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The Use of Skill, Physiological and Anthropometric Variables to Predict Soccer Ability in Elite Youth Soccer Players

Oliver John Morgan

“A report presented towards the degree of Masters of Science with Honours by Research, in Sport and Exercise Sciences, in the Faculty of Health and Life Sciences, Coventry University, 2012.”



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1. Abstract

The aim of the present study was to investigate into whether skill, physiological and anthropometric variables could predict on pitch performance in elite youth soccer players. On pitch performance was determined as overall success in 11 youth soccer matches using 14 elite youth soccer players (mean \pm SD: age 17.4 ± 0.8 years, body mass 72.1 ± 1.2 kg, height 177.8 ± 5.7 cm, % body fat 9.0 ± 1.2 %). Testing consisted of 12 soccer skills tests, 5 physiological tests and 3 anthropometric tests. Match analysis was used to measure success for on/around the ball actions in soccer matches for all 11 players, which accumulated into one overall success for each player. 20m passing accuracy was established as the best predictor of overall success in soccer matches (adjusted $r^2=0.499$, $p=0.009$). Alongside this, dribbling performance with the right foot, alternate juggling, 30m sprint time, counter movement jump height and body mass, all significantly correlated with overall success. The influence of age as a confounding variable was eliminated with the use of age residuals where necessary. In conclusion, the results from skill test variables best correlated with, and predicted, overall success in elite youth soccer players. These results will aid the talent identification process as well as the talent development process in elite youth soccer as it has determined what variables are central to being successful within an elite population at this age range.

2.0 Review of Literature

2.1 Introduction to Talent Identification

Talent identification (TID) has been defined as *‘The process of recognising current participants with the potential to become elite players’* (Williams & Reilly, 2000).

In recent years, there have been an increased number of investigations into creating a mechanistic, objective and most importantly an effective and successful model of talent identification (Yperen, 2009; Figueriedo *et al.*, 2009; Mohamed *et al.*, 2009; Christensen, 2009; Russell *et al.*, 2010; Meylan *et al.*, 2010; Waldron *et al.*, 2010). An earlier talent identification process at a younger age would give a competitive advantage over opponents, as the earlier the talent identification process, the increased likelihood that those selected individuals will become elite as performance can be enhanced within an elite environment (Williams & Reilly, 2000). This efficient and productive process is a system in which all sporting academies and centres of excellence strive for, especially in sports where nurturing elite talent can be financially rewarding; soccer being a prime example. As Jiménez and Pain, (2008) stated... *“Elite sport is not dictated by an equal opportunities policy”*.

This process of identifying talent in team sports is particularly difficult, especially in soccer, due to the many variables that exist in soccer that include skill variables (Waldron *et al.*, 2010), physiological variables and anthropometric variables (Reilly *et al.*, 2000; Stoeln *et al.*, 2005; Le Gall *et al.*, 2010; Penas *et al.*, 2011). Talent identification is a process that is embedded in a four key stage process which is coined, ‘the pursuit of excellence’ (Figure 2.1; Williams & Franks, 1998, from Williams & Reilly, 2000). Here it is evident that identification has reciprocal relationships with selection and development. Outside the sport, the process of detection is present, where individuals thought to have possible advantageous variables for a specific sport are selected. This element is not so prevalent in soccer due to soccer’s high popularity (estimated 265 million active players globally; FIFA, 2007). However, to give an example, an individual who is agile, has quick reflexes and good hand-eye coordination could be detected as a potential tennis, squash or badminton player. Once in the sport, there is an ongoing process of identification, development and selection (Figure 2.1). Players are possibly identified as talented and are placed into a development process.

The development process is the enhancement of the player and this process is already well established in soccer (Burgess & Naughton, 2010). The development process consists mainly of specific soccer coaching. Selection happens in soccer for every match; the selection of the first eleven players. Whilst playing in a team, players could potentially be identified as talented and placed in a development process that is to a higher standard, and the process continues. Identification is an important limiting factor in the developmental phase. Due to the limited resources of development's critical process, it is crucial that these resources are allocated to individuals that can fulfil their maximum potential, whereby the outcome is to an elite level.

