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A Novel Approach to Predicting 3RM Using Velocity-Based Measurement

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Abstract

[Purpose] The purpose of this study was to identify the minimum mean concentric velocity necessary for the successful completion of repetitions in the back squat and bench press. **[Subjects]** Participants were 7 Division 1 Track and Field throwers, 5 females and 2 males, and performed 3RM testing at 90% of their 1RM in both the back squat and bench press, for which the mean concentric velocity of the bar was recorded. **[Results]** A strong negative correlation (r = -0.99) was determined between mean concentric velocity in the back squat and %1RM and a similarly strong negative correlation (r = -0.97) was determined between mean concentric velocity in the bench press and %1RM. Additionally, the lowest mean concentric velocity for repetitions in the back squat was 0.25 m/s and the lowest mean concentric velocity for repetitions in the bench press was 0.12 m/s. **[Conclusion]** To potentially reduce the risk of injury and fatigue leading to overtraining, the strength and conditioning professional should be aware of the respective velocities necessary for the successful completion of repetitions in the back squat and bench press so as to avoid taking an athlete to absolute failure.

Introduction

Traditionally, the strength and conditioning professional has relied upon prescribing training intensities based upon varying percentages of the one repetition maximum (1RM) with concurrent modifications to volume load and training frequency (1). However, such an approach is retrospective in nature in that it only provides quantification of a resistance training session after its conclusion and the information collected can therefore only be used to modify a subsequent session (2). In contrast, velocity-based training is a method that allows coaches and practitioners to determine and assign optimal training loads based upon the velocity at which an athlete can move a given load on a specific day at a specific time independent of 1RM (1). Specifically, the use of VBT is advantageous in that it accounts for fluctuations in muscle performance due to daily variability and thus enables training to be tailored accordingly (3,4). Consequently, VBT provides the strength and conditioning professional with the ability to accommodate for periodic intervals of decreased performance by prescribing the minimum stimulus required to produce positive physiologic adaptation while simultaneously attempting to prevent nonfunctional overreaching during times of high social, academic, or physical stress (1).

In regard to specificity of training, VBT attempts to identify the optimal velocities at which specific movements should be performed in order to optimize training. Adhering to such velocity parameters better ensures the engagement of the appropriate energy systems and training demands in order to increase the likelihood of positive physiologic adaptation and thus greater sport performance (1). Such information is invaluable to the strength and conditioning coach to ensure that an athlete is developing the desired physiologic adaptations through appropriate training. Lastly, VBT provides immediate feedback that can influence motivation and thus improve performance (1). Provided with instantaneous quantitative data, the athlete will often endeavor to increase the velocity of each sequential repetition to best his or her previous performance (1). Such an effect is especially desirable towards the development of power, where how the load is moved is more significant in explaining improvements in functional performance (5,6,7).

The purpose of this study was to identify the minimum mean concentric velocity necessary for the successful completion of repetitions in smaller amplitude exercises, namely the back squat and bench press. Such knowledge would be of practical use to the strength and conditioning professional in the conduction of both testing and training. Specifically, by knowing the minimum mean concentric velocity needed for the successful completion of a repetition in either the back squat or bench press, coaches and practitioners would be able to predict whether an athlete will fail during the next subsequent repetition based upon the mean concentric velocity of the previous repetition. As a result, it would be unnecessary for the strength and conditioning professional to take athletes to absolute failure during either testing or training, thus reducing the risk of injury, improving testing procedures and may prevent excessive fatigue leading to overtraining.

Methods

Subjects

Institutional review board approval was obtained prior to the start of the study and all participants provided written informed consent. Additionally, all procedures and measurements were performed in accordance with the ethical principles regarding human experimentation as specified in the Declaration of Helsinki.

Participants in the study were recruited from Sacred Heart University's Division 1 (NCAA) Track and Field team and consisted exclusively of throwers. Only current athletes holding a roster position on Sacred Heart University's Track and Field team were included. Athletes suffering from acute injuries or those currently undergoing rehabilitation for an injury could elect to participate in only the back squat or bench press testing procedure depending upon the location of injury.

