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# Effects of 6-week Squat, Deadlift, and Hip Thrust Training Programs on Speed, Power, Agility, and Strength in Experienced Lifters

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# EFFECTS OF 6-WEEK SQUAT, DEADLIFT, AND HIP THRUST TRAINING PROGRAMS ON SPEED, POWER, AGILITY, AND STRENGTH IN EXPERIENCED LIFTERS

By

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Abstract

EFFECTS OF 6-WEEK SQUAT, DEADLIFT, OR HIP THRUST TRAINING PROGRAM ON SPEED, POWER, AGILITY, AND STRENGTH IN EXPERIENCED LIFTERS

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The back squat and deadlift are common resistance training exercises used by Strength and Conditioning professionals to enhance lower body strength and sport performance. A relatively new exercise, the hip thrust, differs from both the squat and deadlift due to its horizontal loading pattern. It may, therefore, potentially impact sporting performance uniquely. The aim of this study was to compare the effects of six weeks of resistance training in the back squat, deadlift, or barbell hip thrust on jumping performance, sprinting speed, change of direction, and strength. Twenty-six subjects (n=26; age=22.15 ±2.2; height=180.17cm ±8.37; weight=87.27kg ±15.72) twenty males and six females, with at least 1 year of resistance training experience were recruited and split into 4-groups – Back Squat (BS) (n=8), Deadlift (DL) (n=6), Hip Thrust (HP) (n=8), and Control (C) (n=4). Subjects were pre and post tested for sprinting speed (40-yard and 10-yard sprint), jumping performance (countermovement jump and broad jump), change of direction

(COD) (5-10-5), and a repetition maximum (RM) in the back squat, deadlift, and hip thrust. Subjects in the BS, DL, and HP performed a 6-week condensed linear periodization resistance-training program with training consisting three days per week for a total of 18-training sessions. No significant change was found between any of the speed, jumping, or COD test results. The BS and HP groups showed significant ($p \leq .05$) increase in squat strength and hip thrust strength respectively (BS =+13.92kg; HP =+17.05kg). Although significant differences were not observed in the performance test between experimental groups, small effect change were seen in various performance tests. The DL group was more effective compared to the other experimental groups in the CMJ and deadlift strength (CMJ =+2.37cm; DL =+12.88kg). The BS group was more effective compared to the other experimental groups in the 5-10-5 and squat strength (5-10-5 =-.14sec; BS =+13.92kg). The HP group was more effective compared to the other experimental groups in the broad jump (BJ), 10-yard sprint, 40-yard sprint, and hip thrust strength (BJ =+10.51cm; 10-yard =-.02sec; 40-yard =-.08sec; HP =+17.05kg). It was, therefore concluded that each major exercise may influence performance test differently, and more experimental research needs to be done to find these relationships. It was also recommended that all exercises (BS, DL, and HP) be incorporated in athletic conditioning programs as athletes benefit from each differently.

# Chapter One
# Introduction

## 1.0 Background to the Study

Two common methods used to increase lower body strength are the back squat and deadlift. The back squat and deadlift have been reviewed and studied intensely and have been supported as methods for the development of lower-body strength, power, and speed (Adams, O'Shea, O'Shea, & Slimstein, 1992; Chelly et al., 2009, Chelly et al., 2010; Comfort, Haigh, & Mathews, 2012a; Comfort, Bullock, & Pearson, 2012b; Comfort, Stewart, Bloom, & Clarkson, 2014; López-Segovia, Marquest, Tillaar, & Gonzalez-Badillo, 2011; Swinton, Lloyd, Keogh, Agouris, & Stewart, 2014; Thompson et al., 2015; Turner & Stewart, 2013). Relative strength in the back squat and force in the vertical plane has been shown to correlate to faster running speeds (Chelly et al., 2009; Chelly et al., 2010; Comfort et al., 2012a, 2012b, 2014; López-Segovia et al., 2011; Swinton et al., 2014; Turner & Stewart, 2013; Weyand, Sternlight, & Bellizzi & Wright, 2000), higher vertical jump (Adams et al. 1992; Chelly et al. 2009; Comfort et al. 2014; Swinton et al. 2014; Wilson, Murph, & Walshe, 1996; Young, 2006) and improved change of direction (COD) (Burghelli, Cronin, Levin, & Chaouchi, 2008; Keiner, Sander, Wirth, & Schmidtbleicher, 2014; Spiteri, Cochrane, Hart, Haff, & Nimphius, 2013; Swinton et al., 2014). Likewise, relative strength in the deadlift and force in the vertical plane has been shown to correlate to faster running speed (Swinton et al., 2014; Thompson et al., 2015; Turner & Stewart 2013; Weyand et al., 2000), higher vertical jump (Swinton et al., 2014), and improved change of direction (Burghelli et al., 2008; Coh & Mackala, 2013; Swinton et al., 2014). For these reasons, Strength and Conditioning professionals are likely to use one if not both exercises when programming training for athletes.

## 1.1 Statement of the Problem

The goal of strength and conditioning programs is to increase on-field sport performance. As Strength and Conditioning professionals strive to improve their athlete's on-field performance, a common method is to increase strength and power, especially in the lower body, with the hope this training can carry over to increase speed, change of direction, and on-field performance. Two of the most common movements utilized to enhance strength and power are the back squat and deadlift. However, recent developments in the field of strength and conditioning suggest that there could be a potentially more effective way to enhance strength and power that better carries over to specific on-field performance qualities. A proposed exercise that may be effective at helping to enhance sport performance, is the barbell hip thrust (Contreras, Cronin, & Schoenfeld, 2011). The hip thrust differs from the back squat and deadlift in the manner the lift is loaded and executed, specifically how it is loaded horizontally rather than vertically. The horizontal loading scheme has been proposed as a strategy that may have increased carryover to specific athletic qualities (Contreras, Cronin, Schoenfeld, Nates, & Sonmez, 2013; Randell, Cronin, Keogh, & Gill, 2010).

Comparing the back squat, deadlift, and hip thrust may give further insight for researchers and Strength and Conditioning professional's better understanding and deeper insight as to how, what, and when to implement exercises in athlete's training regimes. The better comparison and detailed look at each exercise may save coaches time and effort while enhancing the benefit to their athletes.

This study sought to compare the results of a 6-week resistance program of the back squat, deadlift and hip thrust. Results were recorded pre and post training in the following performance tests: top-end speed measured by a 40-yard sprint, acceleration speed measured by a 10-yard sprint, jumping performance measured by a countermovement jump and broad jump, change of direction measured by a 5-10-5 (also known as the pro agility drill), and strength measured by a 3RM lift to estimate the maximal strength in each the back squat, deadlift, and hip thrust.

## 1.2 Purpose of the Study

This study examined which resistance-training program, hip thrust, back squat, and deadlift, elicited the greatest performance benefits to sprinting speed, jumping performance, agility, and RM strength.

## 1.3 Study objectives

Specific objectives were as follows.

1. Evaluate Pre and Post-Testing of Hip Thrust group on acceleration, top-end speed, agility, jumping performance, and RM strength.

2. Evaluate Pre and Post-Training of Back Squat group on acceleration, top-end speed, agility, jumping performance, and RM strength.
3. Evaluate Pre and Post-Testing of Deadlift group on acceleration, top-end speed, agility, jumping performance, and RM strength.
4. Establish which resistance training program, squat, deadlift, or hip thrust, had the greatest effect after 6-weeks of training on acceleration, top-end speed, jumping performance, agility, and RM strength.
5. Determine the correlation amongst RM strength in the back squat, deadlift, and hip thrust and acceleration, top-end speed, jumping performance, or agility. For example, does RM strength in the squat correlate to the countermovement jump more strongly.
6. Determine the correlation between each performance tests (10-yard sprint, 40-yard sprint, pro agility, broad jump, countermovement jump). For example, did a high performance in the broad jump correlate most strongly to faster 40-yard sprint times?

## 1.4 Research Questions

1. Comparing Pre and Post-Testing after 6-weeks of Hip Thrust training, what is the influence on improving acceleration, top-end speed, agility, jumping performance, and maximal strength?
2. Comparing Pre and Post-Testing after 6-weeks of back squat training, what is the influence on improving acceleration, top-end speed, agility, jumping performance, or maximal strength?

3. Comparing Pre and Post-Testing after 6-weeks of deadlift training, what is the influence on improving acceleration, top-end speed, agility, jumping performance, or maximal strength?
4. Does a specific resistance training regime (back squat, deadlift, or hip thrust) have a stronger or weaker effect on each of the following: acceleration, top-end speed, agility, jumping performance, and/or maximal strength?
5. Does performance in each performance test correlate to other performance tests? For example, are those who have faster 10-yard sprint, also have higher verticals?

## 1.5 Hypothesis

Counter Movement Jump (CMJ - The hip thrust and deadlift would not increase the CMJ significantly.

Broad Jump (BJ) - The back squat would not increase the BJ significantly.

10-Yard Sprint – The hip thrust and deadlift would not increase the 10-yard sprint significantly.

40-Yard Sprint – The back squat would not increase the 40-yard sprint performance significantly.

5-10-5 – The deadlift would not increase the 5-10-5 significantly.

Strength – All three exercises would increase strength similarly due to the Specific Adaptations to Imposed Demands.

## 1.6 Conceptual Framework

This study followed a condensed, 6-week linear periodization model, transitioning from blocks of training consisting of hypertrophy, to strength, and finally to power. Many strength and conditioning programs follow some form of linear periodization in their training, with the idea that each quality builds and benefits from the previous block. Linear periodization has been shown to be effective in increasing strength, power, and speed, and a good model to develop the qualities needed for advanced training (Hartmann, Bob, Wirth, & Schmidtbleicher, 2009).

