Cardiff School of Sport

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Supervisor: Mr. Rob Meyers	

Comments	**Section**
	Title and Abstract Title to include: A concise indication of the research question/problem. Abstract to include: A concise summary of the empirical study undertaken.
	Introduction and literature review To include: outline of context (theoretical/conceptual/applied) for the question; analysis of findings of previous related research including gaps in the literature and relevant contributions; logical flow to, and clear presentation of the research problem/ question; an indication of any research expectations, (i.e., hypotheses if applicable).
	Methods and Research Design To include: details of the research design and justification for the methods applied; participant details; comprehensive replicable protocol.
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THE RELATIONSHIP BETWEEN STRENGTH, POWER AND CHANGE OF DIRECTION SPEED IN FEMALE GAMES-BASED ATHLETES

Dissertation submitted under the discipline of

SCRAM

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THE RELATIONSHIP BETWEEN STRENGTH, POWER AND CHANGE OF DIRECTION SPEED IN FEMALE GAMES-BASED ATHLETES

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ABSTRACT

Change of direction speed (CODS) is just one of a number of aspects influencing sporting performance in games-based athletes. Although such a study has importance to strength and conditioning coaches in various sports in the method of application to conditioning programming, the performance of agility and CODS has had minimal research despite the importance of these movements in all athletes. The study aimed to investigate whether CODS had a relationship to strength and power determinants. Seven participants (19.5 years ± 0.9) from one of Cardiff Metropolitan University British Universities and Colleges Sport (BUCS) leagues voluntarily took part in the study. All participants completed three consecutive weeks of testing consisting of strength, power and CODS. These weeks comprised of a unilateral and bilateral 1 repetition max (1RM) leg press, unilateral and bilateral vertical jump and an L-run CODS test consisting of three sets of right-cut and three sets of left-cut runs. The main conclusions from this study show that performance measures of bilateral strength and power are strongly related to each other ($r=.864$, $p<0.05$, $r^2= .679$), signifying that strength and power are highly dependent on one another. Relationships between unilateral CODS and unilateral power have no significance ($p>0.05$). Whereas the only significance in all CODS tests and leg press were between the bilateral leg press and right-cut CODS. With little significance between the majority of variables it can be concluded that this study is not a valid indicator of relationships between CODS, strength and power. This dissertation recommends that additional research is done into the relationships between CODS, strength and power to further the knowledge in this field.

CHAPTER 1

INTRODUCTION

1.0 Introduction

Athletes within games-based sports are regularly required to perform changes of direction at maximal and submaximal intensities with minimal recovery time between bouts (Hovanloo & Safania, 2010; Spencer, Bishop, Dawson & Goodman, 2005). Therefore, successful team performance can depend on well-developed decision making and physical skills (Abernethy, 1990), as well as having the ability to recognise patterns of play and execute effective decisions under pressure (Gabbett, Kelly & Sheppard, 2008). A number of studies have assessed strength, power and change of direction capabilities in games-based athletes (Harrison et al., 2004; Kotzamanidis et al., 2005; Stone et al., 2006) and it is greatly commended that these factors have large influences on the success of games-based athletes.

1.1 Maximum Strength

Strength is an essential quality needed to become a successful games-based performer, Stone et al. (2006) defines strength as the ability to produce force and vital quality to games based sports. Agreeing with this statement, Cronin et al. (2007) also believed that strength is a huge component for sporting performance within games based sports. It appears that strength is not only vital as just a single component within sporting performance, but for the impact it has upon other key factors within sport (Tsitskaris et al., 2003). Previous research by Stone et al., (2003) indicated that power production is a product of maximal strength, therefore used by strength and conditioning coaches when pre-planning strength based programmes to maximise improvements (Macintosh, 1974).

1.2 Maximum Power

Cissik (2012) defines power as the capability to exert force quickly. Measuring vertical jump height has been seen to be the simplest way to assess maximal power. The association between jump height and CODS performance has been studied in numerous bilateral tests (Baker & Nance, 1999; Hennessey & Kilty, 2001; Hori et al., 2008). Beachle and Earle (2008) suggest that maximal power output can be underpinned as rate of force development and velocity. Similarly, when both velocity and maximal force reach optimal levels, maximal power is achieved (Stone et al., 2003). Beachle and Earle (2008) also believe that power is a product of speed and is directly associated with speed performance. Vertical jump height is a way of measuring maximal vertical power relevant for sports involving movements in the vertical plane such as netball, basketball and football.

1.3 Change of Direction Speed

Strong correlations have been found between relationship measures of general speed and strength (Wisloff et al., 2004; Meckel et al., 1995; Baker & Nance, 1999), whereas relationships between CODS performance and strength have shown no significant relationships (Negrete, et al., 2000; Vescovi et al., 2008). Difficulty finding relationships in females between strength, power and CODS is resultant of several factors (age, previous training experience) including the need to investigate changes longitudinally (Cronin et al., 2007). Rather than improving strength and power components longitudinally to see a change in CODS, it is requisite for athletes to identify current physical qualities for measured improvements.

1.4 Hypotheses

This investigation hypothesised that (a) there will be a strong correlation between bilateral strength and power. (b) There will be a strong correlation between unilateral strength and unilateral change of direction speed measures. (c) There will be a strong correlation between power and change of direction speed. (d) There will be a strong positive correlation between strength and change of direction speed. The null hypothesises stated that strength, power and change of direction speed will not significantly relate to each other.

CHAPTER 2

LIT REVIEW

2.0 Review of Literature

2.1 Change of direction speed

Games-based athletes have evolved their movement patterns during changes of direction in the last decade, going from a slow-paced and placid to being greatly physically demanding (Kovacs, 2007). Bartlett (2007) defines speed as the rate of change of distance with respect to time, whereas acceleration is the rate of change in speed with respect to time. Barnes et al., (2007) describes agility as the ability to change direction with a minimal loss of control and/or average speed. Although there are no confident definitions for CODS due to being a product of agility, CODS can commonly be described as ‘planned agility’ (Brughelli, Cronin, Levin & Chauachi, 2008). Cox (2002) identified that open skills cannot be pre-planned, whereas closed skills such as sprint running or pre-determined changes of direction, can be pre-planned. Sheppard (2008) indicates that a faster athlete who performs well in CODS and sprint tests will likely be better off engaging in perceptual and decision-making training, as well as reactive agility training therefore increasing the speed at which they change direction. However, O Castillo-Rodriguez et al., (2012) emphasises that sprints with change of direction have been traditionally associated with performance in team sports, thus suggesting that it is vital for athletes playing in team sports to have the ability to react to different stimuli (Oliver & Meyers, 2009). So, to see if there is existing relationships between maximal strength, maximal power and CODS, this study will see if Oliver and Meyers (2009) statement is true which concludes that physical qualities during changes of direction are more important than improving the athletes perceptual abilities.

CODS is a large component of agility, as Young et al., (2002) shows in figure 1. The table allows a coach to prioritize agility/ change of direction speed training of an individual to their specific needs and requirements.

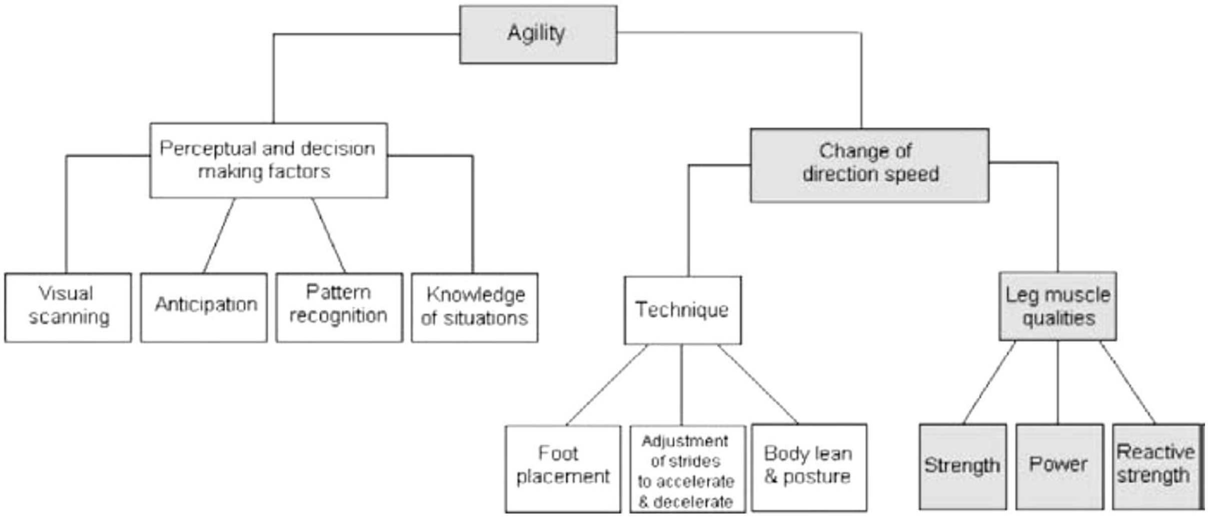

Figure 1. Agility constructs (adapted from Young et al., 2002).

