Fall 2017

Effects of a Unilateral Strength and Plyometric Training Program for Division I Soccer Players

Eric Potter
Old Dominion University, epotter@odu.edu

EFFECTS OF A UNILATERAL STRENGTH AND PLYOMETRIC TRAINING PROGRAM FOR DIVISION I SOCCER PLAYERS

by

Eric Potter
B.S. May 2011, University of Maryland

A Thesis Submitted to the Faculty of Old Dominion University in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE IN EDUCATION

PHYSICAL EDUCATION – COACHING EDUCATION

OLD DOMINION UNIVERSITY
Fall 2017

Approved by:

Dr. Peter Baker

Dr. Stephen Knott

Dr. Xihe Zhu, Chair

ABSTRACT

EFFECTS OF A UNILATERAL STRENGTH AND PLYOMETRIC TRAINING PROGRAM FOR DIVISION I SOCCER PLAYERS

Eric Potter
Old Dominion University, 2017
Director: Dr. Xihe Zhu

The current thesis examined the effects of a unilateral strength and plyometric program on power (bilateral and unilateral vertical jumps), speed (20 meter sprint), and agility (Agility T-Test) in collegiate soccer players compared to a traditional bilateral-based training program. Due to the fact that a majority of the research on performance variables in athletes is done using bilateral lifting and plyometric programs, yet most movements in field sports such as sprinting and changing direction are unilateral-based, this specific topic could have value for enhanced performance for athletic populations. The participants included 34 male and female Division-I soccer players who were paired up and then randomly assigned to a six week unilateral-based or bilateral-based training program. Pre and post tests were conducted prior to and after the six week training, respectively. In relation to pretest results, athletes' bilateral vertical jump, unilateral vertical jump, 20 meter sprint, and T-Agility Test increased after six week training. The test scores were significantly correlated. Multivariate analysis of covariance results showed that pretest covariates were significant predictors for the corresponding posttest outcome, yet there was not a significant difference between the unilateral and bilateral training group's improvements (Wilks' $\lambda = .88$, $F_{3,13} = .37$, $p = .86$). Athletes in the unilateral training group scored slightly better than those in the bilateral training group, yet not significantly. This study demonstrated the value of a unilateral program on power, speed, and agility, but more research has to be conducted to determine if it could actually be a more optimal program than a traditional bilateral-based program.

ACKNOWLEDGMENTS

I would like to acknowledge many people who have contributed to the successful completion of this thesis. I extend many, many thanks to my committee members for their patience and guidance on my research and thorough editing of the thesis draft, particularly Dr. Xihe Zhu. Finally, I appreciate the contributing sport coaches, athletes, and entire university athletic department for the support and allowing me to conduct my research.

Table of Contents

Page

APPENDICES

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

CHAPTER I: INTRODUCTION

Soccer is the most watched and played sport in the world, and it also one of the most diverse sports in terms of energy systems, performance markers, and variety of movements used. Specifically, the sport of soccer requires various degrees of aerobic and anaerobic energy systems depending on the game-plan, opponent, and what position the athlete plays. This study aimed to examine how a typical training program is developed and the type of lifting and power development training programs that are currently implemented at the elite level. Furthermore, this study will expand on current training protocols and evaluate the effects of a potentially more effective training method to improve power, speed, and agility that can potentially translate to improved performance on to the soccer field.

From an energy system perspective, soccer players are required to repeatedly produce maximal or near maximal sprints of short duration (1 - 7 seconds) with brief recovery periods and training the repeat-sprint ability of the players is a huge focus for soccer coaches and programs (Rampinini, Bishop, Marcora, Bravo, Sassi, & Impellizzeri, 2007). For example, it was determined that professional soccer players perform about 50 turns during a game, with most of them consisting of sustained forceful contractions to maintain balance and control of the ball against defensive pressure (Wisløff, Castagna, Helgerud, Jones, & Hoff, 2004). In addition, it was concluded that a sprint bout occurs about every 90 seconds and that sprinting constitutes 1-11% of the total distance covered in a soccer match (Reilly & Thomas, 1976).

Even though soccer includes a lot of high intensity movements such as short distance and short duration sprints (speed) and change of direction (agility), it is considered an endurance sport by most coaches, players, and fans. In a collegiate or professional setting, cardiovascular

endurance training would be emphasized as a key part of practice, an offseason training program, or on an individual basis. Due to this emphasis on cardiovascular endurance, the off the field training such as lifting weights, plyometrics, and power training would receive less attention compared to other sports by most soccer coaches, programs, and organizations. Even though most attention is paid to endurance, multiple studies have demonstrated that strength and plyometric training can improve jump height and speed with no negative affect on cardiovascular endurance (eg., Gorostiaga, Izquierdo, Ruesta, Iribarren, Gonazalez-Badillo, & Ibanez, 2004; Siegler, Gaskill, & Ruby, 2003). Gorostiaga et al. (2004) looked at male soccer players from an experienced and successful regional team and the effect an 11 week strength training program had on 15 meter sprint times (speed), vertical jump height (power), and blood lactate levels running at 13 kilometers per hour (cardiovascular endurance); they found that soccer practice combined with an explosive-type strength training program resulted in significant enhancements in the vertical jump height and the 5 meter sprint performance with no interference with the development of endurance running. In addition, Siegler et al. (2003) examined female high school soccer players following an in-season plyometric, resistance training, and high-intensity anaerobic programs and the effect on body composition, vertical jump, 20 meter speed, and 30 second Wingate test. The results from this study again showed that a strength and plyometric program improved power endurance and speed over aerobic training only and that soccer-specific power endurance training could improve match performance and decrease fatigue in young female soccer players (Siegler et al., 2003).

Other than energy system development, soccer requires many single leg, or unilateral actions, continuously over an extended period of time such as sprinting, cutting, jumping, kicking, turning, and bracing against a defender. More specifically, when a player dribbles, passes, or

shoots the ball, one leg is dominant to forcefully move the ball and the other leg is used to support the body weight (Oshita & Yano, 2010). For this study, we will first test a two legged or bilateral vertical jump to assess basic power production since it is the most widely used power assessment to test athletes (Meylan, 2009). Since most soccer movements and athletic forces such as running and change of direction are generated in a unilateral direction, we will also test a single leg vertical jump assessment for this study since it would be a more sport specific testing assessment (Meylan, 2009). One of the underlying themes behind this study is that in order to improve physical performance and make the training more relevant to the actual performance of the sport, training has to emphasize single leg stability and power and the ability to develop and absorb force in all planes going forward, laterally, and vertically. Each of these aspects has to be addressed and improved to maximize physical performance, decrease the chance for injury, and allow for the greatest transfer of training to the soccer field.

Sprinting only takes up 0.5 - 3.0% of effective play time of a soccer game, but it is still critical to test and train at short duration, high intensities due to the impact of maximal speed on scoring plays (Hoff & Helgerud, 2004). Stolen et al. (2015) even reported that 96% of sprint bouts during a soccer game are shorter than 30 meters. Accordingly, we conducted the 20 meter sprint test to evaluate acceleration and maximal short distance speed since it is very rare that athletes run more than 20 meters in a straight line during a soccer game. The 20 meter sprint has been used for soccer speed testing across the world, and there has been evidence found that elite performers have faster 20 meter sprint times compared to other players; and it is even stated that the main physical difference between elite and non-elite soccer players is their sprinting speed (Arnasonet, Sigurdsson, Gudmundsson, Holme, Engebretsen, & Bahr, 2004).

Similarly, change of direction ability or agility is crucial and players must be able to sprint and move efficiently in multiple directions. More specifically, agility is the ability to accelerate and decelerate rapidly, and change direction, which also can be described as a component of agility (Lockie et al., 2014). One of the main reasons for this specific study was the fact that there is not much research on a unilateral training program versus a bilateral training program and the impact on change of direction or agility. When evaluating one of the few studies implementing a unilateral training stimulus, their analysis revealed significantly greater improvements in change of direction ability from using a unilateral training group. For instance, Fisher and Wallin (2014) observed an absolute change in favor of the unilateral group for the T-test (measured in this study) and the Illinois agility test. In this study, speed is an important physical performance for soccer players, and we are using the assumption and research that the better players and teams would have faster 20 meter sprint times and that a single leg dominant training program would develop more single leg strength and power thus enhance speed, since each stride is unilateral and force production has a direct correlation to running speed.

Over the past decade, physical performance enhancement has become a bigger part of developing soccer athletes throughout the amateur, collegiate, and especially the professional ranks. Strength and power development has been prioritized in their training as a way to decrease injuries, stay stronger throughout the season, and also maximize the speed and physical qualities of the players. Strength is defined as “the integrated result of several force-producing muscles performing maximally either isometrically or dynamically during a single voluntary effort of a defined task” (Hoff & Helgrud, 2004, p.172). From a training standpoint, maximal strength is the first quality that is developed before you can start to implement power training. After a sufficient strength base is developed, power can then be developed since it is a “product of force and

the inverse of time, more specifically the ability to produce as much force as possible in the shortest possible time" (Hoff & Helgrud, 2004, p.172). Research has demonstrated that an increase in maximal strength is usually connected with an improvement in relative strength and therefore, with improvement of power abilities (Hoff & Helgrud, 2004). More specifically, by increasing force in appropriate muscles or muscles groups, acceleration and speed may improve in skills that are directly relevant to soccer such as turning, sprinting, and changing pace (Chelly, Fathloun, Cherif, Amor, Table, & Van Praagh, 2009). Players must be faster and more powerful than the opponent to score goals or to stop goals from being scored (Chelly et al., 2009). All of these movements previously mentioned require muscular strength and power, which is why those physical attributes are so valued and so commonly assessed in soccer players (Rampinini et al., 2007). Based on the previous research, this study assessed two separate training programs, with the assumption that strength is the foundation of all other athletic movements and performance. After each of the training programs, it was hypothesized that there would be an increase in physical performance measures which should translate to increased performance on the soccer field. In summary, the main objective was to evaluate the effects of unilateral training on soccer players' power, speed, and agility, in comparison with bilateral-dominant program, which has been traditionally and still commonly practiced. To the researcher's knowledge, no studies have been directed towards specifically looking at comparing a unilateral-dominant and a bilateral-dominant lifting and plyometric program and their effects on power, speed, and agility.

Purpose

The purpose of this research was to examine the effects of different training programs on the physical performance of collegiate soccer players. Specifically, the physical performance

measures of power, speed, and agility were compared between Division-I athletes utilizing a unilateral-based training program and those following a traditional, bilateral-based training program. Before and after the program, the athletes underwent a testing protocol to determine the effect of the two training programs on the specific performance measures. Upon conclusion of the study, the following questions were answered: (a) Compared with a comparison group following a traditional bilateral-training program, would Division I soccer players taking part in the experiment unilateral-training program improve their power in a double leg and single leg vertical jump? (b) Compared with a comparison group following a traditional bilateral-training program, would collegiate soccer players taking part in the experiment unilateral-training program improve their speed in a 20 meter sprint? (c) Compared with a comparison group following a traditional bilateral-training program, would collegiate soccer players taking part in the experiment unilateral-training program improve their agility in the Illinois Agility test? For this research, it was hypothesized that (a) athletes participating in both unilateral and bilateral training programs would improve power, speed, and agility performance for Division I soccer players, and (b) unilateral training program would yield a greater performance improvement in power, speed, and agility measures, compared to the bilateral training group.

Potential Limitations

There are several potential limitations that could affect the results of this study and they are primarily due to the different coaching staffs and genders involved with the study. Like previously mentioned, the first limitation could be that the different coaching staffs have different practice styles, volume, and intensities as well as placing different values on physical capabilities. The Men's Soccer coaches were more traditional with shorter, high intensity practices, but they did not place as much value on the lifting program for the team. Conversely, the Women's

soccer coaching staff placed a huge emphasis on the physical performance side of soccer but they also conditioned more and practiced for a longer period of time during the week. Due to these factors, the male athlete's results may not be as high since the coaches do not place as high of an importance on the training whereas the female athlete's team may place higher value on it, but the team may be more fatigued and sore from the longer practices and running. Secondly, the two team's competition schedules in the spring could impact the training programs of the two teams. During the offseason, the teams played scrimmages against other teams, which could affect the increases in performance if training sessions could be missed or tapered down due to competition against other teams. In order to account for the different practice intensities and competition schedules, I have been in constant communication with the coaches to alter the programs for both groups as much as possible so that the training effect maintained as similar as possible between the male and female groups.