Linear periodization allows the use of both heavier and lighter loads and it has been shown that the use of both maximal strength (high load, low velocity) and power (low load, high velocity) training is optimal for increased performance (Jone, Bishop, Hunter, & Fleisig, 2001). The training program this study used is such that it provides stimulus all along the whole force-velocity curve and provides stimulus to various loading schemes. The hypertrophy block targeted percentages between 70%-80%; the maximum strength block targeted percentages 80%-100%; and finally the power block targeted percentages from 22%-55%. There is no one percentage that maximizes any one quality; it depends on the individual and the exercise. For example, peak power production in back squat variations has been shown to range from 22%-70% of 1RM, this is why this training model targets many different percentages to target all possible ranges for maximum benefit (Baker, Nance, & Moore 2001; Harris, Cronin, & Hopkins, 2007; Harris, Cronin, Hopkins, & Hansen, 2008a, Harris, Cronin, Hopkins, & Hansen, 2010; Kawamori, Nosaka, & Newton, 2013; McBride, Triplett-McBride, Davie, & Newton, 2002; Soriano, Jimenez-Reyes, Rhea, & Marin, 2015). Despite the different percentage loads used, the intent of every repetition is to move the bar as fast as possible. Fast bar speeds tend to be better for strength gains due to greater recruitment of high-threshold muscle fibers (Liow & Hopkins, 2003; Munn, Herbert, Hancock, & Gandevia, 2005). Rest periods are also prescribed and differ between each phase so the training focus can specifically train the physical quality each block is emphasizing. Literature suggests that when training for strength and power, longer rest periods appear to be best (3-5 minutes) (De Salles et al. 2010). Literature suggests that there is no single range of rest to maximize hypertrophy, but there seems to be a tendency to suggest acute benefits with rest periods of 1-2 minutes (De Salles et al., 2010; Pincivero, Lephart, & Karunakara, 1997; Robinson et al., 1995).

### 1.7 Significance

To the author's knowledge, only one research study has been performed looking at the loaded hip thrust movement in a training study. Contreras, Vigotsky, Schoenfeld, Beardsley & Cronin (2015), performed EMG data collection on the hip thrust and back squat, and they found the hip thrust to produce much greater levels of gluteal and hamstring activation, which suggest potential benefit to the athlete population. The proposed benefits of the hip thrust have been reviewed (Contreras et al., 2011; Contreras et al., 2013), but no study, to the author's knowledge, has actually looked at a strength training program dedicated to the hip thrust and compared the results to traditional movements such as the back squat and deadlift. The potential for an exercise to provide superior strength, power, and performance outcomes would be of significant importance to strength and conditioning coaches.

The fact that this is a previously un-researched topic brings many benefits and potential to the scientific and strength and conditioning community.

## 1.8 Delimitations

This study will be delimited to subjects with at least 1-year of resistance training experience, ages 18 to 25 years of age.

## 1.9 Limitations

The researcher acknowledges the following limitations of this study. First, the small size of the groups and short duration between the pre and post-tests could have impacted the outcome. Additionally, the study was also limited by the fact that outside factors cannot be controlled. Given the nature of the subjects (active, many athletes) we will not be able to control their activities outside of the study. Lastly, the imbalance of genders may be another area of concern, as the subjects consisted of 20-males, but only 6-females.

## 2.0 Operational Definitions

The subjects were tested both pre and post-study in the following tests. The 10-Yard Sprint tested starting acceleration speed. It was timed in seconds and specific down to the tenth of a second.

The 40-Yard Sprint was performed from a standing start position and was used to test top-end running speed. It was timed in seconds and specific down to the hundredth of a second.

The Pro Agility (5-10-5) tested agility and change of direction performance of the subject. It was timed in seconds and specific down to the hundredth of a second.

The Counter Movement Jump (CMJ) tested vertical power production. It was measured in centimeters.

The Broad Jump tested horizontal power production. It was measured in centimeters.

The three-repetition maximum (3RM) was used in each the squat, deadlift, and hip thrust to determine maximal strength. This 3RM was used to estimate the 1RM of the subject by the use of the chart in Appendix C.

All times were measured to the hundredth of a second with either Speed Trap I Timer (Power Systems, Inc. Knoxville, TN) or Coaches Eye (Coaches Eye App – TechSmith Corporation). Measurements on the CMJ were measured to the tenth of an inch with Just Jump Mat (Probiotics, Huntsville, AL) and then converted to centimeters. Measurements of the broad jump will be measured in centimeters using a measuring tape.

## Chapter Two

## Review of Literature

### 2.0 Strength and conditioning and athletic performance

The incorporation of strength and conditioning programs is seen in almost every major sporting team due to the potential effects and outcomes it has on athletic performance. Baker & Newton (2008) examined what physical qualities separated first-division and second-division national league rugby players. The researchers found that strength and maximal power were the best indicators of which players were in the first and second-divisions. Baker & Newton (2008) concluded that strength and conditioning specialists should pay particular attention to increasing lower body strength and power and total body mass through appropriate resistance training while maintaining or improving their 10-m sprint speed.

Kruger, Pilat, Ückert, Frech, & Mooren, (2014) studied 34 professional male handball players in the first division and 21 male players from the second division. They found that both sprinting speed and jumping performance significantly differed between players in the first division and second division. Players in the first division were significantly faster and recorded higher jumping performance scores than those in the second division. This gives reason to the importance of strength and conditioning programs and developing lower body strength, power, and speed and finding what exercises provide the best stimuli to do so.

## 2.1 Training regimens to enhance athletic performance

### 2.1.1 Squats

The back squat is widely regarded as one of the most effective exercises used to enhance athletic performance because it necessitates the coordinated interaction of numerous muscle groups and strengthens the prime movers needed to support explosive athletic movements, such as jumping, running, and lifting (Escamilla, 2001). Chelly et al. (2009) demonstrated training with heavy squats resulted in faster sprint times, increased jump performance, and increased peak power output in junior soccer players. Wisløff, Castagna, Helgerud, Jones, & Hoff, (2004) examined 17 international level soccer players and looked at the relationship between strength in the half squat and sprinting speed and vertical jump. The results concluded that strength in the half squat dictated sprinting speed (0-30m and 10m shuttle run) and vertical jump height.

McBride et al. (2009) performed a study with 17 male Division I-AA football athletes. This study looked at and recorded a 1-rep max (RM) in the back squat and compared it to sprint times in the 5, 10, and 40-yard sprint times. Overall the study found that those athletes with a 1RM/Body Mass of 2.10 or higher had significantly faster sprint times than those with a 1RM/Body Mass of 1.90 or below. They concluded the importance of relative strength in the back squat exercise for faster sprinting speed.

Peterson, Alvar, & Rhea (2006) investigated 44 men and women freshman collegiate athletes and tested them in a maximum back squat, vertical jump, standing broad jump, cone T-test, 20-yard acceleration, and 40-yard sprint. Peterson et al. (2006) showed significant relationship between relative strength and all the performance tests. The researchers concluded that relative strength and measures of power, jumping ability, agility, linear sprint acceleration, and sprinting speed were very strong. They stated that the outcome of this study shows that low-velocity, maximal strength training (especially body mass adjusted strength capacity) is very influential in the performance of powerful, speed-related activities (Peterson et al., 2006).

Finally a recent meta-analysis by Seitz, Reyes, Tran, de Villarreal, & Haff, (2014) looked at 15 studies, consisting of 510 subjects, and they showed strength in the back squat significantly correlated to sprinting speed. They concluded that lower-body strength transfers positively to sprint performance and should be noted as a relevant training regimen to coaches and athletes.

### 2.1.2 Deadlift

The deadlift involves many of the large muscle groups of the lower body and is commonly performed by powerlifters and weightlifters and is regarded as an important exercise for athletes seeking to improve strength and power (Farley, 1995). A recent study by Laffaye, Wagner, & Tombelson, (2014) examined over 250 elite (college and professional) athletes and the different variables that make up a successful vertical jump. The researchers found that concentric force and eccentric rate of force development are the two most important qualities to determine jumping height, and proposed the deadlift as being a major exercise in improving concentric force development. Thompson et al. (2015) demonstrated that 10-weeks of deadlift training in novices resulted in a 7.4% increase in vertical jump and a 40.2% increase in rate of torque development. Swinton et al. (2014) studied 30 well-trained non-professional male rugby union players (age: 24.2 ± 3.9 years) and demonstrated that relative strength in the deadlift was associated with faster sprinting speeds and higher vertical leaps. In fact, the researchers concluded for the 30m sprint and vertical leap, as much as 90% of the performance variation can be explained by relative strength and average/peak power output in the deadlift. Swinton et al. (2014) concluded the importance for coaches to develop an athlete's relative maximum strength. Robbins (2011) showed that peak muscle activation in the deadlift of 10 college-aged participants with at least 1-year of strength and conditioning experience was significantly similar to the peak muscle activation of a vertical jump.

### 2.1.3 The downside of the squat and deadlift

While the studies above show the potential benefits of squats and deadlifts, the results have not been unanimous. Depending on the level of experience, age of the participants, and the length of the study, there have been mixed results. For example, it has been shown that it takes exceptionally large increases in 1RM back squat strength (~23-27%) to only slightly increase sprinting speed (2-3%) (Cronin, Ogden, Lawton, & Brughelli, 2007; Jacobson, Conchola, Glass, & Thompson, 2013). This low level of transference and need to exceptionally increase strength, which can take a very long time, leads many to believe there may be better ways. Speed has also been shown to have no correlation to back squat strength (Harris, Stone, O'Bryant, Proulx, & Johnson, 2000; Harris, Cronin, Hopkins, & Hansen, 2008a, 2010; Kukolj, Ropret, Ugarkovic, & Jaric, 1999; Wilson et al., 1996; Young, 2006) and overall strength in the back squat and deadlift has been questioned to having an actual carryover to the physical demands of sport (Young, 2006).

Harris et al. (2008a) examined 30 elite rugby players and studied the relationship between sprint performance and outputs of a machine squat jump with weights from 20%-1RM. The researchers concluded that it is problematic to confer a direct cause and effect from the squat jump to sprinting speed; and other physical qualities may be more important than maximum strength in the squat (Harris et al. 2008a). Kukolj et al. (1999) looked at 24-male physical education students who were measured for sprinting speed over distances of 0.5-15m and 15-30m and lower body isometric strength. The researchers concluded strength measures were poor indicators of both acceleration speed (0.5m-15m) and maximal running velocity (15m-30m). Barr, Sheppard, Agar-Newman, & Newton (2014) examined international rugby players over a year's time to track change in sprinting speed and maximal strength. They concluded that although increasing lower-body strength is likely important for increasing sprinting speed of players with low training backgrounds, it may not have the same effect with highly trained players.