2.1.2 Relationship to Games Players

The ability for any games-based athlete to change direction with speed and efficiency is almost imperative to successful performance. Young (2006) and Young and Farrow (2006) propose that team sports agility comprises of not only change of direction abilities, but also the capability to anticipate, read and react to game-specific cues in the environment. Speed in changing direction is a clear determinant of sport performance in field sports (Keogh et al., 2003), as the skill to drive away from an opponent or avoid a tackle is vitally important to every athlete involved in a games-based environment. Looking at Figure 1, it is evident to see that an athlete’s technique is going to affect CODS performance. As described by Young and Montgomery (2002), ‘a lower centre of gravity during sprinting seems advantageous,’ due to lateral forces to the ground inducing opposite ground reaction forces for sideways movements or ‘cuts’. ‘Cuts’ indicate directional changes during movements consisting of sprints, however cutting only relates to the segment of time that an athlete’s foot comes into contact with the floor to push off and change direction (Colby et al. 2000; Besier et al. 2001; Sheppard & Young, 2006).

Several studies have shown that athletes who are faster sprinters are not essentially fast in changing direction (Sheppard et al., 2006; Pauole et al., 2000). Whereas straight sprinting speed is commonly thought to be one of the main qualities that contribute to the effectiveness of CODS performance (Hewit et al., 2013). Directional speed is what games-based athletes generally use rather than longer, straight sprints. A study by White (2006) states that directional speed is where the athlete moves linearly, slows down enough to change direction at an angle, and accelerates linearly again. Thus relating to CODS, athletes playing in a games-based situation often play on a restricted playing area, resulting in some players to rarely engage in high-velocity coverage over distances large enough to attain maximum speed (McInnes et al., 1995). In practically all games-based sports you cannot plan where you are going to have to go, due to the unpredictable environment. The need to acknowledge open, reactive situations in games-based sports are common, however CODS is an essential requirement of agility due to being a large physical component of agility. Several authors have argued that COD ability is essential for successful participation in modern-day sports (Williams, 2000 & Gabbett, 2006). Similarly, Abernethy (1990) writes that successful team sport performance depends on well-developed physical qualities and superior anticipation and decision-making skills.

2.1.3 Issues assessing change of direction speed / agility

Several authors have investigated agility using numerous tests, these comprising of an 'L-run', 505 test and an Illinois run (Gabbett, 2002; Gabbett et al., 2008; Meir et al., 2001). However, many limitations for these studies exist, including the 505 test only consisting of one simple cut resulting in not being representative of CODS demands within sport (Gabbett & Benton, 2009). In comparison to 'agility' tests, CODS tends to be easier and simpler to assess as it is commonly referred to as 'planned agility' (Cox, 2002). Therefore, you can create a target or a controlled circuit which is then timed, however because agility is not planned it is more difficult to control and asses during a games environment. Farrow et al., (2005) states that the assessment of agility performance in team-sports athletes further suggests that the ability to use these manoeuvers successfully in the game scenario will depend on other factors such as visual processing, timing, reaction time, perception and anticipation, therefore making it much harder to control as there are lots of areas to look at during performance. Furthermore, Farrow et al., (2005) argues that agility tests that do not consist of a reactive component do not truly represent the participant's true agility performance during any competitive game play. Disagreeing with Farrow et al., (2005), the ‘pre- planned’ element of CODS testing can relate to sport-specific situations as athletes often pre-plan movements during match-play to ensure optimum performance when thinking tactically over the opposition. Due to the amount of directional changes athletes require during participation in sports, during CODS testing Young et al. (2002) found that four directional changes was optimal with shorter distances to associate acceleration. In retrospect, the importance of testing CODS with pre-planned elements is obligatory due to incorporating abilities to accelerate and decelerate rapidly, as well as changing direction (Young & Farrow, 2006).

2.1.4 Ways to test change of direction speed / agility

There is a wealth of literature discussing CODS and agility protocols that demand the participants’ body to rapidly change direction in the horizontal plane, tests such as the 505, Illinois, zigzag slalom and t-tests are common when assessing CODS and agility (Sheppard & Young, 2006). The 505 test has been the predominant measure of games-based agility and footwork. While these tests are valid and reliable measures of the ability to change direction after reaching a high speed (Gabbett et al., 2008), they are planned movements initiated by the athlete (Draper et al., 1985). Knowingly, the acceleration phase of a sprint in games-based athletes tend to be shorter, acquiring top speed within a shorter distance in relation to track sprinters is evident (Baker & Nance, 1999). Young et al., (2002) also found that having four directional changes is optimal whilst reducing to the test to a shorter distance to associate with acceleration when deciding what test to use to measure CODS.

2.1.5 Methods of Assessing CODS

Although the T-test is the more common way of assessing agility (Miller et al. 2006; Pauole et al., 2000; Peterson et al., 2006), the L-run is also a reliable way to test an athlete’s CODS (Gabbett, Kelly & Sheppard, 2008). In many instances, a controlled short distance sprint with numerous changes of direction will provide sufficient information to measure the speed at which it takes an athlete to complete the given test. As Cissik (2012) writes, tests of speed are sprints focused on measuring acceleration and tests of agility are to test the athletes’ ability to change directions. Farrow et al., (2005) used real-life size images projected onto a wall, providing a sport-specific stimulus to the athlete when measuring CODS. Although this is sport-specific, it is especially hard to recreate and difficult to gain definite evidence. The more effective studies primarily use timing gates to collect their data (Oliver & Meyers, 2009; Baker & Nance, 1999). Photo-electric timing gates used recently in sport science research are used for a testing and coaching system. Oliver and Meyers (2009) used Smartspeed to collect linear speed and reactive agility results. A study by Barnes et al., (2007) investigated whether vertical jump height could predict CODS, the results showed that countermovement (CMJ) jump accurately predicts a participants CODS time. Consequently relating to numerous other studies (Hennessy & Kilty, 2001; Nesser et al., 1996; Young et al., 1995) investigating not only sprinting but agility too. These studies also validate the importance of force production vertically during horizontal performances.

2.2 Power

Newton et al., (1999) describes power as the most important factor in sports performance because of the ability to produce force in a brief amount of time is vital to most sports skills. According to Kawamori and Haff (2004), power depends on maximal strength, and stronger athletes have greater power outputs (Cormie et al., 2010; Cronin et al., 2000). Explosive power is commonly used within the sporting environment as athletes tend to react to a stimulus (for example, getting an interception in the air, the athlete will react jumping explosively and vertically). Disagreeing with this, Cronin, Hing and McNair (2004) say that it is unclear why the use of term ‘power’ is used as a mechanical construct to indicate maximal exercise performance. Therefore, strength qualities such as rate of force development impulse and explosive strength are suggested as a better predictor of athletic ability and performance. Brughelli (2008) agrees, stating that muscular and explosive power relies on the rate of force production during co-ordinated movements.

2.2.1 Ways of Measuring/ Testing Power

Vertical jump performance is not the only way of measuring maximal power, others include a drop jump test and concentric leg extension power test (Young & Montgomery, 2002). Olympic lifts can also used (clean/ clean and jerk) when measuring maximal power. These movements require the athlete to move a maximal load at peak velocity in one single effort (Hori et al., 2008). Vertical jumps (countermovement) including unilateral and bilateral are the simple and effective to administer. Though, Garhammer et al., (1993) state that the use of arms during vertical jump testing has been reported to increase the skill and co-ordination requirements of the movement, it is likely to lessen the validity of the vertical jump as a test of lower-body musculature. However, Peterson et al., (2006) says that it would be more appropriate to use jump tests that not only involve the application of vertical ground reaction forces (VGRF), but also horizontal ground reaction forces (HGRF) to predict change of direction performance, given that most human motion is a combination of both of these types of forces. Resulting in an absolute need to have specific tests of VGRF (vertical jump) and HGRF (standing long jump) conducted to provide better understandings of athletes maximal power output. Although the use of a contact mat to asses vertical jump height performance is frequently chosen (Enosken, Tonnessen, Shalfawi, 2009; Klavora, 2000) there are additional ways to assess the maximal jump height of an athlete. Force platforms have reportedly found to be more valid and accurate in comparison to the contact mat (Enosken et al., 2009; Klavora, 2000). Regardless of validity, contact mats are seemingly more appropriate and reliable for use in the field setting due to their practicality advantages such as quick assessment time, cheap, and being easy to transport (Klavora, 2000).

The countermovement jump is deemed to be one of the most valid representations of lower extremity power characteristics that are typically exhibited in CODS protocols (Markovic et al., 2004). Though partaking in a training programme is not optimum, Haff et al., (1997) and Hakkinem and Myllyla, (1990) state that athletes who use explosive exercises within training programs record the highest results when testing for maximal force output (power).

