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Effects of Short-Term Jump Squat Training With and Without Chains on Strength and Power in Recreational Lifters

David C. Archer
Center for Sport Performance and Human Performance Lab, Department of Kinesiology, California State University, Fullerton, CA, USA
E-mail: dvdarcher@csu.fullerton.edu

Lee E. Brown (Corresponding author)
Center for Sport Performance and Human Performance Lab, Department of Kinesiology, California State University, Fullerton, 800 N. State College Blvd., Fullerton, CA 92834-6870, USA
E-mail: leebrown@fullerton.edu

Jared W. Coburn
Center for Sport Performance and Human Performance Lab, Department of Kinesiology, California State University, Fullerton, CA, USA
E-mail: jcoburn@fullerton.edu

Andrew J. Galpin
Center for Sport Performance and Human Performance Lab, Department of Kinesiology, California State University, Fullerton, CA, USA
E-mail: agalpin@fullerton.edu

Phillip C. Drouet
Center for Sport Performance and Human Performance Lab, Department of Kinesiology , California State University, Fullerton, CA, USA
E-mail: phillip.drouet@yahoo.com

Whitney D. Leyva
Center for Sport Performance and Human Performance Lab, Department of Kinesiology , California State University, Fullerton, CA, USA
E-mail: whitleyva@gmail.com

Cameron N. Munger
Center for Sport Performance and Human Performance Lab, Department of Kinesiology, California State University, Fullerton, CA, USA
E-mail: cammunger@gmail.com

Megan A. Wong
Center for Sport Performance and Human Performance Lab, Department of Kinesiology , California State University, Fullerton, CA, USA
E-mail: mwong52493@csu.fullerton.edu

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Abstract

Background: The use of chains in resistance training is a way to accommodate the muscular strength curve. Short-term training and jump squats have been shown to increase back squat strength, but not in conjunction with each other or with chains. Jump squats have also been used to increase jump height and power. **Objectives:** The purpose of this study was to investigate the effects of short-term jump squat training with and without chains on strength and power. **Methods:** Thirty-one resistance-trained men volunteered to participate (age = 23.87 ± 2.2 years, height=174.87 ± 6.94 cm, mass = 82.74 ± 14.95 kg) and were randomly assigned to one of three groups [control (C) = 10, no chains (NC) =10, or chains (CH) = 11]. Participants had their jump height (VJ) and back squat strength (BS) tested before and after a week of training. The NC and CH groups performed three training sessions consisting of five sets of three reps of jump squats at 30% 1RM with 30s rest between sets. The CH group had 20% of their load added by chains when standing erect. The C group did not train. **Results:** A 3 (group: CH, NC, C) x 2 (time: pre, post) mixed factor ANOVA revealed a significant (p = 0.006) interaction for back squat 1RM. Both the CH (pre 142.56 ± 20.40 kg; post 145.66 ± 19.59 kg) and NC (pre 150.00 ± 15.23 kg; post 154.77 ± 15.09 kg) groups significantly increased while the C (pre 157.27 ± 25.35 kg; post 156.36 ± 24.85 kg) group showed no difference. There were no significant interactions (p =0.32) or main effects for VJ (C = pre 50.59 ± 9.39cm; post 51.29 ± 9.68cm; NC = pre 55.29 ± 5.23cm; post 57.39 ± 5.22cm; CH = pre 46.19 ± 5.02; post 47.45 ± 4.62.) **Conclusions:** The CH group was able to increase strength while lifting less overall weight. Coaches may use short-term training with chains to yield a similar increase in back squat strength as without chains.