A longitudinal study followed NCAA I football players at Oklahoma State University over the course of 4-years, and the researchers concluded that while athletes gained much strength in the back squat, they did not improve their sprinting speed, showing a possible disconnect between the back squat and improving sprinting speed (Jacobson et al., 2013).

Young, (2006) reviewed the effect of hypertrophy, strength, and power exercises on sports performance and concluded that general strength training can be beneficial for athletes because of the potential to enhance the force-generating capabilities of muscle, increase total body mass, reduce the risk of sports injuries, and improve core stability. However, direct transfer to improved sports performance is limited by basic strength in experienced, more advanced athletes and it appears that to maximize transfer to on-field performance, training should be as specific as possible, especially with regard to movement pattern and contraction velocity (Young, 2006). The main area of concern identified with the back squat and deadlift is that both are primarily sagittal plane movements with emphasis on axial (top-down) loading. Many sporting movements involve different planar movements that can't be targeted with the squat and deadlift (Young, 2006). For enhanced sport performance, specificity is an important aspect of training and the back squat and deadlift lack specificity of force application in a horizontal manner.

### 2.1.4 Hip Thrust

An important action for improving an athlete's performance is powerful hip extension (Beardsley & Contreras 2014; Contreras et al., 2013). A relatively new exercise that may maximize hip extension strength is the hip thrust (Contreras et al., 2011). It differs from the squat and deadlift in that it loads the body from anterior to posterior and places larger emphasis on horizontal loading. The idea of the hip thrust is intriguing in sport performance for a couple of reasons:

First is how the hip thrust emphasizes full hip extension and activates high levels of gluteal musculature (Beardsley & Contreras 2014; Contreras et al., 2013, 2015). The gluteal muscles power hip extension as well as contribute to hip external rotation and pelvic control (Contreras et al., 2011). Hip extension is a quality that has been proposed as a key factor for improved sprinting, jumping, and lateral movement speed (Beardsley & Contreras 2014; Brughelli, Cronin, Levin, & Chaouachi 2008; Contreras et al., 2013; Shimokochi, Ide, Kokubu, & Nakaoji (2013). This increased level of gluteal activation may also be important because as sprinting speeds increase, the activity of the gluteal musculature also increases (Bartlett, Sumner, Ellis, & Kram, 2014; Beardsley & Contreras 2014; Brughelli, Cronin, & Chaouachi, 2011; Dorn, Schache, & Pandy, 2012; Kyröläinen, Avela, & Komi, 2005; Lieberman, Raichlen, Pontzer, Bramble, & Cutright-Smith 2006; Mann, 1980; Sasaki & Neptune, 2006).

Contreras et al. (2015) recorded EMG on trained females during a hip thrust and back squat. The researchers found the hip thrust to activate greater levels of gluteal and hamstring muscle, leading the researchers to propose further investigation to see if this increased activation of muscle tissue would lead to greater hypertrophy, strength, and performance benefits than the back squat. Shimokochi et al. (2013) looked at 28 females college basketball players, and they found that greater hip extension velocity explained better lateral cutting and sliding maneuvers and training hip extension velocity may be crucial for better lateral acceleration and deceleration. Due to all of these factors, the implementation of the hip thrust may help increase sprinting speed, jumping, and change of direction to a greater degree than the squat and deadlift.

Secondly, the hip thrust is interesting due to the unique ability to load the body horizontally. This is an aspect of training that is very hard to duplicate in a weight room setting, and an aspect the back squat and deadlift cannot provide. This loading pattern may have greater carryover to sprinting speed as recent research has shown high levels of horizontal force application is related to faster sprinting speeds (Brughelli et al., 2011; Buchheit et al., 2014; De Lacey, Brughelli, McGuigan, & Hansen, 2014; Kawamori et al., 2013; Kyröläinen et al., 2005; Lockie, Murphy, Schultz, Knight & de Jonge, 2012; Morin, Edouard & Samozino, 2011; Morin et al., 2012; Morin et al., 2015; Munro, Miller, & Fuglevand, 1987; Randell et al., 2010).

Buchheit et al. (2014) analyzed the horizontal forces of 86 elite youth soccer players during sprinting. The researchers found that horizontal force was significantly correlated with acceleration speed (10m) but not maximum sprinting speed, suggesting horizontal forces may be more important for acceleration performance than maximal sprinting performance. Lockie et al. (2012) summarized by stating that in order to increase acceleration speed, it is important to develop specific horizontal strength and power. Randell et al. (2010) voiced concern to the lack of horizontally loaded exercises and noted the effectiveness of a gym-based lower-body resistance-training program with a horizontal component has not been investigated (Randell et al., 2010).

Lastly, the hip thrust is relatively un-researched and there is still a lot of light that needs to be shed on the potential benefits and drawbacks. As mentioned earlier, Contreras et al. (2015) looked at EMG data of the hip thrust compared to the back squat. They looked at 13 trained females and they found that the hip thrust elicited much greater levels of upper gluteus maximus, lower gluteus maximus, and bicep femoris compared to the back squat. The researchers concluded the hip thrust appears to be superior to back squats in terms of upper gluteus maximus, lower gluteus maximus, and bicep femoris activity. Plummer & Oliver (2014) demonstrated that greater levels of gluteal strength in 42 catchers (baseball and softball) played a direct role in maintaining the stability of the pelvis, and catchers should incorporate strengthening of the entire lumbopelvic-hip complex into their training regimen. Incorporating concentric and eccentric gluteal exercises help to improve musculoskeletal core stability, thereby assisting in upper extremity injury prevention.

2.3 Strength and on-field performance

Maximal running velocity requires high force production (Baker & Nance 1999; Mann, 1980; Mero, Luhtanen, Viitasalo, & Komi, 1981; Weyand et al., 2000; Weyand, Sandell, Prime, & Bundle, 2010). Due to this, a strength and conditioning program can be seen as a method to increase sprinting speed as a byproduct of increasing maximal force production (Baker & Nance 1999; Delecluse et al., 1995).

The specificity of an exercise is also tremendously important for transfer to on-field performance (Delecluse et al., 1995; Randell et al., 2010; Rimmer & Sleivert, 2000, Sale & MacDougall, 1981; Young, 2006). Recent research has shown high levels of horizontal force application is related to faster sprinting speeds (Brughelli et al., 2011; Buchheit et al., 2014; De Lacey et al., 2014; Kawamori et al., 2013; Kyröläinen et al., 2005; Morin et al. 2011, 2012, 2015; Munro et al., 1987) and as many athletics require high power in the horizontal plane, it may be important to engage in exercises containing a high horizontal component, whereas athletes who require power to be exerted in the vertical direction, train using vertical exercises (Chu, 1998; Rimmer & Sleivert, 2000).

From the literature, although it is apparent that force production is necessary in both the vertical and horizontal planes, it is the horizontal forces that experience the greatest increase when accelerating to maximal sprinting velocity (Randell et al. 2010). Brughelli et al. (2011) demonstrated that when progressing from 60% to 100% of maximal running speed, there was no increase in vertical forces, only horizontal. This becomes even more important when the demand to accelerate quickly is an important factor for success in team sports (Baker & Nance, 1999; Randell et al., 2010; Lockie et al., 2012; Rimmer & Sleivert, 2000; Young, James, & Montgomery, 2002).

# Chapter Three

# Methods

## 3.0 Introduction

This study evaluated the outcome of a 6-week resistance-training program performing squats, deadlifts, or hip thrusts.

## 3.1 Research Design

This study consisted of a field experiment design with pretest-posttest conducted on the experimental groups to evaluate change and differences. This study consisted of a 6-week resistance training intervention between three experimental groups and one control group. This research design allows analysis of research questions and evaluate each experimental and control group.

## 3.2 Setting for the Study

This study took place at Building Better Athletes, LLC, in Dubuque, IA. Building Better Athletes, LLC is a sports performance facility founded in 2013 and works with athletes of varying sports, genders, and ages on improving sports performance. Its mission is to provide science based performance training for athletes to enhance their on-field performance.

## 3.3 Study Population

Subjects were from Building Better Athletes, LLC, a sports performance facility that train athletes from youth to professional level. Approximately 100-150 athletes train at this facility throughout the year, consisting of both male and female.

### 3.4 Sample size and sampling procedure

A total of twenty-six (26) participants volunteered to take part in the study. They were split up into four (4) groups. The back squat group had eight (8) subjects, the deadlift group had six (6) subjects, the hip thrust group has eight (8) subjects, and the control group had four (4). All participants had at least 1-year of resistance training experience including experience in all of the three tested exercises. Subject's volunteered through the Building Better Athletes, LLC, a Sports Performance Facility in Dubuque, IA and the study population represented about 15% of the total athlete memberships at Building Better Athletes, LLC. Subjects were informed of the details of the study and signed a consent form (Appendix E) and were chosen randomly (simple randomization).

### 3.5 Data Collection Instruments

The following instruments were used during the study. To test the CMJ the Vertical JumpTest was used: Just Jump Mat, Probiotics, Huntsville, AL. The Just Jump Mat measures vertical jump by calculating time spent in the air. With gravity being a constant, the technology calculates time spent in the air and calculates vertical jump by using a formula. The Just Jump Mat has been shown to have a

Pearson r correlation of .967 (Leard et al. 2007). The CMJ was measured in inches to the tenth of an inch (ie – 26.3”) and then converted to centimeters.

To evaluate the 10-yard sprint and 40-yard sprint the Speed Trap I Timer: Power Systems, Inc. Knoxville, TN. The Speed Trap I Timer system uses electronic timing with lasers. This form of timing measures to the 1/100 of a second is extremely accurate and much more consistent than using hand time. The Speed Trap I Timer consists of a thumb pad timer used by the athlete to start the timer and a laser to stop the timer.

To evaluate the Broad Jump a standard Measuring Tape was used. Subjects put their toes at the starting line and jumped out, horizontally as far as possible. Measurements were taken from the further body part back, so either the left or right heel. The broad jump was measured in total centimeters.

