RHYS CRANE

ST05002586

SPORT AND EXERCISE SCIENCE

UNIVERSITY OF WALES

INSTITUTE CARDIFF

THE EXPORATION OF RELATIONSHIPS THAT EXIST BETWEEN FACTORS THAT AFFECT AGILITY WITHIN A RUGBY SPECIFIC POPULATION

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ABSTRACT

The Game of rugby union is a multi-sprint, multidirectional, evasive team game that requires high-speed total body movements often in response to a stimulus. These evasive movements can occur in the form of a side-step, which can therefore be classified as an agility task. Recent research has led to the conclusion that agility is influenced by both change of direction speed (CODS) and cognitive factors, however there is uncertainty in to which factors and their sub-components have the strongest relationships with agility. The purpose of this study is to explore the relationships that exist between agility and its sub-components within a rugby population. In turn this can provide coaches with a better understanding of agility and improve skills such as the side-step.

20 collegiate male rugby players (n = 10 forwards, and n = 10 backs) completed a series of tests including novel planned agility (PA) and reactive agility (RA) tests, a newly designed lateral jump (LJ) test, a Reactive Strength Index (RSI) jump test, and a 10m and 40m maximal straight sprint test. A number of descriptive stats were applied to the raw data including an Analysis of Variance (ANOVA) and Pearson's Product Correlation Coefficient. The findings were then expressed as a common variance (CV).

The findings suggest that CODS and acceleration have the strongest CV with agility (CV's of 56.4% and 59.1% respectively). RSI and therefore the Stretch Shortening Cycle (SSC) were also found to have some form of relationship with agility, the CV of these variables being consistently around or above 50%. This suggests that improved acceleration and therefore improved agility can come from developing an individual's reactive strength. It can safely be suggested that in order to improve agility and therefore skills such as the side-step, it would be necessary to develop both CODS and acceleration through training. This in turn provides coaches with clarity and direction into the necessary ways of improving agility.

CHAPTER I

INTRODUCTION

1.0 Introduction

Many sports such as rugby union require high-speed total body movements, many of these are in response to the motion of a ball, opposition players, or team mates (Young and Farrow, 2006). According to Sheppard and Young (2006), these movements can be classified as agility. There is however, somewhat of a phenomenon surrounding 'agility' and its definitions within the sports science community (Sheppard and Young, 2006). There have been many different definitions and insights into agility such as 'the ability to change direction with minimal loss of control and/or average speed' (Barnes *et al*., 2007), 'a whole-body change in direction' (Baechle, 1994), and also 'the extent to which perception and decision-making influence agility' as first deliberated by Chelladurai (1976), mentioned in Sheppard and Young's (2006) review of agility literature. The latter mentioned definition of agility has been relatively ignored until now. Sheppard and Young (2006) also highlight that the differences in definitions could be due to the variety of academic disciplines from which the investigators base their research.

In light of this inconsistency that has been found in defining agility Sheppard and Young (2006, p. 922) proposed a new definition as "a rapid whole-body movement with change of velocity or direction in response to a stimulus" which is based around the model designed by Young *et al* (2002) shown in Figure 1. It is also stated that for a movement to be considered an 'agility task' it must be an 'open skill'. This occurs when a movement is not pre-planned or rehearsed and is in reaction to a stimulus (Young *et al*, 2002). This new definition of agility aims to cover all of the components, psychological, biomechanical and physiological that influence agility as a whole making it an interdisciplinary attribute.

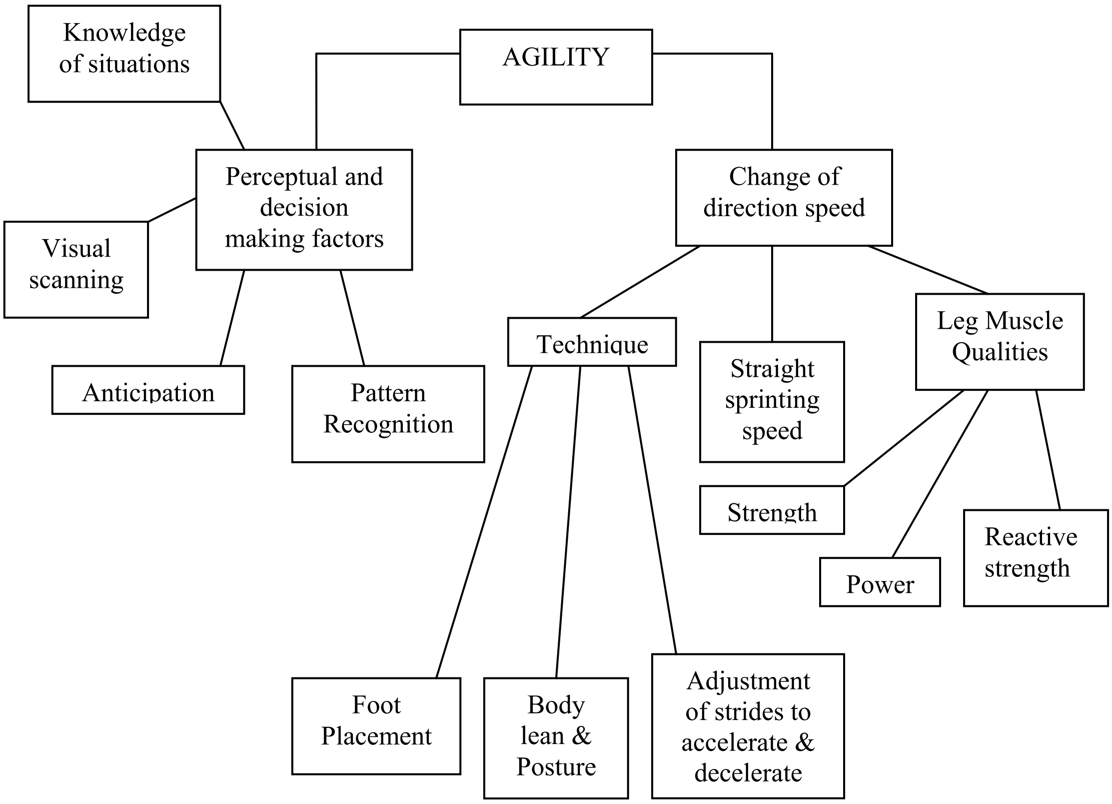

Figure 1. Model indicating the main factors determining agility (adapted from Young *et al.*, 2002)

Research conducted by Young *et al.* (2002), led them to comprehensively outline agility and its influencing factors associated with muscle power and running speed with changes of direction. They outlined the multi-faceted influences involved in agility performance and identified two main components, “change of direction speed” (CODS) and “perceptual and decision making factors” (p.284). As shown by the model in Figure 1 by Young *et al.* (2002), CODS is a sub-component of agility that requires no stimulus (i.e. sprints with a change of direction - COD) as opposed to sprints that could include a COD in response to a stimulus. The variables associated with influencing this COD in response to a stimulus are included in perceptual and decision making factors. This means that in order to investigate agility thoroughly both components and their sub-components need to be assessed together. The extent to which each component influences agility is still unknown.

The Game of rugby union is a multi-sprint, multidirectional sport, interspersed with high intensity activities such as rucking, mauling, side-stepping, and lifting (Pearson, 2001). It is an evasive team game that requires a wide range of playing skills and various forms of physical fitness (Hazeldine and McNab, 1998), agility being only one of these components as shown in Figure 2. A player who possesses high levels of agility is elusive, has tremendous foot co-ordination and is difficult to tackle and is therefore an important weapon in the attacking armoury of any team (Kear, 1996). One element of agility that can be seen on a rugby pitch that is regularly used in tackle evasion is described by Kear (1996) as the side-step. This is a sudden, quick change of direction by an immediate straightening up. Sayers and Washington-King (2005), show that the lateral side-step is a common evasive skill that is used in elite rugby. The side-step can be described as an 'open skill' as it is often used in response to a stimulus provided by a defender in order to evade being tackled. This skill therefore fits into Sheppard and Young's (2006) definition of agility.

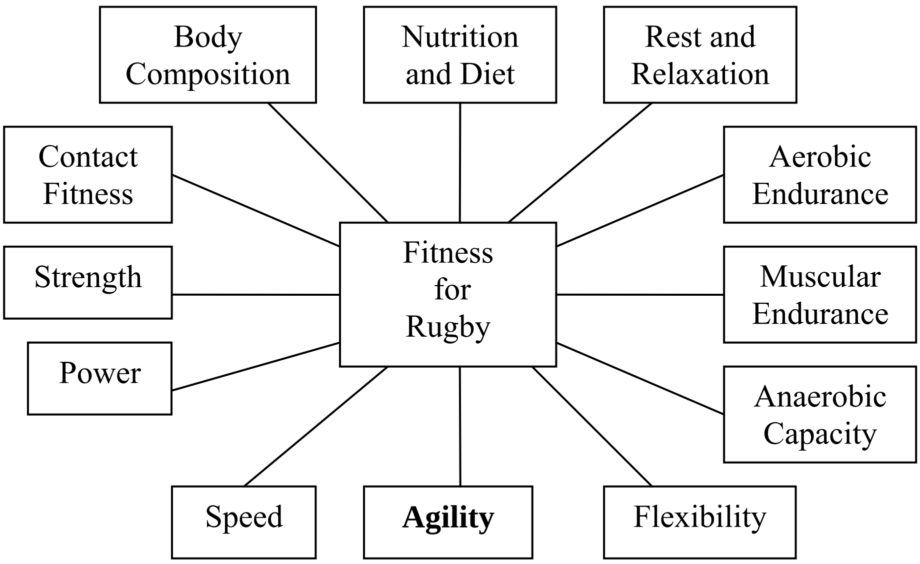

Figure 2. Model of physical fitness for rugby (adapted from Hazeldine and McNab, 1998)

Pearson (2001) states that agility should not be taken for granted and can actually be taught to individual players. This will develop both their attacking and defensive skills. Developing agility benefits a player in many ways such as increasing their fine muscle control allowing individual's to optimise their body alignment as to prevent injury and maximise force exertion during the execution of skills such as the side-step (Pearson, 2001). The best way to train agility however seems to be elusive (Young and Farrow, 2006) especially compared to the other components included in Figure 2 such as speed or power. If it were possible to identify the relative importance of the various contributing factors to agility it would therefore make it easier to develop training strategies to maximise the development of agility and specific skills that involve agility such as the side-step.

1.1 Aim of the Study:

The aim of this study therefore, is to explore any relationships that are found to lie between the variables outlined by Young *et al.* (2002) in Figure 1. Agility will be measured using a rugby related side-step within a rugby specific population. Any relationships that are found within this study could therefore provide coaches with a better understanding of agility as a whole and also lead them to improve rugby related skills such as the side-step through the specific training of certain variables.