Keywords: variable resistance, back squats, novel, vertical jump

1. Introduction

Strength and power are vital for performance in sport. Jumping high utilizes strength to increase power and the vertical jump test is an easy and reliable way to measure power (McLellan, Lovell, & Gass, 2011). Traditional resistance training has been implemented in many programs to increase strength, power, and vertical jump height. One of the standard exercises used is the back squat as it increases lower body strength and power (Neelly, Terry, & Morris, 2010). Jump squats are another exercise that results in an increase in performance (Dalen, Welde, Van Den Tillaar, & Aune , 2013; MacKenzie, S.J., Lavers, R.J., Wallace, 2014). Plyometric exercises utilize the stretch shortening cycle (Adibpour, Bakht, & Behpour, 2012; Alemdaroglu, Dundar, Koklu, & Findikoglu, 2013; Arabatzi, Kellius, & Saez-Saez De Villarreal, 2010). Jump squats use loads from 0-80% of one repetition maximum (1RM) (Bevan, Bunce, Owen, Bennett, Cook, Cunningham, Newton, & Kilduff, 2010; Cormie, McGuigan, & Newton, 2010; Hoffman, Ratamess, Cooper, Kang, Chilakos, & Faigenbaum, 2005; Sleivert, & Taingahue, 2004; Smilios, Pilianidis, Sotiropoulos, Antonakis, & Tokmakidis, 2005; Turner, Unholz, Potts, & Coleman, 2012). However, many training studies have used 30%1RM (Cormie, McGuigan, & Newton, 2010; Thomas, Kraemer, Spiering, Volek, Anderson, & Maresh, 2007).

A popular program, variable resistance training, has also been shown to increase strength and power. Variable resistance training uses elastic bands or chains to add resistance during different parts of the lift depending on where they are applied. Specifically, in a back squat, resistance is added during the concentric phase due to more chain coming off the floor (McMaster, Cronin, & McGuigan, 2009; McMaster, Cronin, & McGuigan, 2010; Neelly, Terry, & Morris, 2010). Elastic bands and chain length and width alter resistance (McMaster, Cronin, & McGuigan, 2009; McMaster, Cronin, & McGuigan, 2010; Wallace, Winchester, & McGuigan, 2006). However, bands have a curvilinear length/tension relationship while chains have a linear length/tension relationship (McMaster, Cronin, & McGuigan, 2009; McMaster, Cronin, & McGuigan, 2010).

Long term training can increase strength and power but short-term training has also has shown to increase strength and speed (Brown & Whitehurst, 2003; Coburn, Housh, Malek, Weir, Cramer, Beck, & Johnson, 2006). Brown demonstrated that two visits increased velocity of isokinetic knee extensions; while Coburn found that three visits increased isokinetic knee strength. However, limited research has combined power training in the short-term.

Powerlifters have implemented variable resistance in their training to increase strength (Swinton, Stewart, Lloyd, Aqouris, & Keogh, 2012). Additionally, it has been shown to increase force, strength, and power of the upper (Ghigiarelli, Nagle, Gross, Robertson, Irrgang, & Myslinski, 2009) and lower body (Israetel, McBride, Nuzzo, Skinner, & Dayne, 2010; Rhea, Kenn, & Dermody, 2009; Wallace, Winchester, & McGuigan, 2006). However, limited research has examined short-term variable resistance training to specifically increase jump height. Therefore, the purpose of this study was to investigate the effects of short-term jump squat training with and without chains on strength and power.

2. Methods

2.1 Participants

Thirty-one healthy males (age=23.87± 2.2 years, mass= 82.74 ± 14.95kg, height =174.87±6.94 cm) volunteered to participate and were randomly assigned to either a chain (CH=11), no chain (NC=10), or control group (C=10). The requirements for participation were that each subject had been resistance training for at least one year, at least three times a week, and could squat at least 1.5 times their body weight with a minimum of 200 lbs. On testing and training days they were asked to not perform any lower body exercises or strenuous activities and not supplement with creatine. All subjects were kinesiology students recruited from classes. All testing was performed in a laboratory setting. On the first day they read and signed a university Institutional Review Board approved informed consent document.

2.2 Procedures

Prior to testing, participants' mass (ES Series Bench Scale, Ohaus Corporation, Pine Brook, NJ) and height (ProDoc Series DHRWM Digital Height Rod, Cardinal Scale MFG, Webb City, MO) were measured. Participants then performed a dynamic warm up consisting of walking knee hugs, lunges, and Frankenstein's for 20 m each. These exercises were used to warm up the lower body (Brown, Weir, 2001).

2.3 Vertical Jump Testing

After the warm up, participants performed two practice countermovement jumps before three maximal jumps using a vertical jump test apparatus (Jones, Brown, Coburn, Noffal, 2015) (Epic Combine Jump Station). If they touched any vanes on the third attempt, they continued jumping until they could not jump any higher. The best trial was used for data analysis. Reliability of the vertical jump test was ICC = 0.98.