To evaluate the Pro Agility the Coaches Eye App: TechSmith Corporation was used. Coaches Eye is an App for your phone or portable computer (iPad, tablet) and it allows to film and review video frame by frame. It also allows timing the video down to the exact frame. In the case of the Pro Agility, the agility test was recorded on the Coaches Eye App and was replayed, frame by frame, and started on the subjects’ first movement and stopped at the first moment the chest crossed the finish line.

### 3.6 Data Collection Procedure

After being placed into their groups, the participants went through baseline tests to evaluate their acceleration speed using the 10-yard sprint; top-end sprinting speed using the 40-yard sprint; jumping performance using the CMJ and broad jump; agility performance using the pro agility (5-10-5), and 3RM in the squat, deadlift, and hip thrust to evaluate maximal strength.

Subjects then followed a 6-week, condensed linear periodization model, which consisted of 2-weeks of hypertrophy emphasis training, 2-weeks of strength emphasis training, and 2-weeks of power emphasis training. The resistance program consisted of 3-days per week of training and focused on each group's particular lift. At the end of the 6-weeks participants then re-tested in all of the above tests, in the same exact manner they were delivered during pre-testing (described below).

This study involved two separate times (pre and post training period) in which subjects went through 2-days of testing. The subjects first went through a dynamic warm-up (Table 2) and performed the following tests in this specific order and the number of trials is in parenthesis.

*Day 1*

- Height
- Weight
- Broad Jump (3)
- CMJ (3)
- 10-Yard Sprint (2)
- Pro Agility (1 each direction)
- 40-Yard Sprint (2)
- 3RM - Squat

After 48-Hours, the participants returned and again went through a dynamic warm-up (Table 2). The participants then performed a 3RM lift in each of the following lifts in this specific order.

*Day 2*

- 3-Rep Max – Hip Thrust
- 3-Rep Max – Deadlift

The reason for the two testing days was to provide adequate rest between bouts of 3RM lifts. Performing a 3RM lift in each of the exercises on the same day would be very stressful and likely lead to great fatigue that may affect the results of the 3RM lift. After obtaining the 3RM, they were converted into an estimate RM by use of Appendix C.

After the pre-testing, participants were then given 72-hours before beginning the 6-week training period. Subjects then began there given group and went through 6-weeks of resistance training with emphasis on one exercise.

- Squat Group
- Deadlift Group
- Hip Thrust Group
- Control Group

During these 6-weeks, participants were asked to reduce and avoid as much conflicting activity as possible.

Subjects trained 3 days per week with total emphasis on their singular lift. There was 48 hours of rest after the first two training sessions of the week and a 72-hour rest following the third training session of the week (Training sessions were on

Mondays, Wednesdays, and Fridays). Training followed a condensed linear periodization model typically followed in many strength and conditioning programs. Below is an outline of the condensed linear periodization model used in this study.

- 2-Weeks of Emphasis on Hypertrophy
- 2-Week of Emphasis on Strength
- 2-Weeks of Emphasis on Power

Thus a total of 6 training sessions were used for each block - hypertrophy, strength, and power - for a total of 18 training sessions. At the end of the 6-weeks of training, subject re-tested in the same tests and same pattern as the two-day pre-testing. The back squat was done to parallel, where the femur is parallel to the ground. This full range of motion squat has been shown to be more effective for strength and hypertrophy results over a partial range of motion squats (Bloomquist et al., 2013; Bryanton, Kennedy, Carey, & Chui, 2012; Drinkwater, Moore, & Bird, 2012; Esformes & Bampouras 2013; Hartmann et al., 2012; McMahon, Morse, Burden, Winwood, & Onambélé, 2014; Pinto et al., 2012)

The deadlift variation used was the conventional deadlift off the floor with standard teaching and technique of this classic deadlift was enforced (Bird & Barrington-Hiigs, 2010).

The hip thrust was taught and used as described by Contreras et al. (2011). It used bumper plates, so the subject could easily slide underneath the bar.

## 3.7 Pilot study

A pilot study was performed to test and evaluate the testing devices and teach assistant data gatherers how to operate and coach the specific drills and lifts. Two interns went through two sessions of learning how to work the Just Jump Mat (used for the CMJ), the Speed Trap I Timing System (used for the 10-yard sprint and 40-yard sprint), the measuring tape (used to evaluate the broad jump), the Coaches Eye App (used to evaluate 5-10-5), and how to coach and assess the squat, deadlift, and hip thrust.

### 3.8 Ethical considerations

Prior to data collections, the researcher underwent IRB with the University of Texas at Tyler and was granted authority to undertake this study. Each subject volunteered and agreed to the guidelines of the study. Each subject was made thoroughly aware of the outline and details of the study and was made aware of their role and ability to withdraw at any moment. No harm, or no risk of subjects was evident.

### 3.9 Data analysis methods

Data was analyzed using SPSS Statistical Software from IBM. The data analysis involved several different descriptive statistics such as comparing the means, minimums, maximums, and standard variations of subjects; ages, sex, height, weight, and testing scores. The use of inferential statistics specifically a mixed measure analysis of variance (ANOVA) was carried out to use to compare between and within group factors via pretest and posttest. Two-way t-tests were used to assess statistical significance between the different significant samples. Power values were be set at $\pi=0.80$. The significance value was set at $p=0.05$. Based on estimated sample sizes of 8 subjects per group, a power analysis for statistical power is approximately 17%.

# Chapter Four

## Results and Discussion

There were twenty-six (26) participants (n=26; age= 22.15 ±2.2; height= 180.17cm ±8.37; weight=87.27kg ±15.72) and they were split into four (4) groups. Table 1 shows the descriptive data for the back squat group, as well as the results in the various performance tests during the pre and post-testing.

**Table 1: Results for Back Squat Group**

| Variable | pre | post | difference | % change |
|---|---|---|---|---|
| Weight (kg) | 92.55 | 93.49 | 0.94 | 1% |
| CMJ (cm) | 61.40 | 62.01 | 0.60 | 1% |
| Broad Jump (cm) | 237.17 | 239.4 | 2.22 | 1% |
| 10-Yard (sec) | 1.87 | 1.87 | 0 | 0 |
| 40-Yard (sec) | 5.33 | 5.29 | -0.04 | 1% |
| 5-10-5 (sec) | 4.86 | 4.72 | -0.14 | 3% |
| RM Squat (kg) | 136.93 | 150.85 | 13.92 | 10%* |
| RM Deadlift (kg) | 157.95 | 159.09 | 1.14 | 1% |
| RM Hip Thrust (kg) | 156.82 | 160.23 | 3.41 | 2% |

*(CMJ = Countermovement Jump; RM = Repetition Maximum; sec=Seconds; cm=Centimeters; kg=Kilograms)*

The back squat showed minimal improvements in jumping performance and sprinting speed. This experimental group did experience an improvement of 3% in the 5-10-5, and this improvement was the greatest of all the experimental groups. Lastly, the back squat showed significant improvement in back squat strength by improving strength by 10% in the back squat lift.  This was done while minimally influencing strength in the deadlift and hip thrust (1% and 2% improvements)

Table 2 shows the results for the deadlift group.

**Table 2: Results for Deadlift Group**

| Variable | pre | post | difference | % change |
|---|---|---|---|---|
| Weight (kg) | 86.22 | 86.88 | 0.66 | 0 |
| CMJ (cm) | 64.22 | 66.59 | 2.37 | 4% |
| Broad Jump (cm) | 244.26 | 253.58 | 9.31 | 4% |
| 10-Yard (sec) | 1.87 | 1.86 | -0.01 | 0 |
| 40-Yard (sec) | 5.28 | 5.24 | -0.04 | 2% |
| 5-10-5 (sec) | 4.86 | 4.77 | -0.09 | 2% |
| RM Squat (kg) | 124.24 | 123.87 | -0.38 | 0 |
| RM Deadlift (kg) | 142.43 | 155.30 | 12.88 | 9% |
| RM Hip Thrust (kg) | 140.30 | 148.74 | 8.44 | 6% |

*(CMJ = Countermovement Jump; RM = Repetition Maximum; sec=Seconds; cm=Centimeters; kg=Kilograms)*

The deadlift group showed 4% improvements in jumping performance, and this improvement was the greatest of the experimental groups in the broad jump and second greatest in the CMJ.  This group improved sprinting performance in the 10-yard and 40-yard dash by 0.01sec and 0.04sec respectively.  In terms of strength, the deadlift group improved strength in the deadlift by almost 13kg, while also improving the hip thrust by 8.44kg.  This was all done while actually reducing strength in the back squat exercise.

Table 3 shows the results for the hip thrust group.

**Table 3: Results for Hip Thrust Group**

| Variable | pre | post | difference | % change |
|---|---|---|---|---|
| Weight (kg) | 82.61 | 83.14 | 0.53 | 0 |
| CMJ (cm) | 57.37 | 58.94 | 1.57 | 3% |
| Broad Jump (cm) | 226.7 | 237.21 | 10.51 | 5% |
| 10-Yard (sec) | 1.92 | 1.90 | -0.02 | 1% |
| 40-Yard (sec) | 5.45 | 5.37 | -0.08 | 2% |
| 5-10-5 (sec) | 4.98 | 4.88 | -0.10 | 2% |
| RM Squat (kg) | 111.08 | 113.64 | 2.56 | 2% |
| RM Deadlift (kg) | 127.27 | 135.23 | 7.95 | 6% |
| RM Hip Thrust (kg) | 144.89 | 161.93 | 17.05 | 12%* |

*(CMJ = Countermovement Jump; RM = Repetition Maximum; sec=Seconds; cm=Centimeters; kg=Kilograms)*

The hip thrust group showed improvements in all of the performance tests, led by a 5% performance increase in the broad jump. The hip thrust group led all the experimental groups in overall improvement in the broad jump, 10-yard dash, and the 40-yard dash. In regards to strength, the hip thrust elicited an improvement of over 17kg in hip thrust strength. This group also improved strength in the deadlift by 6% and back squat by 2%.

Table 4 shows the results for the control group.

