Influence of Vertical Jump Kinetics on Change of Direction Ability

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A Thesis

By

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Abstract

PURPOSE: The purpose of this study is to analyze the relationship between a female athlete's vertical jump and her ability to change direction. METHODS: Sixty Division II female athletes (mean±SD; age= 19.40±1.32; mass= 68.42±11.63kg; height= 169.95±8.67cm) completed body composition testing on the InBody 770© bioelectrical impedance device, performed a countermovement jump (CMJ) and static jump (SJ) on dual force plates, then participated in the 5-0-5 agility test and T-Test, respectively. RESULTS: A strong negative correlation was found between the 5-0-5 agility test and countermovement jump (r= -.421) and the t-test (r= -.557). The static jump and 5-0-5 test also produced a negative correlation r= (-.463) as well as the static jump and t-test (r= -.580). Further, participants exemplified a positive correlation between percent body fat and times for the 5-0-5 (r= .429) and t-test (r= .443). CONCLUSIONS: Those who produced the most power and had the highest vertical jump were also the fastest sprinters in this study when presented with change-of-direction tasks. Lower body power is the best predictor of vertical jump height and change-of-direction speed. PRACTICAL APPLICATION: One important finding is the significant negative correlation between jump height and change-of-direction speed. The results suggest that athletes who produce more power in the vertical direction will also change direction faster. Athletes may look to improve their power output by using strength training exercises such as the squat, deadlift, clean, lunge, etc.

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Introduction

Field and court-based sports often require repetitive, quick movements, both anticipated and unanticipated, during competition. (Bourgeois et al. 2017). Therefore, the ability of an athlete to change direction quickly and with proper mechanics is very important for sports that require change-of-direction (COD). Speed, strength, power and agility are all physical components that play a role in making an athlete successful, however, for COD tasks, power and strength may play a larger role. According to Sheppard and Young (2006), COD ability is determined by technique, leg muscle qualities, and straight sprinting speed. Expanding on this, leg muscle qualities include strength, power, and reactive strength, a fast stretch shortening cycle, which provides reason to believe that increasing power and lower body strength would increase an athlete's ability to change direction.

Several studies have assessed multiple jumping techniques and compared the results to an athlete's ability to change direction using a variety of COD tests jumping assessments may include, but are not limited to, broad jumping, countermovement jumps, static jumps, drop jumps, and vertical jumps (bilateral and unilateral). Forms of agility testing include, but are not limited to, the 5-0-5 agility test, the T-test, the Illinois test, the shuttle run, and the zig-zag test.

Research Questions

- What is the relationship between a bilateral countermovement jump and change of direction ability?
- Does a participant with greater vertical jump height perform agility drills at a faster pace?
- Does a participant with a greater amount of lower body muscle mass jump higher and/or change direction faster?

- Do participants who jump lower and performed the change of direction drills slower have a greater percent body fat?

Hypothesis

- A relationship between a bilateral vertical countermovement jump and change of direction ability should be negatively correlated.
- The higher that a participant jumps, the quicker they should perform agility tests that involve change of direction.
- Participants with greater lower body muscle mass should be able to perform the bilateral vertical countermovement jump higher and change direction faster than those with less lower body muscle mass.
- Participants who jump lower and run should have a greater percent body fat.

Literature Review

Athletes and their workout regimens and protocols are constantly evolving. Strength and conditioning coaches are persistently looking for new and improved ways to help their athletes compete at their peak performance. Improving speed, agility and strength may be examined to help strength and conditioning coaches and athletes customize their workouts to develop certain characteristics to improve their sport performance. The purpose of correlating a jump test to an athlete's change of direction ability is due to the vast amounts of power that are produced with jumping through the activation of the stretch-shortening cycle. "Muscular power is the main determinant of success in many activities and sports" (Meylan et al., 2009). Many of the articles tested a variety of jumps and change of direction patterns as well as acceleration tests.

With that being said, many studies differ in their methods for testing these categories of physical ability, but the purposes for each are all related through the use of different testing procedures to find the best ways for each athlete or sports team to train. Some studies may include several types of jumps or several agility drills, while others only explore a few. In order to evaluate the relationship between change of direction (COD) and jumping, many tests may be used. For example, researchers may choose from a variety of change of direction assessments (COD) such as the 5-0-5 agility test, the T-test, the modified agility test (MAT), etc. Each of these agility drills have been used in research such as Jones et al, (2014) with the drop jump and 5-0-5 test, Lockie et al (2018) with the vertical jump, T-test, and 5-0-5 test, Gabbett et al (2008) with the vertical jump, T-test, and reactive agility test. Researchers may choose each of these tests for a variety of reasons, but with athletes, the specific test may be chosen to display the movements that are most comparable to the skills performed in the specific sport being tested. To test an athletes' ability to vertical jump, they may use a series of tests involving the typical bilateral vertical jump on a switch mat or force plates, unilateral vertical jump to test the differences between each leg, the drop jump, and several types of horizontal or countermovement jumps may be used to help collect further data.

Very few studies involving bilateral vertical jumping and its effect on an athlete's ability to change direction have focused on women's athletics. For example, Swinton, et al. and Yanci et al. (2014) each tested all men, non-professional rugby players (thirty) and soccer players (thirty-nine), respectively. Similar to these two studies, Bourgeois et al. (2014) performed their study on twenty males from a variety of team and individual sports such as rugby, football, basketball, cricket, and weightlifting. Meylan et al. (2009) tested eighty university students who all participated in recreational physical activities, which consisted of forty-four men and thirty-six women, similar to Gabbett et al (2008), whose study involved six males and eight females. Therefore, out of all five reports above only about 24% of subjects tested were female. Sekulic et al (2013) tested a total of 32 college-aged males and 31 college-aged females for their balance, speed and power. This study found significant differences ($p<0.05$) in agility performance, body weight and height, and balance between men and women. Tests performed included the T-test, the Zig-Zag test, the 20yard test, T180 test, the Forward Backward test, the squat jump test, two balance tests, a 10 meter sprint, and a 20 meter sprint. Men performed better in all agility tests and were taller and heavier. However, women performed better in both balance tests (OSI and BBS). Therefore, it is possible that genders should be isolated in studies (Sekulic et al 2013). Previous research has evaluated a participant's ability to change direction that do not use change of direction in their sport. Aside from mostly men being tested, another aspect that could improve this research topic would be to showcase more sports such as volleyball, tennis, lacrosse, and comparable sports at the collegiate level as well.

