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Investigation into Characteristics of Bench Press using PUSH Band

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Introduction

Resistance training is among the most effective practices for increasing an athlete's performance and stimulating muscle hypertrophy (Mangine, 2015). The Specificity Principle states that exercising a specific component of the body, or skill, directly develops that muscle group or skill set (Kenny 2015). Arrangement of the exercise used during specific resistance training relies on three variables: type of exercise, intensity, and volume. The selection of the type of exercise manipulates the remaining two variables, with intensity being the more pertinent of the two. Intensity of resistance exercise increases the emphasis on mechanical stress on the muscle due to an increase of the activation of fast twitch muscle fibers (Fry, 2004). High-volume training involves high repetitions with a short resting period between sets which activates muscle fibers (Mangine, 2015).

The measurement of bar velocity has become increasingly popular in strength and conditioning training. Analysis of the results yields a new perspective on resistance training variables such as fatigue index at percentage of one repetition maximum (1RM), technique, and previous training experience (Mann, 2015). When performing a typical resistance exercise in idealistic conditions, it is assumed that every repetition is performed with maximal intention of effort. However, velocity gradually declines as fatigue develops with each repetition if the magnitude of resistance is too heavy to perform exercise to desired repetitions (Badillo, Marques, and Sanchez-Medina, 2011). Advancing technologies in the area of velocity measurement in exercise supports the decrease in velocity as fatigue develops. These advancements allow velocity measurement to confirm and create optimization of intensity and load selection for appropriate sets and repetition specific to each athlete.

Application of velocity measurement instruments such as TENDO-unit™, GymAware™, T-FORCE™, and Myotest™ (an accelerometer-based system) have been previously effective in velocity measurement in resistance exercise such as bench press and barbell squat (Stock, 2011; Lorenzetti, 2017). Similar products, such as the PUSH™ Band, have been released also and allow for a more convenient application via Bluetooth connectivity with mobile choice. The purpose of training is to yield useful results; without a reliable and accurate source of measurement the progress is less observable. Therefore, if progress is made it cannot be recorded and used effectively to adjust training programs as the trainee becomes increasingly stronger.

There is a need for creating a profile of baseline data using velocity measure for certain exercises, therefore, the purpose of the study was to identify the characteristics of bench press concentric velocity. Specifically analyzing at linearity of 75% and 85% load of their individual 1 RM with average concentric velocity. Data between those loads have been compared with percentage decline and coefficient of variation among results. It is hypothesized that the velocity output will decrease during the change from the 75% relative load of the 1RM to the 85% relative load of 1RM. It is believed that there will be a greater output of velocity during the 75% set than the 85% set. Velocity declines from 75% to 85% due to the resistance increase. This means this type of technology can identify the load specific velocity to help strength coaches identify the optimal resistance for certain training program and goals.

Definitions

1. Exercise Volume: In resistance training, the total number of repetitions performed (Carroll, 2015).
2. Exercise Intensity: The load of an exercise, or the load on the barbell. (Most often notated as the percentage of 1RM.)
3. 1-Repetition Maximum: The maximum load an individual can successfully complete 1 repetition of for a given exercise.
4. Exercise Set: The number of cycles of repetitions that are completed.
5. Exercise Repetition: The number of times a specific exercise is performed.
6. Beats Per Minute (BPM): The number of audible beeps produced by a metronome in a 60 second period.

Literature Review

Accelerometers are a valuable tool in modern training. Accurate monitoring provides both athletes and coaches with statistical information to better monitor the effects of training sessions (Neville, Wixted, Rowlands, and James 2010). An article entitled, "Accelerometers: An Underutilized Resource in Sports Monitoring", reviews a different application of accelerometers and their usefulness in sports training to decide the most efficient way to enhance monitoring. This study was conducted using Australian Football League players and Global Positioning System and accelerometer sensors in order to better analyze ground running in professional athletes. Data was collected to measure stride frequency for step wide bands during constant running speed between 4km/h and 24km/h. The comparison between the two variables founded a linear relationship between stride frequency and speed. The comparison was used in determining player's speed calculated from their stride frequency. The study also concluded that the use of an accelerometer can be more cost effective and efficient compared to the use of GPS units.

