Velocity-Based Training in Football

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ABSTRACT

THE PURPOSE OF THIS PAPER IS TO DISCUSS THE POTENTIAL BENEFITS OF VELOCITY-BASED TRAINING (VBT) AND HOW IT CAN BE USED TO TRAIN VARIOUS PERFORMANCE FACTORS SPECIFIC TO AMERICAN FOOTBALL. THE ADVANTAGES OF VBT ARE ITS ABILITY TO IDENTIFY PROPER TRAINING LOADS WHEN DAY-TO-DAY FLUCTUATIONS IN MUSCLE PERFORMANCE OCCUR, THE ABILITY TO ENHANCE SPECIFICITY OF TRAINING, AND THE ABILITY TO PROVIDE IMMEDIATE FEEDBACK TO IMPROVE MOTIVATION AND PERFORMANCE. USING VBT HAS RESULTED IN TANGIBLE IMPROVEMENTS IN COLLEGIATE FOOTBALL PLAYERS' POWER PRODUCTION, WHICH IS A KEY TO IMPROVING ON-FIELD PERFORMANCE.

For decades, the traditional approach to improve muscle performance measures (e.g., muscle strength and power) has been to train at various percentages of the one repetition maximum (1RM) and modify volume and frequency of training. However, more recently, the notion of using training velocity to achieve specific performance goals has been gaining popularity in strength and conditioning training facilities and in the scientific literature (9,10,13,19,28,33–35). The purpose of this paper is to discuss the potential benefits of velocity-based training (VBT) compared with traditional approaches and how it can be used to train various performance factors specific to American football.

WHAT IS VELOCITY-BASED TRAINING AND WHY SHOULD IT BE USED?

Ever since Delorme (5,6,39) pioneered the use of the term 1RM and used it to design the earliest strength training regimens, the 1RM has served as the gold standard to design training loads to achieve specific performance objectives. However, VBT is a training method used by coaches and practitioners to determine the optimal loading for strength training using the velocity at which an athlete can move a load independent of 1RM. There are a number of compelling reasons why coaches should consider implementing VBT in their training programs over more traditional approaches. First, VBT has distinct advantages over other autoregulatory methods of training and VBT approaches are becoming widely available. Second, VBT can identify proper training loads when fluctuations in muscle performance occur as a result of life stressors. Third, VBT helps identify optimal velocities and specific loads at which to train to enhance specificity of training. Fourth, VBT provides immediate feedback that can play a role in motivation and improved performance. The following section will discuss these benefits in more detail.

IMPROVEMENT OVER EXISTING AUTOREGULATORY METHODS

VBT is a form of autoregulation of training, where day-to-day fluctuations in performance can be accounted for by adjusting the training load (18,22). Although VBT has garnered much recent attention, it is certainly not the only autoregulatory training method for the coach and practitioner. For example, other methods, such as assigning loads based on rating of perceived exertion (RPE) (4,7,23) and the autoregulatory progressive resistance exercise (APRE), have both been shown to be effective in regulating loads. However, both the RPE and APRE methods require the user to wait until a training set has been performed before any adjustments can be made. Alternatively, VBT can provide important quantitative information about performance before the first set. There is a near-perfect linear relationship between mean velocity and %1RM (22). That is, if an athlete is moving the bar much faster than usual during the warm-up period, adjustments can be made in the form of larger increases in warm-up loads and subsequent training loads. Thus, VBT provides an advantage that other autoregulatory methods of training cannot provide until further into the training set. In addition, the increasing availability of different technologies to measure the mean velocity of the lifting bar during strength training is making VBT a user-friendly and practical alternative to existing methods. Linear position transducers (e.g., Tendo [Slovak Republic] and GymAware [Australia]) and accelerometer-based technologies (e.g., Push Strength [Toronto, Canada] and Bar Sensei [Boulder, CO, USA]) have not only made VBT easier to apply for the practitioner but also provided quantifiable data for the researcher

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(3,9,10,12,15,17,27,28,34,38,40) offering new insights into the effect of different training methods.