**Table 4: Results for Control Group**

| Variable | pre | post | difference | % change |
|---|---|---|---|---|
| Weight (kg) | 84.32 | 83.72 | -.60 | 0% |
| CMJ (cm) | 64.45 | 65.28 | 0.83 | 1% |
| Broad Jump (cm) | 237.81 | 239.51 | 1.7 | 1% |
| 10-Yard (sec) | 1.87 | 1.89 | 0.02 | -1% |
| 40-Yard (sec) | 5.47 | 5.48 | 0.01 | 0 |
| 5-10-5 (sec) | 4.97 | 4.90 | -0.07 | 1% |
| RM Squat (kg) | 132.39 | 135.23 | 2.84 | 2% |
| RM Deadlift (kg) | 140.91 | 144.09 | 3.18 | 2% |
| RM Hip Thrust (kg) | 133.85 | 130.68 | -3.17 | -2% |

*(CMJ = Countermovement Jump; RM = Repetition Maximum; sec=Seconds; cm=Centimeters; kg=Kilograms)*

Overall the control group saw fairly neutral results in all the performance tests. The saw minimal improvement in the jumping performance tests and the 5-10-5, but saw a slight reduction in 10-yard and 40-yard sprint speed. The control group saw minor improvements in both back squat and deadlift strength, but saw a loss of strength in the hip thrust.

Table 5 shows the descriptive statistics of the twenty-six (26) subjects that participated in this study, along with the group averages during pre-testing. Overall participants had an average CMJ of 61.30cm ±10.84, broad jump of 235.68cm ±10.84, 10-yard sprint of 1.89sec ± .14, 40-yard sprint of 5.38sec ± .41, 5-10-5 of 4.91sec ± .41, RM squat of 125.35kg ±41.26, RM deadlift of 142.31kg ±39.88, and RM hip thrust of 145.80kg ±33.51.

**Table 5: Participant Details**

| | Overall | Squat Group | Deadlift Group | Hip Thrust Group | Control Group |
|---|---|---|---|---|---|
| Height (cm) | 180.17 ±8.37 | 181.37 ±9.24 | 182.99 ±5.91 | 178.20 ±8.76 | 177.48 ±10.39 |

| | | | | | |
|---|---|---|---|---|---|
| Weight (kg) | 86.75 ±15.91 | 92.55 ±18.48 | 86.22 ±15.20 | 82.57 ±17.71 | 84.32 ±7.15 |
| Age (years) | 22.15 ±2.20 | 22.25 ±2.25 | 21.17 ±2.71 | 22.38 ±2.07 | 23.00 ±1.83 |
| CMJ (cm) | 61.30 ±10.84 | 61.40 ±9.79 | 64.22 ±10.61 | 57.37 ±10.73 | 64.45 ±15.08 |
| Broad Jump (cm) | 235.68 ±30.59 | 237.17 ±29.87 | 244.26 ±26.02 | 226.70 ±22.09 | 237.81 ±55.43 |
| 10-Yard (sec) | 1.89 ±.14 | 1.87 ±.13 | 1.87 ±.17 | 1.92 ±.13 | 1.87 ±.21 |
| 40-Yard (sec) | 5.38 ±.41 | 5.33 ±.32 | 5.28 ±.44 | 5.45 ±.40 | 5.47 ±.66 |
| 5-10-5 (sec) | 4.91 ±.41 | 4.86 ±.40 | 4.86 ±.37 | 4.98 ±.38 | 4.97 ±.66 |
| RM Squat (kg) | 125.35 ±41.26 | 136.93 ±30.82 | 124.24 ±44.85 | 111.08 ±38.04 | 132.39 ±65.38 |
| RM Deadlift (kg) | 142.31 ±39.88 | 157.95 ±30.42 | 142.43 ±42.87 | 127.27 ±42.85 | 140.91 ±49.86 |
| RM Hip Thrust (kg) | 145.80 ±33.51 | 156.82 ±27.06 | 140.30 ±35.51 | 144.89 ±34.61 | 133.85 ±46.62 |

*(CMJ = Countermovement Jump; RM = Repetition Maximum; sec=Seconds; cm=Centimeters; kg=Kilograms)*

An ANOVA was used to between each group to evaluate change from pre to post for each performance test (p<.05). A non-parametric randomization method was used to check the measures and it confirmed the results from the ANOVA for all the tests.

Tables 6-14 show the results from each performance test for each group and significance from each ANOVA test is represented by an asterisk. Only the squat-squat and hip thrust-hip thrust showed significant change, meaning the squat group improved the squat significantly more than the other groups, and the same applies to the hip thrust group for the hip thrust. P-values of each test can be seen in table 6. Further breakdown of these P-values will be discussed in greater depth in the below sections.

**Table 6: Performance Test P-Values**

| ***Test*** | P-Value |
|---|---|
| CMJ | 0.82 |
| Broad Jump | 0.14 |
| 10-Yard Sprint | 0.50 |
| 40-Yard Sprint | 0.39 |
| 5-10-5 | 0.90 |
| Max Squat | 0.01* |
| Max Deadlift | 0.14 |
| Max Hip Thrust | 0.004* |

* Signifies Significance (p≤.05)

Countermovement Jump

Table 7, shows the results for the CMJ. Each experimental group improved the CMJ, but no significant difference was found between groups. The deadlift and hip thrust improved the CMJ by 3% and 4% respectively, while the squat and control each improved by 1%.

**Table 7: CMJ Results**

| | | **CMJ (cm)** | | |
|---|---|---|---|---|
| Group | Pre | Post | Change | % Change |
| HP | 57.37 | 58.94 | 1.57 | 3% |
| BS | 61.4 | 62.01 | 0.6 | 1% |
| DL | 64.22 | 66.59 | 2.37 | 4% |
| Control | 64.45 | 65.28 | 0.83 | 1% |

*(CMJ=Countermovement Jump; HP=Hip Thrust; BS=Back Squat; DL=Deadlift)*

The deadlift improved CMJ most of all the experimental groups, which supports Robbins, (2011) who showed that peak muscle activation in the deadlift is very similar to the peak muscle activation of a CMJ. It is interesting the squat group did not improve the CMJ as much as the deadlift or hip thrust given the similarity of the actions and what previous literature has demonstrated (Adams et al., 1992; Chelly et al., 2009; Comfort et al., 2014; Swinton et al., 2014; Wilson et al., 1996; Young, 2006). Laffaye et al. (2014) found that concentric force was one of the most important qualities to determine jumping height, and proposed the deadlift as being a major exercise in improving concentric force development. The deadlift improved both the CMJ and broad jump by 4% and it out performed both the squat and hip thrust in the CMJ, and was only slightly behind the hip thrust in the broad jump. This outcome may mean the deadlift could be beneficial for sports that require high levels of explosive power, both vertically and horizontally.

Broad Jump

Table 8, shows the results for the broad jump. No significant difference was found between groups. Each experimental group improved their broad jump, led by the hip thrust group with an average of 10.51cm, then the deadlift group by 9.31cm, followed by the squat group 2.22cm, and finally the control group also improved by 1.7cm.

**Table 8: Broad Jump Results**

| | | Broad Jump (cm) | | |
|---|---|---|---|---|
| Group | Pre | Post | Change | % Change |
| HP | 226.7 | 237.21 | 10.51 | 5% |
| BS | 237.17 | 239.4 | 2.22 | 1% |

| | | | | |
|---|---|---|---|---|
| DL | 244.26 | 253.58 | 9.31 | 4% |
| Control | 237.81 | 239.51 | 1.7 | 1% |

*(HP=Hip Thrust; BS=Back Squat; DL=Deadlift)*

The results from the broad jump show a trend for the horizontal action of the hip thrust possibly being more effective at improving the horizontal nature of the broad jump. Also the hip thrust and deadlift point to a trend at improving the broad jump more so than the back squat. This may be a result of greater hamstring activation in both the hip thrust and deadlift than the back squat (Contreras et al., 2015; Ebben et al., 2009).

10-Yard Sprint

Table 9, shows the results for the 10-yard sprint. No significant difference was found between groups. Only the hip thrust and deadlift group resulted in improvement in the 10-yard sprint, while the squat group didn't see a change and the control group decreased in performance.

**Table 9: 10-Yard Sprint Results**

| | | 10-Yard Sprint (sec) | | |
|---|---|---|---|---|
| Group | Pre | Post | Change | % Change |
| HP | 1.92 | 1.90 | -0.02 | 1% |
| BS | 1.87 | 1.87 | 0 | 0 |
| DL | 1.87 | 1.86 | -0.01 | 0 |
| Control | 1.87 | 1.89 | 0.02 | -1% |

*(HP=Hip Thrust; BS=Back Squat; DL=Deadlift)*

40-Yard Sprint

Table 10, shows the results for the 40-yard sprint. No significant difference was found between groups. All of the experimental groups improved performance in the 40-yard sprint, while the control group decreased performance. The hip thrust grouped improved times by .08 seconds, while the squat and deadlift each improved times by .04 seconds.

**Table 10: 40-Yard Sprint Results**

| | | 40-Yard Sprint (sec) | | |
|---|---|---|---|---|
| Group | Pre | Post | Change | % Change |
| HP | 5.45 | 5.37 | -0.08 | 2% |
| BS | 5.33 | 5.29 | -0.04 | 1% |
| DL | 5.28 | 5.24 | -0.04 | 2% |
| Control | 5.47 | 5.48 | 0.01 | 0 |

*(HP=Hip Thrust; BS=Back Squat; DL=Deadlift)*

While the results do not show significant differences between the groups, there does seem to be a trend for the hip thrust offering an advantage in developing 10-yard and 40-yard sprinting speed over the back squat and deadlift. The hip thrust did increase the 10-yard sprint and 40-yard sprint to a greater degree than both the back squat and deadlift group, suggesting there may be benefit to performing movements that have more horizontal emphasis than purely vertical. The horizontal loading pattern of the hip thrust may have greater carryover to sprinting speed due to horizontal force application and its relationship to faster sprinting speeds (Brughelli et al., 2008, 2011; Buchheit et al., 2014; De Lacey et al., 2014; Kawamori et al., 2013; Kyröläinen et al., 2005; Lockie et al., 2012; Morin et al., 2011, 2012, 2015; Munro et al., 1987; Randell et al., 2010). Morin et al. (2015) looked at ground contact forces over a 40m sprint. They found that net horizontal impulse and propulsive horizontal impulse were significantly and closely correlated with 40m mean speed, which may give reason to the horizontally loaded hip thrust giving the biggest improvement compared to the back squat and deadlift group.

