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OPTIMAL LOADING FOR PEAK POWER OUTPUT IN THE BARBELL JUMP SQUAT

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by

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Approved by:

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Graduate School
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TITLE: OPTIMAL LOADING FOR PEAK POWER OUTPUT IN THE BARBELL JUMP SQUAT

MAJOR PROFESSOR: Dr. Philip Anton

The purpose of this study was to find which load is optimal for peak power production in the barbell jump squat. Resistance training and jumping have been the main methods for increasing power production, but it is still unclear which loads are the best for producing the most force during the barbell jump squat. Five resistance trained college students participated in this study. Each participant did the same protocol with the only difference being the weight used during data collection. Participants met on two separate days. The first day was to familiarize the participants with the equipment being used and to go over the study design. On day two participants' height and weight were collected, a ten-minute warm was completed, and data was collected for jumps completed at BW, 5%, 10%, and 15% of EFS 1-RM. The data collected indicated that peak power production was produced between 5 and 15% of EFS 1-RM with most of the participants reaching peak power at 5% EFS 1-RM.

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INTRODUCTION

Being able to develop large amounts of power while participating in sport is crucial for high performance. The relationship between expressing muscular power and the demonstration of dynamic athletic performance during sport is well-documented (Turner, T. 2015, Baker, D. 2001, Bevan, H. 2010). This relationship holds true along the continuum from average activities of daily living to performance at the highest level of sport.

Previous studies show that optimal loading for peak power ranges from 0% (McBride, J. 1999) to 60% of one-repetition maximum (1-RM) (Baker, D. 2001). An early study completed by Kaneko (1983) found that 30% of maximal isometric elbow flexor strength produced the most power output. It was also found that training at loads that maximizes power output result in the greatest increase in muscle power (Kaneko, M. 1983). Due to the broad range of loading recommendations, it is important to find the optimal loads in lifts commonly used during resistance training for sport.

The load thought to be optimal for the jump squat (JS) has been investigated by numerous groups, but the findings range from 0% (McBride, J. 1999) to 60% of 1-RM (Baker, D. 2001). This broad range of loading may be due to different exercises selected to base JS weight from, different participant characteristics, and whether or not body mass (BM) is included in the calculation of power output (Cormie, P. 2007, Dugan G. 2004). It has been acknowledged that BM needs to be included as part of the total load because it represents a significant part of the overall load being moved (Turner T. 2015, Bevan, H. 2010, Cormie, P. 2007, Argus, C. 2011).

There is some debate on whether mean or peak power should be used. It has been found

that peak power and athletic performance have a moderate to strong correlation. Due to this fact, it is reasonable to only report peak power outputs (Thomas T. 2015).

It is accepted that optimal loading for peak power output is dependent on the exercise being used. Many of the studies that involve JS testing use a barbell for external loading. This equipment is representative of what most weight rooms or training facilities would have access to. Therefor we decided to use a barbell for the current study (Argus, C. 2011, Bevan, H. 2010, Cormie, P. 2007, Turner, A. 2012).

The purpose of this investigation was to determine what percentage of estimated front squat (EFS) max produced the greatest peak power in resistance trained males and females during the jump squat exercise with loads of BW alone, 5%, 10%, and 15% of EFS 1-RM.

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METHODS

Subjects

Five resistance trained participants, 3 being division 1 collegiate golfers (2 Females, 1 Male), volunteered to participate in the study (Table 1). Participants were recruited on the basis that they were free of current or previous lower limb injury, at least 18 years of age, and had at least one year of structured resistance training experience. Participants were notified about the potential risks involved with participation and gave their written informed consent, approved by the institutional review board at Southern Illinois University Carbondale.