2.2.2 Relationship between Power and Change of Direction Speed

Power requires the athlete to move at a maximal velocity for a given load/ mass, suggesting that maximal power is likely to have a significant relationship to maximal speed. It appears that power measures influence CODS, although this relationship may only be observed when comparing to tasks of CODS tests over shorter distances (Sheppard & Young, 2006). Barnes et al., (2007) identifies that it is almost certain to assume that jumping, sprinting and CODS performances could be related. Agreeing, Stone (2005) considers maximal strength to be the basic quality that ultimately affects muscular power. Athletes aim to be strong, and as a resultant of being strong, speed and power commonly follow (Nimphius, McGuigan & Newton, 2010). Likewise, Stone et al.

(2003) suggests that maximal power production is a product of increased maximal strength.

The relationship between strength, power and change of direction performance in trained female athletes is diverse when compared with trained males (Hennessy and Kilty, 2001). Although, many authors agree that strong relationships occur between strength, power and CODS (Barnes et al., 2007; Shepphard & Young, 2006). To determine if a relationship is causative, investigation of the changes must be done longitudinally (Cronin et al., 2007), suggesting that athletes should maintain a periodized training program to see if a relationship occurs between the existing factors. However, longitudinal studies are very difficult to set up and manage, they also typically have high drop outs which predisposes the aims and objectives of the study (Nimphius, McGuigan & Newton, 2010; Young & Montgomery, 2002). Lugar and Pook (2004) state that mechanisms of acceleration provide effective framework for developing exercises that will improve sprint performance. Nonetheless, there is currently little research that reveals the relations of unilateral exercises on improved strength and power in women (McCurdy et al., 2005).

2.2.3 Unilateral/ Bilateral Vertical Jump

Negrete and Brophy (2000) found a significant correlation between single-leg squat strength in a weight-bearing stance and single-leg vertical jump height. Though most existing literature contains some sort of training programme to examine the relationships between maximal strength, maximal power and changes of direction speed (Garhammer, 1993), it is evident to see that there is little regarding a cross-sectional study. This would result in major limitations to the study.

Research comparing the relationship between unilateral/ bilateral jump tests and sprint performance is very limited (Maulder et al., 2006, 2005). Unilateral jump performance is likely to have a correlation with sprint performance because sprinting requires a production of forces unilaterally (McCurdy et al., 2010). Measuring the maximal jump height of a unilateral vertical jump is predominantly going to have a higher correlation than using just a bilateral jump as kinematics appear to be more similar during unilateral vertical jumps. Concluding, the relationship between the unilateral jump height and sprint performance was stronger when the jump distance was analysed relative to the subjects' height (Holm et al., 2009). In a study by Nimphius, Mechael, McGuigan and Newton, (2010), significant correlations were found between vertical jump height and sprinting performance though none between jump height and maximal strength were found. Justification for this may attribute to the sporting background of the participants.

2.3 Strength

Stone et al. (2006) defines strength as the ability to produce force and vital quality to game based sports. Agreeing with this, Cronin et al., (2007) believes that strength is a major component for sporting performance, enhancements of strength developed in maximal resistance programs result in the enhancement of running speed. More so, strength is vital to power development at higher levels of force, providing stimuli needed for collateral development of other systems such as connective tissue (Foran, 2001). Berg (2006) agrees, stating that force provides the drive to accelerate the mass of the body, and muscular strength is necessary for all sports. In young adults muscle strength has been related to athletic performance (Verdijk et al. 2009), associating that the stronger the athlete the better their athletic performance is. Although this correlation may not always be correct, Stone (2002) agrees that performers should always strive to become as strong as possible within context to their sport.

2.3.1. Relationships between Strength and CODS

The relationship between 1 repetition max (1RM) lower limb strength scores and CODS test results has been researched by several authors. Many professionals consider maximum strength to be the basic quality that ultimately affects muscular power, irrespective of external resistance (Stone, 2005). Increased strength is ultimately going to have a relationship between the speed at which an athlete can accelerate from a stood still position and change direction efficiently. Young et al., (1995) has investigated the relationship between strength and sprint speed over 2.5m and a 5m distance, the participants used were track athletes and times measured were from a block start. This makes it hard to make comparisons to games based athletes because in a game situation they are never going to begin a sprint from a block, it is likely to be a reactive sprint or pre-planned, dependent on game circumstances. In studies by Negrete and Brophy (2000) and Vescovi and McGuigan (2008), relationship measures between strength and COD performance have been shown. However measures between these two variables may vary due to the time in the training season, age, and the previous experience of the athlete.

When comparing relationships between strength and performance, many studies have found differing results (Baker & Nance, 1999; Cronin & Hansen, 2005; Hennessy & Kilty, 2001). Strength is an important factor when looking at CODS and the relationship to games based players as research findings have suggested that the stronger the athlete the faster they are (Sheppard & Young, 2006). Thus, stronger athletes have more power therefore are more able to exert the force to lift more and run at a quicker pace.

2.3.2 Ways of Testing/ Measuring Strength

Levinger (2009) states that the 1RM method is a reliable and simple method to evaluate maximal strength. More so, Foran (2001) writes that 1RM for a free weight squat or the leg press is to determine a ratio of strength to body weight. Using a 1RM is suitable for all participants as you can only push yourself to your own ability. However, when considering the 1RM test, athletes must prepare, striking a balance between being warmed up enough to prevent injury and doing so much work that it interferes with the results of testing (Cissik, 2012). Good ways of measuring lower body strength include exercises such as back and front squats, as well as the seated leg press. Although there is limited literature supporting the relationship between a seated leg press and CODS, the seated leg press has predominantly the same movement pattern as a 90º free-weight squat. The seated leg press still allows an expression of maximal strength however with little technical ability (Brown, 2001). Whereas the barbell squat is technically demanding, requiring practice and commonly athletes are fixed with the principle that if they are unable to complete a squat without perfect technique, they cannot lift it (Gamble, 2010). Peterson et al., (2006) investigated the relationship between the 1RM (barbell squat) and CODS, summarising that the male correlation (r= -0.169) was not significant in comparison to the significant female correlation (r= 0.408). Although the result in males is negative, (as strength goes up, CODS time goes down) within the female population it is seemingly the opposite. If the correlation was to be positive, it is evident that females who are stronger will be slower on the CODS test. Also signifying that the stronger people were slower, explained by the fact that larger participants lifted greater loads. However due to their greater mass, their COD ability was compromised.

There appears to be substantial differences in strength demands between playing positions in specific sports studied. It has been identified that different playing positions vary in their performance on various strength and speed measures (Mier et al., 2001). This is significant, for example a goal keeper in hockey is not going to require the same strength demands as a player who covers the whole of the pitch. This could be changed by introducing resistance programmes to athlete's weekly training, as previously mentioned by Cronin et al., (2007), that maximal resistance programs result in the enhancement of running speed.

2.3.3 One Repetition Max

There has been much research into the safest and most effective way to measure 1RM leg strength. Using the leg press with athletes who are not familiar with the specific gym equipment is a much safer way of working out the 1RM. This is because it is much more controlled rather than using a free-weight squat with a barbell (likely to challenge the participant more, providing an inaccurate recording of their actual 1RM). More so, Negrete and Brophy (2000) found a significant correlation between single-leg squat strength in a weight-bearing stance and single- leg vertical jump height. A leg press is much easier for all abilities if they have not used the equipment before, although familiarisation sessions are vital. Bogdanis et al., (2011) states that a participant's leg strength is determined by measuring the maximum load that could be back-squatted from a knee angle of approximately 90º for one repetition. Using a seated leg-press also determines the strength of the lower extremity, both unilaterally and bilaterally. Although the squat requires higher muscle activity in comparison to the less press, it should be used with caution with athletes who have had previous injuries or lower extremity problems (Berg, 2001). The seated leg press is more controlled as the machine provides a more stable approach to the same movement (Sherman, n.d.).

Brown (2001), states that the squat is not as safe as the leg press, and because safety enhances the quality of the workout, leg press machines have been designed so that all shapes and sizes can perform the exercise in this manner. Brown (2001) also mentions that the leg press yields the same benefits of the squat but in a much safer respect, resulting in preferring the leg press to the squat technique when measuring 1RM lower limb strength.

CHAPTER 3

METHODOLOGY

3.0 Methodology

This study aims to examine the relationship between maximal strength, power and CODS. Data collection took place at Cardiff Metropolitan University, Cyncoed Campus in the National Indoor Athletics Centre (NIAC), (main track/ diagnostics gym) and Physiology Lab. The first week consisted of the power testing and anthropometric measurements (height and weight), the second week the strength testing and the third the CODS tests. Testing dates were separated by a week to ensure no fatigue accumulated between testing sessions. Noted by Beachle et al., (2008), athletes should never arrive for testing after fatiguing sport activities or work outs. This was taken into consideration and all participants were advised not to have done any vigorous exercise 24 hours pre- testing to any of the testing dates.