The availability of anthropometric data, such as with the InBody, may help researchers conclude why more power could be generated through one leg over the other. For those reports that did not measure anthropometrics, there is no way of comparing athletes with similar scores but different phenotypic traits. Maloney et al (2016) studied the effect of stiffness and asymmetries on an athlete's ability to effectively change direction. They found that vertical stiffness was the best "predictor of COD according to the regression model as greater stiffness led to quicker to performance…the regression analyses also revealed that asymmetry in single leg drop jump height ($p=.001$ and $r = 0.60$) was the second strongest predictor of COD performance". Further, Nimphus et al (2010) studied the relationship between strength, power, speed, and change of direction performance of female softball players. Results of this study revealed a very strong correlation between speed, strength, and change of direction ability ($p<0.05$ and $r=-.73$ to $-.85$). Increases in strength and power translate into performance during sport. If improvements in strength did not translate over to the playing surface, then sports coaches would be less inclined to incorporating resistance training into their training. Increasing strength may improve jumping, sprinting, change of direction, sports performance, and potentiation according to Suchomel et al's (2016) meta-analysis. Further, resistance training may reduce injury rates by increasing the strength of tendons, ligaments, and muscles (Suchomel et al 2016). Moreover, Young et al (2002) had participants perform a squat with a predetermined depth and explode up as fast as possible so that leg extension power could be determined. Then, reactive strength was assessed using a drop jump and several sprint tests were performed (straight sprint, single COD 20-degree, 40-degree, 60-degree left/right, four COD of 60-degree with two left and two right). The entire sample showed right leg dominance and turned left faster. Spiteri et al (2013) also studied COD and its relationship to isometric strength testing and found that stronger athletes displayed greater peak vertical propulsive force and horizontal braking force than weaker athletes. Kawamori et al (2013) tested ground reaction forces between an eight meter sprint and a ten meter sprint. Participants were required to perform a 10m sprint and then the correlations of ground reaction force impulses were evaluated with sprint times. "At 8m from the start, relative net horizontal and propulsive impulses had significant correlations with 10m sprint time, but relative resultant, vertical and braking impulses did not" (Kawamori et al, 2013).

For Meylan et al.'s (2009) subjects, one day of testing began with a dynamic warm up which involved 3 x 10m sprints at 75%, 85%, and 100% of each participant's maximal sprint speed. Then, all eighty participants were given three practice trials for each jump assessment (unilateral vertical, horizontal and lateral on dominant leg), then they were allowed three test trials and the best two were recorded and averaged for further analysis. During each jump test, subjects were required to keep their hands on their hips to prevent the arm swing from skewing the data. After jumping, the 10m sprint and two change of direction sprints (one with the dominant and one with non-dominant) were executed. Each participant was allowed two practice trials and two test trials of each of the three tests. All of the sprints and change of direction assessments were calculated through timing light gates and results found that the best predictor of COD and sprint performance was the horizontal countermovement jump. However, the only jump that was not significantly relevant to the ten meter sprint time was the lateral countermovement jump (Meylan et al, 2009).

Chaouachi et al. (2012) conducted a similar study comparing the countermovement jump and quintuple horizontal jump test to the athletes ability to change direction in the T-test (including side shuffles) and the 5mSS (sprint/sprint) test which involves sprinting out five meters, making a 180-degree turn and sprinting back to the starting line. However, Chaouachi et al's (2012) study took testing a step further by including isokinetic concentric and eccentric knee extensor and flexor strength testing. When analyzed, the results took Sheppard and Young's multicomponent model (referenced) to the next level, stating that the leg muscle qualities that they proposed as a factor of change of direction ability could be further analyzed. "Change of direction ability involves fast acceleration that converts into sudden decelerations requiring high-eccentric strength gradients," (Chaouachi et al.2012). Although eccentric strength is proposed to influence CODA, this study only found a marginal significance (did not reach the threshold of significance) between muscle power and strength and their influence on CODA, but Jones et. al., (2009) found a significant correlation between eccentric knee flexor strength and COD performance (r^2= 0.392, p =0.006). Jones et al, (2009) attributed athlete's COD performance to their strength as well as their straight line sprint time. In addition, a strong correlation was also found between drop jumps, CMJ, 5-0-5, 5m sprint, leg press and other eccentric and concentric strengths (Jones et al, 2009). In Chaouachi et al's (2012) study, the results only showed significance between the CMJ and the 5mSS ($p=0.027$, $r^2=0.50$), which may be due to the low number of direction changes. Further, the angle of the direction change must be taken into consideration. The greater the angle, the more time it will take to change direction (Buchheit et al. 2012).

Castillo-Rodriguez et al (2012) and Cronin and Hansen (2005) both tested the countermovement jump (CMJ) and drop jump while comparing the two to change of direction and sprint time, respectively. Castillo-Rodriguez et al (2012) had 45 male participants perform drop jumps and both bilateral and unilateral countermovement jumps and analyzed their performance with their ability to change direction at a 90-degree angle to the left and right, as well as perform a 180-degree turn using stepwise regression analysis. When analyzed, results conveyed a negative correlation between all COD and jump tests (except the CMJL) which means that the greater the explosive strength of the individual, the less time the COD task took. Significant correlations were also found primarily with right-leg dominant individuals and their ability to change direction to the left by pushing off of their right foot (Castillo-Rodriquez et al, 2012). Further, Cronin and Hansen's (2005) comparison of the drop jump and countermovement jumps to sprint performance also yielded a high correlation. The CMJ can be recognized as a slow stretch-shortening cycle (SSC) while the drop jump (DJ) can be thought of as a fast SSC. Although the CMJ is thought to be slow, according to Cronin and Hansen (2005), the CMJ and the jump squat resulted in the highest correlations with sprint performance (r=-.56 to -.66). Intuitively, one would expect to see a strong correlation between maximal squat strength and jump measures, as well as sprint performance. However, Cronin and Hansen did not find the 3RM squat to be significantly relevant to jumping performance, but there was a relationship between squat strength and torques at the hamstring and quadriceps during sprints.