Descriptive Statistics

	Total (n = 7)	Male (n = 2)	Female (n = 5)
Bodyweight (lb.)	209.3 ± 30.8	247.7 ± 3.8	193.9 ± 19.6
Height (inch)	67.7 ± 3.3	71.5 ± 3.5	66.2 ± 1.8
Training Age (yr.)	4.8 ± 2.7	7 ± 2.8	3.9 ± 2.3
Age (yr.)	20.6 ± 1.0	20.3 ± 0.4	20.8 ± 1.2

Materials

All data was collected using the GymAware Power Tool (ACT, Australia) with a sampling frequency of 50 Hertz. Data was collected using the GymAware Lite software version (2.10) collected on an iPhone 6 (Mac, CA, USA). All data was collected on the iPhone and uploaded into Microsoft Excel version (14.1.0) (IBM, USA) for further analysis.

Procedure

All testing occurred in the motion analysis laboratory and all data was collected in a single testing session. After arriving in the laboratory, all athletes were informed of procedures and then performed a dynamic warm-up consisting of 25 jumping jacks, 10 bodyweight squats, 10 bodyweight lunges per leg, 10 forward arm circles, 10 backward arm circles and 20 bodyweight push-ups. 30-second rest intervals were allowed between warm-up exercises.

Submaximal testing procedure for both the back squat and bench press utilized a loading progression of 10 repetitions with an empty bar (45 lbs.), 5 repetitions at 50% of the athlete's 1RM, 4 repetitions at 60%, 3 repetitions at 70% and 3 repetitions at 80%. Each athlete then performed 3 sets of 3 repetitions at 90% of his or her 1RM, for which the mean concentric velocity of the bar was recorded. In regard to rest times, 1-minute rest intervals were allowed between each consecutive warm-up set while 2-minute rest intervals were permitted between the final warm-up set and each working set. All athletes completed the back squat testing protocol prior to bench press testing and a period of 5 minutes rest was prescribed between exercises.

With respect to form and cueing, athletes were instructed to squat to a depth where the hip crease was below parallel and were encouraged to perform each repetition as explosively as possible. For the bench press, athletes were instructed to touch the bar to the chest before performing the concentric phase of each repetition. To ensure correct form and adequate safety, three spotters were present for each individual lift.

Statistical Analysis

All mean and standard deviation values for both repetitions in the back squat and bench press were calculated using Microsoft Excel version (14.1.0) (IBM, USA). Further, the Pearson product-moment correlation coefficient was used to evaluate the relationship between mean concentric velocity of repetitions in the back squat and bench press and %1RM.

Results

As anticipated, a negative correlation was observed between mean concentric velocity of repetitions and intensity (%1RM) in both the back squat and bench press. Specifically, as loading intensity increased, a simultaneous decrease in the mean concentric velocity of repetitions was observed. The strength and direction of this linear relationship was evaluated using the Pearson product-moment correlation coefficient (r). For repetitions in the back squat, a correlation coefficient of r = -0.99 was determined, indicating a strong negative relationship. For repetitions in the bench press, a value of r = -0.97 was calculated, suggesting a similarly strong negative relationship. See *Figure 1* and *Figure 2* below for illustration.

In regard to a minimum mean concentric velocity observed for the successful completion of repetitions in the back squat, a value of 0.25 m/s was the lowest velocity recorded. For repetitions in the bench press, a value of 0.12 m/s was the lowest mean concentric velocity recorded.