Sakamoto and Sinclair (2006) both analyze the effect of movement velocity on the relationship between training load and number of repetitions, specifically on the bench press. Differences between lifting velocity can contribute to variable results upon bench press resistance training. A slow contracting movement when bench pressing yields hypertrophy in the applied muscle regions along with strength gain. A quick explosive movement yields power development when the muscle contraction is conducted as fast as possible to train for maximal power output. Often, when explosive resistance training is practiced it is event specific. Each test subject was assigned five different loads and four movement velocities over the period of five days. The machine used was a KOLASAL fitness system, which assists in true vertical movement during the bench press, a 13kg barbell, and lubricated rails to reduce any friction created by the mounted slides. The procedure consisted of six total sessions with the subjects having no prior fatigue to refrain from skewing results. Techniques consisted of a shoulder width grip with the bar being completely lowered to the chest and full arm extension per rep. A metronome was used to time concentric and eccentric contractions allowing for four beats per contraction. Four velocities conditions were tested: slow (85 BPM), medium (170 BPM), fast (250BPM), and ballistic (as fast as possible). Test results demonstrated that maximum repetitions can vary with different movement velocities.

Influence of increase in strength and muscular hypertrophy is determined by volume and intensity in resistance training (Mangine, 2015). Mangine's study investigated the effect of high-volume versus high-intensity resistance training on stimulating both muscle size and strength. Thirty-three men who were actively partaking in resistance-training participated in the study. This study called for a specific training protocol two weeks prior to the examination in attempt to get all participants to conform to proper technique, expose the participants to the exercises tested, and establish a level training base among participants. During the bench press testing, participants were expected to lower the bar to their chest and wait for an, "Up" command to ensure the bar was not being bounced off the chest and to be positive that the eccentric and concentric forces were clearly divided. The results found an improvement in both volume and intensity groups, yet there was significantly greater improvement in the intensity group as opposed to the volume group. The intensity group showed a pre-experiment relative load of 108.8 ± 31.8 kg and a post of 123.8 ± 34.1 kg while the volume group showed pre-experiment relative load at 104.5 ± 19.2 kg and post experiment at 110.9 ± 17.5 kg. Their findings were consistent when compared to the body mass.

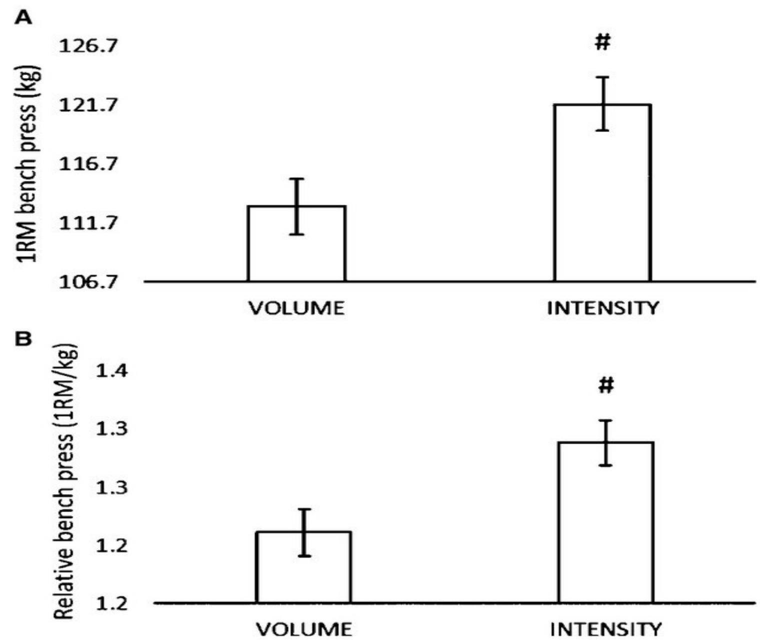

Figure 1. (Mangine, 2015)

The figure above depicts the 1RM and relative bench press strength. Figure A represents bench press (covariate; adjusted pretest mean = 106.7kg) and Figure B represents the relative bench press (covariate; adjusted pretest mean = 1.2kg)

METHODS

Subjects

Nine female collegiate-level athletes voluntarily participated in this study (height (cm) = 168.1±4.7; mass (kg) = 61.8±6.2; body fat (%) = 25.91±4.2). Subject ages ranged from 18 to 21 years, and collegiate sport experience of 1-3 years. All subjects had been instructed by certified strength and conditioning coaches to learn proper technique to perform bench press in their regular training sessions for at least 3 months prior to the study. The data collection occurred as a part of an on-going athlete monitoring program and was gathered during regular training sessions. All subjects signed informed consent in accordance with the University Institutional Review Board.