Yanci et al(2014), Gabbett et al, (2008) and Bourgeois et al, (2017) all used the test-retest method or simply collected their data on two separate occasions. For the soccer players in Yanci et al.'s report, the first day consisted of the athletes familiarizing themselves with the testing protocol, collection of anthropometrics, 5, 10 and 15m sprints, and three change of direction/agility tests (MAT, 5-0-5, and 20y). During the second session, the vertical and horizontal jump tests were completed, then the data collected was used to determine the relationships between each jump, change of direction and sprint split times. According to Yanci et al.'s findings, "significant correlations (p<.05) were found between all horizontal jump tests and the MAT (r=-.40 to -.69) or the 5-0-5 test (r=-.44 to -.58), and between all vertical jump tests and the Y20 test (r=-.36 to -.52) or the 5-0-5 test (r=-.38 to -.62) (Yanci et al.). Similarly, Bourgeois and his team also completed their testing in two days through the test-retest method, with the first day involving change of direction tasks at 180 degrees and 45 degrees. A 5-0-5 was used for two practical reasons; less space required and the relationship that 180-degree turns have during team sports such as basketball, soccer, lacrosse, etc. Next, the 45-degree cut was performed, again to target a task more specific to team sports. However, with this task, the angle of the sprint path after the change of direction step was measured with a goniometer and tape. Timing gates and a high speed digital camera were used to accurately measure the sprint times of each assessment. After change of direction capability was tested, the subjects completed a multidirectional jump assessment (horizontal bilateral jump) in which they began on one foot and jumped 45 degrees to the side and landed on two feet, facing the new direction (Bourgeois et al., 2017). Timing gates and a high speed camera were used to calculate the distance and speed of the jumps when imported into kinematic software. Last, for the two day collections, Gabbett et. al., (2008) tested the effects of open and closed skilled warm up methods "on the performance of speed, change of direction speed, vertical jump, and reactive agility in team sport athletes". Although not directly correlated with the other sources of interest, each of these subjects performed the vertical jump using a Yardstick vertical jump device, 5,10, and 20m sprints calculated by timing gates, the T-test using timing gates, and the reactive agility test. The reactive agility tests requires participants to listen and respond to cues for change of direction during their trial (Gabbett et al.). Similar to Gabbett et al's study, Lockie et al's study (2018) was comprised of the vertical jump, ten-meter sprint, modified t-test (MTT), and the 5-0-5 test. For Division II athletes, a significant correlation was found between the MTT ($p<0.05$) and the 5-0-5 test ($p<0.01$) with vertical jump height (r=--.52 and .66 respectively), and for division I athletes, the 5-0-5 negatively correlated ($p<0.01$) with the jump height (r=-.65) (Lockie et al. 2018).

Chiang (2014) also tested division I female soccer athletes and evaluated the lower body strength and power characteristics influencing change of direction. Participants of this study performed vertical jump and isometric mid-thigh pull testing following a predetermined warm up. Then, COD tests were performed (modified 5-0-5), and 10m sprint tests were performed at least 24 hours after COD tests. Results conveyed moderate to very strong negative correlations between COD and vertical jump variables ($p<0.05$, r= -.41 to -.81) (Chiang, 2014). Magrini et al (2017) evaluated squat jump performance and its ability to differentiate between starters and nonstarters in division I female soccer players. Three squat jump trials were performed and the height was measured by flight time. However, no significant correlation was found between squat jump height and starters vs. nonstarters. Using the agility tests, Illinois test and Pro Agility Test, Vescovi and McGuigan (2008) tested female athletes (high school soccer, college soccer, college lacrosse) and found significant correlations between both agility tests and CMJ in all three sports, but especially in college soccer and college lacrosse ($p<0.0001$, r=-.551--.698). Male and female collegiate soccer players were used in McFarland et al's (2016) study of the relationship between two vertical jump tests and sprint and COD speed. The squat jump and countermovement jump tests were correlated with the T-test and pro agility shuttle and found that for females, the CMJ displayed a greater correlation with both the T-test (r=-.76) and pro agility shuttle(r=-.58) than the squat jump (T-test r=-.68) and (Pro agility r=-.50) (McFarland et al, 2016). Markovic et al (2004) concludes that the squat jump and countermovement jump had the greatest reliability among all jumping tests (ICCa=0.97 and 0.98, respectively).

A third option of testing is presented in Swinton et al.'s (2014) methods. This particular report conducted testing on three separate occasions; day one: sprint and change of direction, day two: maximum strength tests and anthropometrics via a 3-dimensional body scanner, and day three: vertical jumps tests and explosive resistance exercises were performed with submaximal loads. On day one, participants completed 5, 10, and 30m sprints and the 5-0-5 agility test. Each subject was required to complete the 180-degree turn with each foot twice for a total of four trials, and the best time of the four trials was taken for further analysis. A 1RM back squat and deadlift were performed in a randomized order on day two. Each athlete performed warm up sets until they were ready to work towards their maximum squat and deadlift weight. Upon completion of these two tests, the subjects had their anthropometric measurements taken on a Hamamatsu Bodyline scanner which displayed 15 measurements; "BM, lengths (stature, trunk, floor to hip, thigh, lower-leg), widths (shoulder, chest), and girths (chest waist, upper arm, forearm, hip, thigh, calf)" (Swinton et al., 2014). Then, on day three, subjects performed two maximum effort vertical jumps without the use of their arms and "maximum velocity deadlifts and jump squats at 10, 20, 30, 40, 50, 60 and 70% of their previously determined 1RMs" respectively. (Swinton et al., 2014). All jumps and loaded exercises were conducted on force plates under both feet. The highest values of each assessment were taken for further analysis.