Significance

This specific research of a unilateral training program to improve power, speed, agility, and soccer performance compared to a traditional bilateral training program is relevant due to the fact that it combines current research on the positive influence of a specified training program on physical performance and what current elite soccer players are doing training-wise at the same time. If the hypotheses are supported and a unilateral training program is shown to be more effective on improving all of the physical variables tests, it could be implemented as a more beneficial way to train soccer players to obtain optimal performance on the field.

Definitions of Terms

Power: the amount of work produced by the body per unit of time and can be calculated as the product of force and velocity (Hedrick, 1993).

Strength: the ability to exert force under a given set of conditions defined by body position, the body movement by which force is applied, movement type (concentric, eccentric, isometric, plyometric) and movement speed (Harman, 1993).

Bilateral: having or relating to two sides, affecting the right and left sides of the body (Stevenson & Waite, 2011).

Unilateral: occurring on, performed on, or affecting one side of the body or one of its parts.

Speed: the magnitude of a velocity irrespective of direction.

Agility: the ability to quickly change direction of motion while maintaining proper balance.

CHAPTER II: LITERATURE REVIEW

When analyzing current lifting and training programs across the world for athletic populations, the main emphasis is always to improve strength & power, speed, and agility. In most athletic performance programs and in a majority of the research I found, the lower-body strength movements that are emphasized first and maximally loaded are bilateral compound movements such as Barbell Front and Back squats as well as Olympic movements such as Cleans, Snatches, and Jerks. In addition, most of the power and plyometric movements are bilateral movements in the sagittal plane such as double-leg vertical jump, depth jumps, and broad jumps. Only after these "main" movements are completed will programs advance to posterior chain, single leg, and stability movements. For this specific study, we will emphasize single leg movements first in the workouts for the experiment group and load them with similar loads and intensities as a normal bilateral movement would have in most training or research studies. Single leg strength and power development is secondary to bilateral compound movements in most of the researched training programs, and I believe that this could be altered to allow for the maximization of physical and soccer performance. The main single-leg strength movements we will use for the experimental group will be Single Leg Romanian Deadlifts, Bulgarian Split Squats, and Step-Ups. On the other hand, the comparison group will be using Front Squats, Trap Bar Deadlifts and Barbell Hip Thrusts as their main double-leg lifts. In this specific literature review section, we will look at existing research studies on soccer athletes and the relationship that plyometric, bilateral, and unilateral training programs have on power, speed, and agility. Finally, we will explore the relationship between improved physical measures and individual player and team success.

Plyometrics

Along with strength development and basic strength movements, a critical part of the training program that will be used to develop power in this study will be the implementation of plyometric movements. Plyometric training, which includes jumping, bounding, and hopping exercises, are movements that utilize the stretch-shortening cycle of the muscle (Thomas et al, 2009). Plyometrics have consistently been shown to improve the production of muscle force and power, especially the fast force production of the trained muscle (Thomas et al, 2009). Research by Vaszi et al concluded that plyometric training consisting of high impact unilateral and bilateral exercises induced substantial improvements in lower extremity power (Vaczi et al, 2013). More specifically, they found that rapid movements in soccer such as acceleration and deceleration of the body, changes of direction, as well as jumps are often performed and high level of dynamic muscular performance is required at all levels of training status (Vaczi et al, 2013). Plyometric training has been applied in numerous studies, and there is a general consensus that it improves sport specific skills such as agility, sprint and acceleration times, and vertical jump performance (Thomas et al, 2009).

After demonstrating the value of plyometrics on improving general performance measures, we then looked at studies that researched high level soccer players training programs utilizing plyometrics and the influence on power, speed, and agility. In one specific study, subjects who underwent plyometric training compared to a control group who did not participate in any plyometric exercises were able to improve their times significantly on both the T-test and Illinois agility test (Miller, Herniman, Ricard, Cheatham, & Micheal, 2006). More specifically, the t-test times were improved by 4.86% and 2.93% for the Illinois agility test (Miller et al, 2006). Meylan and Malatesta (2009) reported that an 8 week plyometric training program was

associated with significant results including a 7.9% increase in the countermovement jump, 2.1% significant decrease in 10 meter sprint time, and a 9.6% decrease in agility test time of youth soccer players compared to a control group. The authors also concluded that the short-term plyometric program had a beneficial impact on explosive actions, such as sprinting, change of direction, and jumping, which are important determinants of game-winning actions in soccer performance (Meylan & Malatesta, 2009). Finally, researchers have used a semiprofessional soccer club's academy players and randomly assigned them to 6 weeks of depth jump or countermovement training twice per week (Thomas, French, & Hayes, 2009). Both groups experienced improvements in vertical jump height ($p<.05$) and agility time ($p<.05$) and the study concluded that both depth jumps and countermovement plyometrics are worthwhile training activities for improving power and agility in youth soccer players (Thomas et al., 2009). Based on these findings, to increase lower-body power resulting in increased Vertical jump and kicking distance, strength coaches should implement once-weekly, low-impact plyometric training programs with their adolescent athletes (Rubley, Haase, Holcomb, Girouard, & Tandy, 2011). From the research, it is clear that an organized plyometric program implemented correctly could elicit significant improvements in power, speed, and agility.

Bilateral Training Effects

As discussed earlier, most research studies utilize bilateral exercises such as squats and olympic lifts as the main movements for their programs, so there was plenty of research on bilateral programs and effect on power, speed, and agility. One study used 17 international male soccer players from Rosenborg FC, which is the most successful team in Norway, winning the national league 11 years in a row (Wisloff, Castagna, Helgerud, Jones, & Hoff, 2004). They found that maximal strength had a strong correlation to 10 meter sprint time with $r = .94$, 30 meter

sprint time with r = .71 and vertical jumping height at r =.78 (Wisloff et al, 2004). From this study, it is concluded that elite soccer players should focus on maximal strength training with emphasis on maximal concentric movements, which may improve their sprinting and jumping performance (Wisloff et al, 2004). The next study used thirty-four young male soccer players and showed that absolute strength had the highest relationships with countermovement jump height ($r = .760$, $p < .001$) while relative strength showed the strongest relationship with 20 meter sprint times ($r = -.672$, $p < .001$) (Comfort, Stewart, Bloom, & Clarkson, 2014). The authors also reiterated the value of developing high levels of lower-body strength to improve sprint and jump performance in youth soccer players, with stronger athletes demonstrating superior sprint and jump performances (Comfort et al., 2014). A recent study researched 17 professional soccer players over a 6 week in-season strength training program, with the athletes improving their absolute and relative strength significantly (Styles, Matthews, Martyn, & Comfort, 2016). Other than increases in strength, this 6 week training program significantly improved 5 meter sprint times (before = 1.11 ± 0.04 seconds, after = 1.05 ± 0.05 seconds, $p \leq .001$), 10 meter sprint times (before = 1.83 ± 0.05 seconds, after = 1.78 ± 0.05 seconds, $p \leq .001$), and 20 meter sprint times (before = 3.09 ± 0.07 seconds, after = 3.05 ± 0.05 seconds, $p \leq .001$; Styles et al, 2016). Overall, most of the other studies show similar results that a bilateral training program using squats, deadlifts, and Olympic movements can improve strength, power, speed, and agility in an athletic population, but this specific study looked to find out if a unilateral based training program could show greater improvements in performance.

Unilateral Training Effects

With most training programs utilizing bilateral movements as their primary exercises in research studies, the research studies using unilateral training programs are limited, which is another reason why this specific study could have so much value. Young (2006) looked at several previous studies and concluded that unilateral exercises of the whole body elicit significant increases in sprint acceleration performance since sprinting involves unilateral contractions of the leg extensors resulting in total body movement in a horizontal direction. Young (2006) even referred to a 9 week program consisting of unilateral and horizontal plyometric movements that showed significant improvements of 10 meter sprint performance more than sprinting alone. Additionally, Fisher & Wallin (2014) produced a 6 week study of 15 collegiate rugby athletes using a unilateral or bilateral lifting and plyometric program and the impact on agility in the T-test and Illinois Agility Test and speed in the 10 meter sprint. Data analysis showed significantly greater improvements in the unilateral group for the T-test (p<0.05; UNI = -0.63 ± 0.36 seconds; BIL = -0.11 ± 0.03 second) and the Illinois Agility Test (p=0.050; UNI = -0.80 ± 0.25 seconds; BIL = -0.50 ± 0.06 seconds) compared to the bilateral training group. Conversely, there was a significant improvement in the change for the 10 meter sprint in the bilateral group compared to the unilateral group (p = .007; UNI = 0.01 ± 0.12 seconds; BIL = -0.07 ± 0.04 seconds). This specific study supports that unilateral resistance as well as plyometric training can be an effective method of improving change of direction performance beyond that of bilateral training alone (Fisher & Wallin, 2014). Going along with this, some of the literature that have utilized traditional strength and power training programs performing movement bilaterally in the vertical direction (e.g. Olympic-style lifts, squats, deadlifts, plyometrics, vertical jumping) have mostly failed to elicit improvements in change of direction performance (Brughelli et al, 2008). They state that unilat-

eral jump performance may be better related to change of direction ability since all change of direction tests described in that specific article require unilateral propulsion as a combination of vertical and horizontal ground reaction forces (Brughelli et al, 2008). On the other hand, Svenssion (2015) used 14 high national junior level male soccer players and assessed unilateral countermovement jumps and drop jumps on sprint speed at 0 - 30 meters. He found there was no relationship between the two unilateral jumps and any of the sprint distances and he stated that he could not recommend any of the specific jumps to improve performance on the acceleration phase or the top-speed phase (Svensson, 2015). Even though some of the research shows that a unilateral training program has value in improving power, speed, and agility, there is still not enough research to make a conclusive suggestion on the value of unilateral training programs on those performance variables. This warrants the need for the current study, and provides a strong rationale for its value to performance and sport coaches considering that it could be a practical and better alternative to traditional bilateral based training programs.

Performance Variables and Individual and Team Success

It has been shown overall that plyometrics, bilateral training programs, and unilateral training programs can improve power, speed, and agility for high level soccer players. The next important factor we are going to look at is if these improvements actually allow the individual and team to perform the sport of soccer at a higher level. Arnason et al (2004) conducted a study of over 306 soccer players from 17 teams in the two highest divisions of Icelandic professional soccer and found a significant relationship between team average jump height using a countermovement jump and team success defined by final league standing (Arnason et al, 2004). More specifically, the common slope of final team standing was significant ($B = -.36 \pm 0.12$) with

countermovement jump being the independent variable and final league standing being the dependent variable (Arnason et al, 2004). In addition, Kalapotharakos Strimpakos, Vithoulka, Karvounidis, Diamantopoulos, and Kapreli (2006) followed three professional soccer teams in the Greek Championship found that one of the best three teams in the league had higher running velocity, vertical jump nights compared to the middle and the least place team in the league.