Figure 2.1. Talent Detection, Selection, Identification and Development in Sport; 'The Pursuit of Excellence' (Williams & Reilly, 2000)

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In summary, the aim of talent identification is, therefore, to predict future accomplishments. Many different variables have been used to try to fulfil this aim (including physiological, anthropometric, and skill), and many attempts have used multi-variate approaches using all or a combination of these different variables. However there is still not an objective, systematic and effective talent identification model available in soccer. The *key* question that remains

unanswered is, “what are the characteristics that indicate an individual has the potential to develop and perform in sport at a senior level” (Abbot & Collins, 2002).

2.2. Physiological Testing to Identify Talent in Soccer.

Analysis of soccer matches has determined that soccer consists of many different physiological variables; aerobic power, anaerobic power, musculature strength, agility, repeated sprint ability and flexibility (Svensson & Drust, 2005, Stølen *et al.*, 2005; Bloomfield *et al.*, 2007; Randers *et al.*, 2010). Soccer is completed in an intermittent, non-continuous fashion and includes tasks such as jumping, tackling, turning, shooting, passing, dribbling, heading etc (Mohr *et al.*, 2003; Bloomfield *et al.*, 2007).

Table 2.1 demonstrates the reasoning behind the inclusion of physiological testing in talent identification models as, when compared to sub-elite, the elite players have enhanced soccer specific fitness characteristics.

Table 2.1. Supporting evidence for using physiological testing in talent identification

Evidence	Reference
Increase in fatigue decreases short passing ability	Rampinini <i>et al.</i> , (2007)
Distance covered (Elite vs. Sub-Elite - Review)	Stølen <i>et al.</i> , (2005)
VO ₂ MAX (Elite 63.2 vs. Sub-Elite 61.9ml.kg.min ⁻¹)	Arnason <i>et al.</i> , (2004)
Anaerobic power 20m sprint time (Elite 1.80 vs. Sub-elite 1.82secs)	Cometti <i>et al.</i> , (2001)
Power - Counter Movement Jump Height (Elite 55.3 vs. Sub-elite 39.4cm)	Arnason <i>et al.</i> , (2004)

Reilly *et al.*, (2000) used a multivariate approach to identifying talent in soccer. They established that agility tests (40m sprint with runs) and sprint times (over distances of 15m and 30m) were the two most powerful discriminatory variables, out of physiological, anthropometric and skill variables in distinguishing between elite and sub-elite populations of soccer players. Furthermore, it was noted that an individual who possesses above average levels of athleticism, that are more difficult to develop through training (e.g. speed; Young, 2006) maybe more favourable, not only for the clear advantages of this athleticism, but the increases in time that can be spent upon skill development opposed to spending time developing physiological characteristics.

Studies which utilise non-specific soccer tests report no discriminatory power or ability to predict future accomplishments by using physiological testing (Hoare & Warr 2000). This is hardly surprising however, as soccer has a specific, intermittent repetitive sprinting nature (Bloomfield *et al.*, 2007; Di Salvo *et al.*, 2010; Buchheit *et al.*, 2010), therefore testing generic physiological variables will not distinguish between elite soccer players.

Furthermore, the use of non-valid tests questions any discriminatory variables that are proposed, as it is not possible to suggest that a physiological parameter distinguishes between populations, and potentially predicts future accomplishments, when that test has not actually assessed that variable. This limitation is supported by the different tests that are used in the literature to test for the same physiological parameter (Table 2.2).

Table 2.2. Illustrating the different types of tests used for similar physiological variables

Author	Aerobic Capacity	Anaerobic Capacity	Agility	Power	Strength	Other
Reilly <i>et al.</i> , (2000)	Multi Stage Fitness Test	15, 25 & 30m Sprint Times	40m run with turns	Standing Vertical Jump		Repeated Sprint Ability
Hoare & Warr, (2000)	Multi Stage Fitness Test	5, 10, 20m Sprint Times	505 agility Run	Vertical jump		
Edwards <i>et al.</i> , (2003)						Soccer Specific Fitness Test
Vaeyens <i>et al.</i> , (2006)	Shuttle Run Test	Shuttle Tempo Run		Standing Long Jump, Vertical Jump	Hand grip and bent arm hand grip	
Gil <i>et al.</i> , (2007)	Astrand Test	30m Sprint Time		Squat Jump, Drop Jump, Counter Movement Jump		
Le Gall <i>et al.</i> , (2010)		10, 20, 40m Sprint Times		Vertical Jump	Isokinetic Dynamometry	

2.2.1 Physiological Testing and Maturation

Physiological performance testing in a youth population on a one-off occasion may be problematic due to maturation, puberty and growth factor variables (Pearson *et al.*, 2006).

