# POWER OUTPUT AT VARYING LOADS DURING SQUAT JUMPS

[1]Heather Abbott, [1]Chris Taber, [1]Cameron Griggs, [1]Jackson Rhudy, [1]Spencer Keck

[1]Department of Exercise and Sport Science, East Tennessee State University, Johnson City, TN, USA, 37614

**INTRODUCTION**: Sport scientists and strength and conditioning practitioners utilize vertical jump (VJ) testing to assess the force time characteristics of athletes. The VJ is widely tested in athletics because it successfully predicts performance in ballistic strength/power sports (Carlock et al., 2004). VJ offers a noninvasive and non-exhaustive measure for assessing physical performance of athletes. The static jump (SJ) and countermovement jump (CMJ) have also been used to monitor an athlete's training progress or preparedness for competition (Carlock et al., 2004; Hornsby, 2013; Loturco et al., 2015). Performance in the SJ and CMJ depends on the rate at which an athlete can express strength; measured by power production. Underlying variables such as lower body strength, muscle fiber type, Achilles tendon length, Q-angle, body fat percentage, pennation angle and fascicle length of the muscles contribute to power production and jumping performance (Earp et al., 2011; Ferreira, Weiss, Hammond, & Schilling, 2010; Hunter et al., 2015). Some of these variables have been studied extensively while others have received little attention in research.

Power is an important component in the sport of Weightlifting (WL). Garhammer (1993) reviewed literature pertaining to power output in a variety of lifts and found WL movements (snatch and clean and jerk) produced greater power outputs than those seen in traditional lifts (squat, bench, and deadlift) at maximal loads. Garhammer (1993) also reported power outputs observed in VJ tests are similar to those seen in select phases of competition WL lifts; highlighting the efficacy of the VJ for power testing in weightlifters. However, when comparing power production between genders and across varying loads in VJ the literature is unequivocal.

Previous authors have reported that loads equivalent to 30% ((McBride, Triplett-McBride, Davie, & Newton, 1999), 55-59% (Baker, Nance, & Moore, 2001), and 60% (Cormie, McCaulley, Triplett, & McBride, 2007) of 1RM back squat elicits the greatest peak power outputs during static jumps. The results between studies are highly variable, therefore methodological points, and subject populations should be consider. Research has displayed the optimal loading for peak power differs between subjects of varying strength. Specifically 40% of 1RM back squat for stronger group, as opposed to lighter loads for the weaker group (Cormie, McBride, & McCaulley, 2008). Similar research using females has found the optimal load for power output during the SJ to be between body mass (Patterson, Raschner, & Platzer, 2009). The wide range of loads reported to optimize power output in literature are caused by differences in sample population characteristics, data collection, data analysis, and testing protocols. Considering this variability a standard loaded VJ testing protocol across genders is unwarranted when optimal performance is desired. Therefore the purpose of this study is to elucidate the difference in power output between genders in static jumps at various loads.

**METHODS**: Subjects: 9 (men = 4, women = 5) weightlifters participated in this study as part of the East Tennessee State University Olympic Training Site athlete-monitoring program. East Tennessee State University Institutional Review Board approved this retrospective study and all data was collected as part of an ongoing athlete-monitoring program.

Tests: All jumps were performed on Mondays prior to the first training session of the week. All lifters completed a standardized warm up including: 25 Jumping Jacks, 10 Bodyweight Squats, and back squats (5 reps at each jump weight Men- 5x40, 5x60, 5x80 and Women- 5x20,

5x40, 5x60). Following the standardized warm-up, athletes performed a CMJ specific warm-up consisting of one submaximal CMJ at 50%, 75% and 100% effort. To eliminate arm swing and only measure lower-body performance, athletes performed all jumps while holding a near-weightless (0.3 kg) plastic bar across the shoulders. Athletes performed 2 to 4 maximal CMJs at 0 kg. Following the CMJs athletes performed 2 to 4 SJs at progressively increasing loads. A minimum of two jumps were performed at each load, additional jumps were required when consecutive jump difference were greater than 1 cm, or when a countermovement occurs during a static jump. Due to time restriction athletes only jumped a maximum of 4 times at each load. The loads are: Men SJ 0kg, 40kg, 60kg, and 80kg and Women SJ 0kg, 20kg, 40kg, and 60kg. The loads were chosen based on a pilot study equating power outputs between men and women. Athletes were given 60 seconds rest after each jump. All jumps were performed on force plates sampling at 1,000 Hz. From laboratory calibrations, the voltage data obtained from the force plate were then converted to vertical ground reaction forces. All data were collection and analyzed using a custom program (LabVIEW, ver. 2010, National Instruments, Austin, TX).

Statistical Analysis: An Independent T- Test was completed for each load between men and women. The loads were SJ 0/0, SJ 20/40, SJ 40/60, and SJ 60/80 for women and men respectively. A Levene's Test for variance was completed for each T-Test load variable. Confidence intervals were set at 97.5%.