From the speed perspective, several studies have compared the level of soccer player and the difference in their sprinting performances at 20 meters and there is a difference in speed between different levels of soccer players. Imamoglu et al. reported the 20-meter sprint values of professional and amateur soccer players as 2.95±0.17 seconds and 3.07±0.27 seconds (Imamoglu, Agaoglu, & Agaoglu, 2000). Secondly, Eniseler et al. reported values of 2.86 ± 0.10 seconds for premier league soccer players, 2.89 ± 0.07 seconds for second league soccer players, 2.94 ± 0.07 seconds for division 3 players, and 2.96 ± 0.08 seconds for amateur soccer players (Eniseler, Camliyer, & Gode, 1996). Third, Ziyagil et al. reported values of 2.99 ± 0.1 seconds for professional soccer players, and 3.24 ± 0.11 seconds for reserve team players (Ziyagil, Zorba, Sivrikaya, & Mercan, 1997). Alpay reported values of 2.84 ± 0.9 seconds for professional soccer players, and 2.97 ± 0.1 seconds for amateur soccer players (Alpay, 1999). Finally, Çebi reported values of 3.01 ± 0.1 seconds for professional soccer players, and 3.24 ± 0.1 seconds for amateur soccer players (Cebi, 1999). From each of these different studies, it is clear that higher level performers run faster 20 meter sprint times. Using multiple variables, one specific study showed that professional soccer players performed significantly higher than their U-17 counterparts in terms of maximal strength and vertical jumping performance (Lehance et al, 2009). Finally, in a study of 108 professional soccer players and 79 amateur soccer players on regional levels in Turkey, it

was concluded that professional soccer players' running speed and agility performance are statistically significantly higher than amateur soccer players (Kaplan, Erkmen, & Taskin, 2009). In conclusion, the existing research confirms that the best players and the best teams display the highest levels of speed, power, and agility and these are all valid measures to assess for individual and team soccer performance.

CHAPTER III: METHODOLOGY

Participants

Participants in the research are Division I soccer players at a local university in the Mid-Atlantic region of the United States. The university is a public institution with a total student enrollment of over 24,000 students. The university's athletic department competes in Conference USA, which is a Division I athletic conference from colleges and universities located in Virginia, North Carolina, Kentucky, Tennessee, West Virginia, Alabama, Florida, Louisiana, and Texas. For this specific study, there were 34 total participants with 17 of them male and 17 of them female with the ages being between 18 and 22. From a demographic perspective, the athletes involved in this study comprise a large amount of different nationalities and ethnicities with the majority of them being Caucasian (79.4%), 5.9% African American, 8.8% Hispanics, 5.9% multiethnic. Even though most of the players are from the U.S., there are athletes in this study who are originally from France, Australia, England, the Netherlands, Croatia, Czech Republic, and Spain. Since these athletes are high level or elite soccer players, their soccer playing age is very high with all of them playing for at least four years and most of them playing for at least 15 years in high competition, $M = 9.97 \pm 2.46$ years. On the other hand, the training age regarding conditioning and lifting is very scattered, $M = 3.24 \pm 1.33$ years, with a minimum of 1 year, and maximum of 6 years of strength and conditioning training.

Study Design

This study was a quasi-experimental, quantitative design that assessed two different training programs on athletes' speed, power, and agility that have been demonstrated to have a significance to on-field soccer performance. The participants were split into comparable pair groups of

two athletes based on pre-study speed, agility, power measures, and training age. From the selected pair groups, the participants were randomly split up into separate training groups with one of the players taking part in the unilateral training program with the other individual being placed in the bilateral training program. Since both teams had odd numbers of participants, there was one triplet group formed from each team that was created and then split up using the same criteria as the rest of the pair groups. Based on the existing measures of speed, agility, power, and training age, these participants were assigned to their pair (triplet) groups first and then randomly assigned to the training group to ensure equal, comparable groups for the study. Eventually, there were 18 athletes in the unilateral training group, and 16 in the bilateral training group.

Specifically, we examined power with a bilateral and unilateral vertical jump, speed with the 20 meter sprint, and agility with the T-Test Agility Test. All of these variables were assessed before and after the training cycle to measure the results and compare the two groups. We then analyzed the percentage of change between the pre-tests and post-tests on all of the metrics and then determined which training group had the most improvement in relationship to their strength and power program. To control for the other factors, the players' age, training age and playing experiences were collected through a questionnaire as auxiliary variables. The training programs for the unilateral and bilateral groups are detailed below, sharing identical intensity and duration.

Training Program

The training program for this study lasted 6 weeks long and took place during the offseason for the soccer teams. The participants followed the specified lifting/plyometric programs 3 days a week for the first 3 weeks and then 2 times per week the second 3 weeks when they start to have team soccer practice. Each training session included a total-body lift with the lower body portion being completed in the beginning of the workout so that the individuals were

fresher and since the lower body development has been determined as more critical for soccer performance. For each lift day, the dynamic warm-ups included the same for both groups with a combination of hip mobility, glute activation, knee stability, and ankle mobility exercises. After the dynamic warm-up, power movements such as the plyometric variations, Olympic Lifts, and speed-based drills were implemented as part of the planned progression of movements for the two groups. The plyometric variations were split into the single leg and double leg variations depending on training group, with the same volume of reps being done by each group. Once the dynamic warmup and power movements were completed, the groups moved onto the main part of the lift with the strength movements. The control group's main movements were Trap Bar Deadlifts (Figure 1), Glute Bridge / Hip Thrusts (Figure 2), and Barbell Front Squats (Figure 3). On the other hand, the main single-leg strength movements used for the experimental group were variations of Barbell Single Leg RDLs (Figure 4), Step-Ups (Figure 5), and Bulgarian Split Squats (Figure 6).

Figure 1. Trap Bar Deadlift: Bilateral Training Program

Figure 2. Barbell Hip Thrust / Glute Bridge: Bilateral Training Program

Figure 3. Barbell Front Squat: Bilateral Training Program

Figure 4. Barbell Single Leg RDL: Unilateral Training Program

Figure 5. Barbell Step-Ups: Unilateral Training Program

Figure 6. Barbell Bulgarian Split Squat: Unilateral Training Program

Even though the lifting and plyometric programs were the same for the two groups in the weight room based on what training group they were split up into, the practices were different between the men's and women's teams since the coaching staffs were separate. Going along with this, it was assumed that each team introduced and implemented speed and conditioning work into practice as well as jumping and plyometric variations since these variables were part of the

sport and had commonly been used during practice and training. These were likely not be planned and progressed in a typical manner and was determined by the specific coaches based upon practice and individual and team demands.

Measures and Instruments

As previously mentioned, the specific variables and tests were the single and double leg vertical jump to measure power output, 20 meter sprint to measure acceleration and maximal sprinting speed, and the T-Test to measure agility. Additionally, a questionnaire was distributed among the players to collect their demographic, training background, anthropometric information. These variables and how they were measured are described more in-depth below.

Vertical Jump

For this study, we conducted a unilateral and bilateral countermovement vertical jump test using the Just Jump Mats (Figure 7). The Just Jump system is widely used in the sports performance community and it consists of a 68.6 centimeter mobile square mat attached to a handheld computer (Christensen & Nordstrom, 2008). The Just Jump System determines jump height by measuring flight time, which is determined by micro switches located within the mat, which are sensitive to the liftoff of the feet from the mat and to the landing of the feet back on the mat. The flight time measurement can then be entered into a standardized equation, which estimates the jump height (jump height = $[t^2 \times g] \div 8$, where g = acceleration rate due to gravity (9.81 m s^{-2}) and t = flight time) (Nuzzo et al., 2001). Several studies have been conducted on the Just Jump mats and it has been concluded that it is a viable alternative for testing vertical jump based on the manufacturer's reported accuracy of ±0.5 inches (Christensen & Nordstrom, 2008). Furthermore, it has been concluded that the Just Jump mats demonstrate adequate intersession

reliability (i.e., session-to-session reliability) based on high intraclass correlation coefficients (ICCs) and low coefficient of variations (CVs) (Nuzzo et al., 2011). One specific study on the reliability of the Jump Mats that used 35 male and 35 female participants determined that the ICCs for the males were .87 to .93 for the highest jump and .89 to .93 for the average of the three jumps whereas the ICCs for the females were .87 to .94 for the highest jump and .90 to .95 for the average of the three jumps (Moir, Shastri, & Connaboy, 2008). Furthermore, the CVs between the sessions for the males were 4.0 to 5.6% for the highest jump and 4.2 to 5.2% for the average of the three jumps while the CVs between the sessions for the females were 4.4 to 6.6% for the highest jump and 4.1 to 6.03% for the average of the three jumps (Moir et al., 2008). Compared to other vertical jump tests, the Just Jump system is more efficient because there is no need to perform calculations to determine the jump height, thus making it a favorable method of testing large groups (Christensen & Nordstrom, 2008). Furthermore, traditional jump and reach tests such as the Vertec have "problems associated with jumping next to a wall, potential restrictions in shoulder flexibility, and the need to divide attention between the jumps and making a mark" (Klavora, 2000, p.73). In addition, it is relatively easy to simulate a lower initial reach for jump and reach tests where the athlete's initial reach must be obtained so that when this score is subtracted from the final vertical jump score, a higher (inaccurate) value needs to be obtained. Although having athletes reach with both arms to obtain an initial reach would appear to eliminate this potential problem, final measurements would be slightly inflated since the eventual jump and reach is performed with one arm and not two (Klavora, 2000). Overall, the Just Jump system does not allow for much human error with good accuracy because the system's computer determines vertical jump height and the subject is only required to perform the countermovement

jump with adequate technique and land back on the device's mat. The simplicity of the Just Jump test procedures could lead to improved accuracy in the measurement (Leard et al., 2007).

Figure 7. Just Jump Mat Example

20 Meter Sprint / T-Test Agility Test

For the speed and agility components of this study, we utilized an electronic testing system compared to a stopwatch due to the risk of user error and inconsistent results. The specific system was the Brower timing system, TC Model (Figure 8), which was a single-beam model that is commonly used in performance testing environments and a previously validated system (Haugen et al., 2014). Building on previous research, one specific study building by Waldron using elite rugby league players demonstrated that reliability was strongest for measuring 10 meter and 20 meter sprint speed. More specifically, the timing gates were found to be more reliable

than other testing systems with a concurrent validity of 1 - 1.54% compared to 4.69 – 5.16% validity for the GPS accelerator when testing for acceleration (Waldron et al., 2009). The higher reliability of the timing system in addition to the ease of use are the prime reasons that we used this testing device for measuring the 20 meter sprint test (Waldron et al., 2009).

Figure 8. Brower Timing System Example

To measure the 20 meter sprint in this specific study, the researchers measured 20 meters across the field and marked the distance with cones. Each student-athlete got three sprints using the electronic testing system and the fastest time was recorded. On the other hand, agility was assessed for this study by utilizing the T-Test (Figure 9). The T-Test is a commonly used "assessment that measures 4-dimensional agility and body control that evaluates the ability to change directions rapidly while maintaining balance without loss of speed" (Pauole et al, 2000, 444). The test is shaped like a "T" with a starting point 10 yards away from 3 cones that are separated by 5 yards in between (Pauole et al, 2000). The participants start from the starting line and starting at their own choice, sprint 10 yards straight forward and touch the cone, shuffle to

the left 5 yards to touch the cone, shuffle 10 yards to the right to touch the cone, shuffle 5 yards back to the left to the middle cone, and finally run backwards through the starting line as fast as they can (Pauole et al, 2000). From the same study, it was observed that the intraclass reliability of the T-Test was 0.98 across 3 trials and they concluded that the T-Test is a highly reliable test to measure agility and may be used to differentiate between those of low and high levels of sports participation (Pauole et al, 2000). In addition, another study found similar results and concluded that the Agility T-test is reliable test for use with subjects in a team sport environment, with intraclass correlation coefficients ranging from 0.82 to 0.96 for the Agility T-test (Munro & Herrington, 2011). For change of direction and agility tests, validity is difficult to prove because of the lack of a Gold Standard, but researchers "should use highly reliable tests, because these are the only tests that can also have high validity" (Hachana et al., 2013; p. 2752).

