MAXIMAL STRENGTH MEDIATES CONCENTRIC BARBELL VELOCITY AT SQUAT 1RM IN COLLEGIATE MEN'S BASKETBALL ATHLETES

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INTRODUCTION: It has been well-established that load and velocity have an inverse relationship within a resistance exercise test (Gonzalez-Badillo & Sanchez-Medina, 2010; Jovanovic & Flanagan, 2014; Judovtseff, Harris, Crielaard, & Cronin, 2011; Sanchez-Medina & Gonzalez-Badillo, 2011). Moreover, it has been shown that velocity at submaximal loads may be used in the prediction of one repetition maximum (1RM) in the back squat or bench press (Jovanovic & Flanagan, 2014; Judovtseff et al., 2011). A 1RM prediction based on velocities at submaximal loads theoretically allows coaches to account for changes in strength throughout a training program without the significant stress of maximum strength testing (Gonzalez-Badillo & Sanchez-Medina, 2010; Judovtseff et al., 2011). However, not all research agrees with the predictability of 1RM based on velocity as Banyard et al. (2016) observed poor reliability and accuracy in these predictions. Although a novel and practical concept, current notions regarding velocity-based 1RM prediction lack substantiation and often do not limit confounding variables.

In order to fully understand the efficacy of velocity-based 1RM prediction it is important to consider the velocity at 1RM (V1RM) as prediction equations are dependent on V1RM input (Banyard, Nosaka, & Haff, 2016; Jovanovic & Flanagan, 2014). It has been suggested that to complete a repetition of a specific exercise (i.e. back squat vs. bench press), a minimum concentric bar velocity must be achieved (Izquierdo et al., 2006). However, individual differences such as lifting experience may play a role in resultant velocities during resistance training (Zourdos et al., 2016). This suggests V1RM may be influenced by outside factors (i.e. experience, anthropometrics, etc.) and may not be completely stable. The effect of maximal strength on velocity at 1RM has yet to be explored.

The concept of velocity-based training (VBT) shows promise as a useful tool for coaches, however emerging research suggests several limitations that must be explored. More research is certainly needed to determine the efficacy of VBT in resistance training programs. Velocity at 1RM may be influenced by a variety of factors (Banyard et al., 2016; Zourdos et al., 2016), although there is a paucity of research examining these factors, especially in relatively homogenous populations such as team sport athletes. Therefore, the purpose of the current study was to compare the effects of squat strength to mean concentric bar velocity at 1RM.

METHODS: Twenty-one NCAA Division-I men's basketball athletes (age = 20.7 ± 1.4 years, height = 197.8 ± 7.2 cm, body mass = 94.8 ± 7.4 kg, squat 1RM = 162.1 ± 23.3 kg) performed a back squat one repetition maximum (1RM) test as a part of an ongoing athlete monitoring program. Barbell Mean Concentric Velocity (MCV) was collected during each 1RM test using a commercially available device to measure barbell velocity (Kinetic Performance, Canberra ACT, Australia). This study was approved by the university's Institutional Review Board.

Prior to 1RM assessment all subjects completed a standardized warm-up consisting of general dynamic tasks and a specific warm-up consisting of 10 bodyweight squats and 5 bodyweight squat jumps. In order to achieve 1RM in the back squat, a progression based on previously established methods was used (McBride, Triplett-McBride, Davie, & Newton, 2002). Athletes completed one-repetition at each warm-up load and attempted 1RM loads until a certified strength and conditioning coach determined 1RM had been achieved. Additional 1RM attempts were given based on communication between the athlete and coach. If another 1RM attempt was given, a minimum increase of 2kg was prescribed. MCV measurements were collected during all warm-up repetitions and all 1RM attempts. The MCV at 1RM was considered for analysis.

Upon completion of testing, athletes were placed in one of three groups based on their squat 1RM load- strong, moderate, or weak. Mean, standard deviation, and coefficient of variation were calculated to determine within-group variation. Prior to additional analysis, Levene's test was performed to assess homogeneity of variance. Subsequently, a one-way analysis of variance (ANOVA) was performed. Velocity at 1RM was considered the dependent variable while 1RM load was considered the independent variable. The alpha level was set at $p \leq 0.05$ for each statistical test. Between-group comparisons were further examined using a Bonferroni adjustment. Effect sizes using Cohen's *d* and 95% confidence limits were also calculated to compare differences between each group. Effect size magnitudes were interpreted based on a previously established scale (Hopkins, 2002). These data were analyzed using Microsoft Excel™ 2010, (Version 2010, Redmond, WA, USA).

