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### Examination of Bar Velocity in Barbell Back Squat

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## Examination of Bar Velocity in Barbell Back Squat

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# EXAMINATION OF BAR VELOCITY IN BARBELL BACK SQUAT



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## PURPOSE

The purpose of this study was to examine rep-to-rep bar velocity in the barbell back squat. The study mainly focused on changes in bar velocity over 10 repetitions at a relative intensity of 78-80% of 1RM. This study also examined changes in variations over the 10 repetitions.

## INTRODUCTION

Bar velocity measurement is increasing its popularity in strength and conditioning to measure how fast lifters are moving external loads in training. Instruments such as TENDO-unit™ and gymAware™ have been used to measure bar velocity with a wired connection to the bar (Cronin, Jones, & Hagstrom, 2007; Gonzalez, Hoffman, Rogowski, Burgos, Manalo, Weise, Fragala, & Stout, 2013). This type of measurements have focused on back squat, bench press along with some explosive lifts. In recent years, wireless instruments (via Bluetooth™ connection) such as PUSH™ and BarSensei™ are used for a similar purpose, but provide a user-friendly approach with “no wires” in the testing environment. The PUSH™ unit provides versatility to accommodate non-bar exercises such as dumbbell, kettlebell, and medicine balls. This gives users the ability to test velocity in different types of exercises at chosen intensity.

The force-velocity curve described in the textbook is somewhat a theory-based shape. When lifters perform an exercise at a given intensity over relatively high repetitions (e.g. 10 repetitions), possible velocity variations at given resistance has not yet been identified or cautiously been checked in a practical setting. While identifying load specific velocity changes seem important and necessary from a safety perspective (Ratamess, Alver, Evetoch, Housh, Kibler, Kraemer, & Triplett, 2009), changes in bar velocity from repetition to repetition (rep-to-rep) could also aid coaches in identifying an athlete's capability to maintain bar velocity throughout a set of lifting, and thus provide feedback.

This study specifically focus on changes and variation of bar velocity in relatively high repetitions. From a practical stand point, velocity variations would come from various factors such as acute fatigues, due to intensity (high percentage (%) of repetition maximum (RM)), technique, and training experience. A comparison of bar velocity changes at different intensities has been investigated before, but the same loads over repetitions also seem relevant and would provide practical knowledge to strength and conditioning coaches.



Figure 1a. Placement of PUSH™ band on the forearm.

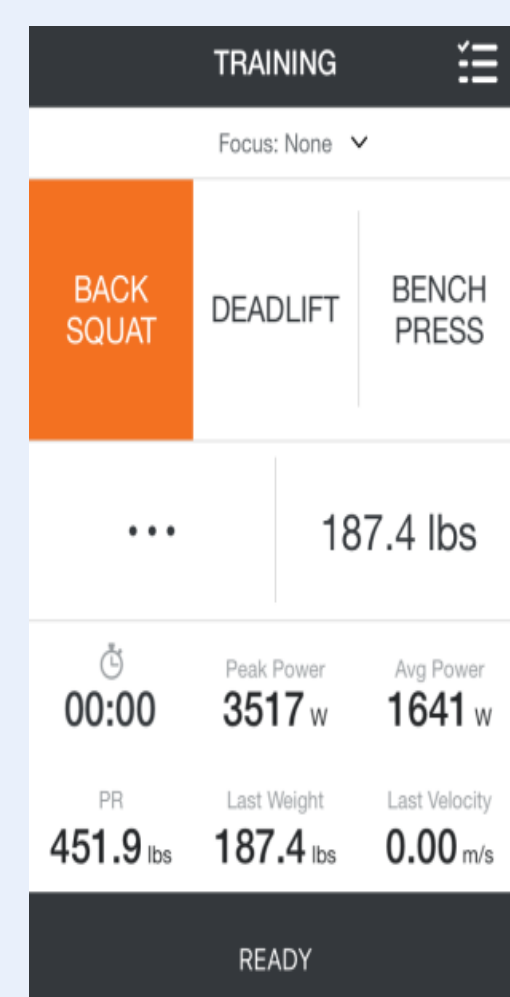


Figure 1b. PUSH™ application software of the smartphone.

## METHODS

Nineteen female collegiate-level athletes participated the study. Participants' age ranged from 18 to 21, and in collegiate athletic experience at maximum of 3 years apart. All participants had been instructed by qualified (certified) strength and conditioning coaches to obtain proper technique to perform a barbell back squat. The data collection is a part of on-going athlete monitoring program and was obtained during regular training days. All participants signed informed consent in accordance with the University Institutional Review Board.