CHAPTER II

REVIEW OF LITERATURE

2.0 Review of Literature

The majority of research that has been conducted in the area of agility is generally based around either one or the other aspects that influence agility, these aspects being either CODS or the cognitive factors as described by Young *et al*. (2002) in Figure 1. Within the research there seems to be rather a bias towards the physiological side of agility (Young and Farrow, 2006), rarely looking into both the physiological and psychological factors and the impact they have upon agility together. Until recently, the general impression was that agility was based around CODS factors. According to Sheppard *et al*. (2006), there is no literature that evaluates a sport-specific, physical performance test of agility that includes anticipation and decision making using a three-dimensional stimulus. A possible reason for this is that the cognitive variables described in Young *et al*.'s (2002) model (Figure 1) such as visual scanning, anticipation, pattern recognition and knowledge of situations are harder to measure individually than measuring the influence they have together defined as perceptual and decision making factors. The inclusion of these cognitive factors within more recent research has however lead to alternative findings based around agility providing new avenues for future research such as that of this study.

2.1 Agility as a Performance Parameter

One area of research into agility is how agility amongst other performance variables and characteristics such as speed, endurance, body mass, and power etc have impacted on overall sporting performance. A study by Gabbett (2002a) looked at how physiological characteristics including agility (measured using the Illinois Agility Run) influenced team selection in rugby league. The only differences found by Gabbett (2002a) in relation to agility were that between forwards and backs. Other similar studies that have used the Illinois Agility Run include Gabbett (2002b) and Philippaerts *et al*. (2006). These studies attempted to quantify the influence that agility has on the physiological characteristics of football and Rugby League players. Another test used to measure the COD aspect of agility is the L-run. Meir *et al*. (2001), Polman *et al*. (2004), Gabbett (2006) and Gabbett *et al*. (2007b) all use the L-run to assess agility and its relationship to overall physical fitness in different team sports. Gabbet *et al*. (2007a) however, is the only study where the T-Test is used as a measure of agility within rugby. Effectively, all of these tests measure CODS, just in different ways. Research within this dimension of agility testing could be useful in identifying or allocating player positions, playing standards within a team or assessing the differences between senior and youth players. The various field tests have all been proven to be relatively reliable in assessing the physiological component of agility. This type of research may therefore have a more limited application in the assessment of agility and all of its sub-components.

2.2 The Influence of Change of Direction Speed on Agility

As mentioned previously, a lot of research surrounding agility and agility testing focuses on the COD component of agility. Researchers often refer to a COD as 'agility' for example Polman *et al*. (2004). This is also reflected in the tests that are used to measure the agility of participants. As described before, these tests such as the T-Test, Illinois Agility Run and the L-Run are all tests of pre-planned agility (i.e. CODS), eliminating the decision making process. Little and Williams (2005) conducted a study into the extent of the relationship between 3 different speed components they identified as maximum speed, acceleration and agility (defined as the ability to change direction) all of which impact on soccer performance. Agility was measured using a zigzag formation of cones. Although they found correlations between all the tests, the extent to which they influenced one another was low. It was concluded that speed, acceleration and agility (in terms of COD) are specific qualities and relatively unrelated to one another. Testing of each component should therefore be more specific. This is supported by Buttifant *et al*. (1999), who propose that agility should be broken down into its basic components with each being measured individually. From their findings using the Illinois Agility Run, Buttifant *et al*. (1999) proposed an area of future research into the measurement of reactivity by eliminating the speed component and placing more emphasis on the agility parameter. Further support for placing more emphasis on the perceptual component of agility is provided by Young *et al*. (2001) after researching into the specificity of sprint and agility training methods. Young *et al*. (2001) found that there is a limited transfer between the two training methods, and that the more complex the agility task the less transfer there is from the speed training. The agility tests used in this study again solely focused on CODS and involved 7 different 30m tests varying from a straight 30m run to five COD with varying angles. It was again suggested that further research should take into account these unknown perceptual skills in the design and testing of agility. In all of the prior mentioned studies however, agility as a whole, and by its new definition, was not assessed completely. Only COD was assessed and although the correct suggestions were made in that future research should include a perceptual aspect in new agility tests, the assumption that agility (within its new definition) is not related to speed or acceleration may be incorrect due to the exclusion of these perceptual factors. The findings of previous research could therefore possibly be deemed unreliable.

2.2.1 The Relationship between Technique and Agility

The ability to perform a COD must also be influenced by the technique and the body position of the individual in question (Young and Farrow, 2006). Sayers (2000) found that the technique used by rugby players in comparison to the technique of track athletes was lower to the ground with a relatively high step frequency enabling a rugby player to make a faster COD. Sheppard and Young (2006) suggest that a forward lean and a low centre of gravity are essential in optimizing acceleration, deceleration and stability therefore a better CODS can be obtained. Inconsistently, Little and Williams (2005) and Young *et al*. (2001), suggest that there is a low correlation between straight-line sprint speed and agility. The description of the acceleration phase for a sprinter by Brown *et al* (2005) however, involves a low centre of gravity and a forward lean providing support as to why acceleration may be more closely related to agility or CODS (Little and Williams, 2005), and also posing further questions over the findings of previous research. Besier *et al*. (2001) found that there was a greater external loading on the knee joint during a random un-planned COD in comparison to that of a known pre-planned COD. These findings validate the inclusion of technique in influencing CODS providing evidence that technique is different when perceptual skills are being used. These differences are thought to be related to a sub-optimal pressure imposed by the time-stress of reacting to a stimulus (Sheppard and Young, 2006).

2.2.2 The Relationship between Jumping and Agility

Young and Farrow (2006, p. 26), report that "It is an oversimplification to suggest that the leg muscle groups are solely responsible for COD movements". They propose that it is necessary to develop adequate core stability so that when a COD is made the body transmits the ground reaction forces and moves effectively rather than absorbing the forces. This can be applied to all aspects that involve the use of the body's core muscles and the ability to transmit forces such as when jumping. Young and Farrow (2006) also state that strength, power and reactive strength can potentially influence CODS. They propose that for a cutting movement to produce a lateral change in direction, the stretch shortening cycle (SSC) must also be involved.

The SCC is measured through various jumping tests. The counter movement jump (CMJ) and 5 bound jump (5BJ) tests have shown strong correlations with sprinting, acceleration and maximum velocity (Hennesy and Kilty, 2001). The 5BJ test was used to assess the repetitive SSC muscular contractions where as the CMJ was used to test the long SSC action. The 5BJ test is similar to that of the drop jump (DJ) test used in some studies (Young *et al*., 2002) as a measure of reactive strength. The DJ gives a reactive strength index (RSI) score by dividing DJ height by the ground contact time prior to take-off (Barnes *et al*., 2007). Alternatively, the 5BJ measures the jump height of the first jump and then uses the measured contact time divided by the following jump height to give an RSI score. Barnes *et al*. (2007) suggets that there are similarities between the contact times of the agility test and the DJ test used, however the correlation between the two could have been low due to the lack of a DJ movement in sport. This acknowledgment provides a sound reasoning that due to the similar movements in a rebound jump and some sports specific movements (e.g. the quick, stiff legged movements of a side-step), the contact time between a rebound jump (representing the repetitive SSC and RSI) and an agility test could show high correlations however there is no research into this. If there is a correlation between SSC and acceleration, and SSC and agility testing, it could be assumed that there should be a correlation between agility testing and acceleration.

Young *et al*. (2002), report that muscle imbalances between opposite legs can influence CODS. They found that a significantly lower COD (either left or right) was related to the weaker leg in a unilateral DJ test. Much of the research conducted into the SSC and power focuses on testing that revolves around the vertical plane of motion (Hennesy and Kilty, 2001; Young *et al*., 2002; Barnes *et al*., 2007). There is little research in to that of lateral sideways power and SSC tests. Sinnett *et al*. (2001) performed a plyometric leap test that involved leaping from one leg to the other in a forward direction resulting in a total distance. There is however little, if no research into the lateral jumping movement within this horizontal plane that associates muscle imbalances that could influence agile sporting movements such as the side-step. Therefore this area of research is open to new ideas and possible forms of testing to assess these factors.

2.3 The Influence of Cognitive Factors on Agility

As mentioned previously the majority of research conducted into agility focuses on the physiological aspects that influence agility or more specifically CODS. By comparison, the psychological aspects and the extent to which variables such as perception and decision making factors influence agility has been somewhat neglected until recently. Young and Farrow (2006) state that although an athlete may have an average CODS they can still be very agile if they possess high perceptual and decision making skills.

Earlier tests of reactive agility (RA) often involved the subjects having to change direction in reaction to a stimulus such as light or onscreen image. Hertel *et al*. (1999) developed a device named the Cybex Reactor. Subjects looked at a monitor ahead of them and then had to move to 1 of 14 target sensors linked to a computer shown on the monitor. The Reactor then assessed the total time it took a subject to complete all of the pre-programmed moves. The Reactor test would be useful in assessing agility tasks that require multiple movements such as many court sports however it is not suitable for more one off explosive agility movements for instance the side-step that occurs in field sports such as rugby. It is also a difficult test to administer consistently for a number of reasons including the inaccessibility to testing equipment.

Another RA test conducted by Besier *et al*. (2001) looked into the potential injury risks from the external loading of the knee joint during running and cutting manoeuvres in reaction to a stimulus using a force plate. This time the stimulus was an LED on an electronic board ahead of the athlete. As the subject passed through the timing gates after an initial run up, the board was triggered to randomly indicated whether they had to either run straight ahead, sidestep 30^{o}, 60^{o},or perform a crossover cut to 30^{o}. This made the test more games specific. Tests were conducted under pre-planned and unanticipated conditions. It was found that the inclusion of a stimulus increased the external loads on the knee indicating that there are differences between planned agility (PA) and RA. These forms of testing essentially focus on reaction time as well as CODS components. An athlete with a quicker reaction time would have an advantage over slower athletes in reaction to a stimulus, however as Young and Farrow (2006) imply, reaction time does not determine the speed of a response to a stimulus on the field. They maintain that athletes anticipate what is about to occur on the field due to the actions, movements, or position of a player or the ball. This type of testing has failed to take this into account.

More recently an advanced agility test in netball was devised by Farrow *et al*. (2005). They state that movement patterns of players within a game situation, particularly when defending, are initiated by the trigger of an opponent's movement. In order to examine a player's agility accurately, an agility test must therefore cater for the reactive aspect of performance through the inclusion of a visual-perceptual test component. This innovative test involved a subject having to react to the movements of life size video-clip of another netballer. This test was then compared to the 505 agility test, the standard (pre-planned) agility test in netball. The two tests were found to be unrelated showing that they were measuring two different types of agility. The main outcome from these findings was particularly useful in differentiating between playing standards. Although the reactive test was slower than the planned test at all skill levels, the reaction test of the higher skilled players was quicker than that of lower rated players. This is accurate evidence that tests of planned agility do not provide a true indication of an athlete's performance in a team-sport setting due the neglect of perceptual factors that influence agility within this environment. This form of testing was found to be reliable, however it is again very limited due to the lack of access and its complexity in replicating it. The extent to which this test could be replicated to assess different team sports is also unknown. Farrow *et al*. (2005) conclude that the inclusion of a sports-specific perceptual stimulus is non-negotiable in the development of future tests of team-specific agility.