Table 1. Participant characteristics

Variables	Mean ± SD
Age (y)	23.2 ± 2.93
Body Mass (kg)	81.18 ± 18.73
Height (m)	1.77 ± 0.15
1-RM front squat (kg)	117.94 ± 55.72
Sex	3 Male 2 Female

Protocol study design

Participants visited the facility on two separate occasions. The first was to familiarize the participants to the equipment that would be used and review the procedures for data collection. Participants were asked to not perform lower body resistance training for at least 48 hours before their second session. During the second session participants' height and body weight were collected along with JS data.

1-RM Estimation

The collegiate golfer's front squat 1-RM was estimated using weight used in their team's strength and conditioning program. The golfers performed a repetition maximum test and based off these numbers, the Epley equation was used to calculate their estimated 1-RM. The other 2

participants had performed a 1-RM front squat withing 14 days of data collection and these numbers were used to calculate the weight used during data collection.

Jump Squat Testing

Prior to data collection, participants performed a warmup including 5 minutes of treadmill walking at a self-selected pace and 5 minutes of a dynamic warm up. The dynamic warm up consisted of walking knee hugs, quad pulls, straight leg kicks, single leg RDL, hamstring scoops, open the gate marches and skips, body weight squats, forward lunges, lateral shuffle, skips for height and distance, and carioca. After the warmup, participants performed 5 BW jump squats followed by 3 minutes of rest. Participants performed 3 maximum effort jumps using just BW, 5%, 10%, and 15% of EFS 1-RM. Before each set, participants were encouraged to jump with maximal effort each repetition. Each set was separated by 3 minutes of rest to allow for complete recovery. Jump squat weight was completed in an ascending order starting at body weight alone and ending with 15% of EFS 1-RM.

Instrumentation

Each of the testing sets was evaluated using the EliteForm (Figure 1-4) bar tracking system. Briefly, the system uses cameras to track the velocity at which the bar is moving, based off the velocity and vertical displacement of the bar along with body weight and bar weight, power output can be calculated. Before each participant, the machine was recalibrated to ensure the most accurate readings. Participants were asked to stand and jump on a marked spot on the floor to keep the jump take-off and landing as consistent as possible.