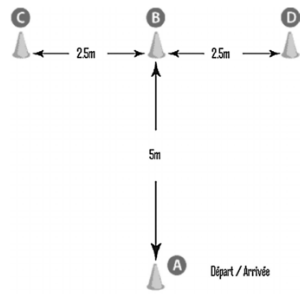
After all procedures had taken place and the data had been analyzed, the results found in Meylan et al.'s (2009) study were that the best predictors of change of direction performance in women was the vertical countermovement jump and the horizontal countermovement jump. For men, the horizontal countermovement jump was the best predictor of change of direction performance with a shared variance of 35%. Therefore, it would provide researchers with a better understanding of each gender as their own. Men are typically stronger and more powerful than women when compared to each other, because their cross sectional muscle mass is typically larger in comparison. Furthermore, based on the results, compared to others that were done prior, Meylan et al. (2009) "claimed that jumps that involved the combination of both horizontal and vertical ground-reaction forces may better predict COD ability". Yanci et al. (2014) found significant correlations of their study were also between horizontal and vertical jumping and the 5-0-5 or Y20 tests. The correlation between the vertical countermovement jump with stationary arms, similar to Meylan et al.'s testing, had the second highest overall at -0.60 as opposed to the horizontal countermovement jump with stationary arms at -0.51. Bourgeois et al.'s (2017) results showed that all multidirectional jump (MDJ) distances did in fact help predict change of direction performance. However, due to the use of a high speed camera, it became apparent that the subjects were trying to change their posture and jumping mechanics to optimize their abilities which may have skewed the data by not creating a set standard for jumping such as requiring the participants to hold a PVC pipe across one's back. As for the influence of closed skill versus open skill warm-ups, Gabbett et al. (2008) did not find any significant differences between either warm-up type in an athlete's change of direction ability, speed, vertical jump, or reactive agility. Finally, Swinton et al. (2014) concluded that "performance in the vertical jump was best explained by an athlete's maximum strength capabilities and their ability to develop high velocities, whereas, performance in the 5m sprint and 5-0-5 agility tests were best explained by maximum strength scores and rate of force development". Therefore, the correlation between vertical jump height and the 5-0-5 agility test were not as strong as in other studies similar to this particular one. Instead, it is suggested that maximum strength is a better determinant for an athlete's ability to change direction. Another aspect of strength that may influence performance, specifically vertical jump performance is hip flexor strength.

Deane et al. (2005) split participants into two groups, a control group and a group undergoing a hip flexor strengthening program over eight weeks. Participants performed a pre and post-test to compare results. Those who went through the hip flexor strengthening program lowered their 40yd dash time and 10yd sprint times by 0.233 seconds and 0.241 seconds, respectively. On average, a 0.646 second decrease in shuttle run time was also displayed (Deane et al, 2005). Although the group who went through the hip flexor program decreased their times, the control group did not have noticable changes in sprint time.

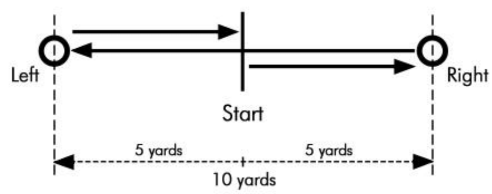
Directions for Future Research

Although all of these studies had their own unique subjects, methods, and results, each one of them was aimed at improving the athletes for their sport, whether that be amateur or professional.

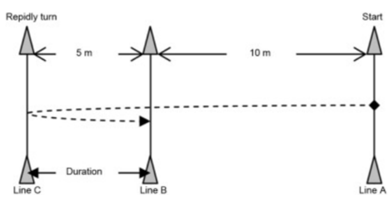
Modified Agility Test (MAT):



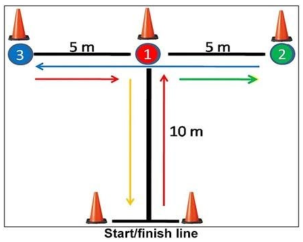
Pro Agility Test:



5-0-5:



T-test:



Methods

Participants

With approval from the head coaches, participants were recruited from Division II women's sports teams whose sports involved change of direction during play. Participants played either, volleyball, basketball, soccer, tennis or lacrosse. All procedures were approved by the University's Institutional Review Board prior to data collection. Participants were informed of the procedures and risks associated with participation in this study prior to signing an, IRB approved, informed consent document.

Table 1: Number of Participants and Demographic Data

Number of Participants	
Basketball	15
Tennis	7
Lacrosse	26
Volleyball	12
Total	60

	Basketball	Tennis	Lacrosse	Volleyball
Age (y/o)	19.40 ±1.32			
	19.33±1.5	19.35±1.26	19.86±1.57	19.33±1.15
Height (cm)	169.95±8.67			
	173.74±7.04	166.32±7.81	164.74±5.37	176.11±8.74
Mass (kg)	68.42±11.63			
	71.83±10.45	59.84±6.58	66.15±12.40	74.09±10.18

Assessments and Measures

All testing procedures were performed on the same testing day for each sport. Participants were instructed to show up in pairs every 10 minutes. Upon entering the lab, participants were instructed to partake in body composition testing on the InBody 770© bioelectrical impedance device. Participants were instructed to wear their daily practice uniform so that all athletes could be normalized for each team. After the collection of anthropometrics, athletes were instructed to perform 25 jumping jacks before the familiarization protocol for countermovement and static jumps. Once they stepped onto the force plates, participants were instructed told to hold a PVC pipe across their shoulders, similar to how they would hold a barbell during a back squat. Then, they were required to perform 50%, 75% and 100% effort practice jumps for both static and countermovement conditions. The command, “3, 2, 1, Jump” signaled when the participant was expected to jump. Participants performed at least two maximal effort jumps at each condition, then their average performance was taken for further analysis.

After completion of body composition and vertical jumping, participants were instructed to go upstairs to the university's auxiliary gymnasium where COD testing was held. Upon entering the gym, athletes performed a quick dynamic warm up for a fifteen meter distance that proceeded as follows; Jog down and backpedal back twice, side shuffle both directions, karaoke both directions, knee hugs down, figure four back, bows down, and a fifty percent sprint back to the starting line. The first COD test performed was the 5-0-5 agility test (Figure 1) which required athletes to start at a marked position, sprint fifteen meters through the timing gates, set up ten meters from the start, make a 180-degree turn, and sprint back through the timing gates. Each subject was given three familiarization trials with the 5-0-5 agility test followed by at least three test trials. Participants were instructed to change direction with their right foot three times and their left foot three times. Following the test trials for the 5-0-5 agility test, participants were asked to perform a T-Test (Figure 2) which required the participant to sprint forward 10 meters, make a 90-degree turn to the right and sprint to a cone 5 meters from the center, then they had to round the cone to sprint back through the center and go 5 meters to the left of the center line. Once this cone was reached, the subject rounded the cone, now facing the center again, sprinted back 5 meters to the center, and made a 90-degree turn to the right to finish with a 10-meter sprint back to the starting line through the timing gates. For this test, timing gates were set up at the start/finish line to find the total time to complete. As with the 5-0-5 agility test, two familiarization trials were given, followed by at least two test trials. The average performance for both tests were taken for further analysis.