Pro Agility (5-10-5)

Table 11, shows the results for the pro agility. No significant difference was found between groups. The squat group saw the largest performance improvement of .14 seconds, with the hip thrust and deadlift followed with improvements by .10 seconds and .09 seconds respectively. The control group also saw an improvement by .07 seconds.

**Table 11: 5-10-5 Results**

| | | 5-10-5 (sec) | | |
|---|---|---|---|---|
| Group | Pre | Post | Change | % Change |
| HP | 4.98 | 4.88 | -0.10 | 2% |
| BS | 4.86 | 4.72 | -0.14 | 3% |
| DL | 4.86 | 4.77 | -0.09 | 2% |
| Control | 4.97 | 4.9 | -0.07 | 1% |

*(HP=Hip Thrust; BS=Back Squat; DL=Deadlift)*

Of the three lifts, the squat involves the most concentrated eccentric portion. The hip thrust has a much smaller range of motion and the eccentric portion is eliminated by the plates touching the ground each repetition. The same holds true for the deadlift in which the weight is quickly lowered to the ground to be reset, eliminating much of the eccentric portion. Given the nature of these actions, one might expect to see the results in the 5-10-5 agility, which requires overcoming great eccentric forces in a loaded position, and it has been shown that greater eccentric strength produces faster COD actions (Anderson et al., 1991; Jones, Bampouras, & Marrin 2009; Spiteri et al., 2014; Spiteri et al., 2015a). Spiteri, Newton, & Nimphius (2015b) demonstrated greater anterior muscle activation (quadriceps) related to better COD performance (Spiteri et al., 2015b). The back squat has been found to illicit greater quadriceps activation than the deadlift (Ebben et al., 2009), and Contreras et al. (2015) found the back squat produced 10.5% greater mean and 28% greater peak quadriceps activation over the hip thrust, but these differences were not found be significant (Contreras et al. 2015). These results correspond with Keiner et al. (2014), who demonstrated, long-term strength development in the squat is related to improved performance in COD sprints.

Estimated Max Squat

Table 12, shows the results for the estimated max back squat. The back squat group significantly increased performance compared to the other groups. The back squat group improved strength in the squat by 10%, while the hip thrust and control groups improved squat strength by 2%. The deadlift group did not see a percent change and actually decreased performance by .38kg.

**Table 12: Repetition Maximum Squat Results**

| Squat (kg) |
|---|

| Group | Pre | Post | Change | % Change |
|---|---|---|---|---|
| HP | 111.08 | 113.64 | 2.56 | 2% |
| BS | 136.93 | 150.85 | 13.92 | 10%* |
| DL | 124.24 | 123.87 | -0.38 | 0 |
| Control | 132.39 | 135.23 | 2.84 | 2% |

*Represents level of significance (p<.05)
*(HP=Hip Thrust; BS=Back Squat; DL=Deadlift)*

Estimated Max Deadlift

Table 13, shows the results for the estimated max deadlift. No significant difference was found between groups. While no significant difference was found between groups, the deadlift group did improve strength in the deadlift by almost 13kg. The hip thrust group improved strength in the deadlift by almost 8kg; while the control group improved strength in the deadlift (+3.18kg) more so than the back squat group (+1.14kg).

**Table 13: Repetition Maximum Deadlift Results**

| | | **Deadlift (kg)** | | |
|---|---|---|---|---|
| Group | Pre | Post | Change | % Change |
| HP | 127.27 | 135.23 | 7.95 | 6% |
| BS | 157.95 | 159.09 | 1.14 | 1% |
| DL | 142.43 | 155.3 | 12.88 | 9% |
| Control | 140.91 | 144.09 | 3.18 | 2% |

*(HP=Hip Thrust; BS=Back Squat; DL=Deadlift)*

Estimated Max Hip Thrust

Table 14, shows the results for the estimated repetition maximum in the hip thrust. The hip thrust group significantly improved strength in the hip thrust compared to the other groups. The hip thrust group improved strength in the hip thrust by 17.05kg. The deadlift and squat group also improved squat in the hip thrust by 8.44kg and 3.41kg respectively, while the control group decreased strength in the hip thrust by 3.17kg.

**Table 14: Repetition Maximum Hip Thrust Results**

| | | Hip Thrust (kg) | | |
|---|---|---|---|---|
| Group | Pre | Post | Change | % Change |
| HP | 144.89 | 161.93 | 17.05 | 12%* |
| BS | 156.82 | 160.23 | 3.41 | 2% |
| DL | 140.3 | 148.74 | 8.44 | 6% |
| Control | 133.85 | 130.68 | -3.17 | -2% |

* Represents level of significance (p<.05)
*(HP=Hip Thrust; BS=Back Squat; DL=Deadlift)*

The results from the estimated repetition maximum changes in each lift give some interesting discussion points. First, the study clearly demonstrates the SAID Principle (Specific Adaptations to Imposed Demands) at work. Each group focused solely on a single exercise for 6-weeks, and this resulted in that exercise receiving the most gain in strength; back squat (+13.92kg), deadlift (+12.88kg), hip thrust (+17.05kg). It is clear for coaches and athletes, if you want to get stronger in a specific lift, you must perform that lift. While that outcome was expected, what's interesting is the crossover from the hip thrust to the deadlift. The deadlift group improved strength in the hip thrust by 7.95kg; and the hip thrust group improved strength in the deadlift by 8.44kg. These strong improvements took place despite not affecting the back squat very strongly (DL= -.39kg, HP= 2.56kg). These results between the back squat and deadlift groups concur with Hales, Johnson, & Johnson

(2009) who concluded kinematic analysis of the back squat and the conventional deadlift indicate that the individual lifts are markedly different, implying that no direct or specific cross-over effect exists between the individual lifts (Hales et el., 2009).

Table 15 shows correlation coefficients to find the strength of relationships between the various performance tests. Strength was normalized by converting to relative strength, by dividing the estimated 1RM strength of each participant by his or her body weight. Strong correlations (r≥.70) are shown bolded and in italics in table 15.

**Table 15: Correlation Coefficients – Performance Tests**

| **Tests** | *Hgt* | *Wgt* | *CMJ* | *Broad* | *10y* | *40y* | *5-10-5* | *R-Sqt* | *R-DL* | *R-HP* |
|---|---|---|---|---|---|---|---|---|---|---|
| Hgt | 1 | | | | | | | | | |
| Wgt | 0.47 | 1 | | | | | | | | |
| CMJ | 0.12 | 0.05 | 1 | | | | | | | |
| Broad | 0.13 | 0.23 | ***0.89*** | 1 | | | | | | |
| 10y | -0.14 | 0.00 | ***-0.88*** | ***-0.84*** | 1 | | | | | |
| 40y | -0.06 | 0.07 | ***-0.81*** | ***-0.78*** | ***0.91*** | 1 | | | | |
| 5-10-5 | -0.16 | -0.11 | ***-0.84*** | ***-0.82*** | ***0.89*** | ***0.93*** | 1 | | | |
| *R-Sqt* | -0.20 | -0.05 | ***0.75*** | 0.69 | ***-0.72*** | ***-0.75*** | ***-0.72*** | 1 | | |
| *R-DL* | -0.07 | -0.17 | ***0.78*** | ***0.75*** | ***-0.85*** | ***-0.84*** | ***-0.78*** | ***0.88*** | 1 | |
| *R-HP* | -0.17 | -0.28 | 0.56 | 0.55 | ***-0.70*** | ***-0.81*** | -0.68 | ***0.71*** | ***0.77*** | 1 |

*(R-Sqt = Relative Squat Strength; R-DL = Relative Deadlift Strength; R-HP = Relative Hip Thrust Strength; Wgt = Body Weight; Hgt = Height; CMJ=Countermovement Jump; Broad = Broad Jump)*

Very strong correlations were found between the 5-10-5 and both the 10-yard (r=0.89) and 40-yard sprints (r=0.93). The relationship between linear sprinting speed and agility has been shown to have weak correlation, (Little & Williams, 2005; Salaj & Markovic, 2011; Sassi et al., 2009; Young et al., 2002) but others have shown strong correlation (Alemdaroğlu, 2012; Nimphius, McGuigan, & Newton, 2010; Vescovi & Mcguigan, 2008). Some of the discussion on this topic revolves around weather the agility drill is open vs closed. The 5-10-5 is a closed drill, with a set start, specific changes of direction, and a set finish. Most athletic movement involves open agility with reactive components, un-determined routes and directions, and cognitive recognition. The results from this study may mean performance in linear sprinting speed and closed agility drills are correlated.

The CMJ also showed strong correlation to the 5-10-5 (r= -0.84). These results confirm the results shown by Castillo-Rodríguez, Fernández-García, Chinchilla-Minguet, & Carnero (2012) who showed that vertical jumped was the best indicator of change of direction performance.

The CMJ and broad jump both correlated strongly to the 10-yard and 40-yard sprint. Previous literature shows a divide as to which is a better indicator of sprint performance. Markström & Olsson (2013) found that CMJ height was a key predictor in max running velocity at 10m. Vescovi & Mcguigan (2008) showed a strong correlation between CMJ and sprinting speed, and this relationship strengthened with the longer distances (30-40 yards > 10-20 yards). Marques & Izquierdo (2014) also showed CMJ had strong correlation (r=0.63) to the 10m sprint. On the other hand, Brechue, Mayhew, & Piper (2010) showed strong correlation (r= -0.80) between the standing long jump and sprinting speeds over 40-yards. Maulder & Cronin (2005) also found horizontal jump performance to be a better indicator of sprint performance than vertical jump performance. This study showed almost identical correlation coefficients between the CMJ and broad jump, and the 10-yard and 40-yard sprints. Overall, it's appears that jumping performance, in either the vertical or horizontal plane, has strong relationship to sprinting speed, demonstrating a possible relationship in neuromuscular functioning between jumping and sprinting.