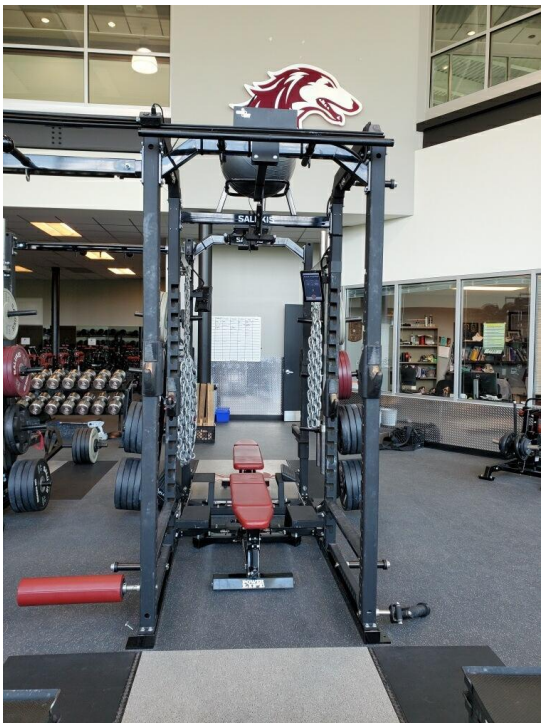

Figure 1 - Overview

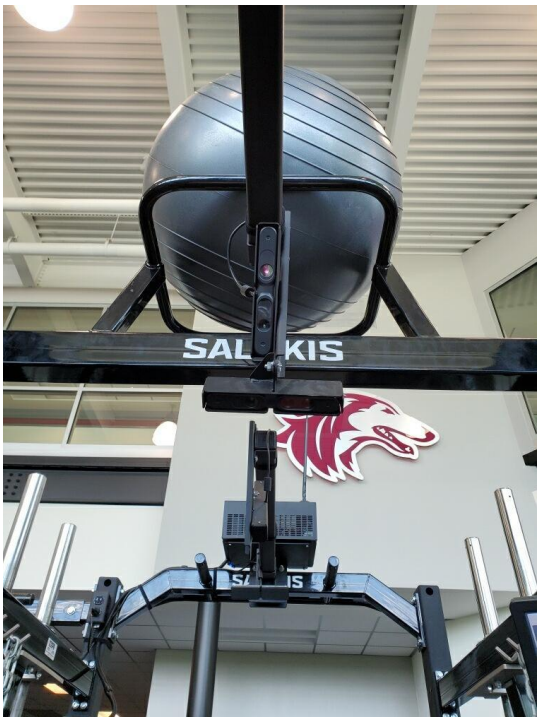

Figure 2 - Cameras

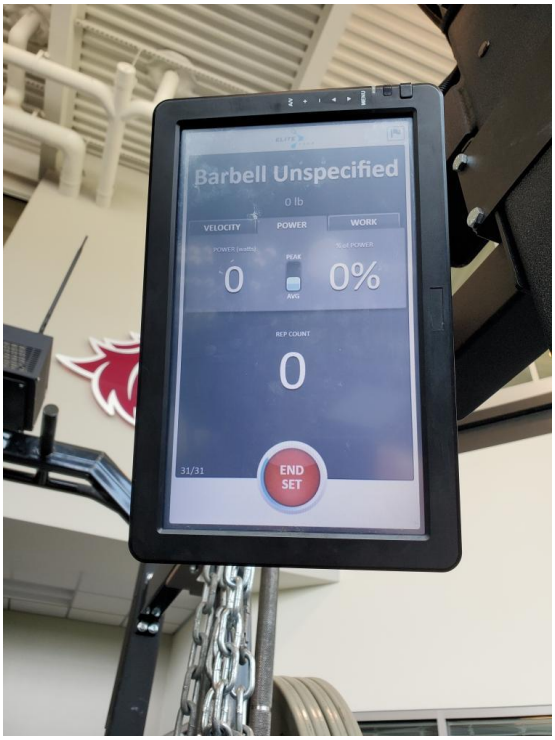

Figure 3 - Tablet

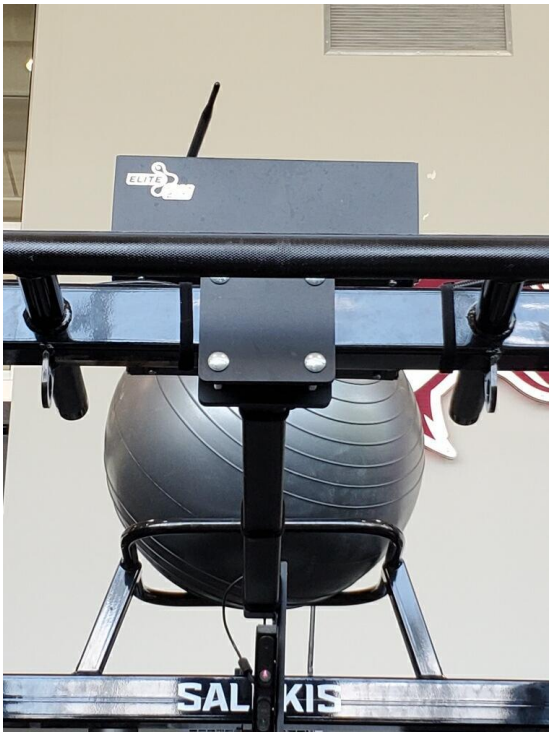

Figure 4 - Server

Analysis

The average peak power for each JS trial (BW, 5% 10%, 15% of EFS 1-RM) was done by adding the three peak power scores from each trial and dividing the sum by three. To find the average peak power scores for the females the average peak power of each trial done by females was summed and divided by two. Average peak power for the males was computed by summing each male participants' average peak power and dividing it by three.