Procedures

Data considered for this study barbell bench press performance of 3 sets of 5 repetitions (3x5) at a relative intensity of 75 and 80% of 1RM. The barbell average velocity in a concentric portion of the exercise were collected with PUSH™ bands, using application of software on a smartphone. In the application software, there was a process of choosing exercise (barbell bench press) and intensity (specific weights for each subject's 75% and 85% of 1RM). Previous studies on this wireless device show small error, high reliability, and validation with Vicon™ motion capture system and linear transducer setup (Balsalobre-Fernandez, Kuzdub, Poveda-Ortiz, & del Campo-Vecino, 2015; Sato, Beckham, Carroll, Bazyler, Sha, & Haff, 2015). Therefore, the error of measurement is assumed minimal and acceptable ranges.

All subjects performed a dynamic, total body warm-up prior to beginning the test and warmed up with lighter weights for the bench press. When they reached 75%, they placed PUSH™ band on their forearm (see Figure 2), application software from their smartphone was used to operate the setting. Prior to performing the bench press, subjects pressed "ready" to start the wireless sensor. They performed the exercise 3x5 at 75% of 1RM at first set. When completed, they pressed "stop" button. After the 75% set, all subjects performed the bench press at 85% of 1RM.

Data analysis

All data were stored on the application software and exported to an excel spread sheet after the sessions. Each subject's two 3x5s were collected, and middle three repetitions (2nd, 3rd, and 4th rep) were considered for analysis. The three repetitions from nine subjects were used for data analysis. The data set of 75% and 85% were analyzed using Pearson Correlation Analysis for linearity purpose. Also, comparison of average data as a percent fall-off from 75% to 85% was done using Paired-sample T-test and coefficient of variation (CV) analysis was added.

Figure 2. Placement of PUSH™ band on the forearm.

Results

Table 1 is a Paired Sample t-Test using data from the study's outcome. The data collected and compared showed a small variance among each subject tested. The results did support a difference in velocity among the mean of the 75% 1RM test and 85% 1RM among the 27 total observations. For Pearson correlation analysis, there is a strong relationship between 75% and 85% 1RM, showing the linearity of each individual's drop from 75% to 85%. Figure 3 shows the Linear Trends of the data collected and summarized all statistical results found in the study.

t-Test: Paired Two Sample for Means	*75% 1RM*	*85% 1RM*
Mean	0.6985 m/s	0.5351 m/s
Variance	0.0335 m/s	0.0169 m/s
Observations	27	27
Pearson Correlation	0.8977	
Hypothesized Mean Difference	0	
df	26	
t Stat	9.667	
P(T<=t) one-tail	2.13533E-10	
t Critical one-tail	1.7056	
P(T<=t) two-tail	4.27066E-10	
t Critical two-tail	2.0555	

Table 1

A statistical results from Paired sample T-test and Pearson correlation analysis.