FLUCTUATIONS IN MUSCLE PERFORMANCE BECAUSE OF LIFE STRESS

VBT can also help identify proper training loads when fluctuations in performance occur as a result of life stressors. Stress is a condition with specific outcomes from nonspecific inputs. When stress is encountered, the adrenal cortex responds by producing glucocorticoids, the adrenal glands secrete epinephrine, and the pancreas decreases insulin production (36). These events occur in a similar manner whether one is experiencing life stress or the physical stress encountered through resistance training, conditioning, or sport skill acquisition (20). Life stressors that an athlete encounters not only affect onset of injury but also affect training for sport (1,29). Petrie (30) showed that increases in life stress increased the incidence of injury 3-fold in some athletes. This is put into better context when one takes into account the imbalance of "life" hours versus "training" hours for a collegiate athlete. For example, football players typically may train 2–3 h/wk during the in-season period and up to 8 h/wk during the off-season period, as mandated by the National Collegiate Athletics Association (NCAA) (26). Furthermore, football players may practice up to 20 h/wk during the in-season period (inclusive of weight training and sports practice). To better understand how athletes adapt to and recover from stress, strength and conditioning coaches should be aware that football players experience life stressors throughout the 168 hours in a week, not only the 8–20 hours of training and practicing. Also, researchers have recently shown that during times of high academic stress and low physical stress (i.e., in-season examination weeks), division 1 collegiate football players sustained the same number of injuries as times of high physical stress and low academic stress (i.e., training camp) (20).

Recently, Moore and Fry (24) examined how a football team at a Division 1 university responded to physical stress during the course of an entire spring semester. The spring semester consisted of 3 distinct training periods:

- Weight room training under the supervision of a strength and conditioning coach.
- Weight room training under the supervision of strength and conditioning coach plus winter conditioning conducted independently by the football coaches.
- Weight room training plus spring practice, followed by subsequent additional weight room training.

Over the course of the semester, athletes saw initial improvements in strength, power, speed, and the stress hormone profile during the first training period that occurred only in the weight room. However, as additional physical conditioning stress was added (during the second training period), there was a significant regression in performance, with muscle strength, power, and hormonal responses falling below baseline (24). Moreover, these measures did not return to baseline until the end of the semester. The researchers (24) hypothesized that this was because of improper loading, which was the result of combining the conditioning and strength training phases, resulting in an excessive total training load. In effect, this may have resulted in the occurrence of nonfunctional overreaching (24), where too many stressors imposed upon the athlete did not allow sufficient recovery, which led to the onset of overtraining/overreaching in some athletes.

Whether from accumulation of life stressors or physical stressors results in a decrement in performance, VBT is an option for the strength and conditioning coach to select the proper loads in an attempt to prevent nonfunctional overreaching. Izquierdo et al. (13) demonstrated that mean velocity is a very stable metric and that there is a high positive correlation between the mean velocity of the barbell and %1RM. Although the 1RM may fluctuate over time, the %1RM and mean velocity remain quite stable. As an example, if an athlete with a 1RM of 300 kg were to move 60% of their 1RM at 0.8 m/s, they would be moving 180 kg at 0.8 m/s. If, after several months of training and adaptation, the external load that they could move at 0.8 m/s was now 198 kg, the stability between mean velocity and 1RM (the velocity-load profile) would very closely identify the athlete's new 1RM at 330 kg because the relationship between a mean velocity of 0.8 m/s and 1RM is 60% of their 1RM (10).

A critical component of VBT is that training at a mean velocity rather than at a %1RM will allow the athlete to use the appropriate load for a given day. Because the onset of individual stressors (e.g., sports stress, life stress, and social stress) will result in day-to-day fluctuations in the ability to move external resistances (8), the athlete and coach must rethink the notion of the 1RM as being a consistent nonvarying value. Jovanovic and Flanagan (17) showed that the 1RM estimated using the velocity-load profile from Gonzalez-Badillo and Sanchez-Medina (10) ranged from ±18% compared with a previously established 1RM. Thus, the athlete who is prescribed a load of 70% of 1RM for training may in actuality be lifting in a range of 52%–88% of 1RM. However, if the athlete was using VBT to account for the daily variability in 1RM, he or she would be training at the appropriate load for that training session. By using velocity, the strength and conditioning coach is no longer relying on what may be an erroneous 1RM value from the previous training cycle but is instead using a 1RM that is appropriate based on the physiological condition of the athlete on a particular day. These findings are congruent with the recommendation by Mann (19) on determining the proper training loads in athletes.