Similar findings in differentiating between the levels of player abilities were found by Sheppard *et al* (2006). They designed a more practical, accessible RA test for football. In comparison to the testing of Farrow *et al*. (2005) where a video was used, Sheppard *et al* (2006) used a manual method of sports-specific stimulus within the RA test. When the tester made an initial movement to the left or right the test began. The subject was then required to react and move in the direction of the stimulus (the tester) through a timing gate to finish the test. There was a set protocol for the tester restricting the chances of different movements inducing different reactions and there was no significant difference found between that of two different testers in the reliability of this study. If the test however, was to be completed outside of these test conditions, random error within the tester's actions (human error) to provide a stimulus may differ throughout the testing therefore affecting the reaction of the subject making the test less reliable. Sheppard *et al*. (2006) also found that traditional closed sprint and CODS tests may not adequately distinguish between differing playing abilities.

2.4 Conclusions from Previous Agility Literature

In light of the literature that has been reviewed surrounding agility and the research question that has been proposed, agility testing seems to be entering a new dimension and many areas of this dimension are yet to be explored. Agility was once thought to revolve solely around CODS and the testing used to measure agility reflected this assumption. It has been established that when agility testing is applied in the sporting environment the limited form of CODS testing excludes the cognitive issues that evidently influence agility therefore new tests of agility are required. This has led to the most recent research with innovative tests that attempt to measure both CODS and cognitive factors that are defined as affecting agility. Some of these tests are inaccessible or fundamentally flawed and there are still many areas of agility that need to be explored. Since these new revelations, no such research has been found that specifically attempts to explore the relationships between certain variables that are thought to affect agility the most. The environments in which agility is seen are different whether it is on a netball court, football pitch or rugby pitch. There are different dimensions to the various games that produce different movements considered as agility and therefore it is hard to design an agility test that can be applied to all sports. There seems to have been no specific research into the side-step seen in rugby, which reflects the new definition of agility by Sheppard and Young (2006), in relation to agility testing. This research is therefore an attempt to explore the relationships between certain variables that are thought to affect agility the most and therefore influence agile movements such as the side-step within a rugby context.

CHAPTER III

METHODOLOGY

3.0 Methodology

3.1 Pilot Testing

Prior to the data collection of the main research study, it was necessary to determine the exact dimensions of the new tests being used and also the protocol for all tests by conducting a pilot study. This allowed the researcher a familiarisation period with the testing equipment and also the fine tuning of the protocol.

3.2 Sample Population

The sample for this study was selected from the University of Wales Institute, Cardiff (UWIC) rugby union squad. The twenty male students (n=10 forwards, n=10 backs) were part of the ‘Rugby Excellence Squad’ (elite members of the UWIC RFC Squad) that train on a full time basis. UWIC RFC compete in Division one of the Welsh Asda League’s and also in the Premier South Division of the British University Sports Association (BUSA).

3.3 Protocol

All testing was completed in the National Indoor Athletics Centre (NIAC). All subjects completed an informed consent form and perceived activity readiness questionnaire (PAR-Q) before taking part in any testing (see Appendices 1 and 2). This ensured that subjects were healthy and fit enough to partake in the testing and detailed the purpose of the research, testing procedures and what was entailed, the possible risks involved and also ensured anonymity throughout. All subjects were required to wear appropriate clothing and footwear to participate in the testing. Each subject conducted a warm-up followed by each of the following individual tests, a Straight Sprint, Planned Agility, Reactive Agility, Rebound Jump and a Lateral Jump test in a random order within the same day.

3.3.1 Warm-up

All subjects completed a warm up that included a 200m jog around the indoor track in NIAC followed by a series of 3-5 short sprints and jumps (laterally and vertically), and dynamic stretches. This warm up was repeated if there were any delays between tests.

3.3.2 Height and Weight

Height and weight were measured prior to the beginning of the warm-up. Height was measured using a Leicester Height Measurer (SECA: Hamburg, Germany) which is accurate to the nearest 0.01cm. Subjects were required to remove footwear, stand straight with their feet together. Subjects were asked to breath in, stretch up, breath out, and a measurement was then taken.

Weight was measured using SECA digital scales (Model 770: Hamburg, Germany) which are accurate to the nearest 0.1kg. Subjects were asked to remove all clothing apart from their shorts and step onto the scales. After 3 Seconds the reading shown on the scales was taken and noted down.

3.3.3 Straight Sprint Test

Using the Smartspeed Timing Gate System (Fusionsport, Brisbane, Australia) 10m and 40m straight sprint times were gathered. The Smartspeed system has been found to be reliable with a standard error of < 0.03s over 5, 10 and 20m distances (D'Auria et al., 2006). The testing system was set up as shown in Figure 3 over three lanes. Gates were accurately placed at the start line, 10m interval and finish line (40m) in both lanes using a measuring tape.

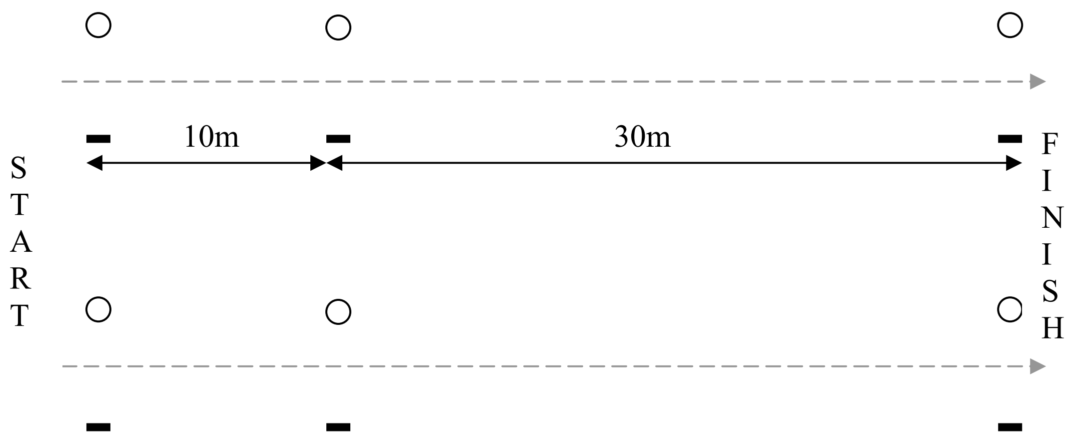

Figure 3. Straight sprint test set-up

Subjects were timed in pairs with someone who was deemed to be competitive over this distance as to incorporate an element of competition and gain maximal efforts. In preparation, subjects stood 30cm back from the start line (marked by tape) as not to break the beam and start the timing before they sprinted. When the subjects were ready, they were told to take up a standing sprint start position behind the start line, on the starter's instruction they maximally sprinted 40m. Reaction time therefore did not affect the results as the timing started when the subject broke the sensor beam by running through it, not on the starters command. No practice runs were deemed necessary to familiarise subjects with this test due to its simplicity. Subjects performed three recorded maximal trials.

3.3.4 Agility Testing

A new test for both planned agility (PA) and reactive agility (RA) was designed for this investigation. The test was designed based around the resources available to the researcher and the protocols used in previous research from Besier *et al.* (2001), Farrow *et al*. (2005), Sheppard *et al*. (2006) and also new research that is yet to be published by Oliver (2008). This unpublished research looked into the reliability and relationships of 10m straight sprints (SS), PA and RA. The testing protocol used in this study is primarily based on the work of Oliver (2008) where the agility tests used very similar protocol. Barriers were used to prevent subjects from cutting corners and lights were used as a stimulus for RA testing. Reliability was expressed using the Coefficient of Variation, this was found to be $< 4\%$ for all relationships including means of cuts both left and right. All relationships between PA, RA and SS were found to have an r-value of $r > 0.9$ ($p < 0.001$) which shows a very strong correlation between the variables and that this was not a chance occurrence. The similarities in test protocols between the SS test and agility tests are the reason for the innovative findings of Oliver (2008) suggesting that SS and agility do relate to one another. This has formed the fundamentals of the new testing protocols of PA and RA within this study.

As with the testing in Oliver's (2008) research, the new tests for this research study were designed so that PA and RA were measured within the same dimensions (i.e. the same test set-up), the only difference between the tests was the presence of a stimulus within the reactive test.

The Smartspeed System was used to measure the times in the RA and PA tests and was set up as shown in Figure 4.