Figure 2.2 illustrates the effect of puberty on anthropometric and physiological characteristics, demonstrating clearly how it can become a confounding variable if ignored in physiological testing when identifying talent. Therefore, in order to eliminate puberty and growth factors as confounding variables, physiological testing must happen throughout the season, where a profile for each player can be created (Pearson *et al.*, 2006; Meylan *et al.*, 2010).

Figure 2.2. Effects of puberty on anthropometric and physiological variables. Taken from Pearson *et al.*, (2006)

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2.3 Skill Testing to Identify Talent in Soccer.

Skill testing has been incorporated into many talent identification systems within many sports and has successfully discriminated between many groups of elite and sub-elite athletes (Table 2.3).

Table 2.3. Skill based discriminating variables between elite and sub-elite in soccer

Authors	Discriminating Variables	Method	Tests
Waldron & Worsfold, (2010)	Short Passing, Long Passing, Shooting & Dribbling	Match Analysis	Short Passing, Long Passing, Shooting, Dribbling, Tackles, Interceptions
Russell <i>et al.</i> , (2010)	Passing, Shooting & Dribbling	Open skills testing	Passing, Shooting & Dribbling
Huijgen <i>et al.</i> , (2009)	Dribbling	Closed Skills Testing	Dribbling
Vaeyens <i>et al.</i> , (2006)	Soccer Technique	Closed Skills Testing	Dribbling, Lob pass, Shooting accuracy, Juggling

Skill testing has been used in the majority of talent identification models simply due to the acknowledgement that the most important aspect of soccer is the successful execution of skill (Ali, 2011).

The major impediments to skill based testing within soccer to identify talent are the use of tests that are; technique based tests rather than skill based tests, non-specific or non-functional tests, closed-skills tests opposed to open-skills tests, ignoring the confounding variable of playing position upon testing and the fact that some TID models and studies do not test enough skills.

The definition of a skill is, “*the learned ability to select and perform the correct technique as determined by demands of the situation*” (Ali *et al.*, 2007) “*with the minimum outlay of energy or of time and energy*” (Knap, 1977). The major difference in soccer between a skill

and a technique is that a skill is opposed and a technique is not. Thereby, all tests *must* include some aspect of opposition or taxing of the skill in some other way in order to be truly valid (Ali *et al.*, 2011). Skills including dribbling and shooting are completed in the game in an attacking nature and have to be completed quickly in order to beat a player or due to the threat of being tackled, etc. Therefore, these tasks are usually completed at a maximum or near maximum speed. This is important in skills testing because testing under a time pressure will distinguish between greater and lesser technically proficient populations (Ali *et al.* 2007). Less capable individuals will sacrifice either speed or precision in order to maximise or preserve the other. This was described by Fitts and Posner (1967, sourced from Russell *et al.*, 2010) as the ‘speed-accuracy trade-off’. However, in many skills based tests, there are no incentives, encouragement, or requirements to perform the skill to such a speed that this phenomenon will be initiated (Hoare & Warr, 2000; Reilly *et al.*, 2000).

Soccer skills are performed in environments that are non-predictable and unstable (open-skills). Tests aspire to obtain high ecological validity to be able to represent match performance, therefore a battery of tests should not include closed skills (predictable and stable environment) tests. Despite this necessity, studies in the literature incorporate many closed-skilled tests (Hoare & Warr, 2000; Reilly *et al.*, 2000; Rosch *et al.*, 2000; Wilson, 2009; Vaeyens *et al.*, 2009). The most frequent skills tests used (shooting, passing, dribbling) are all particularly subject to this criticism. The reasoning behind this is most likely because of the simplicity of completing the tests. If the tests are simple to set up and administer then very little would change between trials and therefore would lead to higher repeatability. So despite the results being bound to the limitations of closed-skill tests, the results are consistent and can have high value in field environments.