SPECIFICITY OF TRAINING

Another benefit of VBT is that training at optimal velocities and specific loads can maximize training specificity, the utilization of the appropriate energy systems, and training demands to increase the likelihood of a positive adaptation. The specific adaptations to imposed demands principle (25) governs training in general. The strength and conditioning coach must know exactly what training outcomes are desired and design the training program to elicit those outcomes/adaptations (25). For instance, if an athlete desires to improve his 40-yard dash time, the strength and conditioning coach would not focus on exercises to improve endurance but would target exercises that produce maximal power for time periods of less than 10 seconds to bring about the desired outcome.

Specificity of training is of particular importance in the training of the football athlete. Although football-specific factors can be trained with most exercises, the success of this training will depend on the load and mean velocity of movement. At any submaximal percentage of 1RM, an athlete can consciously move the barbell at either a faster or a slower velocity. Although 2 athletes may be assigned a similar exercise (e.g., squat or bench press) with regard to sets, repetitions, and %1RM, the manner in which they move the barbell will result in very different outcomes. If athlete A moves the bar slowly and easily at a given intensity, the adaptation may resemble muscle hypertrophy and increases in muscle strength. If athlete B moves the bar as fast as possible at the same relative intensity, improvements in muscle strength and power will be much greater; however, the adaptations of hypertrophy are not well known (28). Thus, controlling the velocity of load allows the coach to develop the desired training outcome. In the following paragraphs, we will describe how specificity of training using velocity can maximize the factors most applicable to football: absolute strength, strength-speed, speed-strength, and starting-strength.

Absolute strength is easily monitored using mean velocity because mean velocity and %1RM are directly related (16). Using mean velocity, the coach knows that the athlete is moving the appropriate load for absolute strength training on a given day. Researchers have shown that lower-body movements, such as the back squat, tend to have a 100% 1RM moving at a velocity of approximately 0.3 m/s. Conversely, upper-body movements, which have a shorter range of motion, tend to have a 100% 1RM moving at a velocity of approximately 0.15 m/s. This is most likely because of the difference in amplitude or range of motion that the athlete must go through to complete the movement (13). Because most athletes have longer legs than arms, a higher velocity is required to complete the range of motion for the lower-body exercises compared with upper-body exercises. By using these average velocities instead of the 1RM, the coach knows the athlete is moving the appropriate load on a given day to maximize absolute strength.

Strength-speed can be described as moving a moderately heavy load at a moderate velocity and was first described by Roman in *Training of the Weightlifter* (32). The advantage of having strength-speed to the football player is exemplified in positions played at the line of scrimmage. Linemen, for example, are attempting to accelerate against an external load of their opponent and the opponent's inertia and must do so rapidly to move the mass of their opponent out of the way. The mean velocity of 0.75–1.0 m/s presented by Roman (32) and later corroborated by Jandacka and Beremlijski (15) and Jidovtseff et al. (16) represents the optimal velocity at which to maximize this trait. Although different terms, such as "load-velocity" (15,16,32), "dynamic strength," and "dynamic effort" (37), have been used to describe strength-speed (15,16,32), Roman's pioneering nomenclature is what is typically used to describe this trait. It should also be clarified that nomenclature used by Siff (37) (i.e., dynamic effort method) is simply a method to develop the trait of strength-speed.

Speed-strength can be described as moving a lighter load at high velocity and is a means to improve explosive strength (37). The advantage of having speed-strength to the football player is exemplified in the explosiveness of a player coming out of the stance at the line of scrimmage. Work done by Jacobson et al. (14) and Mann and Jacobson (21) found that football players typically explode out of their stance at a mean velocity of 1.09 m/s, which is in the speed-strength zone. The term speed-strength was again coined by Roman (32) and later supported by Jandacka and Beremlijski (15) and Jidovtseff et al. (16), who called it "average velocity-load." To maximize speed-strength, a mean velocity of 1.0–1.5 m/s is required during the exercise; however, where the required velocity falls within that range is dependent upon the amplitude of motion. Squats and bench press exercises with smaller amplitudes of motion fall into a range more typically found between 1.0 and 1.3 m/s, whereas a lift, such as a hang clean with a greater amplitude of motion, has a mean velocity of 1.45 m/s.