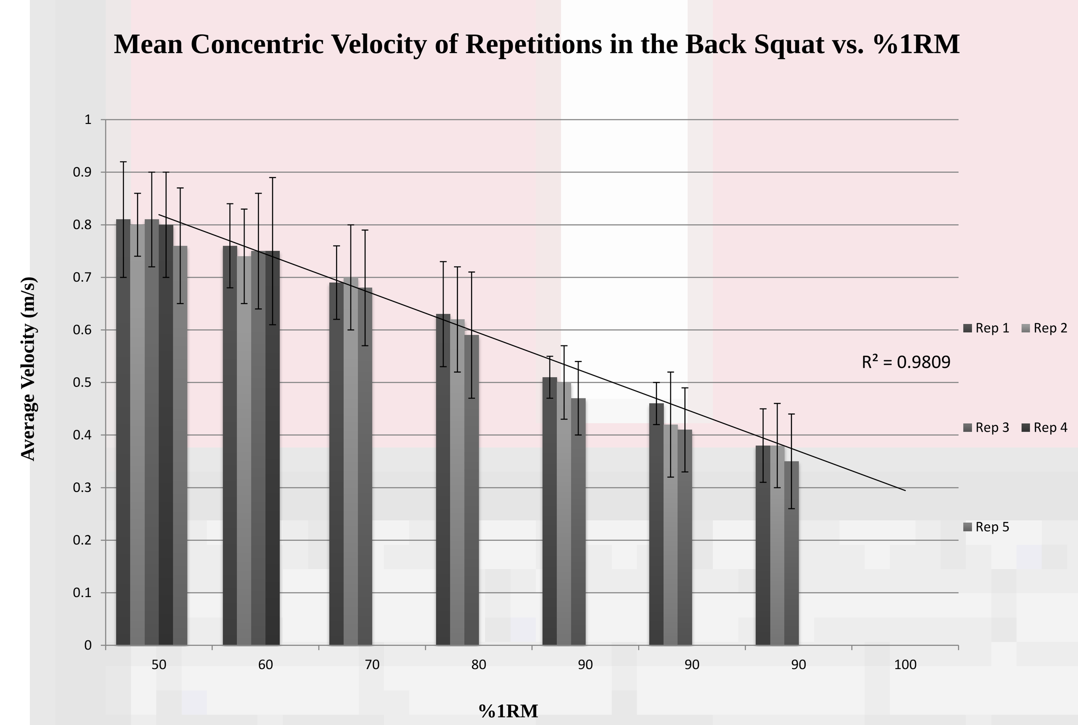

Figure 1

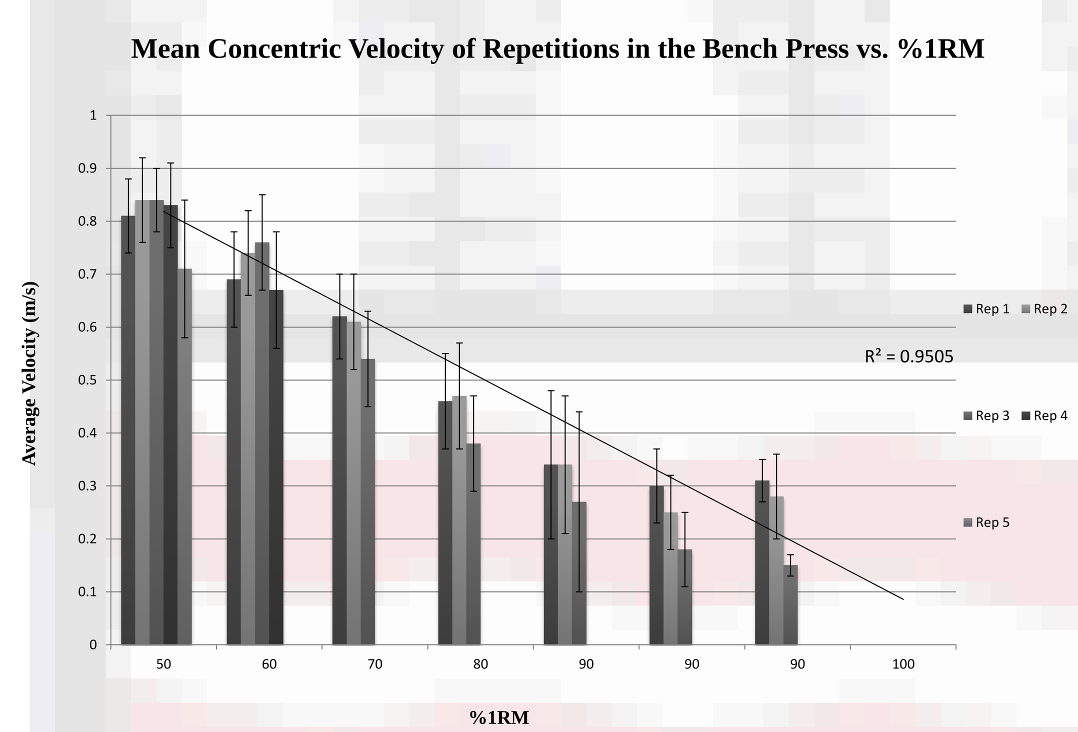

Figure 2

Discussion

Results show an inverse correlation between loading intensity (%1RM) and mean concentric velocity. Such a relationship aligns with the findings of previous studies and has been well-documented in the literature (8,9,10). As demonstrated by Gonzalez-Badillo and Sanchez-Medina (8), a definitive relationship exists between relative load and mean velocity in which one variable can be used to estimate the other with great precision. Further, the identification of respective minimum mean concentric velocities necessary for the successful completion of repetitions in the back squat (0.25 m/s) and bench press (0.12 m/s) are similar to the results obtained in other studies. Specifically, according to Mann et al. (1), lower-body movements, such as the back squat, typically involve a 100% 1RM load moving at an approximate velocity of 0.3 m/s. In contrast, upper-body movements, such as the bench press, tend to display a 100% 1RM load moving at a velocity of approximately 0.15 m/s (1). The noted disparity between 100% 1RM velocities in the back squat and bench press may be attributed to the varying amplitude or range of motion the athlete must cycle through to complete the movement pattern (1).

This study entails several significant limitations. First, the sample population was small (n_{total} = 7), unequally distributed between male and female participants (71% female), and not representative of various sport disciplines, given that participants were composed exclusively of Track and Field throwers. Consequently, the generalizability of results obtained in this study is severely compromised. A second limitation lies with the reliance upon athletes' self-reported 1RM. Specifically, participating athletes were instructed to report their most recent 1RM loads; however, given that many had not undergone 1RM testing for a period of several months, evident physiologic adaptations and progressions in performance had taken place. As a result, multiple athletes were able to move 90% of their supposed 1RM load at higher velocities than anticipated and therefore did not represent a true measurement of their 3RM ability.

Future research into the use of VBT as a means to identify the minimum mean concentric velocities necessary for successful completion of repetitions in the back squat and bench press during 3RM testing would benefit from the collection of data owed to a significantly larger sample population, equally distributed between males and females, and representative of various sport disciplines. Such research might have the potential to highlight differences in minimum mean concentric velocity thresholds due to anthropometric differences between males and females, which would be valuable to the strength and conditioning professional in the prescription of training intensities. Lastly, given that this study focused only on exercises involving smaller amplitudes of motion, future research would benefit from the analysis of exercises requiring greater amplitudes of motion, such as the hang clean.

CONCLUSION

According to the results obtained from this study, a minimum mean concentric velocity of 0.25 m/s is required for repetitions in the back squat whereas a minimum mean concentric velocity of 0.12 m/s is required for repetitions in the bench press. Taking into consideration individual variation due to training age, the coach or practitioner should be on alert for velocities approaching the aforementioned values when testing or training using a velocity-based approach. Specifically, by noting when an athlete approaches the aforementioned minimum velocity values, it becomes possible to predict the approximate repetition at which absolute muscular failure will occur. As a result, by avoiding taking an athlete to absolute failure, the risk of injury and fatigue leading to overtraining may potentially be reduced.

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