2.4 1RM Back Squat Testing

For the back squat, a safety squat device (Safety Squat; Bigger Faster Strong, Salt Lake City, UT) was used to ensure that each participant squatted to parallel at the top of the quadriceps. They warmed up by squatting 10 repetitions at 50% of their predicted 1RM, five repetitions at 70%, three repetitions at 80%, and one repetition at 90%. They then had a max of five attempts to reach their 1RM. There were 3 min of rest between warm up and max attempts (Brown, Weir, 2001).

2.5 Training

There were three training sessions total and the NC and CH groups performed jump squats for five sets of three repetitions with 30 s rest (Moreno, Brown, Coburn, Judelson, 2014). They were instructed to perform a quarter squat and jump as high as possible. Each session was separated by 48 hrs. The C group was instructed to not do any lower body training for the entire week.

2.6 Load

The load for the CH and NC group was matched at approximately 30%1RM (Nijem, Coburn, Brown, Lynn, Ciccone, 2016). The weight for the CH group was quantified by having subjects stand upright with an unloaded barbell. Large chains were suspended from smaller chains in a double loop method (Figure 1). Chains were then added to each side until the desired load of 20% was reached. The remaining weight was then added to the bar via weight plates to equal the prescribed 30% 1RM load. The weight for the NC group came entirely from weight plates on the bar.

Figure 1. Barbell with double loop chain load

2.7 Statistical Analyses

A 3 (group = C, NC, CH) x 2 (time = pre, post) mixed factor ANOVA was used. Alpha level was set at 0.05. Follow up tests were paired samples t-tests. SPSS version 22 was used for all analyses.

3. Results

3.1 Back Squat 1RM

There was a significant (p = 0.006) interaction of group x time. Both the CH and NC groups showed a significant increase from pre to post while the C group showed no change (Table 1). There were no significant differences between the CH and NC group.

Table 1. Mean (SD) of one repetition maximum (1RM) back squat (BS) with p-value and 95% confidence interval (95% CI) between control (C), no chain (NC), and chain (CH) groups.

	C			NC			CH		
	Pre	Post	p-value, (95% CI)	Pre	Post	p-value, (95% CI)	Pre	Post	p-value, (95% CI)
1RM BS (kg)	157.27 (25.35)	156.36 (24.85)	0.46 (-3.89 - 7.89)	150.00 (15.23)	154.77* (15.09)	0.001 (15.4 - -5.6)	142.56 (20.40)	145.66* (19.59)	0.031 (12.88 - -.76)

*Significantly greater than pre.

3.2 Vertical Jump

There were no significant (p = 0.32) interactions or main effects for time (p = 0.63) or condition (p = 0.11) (table 2).

Table 2. Mean (SD) of EPIC vertical jump (VJ) with p-value and 95% confidence interval (95% CI) between control (C), no chain (NC), and chain (CH) groups.

	C			NC			CH		
	Pre	Post	p-value, (95% CI)	Pre	Post	p-value, (95% CI)	Pre	Post	p-value, (95% CI)
VJ (cm)	50.59 (9.39)	51.29 (9.68)	0.6, (-2.01 - 3.28)	55.29 (5.23)	57.39 (5.22)	0.047, (-2.78 - -.02)	46.19 (5.02)	47.45 (4.62)	0.99, (-1.89 - -1.89)

4. Discussion

The purpose of this study was to determine the effects of short-term jump squat training with and without chains on strength and power. The major finding was that 1RM back squat strength increased for both the CH and NC groups with no change in the control group. These results may be due to neurological adaptations such as increased motor unit recruitment or firing rate (Aagaard, Simonsen, Andersen, Magnusson, Dyhre-Poulsen, 2002; Cormie, McGuigan, & Newton, 2010; Cormie, McGuigan, & Newton, 2011; Gabriel, Kamen, & Frost, 2006).