3.1 Participants

The study used eight under-graduate students from Cardiff Metropolitan University. All participants were female and involved in the British Universities and College Sport (BUCS) league within the university. Measurements of stature to the nearest 0.5cm (Wall Harpenden Stadiometer, Holtain Ltd, Croswell, Crymych), mass to the nearest 0.1kg (SECA-Model 770 Digital Scales, Hamburg, Germany) and age were taken. (Mean ± Standard Deviation: mass = 65.6 ± 7.53kg, stature = 172.56 ± 3.90cm and age = 19.5 ± 0.93 years). Participants were asked to take off shoes when height and weight was measured to provide a more accurate recording.

Prior to enrolment in the study, each participant was provided with detailed participation information regarding the study (Appendix A). This included the research question, any risks they may come across when participating in the study and a statement to make them aware that they could drop out at any point. They were also made aware that any information taken from them would remain confidential. Once read, participants were provided with an informed consent form (Appendix B), in order to comply with the ethical approval granted by the Cardiff School of Sport Research Ethics Committee (CSSREC) (Appendix C).

3.2. Power Testing

A Smart jump contact mat (FusionSport, Brisbane, Australia) was used to record accurate and reliable data. This equipment recorded the exact height that each participant jumped, recording from the time they left the contact mat to the time they came into contact with it again.

Before any participants completed the jumps, they were individually shown the correct technique, in order to improve reliability during the procedure. Power testing required nine jumps to be conducted by each participant. Six were unilateral (three on each leg) and three were bilateral. Each participant was allowed 30 seconds rest in between each jump to ensure that fatigue did not occur. The best result was taken from each of the three jumps. A study by Reeve and Tyler (2013) reported that a contact mat is a valid tool for assessing vertical jump height, especially when compared with a 3-camera motion analysis system (Leard et al., 2007).

3.3 Strength Testing

For each participant it was mandatory to complete a five minute 'RAMP' style warm up, (raise, activate and mobilise, potentiate) prior to testing, to ensure optimal preparation for performance (Jeffreys, 2006). Incorporating a 'RAMP' warm up has positive effects on performance for example improvements in rate of force development (Asmussen, Bonde-Peterson & Jorgenson, 1976), faster muscle contractions (Hoffman, 2000) and improvements in muscle strength and power (Bergh & Ekblom, 1979). Whilst raising body temperature and activating specific muscle groups, the 'RAMP' warm up more importantly has the effect of activating all the key muscles involved in the required movements (Jeffreys, 2006).

The 1RM protocol outlined by Cissik (2012) was used to determine the maximal strength of the participants. After performing an appropriate 'RAMP' warm up, each participant was shown the correct technique on the seated leg press to minimise any risk to injury by incorrect practice. They were then asked to sit in the leg press machine (Sportesse Leg Press, Westhay, Somerset), making any adjustments to ensure it was the right height, and so that comfort was maximised. Though the participants were already warm, an additional, specific warm up using the machine was conducted as well as familiarity of equipment being used. 1 set of 10 repetitions at 50% estimated 1RM was conducted, with each set separated by a 2 minute interval. Subsequently, 6 repetitions with estimated 75% 1RM, 3 repetitions with estimated 85% 1RM and 1 repetition with an estimated 95% of 1RM were completed by each participant in turn. The increase was continued, with weight being added gradually after each successful lift until failure occurred. Because of the intensity, each participant was given a rest period of 3-5 minutes between each maximal repetition (Robinson et al. 1995). If the 1RM was not established within 6 attempts, the subject was advised to return to complete their assessment (Abernethy, 2005).

3.4 Change of Direction Speed (CODS) Testing

A CODS test for was completed by an ‘L-run’, set up in the indoor running track inside of the NIAC sports complex. The L-run protocol outlined by Cissik (2012) was utilised for this element of the study. Testing involved having 3 cones in the shape of an ‘L’ placed 5m away from each other (Figure 2). Each participant completed exactly the same amount of runs (six), three on the right and three on the left leg. Whilst all participants were instructed to run as quickly and efficiently as possible along the ‘L’ run to return back to the starting point, times were measured using Smart speed photo-electric timing gates (FusionSport, Brisbane, Australia). This provided results that were accurate and reliable as exact times were taken when the infra-red beam was crossed (to the nearest 0.001 seconds) at the finish line (Gabbett et al., 2008).

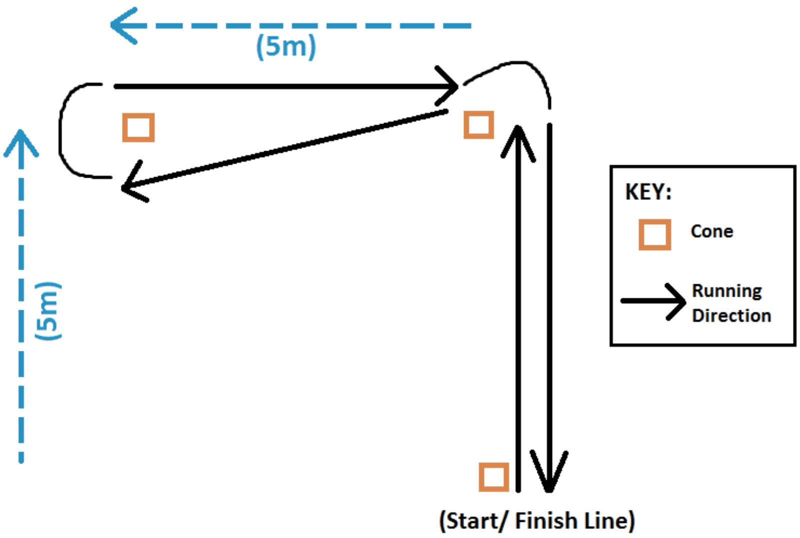

Figure 2. Left- cut ‘L’-Run.

3.5 Data and Statistical Analysis

To determine if there is a relationship between lower extremity strength, power and CODS, data analysis was implemented using statistical package for social sciences (SPSS version 17.0 for Windows). Prior to this, raw data was recorded using spread sheet software (Microsoft, Excel, USA). A Pearson’s product moment correlation coefficient *(r)* was calculated between all variables to determine the measure of linear correlation (dependence). Also, coefficients of determination were calculated (r^2 values). Relationship values range between +1 and -1, where 1 is a total positive correlation, 0 is no correlation and -1 is a negative correlation. Values of +.1 represent a small effect, +.3 is a medium effect and +.5 is a large effect (Field, 2009). Additionally at a later date, a paired t-test was also used to establish variables between unilateral (right and left) legs. Significance for this was set at $P < 0.05$.

CHAPTER 4

RESULTS

4.0 Results

Anthropometric characteristics (mean ± SD) of each participant prior to the study have been presented below in Table 1. The final sample size was n = 7. During the 3-week period that testing was conducted, one participant suffered a moderate-long term injury. This was unrelated to the study and the participant was therefore forced to withdraw from the study. As a result, any information already taken from the participant was removed.

Table 1. Anthropometric measurements (mean ± SD) for [n=7] participants.

Age (years)	Mass (kg)	Height (cm)
19.5 ± 0.9	65.6 ± 7.5	172.5 ± 3.9

Table 2 illustrates whether there is significance in the data collected from [n=7] variables. It indicates that a high percentage of the data have relationships with each other.

A significant relationship existed between JHB and LPB (r=.824, p<0.05, r^2=.679) as well as LPL and LPR (r=.866, p<0.05, r^2=.750). All jump protocols (unilateral and bilateral vertical jump height) significantly related to each other ($p < 0.05$), although no significant relationships were found between CODSL and any other variables ($p > 0.05$). Additionally, relationships between CODSR and CODSL have no significant relationship which is understandable as they measure different variables (right and left leg).

Although some correlations are significant, weak relationships between the majority of common variance values, with values below 50% were found, suggesting that they are independent and measure dissimilar variables.

Table 2. Pearson's Correlation Matrix [n=7] among left and right power (jump height), strength (leg press) and change of direction speed test (L-run).

	JHR	JHB	LPR	LPL	LPB	CODSR	CODSL
JHL	.953*	.863*	-.094	-.320	.939**	-.756	-.456
JHR		.941**	-.067	-.304	.939**	-.682	-.380
JHB			-.218	-.455	.824*	-.625	-.206
LPR				.866*	.104	-.228	-.253
LPL					-.201	.221	-.064
LPB						-.813*	-.355
CODSR							.460

***p < 0.01*
**p < 0.05*
JHR, Jump Height Right; **JHL**, Jump Height Left; **JHB**, Jump Height Bilateral; **LPR**, Leg Press Right; **LPL**, Leg Press Left; **LPB**, Leg Press Bilateral; **CODSR,** Change of Direction Speed Right; **CODSL**, Change of Direction Speed Left.

The results of the paired t-test revealed that there was no significance between right and left jump height (JH R/L), leg press (LP R/L) or CODS (R/L), (P < *0.05)*.

Figure 3 illustrates the relationship between a bilateral leg press and bilateral jump height, showing that there is a positive linear correlation (r=.824, p<0.05, r^2 = .679). The graph indicates that the stronger the participant, the higher they could jump.