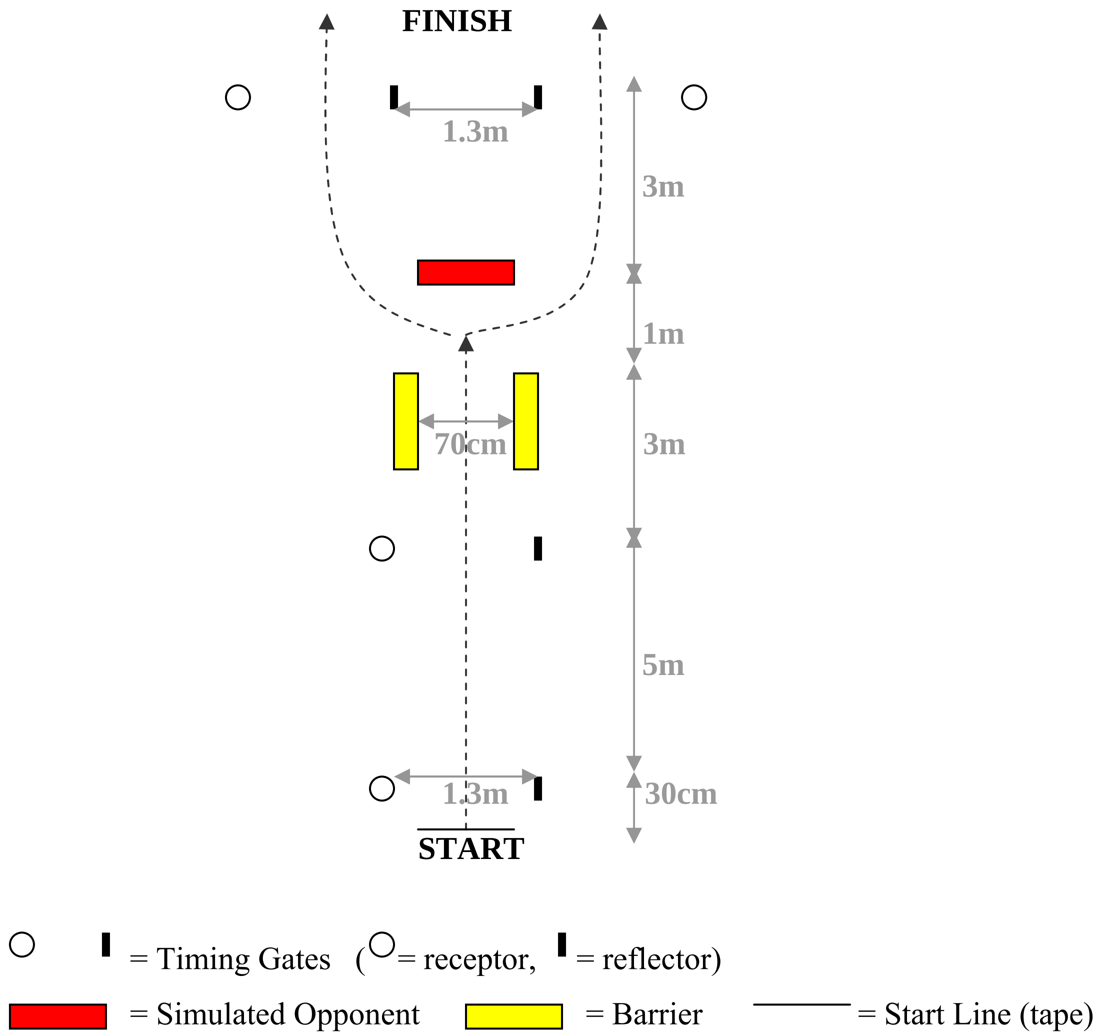

Figure 4. Agility Test set-up

The red obstacle ahead of the subject simulated an opponent that the subject had to avoid using a side-step motion either left or right. The first split time was taken over an initial 5m up to the second timing gate, and the second split time was taken over 7m up to the third set of gates (either left of right). The only difference between the PA and RA tests was that in the RA test, as the subject passed through the second timing gate (5m) either the left or right gate flashed, indicating the direction in which the subject should step. The flashing represents a gap or a stimulus that has developed, indicating the direction in which to avoid the opposition. A foam barrier (Dimensions: 70cm high, 90cm wide, 30cm deep at base) was used to represent the simulated opponent and it was placed 4m back from the second gate as to give the subject enough time so that they could react and maintain speed throughout the test whilst still under pressure to perform and react correctly. This distance was decided upon after pilot testing. A shorter distance showed that subjects weren't completing the test maximally as they couldn't react in time to the stimulus. 4m was found to provide enough time and space in order for subjects to react maximally whilst still being under pressure within a safe, game realistic environment.

Whilst in the process of pilot testing it was also found that during the RA test the correct side-step movement was used due to the reactive aspect and therefore pressures of the test. During the PA test however, subjects used a swerving motion to avoid the simulated opponent. To isolate this side-step motion, another two foam barriers were placed 70cm apart with the outer edges in line with the edge of the running lane (1.3m) and 1m away from the simulated defender (as shown in Figure 4). This prevented a swerving technique and promoted the use of the side-step motion to avoid the obstacle safely within the 1m gap.

3.3.5 Planned Agility Test

CODS was assessed (PA) using the set-up shown in Figure 4. The flashing lights were disabled for this test. The subject was given a pre planned route and was told to step to either the left or right when avoiding the simulated defender. Each subject was given one practice trial in each direction to familiarise themselves with the test set-up and performed three recorded trials in each direction. As in the straight sprinting tests, the subjects stood 30cm back from the start line (marked by tape) as not to break the beam and start the timing before they began. The subjects were asked to complete the tests with maximum exertion and start from a standing sprint start position when they were ready. A walk back recovery was considered adequate recovery between trials. A trail was deemed void if the subject made substantial contact with any of the foam barriers.

3.3.6 Reactive Agility Test

The RA and cognitive factors were measured using the same set up as in Figure 4. The Smartspeed System was set to randomly indicate the direction in which the individual needs to side-step after the second gate was broken (on average 0.04s; Oliver, 2008) by flashing. Subjects were given one random practice trail and then completed four recorded random trials. To ensure that maximal effort was exerted by subjects in this test, they were told that the initial 5m split time recorded in the PA test was to be compared to the 5m split time of that in the RA test. The subject was also told that they must react to the stimulus and not attempt to predict the direction of it. A trail was deemed void if the subject made substantial contact with any of the foam barriers or went the wrong way during the RA test.

3.3.7 RSI Jump Test

The Reactive Strength Index (RSI) jump test was used to generate RSI of five consecutive stiff legged jumps. This was measured again using the Smartspeed Timing System in conjunction with a SmartJump Contact Mat (Fusionsport, Brisbane, Australia). The jump mat was linked to one Smartspeed receptor and the jumping programme was used. It was explained to the subject that in order for the test to be valid the subject must have their hands on their hips throughout the test as not to generate momentum with their arms, and to land on the mat after each jump. After entering the subject’s weight and changing the programme to measure the contact time for five consecutive jumps, the subject was asked to step onto the mat. Once the system was set the subject was asked to perform one maximal squat jump followed by four consecutive stiff legged jumps as high, and as fast as they could, without letting their heels touch the floor. Each subject had one familiarisation trial and then performed three recorded trials with at least 2 minutes rest between trials.

3.3.8 Lateral Jump Test

To asses explosive power, individual leg strength and any imbalances between left and right legs in relation to a side-step movement within the horizontal plane, a lateral jump (LJ) test was designed. A 90^{o} single leg jump is a similar movement to the movement replicated when making a side-step.

Using a levelled sandpit, cones were laid out at a 90° angle with the measuring tape running parallel. The subject was asked to stand side on (90°) to the sand pit facing forwards with the foot of their jumping leg level with the beginning of the measuring tape. They were then asked perform a maximal single leg jump sideways off their jumping leg in line with the cones at a 90° angel and land on their opposite leg. As in the RSI jump test, it was explained to the subject that in order for the test to be valid the subject must have their hands on their hips throughout the test as not to generate momentum with their arms and gain an unfair advantage. The sand was dampened so that when the subject landed a definite mark was made in the sand. The measurement was taken as the distance between the inside of the take off foot to the inside of the landing foot. This was visually observed and noted down by the researcher. The sand was racked flat after each jump. Subjects were permitted one practice jump off each leg after a demonstration by the researcher. Six maximal jumps were then recorded (three off each leg), alternating between legs.

3.4 Statistical Analysis

A number of descriptive stats were applied to the raw data in order to give meaning the results and find any relationships that were related to the aim of the study. All statistical analyses were performed using the Minitab 14.0 package and Microsoft Excel.

A One-way ANOVA was used to determine the differences between the means of each variable between backs and forwards. The means were considered to be significantly different if the P-Value was ≤ 0.05. Pearson's Product Correlation Coefficient was then used to asses the extent of relationship's between variables, specifically each variable and RA (RA is considered to be the true score of agility). Each variable was then correlated against all other variables. A relationship was considered to be significant if the P-Value was ≤ 0.05. The Coefficient of Determination (r^2-value) was then calculated by squaring the r-value also given from Pearson's Product Correlation Coefficient. To generate a common variance (CV) score in order show the relationship between variables as a percentage, the Coefficient of Determination was multiplied by 100. Thomas and Nelson (1996), state that the CV can be accepted if it is found to be ≥ 50%.

CHAPTER IV

RESULTS

4.0 Results

Table 1. The mean and standard deviations of the test variables within the whole group and back's and forward's groups independently

Variable	Group (n=20)		Backs (n=10)		Forwards (n=10)	
	Mean	**SD ±**	**Mean**	**SD ±**	**Mean**	**SD ±**
Weight (kg)	100.12	17.38	87.70*	5.13	112.54*	16.38
Height (cm)	185.34	6.29	182.19*	5.32	188.48*	5.48
RSI Average	1.22	0.31	1.40*	0.31	1.03*	0.14
RSI Max	1.43	0.38	1.67*	0.35	1.19*	0.19
Lat Jump (cm)						
Left Leg	189.25	9.28	189.00	8.79	189.50	9.80
Right Leg	189.70	6.21	186.80*	5.42	192.60*	5.48
Mean	189.48	6.60	187.90	6.79	191.05	5.93
PA (s)						
Left	2.45	0.14	2.38*	0.09	2.52*	0.14
Right	2.44	0.17	2.37	0.12	2.51	0.17
Mean	2.44	0.15	2.37*	0.10	2.52*	0.15
10m (s)	1.77	0.12	1.72*	0.09	1.83*	0.12
40m (s)	5.42	0.29	5.25*	0.24	5.58*	0.23
RA (s)	2.64	0.14	2.58*	0.11	2.71*	0.12

***** P-Value ≤ 0.05 (ANOVA) between backs and forwards

Table 2. The r-values and the Common Variances of correlations between all variables and RA

	Group (n=20)		Backs (n=10)		Forwards (n=10)	
Variable vs RA	**r - value**	**CV (%)**	**r - value**	**CV (%)**	**r - value**	**CV (%)**
Weight (kg)	0.587*	35.5*	0.027	0.1	0.513	26.3
Height (cm)	0.308	9.5	0.126	1.6	-0.013	0.01
RSI Average	-0.664*	44.1*	-0.508	25.8	-0.652*	43.5*
RSI Max	-0.649*	42.1*	-0.651*	42.4*	-0.387	5
LJ (cm)						
Left Leg	-0.519*	26.9*	-0.661*	43.7*	-0.590	34.8
Right Leg	0.147	2.2	-0.410	16.8	0.144	2.1
Mean	-0.296	8.8	-0.591	34.9	-0.421	17.7
PA (s)						
Left	0.792*	62.7*	0.484	23.4	0.884*	78.1*
Right	0.679*	46.1*	0.348	12.1	0.773*	59.8*
Mean	0.751*	56.4*	0.414	17.1	0.855*	73.1*
10m (s)	0.769*	59.1*	-0.648*	43*	0.730*	53.3*
40m (s)	0.685*	46.9*	0.502	25.2	0.602	36.2

* P-Value ≤ 0.05 (Pearson's Product Correlation Coefficient)

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Table 3. The Common Variance (%) for the whole group's variable scores correlated against one another