RESULTS: Descriptive group values for back squat 1RM and velocity at 1RM are displayed in Table 1. Levene's test indicated homogeneity of variance between the analyzed groups. One-way ANOVA indicated a significant difference in V1RM between strength-related groups ($p < 0.001$). Post-hoc testing indicated statistically significant between-group differences when comparing both strong and moderate groups to the weaker group for V1RM ($p = 0.03$ and $p = 0.02$, respectively). However, a non-significant difference in V1RM was observed between the strong and moderate groups ($p = 0.05$). Very large effects were observed between both strong and weak groups ($d = 2.59$) and between moderate and weak groups ($d = 2.14$). A trivial effect was observed between strong and moderate groups ($d = 0.11$) (Figure 2).

Table 1. Group Descriptive Statistics for 1RM and Velocity

	Mean	SD	CV (%)
Strong- Back Squat 1RM (kg)	186.30	6.34	3.40
Strong- Velocity at 1RM ($m \cdot s^{-1}$)	0.32	0.10	31.14
Moderate- Back Squat 1RM (kg)	168.80	6.79	4.02
Moderate- Velocity at 1RM ($m \cdot s^{-1}$)	0.31	0.08	26.38
Weak- Back Squat 1RM (kg)	162.06	8.66	5.34
Weak- Velocity at 1RM ($m \cdot s^{-1}$)	0.51	0.07	14.70

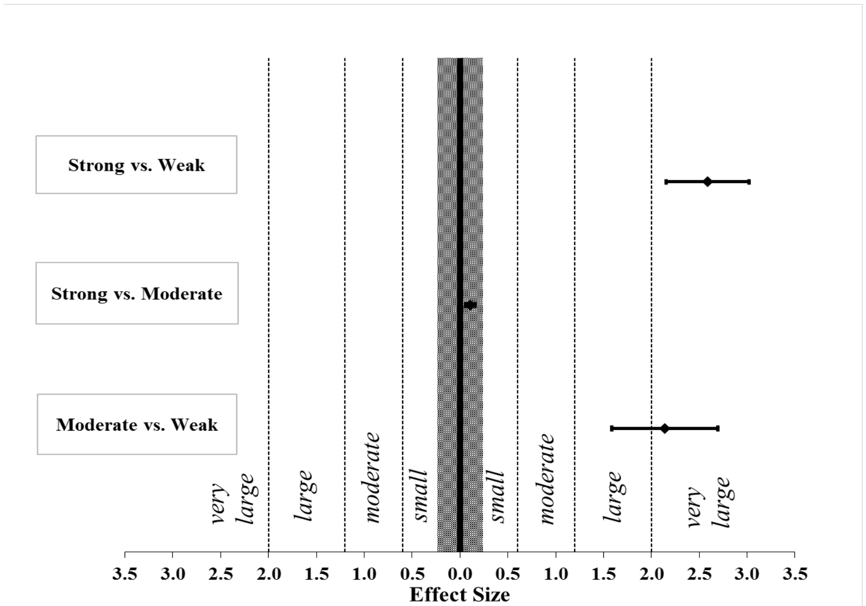

Figure 1. Effect size of MCV at 1RM between strength-determined groups. 95% CL are displayed as error bars.

DISCUSSION: The primary result of this study indicated a significantly lesser V1RM when comparing strong and moderate groups to the weak group. This finding supports that of Zourdos et al. (2016) who observed more experienced lifters having lower V1RM compared with less experienced lifters. The results of the current study suggest that strength may mediate, in part, the V1RM. Theoretically, the closer an athlete is to zero velocity, the closer an athlete is to their true 1RM as opposed to their tested 1RM. One possible explanation for this is stronger athletes may have more stable technique at maximal intensities while weaker athletes may alter technical execution (e.g. lesser squat depth, trunk flexion), thus affecting kinematic outputs.

While effect size statistics revealed very large effects for both strong and moderate groups compared to the weak group, a higher degree of confidence was associated with the strong vs. weak effect compared to the moderate vs. weak. This provides additional support that stronger athletes had lesser V1RM compared to weaker athletes. This is an important consideration for coaches when basing training loads on 1RM values. If weaker athletes are not able to produce accurate maximal strength values compared to stronger athletes, coaches should exercise caution when prescribing training loads based on 1RM testing numbers. However, relatively high within-group variability was observed in all groups, indicating the current results should be interpreted carefully. Developing maximal strength in weaker athletes could prove important for both providing accurate 1RM test numbers and subsequently enhance the training process via accurate load prescription. While these results provide support to previous research regarding individual differences affecting the stability of V1RM(Zourdos et al., 2016), more controlled and comprehensive research studies are needed. These studies should focus on determining contributing factors to concentric bar velocity in response to resistance training.

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