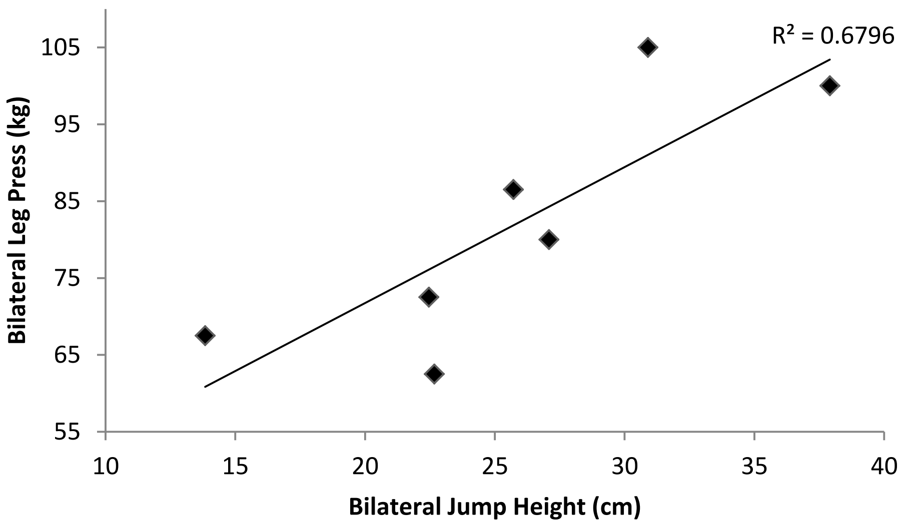

Figure 3. The relationship between bilateral leg press and jump height in [n = 7] participants.

The relationship between right leg jump height and the time it took for each participant to complete the right cut CODS test is shown in figure 4. Though the scatter chart shows a negative linear correlation (r =.-682, p<0.05, $r^{2=}$ .464).

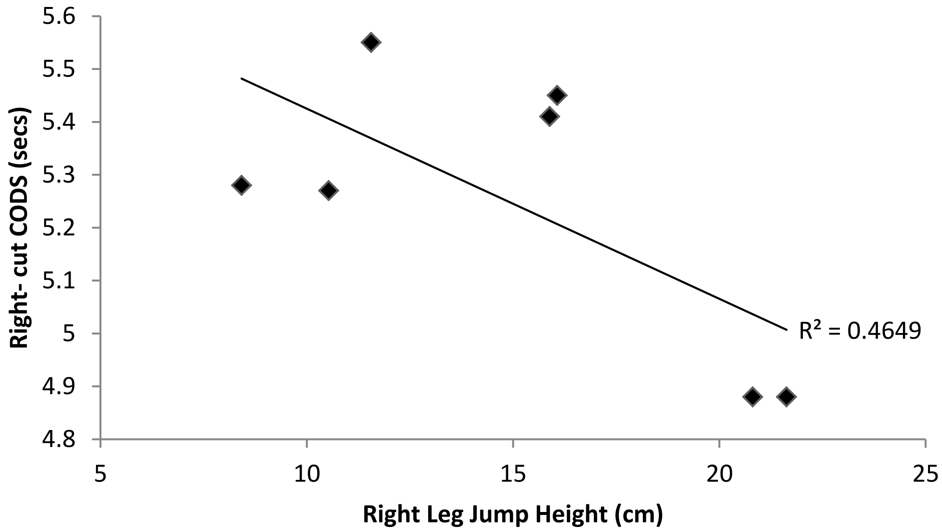

Figure 4. The relationship between right leg jump height and right-cut CODS.

Figure 5 demonstrates a negative linear correlation (r = -.228, p<0.05, r^2 =.051) between the strength of the right leg in comparison to the right-cut CODS test. There is a high likelihood that although the participants are cutting to the right, they are primarily going to be pushing off of their left leg, causing a lower score for the 'right-cut' CODS. The difference between these two variables was once again statistically non-significant.

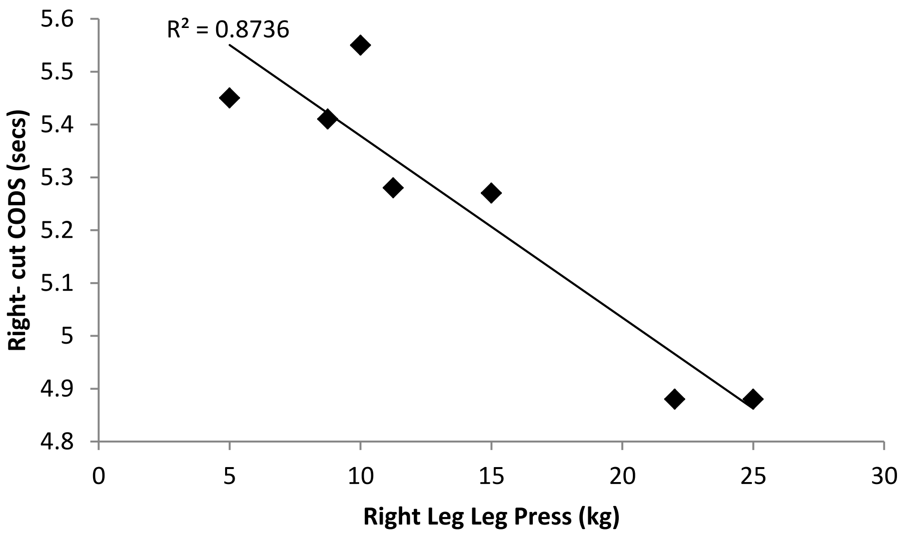

Figure 5. The relationship between right-cut CODS and right leg press score.

A positive, linear correlation (r = -.320, p<0.05, r^2= .102*)* found between the left leg strength and left leg jump height between all participants is shown in figure 6. Though statistically insignificant, the figure suggests that the stronger the participant is in their left leg, the higher they can jump off of it.

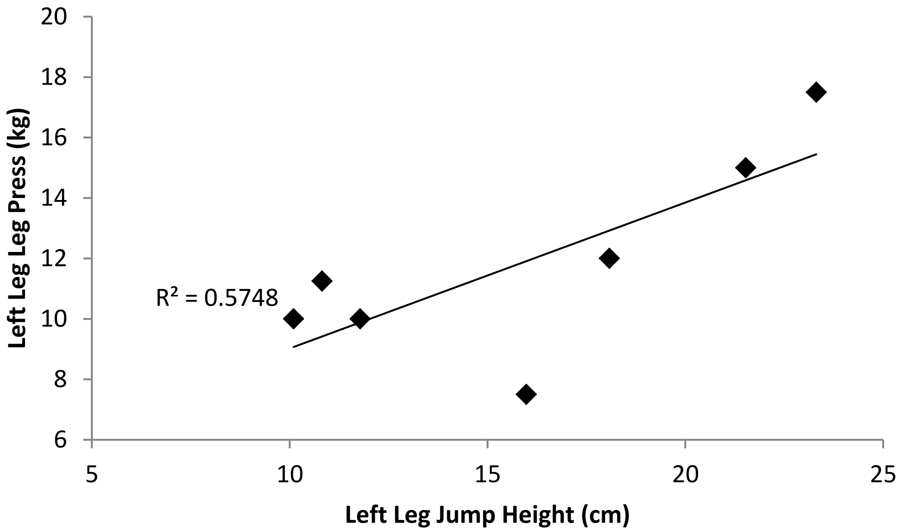

Figure 6. The relationship between the left leg press and right-cut CODS.

A negative correlation between right leg strength and left leg cut during the CODS test in all participants is shown in figure 7. Though a non-positive correlation is shown between these two variables (*r* = -.253, p<0.05, r^2=.064) during the left-cut CODS test, participants are probable to push off of their right leg, thus, the stronger the participant is in their right leg the quicker their CODS test result should be.

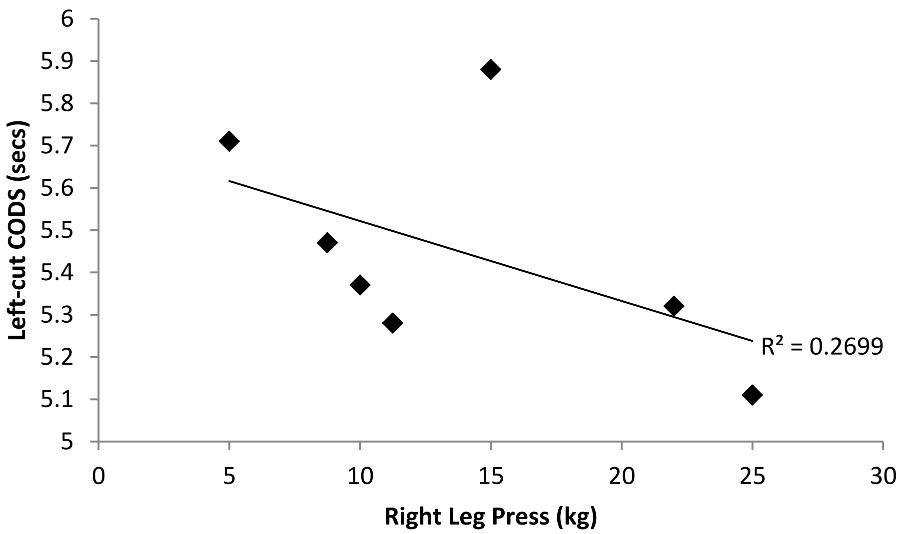

Figure 7. Relationship between leg press score and CODS time in the left leg.