		Weight (kg)	Height(cm)	RSI Average	RSI Max	LJ (cm)			PA (s)			10m(s)	40m(s)	RA(s)
						Left	Right	Mean	Left	Right	Mean			
Weight (kg)														
Height (cm)		26.4*												
RSI Average		39.5*	13											
RSI Max		44.9*	15.5	81.7*										
LJ(cm)	Left Leg	6.4	1	13.1	17									
	Right Leg	9.4	10.7	3.2	0.7	18.4								
	Mean	0.1	0.7	2.9	6.4	81.9*	59.6*							
PA(s)	Left	52.6*	14.7	54*	45.6*	23.8*	0.9	9						
	Right	30*	2.3	40*	30.6*	14.3	1.3	10.2	77.4*					
	Mean	42*	6.8	47.1*	39.3*	19.7*	0.1	10.6	92.7*	95.2*				
10m (s)		26.6*	4.5	46*	34*	24.4*	2.2	6.9	61.9*	48.3*	57.8*			
40m (s)		36.7*	3.5	46.9*	40.8*	15.6	0.8	5.6	60*	56.3*	62.6*	81.5*		
RA (s)		34.5*	9.5	44.1*	42.1*	26.9*	2.2	8.8	62.7*	46.1*	56.4*	59.1*	46.9*	

* P-Value ≤ 0.05 (Pearson's Product Correlation Coefficient)

Table 4. The Common Variance (%) for all variables relevant to back's scores correlated against one another

		Weight(kg)	Height(cm)	RSI Average	RSI Max	LJ (cm)			PA (s)			10m(s)	40m(s)	RA(s)
						Left	Right	Mean	Left	Right	Mean			
Weight (kg)														
Height (cm)		0												
RSI Average		9.4	0.4											
RSI Max		0.9	1.1	82.3*										
LJ (cm)	Left Leg	3.7	0.1	22.8	33.4									
	Right Leg	8.2	13.4	10.7	18.4	67.1*								
	Mean	5.7%	1.7	19.4	29.7	94.7*	86.3*							
PA (s)	Left	4.3	0.9	53.7*	57.6*	29.3	33.5	33.8						
	Right	11.2	21.7	34.8	33.2	13.7	29.2	20.7	70.6*					
	Mean	8.9	11.6	45.4*	45.2*	21	33.9	27.9	85.8*	94.9*				
10m (s)		5.8	9.3	57.9*	62.1*	47.6*	58.2*	56.4*	55.7*	52.3*	57.8*			
40m (s)		0.1	34.6	34.9	35.6	32.9	55.7*	44.8*	45.2*	72.5*	66.5*	74.8*		
RA (s)		0.01	1.6	25.8	42.3*	43.6*	16.8	34.9	23.4	12.1	17.3	42*	25.2	

* P-Value ≤ 0.05 (Pearson's Product Correlation Coefficient)

Table 5. The Common Variance (%) for all variables relevant to forward's scores correlated against one another

		Weight(kg)	**Height(cm)**	**RSI Average**	**RSI Max**	**LJ (cm)**			**PA (s)**			**10m(s)**	**40m(s)**	**RA(s)**
						Left	Right	Mean	Left	Right	Mean			
Weight (kg)														
Height (cm)		12.3												
RSI Average		42.6*	15.8											
RSI Max		60.8*	0.4	31.5										
LJ (cm)	Left Leg	42.1*	5.6	37.9	42.8*									
	Right Leg	4.4	2.8	3.4	6.6	1.8								
	Mean	40.1*	7.5	18	43*	79*	32.8							
PA (s)	Left	59.4*	10.8	56.6*	15.4	40.6*	0.04	26.8						
	Right	32	3.6	21.5	4.7	23.6	10.4	30.4	73.6*					
	Mean	47.1*	6.9	37.7	9.5	33.9	3.3	31.9	91.4*	94.3*				
10m (s)		10.8	2.4	12.4	1.6	21.4	18	3.4	49.4*	29.5	41.1*			
40m (s)		33.9	10	15	0.3	19.6	7.6	5.7	54.6*	30	43.7*	81.2*		
RA (s)		26.3	0.01	42.5*	5	34.8	2.1	17.7	78.1*	59.8*	73.1*	53.3*	36.2	

* P-Value ≤ 0.05 (Pearson's Product Correlation Coefficient)

Table 1 show's that significant differences exist between backs and forwards within all variables with the exception of LJ left, LJ mean and PA right. From Tables 2, 3, 4 and 5 it can be seen that the strongest CV's that relate to the aim of the study lie between PA, 10m time and RA within the whole group. Significant CV's are also shown to exist between 10m and RA within the backs and forwards groups individually, however the acceptance of these CV's differs (Backs < 50% and Forwards > 50%). Although there is a CV less than 50%, RSI average has a similar significant relationship with PA mean, 10m time and RA within the whole group with a CV > 40% in each case. CV's between RSI with PA mean and 10m in the forwards and RA in the backs, have however been found to be non significant.

All relevant relationships relating to the main findings of the study are displayed in Figures 5 through to 12 to illustrate their significance, correlation, CV and also show the differences in relationships between the back and forward groups.

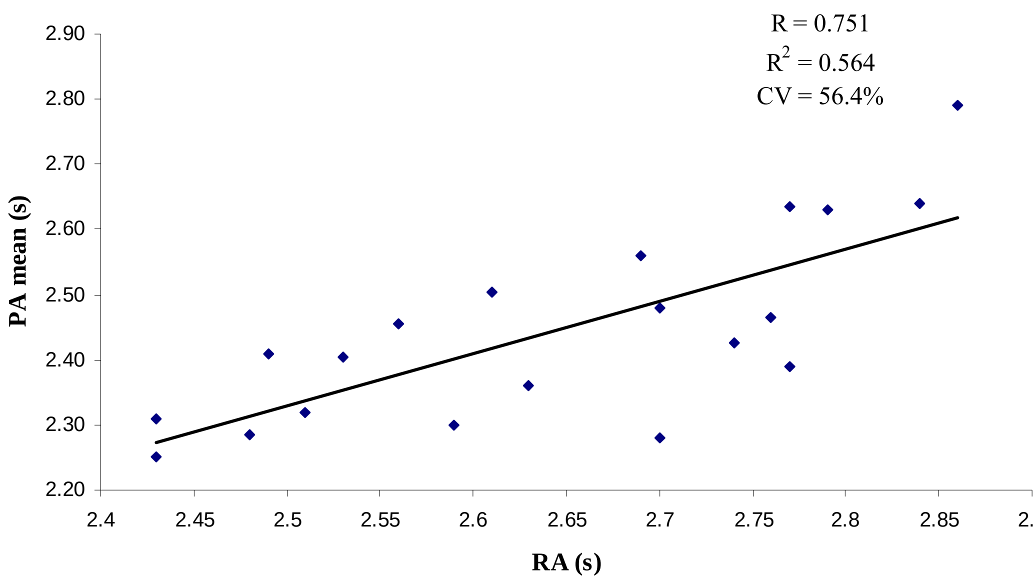

Figure 5. Correlation of PA mean and RA within the whole group

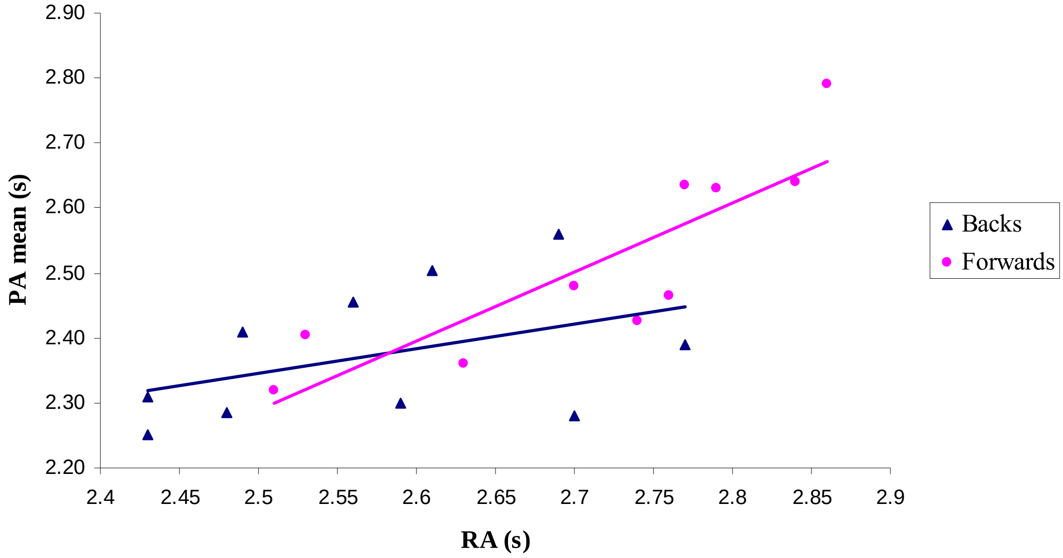

Figure 6. Correlation of PA mean and RA within the whole group showing backs and forwards individually