Starting-strength is the ability to overcome inertia rapidly and is developed by using extremely light loads moved at extremely high velocities (2). For the football player, starting-strength is important to a position player such as a receiver who needs to be able to rapidly overcome inertia on their first step to achieve high-velocity movements off the line (2). Researchers have shown that the mean velocity to improve starting-strength ranges from 1.3 to 1.8 m/s and higher depending on the amplitude of motion (2). For smaller amplitude exercises, such as a squat or bench press, a mean velocity of 1.3 m/s would be used, whereas lifts with much greater amplitude of motion (e.g., a minimal-loaded squat jump) may require a mean velocity of 1.8 m/s.

Through observation, experience, and existing research, the authors believe that many coaches employ loads that are either too heavy or bar velocities that are too slow to maximize training effects. When the velocity of athletes performing hang cleans was measured by attaching the tether of a linear position transducer to the bar, the authors found the mean velocity of the bar was between 0.6 and 0.8 m/s, far below the recommended 1.4 m/s velocity for this lift (19). In subsequent semesters of training, athletes were required to meet the additional stipulation that the movement be completed at or above the required velocity. Once this minimum velocity for the hang clean was achieved, a strong relationship between the lift and vertical jump was observed.

IMPROVING RESULTS BECAUSE OF IMMEDIATE FEEDBACK

Another important benefit to VBT is the immediate feedback that is provided to the athlete. It is the authors' experience that athlete's motivation is enhanced when presented with a number that quantifies performance. Immediately after the repetition, the athlete knows whether the repetition met objective criteria for improved performance. With this knowledge, the athlete will also often attempt to increase the velocity of each subsequent repetition to best their previous performance. Immediate knowledge of results also enables athletes to compete against each other, attempting to outperform each other by velocity or weight. When the athlete has a benchmark with which to compare himself to his own past performance and that of his teammates, the authors have found that this provides compelling motivation for maximal improvement during every training session.

Our observations are supported by Randell et al. (31), who studied 2 groups of athletes participating in jump squats, one of which received velocity feedback at each session while the other received no feedback at all. The velocity feedback group significantly improved their jumping and sprinting ability over the nonfeedback group. The authors concluded that the improvements seen in the feedback group were a result of a higher total power accumulation over the course of each set and workout, suggesting that velocity feedback from the previous repetition caused the subjects to try to beat their previous repetitions in terms of speed or power. By consistently achieving higher power values, the body will adapt by producing greater improvements in power (36).

VELOCITY-BASED TRAINING IN PRACTICE

Since 2004, the authors have been experimenting with VBT to find the most effective and efficient method of implementation. It is currently being used in the determination of loads for in-season dynamic effort and also for Olympic-style weightlifting. VBT is implemented only after initial training levels to improve technique and absolute strength have been reached by the individual athlete. After these initial levels have been met and a high level of trust has been established between the athlete and coach, VBT will be introduced. Trust between coach and athlete is paramount because a high level of autonomy is required of the athlete in the selection of loads necessary to maximize their performance. Trust helps ensure that athletes will consistently give their best effort, which is essential to maximizing the beneficial effect of this type of training. Allowing the athletes the autonomy to self-select loads, with some guidelines, has been shown to be an effective way to increase strength and performance (24).

For the dynamic effort method, which is developing strength-speed (37), mean velocity is determined and used because it is considered to be the most stable metric (10). The mean velocity is more stable for non-Olympic lifts because the entirety of the movement matters. In exercises, such as the bench press, the lifter will actually spend only 34% of the time in acceleration and 66% of the time in deceleration (2). When considering the range of average velocities for a particular training task (e.g., 0.75–1.0 m/s), either an ascending or a descending order is applied depending on the goal(s) of that training period. For example, if the primary goal of the training cycle is improvement in strength, then the order would be from fastest velocity (lightest load) to slowest velocity (heaviest load). If the primary goal of the training cycle is improvement in power, then the order would be from slowest to fastest velocity. A typical 3-week cycle for an athlete wanting to improve strength or power during this cycle of training is outlined in the Table.