The scatterplot shown in Figure 8 expresses the linear regression between left-cut CODS time and the right leg jump height (r =.380, p<0.05, r^2 = .144). This shows a weak to moderate correlation between the two variables, though not significantly correlated. The correlation shows that although the correlation is not significant, that on some instances the higher the participant can jump off of their right leg, the quicker they were on the left-cut CODS test.

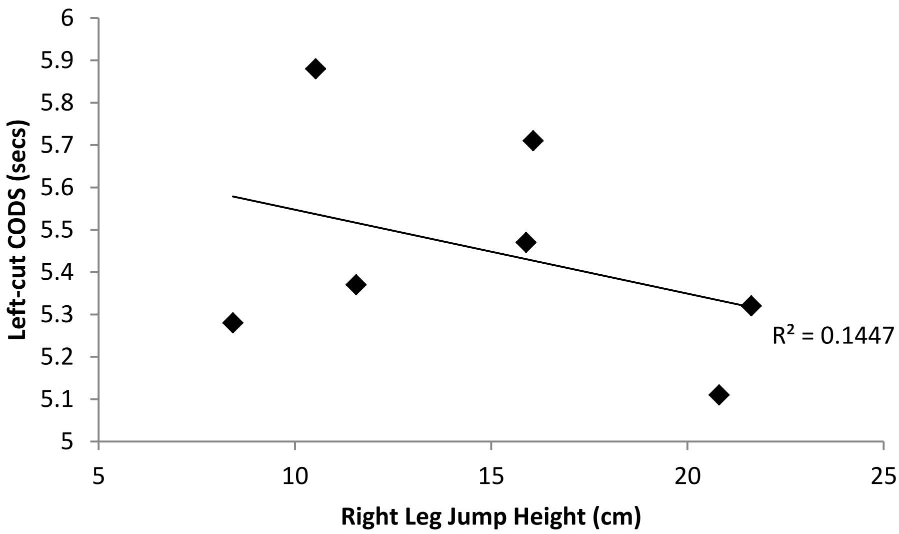

Figure 8. The relationship between left-cut CODS time and left leg jump height.

The scatter plot in figure 9 shows a positive negative correlation (r = .064, p<0.05, r^2 = .004). Though these two sets of data are significant to each other, there is still a correlation suggesting that the stronger the participant during the 1RM leg press, the quicker they are on the CODS test, though this has to be justified.

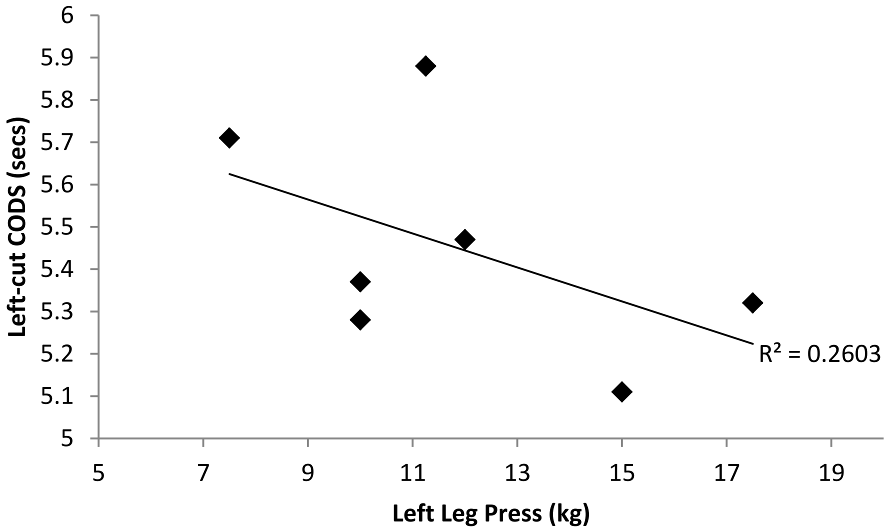

Figure 9. The relationship between left-cut CODS and left leg press.

Below, figure 10 illustrates that when participants completed the L-run they performed quicker during the right- cut in comparison to the left. Though the run included a right cut, it meant that each participant pushed off of their left leg to complete the test. Similarly, when completing the left-cut run, participants pushed off of their right (dominant) leg suggesting that although they were running to their left, they used their right leg power to complete the test. Therefore resulting in no significant difference between the time in which it took each participant to complete the CODS test on right and left legs (M= -.202, SD= .268, t (6) = -1.99, P = 0.93).

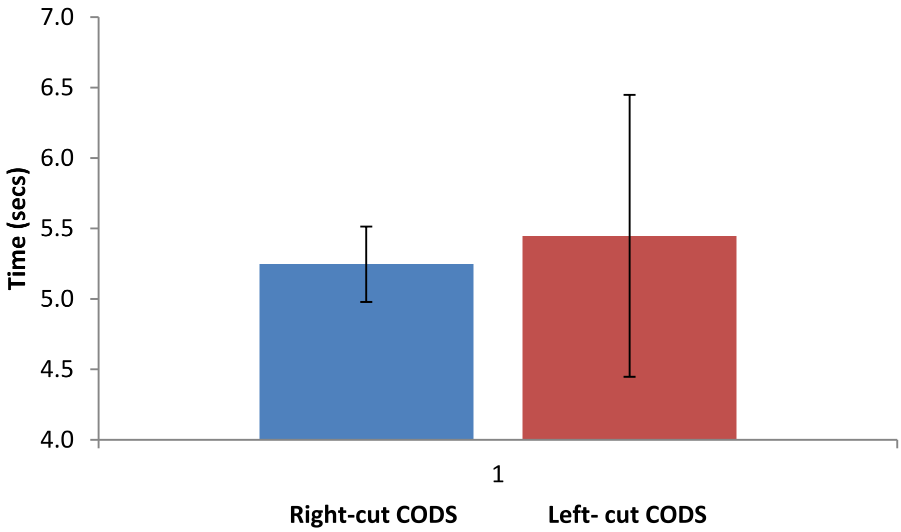

Figure 10. Right and left CODS when completing the ‘L’ run.

Figure 11 demonstrates that no direct significance was found in the time it took each participant to complete the unilateral vertical jumps (M= .955, SD = 1.59, t (6) = 1.58, P = .164). Each participant completing the unilateral vertical jump succeeded in jumping higher off of their left leg, though all participants that took part in the study had dominant right legs.

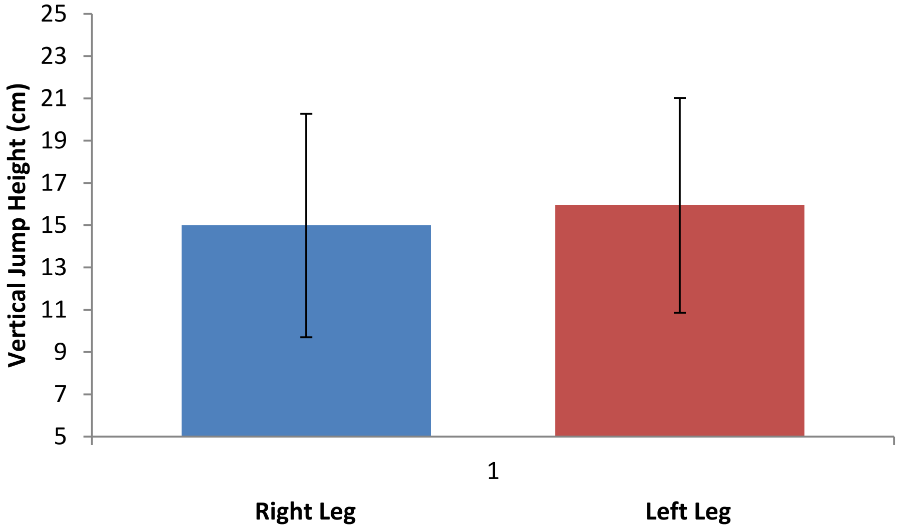

Figure 11. Right and left jump height (cm) during countermovement vertical jump.

Figure 12 displays that the right leg was evidently stronger than the left when completing a seated 1RM leg press (M= 1.964, SD = 4.57, t (6) = 1.136, P = .299). The likelihood of this is primarily due to dominance in the right leg of all participants. However again, no significance between these two sets of data were found.