Short-term resistance training can result in neural adaptations in the absence of hypertrophic changes, such as increased motor unit firing rate (Gabriel, Kamen, & Frost, 2006). Increasing firing rate has been shown to increase muscular force (Cormie, McGuigan, & Newton, 2010; Gabriel, Kamen, & Frost, 2006). High firing rates are also important for increasing rate of force development (Aagaard, Simonsen, Andersen, Magnusson, Dyhre-Poulsen, 2002; Ratamess). Another adaptation is motor unit recruitment. Motor units move from smaller slow-twitch to larger fast-twitch depending on the load or speed of the movement (Gabriel, Kamen, & Frost, 2006, Ratamess). Movements that are slow and light use primarily small motor units while heavy, fast, and explosive require large motor units (Ratamess). Previous research has shown that these adaptations can occur in only one week. Brown (Brown & Whitehurst, 2003) and Coburn (Coburn, Housh, Malek, Weir, Cramer, Beck, & Johnson, 2006) studied the effects of short-term training with two or three visits respectively. Brown found that two visits showed an increase in velocity, but not force, while Coburn found that three visits showed an increase in force. Tillin et al. (Tillin & Folland 2014) examined the short-term effects of maximal vs. explosive strength training in an isometric knee extension. They found that maximal training resulted in greater improvement in voluntary contractions, but explosive training had a greater increase in early phase force. Both of these adaptations occurred at the onset of training and promoted strength gains. The current study supports this as short-term explosive training increased strength gains and early phase force.

Variable resistance has been used in different types of training. The use of bands or chains are designed to alter the strength curve of an exercise. This causes the load to increase as the lifter rises during the concentric action and can be more explosive (McMaster, T., Cronin, J., McGuigan, 2009). Rhea (Rhea, Kenn, & Dermody, 2009) found that the use of bands with fast movements increased peak power greater than slow heavy movements yet both similarly increased maximal strength. The current study also demonstrated that variable resistance increased strength. However, power was unaffected in their study, which may have been due to the relatively heavy loads used. Galpin (Galpin et al., 2015) also examined the effects of different loads using variable resistance. Their study used banded deadlifts at 60% and 85% 1RM using different resistances (B1=15% resistance, B2 = 35% resistance.) Results showed that force decreased as tension increased. However, velocity was greater for the two banded deadlift conditions at 60% than the free weight deadlift, but B2 was greatest at 85% 1RM. Peak power was also higher for the banded conditions than with free weights. This current study used a lighter intensity and found an increases in strength for the CH and NC groups, but no changes in power for any group.

McCurdy (McCurdy, Langford, Ernest, Jenkerson, & Doscher, 2009) also found that training with and without chains increased strength. They compared the bench press with chains supplying all of the weight to plate loaded alone. Both increased strength with no significant differences between conditions. In the current study, the CH group trained with less overall weight, but still showed a significant increase in strength. We hypothesized that the chain group would have a greater increase in vertical jump height due to lifting less weight with greater speed and acceleration. However, this was not the case as no group demonstrated a change in vertical jump height. The weight that the chains provided was a relatively light load, so there may have only been a small increase in acceleration during the concentric phase.

There have been few studies examining the load that chains supply to a lift. A study by Nijem (Nijem, Coburn, Brown, Lynn, & Ciccone, 2016) had subjects perform deadlifts using a load of 20% of the weight supplied by chains at the top of the lift. The current study used the same loading scheme, but used the double loop method to suspend the chains from a standing position which supplied more variable resistance than having the larger chains hanging directly to the floor (Neelly, Terry, & Morris, 2010). The load supplied by the chains for the CH group was matched to the NC at 30%1RM. One possible reason why there were no significant differences was that the CH group lifted less total weight. Matching the total weight at the bottom of the jump squat may have resulted in greater power or strength gains.

Training intensity plays a key role in the adaptation of power. Many studies have examined 30%1RM for peak power in jump squats (Cormie, McGuigan, & Newton, 2010, Thomas, Kraemer, Spiering, Volek, Anderson, & Maresh, 2007). McBride (McBride, Triplett-McBride, Davie, & Newton, 2002) examined the effects of eight weeks of jump squat training using light loads (30%1RM) or heavy loads (80%1RM). Both groups had an increase in strength, but the lighter load group also increased velocity. However, other studies have identified different intensities for optimal peak power.