Regardless of the cycle, the athlete is given an initial "starting weight" from where he or she will begin the session. The load will then be adjusted accordingly to ensure that the athlete is able to maintain the given velocity. For dynamic effort, the initial loads are usually in the 40%–50% range. Although the athlete is often able to use significantly heavier loads on the initial set (e.g., up to 65–75% of 1RM), it is critical, given the possible presence of life stressors, that the athlete is able to provide a load that will maximize the athlete's confidence. After the initial starting weight, adjustments will be made for each and every set. If the velocity of

Table
Two examples of 3-week waves using velocity for in-season training

Week	Sets/repetitions	Velocity, m/s
Cycle for power		
Week 1	6 × 3	0.75
Week 2	6 × 3	0.85
Week 3	6 × 3	0.95
Cycle for strength		
Week 1	6 × 3	0.95
Week 2	6 × 3	0.85
Week 3	6 × 3	0.75

the preceding set was faster than the range of velocities required for the particular trait (i.e., absolute strength, strength-speed, etc.), then the load will need to be increased. If the velocity of the preceding set was below the range of velocities required, then the load will be decreased.

As opposed to the traditional lifts described earlier (e.g., squats, bench press), which use mean velocity, Olympic-style lifts use peak velocity to determine load. Because Olympic-style lifts are ballistic exercises, the entirety of the movement is not as critical for evaluation of the lift. Harbili and Alptekin (11) found that the peak velocity occurs at the top of the second pull of the clean or snatch when the movement is done properly. Thus, peak velocity helps define the critical moment of the movement and thus is a clearer determinant of the success of the lift. The actual velocity of Olympic-style weightlifting movements will be predetermined with a range. If an athlete's peak velocity is too low, load will need to be reduced. If peak velocity is too high, then load will need to be increased.

The implementation of VBT allows the staff to monitor and use the appropriate loads for the athlete for any given day. This is especially effective in season, where different athletes are receiving varying amounts of playing and practice time. Starters will experience more fatigue because of the greater number of repetitions in both practices and games compared with those who are not starting or are in a developmental phase of their career.

In the authors' experience, VBT provides a strong stimulus for improvement in muscle power compared with traditional approaches that can be sustained over time. The authors anticipate making more definitive conclusions regarding the benefits of VBT as data are collected and analyzed on increasing numbers of athletes in the coming years.

POTENTIAL LIMITATIONS OF VBT

There are several limitations of VBT. First, the expense of the technology to assess velocity may make it impractical for some. Although prices have dropped in recent years, the cost may approach $400 for accelerometer-based units, whereas linear position transducers may exceed $1,800. Second, VBT requires the coach to relinquish some control in the weight room. As previously described, VBT requires an element of trust between coach and athlete. The coach must trust that the athlete can make proper decisions regarding load selection and that the athlete is giving their maximal effort on each set of exercises. Although this may be difficult for some coaches, increased autonomy for the athlete may actually increase effort and results (22). Third, tracking of the data may prove complex and/or time consuming. Some units will collect the data for the user after some up-front data entry, saving this information onto a web-based server. Other units, however, do not have this feature, and the coach must manually record any data that they would like to keep or analyze.

PRACTICAL APPLICATION AND SUMMARY

For the coach and practitioner, VBT offers a novel and unique way to maximize performance in the athlete. By training within the range of the various velocity profiles, the practitioner can ensure that they are getting the best from their athlete on each training day and ensure a high transfer of training to the specific trait. For the athlete, VBT will be a new approach to their training, which will not only motivate but also further increase the quality of their training.

VBT is a useful tool to coaches and practitioners who want to maximize athletic performance. VBT helps match the proper load with the desired trait being trained, aids in countering external stressors that influence adaptation from training, and serves as a motivational tool to increase the quality of work performed. The authors' experience using VBT has demonstrated tangible improvements in power production, which is the key to improving on-field performance in the collegiate football player.

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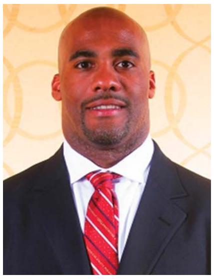

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