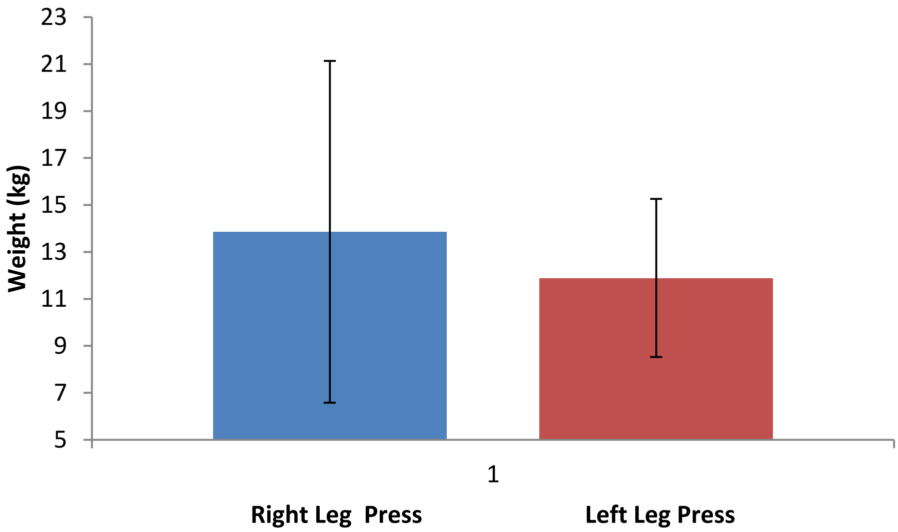

Figure 12. Right and left leg strength during the 1RM seated leg press.

CHAPTER 5

DISCUSSION

5.0 Discussion

5.1 Purpose of the Study

The purpose of this study was to assess the relationship between strength, power and change of direction speed in female games-based players. Though there are already numerous studies in this area, there is a distinct lack of research in the field of unilateral strength and power in female games-based players (Cronin, Odgen, Lawton & Brughelli, 2007); therefore this is the first study into the relationships between strength, power, and change of direction speed within female athletes.

5.2 Key Findings

The key findings of this study show significant relationships existed between bilateral strength and power as well as left and right 1RM strength. All jump variables (left and right) measuring height significantly correlate with each other. Though, little to no significance was found between any CODS measures. Unilateral 1RM leg press and jump height have significant correlations, suggesting that an increase in one of them will have an influence on the other, for example the stronger the participant the quicker and more efficient they will be at changing direction. Similarly, minor relationships between unilateral variables exist and it is probable that a change of result in the right leg will not have an impact on left leg results; an exception of this is jump height, where all relationships (unilateral and bilateral) are significant to one another. Young et al. (2002) disagrees, stating that the importance of leg power to agility is unclear.

Agreeing with the null hypothesis that 'strength, power and CODS will not significantly relate to each other, studies by Baker and Nance (1999); Cronin and Hansen (2005); Sheppard and Young (2006) have also shown that relationships among strength and CODS capabilities to be not significantly correlated. Difficulty finding whether clear relationships exist between strength, power and CODS is resultant of many factors, comprising of assessing changes longitudinally (Cronin, Ogden, Lawton & Brughelli, 2007) and the differences between participant's previous training experience, level of skill and the time in the training season (Baker & Nance, 1999; Cronin & Hansen, 2005; Hennessey & Kilty, 2001; Vescovi & McGuigan, 2008). Brughelli et al. (2008) also states that strength and power variables are not significantly correlated with CODS performance on a consistent enough basis to provide quantifying these relationships.

Similar to the results of this study, several studies have shown no relationships to exist between bilateral jump height, strength and CODS performance (Barnes et al., 2007; Sheppard & Young, 2006; Young & Montgomery, 2002). These relationships between strength, power and CODS may not occur because there are so many influences regarding each component. When looking at strength, power and CODS, they all assess distinct but different qualities (Sheppard & Young, 2006). Similarly, the unplanned nature of agility during changes of direction is knowingly different from strength and power because there are no decision making factors within that environment (Farrow et al., 2005), this may signify why differences in the results exist.

5.3 Maximal Strength and Change of Direction Speed

As can be observed by Table 2, the only significant relationship amongst 1RM strength scores and unilateral CODS was between CODSR and LPB (r^2=0.66). This result is an anomaly as it is expected that no relationship would occur between bilateral leg press and right/left-cut CODS. This is because participants are required to make numerous changes of direction rather than just right of left. Equally, numerous studies have demonstrated strong relationships between measures of strength and CODS (Negrete & Brophy, 2000; Vescovi & McGuigan, 2008).

Within the female population, Brughelli et al., (2008) states that stronger participants were slower, this is explained by the heavier participants lifting larger weights. Although fit, young, healthy female participants were used in this study, differences in maximal muscle strength have been found between untrained and trained individuals (Laubach, 1976); suggesting significantly un-trained females have a smaller muscle mass making them heavier and slower when partaking in CODS tests.

Previous literature by Nimphius, McGuigan and Newton (2010) summarised that relative strength has strong correlations with speed and change of direction ability. Therefore the ability to accelerate and decelerate during changes of direction would be more dependent on the ability to move their body mass quickly and efficiently. Although a study by Kovaleski et al. (2001) has shown absolute strength to have a relationship with the ability to change direction, it doesn't take into account that the participants are required to produce enough force to accelerate and decelerate their own body weight. This therefore results in relative strength to be a better indicator of change of direction performance (Nimphius, McGuigan & Newton, 2010).

Validity was met during testing by ensuring that CODS was measured unilaterally rather than just the right or left leg cut. Barnes et al., (2007) and Young et al., (2002) both compose that bilateral differences and leg dominance is imperative in the ability to change direction within team field sports. Therefore, agreeing with the hypothesis that maximal unilateral strength will have a strong correlation to unilateral change of direction speed.

5.4 Maximal Power and Change of Direction Speed

Little research has been done to look at the relationships between power and CODS, both Markovic (2007) and Peterson et al. (2006) investigated the relationship between these two variables finalising that weak significance was found. However, this isn't a good indicator between the two variables because in both studies only bilateral leg power was analysed rather than bilateral and unilateral differences. The work of Peterson et al., (2006), expresses that jump height is a measure of leg power, resulting in relationships between vertical jump height and power output sharing minimal variance (r=0.420).

The most common type of jump used to predict CODS is the vertical countermovement jump (Brughelli et al. 2008). Similar to this current study, female participants within a sport specific CODS protocol were used by Barnes et al. (2007) and it was found that the countermovement jump significantly correlated with just 34% common variance ($r= -0.03$, $p <0.05$). Equally, Vescovi and McGuigan (2008) again found low common variance (24-33%) among correlations between CODS and countermovement jumps. Based on these results, it is evident that vertical jump performance does not dictate a successful CODS performance, though looking into the unilateral vertical jump performance results may change this approach. The ranges in common variance within both sets of literature and this present study are further shown through weak linear regression. Furthermore, Nimphius, McGuigan and Newton (2010) mention that when considering relationships between sprint and vertical jump performance it must be considered the influence of the type of vertical jump performed (use of arms or no arms). To complete a CODS test quickly, efficient changes of direction must be achieved including short sprints and rapid cuts. Unilateral power and strength are obligatory as unilaterally the participant is going to need to push-off to execute the change of direction. Although this study and previous research didn’t see any significant relationships between CODS and strength/ power, it should be estimated that some significance between lower body strength, power and CODS would exist (Baker & Nance, 1999; Cronin & Hansen, 2005; Hennessy & Kilty, 2001).

Pauoloe et al., (2000) found significant correlations between CODS tests and countermovement jump height (r= -0.49 to -0.55, p<0.05) explaining a moderate relationship between jump height and CODS performance. Although common variance below 50% recognises no relationship and signifies two independent variables, Sassi et al., (2009) states that CODS must be a complex concept requiring interaction of several biomechanical and physiological factors. For example, sprinting and jumping demands are uni-directional movements whereas CODS is multi-directional, demanding changes of the body direction around vertical axis (Markovic, 2007). In the current study, hypothesis (c) states that there will be a strong correlation between power and change of direction speed. With reference to previous literature and this present study and its findings, it is ultimately clear that unilateral power being measured by vertical jump height has no correlation to CODS. Markovic (2007) also states that motor abilities such as movement co-ordination are likely play a larger role in successful CODS test performance than muscle power or strength, though this cannot be justified based on existing literature.

5.5 Maximal Strength and Maximal Power

All variables measuring strength and power significantly correlated (r=0.67), this was expected as the stronger the participant, the higher they should be able to jump. Schmidtbleicher (1992) says that maximal strength is the primary variable affecting maximal power output; therefore subjects with the higher maximal strength should present the highest power output. Measures of strength and power are shown to have strong correlations. Baker and Nance (1999) and Stone et al. (2003) showed strength is significantly correlated with power within the participants tested, also finding out that the strongest 5 participants were the ones who produced the highest power output. This also verifies that the hypothesis in this current study ‘strength and power will have significant relationships’ is correct.