Turner (Turner, Unholz, Potts, & Coleman, 2012) found that jump squat peak power for rugby players was at 20-30%1RM while Slievart (41) found it was between 50-70%. Finally, Bevan (Bevan, Bunce, Owen, Bennett, Cook, Cunningham, Newton, & Kilduff, 2010) and Jimenez-Reyes (Jimenez-Reyes, Pareja-Blanco, Balsalobre-Fernandez, Cuadrado-Penafiel, Ortega-Becerra, & Gonzalez-Badillo, 2015) found peak power at 0%1RM. The current study used 30%1RM but did not see a significant increase in vertical jump height. This could be due to not enough volume.

Adequate volume and frequency are required to increase power. Cormie (Cormie, McGuigan, & Newton, 2010) examined the effects of 10 weeks of power training and found that seven sets of six repetitions at 0%1RM twice a week with five sets of five repetitions at 30%1RM once a week caused an increase in power for both strong and weak individuals. The current study used five sets of three repetitions for only three visits resulting in an increase in strength for both groups, but not explosiveness. Perhaps a longer study may have positively influenced power.

Variability is needed in a training program to decrease staleness. One way to add variety to a program is by using novel training as it provides a new type of stressor (Haff, Hobbs, Haff, Sands, Pierce, & Stone, 2008). Resistance training is novel to untrained individuals, and they will normally experience some type of improvement (Gamble, 2008). Another type of novel stressor is kettlebell training. Otto (Otto, Coburn, Brown, & Spiering, 2012) compared the effects of kettlebell swings to Olympic weightlifting during a 6-week training program. They found that both forms of training increased strength in the back squat, but the increase with weightlifting was greater. The current study was not as long as Otto, but also showed that novel training can increase strength.

Specificity of training is also needed for a training program. Transferability is how well the specific training transfers to a movement or skill (Gamble, 2008). Studies have shown that specific training has greater transferability (Barak, Ayalon, & Dvir, 2004, Cale-Benzoor, Dickstein, Arnon, & Ayalon, 2014). The current study demonstrated that jump squats had greater transferability to the back squat than to the vertical jump. The squatting portion of the jump squat directly resembles the back squat. Although the jump squat utilizes triple extension of the knee, hip, and ankle, the training did not transfer to an increase in jump height. This could be due to the load of the jump squats being more than body weight, so acceleration, force, and power were altered.

5. Conclusion

The findings of the current study demonstrate that short-term jump squat training with or without chains increased 1RM back squat strength. The chain group, while lifting less overall weight, was still able to increase their 1RM strength. However, the training intensity, volume, or duration was not sufficient to increase power. Further research should focus on a longer duration of training and also examine matching chain loads at different positions of the lift. Coaches and athletes may use short-term training with chains to yield a similar increase in back squat strength as traditional loaded jump squats. Coaches and athletes can also use this type of training as a taper to reduce volume without risking a decrease in back squat strength. This jump squat training scheme may be beneficial if time is limited as the training was only approximately three to five minutes.

References

Aagaard, P., Simonsen, E.B., Andersen, J.L., Magnusson, P., & Dyhre-Poulsen, P. (2002). Increased rate of force development and neural drive of human skeletal muscle following resistance training. *Journal of Applied Physiology, 93, 1318-1326.*

Adibpour, N., Bakht, H.N., & Behpour, N. (2012). Comparison of the effect of plyometric and weight training programs on vertical jumps in female basketball players. *World Journal of Sport Sciences, 7(2), 99-104.*

Alemdaroglu, U., Dundar, U., Koklu, Y., Findikoglu, G. (2013). The effect of exercise order incorporating plyometric and resistance training on isokinetic leg strength and vertical jump performance: A comparative study. *Isokinetics and Exercise Science, 21, 211-21.*

Arabatzi, F., Kellius, E., Saez-Saez De Villarreal, E. (2010). Vertical jump biomechanics after plyometric, weight lifting, and combined weight lifting + plyometric training. *Journal of Strength and Conditioning Research, 24(9), 240-2448.*

Barak, Y., Ayalon, M., & Dvir, Z. (2004). Transferability of strength gains from limited to full range of motion. *Medicine and Science in Sports Medicine, 36(8), 1413-1420.*

Bevan, H.R., Bunce, P.J., Owen, N.J., Bennett, M.A., Cook, C.J., Cunningham, D.J., Newton, R.U., & Kilduff, L.P. (2010). Optimal loading for the development of peak power output in professional rugby players. *Journal of Strength and Conditioning Research, 24(1), 43-47.*