Variables

The independent variable was the percentage load used during jump squat testing. The dependent variable was the power output produced during each jump.

HEADING 3

RESULTS

The average peak power output for each participants trials are summarized in Table 2.

Table 2 Average peak power output per participant

Average of the three attempts

P	BW	5%	10%	15%
1	1346.3	**1350.3**	1348.7	1342
2	1816.7	**1856.3**	1741.3	1695
3	3584.3	3747.7	**3929.7**	3544.7
4	3078	3241.3	3127.7	**3368.3**
5	3022	**3092.7**	3027	3024.3

Bold face are the individual peaks in watts (W). P=Participant

Participant 1's peak power occurred at 5% of EFS 1-RM this output was higher than BW, 10% and 15% by 0.3%, 0.12%, and 0.61% respectively. Participant 2's peak power also occurred at 5% EFS 1-RM which was 2.13%, 6.2%, and 8.69% higher than BW, 10%, and 15% of EFS 1-RM, respectively. Participant 3's peak power occurred at 10% EFS 1-RM which was 8.79%, 4.63%, 9.8% higher than BW, 5%, and 15% of EFS 1-RM, respectively. Participant 4's peak output occurred at 15% which was 8.62%, 3.77%, and 7.14% higher than BW, 5%, and 10% of EFS 1-RM, respectively. Participant 5's peak output occurred at 5% of EFS 1-RM which was 2.29%, 2.12% and 2.21% higher than BW, 10%, and 15% of EFS 1-RM, respectively.

As a group, the females' average peak power occurred at 5% EFS 1-RM and as a group the male average peak power occurred at 10% EFS 1-RM. Numbers for group averages and standard deviations are on Table 3.

Table 3

Average power (W) for males and females

	BW	SD±	5%	SD±	10%	SD±	15%	SD±
female	1581.5	332.6	**1603.3**	357.8	1545	277.7	1518.5	249.6
male	3228.1	309.8	3360.6	343.4	**3361.4**	494.7	3312.4	264.6

SD= Standard Deviation Bold face are group average peaks in watts

The female average peak power was 1.6%, 3.63%, and 5.29% greater than BW, 10%, and 15% EFS 1-RM. The male average peak power was 3.97%, 0.02%, and 1.46% greater than BW, 5%, and 15% of EFS 1-RM.

HEADING 4

DISCUSSION

The results of this study suggest that peak power output during the barbell jump squat is produced somewhere between 5 and 15% of EFS 1-RM. More specifically, 3 out of the 5 participants achieved peak power at 5% while the remaining 2 achieved it at 10% and 15%. As Dayne's (2011) study concluded, performing JSs at body mass will increase power production at loads on the light end of the loading spectrum only. The current study's findings support this conclusion as the majority of participants achieved peak power at only 5% of EFS 1-RM.

As Turner's (2015) study found that only two of the 17 participants had meaningfully different power outputs at different loads. This suggests that there is likely a range of loads that will optimize peak power in most participants and not just one specific load. These findings are relevant to the current study because many of the participants had small percentage differences in peak power at each load.

The thought that there is one load percentage that will produce the most power for everyone is short-sighted and over generalizes different strength abilities and previous training experience in individuals. It is the most ideal to use technology that measures peak power output, velocity, or force production of the exercise to know exactly what athletic qualities are being trained. If this equipment is not available, then the next best thing would be to prescribe a jump squat load based off frequently trained lower body movements that athletes are familiar with. With more research being done it is becoming easier to predict which loads will be the most beneficial to produce peak power. The majority of these optimal loads appear to be between BW and 20% of 1-RM (Argus, C. 2011, Dayne, A. 2011, Turner, S. 2015).

Since this was an acute study and only looked at loads that produced the highest peak power it cannot be determined that these loads are the best for developing peak power over a longer period. Long term studies looking at light vs heavier load power training will need to be completed to determine which loads are best for developing power over a longer period.

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