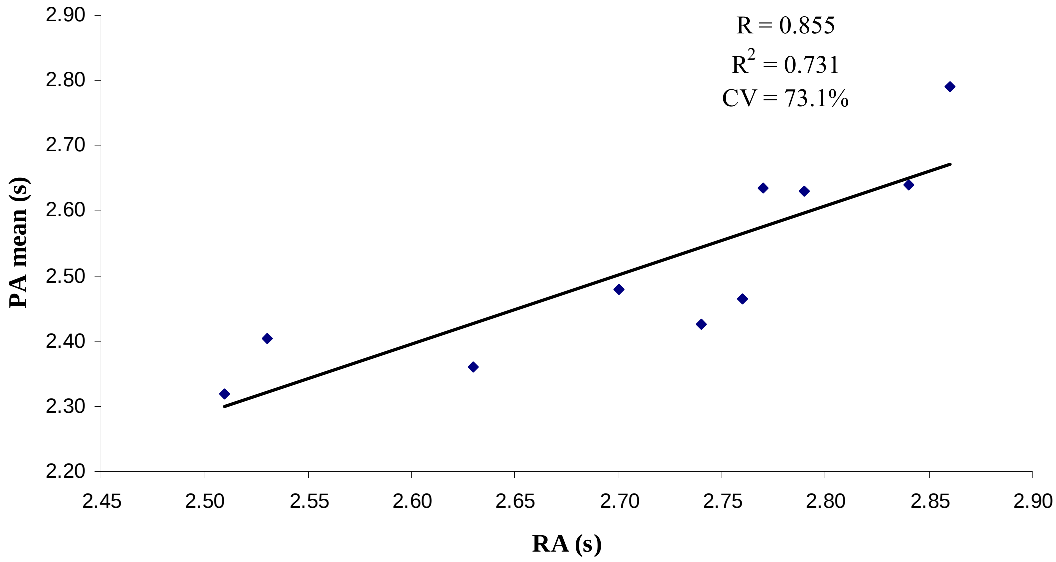

Figure 7. Correlation of PA mean and RA within the forwards

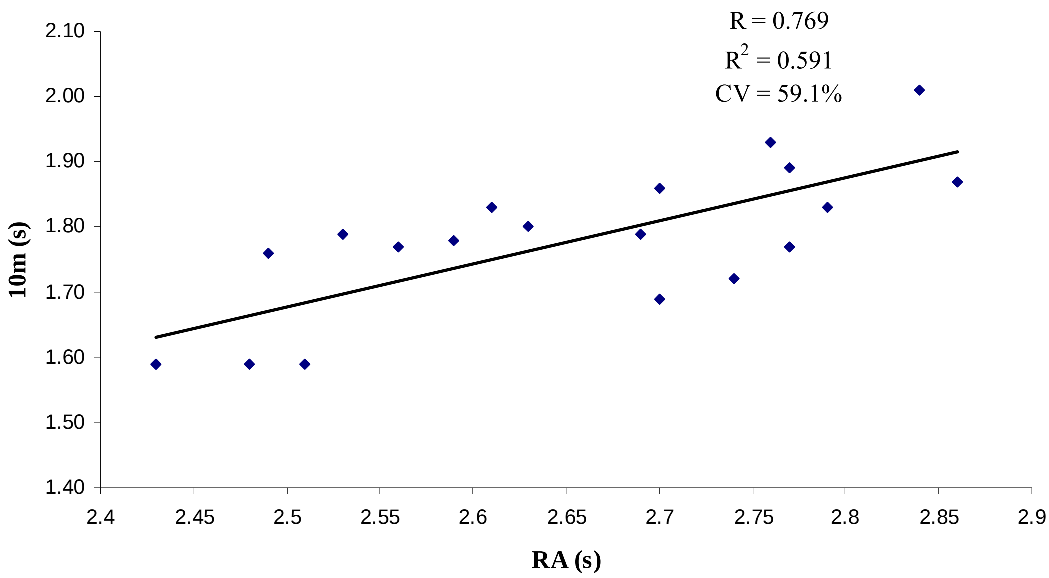

Figure 8. Correlation of 10m time and RA within the whole group

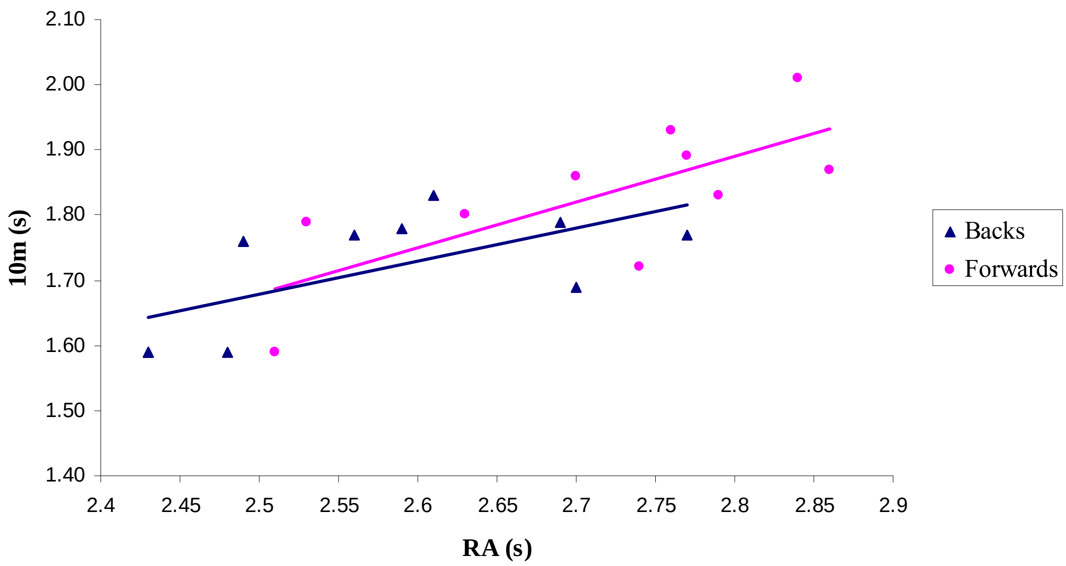

Figure 9. Correlation of 10m and RA within the whole group showing backs and forwards individually

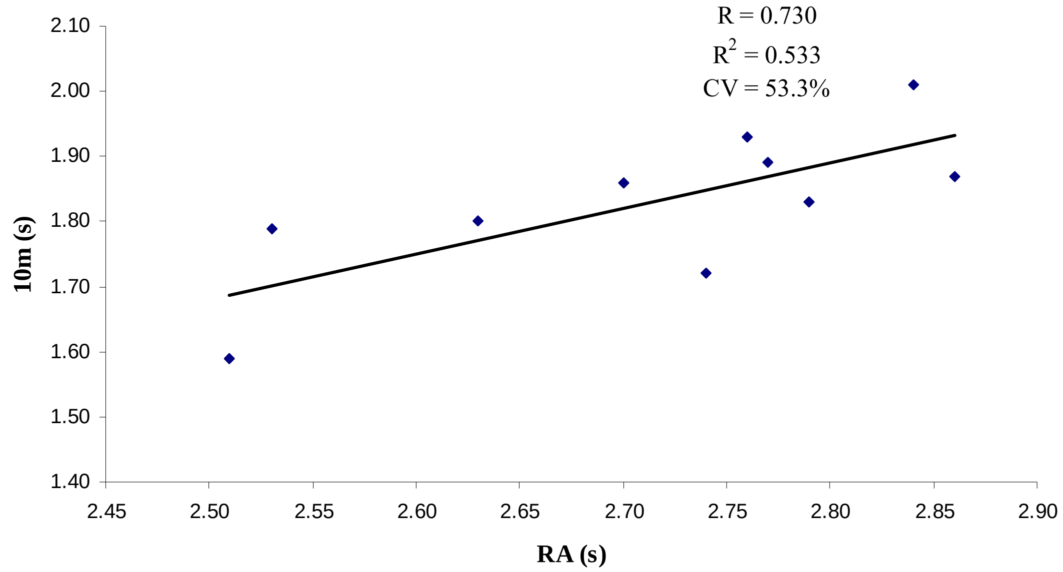

Figure 10. Correlation of 10m and RA within the forwards

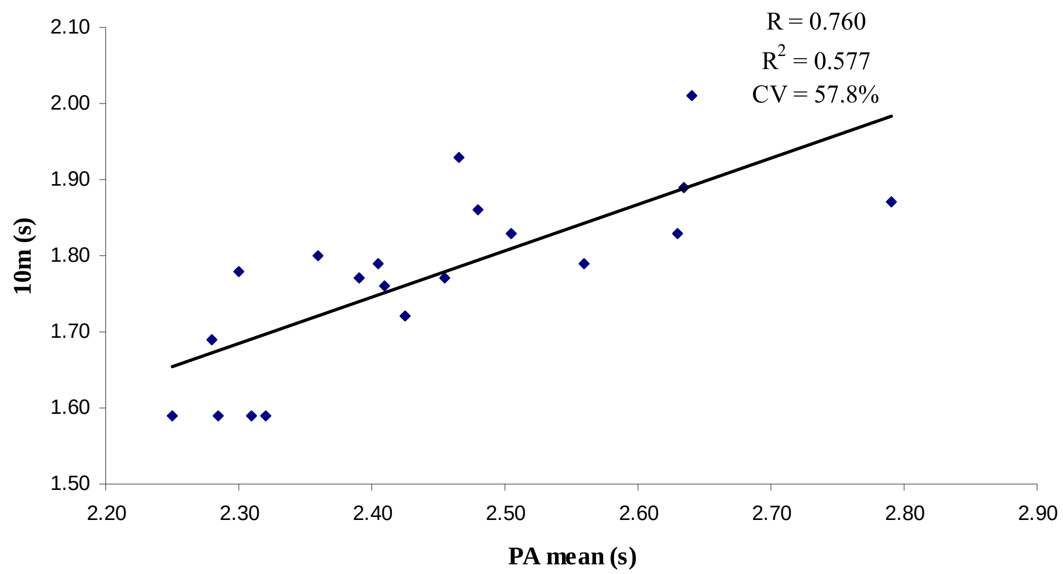

Figure 11. Correlation of 10m and PA mean within the whole group

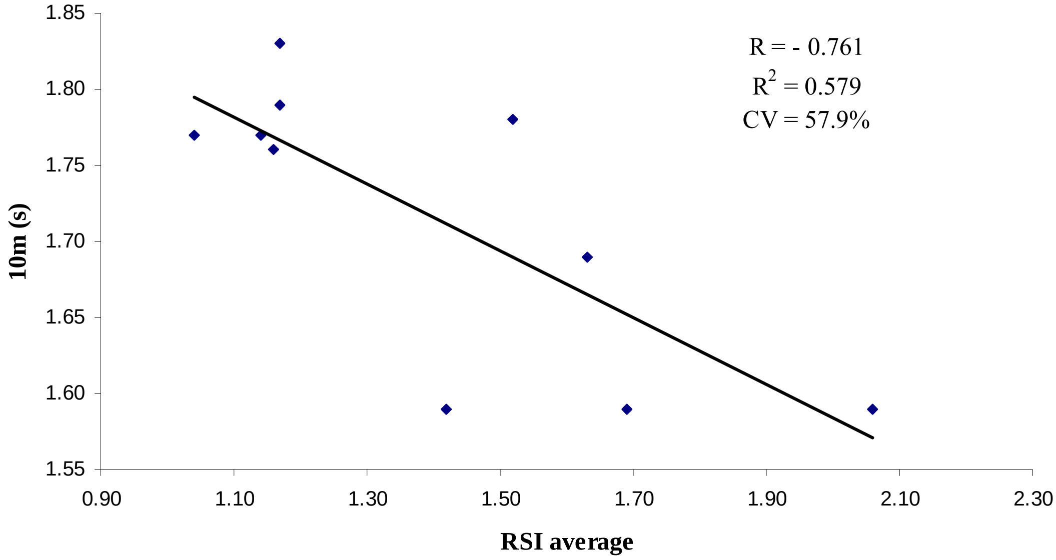

Figure 12. Correlation of 10m and RSI average within the backs

CHAPTER V

DISCUSSION

5.0 Discussion

Acceleration and CODS and have been found to have the strongest relationships with agility that relevant to aims of the study (see Figures 5 and 8). The RSI and SSC have also been found to have some form of relationship with agility (shown in Tables 2, 3, 4 and 5). The CV of these variables (being consistently around or above 50%) suggests that we can be confident that each variable has a significant impact upon RA.

The results show that PA (mean score) and 10m times of the whole group have a CV of 56.4% and 59.1% respectively with the agility test (RA). This suggests that there we can be relatively confident that these relationships are meaningful (Thomas and Nelson, 1996) and that the CODS, acceleration, and RA tests are measuring a general quality. This finding was echoed by the unpublished work of Oliver (2008) in a reliability study of reactive agility and acceleration, however the CV between the 10m test and agility were stronger than in this present study. This may have been due to the parallel dimensions of the tests (10m SS and 10m cuts right and left) where as the RA test used in this study covered a greater distance than the 10m acceleration test.

