete's one-repetition maximum (1RM), assessing tiredness levels, providing real-time feedback on athlete performance, and reducing the risk of injuries. Additional research is required to thoroughly investigate the application of VBT only with high-performance athletes.

S (study design): Systematic reviews and Meta analysis and RCT evaluating the effects of VBT for peak performance, injury and recovery [6].

Data Extraction

The data extraction process consisted of an initial examination and the removal of redundant articles. Afterwards, a thorough examination of titles and abstracts was conducted to evaluate the pertinence of the publications. Complete articles were obtained to provide a comprehensive screening procedure. The researcher autonomously analyzed the complete texts to verify coherence and pertinence. The selected papers were systematically analyzed to extract and document information regarding author details, study objectives, utilization of VBT in resistance training protocols, participant demographics (including sports background, gender, age, training experience, workout session frequency, and duration per week). To streamline the review process, duplicate search outcomes were eliminated, resulting in a completed list of relevant publications. The flow diagram of the search is presented in **Figure 2.**

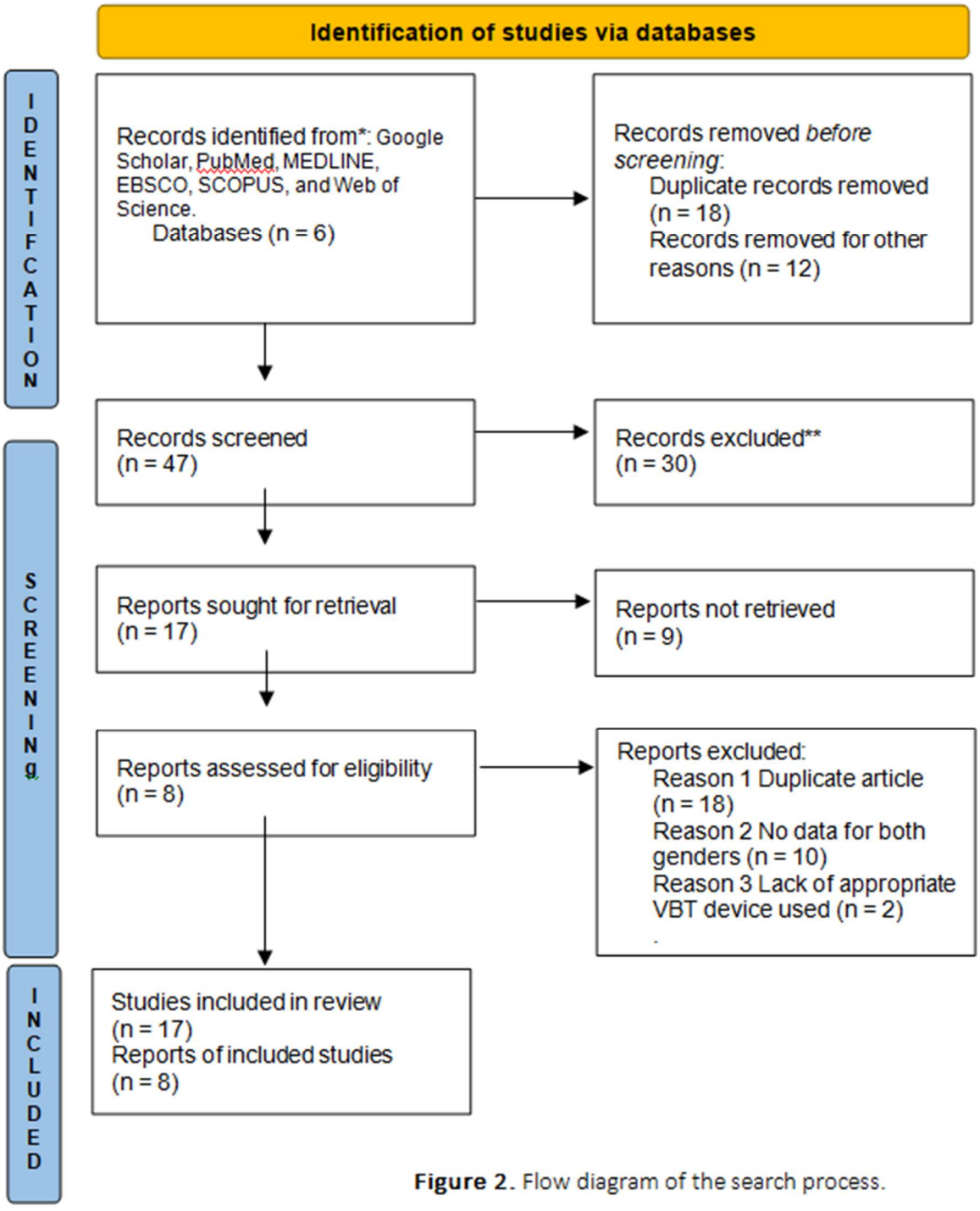

Figure 2. Flow diagram of the search process.