Brown, L.E., & Weir, J.P. (2001). ASEP procedures recommendation I: Accurate assessment of muscular strength and power. *Journal of Exercise Physiology Online, 4(3), 1-21.*

Brown, L.E., & Whitehurst, M. (2003). The effect of short-term isokinetic training on force and rate of velocity development. *Journal of Strength and Conditioning Research, 17(1), 88-94.*

Cale-Benzoor, M.C., Dickstein, R., Arnon, M., & Ayalon, M. (2014). Strength enhancement with limited range closed kinetic chain isokinetic exercise of the upper extremity. *Isokinetics and Exercise Science, 22, 37-46.*

Coburn, J.W. Housh, T.J., Malek, M.H., Weir, J.P., Cramer, J.T., Beck, T.W., & Johnson, G.O. (2006). Neuromuscular responses to three days of velocity-specific isokinetic training. *Journal of Strength and Conditioning Research, 20(4), 892-898.*

Cormie, P., McGuigan, M.R., & Newton, R.U. (2010). Adaptations in athletic performance after ballistic power versus strength training. *Medicine & Science in Sport & Exercise, 42(8), 1582-1598.*

Dalen, T., Welde, B., Van Den Tillaar, R., & Aune, T.K. (2013). Effect of single vs. multi joint ballistic resistance training upon vertical jump performance. *Acta Kinesiologiae Tartuensis, 19, 86-97.*

Gabriel, D.A., Kamen, G., & Frost, G. (2006). Neural adaptations to resistive exercise: Mechanisms and recommendations for training practices. *Sports Medicine, 36(2), 133-149.*

Galpin, A.J., Malyszek, K.K., Davis, K.A., Record, S.M., Brown, L.E., Coburn, J.W., Harmon, R.A., Steele, J.M., & Manolovitz, A.D. (2015.) Acute effects of elastic bands on kinetic characteristics during the deadlift at moderate and heavy loads. *Journal of Strength and Conditioning Research,29(12), 3271-3278.*

Gamble, P. (2008). Implications and applications of training specificity for coaches and athletes. *Strength and Conditioning Journal, 28(3), 54-58.*

Ghigiarelli, J.J., Nagle E.F., Gross, F.L., Robertson, R.J., Irrgang, J.J., & Myslinski, T. (2009). The effects of a 7-week heavy elastic band and weight chain program on upper-body strength and upper-body power in a sample of division 1-AA football players. *Journal of Strength and Conditioning Research, 23(3), 756-764.*

Haff, G.G., Hobbs, R.T., Haff, E.E., Sands, W.A., Pierce, K.C., & Stone, M.H. (2008). Cluster training: A novel method for introducing training program variation. *Strength Conditioning Journal, 30, 67-76,*

Hoffman J.R., Ratamess, N.A., Cooper, J.J., Kang, J, Chilakos, A., & Faigenbaum, A.D. (2005). Comparison of loaded and unloaded jump squat training on strength/power performance in college football players. *Journal of Strength and Conditioning Research, 19(4), 810-815.*

Israetel, M. A., McBride, J.M., Nuzzo, J.L., Skinner J.W., & Dayne, A.M. (2010). Kinetic and kinematic differences between squats performed with and without elastic bands. *Journal of Strength and Conditioning Research, 24(1), 190-194.*

Jimenez-Reyes, P., Pareja-Blanco, F., Balsalobre-Fernandez, C., Cuadrado-Penafiel, V., Ortega-Becerra, M.A., & Gonzalez-Badillo, J.J. (2015). Jump-squat performance and its relationship with relative training intensity in high-level athletes. *International Journal of Sports Physiology and Performance, 10, 1036-1040.*

Jones, A., Brown, L.E., Coburn, J.W., & Noffal, G.J. (2015). Effects of foam rolling on vertical jump performance. *International Journal of Kinesiology & Sport Science, 3(3), 38-42.*

MacKenzie, S.J., Lavers, R.J., & Wallace, B.B. (2014). A biomechanical comparison of the vertical jump, power clean, and jump squat. *Journal of Sports Sciences, 1-10.*