Figure 1

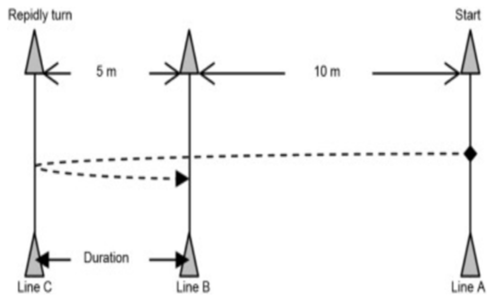
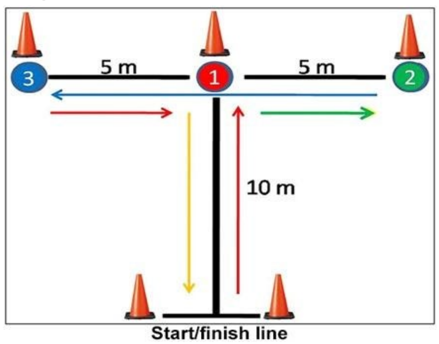


Figure 2

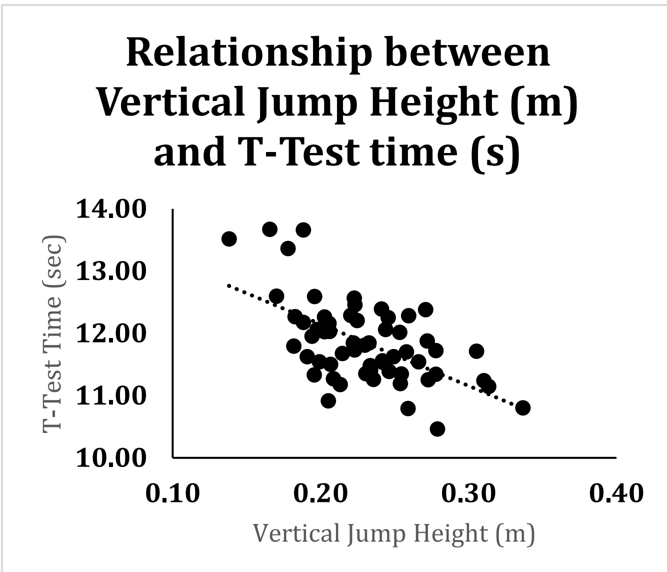


Statistical Analysis

Data are represented as mean (SD). A Pearson product-moment correlation was used to determine the relationship between selected variables. Statistical significance was set at $p < 0.05$.

Results

After interpreting data from all sixty participants, there is evidence to support that athletes who are able to jump higher will also perform change-of-direction tasks at a quicker rate than individuals who jump at a lower height. A strong negative correlation was found between the 5-0-5 agility test and countermovement jump (r= -.421) and the t-test (r= -.557). The static jump and 5-0-5 test also produced a negative correlation r= (-.463) as well as the static jump and t-test (r= -.580). Further, participants exemplified a positive correlation between percent body fat and times for the 5-0-5 (r= .429) and t-test (r= .443). Therefore, the greater percent body fat of an individual, the greater the time on the agility test. A secondary analysis was also conducted which separated the top twenty participants from the worst twenty participants. Results remained the same, and provides evidence to support that the best twenty did not perform both tasks better by chance. Our results also provided evidence that supports vertical for production influencing movement in horizontal drills such as the change-of-direction tasks.