What's interesting is many of the correlations do not coincide with the results from each experimental group. For example, the back squat group increased CMJ the least of the experimental groups and even the control group improved to a greater degree (0.60cm vs 0.83cm). Despite this, relative back squat strength has a strong correlation to the CMJ (r=0.75). Relative strength in the hip thrust had only moderate correlation to both the CMJ (r=0.55) and broad jump (r=0.56), while both the back squat (CMJ: r=0.75; Broad Jump: r=0.69) and deadlift (CMJ: r=0.78; Broad Jump: r=0.75) had very strong correlations. Overall, relative strength in the deadlift correlated very strongly (r=0.70) with every performance measure. Relative strength in the back squat correlated very strongly (r=0.70) with every performance measure, except the broad jump and even that correlated strongly (r=0.69). Relative strength in hip thrust correlated very strongly to only the 10-yard (r=0.70) and 40-yard sprints (r=0.81). This is interesting because the hip thrust group improved every performance measure to the greatest degree except for the broad jump and 5-10-5. Despite this, the hip thrust only showed strong correlations with the speed measures (10-yard and 40-yard sprints). The back squat group showed the least improvement of the experimental groups in all the performance measures except for the 5-10-5, but showed strong correlations to all the performance measure except the broad jump.

## Chapter Five

## Summary, Conclusions and Recommendations

### 5.1 Summary

This study aimed at accomplishing the following specific objectives by examining whether three resistance-training programs entailing the hip thrust, back squat, or deadlift, elicited the same performance benefits to sprinting speed, jumping performance, agility, and RM strength. Specific objectives were as follows.

1. Evaluate Pre and Post-Testing of hip thrust group on acceleration, top-end speed, agility, jumping performance, and RM strength.
2. Evaluate Pre and Post-Training of back squat group on acceleration, top-end speed, agility, jumping performance, and RM strength.
3. Evaluate Pre and Post-Testing of deadlift group on acceleration, top-end speed, agility, jumping performance, and RM strength.
4. Establish which resistance training program, back squat, deadlift, or hip thrust, had the greatest effect after 6-weeks of training on acceleration, top-end speed, jumping performance, agility, and RM strength.
5. Determine the correlation amongst RM strength in the back squat, deadlift, and hip thrust and acceleration, top-end speed, jumping performance, or

agility. For example, does RM strength in the squat correlate to the countermovement jump more strongly?

6. Determine the correlation between each performance tests (10-yard sprint, 40-yard sprint, pro agility, broad jump, countermovement jump). For example, did a high performance in the broad jump correlate most strongly to faster 40-yard sprint times?

From the data collected, the following were the findings including:

a. The hip thrust group significantly increases strength in the hip thrust exercise (+17.05kg; p= .004) , but failed to elicit significant improvements in sprinting speed, jumping performance, or agility performance. The hip thrust did improve CMJ by 3%, broad jump by 5%, 10-yard sprint by 1%, 40-yard sprint by 2%, 5-10-5 by 2%, strength in the back squat by 2%, and strength in the deadlift by 6%.
b. The BS group significantly increases strength in the back squat exercise (+13.92kg, p= .01 ;), but failed to elicit significant improvements in sprinting speed, jumping performance, or agility performance. The back squat did improve CMJ by 1%, broad jump by 1%, 40-yard sprint by 1%, 5-10-5 by 3%, strength in the deadlift by 1%, and strength in the hip thrust by 2%. The back squat did not improve the 10-yard sprint.
c. The deadlift group failed to elicit significant improvements in sprinting speed, jumping performance, agility performance, or strength. The deadlift group did improve CMJ by 4%, broad jump by 4%, 40-yard sprint

by 2%, 5-10-5 by 2%, strength in the hip thrust by 6%, and strength in the deadlift by 9%. The deadlift group did not improve strength in the back squat.

d. Although significant differences were not observed in the performance tests between experimental groups, small effect change were seen in various performance tests. The deadlift group was most effective compared to the other experimental groups in the CMJ and deadlift strength (CMJ = +2.37cm; DL = +12.88kg). The back squat group was more effective compared to the other experimental groups in the 5-10-5 and back squat strength (5-10-5 = -.14sec; BS = +13.92kg). The hip thrust group was more effective compared to the other experimental groups in the broad jump, 10-yard sprint, 40-yard sprint, and hip thrust strength (Broad Jump = +10.51cm; 10-yard = -.02; 40-yard = -.08; hip thrust = +17.05kg).

e. Strong correlations were found between relative strength in the hip thrust, back squat, and deadlift and various performance tests. Relative strength in the back squat was very strongly correlated (r>0.70) with all of the performance tests except for the broad jump. Relative strength in the deadlift was very strongly (r>0.70) correlated with every single performance test. The hip thrust was very strongly correlated (r>0.70) with only the 10-yard and 40-yard sprints.

f. The study also sought to determine the correlation between each performance tests (10-yard sprint, 40-yard sprint, pro agility, broad jump, countermovement jump). For example, did a high performance in the broad jump correlate most strongly to faster 40-yard sprint times? The results showed that there was strong correlation (r>0.70) with each other. It appears that there is a strong carryover and relationship between sprinting performance, jumping performance, and agility performance.

5.2 Conclusions

The back squat, deadlift, and hip thrust each demonstrated varying degrees of enhancing performance in each test (10-yard sprint, 40-yard sprint, vertical jump, horizontal jump, and 5-10-5), but no group showed a significant advantage over the others. The back squat group improved the CMJ by 0.60cm, broad jump by 2.22cm, 40-yard sprint by 0.04sec, 5-10-5 by 0.14sec, strength in the deadlift by 1.14kg, strength in the hip thrust by 3.41kg, strength in the back squat by 13.92kg, and resulted in no change for the 10-yard sprint.

The deadlift group improved the CMJ by 2.37cm, broad jump by 9.31cm, 10-yard sprint by 0.01sec, 40-yard sprint by 0.04sec, 5-10-5 by 0.09sec, strength in the hip thrust by 8.44kg, strength in the deadlift by 12.88kg, and actually resulted in a decrease in back squat strength by 0.38kg.

The hip thrust group improved the CMJ by 1.57cm, broad jump by 10.51cm, 10-yard sprint by 0.02sec, 40-yard sprint by 0.08sec, 5-10-5 by 0.10sec, strength in the hip thrust by 17.05kg, strength in the deadlift by 7.95kg, and strength in the back squat by 2.56kg.

Overall strength measures were significantly improved in the back squat and hip thrust groups for their respective lifts. In conclusion, the back squat and hip thrust exhibit advantages in developing strength in their respective exercises. However, the back squat, deadlift, and hip thrust offer no significant advantage over each other in enhancing speed, jumping, or change of direction performance.

## 5.3 Recommendations

### 5.3.1 Recommendations for Practice

The results of this study indicate that neither exercise offer a clear performance advantage over the others and it appears that each has its place in a strength and conditioning program. It is in the opinion of the researcher, that each exercise be utilized by strength and conditioning coaches while designing training programs so as to have a well-rounded athletic development program for their athletes.

### 5.3.2 Recommendation for Further Research

While the results do not show significant differences between the groups, there does seem to be a trend for future research to pursue. The hip thrust did increase the broad jump, 10-yard sprint, and 40-yard sprint to a greater degree than both the squat and deadlift group, suggesting there may be benefit to performing movements that have more horizontal emphasis than purely vertical. The horizontal loading pattern of the hip thrust may have greater carryover to sprinting speed due to horizontal force application and its relationship to faster sprinting speeds

(Brughelli et al., 2008, 2011; Buchheit et al., 2014; De Lacey et al., 2014; Kawamori et al., 2013; Kyröläinen et al., 2005; Lockie et al., 2012; Morin et al., 2011, 2012, 2015; Munro et al., 1987; Randell et al., 2010). Further research needs to be done to clarify this relationship and its carryover, but this study gives reason to further pursuing this area of research.

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## Appendix A: Training Template

After the dynamic warm-up (Appendix B) the subject will set-up for their particular lift. For example, if they are in the squat group, they will set-up a bar and perform two warm-up sets of five reps at loads of 30% and 50%. After these two warm-up sets, the subject will then go into the given workout for the day with the prescribed sets and reps, weight, and rest periods.

**Week 1**

**Day 1**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 4x8 | 72% | 90sec |
| | | |

**Day 2**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 4x6 | 77% | 90sec |
| | | |

**Day 3**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 3x6 | 80% | 90sec |
| 1xRM | 70% | |

**Week 2**

**Day 1**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 4x10 | 72% | 90sec |
| | | |

**Day 2**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 4x8 | 77% | 90sec |
| | | |

**Day 3**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 4x6 | 80% | 90sec |
| 1xRM | 70% | |

**Week 3**

**Day 1**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 4x4 | 85% | 4min |
| | | |

**Day 2**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 4x5 | 80% | 4min |
| | | |

**Day 3**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 2x5 | 82% | 4min |
| 2x2 | 90% | 4mn |

**Week 4**

**Day 1**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 5x3 | 88% | 4min |
| | | |

**Day 2**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 5x4 | 82% | 4min |
| | | |

**Day 3**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 2x2 | 95% | 4min |
| 2x1 | 100% | 4min |

**Week 5**

**Day 1**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 5x2 | 50% | 2.5min |

**Day 2**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 5x4 | 25% | 2.5min |

**Day 3**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 5x3 | 35% | 2.5min |

**Week 6**

**Day 1**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | 1.5min<br>1.5min |
| 6x2 | 55% | 2.5min |

**Day 2**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | |
| 6x4 | 30% | 2.5min |

**Day 3**

| SetxReps | Percent | Rest |
|---|---|---|
| 1x5<br>1x5 | 30%<br>50% | |
| 6x3 | 40% | 2.5min |

Appendix B

Every training session will begin with the subjects going through a dynamic warm-up.

| **Movement** | **Distance** |
|---|---|
| Knee Hugs | 15-yards |
| Walking Lunge | 15-yards |
| Lateral Lunge | 15-yards (each direction) |
| “A” Skip | 15-yards |
| “A” Run | 15-yards |
| Carioca | 15-yards (each direction) |
| Backward Open Hip | 15-yards |
| Zombie Walks | 15-yards |
| “A” Run | 15-yards |

Appendix C: Subject Scoring Card

Scorecard used during pre and post testing to input data.

| Initials | Number | Group | Sex | Height | Weight | Age | Vertical | Broad□ump | 10-Yard | 40-Yard | 5-10-5 | Est□Sqt | Est□DL | Est□HP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | |

Appendix D: Rep Max Calculator

Weight used during the 3RM test was used to get an estimated 1RM.