N	Age (yr)	Height (cm)	Mass (kg)	Body Fat (%)
19	18-21	170.5±5.7	65.5±7.1	27.08±5.2

Data were collected during the team's weight training schedule at identical time. Weekly relative intensity (%1RM) and training volume were already planned prior to the data collection. Data considered for this current study was when athletes performed barbell back squat of 3 sets of 10 repetitions (3x10) at a relative intensity of 78-80% of 1RM.

Velocity data were collected with PUSH™ bands, using application of software on a smartphone to select the exercise (barbell back squat) and the load lifted.

All participants performed an identical order of dynamic warm-up prior to beginning exercises and also warmed up with lighter weights for the back squat. When they reached the work set, they placed PUSH™ band on their forearm (see Figure 1a). Application software from their smartphone was used to operate the setting. Exercise and loads were chosen from the software (see Figure 1b).

Each individual's 3x10 are averaged from 3 data per repetition per participant. Ten repetitions' mean and standard deviation were summarized for data analysis. One-way repeated measure ANOVA was performed to identify the difference of rep-to-rep average bar velocity (IBM SPSS ver. 22, IBM, New York, USA). *p* value was set at 0.05 for significance. Furthermore, coefficient of variation (CV) from each repetition was examined to capture its changes over the 10 repetitions.

## RESULTS

The average bar velocity decrease was statistically significant ( $F(1,17)=45.06$ ,  $p<0.0001$ ), indicating that the bar velocity decreased as the repetitions approach the 10<sup>th</sup> repetition (see Table 1).

As a post-hoc test, a pairwise *t*-test comparison was done to further examine the actual rep-to-rep differences. Although the back to back repetitions such as 1<sup>st</sup> and 2<sup>nd</sup> repetitions or 3<sup>rd</sup> and 4<sup>th</sup> repetitions did not show statistical difference, the further the repetitions were away from each other, the greater the *p* values and *t* scores. Comparison of average 1<sup>st</sup> and 10<sup>th</sup> repetitions differed by 20.42%. Comparison between 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> repetitions with the 10<sup>th</sup> repetition differed by 14.5%, 13.29%, 11.93%, 10.17%, respectively.

The current study further analyzed the coefficient of variance (CV) from each repetition to see changes over the 10 repetitions. The CV was increasing as the repetitions went towards 10 (see Table 1). Further analysis was done to investigate the CV changes over the repetitions from each individual. Interestingly, those participants who produced a faster bar velocity (top 6 out of 19, ranging from 0.75-0.88 m/s) showed relatively small CV (ranging from 1.74-2.96%). Athletes with slower bar velocities (bottom 6 out of 19), bar velocity was 0.59-0.70 m/s with the CV of 9.00-14.43%.

Table 1

Descriptive data on bar velocity from repetition to repetition

	1	2	3	4	5	6	7	8	9	10
Mean	0.83	0.78	0.78	0.77	0.76	0.74	0.73	0.73	0.70	0.69
SD	0.07	0.08	0.08	0.08	0.08	0.09	0.10	0.09	0.10	0.10
CV	7.88	9.80	10.52	10.85	10.73	12.77	13.68	12.46	13.58	14.00

## DISCUSSION & CONCLUSION

The primary purpose of this study was to examine the changes in bar velocity over the 10 repetitions at a relative intensity of 78-80% of 1RM. It is obvious that the bar velocity started to decrease as the repetitions increased. There was a gradual decrease of velocity in group average and also from each individual, confirming that over the 10 repetitions bar velocity changes with a relative intensity of around 80% of 1RM.

From a practical stand point, a minimum threshold of back squat bar velocity from previous study was around 0.25-0.30 m/s to be the consideration of maximal strength at 77-84% of 1RM and absolute 1RM test (Carroll, 2015; Jovanovic & Flanagan, 2014). Based on the information, 0.69 m/s at the 10<sup>th</sup> repetition may be underestimating the 1RM.

This study also examined changes in bar velocity variations over the 10 repetitions. From the 19 participants, CV was relatively low (up to 14%), indicating the homogeneity of the athletes in the current study. But the study also revealed gradual gain in CV from 7.88% to 14%, indicating that as the repetitions proceeded, individual responses differed. This may indicate a lack of sufficient strength to perform the back squat over 10 repetitions with consistent bar velocity as compared to those who displayed a relatively higher bar velocity. Further investigation in this measure is necessary. To bridge the gap between science and practice, ways to analyze the raw data seems to be next step. While average data as a trend of tested participants, is indeed important data reporting technique. It is also important to investigate each individual response to the stimulus. For example, in the current study, an individual who displayed high velocity had very small CV during the 10 repetitions, indicating small to no changes in the bar velocity. In comparison, slow velocity individuals had higher CV, indicating inconsistency in the bar velocity (typically it was due to velocity decrease). Thus, the data must be shared with coaches and strength coaches to focus on technique and physical improvement to reduce the velocity variation during a relatively high repetition sets.

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