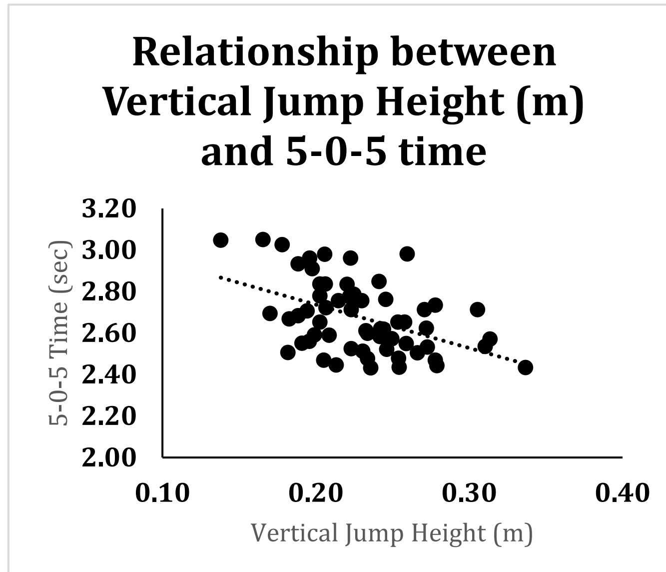


Figure 1: VJ Height vs. T-Test Time

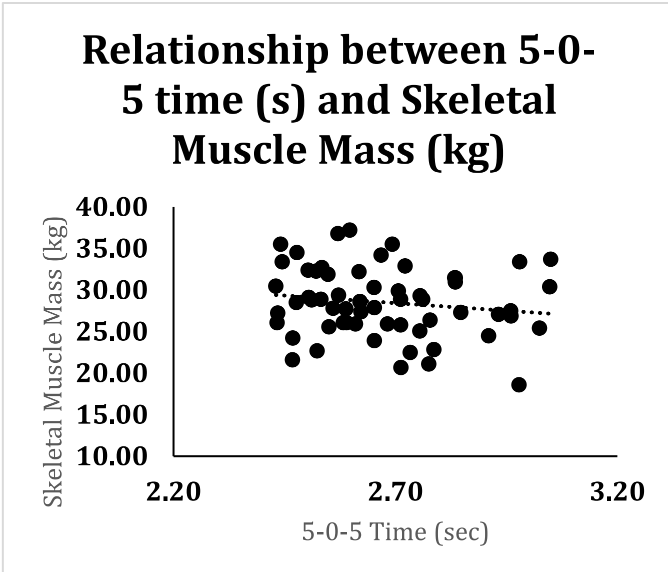
Figure 2: VJ Height vs. 5-0-5 Time

~~Figure 3: 5-0-5 Time vs. Muscle Mass~~

~~Figure 4: 5-0-5 Time vs. PBF~~

~~Figure 5: T-Test Time vs. Muscle Mass~~

~~Figure 6: T-Test Time vs. PBF~~



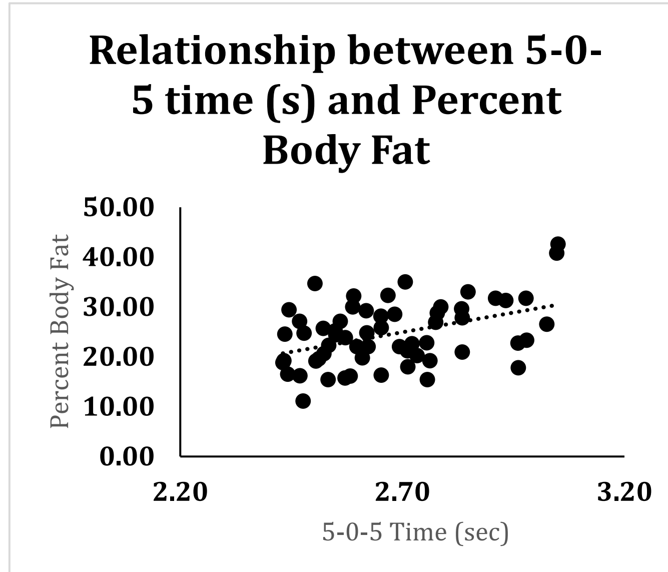
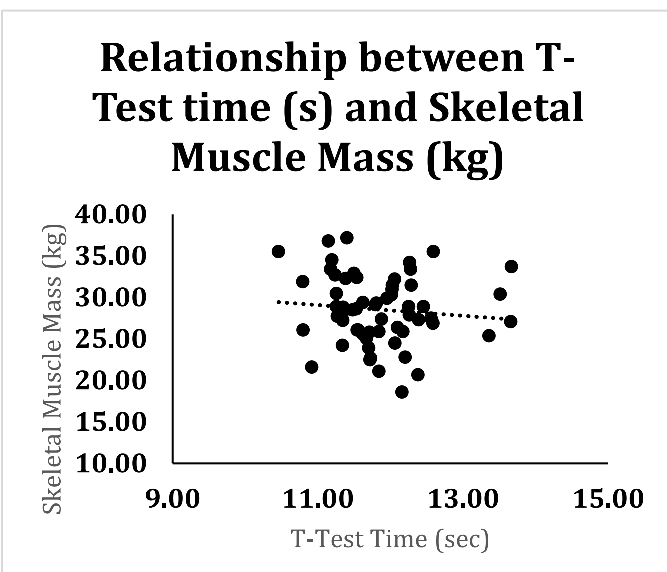


Figure 3: 5-0-5 Time vs. Muscle Mass Figure 4: 5-0-5 Time vs. PBF



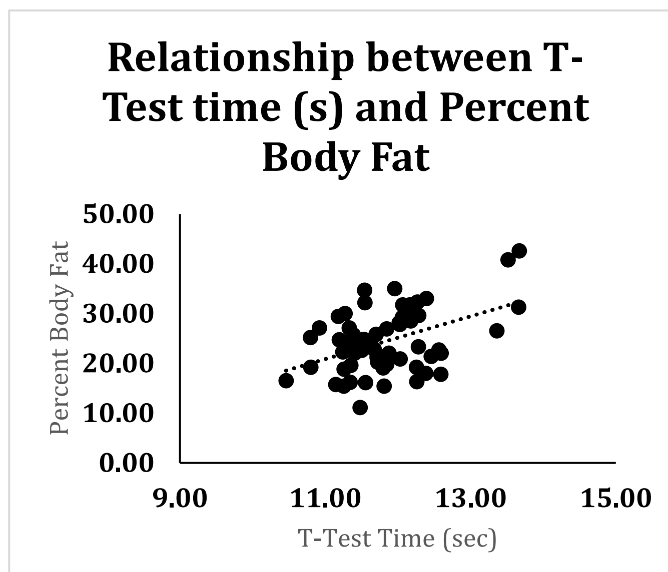
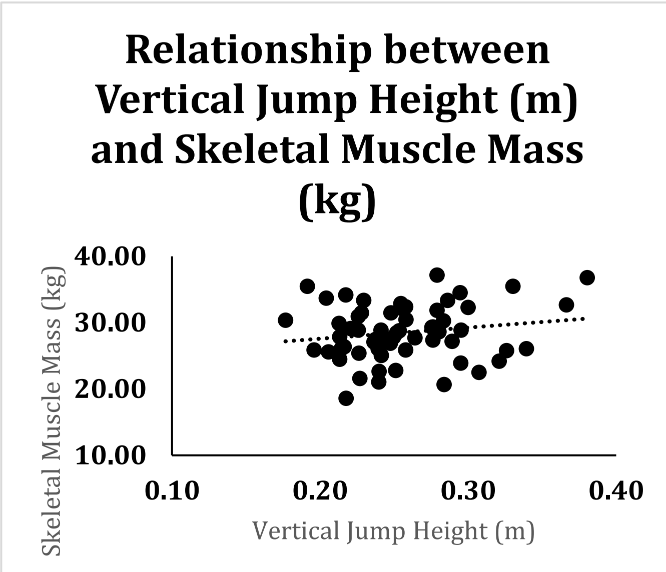