Estimating 1RM and Training Loads

| Max Reps (RM) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **% 1 RM** | **100%** | **95%** | **93%** | **90%** | **87%** | **85%** | **83%** | **80%** | **77%** | **75%** | **67%** | **65%** |
| Load (lb or kg) | **10** | 10 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 7 | 7 |
| | **20** | 19 | 19 | 18 | 17 | 17 | 17 | 16 | 15 | 15 | 13 | 13 |
| | **30** | 29 | 28 | 27 | 26 | 26 | 25 | 24 | 23 | 23 | 20 | 20 |
| | **40** | 38 | 37 | 36 | 35 | 34 | 33 | 32 | 31 | 30 | 27 | 26 |
| | **50** | 48 | 47 | 45 | 44 | 43 | 42 | 40 | 39 | 38 | 34 | 33 |
| | **60** | 57 | 56 | 54 | 52 | 51 | 50 | 48 | 46 | 45 | 40 | 39 |
| | **70** | 67 | 65 | 63 | 61 | 60 | 58 | 56 | 54 | 53 | 47 | 46 |
| | **80** | 76 | 74 | 72 | 70 | 68 | 66 | 64 | 62 | 60 | 54 | 52 |
| | **90** | 86 | 84 | 81 | 78 | 77 | 75 | 72 | 69 | 68 | 60 | 59 |
| | **100** | 95 | 93 | 90 | 87 | 85 | 83 | 80 | 77 | 75 | 67 | 65 |
| | **110** | 105 | 102 | 99 | 96 | 94 | 91 | 88 | 85 | 83 | 74 | 72 |
| | **120** | 114 | 112 | 108 | 104 | 102 | 100 | 96 | 92 | 90 | 80 | 78 |
| | **130** | 124 | 121 | 117 | 113 | 111 | 108 | 104 | 100 | 98 | 87 | 85 |
| | **140** | 133 | 130 | 126 | 122 | 119 | 116 | 112 | 108 | 105 | 94 | 91 |
| | **150** | 143 | 140 | 135 | 131 | 128 | 125 | 120 | 116 | 113 | 101 | 98 |
| | **160** | 152 | 149 | 144 | 139 | 136 | 133 | 128 | 123 | 120 | 107 | 104 |
| | **170** | 162 | 158 | 153 | 148 | 145 | 141 | 136 | 131 | 128 | 114 | 111 |
| | **180** | 171 | 167 | 162 | 157 | 153 | 149 | 144 | 139 | 135 | 121 | 117 |
| | **190** | 181 | 177 | 171 | 165 | 162 | 158 | 152 | 146 | 143 | 127 | 124 |
| | **200** | 190 | 186 | 180 | 174 | 170 | 166 | 160 | 154 | 150 | 134 | 130 |
| | **210** | 200 | 195 | 189 | 183 | 179 | 174 | 168 | 162 | 158 | 141 | 137 |
| | **220** | 209 | 205 | 198 | 191 | 187 | 183 | 176 | 169 | 165 | 147 | 143 |
| | **230** | 219 | 214 | 207 | 200 | 196 | 191 | 184 | 177 | 173 | 154 | 150 |
| | **240** | 228 | 223 | 216 | 209 | 204 | 199 | 192 | 185 | 180 | 161 | 156 |
| | **250** | 238 | 233 | 225 | 218 | 213 | 208 | 200 | 193 | 188 | 168 | 163 |
| | **260** | 247 | 242 | 234 | 226 | 221 | 216 | 208 | 200 | 195 | 174 | 169 |
| | **270** | 257 | 251 | 243 | 235 | 230 | 224 | 216 | 208 | 203 | 181 | 176 |
| | **280** | 266 | 260 | 252 | 244 | 238 | 232 | 224 | 216 | 210 | 188 | 182 |
| | **290** | 276 | 270 | 261 | 252 | 247 | 241 | 232 | 223 | 218 | 194 | 189 |
| | **300** | 285 | 279 | 270 | 261 | 255 | 249 | 240 | 231 | 225 | 201 | 195 |

*Ref: Baechle, Thomas, Earle, Roger, Essentials of Strength Traning and Conditioning, 2nd Ed.*

Appendix E: University of Texas at Tyler IRB Consent Form

**THE UNIVERSITY OF TEXAS AT TYLER**

**Informed Consent to Participate in Research**

**Institutional Review Board # Sp2015-85**
**Approval Date: April 28, 2015**

**Project Title**: Effect of 6-Week Resistance Training In Squat, Deadlift, or Hip Thrust on Sprinting Speed, Jumping Performance, Agility, and Strength in Experienced Lifters

**Principal Investigator:** Michael Zweifel

**Participant's Name:**

**To the Participant:**

You are being asked to take part in this study at The University of Texas at Tyler (UT Tyler). This permission form explains:

- Why this research study is being done.
- What you will be doing if you take part in the study.
- Any risks and benefits you can expect if you take part in this study.

After talking with the person who asks you to take part in the study, you should be able to:

- Understand what the study is about.
- Choose to take part in this study because you understand what will happen

**Description of Project:**
To study the different effects of a 6-week resistance training program of squats vs deadlifts vs hip thrusts on sprinting speed, jumping performance, agility, and strength.

**5. Research Procedures**

If you agree to be in this study, we will ask you to do the following things:

- You will be put into 1 of 4 groups: a squat group, deadlift group, hip thrust group, or control group
- After you are put into your group, you will see how fast your can run by running a 10-yard and 40-yard sprint; how high you can jump by doing a vertical jump; how far you can jump by doing a broad jump; how fast your

agility is by doing a 5-10-5; and how strong you are by doing a 3 repetition maximum in the squat, deadlift, and hip thrust.

- After all of this, you will go through 6-weeks of resistance training, consisting of 3 days of training per week
- Each training sessions will last about 30-minutes
- After the 6-weeks of training, you will once again be tested to see how fast you can run, how high you can jump, how far you can jump, how fast your agility is, and how strong you are with the same exact tests as you did at the start of the study.
- Receive your physician's approval for participation in this study

**Side Effects/Risks**

- This study will include intense physical activity that may leave you tired and sore
- You will be monitored for chest tightness, troubled breathing, nausea, muscle cramps, and light-headedness. If any of these occur, you must notify the principle investigator (Michael Zweifel)
- You will be asked to report to the principle investigator if anything does not feel normal
- The Principle Investigator is CPR, First Aid, and AED certified as well as a Certified Strength and Conditioning Specialist to ensure your health and safety.

**Potential Benefits**

The nature of this project has not been previously studied, so with it comes many potential benefits for Strength and Conditioning professionals.

**Understanding of Participants**

**8.** I have been given a chance to ask any questions about this research study. The researcher has answered my questions.

**9.** If I sign this consent form I know it means that:

- I am taking part in this study because I want to. I chose to take part in this study after having been told about the study and how it will affect me.

- I know that I am free to not be in this study. If I choose to not take part in the study, then nothing will happen to me as a result of my choice.

- I know that I have been told that if I choose to be in the study, then I can stop at any time. I know that if I do stop being a part of the study, then nothing will happen to me.

- I will be told about any new information that may affect my wanting to continue to be part of this study.

- The study may be changed or stopped at any time by the researcher or by The University of Texas at Tyler.

- The researcher will get my written permission for any changes that may affect me.

- I am aware and understand the physical demands required of this study. I give consent that I have been cleared by a Doctor to perform such physical activity and do not have any lung, heart, or any other health problems.

**10.** I have been promised that that my name will not be in any reports about this study unless I give my permission.

**11.** I also understand that any information collected during this study may be shared as long as no identifying information such as my name, address, or other contact information is provided). This information can include health information. Information may be shared with:

- Organization giving money to be able to conduct this study
- Other researchers interested in putting together your information with information from other studies
- Information shared through presentations or publications

**12.** I understand The UT Tyler Institutional Review Board (the group that makes sure that research is done correctly and that procedures are in place to protect the safety of research participants) may look at the research documents. These documents may have information that identifies me on them. This is a part of their monitoring procedure. I also understand that my personal information will not be shared with anyone.

**13.** I have been told about any possible risks that can happen with my taking part in this research project.

**14.** I also understand that I will not be given money for any patents or discoveries that may result from my taking part in this research.

**15.** If I have any questions concerning my participation in this project, I will contact the principal researcher: Michael Zweifel at (262)-949-9323 or email buildingbetterathletes.bba@gmail.com.

**16.** If I have any questions concerning my rights as a research subject, I will contact Dr. Gloria Duke, Chair of the IRB, at (903) 566-7023, gduke@uttyler.edu,
or the University's Office of Sponsored Research:

The University of Texas at Tyler
c/o Office of Sponsored Research
3900 University Blvd
Tyler, TX 75799

I understand that I may contact Dr. Duke with questions about research-related injuries.

## 17. CONSENT/PERMISSION FOR PARTICIPATION IN THIS RESEARCH STUDY

I have read and understood what has been explained to me. I give my permission to take part in this study as it is explained to me. I give the study researcher permission to register me in this study. I have received a signed copy of this consent form.

______________________________________ ______________________
Signature of Participant Date

______________________________________ __________ ______________
Signature of Person Responsible (e.g., legal guardian) Relationship to Participant

______________________________________
Witness to Signature

**18.** I have discussed this project with the participant, using language that is understandable and appropriate. I believe that I have fully informed this participant of the nature of this study and its possible benefits and risks. I believe the participant understood this explanation.

__________________________________ _______________
Researcher/Principal Investigator Date