The fact that agility has been found to have an accepted CV with acceleration challenges the findings of Little and Williams (2005) who have previously established speed (specifically acceleration) and agility to be separate specific qualities. Little and Williams (2005) found that although the acceleration (10m) test had high statistical significance in correlation to agility the common variance between the two variables was found to be less than 50%. This led them to the conclusion that these variables are independent and do not effect one another. The results of Little and Williams (2005) also show that maximum speed had more of a CV with agility than acceleration which is again the opposite to the findings of this present research. This could be due to the differences in stride patterns between agile movements and maximum speed which is supported by the inclusion of stride pattern adjustments as a variable within Young *et al.*'s (2002) model of agility (see Figure 1). This suggests that the stride pattern used when at maximum speed could be different to that used in agile movements. These findings are consistent with that of

Buttifant *et al*. (1999) who also found very low correlations between speed and agility, approximately 10% of the agility test could be accounted for by sprint speed. Contrasts between the findings of previous research compared to this study and the work of Oliver (2008) could be due to the differences in the dimensions between the agility and sprint tests or the inclusion of a stimulus within agility tests, thus making the physical requirements of the tests different which in turn produce varying results. Despite the differences between the protocols of this study and Oliver's (2008), the principle of using the same form of stimulus allows us to suggest that an unknown quantity of agility can be accounted for by acceleration and CODS. This is supported by the fact that there is a CV > 50% in both studies. This could be due to the inclusion of a stimulus in the agility test suggesting that quicker agility times are influenced by an individual's capability to accelerate and change direction at speed. This is evidence that CODS and acceleration do influence agility, supporting the theoretical model designed by Young *et al*. (2002) as shown in Figure 1. The amount each of these variables affects agility however is still to be quantified.

The findings of these studies are evidently population specific (Little and Williams, 2005; and Buttifant *et al*., 1999; both used soccer players) and cannot be applied to any other populations. Oliver (2008) however, used a general population sample within his reliability study of agility and acceleration testing. The sample consisted of subjects from varying games backgrounds including multiple sprint sports such as football and rugby, racket sports, athletics, and cricket (13 of the 19 subjects were however rugby players). The findings were consistent over the four trials making the study more reliable and therefore they can be applied to independent populations such as that in this study. It was also found that there was a greater learning effect present in the 10m acceleration test than the RA test. This is due to the use of a random stimulus which obviously cannot be learnt. As stated previously, these findings suggest that this form of stimulus is reliable. Therefore the common variance that was found to be > 50 % between the 10m tests, PA and RA, allow us to suggest that the findings of this study are valid and accepted.

A CV > 50% has been found between both acceleration and CODS with RA (CV of 59.1% and 56.4% respectively) as shown in Table 2 and Figures 5 and 8. This can partly be explained by the accepted CV's found between the SSC and acceleration in the backs and partly by the accepted CV's found between acceleration, CODS and agility within the whole group. The CV's found between RSI average with PA and RA have been found to be significant at 44.1% and 47.1% respectively. According to Thomas and Nelson (1996) these CV's cannot be accepted as being meaningful due to being < 50%, however the SSC evidently has a similar influence throughout the groups upon agility whether it be within a COD or in response to a stimulus. This is supported by the findings that RSI and 10m time have a significant CV of 57.9% within the backs (see Table 4 and Figure 12). This suggests that the tests of the SSC and acceleration are also measuring a general quality. Acceleration has also been found to share a general quality with CODS (CV of 57.8%) and RA (CV of 59.1%) within the group as shown in Table 3 and Figures 8 and 11. It could therefore be correctly assumed that from the relationships described, the SSC may have an influence upon agility. These findings are supported by Barnes *et al* (2007) who found that when using regression analysis the counter-movement jump was a significant predictor of agility performance, explaining approximately 34% of the variance. This is also consistent with the work of Hennessy and Kilty (2001) who found that the short SSC was significantly related to sprint performance. Although these studies used a variation of the RSI jump used in the current research, the results are consistent with the present findings indicating that the vertical domain is an important predictor for both sprint and agility performance.

The CV of more than 50% that are seen between RA, 10m time and PA within the whole group can be explained to some degree by the presence of heterogeneity within the data. This is due to the differences in correlations seen in the backs and more specifically forwards groups individually, and is shown by the correlations in Figures 6 and 9 and the r-values and CV's displayed in Table 2. As illustrated in Figures 6 and 9 the backs scores (n=10) are grouped together with a lower correlation and the forwards scores (n=10) are grouped together with a higher correlation leading to a positive correlation and CV > 50% of the whole group's scores. We can also see that the forwards are a more heterogeneous group individually. This heterogeneity within the whole group has occurred due the assumption that there are two categories of player that share similar characteristics, backs and forwards. This is evidently not the case. The forwards are separated due to their specific positions and the specific qualities required for playing in these positions. For example, the forwards with faster times are more likely to be back row players and at the other end of the spectrum with slower times are the front five players where other variables such as weight influence speed more (as shown in Tables 4 and 5) making them more heterogonous as an individual group. There are fewer discrepancies between the backs scores and the backs are faster in all areas compared to the forwards, this makes them more homogenous. Heterogeneity within the whole group has led to the positive correlation of the whole group score and a CV > 50% between RA, PA and 10m time suggesting that these variables are interrelated and have an unknown quantity of influence upon agility.

The significant CV of 73.1% between the PA and RA tests within the forwards (see Figure 7) suggests that the assets on which forwards call upon to complete the PA test are very similar to those called upon to complete the RA test (see Figure 10). The fact that there is a greater CV between CODS, RSI and acceleration with RA in the forwards than that of the backs (see Tables 4 and 5) supports the suggestion that the forwards rely more on their physiological assets, those variables associated with CODS as shown by Young *et al*. (2002) in Figure 1, than their psychological assets (such as perceptual and decision making factors) when reacting to a stimulus in the RA test. This could be due to the unfamiliar experience of having to perform a side-step in response to a stimulus within a game related situation. Within the backs however, a low CV of 17.3% suggests that the assets called upon during the PA test are different to that in the RA test. This is supported by the fact that the CV within the backs between acceleration and RSI with RA is lower than that of the forwards. This indicates that there are variables other than those that are classified by Young *et al*. (2002) as variables of CODS, but classified as perceptual and decision making variables that play a part in influencing agility within the backs. This could be due to the fact that backs are familiar with having to perform a side-step movement in response to a stimulus and therefore call on their psychological assets as well as their physiological assets to assist them in this process of reacting to the stimulus successfully. From this research it is not clear which elements of the model produced by Young *et al*. (2002) shown in Figure 1 affect agility the most within the backs and forwards as independent groups.

It has been found that there is a low CV between PA and RA with the LJ scores of the whole group. Whilst some CV's were found to be significant all were lower than 27%. This suggests that the lateral strength of an individual and imbalances found between legs does not share a general quality with either RA or PA and that they are relatively unrelated. This could be due to the fact that the best RA score was used as a reflection of an individual's agility irrespective of the direction they stepped in. From looking at the raw data in Appendix 3, it is evident that only seven out of the twenty subjects (35%) according to the LJ test used their favoured foot whilst obtaining their best RA score. This could be due to the fact that each subject only completed 4 trials of the RA test irrespective of direction, meaning they could have only stepped off one leg throughout the RA test, and not necessarily their dominant one. This increases the possibility that in some cases an optimal RA score may have not been obtained. This would also be the case if the PA test had been used to asses lateral leg strength and muscle imbalances between legs. The data shows that in this case, ten out the twenty subjects (50%) stepped of their dominant leg in reference to the PA test.

The low CV's shown in Table 3 between the LJ and PA test within the whole group is a rather surprising result in that it would be expected that individuals would have a faster PA time in the direction that involved stepping off their dominant leg from the LJ test. From looking at tables 3, 4 and 5 this is evidently not the case. The LJ test was a new test designed for this study to isolate and measure the strength and muscular imbalances between legs and the influence it has on CODS and agility. The low CV's however, found between the LJ off each leg and PA could be explained by the individuals compensating for their weaker leg in other areas such as a change in technique or a reduction in speed prior to the side-step. The low CV's found between PA and RA with the LJ could also be attributed to the fact that the LJ test is assessing a different type of SSC to that used in the agile movement of the side-step as seen in the PA and RA tests. Hennessy and Kilty (2001) found that the short SSC associated with sprinting is also associated with rebound jumps due to the similarities in contact time between the sprinting and jumping tests. Barnes *et al*. (2007) suggest that there are similarities between the contact times in tests of sprinting and agility therefore the short SSC could also influence agility times. This may imply that the LJ test used in this research may not be testing the short SSC. It could therefore be suggested that muscle imbalances and lateral leg strength assessed within this context could be totally independent variables in relation to a side-step measured within this environment and any influence these variables may have on agility is minimal.

5.1 Limitations and Future Research:

Cohen and Holiday (1982), state that the power of statistical analysis is influenced by the number of subjects. At approximately n=15 the power levels off, therefore the sample size of n=20 subjects selected in this study ensured that the analysis protocol applied to the results of the whole group was sensitive enough to detect any significance. On the other hand this means that during the analysis of the backs and forwards groups independently, the power of the statistical analysis is reduced and the significance of the results found may be skewed. In turn, the extent to which the conclusions drawn from the findings are reliable, regarding the forwards and backs groups independently, is unknown. This problem could easily be rectified in future studies by increasing the sample population size of each group (backs and forwards) to more than 15. The heterogeneity (specifically within the forwards group) could be significantly reduced by creating sub groups from within the designated groups themselves. For example, the forwards group could be broken down into front five and back row, and the backs group could be broken down into halfbacks and outside backs. This should make the data more homogenous and therefore more reliable in terms of the conclusions.

In order to complete the study it was necessary to design new tests that allowed certain variables such as agility (RA test) or the muscle imbalances (LJ test) from the model of Young *et al*. (2002) shown in Figure 1, to be assessed within the context of a side-step. It could be argued that in order for these new findings and conclusions to be accepted a reliability study needs to be conducted. Testing the data for reliability fell outside the requirements of this current study, however it is an avenue of future research that could strengthen these findings. It could also lead to modifications of the protocol where measurement techniques could to be refined. One such instance of this occurs in the current protocol of the LJ test. The LJ test measures the individual leg strength at an angle of 90^{o} under the assumption that the side-step used in the PA and RA tests is always at 90^{o}. For certain individuals who don't side-step at 90^{o} however, the variable that the LJ test is measuring has no influence upon agility at all. The LJ test could therefore be somehow modified or adapted so that it measures the same angle that is used in the side-step (possibly being specific to each individual). The number of trials within the RA test could also be increased until at least two trails in each direction have been obtained. These results could therefore be correlated to the LJ test results of each leg independently and also the results obtained in each direction of the PA test. This may then show alternative, possibly stronger CV's between the RA, PA and LJ tests.