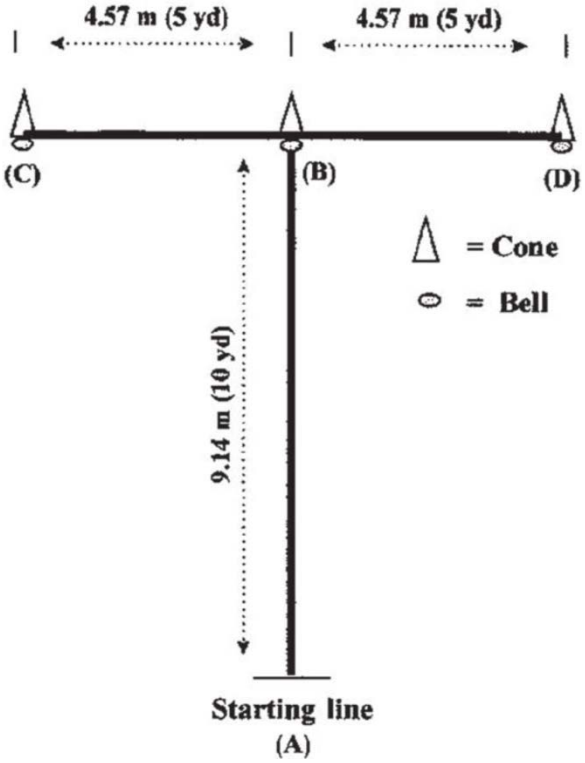

Figure 9. T-Agility Test

Questionnaire

A short questionnaire (Appendix A) was then used to collect the soccer players' demographic, anthropometric, and training background data. The questionnaire included short questions requesting players' information about their age, gender, ethnicity, height, weight, years of training, position (forward, midfielder, defense, etc.), competition at Division I level as well as their expectations for these performances. This data was used as descriptors and auxiliary variables to control for variability.

Data Collection and Procedures

After approval of the study protocols, the researcher obtained permission to perform research with specific human subjects from the University Human Subjects Review Committee. An application for the use of human subjects for research purposes was sent to the Darden College of Education Human Subject Committee at Old Dominion University. Furthermore, after approval, permission was obtained from the specific Athletic Department, athletes, and coaches. Information observed and collected will be kept confidential as outlined by the Old Dominion University Social and Behavioral Responsible Conduct of Research Modules. Reports including any personal information had all identifying characteristics removed and the use of pseudonyms were existent. The storage of all data prior to disposal are on a locked and secured computer system, with all of the data being destroyed after the project is finished.

In preparation for the research period, the researcher met with each of the participating administrators, coaches, and athletes to discuss the goals of the study and the specific training programs and protocols to be followed during both the bilateral and unilateral training sessions.

In addition, the specific sport coaches planed their practices and conditioning sessions to go along with the strength and power development experiment programs.

During the research period, athletes reported to lifting, practice, and conditioning sessions as regularly scheduled events and the sports performance and sport coaches informed them that a research study was being performed in the physical education department and their participation was voluntary, not required, and that the programs were designed to improve performance on the soccer field. With all of the athlete's being over the age of 18 at the initial start of the study, each athlete could give individual consent to take part in the study. Student-athletes who do not wish to participate in the study continued to perform all the training components with the rest of the teams, but their specific data were not collected by the researcher or included in the statistical analyses and final research report.

Prior to the start of the research, the student-athletes in the unilateral group were introduced to the program and different exercise variations that would be implemented compared to movements that take place in a traditional bilateral training program. The reason for this was to explain to each individual athlete how the unilateral training program worked, and how it potentially benefit them as an athlete. Furthermore, the unilateral training group was explained as a potentially better way to increase jumping height, sprinting speed, agility, and ultimately soccer performance since most of their sport is based off on one leg. On the other hand, the student-athletes in the bilateral training group were not required to be introduced to their specific program since it was a normal training program that they were already used to. In addition, all of the student-athletes underwent all of the specific tests such as the bilateral and unilateral vertical jump test to measure power, 20 meter sprint to measure speed, and T-Test to measure agility.

At the beginning of each training session, the student-athletes entered the weight room or practice field in their assigned groups and were given directions on what lift or movements they have for that day. The sports performance coach was trained in properly teaching and explaining the movements and the programs and also coaching throughout each session. As the research period started, the student-athletes should have a clear understanding why they were taking part in each specific program and how to follow each program to the best of their ability. The goal of both the bilateral and unilateral training groups was to develop their physical capabilities through the improvement of power, speed, and agility. Through participation in the research training sessions, these student-athletes are likely to improve physical performance, which would directly correlate to performance on the soccer field.

After the research period, each of the soccer student-athletes underwent the same tests that they took before the program started, which included the vertical jump tests, 20 meter sprint, and T-Agility Test. All of the participants completed each of the tests before they were dismissed from the study. The data collected by the performance coach was then given to the researcher at the end of the research study and it was transferred and kept in a confidential manner for future analysis.

Data Analysis

To answer the research questions, the following data analysis techniques were used. First, a descriptive data analysis was conducted to report the players' background as well as performance data and normality and variability of the variables. Secondly, a correlation analysis was conducted to check the level of correlation between the dependent variables, namely, agility, power, and speed. If needed, data transformation would be conducted to ensure distribution

symmetry such that parametric inferential analysis can be used. Specifically, if the dependent variables are significantly correlated, a multivariate analysis of covariance would be conducted to determine the effects of unilateral training on agility, power, and speed, in comparison with the bilateral training. Interaction effects such as gender would also be examined. These data analyses were conducted using IBM SPSS, and alpha were set at .05 for significance tests.

CHAPTER IV: RESULTS

The purpose of the present study was to examine the effects of a unilateral training program versus a bilateral training program implemented into an offseason program for collegiate soccer players. It was hypothesized that a unilateral-based strength and plyometric program would increase power measured in the single leg and double leg vertical jumps, speed measured in the 20 meter sprint, and agility in the T-Test compared to a control group utilizing an identical, but bilateral-based strength and plyometric program.

Thirty four members of the men's and women's soccer teams initially participated in this investigation. A high attrition rate of 29% was observed due to several lower body injuries from playing as well as resignation and dismissal from the teams. The male team lost 53% of their subjects, with almost half of them being dismissed from the team by the coach near the end of the offseason. Overall, the study ended up having only 24 full participants (12 in the bilateral, and 12 in the unilateral group) for all of the performance variables with another five participants who could participate in most of the performance variables depending on injury status.

Table 1. Demographic, Anthropomorphic, and Experience Information (M ± SD)

Variable	Group Total	Bilateral Group	Unilateral Group
Age (year)	19.79 ± 1.23	20.00 ± 1.15	19.61 ± 1.29
Height (m)	1.76 ± .09	1.76 ± .08	1.76 ± .09
Weight (kg)	70.69 ± 7.76	68.83 ± 7.92	71.59 ± 7.60
Years at DI Level	2.09 ± 0.87	2.13 ± 0.81	2.06 ± 0.94

Strength Training Age (year)	3.24 ± 1.33	3.50 ± 1.21	3.00 ± 1.41
Playing Experience (year)	9.97 ± 2.46	10.31 ± 1.96	9.67 ± 2.85

Following initial approval of the study, subjects completed a survey consisting of demographic, training history, and anthropomorphic questions, which are all displayed in Appendix A. As seen in Table 1, the average demographic, anthropometric, and training experiences are very similar between unilateral and bilateral groups ($p > .05$). The athletes were then tested on all of the performance variables, which include maximal double leg and single leg vertical jumps on the Jump Mat as well as the 20 meter sprint and T-Test using the Brower Timing System. Pre and post-test results of the single and double leg vertical jumps, 20 meter sprint, and T-Test are displayed on Table 2.

Table 2. Vertical Jump Testing, 20 meter sprint, and T-Agility Test Results (M ± SD)

Variable	Group Total	Bilateral Training Group	Unilateral Training Group
Pre-Test Bilateral Vertical Jump (cm)	54.35 ± 7.64	54.91 ± 7.01	54.23 ± 8.48
Post Test Bilateral Vertical Jump (cm)	56.21 ± 7.52	56.67 ± 7.84	55.78 ± 7.52
Pre-Test Right Leg Vertical Jump (cm)	34.44 ± 4.75	34.37 ± 5.44	34.54 ± 4.06

Post-Test Right Leg Vertical Jump (cm)	38.76 ± 4.57	38.89 ± 5.11	38.63 ± 4.19
Pre-Test Left Leg Vertical Jump (cm)	35.92 ± 5.28	36.32 ± 4.85	35.51 ± 5.82
Post-Test Left Leg Vertical Jump (cm)	39.65 ± 4.80	39.24 ± 5.03	40.08 ± 4.80
Pre-Test 20 meter sprint (seconds)	3.57 ± 0.20	3.54 ± 0.20	3.61 ± 0.21
Post-Test 20 meter sprint (seconds)	3.53 ± 0.19	3.47 ± 0.21	3.54 ± 0.19
Pre-Test T-Test (seconds)	10.79 ± 0.65	10.67 ± 0.69	10.93 ± 0.62
Post-Test T-Test (seconds)	10.71 ± 0.61	10.61 ± 0.69	10.81 ± 0.53

Vertical Jump

Power was measured using the Just Jump Mat. Participants were tested at the beginning and after the 6 week training programs. As seen in Figure 10, both of the training protocols resulted in improvements in the bilateral, right leg, and left leg vertical jumps heights. The total group of athletes using the unilateral-based program had an increase in their bilateral vertical jump compared to the increase in the control bilateral training group. The improvements were 5.26% higher in the experimental single leg training group compared to a 4.04% increase in the double leg training group. More specifically, the right leg had a 11.20% increase from the unilateral training program versus an 13.12% increase from the bilateral training program. On the other hand, there was an increase due to the unilateral training program compared to an increase on the left leg from the bilateral training program with 11.65% increase in the unilateral group

compared to a 9.77% increase in the bilateral training group. Overall, the unilateral group reported slightly higher percentage improvement compared to the bilateral group.

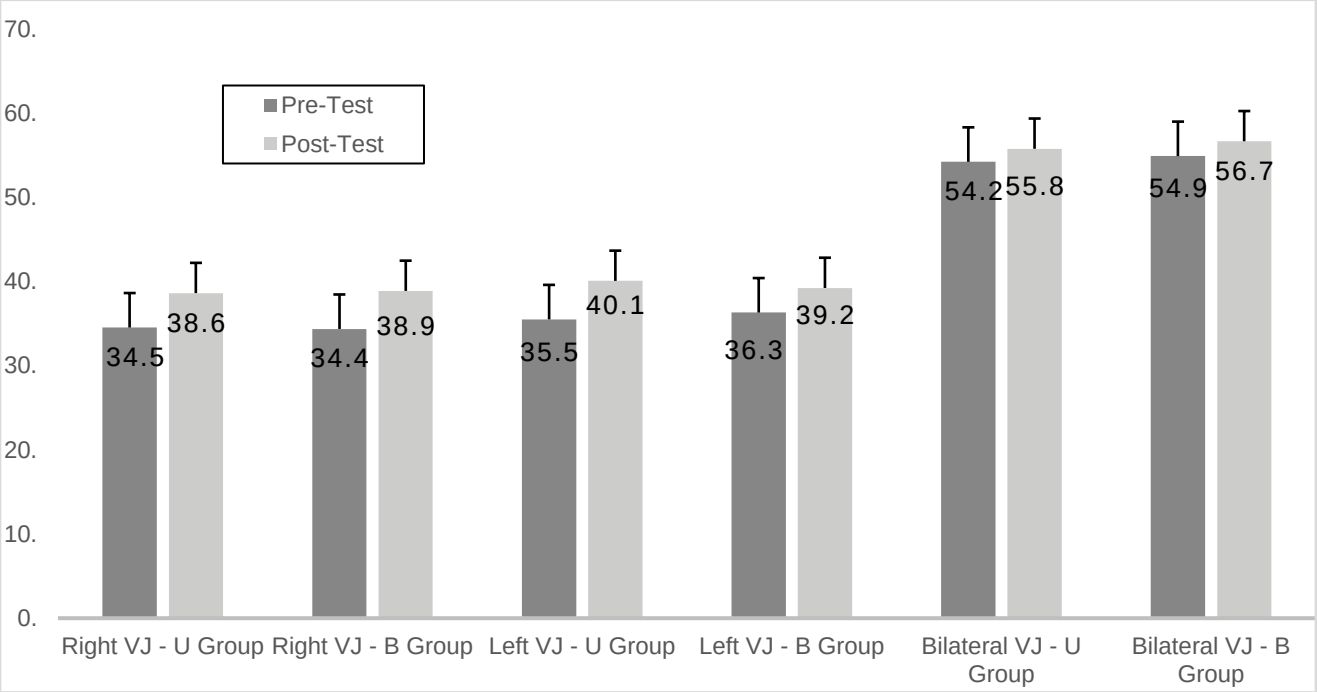

Figure 10. Vertical Jump Results in cm pre and post-test following the 6 week lifting and plyometric program

20 Meter Sprint

Speed was measured using the Brower Timing System at the beginning and after the 6 week training programs with similar results to the vertical jump. As seen in Figure 11, both of the training protocols resulted in improvements in the 20 meter sprint, but the bilateral training group had a greater decrease between the 20 meter sprint times than those in unilateral group. Specifically, the Unilateral group had a 1.99% decrease while the bilateral group had a 2.14% decrease in the 20 meter sprint.