Current knowledge in literature shows that sprinting performance requires high force production (Mero et al. 1992), resulting in strength and power movements having huge significance for improvements of running speed (Delecuse et al., 1995). 1RM strength and maximal power outputs have been shown to have high correlations during unloaded jumps (Gamble, 2010). Knowing this, it is evident that participants in this study who performed the heaviest 1RM (bilateral and unilateral) scores should produce the fastest times during the CODS test. Other than the only significant correlation between LPB and CODSR, both unilateral leg press and CODS results showed no correlation (Table 7). This is opposite of what was expected as the stronger the participant is the more powerful and faster you would expect them to be able to run. Young and Montgomery (2002) agree, summarising that 'relationships between strength and change of direction performance exist due to the similarity in push off mechanisms used to change direction'.

5.6 Limitations

A major limitation of the study was the amount of participants that were involved (n = 7). Although great effort was put in to get as many participants as possible, numerous participants were unreliable and it was a struggle to find a time and date that all participants could come for testing. Initially, 10 participants were tested during the planning stage of the protocol, but due to an injury and some individuals not being able to make the set testing dates only 7 participants completed all elements of the study. Even though this is a tolerable amount, studies by McCurdy et al., (2005); Peterson, Alvar and Rhea, (2006); Cronin et al. (2003); Gabbett, (2006) and Harris et al. (2000) use an average of 47 participants, providing more statistical power and confidence to the results. Having more participants would have also improved significance between the variables as there is more rationale for the effect of one variable on another.

Prior to strength testing, familiarisation of sessions were inevitable. However during the strength testing, complications with the leg press machine arose. When completing the 1RM test protocol, one participant found it hard to perform the leg press and was unable to push the force of the machine (with no weight), resulting in being forced to withdraw. To address the problem, the participant was asked to come back at a later date to complete the test when equipment had been adjusted appropriately. Definite familiarisation sessions should have been conducted before any participants used any of the equipment throughout all testing dates (leg press, timing gates and contact mat). Ensuring that participants had familiarisation sessions before testing and knew how to the equipment thoroughly would have saved time and ensured that no mistakes were made on the day.

Furthermore, there was a potential limitation during the CODS testing, this was that the stimulus to proceed was a green ‘go’ light, however it may have been more appropriate to use a sport specific cue (Sheppard et al., 2006). Using a sport specific cue would present the athlete some ambition, with the need to anticipate the timing similarly to a game situation. Nonetheless, using this type of test would provide too many variables, creating a problem so it was not chosen to be used during testing.

Using the contact mat to record jump height (cm), when a force plate could have been used would have given force characteristics. Characteristics such as peak force, rate of force development, ground reaction force, as well as different planes of movement (X, Y and Z), rather than just jump height reading. This would have resulted in a better understanding of the relationships and significance between the three chosen variables.

Finally, although participants were asked to refrain from participation in vigorous exercise 24 hour prior to each testing date, it cannot be guaranteed that these expectations were met as refraining from participation was not monitored strictly to ensure optimum results.

5.7 Future Research

In order to finalise understandings between CODS, power and strength, several suggestions have been put forward. Firstly, it would be more appropriate to look at relationships between strength, power and CODS longitudinally through a training programme; relationships vary with time and should be investigated over longer time periods to better determine if these cross-sectional relationships actually reflect a deterministic relationship (Nimphius, McGuigan & Newton, 2010). This will then lead to stronger relationships as motor abilities such as movement co-ordination may prove to play a larger role in successful CODS performance rather than testing muscle strength or power (Markovic, 2007). Cronin (2007) also states that there is limited research in the area of strength, power and change of direction performance longitudinally in females in comparison to males thus another reason to look at these variables over a longer time period.

CHAPTER 6

CONCLUSION

6.0 Conclusion

The aim of this study was to see if relationships existed between strength, power and CODS within female athletes. It was hypothesised that relationships would occur between all variables as it is generally expected that one variable may have an influence on another, as suggested by several studies (Baker & Nance, 1999; Cronin & Hansen, 2005; Negrete & Brophy, 2000; Nimphius, McGuigan & Newton; Vescovi & McGuigan, 2008).

Hypothesis (a) 'There will be a relationship between bilateral strength and power' was accepted due to the high significance found between the two variables ($p<0.05$). Whereas hypothesis (b) was declined, as no relationship was found between the dominant limb strength and CODS. Equally, both hypothesis (c) and (d) were rejected, resultant of strength and power measures having no significance to CODS. Additionally, the null hypothesis stating that 'strength, power and change of direction speed will not significantly relate to each other' was neither accepted, nor rejected due to numerous factors discussed. Through detailed analysis and the high amount of rejected hypotheses it makes it clear that this study is in need of further research for appropriate justification.

It can be concluded from a review of current literature that measures of CODS cannot always be determined by strength and power. Though some literature has suggested that there is a link between strength, power and CODS variables, some have not. Therefore because this study has shown certain relationships are not significant, there is still much ambiguity regarding this subject. Results within this study help to explain that investigation into further concepts will provide better understandings as an alternative of just looking at strength and power measures when assuming CODS.

To summarise the findings of this study, it is clear that strength and power are highly dependent on one another, whereas the study as a whole failed to demonstrate a relationship between strength, power and change of direction speed.

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APPENDICES

APPENDIX A

PARTICIPANT INFORMATION SHEET

Appendix A1: Participant Information Sheet

Title of Project: The Relationship between Strength and Power and Change of Direction Speed in Female Game-Based Players

Participant Information Sheet

Background of Study:

This research study is to see whether there is a relationship between the lower limb strength and power and change of direction speed (CODS). The testing will be held at Cardiff Metropolitan University in the NIAC (National Indoor Activity Centre) situated on Cyncoed Campus, Cardiff.

Your participation within the research study

Why have you been asked?

- You have been asked to be involved in this study because you play for Cardiff Metropolitan University in one of the BUCS teams.
- You are fit and healthy and have not had a lower extremity injury within the last 12 months of participation.
- Change of direction speed (CODS) is an important factor in any games-based sport enabling you to perform better if your change of direction is efficient.

The areas the study will examine:

- Change of direction speed (CODS)
- Strength testing, including 1RM of a lower limb exercise.
- Power testing, including a one and two legged jump onto a mat.

What will happen once you agree to be involved in this study?

- You will meet on two consecutive occasions, once to do the strength test and once to do the power and change of direction speed testing.
- The strength test will involve a bilateral and unilateral 1RM lower limb test, for example a leg press.
- The power test will involve unilateral and a bilateral drop jump test.
- You will be asked to come to a selected time in order to complete these procedures.

Are there any risks involved?

- Ensuring that you are warmed up will minimise any risks of injury.
- The 1RM test will be a risk to you if you do not follow the correct protocol and warm up correctly.
- If you are feeling unwell on the day of testing it is up to you as the participant to tell me whether you are well enough to continue or if you do not want to take part in the testing.

Are there any benefits involved?

- You will be measuring your lower limb strength and power, giving you a clear indication of your 1RM of a specific exercise.

Your rights within the study

- Being a student at Cardiff Metropolitan University (UWIC) means you are fully covered for insurance if anything was to go wrong during testing.
- Also, all personal information that is taken from you will be kept confidential, when testing you will be given an ID number to prevent anyone finding out your name.
- You have the right to withdraw at any stage of this testing.

Do you have to participate?

- If you begin the research study and do not want to continue any more that is fine, you just have to communicate and let me know.

What happens to data collected?

- All data from all of the testing scenarios will be kept confidential. It will not be shared with anybody else and nobody will be able to see it.

Have you got any questions?

- Feel free to ask any questions, if you have any queries or any problems throughout any of the testing, just ask.

Thank you.

Robyn Griffin
Email: st20002688@cardiffmet.ac.uk

APPENDIX B

INFORMED CONSENT FORM

Appendix B1: Informed Consent Form

INFORMED CONSENT FORM

Title of Project: The Relationship between Strength, Power and Change of Direction Speed in Female Game-Based Players

Name of Researcher: Robyn Griffin

Participant to complete this: (please tick appropriate)

☐ I confirm that I have read the information sheet dated …../……/……

☐ I understand that my participation in this study is my choice and if I want to leave at any point I can.

☐ I understand that if this happens, Cardiff Metropolitan University (UWIC) will not be affected in any way.

☐ I know that all personal information that is taken from me will be kept confidential and will not be shared with anyone else.

☐ I agree with the conditions and am happy to be participating in this study.

Name: ……………………………………………………………………………….

Surname: ……………………………………………………………………………

Signature: ……………………………………………………………………………..

Date: ……/……/……

Name and Surname of Person taking consent: ……………………………………………….

Signature: ……………………………………………………………………………………………

Date: ……/……/……

APPENDIX C

ETHICS STATUS

Appendix C1: Ethical Status Form

Date: 18/03/14

To: Robyn Griffin

Project reference number: 14/3/29U

Your project was recommended for approval by myself as supervisor and formally approved at the Cardiff School of Sport Research Ethics Committee meeting of 29th May 2013.

Yours sincerely

Rob Meyers
Supervisor