McBride, J, Triplett-McBride T, Davie, A, & Newton, R. (2002). The effect of heavy- vs. Light-load jump squats on the development of strength, power, and speed. *Journal of Strength and Conditioning Research, 16, 75-82.*

McCurdy, K., Langford, G., Ernest, J., Jenkerson, D., & Doscher, M. (2009). Comparison of chain- and plate-loaded bench press training on strength, joint pain, and muscle soreness in division II baseball players. *Journal of Strength and Conditioning Research, 23(1), 187-195.*

McLellan, C.P., Lovell, D.I., & Gass, G.C. (2011). The role of rate of force development on vertical jump performance. *Journal of Strength and Conditioning Research, 25(2), 379-385.*

McMaster, T., Cronin, J., & McGuigan, M. (2009). Forms of variable resistance training. *Strength and Conditioning Journal, 31(1), 50-64.*

McMaster, T., Cronin, J., & McGuigan, M. (2010). Quantification of rubber and chain-based resistance modes. *Journal of Strength and Conditioning Research,24(8), 2056-2064.*

Moreno, S.D., Brown, L.E., Coburn, J.W., & Judelson, D.A. (2014.) Effect of cluster sets on plyometric jump power. *Journal of Strength and Conditioning Research, 28(9), 2424-2428.*

Neelly, K.R., Terry, J. G., & Morris, M.J. (2010). A mechanical comparison of linear and double-looped hung supplemental heavy chain resistance to the back squat: A case study. *Journal of Strength and Conditioning Research, 24(1), 278-281.*

Nijem, R.M., Coburn, J.W., Brown, L.E., Lynn, S.K., & Ciccone, A.B. (2016). An electromyographic and force plate analysis of the deadlift performed with and without chains. *Journal of Strength and Conditioning Research, 30(5), 1177-1182.*

Otto, W.H., Coburn, J.W., Brown, L.E., & Spiering, B.A. (2012). Effects of weightlifting vs. kettlebell training on vertical jump, strength, and body composition. *Journal of Strength and Conditioning Research, 26(5), 1199-1202.*

Ratamess, N.A. adaptations to anaerobic training programs. In Baechle, T.R., & Earle, R.W. (Eds.), *Essentials of Strength Training and Conditioning* (pp. 90-113). Human Kinetics.

Rhea, M.R., Kenn, J.G., & Dermody, B.M. (2009). Alterations in speed of squat movement and the use of accommodated resistance among college athletes training for power. *Journal of Strength and Conditioning Research, 23(9), 2645-2650.*

Sleivert,G., & Taingahue, M. (2004). The relationship between maximal jump-squat power and sprint acceleration in athletes. *European Journal of Applied Physiology, 91, 46-52.*

Smilios, I., Pilianidis, T., Sotiropoulos, K., Antonakis, M., & Tokmakidis, S.P. (2005). Short-term effects of selected exercise and load in contrast training on vertical jump performance. *Journal of Strength and Conditioning Research, 19(1), 135-139.*

Swinton, P.A., Stewart, A.D., Lloyd, R., Aqouris, I., & Keogh, J.W. (2012). Effect of load positioning on the kinematics and kinetics of weighted vertical jumps. *Journal of Strength and Conditioning Research, 26(4), 906-913.*

Thomas, G.A., Kraemer, W.J., Spiering, B.A., Volek, J.S., Anderson, J.M., & Maresh, C.M. (2007). Maximal power at different percentages of one repetition maximum: influence of resistance and gender. *Journal of Strength and Conditioning Research, 21(2), 336-342.*

Tillin, N.A., & Folland, J.P. (2014). Maximal and explosive strength training elicit distinct neuromuscular adaptations, specific to the training stimulus. *European Journal of Applied Physiology, 114, 365-374.*

Turner, A.P., Unholz, C.N., Potts, N., & Coleman, S.G.S. (2012). Peak power, force, and velocity during jump squats in professional rugby players. *Journal of Strength and Conditioning Research, 26(6), 1594-1600.*

Wallace, B.J., Winchester, J.B, & McGuigan, M.R. (2006). Effects of elastic bands on force and power characteristics during the back squat exercise. *Journal of Strength and Conditioning Research, 20(2), 268-272.*