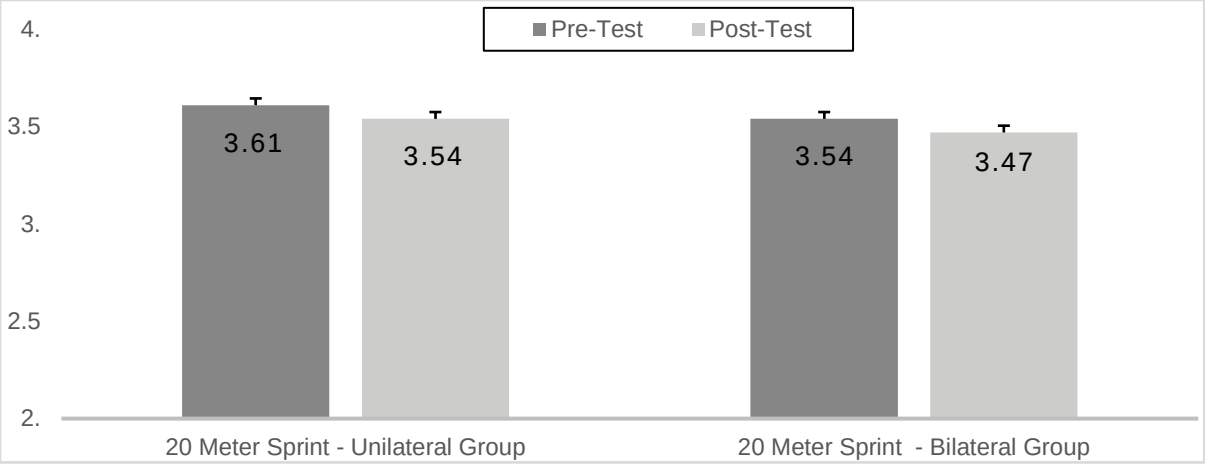

Figure 11. 20 Meter Sprint Results (in second) pre and post-test following the 6 week lifting and plyometric program

T-Test Agility Test

Agility was measured through T-test and participant completion time was recorded using the Brower Timing System. This time beginning and after the training programs with similar results to the vertical jump. As shown in Figure 12, both of the training protocols resulted in improvements in the T-Agility Test, but the bilateral training group had a bigger difference between the T-Agility Test times. Specifically, the unilateral group had a 0.43% decrease while the bilateral group had a 0.52% decrease in the T-Agility Test.

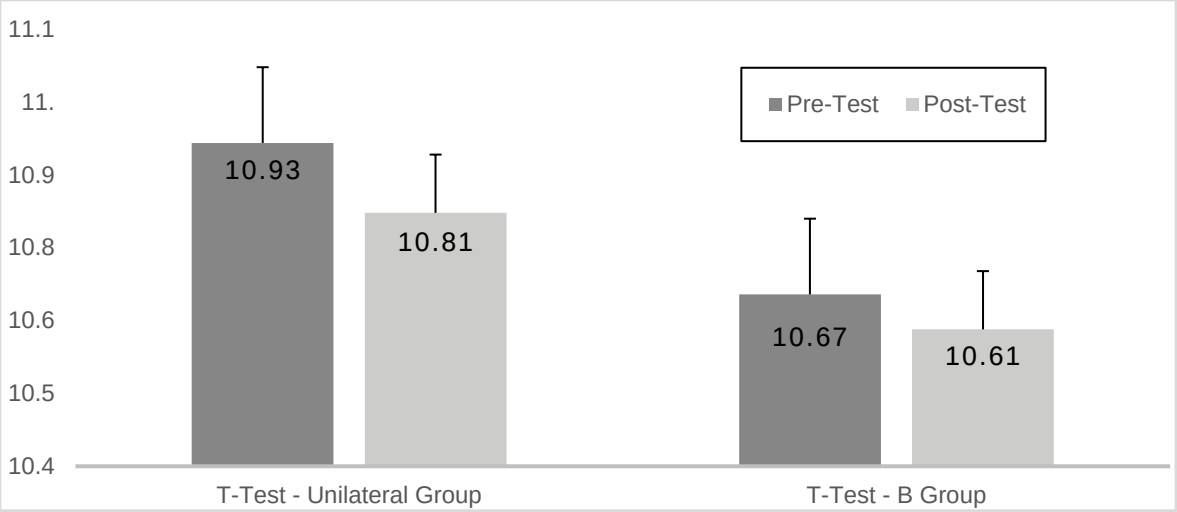

Figure 12. T-Agility Test results pre and post-test following the 6 week lifting and plyometric program in seconds

Is the Group Difference Significant?

Before testing for group difference significance, two assumptions were conducted and assumptions of equal covariance and error variances were assumed. Specifically, Levene's test of equality in error variances show that equal error variances between two groups in the testing variables are assumed, *p*s ≥ .09. Box's $M = 11.25$, $F = .56$, $p = 0.91$, showing that equality of covariance matrices were assumed. Additionally, I examined the correlation coefficient between pre post outcome measures, the results (Table 3) suggest that the variables are either moderately or highly correlated. As such, the multivariate covariance analysis of variances (MANCOVA) was conducted.

Table 3. Correlation Coefficients between Pre and Post Test Performances

Variable	2	3	4	5	6	7	8	9	10
1. Post DL	.72	.75	-.63	-.75	.95	.72	67	-.60	-.76
2. Post LDL	1	.80	-.52	-.58	.72	.81	.69	-.46	-.51
3.Post RDL		1	-.44	-.61	.70	.62	.66	-.41	-.53
4. Post 20m			1	.82	-.66	-.55	-.50	.98	.83
5. Post T test				1	-.71	-.59	-.68	.78	.99
6. Pre DL					1	.75	.70	-.62	-.71
7. Pre LDL						1	.64	-.55	-.60
8. Pre RDL							1	-.50	-.62
9. Pre 20m								1	.86
10. Pre T test									1

Note. All correlation coefficients significant at $p < .05$.

Using the pretest measures as covariance, group (unilateral vs bilateral) as the predicting variable, MANCOVA results showed that the pretest covariates were significant predictors for their corresponding posttest outcome. Adjusting for pretest performances, however, there was no significant difference in the posttest measures between these two training groups, Wilks' $\lambda = .88$, $F_{3,13} = .37$, $p = .86$.

Summary

Results of the six week intervention using both unilateral-based and bilateral-based lifting and plyometric programs showed an increase in all the performance measures of vertical jump, 20 meter run, and T test. Both groups showed an increase in power, speed, and agility. Even though the improvement in the unilateral group is mostly greater than the bilateral group, there were no significant differences between the groups that could conclude a unilateral-based training program was more effective than a bilateral training program in improving power, speed, and agility.

CHAPTER V: DISCUSSION

The purpose of the present study was to determine the effects of a unilateral training program versus a bilateral training program implemented into an offseason program for collegiate soccer players on power, speed, and agility. Most research in the past regarding improvements in power, speed, and agility for athletes have been developed based on a premise of using bilateral movements such as the back squat, Olympic lifts, and deadlifts. This appears contradictory since a majority of athletic movements in actual sport situations such as running, changing direction, and bounding are done using primarily one leg. Even though this is the case, there has been a limited amount of research on the benefit of unilateral-based training program and only several that have shown an actual benefit.

Specifically, a unilateral based training program for soccer players would be relevant since when a player dribbles, passes, or shoots the ball, one leg is dominant to forcefully move the ball and the other leg is used to support the body weight (Oshita & Yano, 2010). Although the effectiveness of a unilateral based training program remains unclear, several studies have shown improvements in power, speed, and agility (Fisher & Wallin, 2014; Young, 2006; Brughelli et al., 2008). Based on the previous section, this specific study improves on previous research and demonstrated that a unilateral based training program could have success in improving power, speed, and agility even though it may not improve more than a traditional bilateral training program. The findings in this study were in general consistent with the existing findings, but could not provide empirical evidence to support that unilateral training reaps significantly greater gain than bilateral training. This study is a step in the right direction in terms of maximizing athletic performance and training high level and elite athletes, but more research has to be done on the effectiveness of single leg training with athletes.

Bilateral and Unilateral Vertical Jump

With such an emphasis on strength and plyometric movements in the training programs, it was hypothesized that the jumping measurements would increase the most for both groups and the unilateral group would have similar, if not better, improvements. All three of the jumping tests increased significantly in both groups over the 6 week program with a 5.26% increase in the single leg training group compared to a 4.04% increase in the double leg training group. In addition, the right leg had an 11.20% increase in the unilateral training program versus an 13.12% increase from the bilateral training program. Finally, there was an 11.65% increase in the left leg from the unilateral group compared to a 9.77% increase in the left leg from the bilateral training group. After looking over all of the vertical jump percentage increases, it initially shows how impactful a solid training program based on strength and plyometric can be for power development of athletes, especially soccer players. When comparing the groups, the results did not completely support what the initial hypothesis on the power improvement.

Looking at the bilateral vertical jump, the increase by the unilateral training program was much more (5.26%) than the bilateral training group (4.04%). When trying to explore reasons for the differences in the two groups especially with the one strictly using double leg movements and jumps having a lower increase, we had to look at some of the other variables. The three variables that could help explain the reasoning by this would be the chronological age, playing experience, and also strength training age. The unilateral group was almost half a year younger in both age ($19.61 < 20$) and strength training age ($3 < 3.5$) with also much less competitive playing experience ($9.67 < 10.31$). With the unilateral group being younger in all three of those aspects, they most likely have lower strength, coordination, and body control levels. This less trained

state compared to the bilateral training group would allow them to be more responsive to a training stimulus than athletes who are older and have trained more, even if their focus is on a different outcome.

For soccer players, they all label their dominant foot as the one that they primarily use therefore feel stronger kicking with. In this specific data pool, 82.4% of the subjects stated that they were right foot dominant while only 17.6% of the subject said they were dominant with their left foot. In contrast, the strong leg for strength and power purposes that has to brace the body and plant into the ground would be the opposite leg. For example, if a player kicks with the right leg, they have to plant and lift the entire weight of the body on the left leg. This would technically make their left leg their stronger and more trained leg. From our results, it makes sense that the unilateral training group had a higher increase in the right leg since it was more untrained and that group primarily used single leg training in their workouts. On the other hand, the much higher increase on the left leg from the bilateral group could be the body using that side more for all of the main lifts and jumps like it always has whereas the unilateral training group is spending more time and energy on how to use the right leg more efficiently and effectively. These findings back up how important single leg training is and the huge improvements with each leg and also both training groups show how untrained athletes are from a single leg perspective and how underutilized it is as a training tool.

These findings support previous studies using strength and plyometric training programs focused on improving vertical jump performance in youth athletes, primarily soccer players. One article that found similar results was the Thomas study, which compared a six-week training program using depth jumps and countermovement jumps on speed and power in 12 male youth soccer players (Thomas et al., 2009). This study was also randomized between the groups and

similar to our study as it took place when the participants took part in soccer sessions at least 4 times per week and each of the participants had played competitive soccer for at least 4 years They concluded that both groups had increases in vertical jump due to the depth jump and countermovement jump training programs (Thomas et al., 2009). Even though they didn't measure unilateral training versus bilateral training programs, both groups showed increases in jump performance similarly to our current study. Several other studies also found similar results showing vertical jump performance was improved from a strength and plyometric program in high school or college aged soccer athletes (Gorostiaga et al., 2004; Myer et al., 2005; Wisloff et al., 2004).