Figure 5: T-Test Time vs. Muscle Mass

Figure 6: T-Test Time vs. PBF



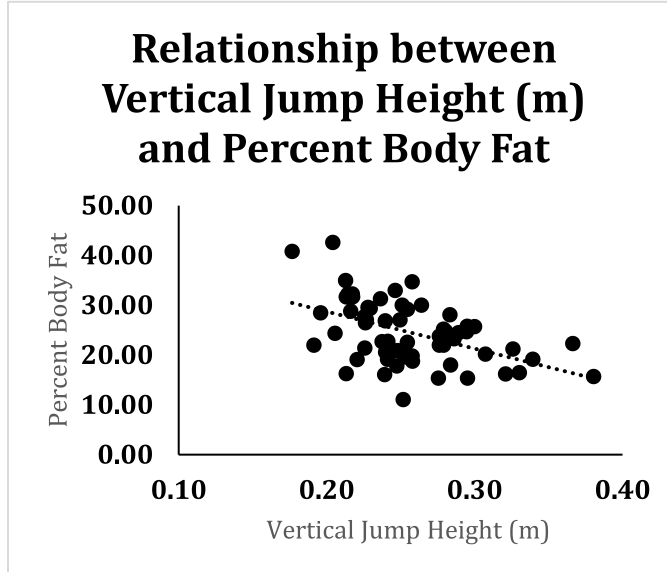


Figure 7: VJ Height vs. Muscle Mass

Figure 8: VJ Height vs. PBF

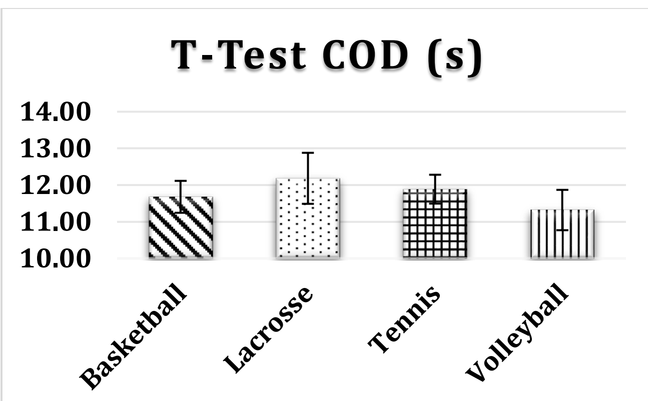


Figure 9: Comparison of T-Test for all Sports

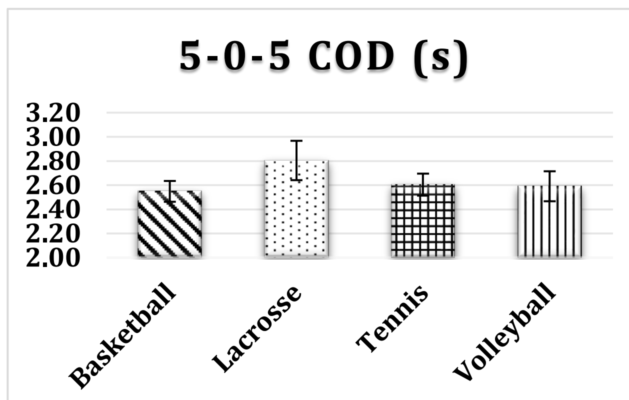
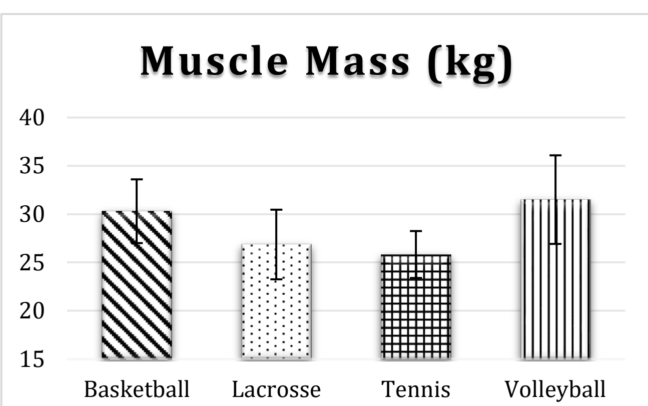


Figure 10: Comparison of 5-0-5 for all Sports



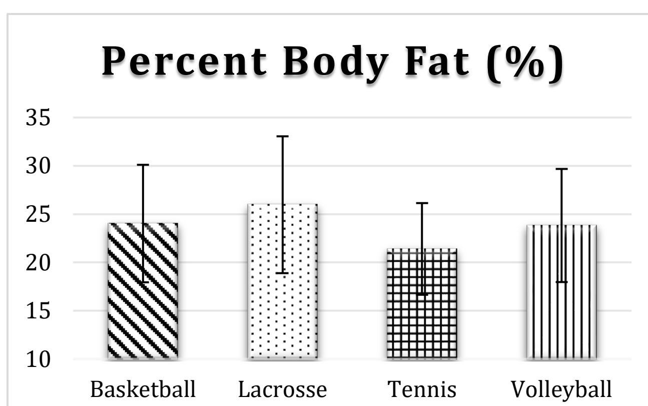
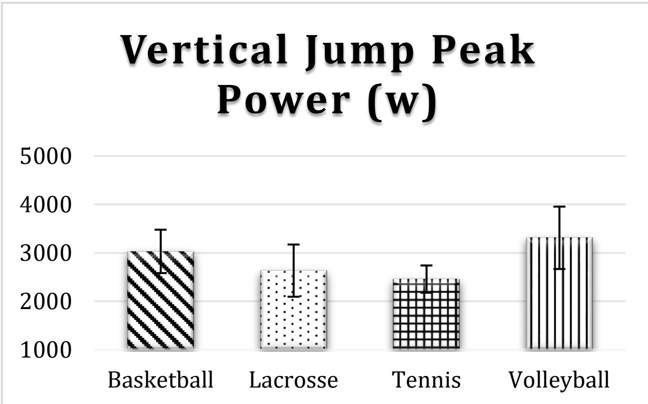


Figure 11: Comparison of Muscle Mass for all Sports Figure 12: Comparison of PBF for all Sports