RESULTS

General Characteristics of the Studies

Ultimately, a total of seventeen pertinent studies were identified as suitable for inclusion in this extensive review. Subsequently, a thorough evaluation was conducted, revealing eight studies that specifically investigated VBT and the most effective approaches for achieving optimal athletic performance, minimizing injuries, and facilitating recovery in athletes. These findings are detailed in Figure 2. In total, 241 participants were recruited for these investigations. The research group consisted of only 23 females, representing a mere 9 percent of the total number of subjects, as indicated by just three investigations. The majority of research focused on relatively experienced groups of reaction time (RT) individuals, with the exception of one group of elite athletes, specifically rowers. Furthermore, the research did not make any

reference to competitors competing at the Olympic level. It is well understood that VBT, or Velocity-Based Training, is primarily intended for high-level athletes.

DISCUSSION

The objective of this extensive analysis is to determine the most effective methods for utilizing VBT (Velocity-Based Training) to optimize peak athletic performance, minimize injuries, and improve recovery capacity for maximal strength and power in athletes. According to the findings of this review, it is evident that VBT has multiple applications: The velocity zone method refers to a technique used to analyze seismic data by examining the changes in velocity. It is also known as the velocity loss. The objective of this extensive analysis is to determine the most effective methods of utilizing VBT (Velocity-Based Training) to optimize peak athletic performance, minimize injuries, and improve recovery capacity for maximal strength and power in athletes. According to the findings of this review, VBT has multiple applications, including the velocity zones method, the velocity loss method, exercise readiness assessment, real-time velocity feedback method, and enhancing overall and specific performance.

Velocity Zones Method

Velocity-based training (VBT) is notable for its ability to assist athletes in performing precise actions at predetermined speeds. Studies suggest that simply increasing the velocity of a weight or body movement does not automatically improve performance [7]. In order to go more into the matter, a study was undertaken, encompassing a group of thirteen male powerlifters. The participants were selected for a study where they were given the goal of reaching an average speed of 1.0 m/sec while performing a bench press set with free weights at 45% of their maximum weight that they can lift once (1RM) in one session. During all testing sessions, participants were provided with prompt input on their barbell velocity after each repetition. This feedback was delivered by a tablet and GymA-ware linear position transducer. The highest average velocity achieved in each group was compared using a repeated measures analysis of variance and Tukey's post-hoc test. The number of repetitions performed during an RM test at 75% of the one-repetition maximum (1RM) was assessed using a Wilcoxon signed-rank test after completing four sets of five repetitions. The results showed that participants demonstrated higher velocity when asked to accomplish the desired speed (0.84 ± 1.0 m/sec) compared to when they were told to move as quickly as they could (0.82 ± 0.09 m/sec) ($p < 0.001$). Nevertheless, there were no discernible disparities in the quantity of repetitions executed during the subsequent RM test between the two testing sessions ($p = 0.43$). The study found that setting a difficult target velocity resulted in higher movement velocities compared to asking participants to move as rapidly as possible, without reducing the number of repetitions completed during a subsequent RM test. Promoting individuals to achieve a demanding target speed during training sessions may be an effective approach for inducing velocity-specific training adaptations [8].

Velocity Loss Method

Evaluating the fatigue index of athletes is a vital component of velocity-based training (VBT) that helps strength and conditioning (S&C) coaches prevent overtraining, which is a major cause of injuries [9]. In a recent study involving thirty physically active male participants, researchers aimed to examine the impact of various velocity loss thresholds on alterations in muscle contractile characteristics and muscle oxygenation following a single session of resistance training (RT). Within the crossover trial, participants were instructed to perform three sets of squats at a velocity of approximately 0.75 m·s−1. They were given two different velocity loss thresholds, namely 20% (VL20) and 40% (VL40), in a random sequence. The findings of this experiment suggest that strength and conditioning coaches and athletes should acknowledge that VL40 induces more significant mechanical and neuromuscular deficits compared to VL20, which is essential for muscle growth. However, VL40 also causes a prolonged reduction in oxygen availability compared to VL20, which may lead to a shift from fast to slow muscle fiber types [10].