Expanding on a standard strength program improving vertical jump performance, the next study that was beneficial to our findings was a 6 week study that used 20 female Division-I soccer players in Spain since there isn't much research done on female soccer players. It was found that the plyometric group using unilateral and bilateral plyometrics had significant improvements in vertical jump height after 6 weeks compared to the control group not using plyometric training (Campo et al., 2009). The one major difference between the Campo et al.'s study and the current one was the fact that there was no weight lifting program involved in either training group, which was the main factor being investigated during our current study. This study had partial significance to explaining our results since it included unilateral and bilateral plyometric movements as well as a similar population, sample size, and duration, but it still missed the weight lifting portion. Similarly to our study, Vasci et al. (2013) used a 6 week program with male athletes of similar age to compare a unilateral and bilateral plyometric training program on vertical jump performance. They concluded that the "plyometric training consisting of high impact unilateral and bilateral exercises induced remarkable improvements in lower extremity power measured in vertical jump performance" (Vasci et al., 2013, p. 20). Even though there hasn't been any other

specific research on a single leg versus a double leg lifting and plyometric training program on vertical jump performance, our study found similar improvements to vertical jump performance as compared to standard 6-12 week strength training and plyometric programs on college aged soccer players. Hopefully, this research is the start of more studies in the future that compare bilateral and unilateral training techniques to measure improvements in physical and athletics performance variables.

20 Meter Sprint

Both training protocols in this study resulted in improvements in the 20 meter sprint, but the bilateral training group had a bigger difference between the 20 meter sprint times with a 1.99% decrease in the unilateral group and 2.14% decrease in the bilateral group. As the literature review had stated, research has shown that increased strength and power have a positive impact on speed and the hypothesis was that the 20 meter sprint times would increase over the six week training program. Our results were supported by prior research that demonstrated that sprint times would improve following a plyometric and resistance based training program in high school athletes (Myer et al., 2005). Even though our results were similar to findings in Myer et al. (2005), our improvements were not as drastic since we did not include a specific speed training portion as part of our intervention programs. Moreover, our results also coincided with the increased strength and improved speed in international male soccer players participating in Wisloff et al.'s (2004) study. The setup was slightly different though since we did not have a specific measure for maximal strength and only assumed that the athletes got stronger after taking part in the 6 week training program, which led to the improvements in speed.

Compared to the jump measures, the speed variable (20 meter run) increased much less and there was not as much difference between the two groups. Regardless what training program

the athletes were on, they would have seen a small increase due to the amount of running they did on a regular basis as part of practice, and the fact they may approach speed plateau. Both teams practiced 3-5 times per week with sprinting as a major part of practice each day. After looking at this specific variable, I think it could be concluded that the bilateral and unilateral training programs had a minor effect on the increases in speed, but the larger impact was the sprinting and conditioning as part of practice multiple times per week. Even though the practice was known to be taking place every day, the sessions were completely independent each day and ranged from 90 to 150 minutes, which could have played a role in the performance measures and lifting sessions all throughout the whole program.

T-Agility Test

One hypothesis for this program was that with an increase in strength and power due to a 6 week lifting and plyometric program (while also conditioning and practicing on a regular basis), the participants' agility measured by the T-Test would increase. As discussed previously, both of the training protocols resulted in minor improvements with no significance in the T-Agility Test over 6 weeks, with the unilateral group having a 0.43% decrease compared to a 0.52% decrease in bilateral group. Compared to all of the other measures we researched, the T-Test Agility scores showed the least amount of improvement after the 6 weeks and also between the two groups. Even though the results were very small and insignificant, this is not surprising since it has been shown in other studies that strength and plyometric training programs have a small, if not unconnected impact on change of direction or agility. It has even been supported that agility and speed could be independent from each other and that an "agility program should be specific and independent from strength and speed training programs" (Alves et al., 2010, p. 937). Furthermore, since this training program only specifically focused on the strength and

plyometric component of physical training and not on any agility training, the small increases in both groups make sense. As shown by this specific study and also from other research, it would be expected that for the agility component to be increased significantly, the training program should actually train the change of direction and agility component.

The general results were similar to previous studies that have shown strength and plyometric programs can lead to improvements in agility compared to a control group measured in the T-Agility Test. Two separate 6 week programs that both used youth / college-aged male soccer players found that bilateral and unilateral plyometric training programs can lead to decreases in T-Agility Test times (Thomas et al., 2009; Vasci et al., 2013) compared to control groups. With our study comparing unilateral and bilateral lifting programs as the separate study groups and also using agility as a variable measured even though we didn't train it specifically during the study, it has become clear that our results could not be fully supported by previous research. Based on previous studies on male and female college or professional soccer players, our study made an assumption that increased strength and power would lead to improved agility scores, specifically the T-Agility test. Our study was different than any other study since we basically had two experimental groups and no true “control” group, with the main difference being the specific training technique being used. This led to both groups having a consistent training stimulus and as predicted, both groups decreased their T-Agility Test times even though we couldn't significantly say which group improved by a higher or more significant margin. Our study design was also interesting and different because we did not implement any agility training as part of either group’s training program but still measured the T-Agility Test and recorded overall improvements. In the future, more unilateral versus bilateral study designs would have a lot of value for continued progress in physical development for athletic performance improvement.

Limitations

The present study contained several limitations which may have contributed to the results observed. First, this study finished with a relatively small sample size of 24 participants, which could not make the results completely representative of all collegiate soccer players. Secondly, the unilateral group took significantly longer (approximately 10-15 minutes) to complete each training session since they basically had double the reps of each of their main exercises. Due to this, the bilateral group had less total time training per session and that could have added total fatigue and stress on the unilateral group after the 6 week program. Third, in the present study, subjects in both groups were still expected to participate in soccer practice on a daily basis. Based on this study measuring maximal effort and high intensity variables, playing and conditioning could have affected the mindset, focus levels, and body "freshness" of all of the participants and possibly negatively impacted the variables we were measuring. Fourth, there were uncontrolled canceled sessions. The men's soccer coaches as well as the women's soccer coaches both cancelled one training session during the 6 week intervention period while also limited several other sessions due to the athletes being "fatigued" or "sore". More specifically, each coach cancelled the last planned training session of the program due to a competition on the following weekend. Even though all of the athletes were still exposed to the same sessions, this could have had an impact on the results that we saw and limited the increases we might have seen. Finally, limited strength training experience could be a factor. Even though there was improvements by both groups over the 6 week training program, this improvement could have been due to a low training age with results being mostly due to neurological changes and not as much physiological changes.

Conclusion

The main findings of this study suggests that the use of a unilateral-based lifting and plyometric program as part of a comprehensive six week offseason strength and conditioning program can improve power measured by single leg and double leg vertical jumps, 20 meter sprint speed, and Agility T-Test speed for Division I male and female soccer players. Even though the results were similar compared to the control and a traditional bilateral-based training program, a unilateral-based training program should be considered a potential method for improving strength, power, and speed. The unilateral group showed a slightly better, though not significant performance improvement in the tests. This could be beneficial for athletes, especially soccer players since they would be exposed to more movements that could transfer over more specifically to the sport that they play and are training for. In addition, a unilateral based program could also be inserted into a full program and used as a completely different training tool. Furthermore, these methods could be intermittently used as a separate training tool for different macrocycles depending on the season and or specific goals for the athlete.

Recommendations for Future Research

Based upon the finding of this investigation, future research involving a lifting and plyometric program based on unilateral training for soccer players or any athlete should consider the following factors.

First, there is a need to lengthen the duration of the training program. This recommendation is based on previous studies that have shown that longer interventions have led to larger improvements in Vertical Jump, 20 Meter Sprint, and T-Agility Test. For example, Chelly et al. (2009) revealed a 10% improvement in squat jump performance after a 8 week training program

whereas Campo et al. (2009) demonstrated a 12.8% increase in countermovement group over a 12 week lifting program. Sprint-wise, Hoff and Helegrud (2004) found that an 8 week training program increased 20 meter sprint speed by 1.8% and that sprint speed increased almost by 2 meters over 20 meters. Finally, from a review, there has been reported a 3.6% time improvement after 12 weeks of training and a 2.8% decrease in T-Agility Test time over 15 weeks of training (Brughelli et al., 2010). The previous research is relevant since the duration of the training program in this investigation was approximately six weeks and it took place during an offseason where the athletes were still participating in team practice and conditioning on a regular basis. It would be of interest to explore the effects of a unilateral training program using these modalities if participants were exposed to more training sessions using this specific program. Participants in the unilateral training program had not participated in this specific type of training prior and showed a high adherence rate to the specific training method. However, the lack of a significant difference between the two groups possibly could have been due to subjects' pre-existing high level of continuous training state. Therefore, based on the encouraging trends of the unilateral training group in this study and more successful previous study interventions, a longer training program could be necessary (i.e. 10-12 weeks).

Second, future research should consider increasing the frequency of exposure to unilateral (vs bilateral) training. In this study, subjects were exposed to single leg training three days a week for three weeks and only two days a week for three weeks. It would be interesting to explore the effects increasing the frequency of training sessions to at least three days per week for the entire program and also having the sport coach implement some of the plyometric or strength movements as part of team practice during the program.

Third, future research should utilize separate exercises that are similar movement patterns with the only difference being whether it is double or single leg variation. More specifically, the three movements could be Barbell RDLs and Barbell Single Leg RDLS, trap bar deadlifts versus trap bar Bulgarian split squats, and barbell double leg hip thruster versus barbell single leg Glute Bridge. This small change to the movements could make the results even more valid and reliable with the comparison really being whether it was single leg or double leg and not the exact movement.

Fourth, future research should assess different sports that incorporate different types of athletes. Since soccer has such a complex set of energy systems used and a lot of soccer programs prioritize endurance training and not strength training, it would be of interest to use different types of athletes especially strength athletes like football and baseball to see if there would be more of an improvement than soccer. Most other sports require unilateral movement also so the basis of this particular study would still have relevance on other sports and other types of athletes. Conducting research using other sport athletes could also improve the validity and reliability of unilateral training movements versus bilateral training movements on a large scale across all performance training programs.

Finally, research is needed to explore gender as a key variable in the research. Even though I used both genders as part of the participant sample, it was mainly used to increase the total amount of participants. After the study was completed, it was observed that the female participants had higher response rates and percentages of improvement, especially for the single leg jump test. This is an interesting result since the ages, strength and conditioning training ages, and competitive soccer history between the two gender groups were very similar before the study

began. This could show an actual different response rate between the two genders and it could be a valuable area to study for performance improvements for athletes in the future.

References

Alves, J. M. V. M., Rebelo, A. N., Abrantes, C., & Sampaio, J. (2010). Short-term effects of complex and contrast training in soccer players' vertical jump, sprint, and agility abilities. *The Journal of Strength & Conditioning Research*, *24*(8), 936-941.

Alpay, F. (1999). *Evaluation of performance cause of fatigue on repeated sprints of soccer players* (Unpublished Master's Thesis). Ondokuz Mayis University, Samsun, Turkey.

Arnason, A., Sigurdsson, S. B., Gudmundsson, A., Holme, I., Engebretsen, L., & Bahr, R. (2004). Physical fitness, injuries, and team performance in soccer. *Medicine & Science in Sports & Exercise*, *36*(2), 278-285.

Brughelli, M., Cronin, J., Levin, G., & Chaouachi, A. (2008). Understanding change of direction ability in sport. *Sports Medicine*, *38*(12), 1045-1063.

Campo, S. S., Vaeyens, R., Philippaerts, R. M., Redondo, J. C., de Benito, A. M., & Cuadrado, G. (2009). Effects of lower-limb plyometric training on body composition, explosive strength, and kicking speed in female soccer players. *The Journal of Strength & Conditioning Research*, *23*(6), 1714-1722.