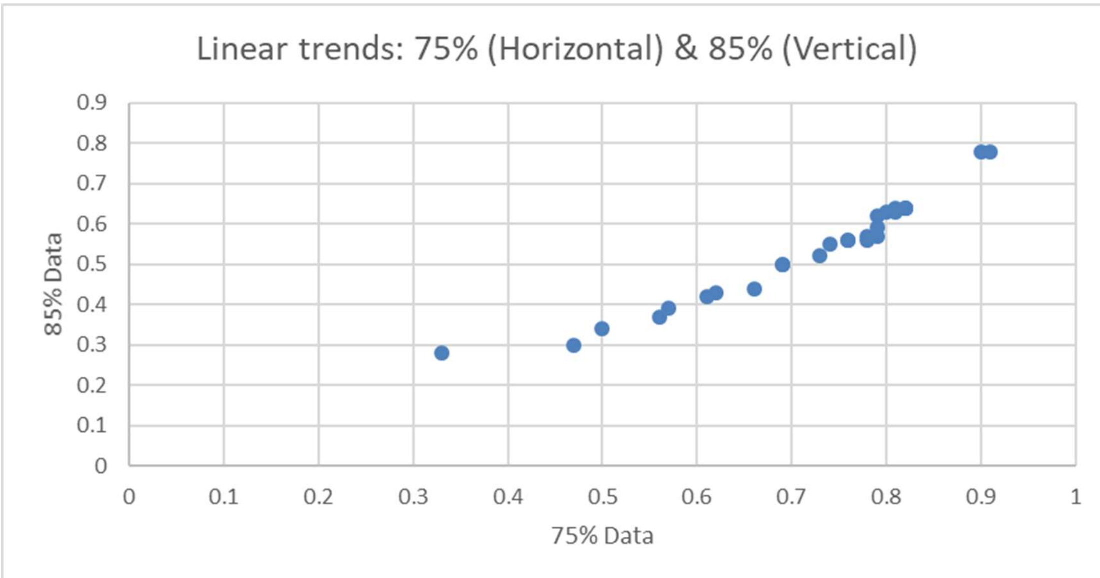

Figure 3

Linear trend analysis between 75% and 85% of 1RM bench press.

Discussion

The primary purpose of this study was to examine the characteristics of bench press concentric velocity at 75% and 85% of the 1RM from the middle three repetitions of a five repetition set. Though it is expected to observe a decrease in velocity, the study has confirmed such findings among not only individual subjects but also in group averages. Selecting female collegiate athletes who have been previously coached in proper bench press technique allowed for a consistent subject of similar calibers to be used for this study. Use of the PUSH™ bands created a small margin of error in data collection (Sato, et al., 2015). This was supported due to the previous verification of legitimacy against the Vicon™ motion capture system and linear transducer setup (Balsalobre-Fernandez, 2015; Sato, 2015). The concentric average velocity was measured against the load of 75% and 85% of the subjects 1RM with the PUSH™ band attached to the forearm preforming the bench press.

The findings in the current study support the hypothesis that there is a statistically significant decrease in average concentric velocity from 75% to 85% of 1RM, confirming that resistance influence the speed of lift. The repetitions that were observed, barring an unfatigued 1st repetition and fatigued 5th repetition, were the 2nd, 3rd, and 4th repetition during the bench press. The participants tested were unable to maintain the same velocity when testing at the higher percentage of the 1RM as opposed to the lesser weight.

The information and data gathered from the PUSH band is foundational for designing a resistance training program. The data gathered will give trainers and coaches the ability to see weaknesses in athletes from a base line data and therefore target true weaknesses when designing a personalized resistance weight training program. Acknowledging the decrease in velocity during the 75% and 85% of the 1RM and noting how many reps it takes to diminish the velocity coaches are able to determine whether or not the weakness spawns from a lack of strength or a lack of endurance.

Another approach on this study may be applying various resistance exercises to different muscle groups as well as different extremities. Studies examining the lower extremities with exercises such as the barbell squat or the straight leg deadlift may also be beneficial. For the upper extremities, a similar study could be conducted using the overhead press. Analyzing smaller muscle groups that initiate the overhead press (Anterior Deltoids, Supraspinatus, Infraspinatus, Teres Minor and Sub-Scapularis etc.) could yield varying velocity results. Yet, exercises such as a hang clean may not be suited for this study due to the fact that the velocity measurement will have too many variations with change in position.

Future studies should consider a potential different range in the percentage of 1RM. A different range may yield a new data set that could focus on strength endurance with lighter weight, options could potentially consist of 60% and 70% of 1RM. A potential change in the number of repetitions may yield practical results also. Lowering he number of repetitions to three repetitions and collecting all three may remove fatigue during testing. In terms of a chronic change to the study, an observation on bar velocity over time throughout the athlete’s physical advancement may be able to provide further evidence that physical strength has a role in minimizing bar velocity decrease.

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