Velocity Technology used for Monitoring

The reliability of study outcomes in velocity-based training (VBT) protocols heavily depends on the use of suitable technical instruments. Several study have identified the diverse benefits and drawbacks associated with multiple reliable velocity-measuring systems. Moreover, different manufacturers of velocity measurement equipment utilize unique algorithms, which can introduce complications and impracticalities when used in athlete training [11]. A study was conducted with 22 resistance training athletes who were recreationally active. These athletes had a minimum of 3 years of experience in free-weighted back squats. The group consisted of 12 males and 10 females, with an average age of 29.1 ± 5.2. The study aimed to evaluate the accuracy and precision of the Apple Watch 7 and the Enode Pro device. The objective was to assess the average, maximum, and propulsive speed during free-weighted back squats in comparison to Vicon, which served as the benchmark criterion. The motion data was processed using an automated Python approach to generate velocity parameters from both Vicon optical motion capture and the Apple Watch. The study utilized the Apple Watch installed on a barbell (correlation coefficient r = 0.971–0.979,

standard error of estimate SEE = 0.049), the Apple Watch worn on the wrist (r = 0.952–0.965, SEE = 0.064), and the Enode Pro mounted on a barbell (r = 0.959–0.971, SEE = 0.059). The findings demonstrated that all three devices were capable of reliably measuring mean velocity. In addition, the Apple Watch attached to the barbell showed excellent accuracy in measuring propulsive and peak lifting velocity (Vpeak: r = 0.952–0.965, SEE = 0.092; Vprop: r = 0.973–0.981, SEE = 0.05). The findings on the validity of the Apple Watch offer interesting possibilities for incorporating velocity-based training applications into popular consumer wearable's [12].

Exercise Readiness and Real-Time Velocity Feedback

One of the most important and essential components of velocity-based training (VBT) is its use of a biofeedback mechanism and real-time performance monitoring. This feature offers a notable benefit for competitive athletes, especially considering that top-tier athletes continuously perform at extremely demanding levels of intensity [13, 14]. A study was done to examine the effects of VBT on improving many aspects of lower limb performance, such as maximal strength, strength endurance, vertical jump height, and sprinting ability, in persons with previous training experience. We conducted a comprehensive search across multiple databases, including as PubMed, Web of Science, Embase, EBSCO, Cochrane, CNKI (in Chinese), and the Wanfang Database (in Chinese), to identify pertinent research on VBT that especially focused on enhancing the lower extremities. Only randomized controlled trials that solely utilized VBT without any additional training elements were eligible for inclusion. The meta-analysis included a total of nine trials, which involved 253 male participants who had undergone training for at least one year. The collective findings indicate that VBT had a significant positive impact on lower limb maximal strength (SMD = 0.76; $p < 0.001$; I2 = 0%), strength endurance (SMD = 1.19; $p < 0.001$; I2 = 2%), countermovement jump performance (SMD = 0.53; $p < 0.001$; I2 = 0%), and sprinting ability (SMD of sprint time = 0.40; $p < 0.001$; I2 = 0%).

CONCLUSION

Based on the synthesis findings, we can make some crucial velocity-based training (VBT) program implementation recommendations. A study sample should include strength and power sports pros with at least 2–3 years of resistance training experience. Sports scientists can focus on boosting performance indicators like strength, power, and speed with this technique. Performance outcomes must be prioritized since VBT focuses on four key metrics: MCV, PCV, MPV, and VL [12]. Increase female athlete involvement and balance the gender ratio in research to address prejudices and better understand VBT (velocity-based training) in both men and women. Only the latest technology should be used throughout the investigation to ensure data consistency and reliability. To span the periodization cycle, investigations should be 12–16 weeks long. Before implementing VBT in training facilities, athletes and coaches need extensive knowledge and assistance. This instruction should include clear measurements, explicit vocabulary, and a regular study schedule throughout the trial. VBT (velocity-based training) results for athletes of different sizes depend on anthropometric factors like height, limb length, and range of motion (ROM). The variation in outcomes among seemingly equal athletes emphasizes the importance of anthropometric characteristics. Exercise readiness data and real-time feedback during training may improve sport-specific attributes. This strategy helps athletes meet performance and responsibility standards. Strength and conditioning coaches must understand VBT measures to avoid misinterpretation of research findings and ensure precise and significant effects on athletic performance, injury prevention, and recovery. A VBT study must be precise to yield useful results.

DECLARATIONS

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Conflicts of Interest

The author does not have any professional affiliations with any manufacturers or businesses that would gain from the current study's findings.

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