Çebi M (1999). *Comparison of anthropometric and physiological parameters in professional And amateur soccer players*. Samsun, Turkey: Institute of Health Sciences, Ondokuz Mayis University. Unpublished Master's Thesis.

Chelly, M. S., Fathloun, M., Cherif, N., Amar, M. B., Tabka, Z., & Van Praagh, E. (2009). Ef fects of a back squat training program on leg power, jump, and sprint performances in junior soccer players. *The Journal of Strength & Conditioning Research*, *23*(8), 2241-2249.

Christensen, B. K., & Nordstrom, B. J. (2008). The effects of proprioceptive neuromuscular fa cilitation and dynamic stretching techniques on vertical jump performance. *The Journal of Strength & Conditioning Research*, *22*(6), 1826-1831.

Comfort, P., Stewart, A., Bloom, L., & Clarkson, B. (2014). Relationships between strength, sprint, and jump performance in well-trained youth soccer players. *The Journal of Strength & Conditioning Research*, *28*(1), 173-177.

Dictionary, M. W. (2006). *The Merriam-Webster Dictionary*. Merriam-Webster, Incorporated.

Eniseler N, Çamliyer H, & Göde O (1996). Comparison of 30 meter sprint performance of foot

ballers in different leagues according to their Positions. *Journal of Technology & Football Science, 3*,3–9.

Fisher, J., & Wallin, M. (2014). Unilateral versus Bilateral Lower-body Resistance and Plyometric Training for Change of Direction Speed. *Journal of Athletic Enhancement, 3*(6*)*, 1-5.

Gorostiaga, E. M., Izquierdo, M., Ruesta, M., Iribarren, J., Gonzalez-Badillo, J. J., & Ibanez, J. (2004). Strength training effects on physical performance and serum hormones in young soccer players. *European Journal of Applied Physiology, 91*(5), 698-707.

Hachana, Y., Chaabene, H., Nabli, M. A., Moualhi, J., Farhat, H., & Elloumi, M. (2013). Test-retest reliability, criterion-related validity, and minimal detectable change of the Illinois agility test in male team sport athletes. *The Journal of Strength & Conditioning Research, 27*(10), 2752-2759.

Harman, E. (1993). EXERCISE PHYSIOLOGY: Strength and Power: A Definition of Terms. *Strength & Conditioning Journal, 15*(6), 18-21.

Haugen, T. A., Tønnessen, E., Svendsen, I. S., & Seiler, S. (2014). Sprint time differences between single-and dual-beam timing systems. *The Journal of Strength & Conditioning Research*, *28*(8), 2376-2379.

Hedrick, A. (1993). Strength Training: Literature Review: High Speed Resistance Training. *Strength & Conditioning Journal*, *15*(6), 22-30.

Hoff, J., & Helgerud, J. (2004). Endurance and strength training for soccer players. *Sports Medicine*, *34*(3), 165-180.

Imamoglu, O., Agaoglu, SA, & Agaoglu, YS. (2000). Comparison of Sprint and Reaction Times of Professional and Amateur Football Players. I. *Gazi Physical Education and Sport Sciences Congress*, I, 101–108.

Kalapotharakos, V. I., Strimpakos, N., Vithoulka, I., & Karvounidis, C. (2006). Physiological characteristics of elite professional soccer teams of different ranking. *Journal of Sports Medicine and Physical Fitness*, *46*(4), 515-519.

Kaplan, T., Erkmen, N., & Taskin, H. (2009). The evaluation of the running speed and agility performance in professional and amateur soccer players. *The Journal of Strength & Conditioning Research*, *23*(3), 774-778.

Klavora, P. (2000). Vertical-jump tests: a critical review. *Strength & Conditioning Journal*, *22*(5), 70-75.

Leard, J. S., Cirillo, M. A., Katsnelson, E., Kimiatek, D. A., Miller, T. W., Trebincevic, K., & Garbalosa, J. C. (2007). Validity of two alternative systems for measuring vertical jump height. *The Journal of Strength & Conditioning Research*, *21*(4), 1296-1299.

Lehance, C., Binet, J., Bury, T., & Croisier, J. L. (2009). Muscular strength, functional performances and injury risk in professional and junior elite soccer players. *Scandinavian Journal of Medicine & Science in sports*, *19*(2), 243-251.

Lockie, R. G., Callaghan, S. J., Berry, S. P., Cooke, E. R., Jordan, C. A., Luczo, T. M., & Jeffriess, M. D. (2014). Relationship between unilateral jumping ability and asymmetry on multidirectional speed in team-sport athletes. *The Journal of Strength & Conditioning Research*, *28*(12), 3557-3566.

Meylan, C., & Malatesta, D. (2009). Effects of in-season plyometric training within soccer practice on explosive actions of young players. *The Journal of Strength & Conditioning Research*, *23*(9), 2605-2613.

Miller, M. G., Herniman, J. J., Ricard, M. D., Cheatham, C. C., & Michael, T. J. (2006). The ef fects of a 6-week plyometric training program on agility. *Journal of Sports Science and Medicine*, *5*(3), 459-465.

Moir, G., Shastri, P., & Connaboy, C. (2008). Intersession reliability of vertical jump height in women and men. *The Journal of Strength & Conditioning Research*, *22*(6), 1779-1784.

Munro, A. G., & Herrington, L. C. (2011). Between-session reliability of four hop tests and the agility T-test. *The Journal of Strength & Conditioning Research*, *25*(5), 1470-1477.

Myer, G. D., Ford, K. R., Palumbo, J. P., & Hewett, T. E. (2005). Neuromuscular training improves performance and lower-extremity biomechanics in female athletes. *Journal of Strength and conditioning Research*, *19*(1), 51-60.

Nuzzo, J. L., Anning, J. H., & Scharfenberg, J. M. (2011). The reliability of three devices used for measuring vertical jump height. *The Journal of Strength & Conditioning Research*, *25*(9), 2580-2590.

Oshita K, & Yano S. (2010). Asymmetry of force fluctuation during low intensity isometric con

traction in leg muscle. *International Journal of Exercise Science, 3*(2), 68-77.

Pauole, K., Madole, K., & GARHAMMER, I. (2000). College-Aged Men and Women. *Journal of strength and conditioning research, 14*(4), 443-150.

Rampinini, E., Bishop, D., Marcora, S. M., Bravo, D. F., Sassi, R., & Impellizzeri, F. M. (2007). Validity of simple field tests as indicators of match-related physical performance in top-level professional soccer players. *International Journal of Sports Medicine, 28*(3), 228-235.

Reilly, T & Thomas, V. (1976). A motion analysis of work-rate in different positional roles in professional football match-play. *Journal of Human Movement Studies, 2*(2), 87–97.

Rubley, M. D., Haase, A. C., Holcomb, W. R., Girouard, T. J., & Tandy, R. D. (2011). The effect of plyometric training on power and kicking distance in female adolescent soccer players. *The Journal of Strength & Conditioning Research*, *25*(1), 129-134.

Siegler, J., Gaskill, S., & Ruby, B. (2003). Changes evaluated in soccer-specific power endur ance either with or without a 10-week, in-season, intermittent, high-intensity training pro tocol. *The Journal of Strength & Conditioning Research*, *17*(2), 379-387.

Stevenson, A., & Waite, M. (Eds.). (2011). *Concise Oxford English Dictionary*: Book & CD-ROM Set. Oxford University Press.

Stolen, T, Chamari, K, Castagna, C, and Wisloff, U. (2005) Physiology of soccer: An update. *Sports Medicine, 35*, 501–536.

Styles, W. J., Matthews, M. J., & Comfort, P. (2016). Effects of Strength Training on Squat and Sprint Performance in Soccer Players. *The Journal of Strength & Conditioning Research*, *30*(6), 1534-1539.

Svensson, P. (2015). *A correlation study between unilateral countermovement jumps, unilateral drop jumps and different sprint distances*. Halmstad University. Unpublished Thesis.

Thomas, K., French, D., & Hayes, P. R. (2009). The effect of two plyometric training techniques on muscular power and agility in youth soccer players. *The Journal of Strength & Conditioning Research*, *23*(1), 332-335.

Váczi, M., Tollár, J., Meszler, B., Juhász, I., & Karsai, I. (2013). Short-term high intensity

plyometric training program improves strength, power and agility in male soccer players. *Journal of Human Kinetics*, *36*(1), 17-26.

Waldron, M., Worsfold, P., Twist, C., & Lamb, K. (2011). Concurrent validity and test–retest reliability of a global positioning system (GPS) and timing gates to assess sprint performance variables. *Journal of Sports Sciences*, *29*(15), 1613-1619.

Wisløff, U., Castagna, C., Helgerud, J., Jones, R., & Hoff, J. (2004). Strong correlation of maximal squat strength with sprint performance and vertical jump height in elite soccer players. *British Journal of Sports Medicine*, *38*(3), 285-288.

Young, W. B. (2006). Transfer of strength and power training to sports performance. *International Journal of Sports Physiology and Performance*, *1*(2), 74-83.

Ziyagil, MA, Zorba, E., Sivrikaya, K., & Mercan, M. (1997). Analysis of somatotype and speed performance of Trabzonspor footballers in different age groups. *Journal of Technology & Football Science*, *4*, 28–31.

Appendix A

Training and Play Experiences

Gender [circle one]: Female Male

Height: _____ feet _____ inches

Weight: _____ pounds

Dominant Foot [circle one]: Right Left

Athletic Class [circle one]: Freshman Sophomore Junior Senior

Ethnicity [Circle one]:

African American Asian Caucasian Hispanic Native American Other: _____

Age: _____ years old.

Years playing at the Division I level: _____

Years Playing and Training for Competitive Soccer: _____Years

Years participating in regular/formal strength and conditioning program: _____

Years.

Main position [circle one]: Forward Midfield Defense Goalkeeper

Double Leg Vertical Jump Prediction: _____ inches

Right Leg Vertical Jump Prediction: _____ inches

Left Leg Vertical Jump Prediction: _____ inches

20 Meter Sprint Prediction: _____ seconds

T-Test Agility Test Prediction: _____ seconds

Through six weeks of training, I expect a _____ % increase in double leg vertical jump, _____ % increase in right and left leg vertical jump, _____ % decrease in 20 meter sprint time, and _____ % decrease in T-Test Agility Test.