**RESULTS**: The Leven's Test showed that all variables had equal variance between men and women. A p value of >.025 was found at JH 0 and PP at 0 indicating a difference between men and women for JH and PP. The JH and PP at 20/40 had a p-value that was < .025, indicating similar JH and PP between men and women. P values at 40/60 and 60/80 indicated significance between PP, but between not JH.

**DISCUSSION**: An attempt was made to find a standardized weight to elicit a similar power output between males and females during static jumps. When both sexes jumped with unweighted loads power outputs were variable. Of the examined loads between men and women respectively, only 20/40 showed similar power outputs. When coaches are attempting to select loads for static jumps between sexes, a standardized loading protocol specific to the strength, and power requirements of the sport being tested is needed. For our specific athletes continued research is needed to determine a better loading strategy between males and females, specifically as the loads increase. Specific considerations are needed for determining similar power outputs given that they will vary based on the strength of the individual athletes.

Table 1: Descriptive statistics of jump height and peak power at each load

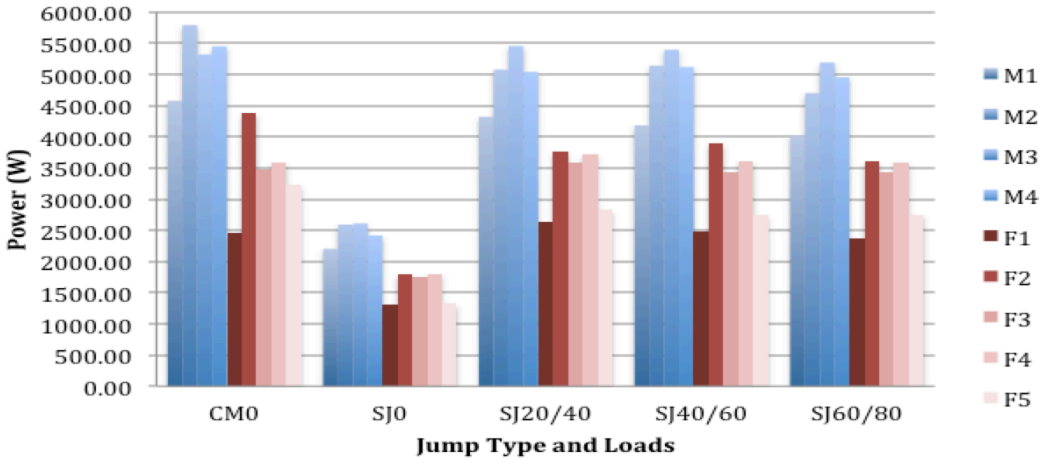
| SJ 0 97.5 % CI | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Group | Mean | SD | Lower | Upper | CV | t | p | ES |
| JH (m) | Female | 0.22 | 0.05 | 0.0252 | 0.1953 | 22.8 | 6.107 | 0.0043 | 2.93 |
| | Male | 0.33 | 0.01 | 0.02696 | 0.19635 | 4.47 | | | |
| PP/SM (units) | Female | 43.68 | 5.45 | 7.68618 | 26.951 | 12.49 | 3.627 | 0.009 | 1.87 |
| | Male | 61.00 | 2.74 | 8.05582 | 26.581 | 4.49 | | | |

| Static Jump 20/40 97.5 % CI | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Group | Mean | SD | Lower | Upper | CV | t | p | ES |
| JH (m) | Female | 0.18 | 0.03 | -0.00723 | 0.10443 | 18.38 | 3.894 | 0.089 | 1.68 |
| | Male | 0.23 | 0.01 | -0.00748 | 0.10468 | 4.58 | | | |
| PP/SM (units) | Female | 36.14 | 1.94 | -2.72734 | 10.54546 | 5.37 | 1.797 | 0.222 | 1.41 |
| | Male | 40.05 | 4.06 | -4.93276 | 12.75087 | 10.14 | | | |

| SJ 40/60 97.5 % CI | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Group | Mean | SD | Lower | Upper | CV | t | p | ES |
| JH (m) | Female | 0.13 | 0.03 | -0.01133 | 0.09758 | 22.09 | 1.27 | 0.296 | 1.75 |
| | Male | 0.17 | 0.02 | -0.00919 | 0.09544 | 11.37 | | | |
| PP/SM (units) | Female | 28.05 | 3.03 | 1.39952 | 13.61749 | 10.81 | 0.164 | 0.696 | 1.65 |
| | Male | 35.56 | 2.55 | 1.48699 | 13.53002 | 7.16 | | | |

| SJ 60/80 97.5 % CI | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Group | Mean | SD | Lower | Upper | CV | t | p | ES |
| JH (m) | Female | 0.10 | 0.02 | -0.01394 | 0.07829 | 24.21 | 2.963 | 0.129 | 1.59 |
| | Male | 0.13 | 0.02 | -0.01209 | 0.07644 | 12.41 | | | |
| PP/SM (units) | Female | 23.32 | 2.72 | 0.93581 | 11.591 | 11.67 | 0.504 | 0.501 | 1.66 |
| | Male | 29.58 | 2.10 | 1.08306 | 11.444 | 7.1 | | | |

Figure 1: Power output at varying loads between male and female weightlifters



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