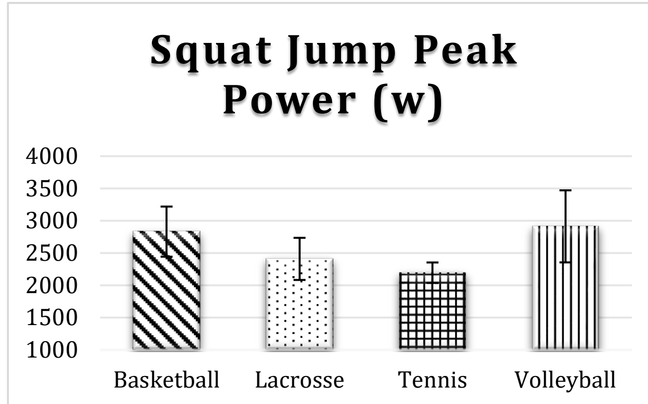
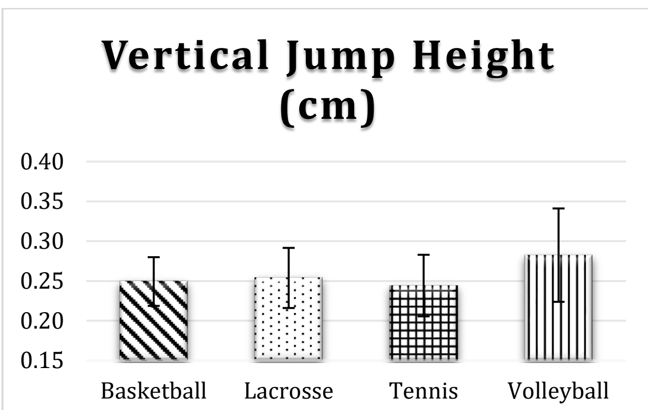


Figure 13: Comparison of VJ Peak Power for all Sports Figure 14: Comparison for SJ Peak Power for all Sports



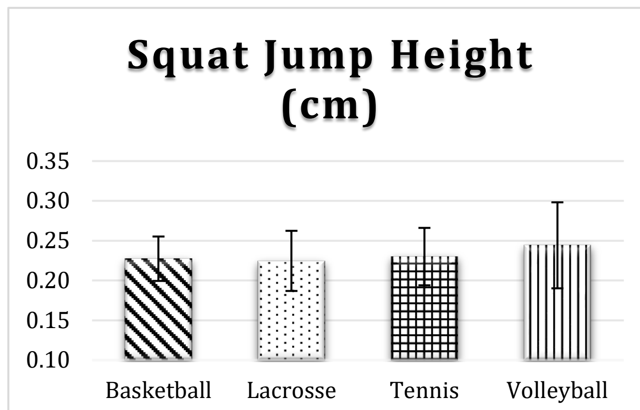


Figure 15: Comparison of VJ Height for all Sports Figure 16: Comparison of SJ Height for all Sports

Table 2: Athropometric, Jumping and Agility Results by Team

	Basketball	Tennis	Lacrosse	Volleyball
% Body Fat	24.52±6.40			
	24.03±6.08	21.40±4.74	25.97±7.08	23.83±5.85

Static Jump	0.23±0.04			
	0.23±0.03	0.22±0.04	0.23±0.04	0.24±0.05
CMJ	0.26±0.04			
	0.25±0.03	0.25±0.04	0.24±0.04	0.28±0.06
5-0-5	2.67±0.17			
	2.55±0.09	2.80±0.16	2.61±0.09	2.59±0.12
T-test	11.85±0.66			
	11.68±0.44	12.19±0.70	11.89±0.39	11.32±0.55

Discussion

Based on the results of this study and the results of previous studies there is support to suggest that these results did not occur by chance. Those who produced the most power and had the highest vertical jump also completed agility drills at a faster rate when presented with change-of-direction tasks.

This is supported by Castillo-Rodriguez et al. (2012). The results conveyed a negative correlation between all COD and jump tests (except the Lateral Countermovement Jump) which suggests that the greater the explosive strength of the individual, the less time the COD task took. According to Lockie et al (2018) their results support the present research. Lockie et al, found a significant correlation between the MTT ($p<0.05$) and the 5-0-5 test ($p<0.01$) with vertical jump height (r=--.52 and .66 respectively) for division II athletes, and for division I athletes, the 5-0-5 negatively correlated ($p<0.01$) with the jump height (r=-.65) (Lockie et al. 2018). Chiang (2014) evaluated division I female soccer athletes lower body strength and power characteristics change of direction ability. Results suggest moderate to very strong negative correlations between COD and vertical jump variables ($p<0.05$, $r= -.41$ to $-.81$) (Chiang, 2014). Furthermore, using the agility tests, Illinois test and Pro Agility Test, Vescovi and McGuigan (2008) tested female athletes (high school soccer, college soccer, college lacrosse) and found significant correlations between both agility tests and CMJ in all three sports, but especially in college soccer and college lacrosse ($p<0.0001$, r=-.551--.698).

Athletes who can produce explosive power in the vertical direction are more likely to have a higher vertical jump. Those who jump higher translate that power in the horizontal direction as well and therefore, will perform agility drills quicker.

Individuals with a greater amount of lower body muscle mass are more likely to be heavier, which may slow them down during the agility drills and may cause them to jump lower due to the mass amounts of muscle that they will have to move off of the floor.

Practical Applications

Lower body power is an important factor in vertical jump height and change-of-direction speed. Athletes may look to improve their power output by using strength training exercises such as the squat, deadlift, clean, lunge, etc.

Swinton (2014) and his team also tested each athlete’s 1RM for squats and deadlifts, which is beneficial when determining the strength of the athlete’s lower body musculature which could coincide with their ability to activate the stretch shortening cycle during the vertical jump.

Future Research Recommendations

After reviewing the literature, there were some areas where additional research was warranted, one in particular having been separating genders due to the physical and physiological differences that appear between men and women. Many published articles focused on all male participants, a combination of both men and women or a combination of athletes and non-athletes. Therefore, the relationship between jumping, and COD is still unclear in many studies, and there are plenty of relationships left to be studied and quantified

Another suggestion would be to perform the 5-0-5 agility test as the sole determinant in change of direction, because it requires a full 180-degree turn and involves sprints rather than shuffling as in the T-test. This would help make the study more specific to the sport but also generalize it for the population. As for jumping, testing the two-foot horizontal jump versus the two-foot vertical jump and performing a paired t-test would seem to be the best option in order to determine which style provides a greater power output. Another possibility for jumping would be to have subjects complete a drop jump into a vertical jump, but testing this style of jump may need to be individualized for each athlete and adjusted for their height.

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