Appendix B

Sample Unilateral Training Program

15 Yard DYNAMIC WARMUP - Each Active Exercise is Down & Back

Jog >> 75% Strider >> Knee Hugs >> Quad Pull w/ Toe Reach >> Skip for Height >> Frankensteins >> Carioke facing same direction >> Sprint ***+ 10 meter Maximal sprint x 5***

Glute Activation: Band X-Walks: 2 x 10 steps laterally each direction / Knee Prep: TKEs: 2 x 20 each leg / Ankle Mobility: Band 3 Way Ankle: 2 x 10 each direction

Plyos	**Single Leg (SL) Plyometric Work**	SL Vert Jumps - 2 x 5 each SL Broad Jump to Opposite Foot - 2 x 5 each		SL Vert Jumps - 2 x 5 each SL Broad Jump to Opposite Foot - 2 x 5 each		SL Vert Jumps - 2 x 5 each SL Broad Jump to Opposite Foot - 2 x 5 each		SL Vert Jumps - 3 x 5 each SL Broad Jump to Same Foot - 3 x 5 each		SL Vert Jumps - 3 x 5 each SL Broad Jump to Same Foot - 3 x 5 each		SL Vert Jumps - 3 x 5 each SL Broad Jump to Same Foot - 3 x 5 each	
Olympic	**Hang Cleans**	4 x 5 (Technique)		4 x 5 (Technique)		4 x 4 (Technique)		4 x 4 (Technique)		4 x 3 (Technique)		4 x 3 (Technique)	
Main UL MVMT	**Barbell Bulgarian Split Squats**		x8 each		x8 each		x8 each		x8 each		x6 each		x6 each
			x8 each		x8 each		x8 each		x8 each		x6 each		x6 each
			x8 each		x8 each		x6 each		x6 each		x4 each		x4 each
			x8 each		x8 each		x6 each		x6 each		x4 each		x4 each
							x6 each		x6 each		x4 each		x4 each
											x4 each		x4 each
B1	**Trap Bar Deadlifts**	2 x 10		2 x 10		2 x 8		2 x 8		2 x 6		2 x 6	
B2	**Glute Hams**	2 x 10		2 x 10		WTD - 2 x 8		WTD - 2 x 8		WTD - 2 x 6		WTD - 2 x 6	
B3	**Pistol Squats**	2 x 10 each		2 x 10 each		WTD - 2 x 8 each		WTD - 2 x 8 each		WTD - 2 x 6 each		WTD - 2 x 6 each	

---

15 Yard DYNAMIC WARMUP - Each Active Exercise is Down & Back

Jog >> 75% Strider >> Knee Hugs >> Quad Pull w/ Toe Reach >> Skip for Height >> Frankensteins >> Carioke facing same direction >> Sprint >> Sprint >> ***+ 40 meter Maximal sprint x 4***

Glute Activation: Birddog Series: 2 x10 each (Leg up / Circles Frwd / Circles Bkwrd / Kick Back) / Knee Prep: Peterson Step Downs - 2 x10 each / Ankle Mobility: SL Calf Raises / Toe ups - 2 x10 each

Plyos	**Single Leg (SL) Plyometric Work**	Lateral Bounds - 2 x 5 each 3" Rebound SL Jumps to Small Box - 2 x 5 each		Lateral Bounds - 2 x 5 each 3" Rebound SL Jumps to Small Box - 2 x 5 each		Lateral Bounds - 2 x 5 each 3" Rebound SL Jumps to Small Box - 2 x 5 each		Rebound Lateral Bounds - 2 x 5 each 6" Rebound SL Jumps to Small Box - 2 x 5 each		Rebound Lateral Bounds - 2 x 5 each 6" Rebound SL Jumps to Small Box - 2 x 5 each		Rebound Lateral Bounds - 2 x 5 each 6" Rebound SL Jumps to Small Box - 2 x 5 each	
Olympic	**Power Cleans**	5, 5, 3, 3		5, 5, 3, 3		4, 4, 2, 2		4, 4, 2, 2		4, 4, 2, 2, 1, 1		4, 4, 2, 2, 1, 1	
Main UL MVMT	**Barbell Step-Ups**		x8 each		x8 each		x8 each		x8 each		x6 each		x6 each
			x8 each		x8 each		x8 each		x8 each		x6 each		x6 each
			x8 each		x8 each		x6 each		x6 each		x4 each		x4 each
			x8 each		x8 each		x6 each		x6 each		x4 each		x4 each
							x6 each		x6 each		x4 each		x4 each
											x4 each		x4 each
B1	**Back Squats**	2 x 10		2 x 10		2 x 8		2 x 8		2 x 6		2 x 6	
B2	**Razor Curls**	2 x 10		2 x 10		WTD - 2 x 8		WTD - 2 x 8		WTD - 2 x 6		WTD - 2 x 6	
B3	**Skater Squats**	2 x 10 each		2 x 10 each		WTD - 2 x 8 each		WTD - 2 x 8 each		WTD - 2 x 6 each		WTD - 2 x 6 each	

---

15 Yard DYNAMIC WARMUP - Each Active Exercise is Down & Back

Jog >> 75% Strider >> Knee Hugs >> Quad Pull w/ Toe Reach >> Skip for Height >> Frankensteins >> Carioke facing same direction >> Sprint >> Sprint ***+ Pro-Agility Test x 5 reps***

Glute Activation: Band X-Walks: 2 x 10 steps laterally each direction / Knee Prep: TKEs: 2 x 20 each leg / Ankle Mobility: Band 3 Way Ankle: 2 x 10 each direction

Main UL MVMT	**Barbell Single Leg Romanian Deadlifts**		x8 each		x8 each		x6 each
			x8 each		x8 each		x6 each
			x8 each		x8 each		x6 each
			x8 each		x8 each		x6 each
			x8 each		x6 each		x6 each
			x8 each		x6 each		x6 each
B1	**Barbell Hip Thrusts**	2 x 10		2 x 10		2 x 10	
B2	**Leg Curls**	2 x 10		2 x 10		2 x 10	
B3	**Split Squats**	2 x 10 each		2 x 10 each		2 x 10 each	

Appendix C

Sample Bilateral Training Program

15 Yard DYNAMIC WARMUP - Each Active Exercise is Down & Back

Jog >> 75% Strider >> Knee Hugs >> Quad Pull w/ Toe Reach >> Skip for Height >> Frankensteins >> Carioke facing same direction >> Sprint ***+ 10 meter Maximal sprint x 5***

Glute Activation: Band X-Walks: 2 x 10 steps laterally each direction / Knee Prep: TKEs: 2 x 20 each leg / Ankle Mobility: Band 3 Way Ankle: 2 x 10 each direction

Plyos	**Double Leg (DL) Plyometric Work**	DL Vert Jumps - 2 x 5 DL Broad Jump - 2 x 5		DL Vert Jumps - 2 x 5 DL Broad Jump - 2 x 5		DL Vert Jumps - 2 x 5 DL Broad Jump - 2 x 5		DL Vert Jumps - 3 x 5 DL Broad Jump - 3 x 5		DL Vert Jumps - 3 x 5 DL Broad Jump - 3 x 5		DL Vert Jumps - 3 x 5 DL Broad Jump - 3 x 5	
Olympic	**Hang Cleans**	4 x 5 (Technique)		4 x 5 (Technique)		4 x 4 (Technique)		4 x 4 (Technique)		4 x 3 (Technique)		4 x 3 (Technique)	
Main BL MVMT	**Trap Bar Deadlifts**		x8		x8		x8		x8		x6		x6
			x8		x8		x8		x8		x6		x6
			x8		x8		x6		x6		x4		x4
			x8		x8		x6		x6		x4		x4
							x6		x6		x4		x4
											x4		x4
B1	**Barbell Bulgarian Split**	2 x 10 each		2 x 10 each		2 x 8 each		2 x 8 each		2 x 6 each		2 x 6 each	
B2	**Glute Hams**	2 x 10		2 x 10		WTD - 2 x 8		WTD - 2 x 8		WTD - 2 x 6		WTD - 2 x 6	
B3	**Pistol Squats**	2 x 10 each		2 x 10 each		WTD - 2 x 8 each		WTD - 2 x 8 each		WTD - 2 x 6 each		WTD - 2 x 6 each	

---

15 Yard DYNAMIC WARMUP - Each Active Exercise is Down & Back

Jog >> 75% Strider >> Knee Hugs >> Quad Pull w/ Toe Reach >> Skip for Height >> Frankensteins >> Carioke facing same direction >> Sprint >> Sprint >> ***+ 40 meter Maximal sprint x 4***

Glute Activation: Birddog Series: 2 x10 each (Leg up / Circles Frwd / Circles Bkwrd / Kick Back) / Knee Prep: Peterson Step Downs - 2 x10 each / Ankle Mobility: SL Calf Raises / Toe ups - 2 x10 each

Plyos	**Double Leg (DL) Plyometric Work**	DL Lateral Bounds - 2 x 5 each way 6" Rebound DL Jumps to Small Box - 2 x 5		DL Lateral Bounds - 2 x 5 each way 6" Rebound DL Jumps to Small Box - 2 x 5		DL Lateral Bounds - 2 x 5 each way 6" Rebound DL Jumps to Small Box - 2 x 5		DL Rebound Lateral Hops - 3 x 5 each way 12" Rebound DL Jumps to Small Box - 3 x 5		DL Rebound Lateral Hops - 3 x 5 each way 12" Rebound DL Jumps to Small Box - 3 x 5		DL Rebound Lateral Hops - 3 x 5 each way 12" Rebound DL Jumps to Small Box - 3 x 5	
Olympic	**Power Cleans**	5, 5, 3, 3		5, 5, 3, 3		4, 4, 2, 2		4, 4, 2, 2		4, 4, 2, 2, 1, 1		4, 4, 2, 2, 1, 1	
Main BL MVMT	**Back Squats**		x8		x8		x8		x8		x6		x6
			x8		x8		x8		x8		x6		x6
			x8		x8		x6		x6		x4		x4
			x8		x8		x6		x6		x4		x4
							x6		x6		x4		x4
											x4		x4
B1	**Barbell Step-Ups**	2 x 10 each		2 x 10 each		2 x 8 each		2 x 8 each		2 x 6 each		2 x 6 each	
B2	**Razor Curls**	2 x 10		2 x 10		WTD - 2 x 8		WTD - 2 x 8		WTD - 2 x 6		WTD - 2 x 6	
B3	**Skater Squats**	2 x 10 each		2 x 10 each		WTD - 2 x 8 each		WTD - 2 x 8 each		WTD - 2 x 6 each		WTD - 2 x 6 each	

---

15 Yard DYNAMIC WARMUP - Each Active Exercise is Down & Back

Jog >> 75% Strider >> Knee Hugs >> Quad Pull w/ Toe Reach >> Skip for Height >> Frankensteins >> Carioke facing same direction >> Sprint >> Sprint ***+ Pro-Agility Test x 5 reps***

Glute Activation: Band X-Walks: 2 x 10 steps laterally each direction / Knee Prep: TKEs: 2 x 20 each leg / Ankle Mobility: Band 3 Way Ankle: 2 x 10 each direction

Main BL MVMT	**Barbell Hip Thrusts**		x8		x8		x6
			x8		x8		x6
			x8		x8		x6
			x8		x8		x6
			x8		x6		x6
			x8		x6		x6
B1	**Barbell Single Leg RDLs**	2 x 10 each		2 x 10 each		2 x 10 each	
B2	**Leg Curls**	2 x 10		2 x 10		2 x 10	
B3	**Split Squats**	2 x 10 each		2 x 10 each		2 x 10 each	

Appendix D

Personal Resume

Eric Potter, CSCS, USAW
223 Broad Street, Portsmouth, VA 23707
Phone: 757-683-3375 Email: epotter@odu.edu

EXPERIENCE

Old Dominion University, Norfolk, VA **July 2016 – Current**
Associate Director of Sports Performance
- Directly responsible for strength and conditioning programs for Men's Basketball, Men's Soccer, Women's Soccer, Men's Golf, and Women's Golf
- Oversee Sports Performance yearly budget and nutrition and supplementation programs

Old Dominion University, Norfolk, VA **August 2013 – July 2016**
Assistant Director of Sports Performance
- Directly responsible for strength and conditioning programs for Baseball, Wrestling, and Women's Soccer
- Assisted with implementation of strength and conditioning and testing programs for Men's Basketball

Old Dominion University, Norfolk, VA **January 2013 – August 2013**
Strength and Conditioning Intern
- Assisted with strength and conditioning programs for Football and Field Hockey
- Directed the Jim Jarrett weight room on an interim basis from May to August 2013

Mid-Atlantic Sports Academy, Millersville, MD **August 2011 – March 2012**
Strength and Conditioning Coach
- Directed strength and conditioning programs for over 30 high school basketball players
- Coordinated the scheduling and set up for over 20 youth sports team's practices and conditioning sessions

Oakland Athletics Baseball Organization, Arizona & Vermont **June 2011 - June 2012**
Professional Baseball Player
- Drafted in the 19th round of the 2011 MLB Draft by the Oakland Athletics
- Participated in strength program focused on Functional Movement Screen and corrective exercises

EDUCATION

University of Maryland - B.S. in Kinesiology: May 2011
Old Dominion University - M.S. Ed. in Physical Education, Coaching Emphasis: Fall 2017

CERTIFICATIONS

National Strength and Conditioning Association (NSCA) - (CSCS)
United States Weightlifting (USAW) - Level I Sports Performance Coach
Precision Nutrition (PN) – Precision Nutrition Level 1 Certified (PN1)