The structure of the PA and RA tests are practical, however that fact that there is a high CV's between the two suggests that they are measuring the same qualities. This could mean one of two things. Either agility relies highly upon the CODS variables as shown in the data, or that the stimulus used in the RA test wasn't strong enough to invoke a significant difference and show a clear distinction between the two tests and influence the use of the psychological characteristics outlined by Young *et al*. (2002) in Figure 1. Farrow *et al*. (2005) outlined a sports-specific stimulus as being an absolute necessity, therefore the stimulus used in the RA test could have been too weak to be classified as sports-specific. A stronger, more sports-specific stimulus such as a live individual or life-size video as used by Farrow *et al*. (2005) and Sheppard *et al*. (2006) may therefore be required to invoke these changes in future research. It could also determine whether the stimulus used in this study was strong enough by comparison. This could therefore affect the acceptance of the findings of this study.

More specific testing could have also been carried out on each of the decision making and perceptual variables outlined by Young *et al*. (2002) in Figure 1. This could be due to the difficulty in isolating these cognitive factors and measuring them within a sporting context to assess their impact upon agility as a whole (Sheppard *et al*., 2006). Future research could aim to quantify the extent to which agility is influenced by CODS and perceptual and decision making factors and the extent to which each of these variables are further influenced by their subcomponents.

Finally, the analysis protocol that has been applied to the data is only sufficient enough to generate CV between only two variables totally independent from all other variables. This means that it is not possible to quantify the extent to which each variable influences agility in comparison to all other measured variables. A Stepwise Linear Regression equation could therefore be used in future to quantify these variables in terms of their influence upon agility.

CHAPTER VI

CONCLUSION

6.0 Conclusion

Based on the findings of this study it can be suggested that CODS and acceleration have the strongest relationships with agility. Although the extents to which these variables influence agility cannot be identified from this research, it can safely be suggested that in order to improve agility and therefore skills such as the side-step, it would be necessary to develop both CODS and acceleration through training. This in turn provides coaches with clarity and direction into the necessary ways of improving agility. The techniques that should be used in order to train these variables cannot be determined from this research. It was found however that a relationship exists between acceleration and RSI. This suggests that improved acceleration and therefore improved agility can come from developing an individual's reactive strength (i.e. power).

The current research suggests that forwards and backs rely on different variables (shown in Figure 1) when performing agile movements such as the side-step, however all elements of Young *et al.*'s (2002) model should be addressed when aiming to improve agility as a whole within a rugby population. Training techniques employed by coaches should therefore include drills that improve both the physiological and psychological variables associated with agility although there should be a greater emphasis on training acceleration, CODS and reactive strength. This will aid all players, regardless of playing position, in the effective development of their agility and therefore improve skills such as the side-step.

6.1 Further Recommendations:

Areas surrounding the findings of this current study that require further research should include identifying the best training techniques for developing these variables shown to affect agility. This could further refine the drills and training techniques that are relevant to developing each aspect of agility and gaining a greater ability to perform agility tasks like the side-step. Further research could also show the extent to which each variable impacts upon agility through the use of stepwise regression. This could further enable training to become more specific in developing agility tasks such as the side-step within rugby players due to the coaches greater understanding of which variables influence agility the most. Increasing the subject numbers within future studies will increase the power of any findings that may support the findings of this study or generate alternative conclusions. Reliability studies should be conducted to verify the use the tests used within this study so that the findings and any future research surrounding this study can be built upon. Testing should also become more specific to the game of rugby via the use of a more sports-specific stimulus within the testing protocol. Future findings can then be better applied to the game and the whole outcome of the research will therefore become more successful in improving agility.

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APPENDICES

Appendix 1. Informed Consent form.

Dear Subject,

I am a Level 3 undergraduate/postgraduate student in the School of Sport, PE, & Recreation, at the University of Wales Institute Cardiff. The title of my dissertation is "The exploration of relationships that exist between factors that affect agility within a rugby specific population", and I wonder if you would be kind enough to help with my research.

The research aims to discover any relationships that exist between the variables associated with influencing agility, these being change of direction speed and cognitive factors. As a subject, you will be asked to perform a number of tests involving a series of maximal jumps, maximal sprints and some change of direction tests, some in response to a stimulus in relation to a lateral side-step. The research may prove beneficial you as individual for personal reference. It is also a relatively new area of research and may provide coaches with a better understanding of which physical attributes influence agility. This could therefore develop agility training in specific agile movements such as the side-step so that it can be applied in game specific situations.

There are no risks involved in the study, but in the event of an accident the appropriate services will be contacted immediately as your safety is paramount.

Participation is entirely voluntary. You are free to withdraw at any stage of the research process.

Confidentiality will be upheld as far as humanly possible. The results of your completed tests will be kept strictly confidential in accordance with the provisions of the Data Protection Act (1998). Only the principle investigator and supervisors will have access to the information. Your name or any such identifiable data will not appear in any academic papers resulting from the research.

I would like to express my deep appreciation for your assistance in this investigation. Your part in this research would be significant and influential. If you are willing to participate, please read the slip overleaf carefully, and sign. If you have any queries, please do not hesitate to contact me.

Thank you. I look forward to hearing from you.

Yours sincerely,

R. Crane

………………………………………………

I have read and fully understood the request to be a subject in the research of Mr. R. Crane. I understand what I have to do. I understand the risks involved, and the measures in place in the event of an accident. I understand that participation is entirely voluntary, and that withdrawal is possible at any time. I understand the measures that will be taken to uphold confidentiality as far as possible.

I agree to participate.

Signature…………………………………………….. *Date*……………………

Appendix 2. PAR-Q form

Physical Activity Readiness Questionnaire (PAR-Q)

Name: ……………………………………..

Please circle the following questions appropriately:

1. Has your doctor ever said you have heart trouble? Yes / No

2. Do you frequently suffer from pains in the chest? Yes / No

3. Do you often feel faint or have spells of severe dizziness? Yes / No

4. Has a doctor ever said you blood pressure was too high? Yes / No

5. Has your doctor ever said that you have a bone or joint Problem such as arthritis that has been aggravated by Exercise, or might be made worse with exercise? Yes / No

6. Have you acquired any ligament damage to your lower Limbs that may become injured or aggravated by jumping exercise?

7. Is there a good physical reason not mentioned here why you Should not take part in a fitness test? Yes / No

8. Are you **un**accustomed to vigorous exercise? Yes / No

If you have answered yes to any of these questions listed above, please add detail below. Similarly, if there are any situations which will prevent you from exercising write them here (or let us know if they arise throughout the testing)

If your situation changes regarding your responses to these questions, please notify the test administrator.

Signed …………………………………

Date …………………………………

Appendix 3. Raw Data Table

Subject Number	Weight (kg)	Height (cm)	RSI average	Max RSI	Lat Jump (cm) Left Leg	Lat Jump (cm) Right Leg	Lat Jump (cm) Mean	PA (s) Left	PA (s) Right	PA (s) Mean	10m (s)	40m (s)	RA Time (s)	RA Direction (R/L)
Backs														
1	80.2	183.1	2.06	2.27	204	192	198	2.29	2.33	2.31	1.59	5.07	2.43	R
2	92.9	185.8	1.16	1.4	193	186	189.5	2.46	2.36	2.41	1.76	5.14	2.49	L
3	85.7	178.4	1.69	2.01	195	189	192	2.32	2.25	2.29	1.59	5.05	2.48	L
4	94.5	185.3	1.42	1.95	200	198	199	2.27	2.23	2.25	1.59	4.85	2.43	R
5	82	183.2	1.17	1.27	179	182	180.5	2.54	2.58	2.56	1.79	5.43	2.69	R
6	90	178.4	1.52	1.67	181	180	180.5	2.3	2.3	2.30	1.78	5.36	2.59	R
7	90.2	186.1	1.04	1.13	190	191	190.5	2.4	2.38	2.39	1.77	5.36	2.77	L
8	89.4	189.5	1.63	1.91	181	186	183.5	2.35	2.21	2.28	1.69	5.02	2.7	R
9	81	182.6	1.14	1.42	177	181	179	2.45	2.46	2.46	1.77	5.52	2.56	L
10	91.1	169.5	1.17	1.69	190	183	186.5	2.45	2.56	2.51	1.83	5.66	2.61	L
MEAN	**87.70**	**182.19**	**1.40**	**1.67**	**189.00**	**186.80**	**187.90**	**2.38**	**2.37**	**2.37**	**1.72**	**5.25**	**2.58**	
SD	**5.13**	**5.32**	**0.31**	**0.35**	**8.79**	**5.42**	**6.79**	**0.09**	**0.12**	**0.10**	**0.09**	**0.24**	**0.11**	
Forwards														
11	108	183.5	1.17	1.32	188	186	187	2.55	2.72	2.64	1.89	5.7	2.77	L
12	118.2	181	1.13	1.18	199	197	198	2.5	2.46	2.48	1.86	5.71	2.70	R
13	119.8	186.5	0.92	0.99	172	199	185.5	2.54	2.39	2.47	1.93	5.74	2.76	L
14	112.4	187.4	1.02	1.09	181	189	185	2.59	2.67	2.63	1.83	5.43	2.79	L
15	97.4	187.3	1.05	1.15	199	190	194.5	2.31	2.33	2.32	1.59	5.16	2.51	R
16	115	198.1	1.18	1.25	191	187	189	2.42	2.39	2.41	1.79	5.64	2.53	R
17	151.2	195	0.75	0.85	179	190	184.5	2.81	2.77	2.79	1.87	5.83	2.86	L
18	105.4	194.3	0.89	1.47	191	199	195	2.65	2.63	2.64	2.01	5.85	2.84	R
19	108	185.5	1.04	1.19	192	189	190.5	2.45	2.4	2.43	1.72	5.33	2.74	R
20	90	186.2	1.16	1.42	203	200	201.5	2.4	2.32	2.36	1.8	5.45	2.63	L
MEAN	**112.54**	**188.48**	**1.03**	**1.19**	**189.50**	**192.60**	**191.05**	**2.52**	**2.51**	**2.52**	**1.83**	**5.58**	**2.71**	
SD	**16.38**	**5.48**	**0.14**	**0.19**	**9.80**	**5.48**	**5.93**	**0.14**	**0.17**	**0.15**	**0.12**	**0.23**	**0.12**	
TOTAL MEAN	**100.12**	**185.34**	**1.22**	**1.43**	**189.25**	**189.70**	**189.48**	**2.45**	**2.44**	**2.44**	**1.77**	**5.42**	**2.64**	
TOTAL SD	**17.38**	**6.29**	**0.31**	**0.38**	**9.28**	**6.21**	**6.60**	**0.14**	**0.17**	**0.15**	**0.12**	**0.29**	**0.14**	