Playing positions as a confounding variable is prominent within numerous studies simply due to the ignorance of including what are the key games skills in all positions. For example many studies simply choose shooting, dribbling and passing (Table 2.3), however a defensive minded player could be very skilled at intercepting, tackling, heading, blocking etc. Yet, the exclusion of these skills in testing could result in poor performances and thus portray an individual like this to be labelled poorly skilled, whereas within a specific position in a team, with a specific role they would likely to be more skilled in that position than their colleagues who normally play in other positions.

When comparing and evaluating recent studies (Russell *et al.*, 2010) to older studies (Reilly *et al.*, 2000; Hoare & Warr, 2000) there are remarkable differences in methodologies, based on the recognition of the restrictions of using closed-skilled, subjective, technique based testing with low ecological validity. Thus newer studies are developing objective, open-skilled, 'skills' tests with higher ecological validity. Russell *et al.*, (2010) produced reliable and valid passing, shooting and dribbling tests, whereby they suggested that when skill testing, speed, precision, and success should all be evaluated to affirm the overall skill quality. Ali *et al.*, (2007) supports this theory and found that elite soccer players completed the Loughborough Short Passing Test quicker (5%) and performed each shot sequence quicker ($p=0.0001$) in the Loughborough Soccer Shooting Test. In addition, Hoare & Warr (2000) used subjective match analysis alongside testing to evaluate skill levels in soccer players, whereas Waldron & Worsfold (2010) devised an objective match analysis system. The benefits of an objective system opposed to subjective analyses are repeatability, accuracy and thus the ability for comparisons between studies and populations.

2.4. Anthropometric Testing to Identify Talent in Soccer

The use of anthropometric differences between elite and sub-elite players for talent identification are not as evident in the literature compared to physiological and skill parameters (Reilly *et al.*, 2000). However there is evidence to suggest that anthropometry should have a place within a systematic, objective talent identification model. Le Gall *et al.*, (2010) established a significant difference between international and amateur players at the Under-16 level in height ($p<0.05$) but not in body mass or percentage of body fat. A number of studies have identified a difference among positions in soccer regarding some anthropometrical data. Bangsbo (1994c, sourced from Reilly *et al.*, 2000) discovered that goalkeepers and central defenders were the heaviest and tallest out of 65 Danish elite soccer players. Sutton *et al.*, (2009) determined that the best body composition variables to distinguish between elite soccer players and low-activity referees (matched for age, height and body mass) were lean mass and bone mineral density. Sutton *et al.*, (2009) also suggested that there is a body composition threshold for elite outfield players. Reilly *et al.*, (2000) also supports this theory of a threshold of body composition as they demonstrated a significant difference ($p<0.05$) between elite and sub-elite soccer players.

2.5. Match Analysis to Identify Talent in Soccer

Match analysis (also termed notational analysis) is a technique that has been used in research and in sporting environments to distinguish successfulness of athletes (Hughes & Franks, 2004; Tenga *et al.*, 2010; Waldron & Worsfold, 2011; Hughes *et al.*, 2012; Castellano *et al.*, 2012). Match analysis is the process of recording events during a game (Franks & Hughes, 2004), and within an invasion team sport such as soccer, the analysis encompasses individual as well as team events (Hughes *et al.*, 2012). Hughes and Franks (2004) stated that there are five rationales for notational analysis; i) analysis of movement, ii) educational use for both coaches and players, iii) tactical evaluation, iv) development of a data base/modelling, v) technical evaluation.

Originally, subjective coaches' observations were used in order to recall events in matches and assess the effectiveness of players. However, previous research has suggested that only 30% of key factors that dictated successful performance in soccer were recalled by the coaches (Franks & Miller, 1986). Later research, also in soccer, has also suggested that in post-match analysis following a 45 minute game, coaches were less than 45% accurate in recalling events (Franks, 1993). In addition, in determining what the main technical variables are, coaches have varying opinions. This ambiguity and the lack of accuracy portray the limitations of subjective assessments. Match analysis, in particular the use of filming and objective data has been in used in sports such as soccer due to the demand of more accurate and reliable processes of feedback (Hughes *et al.*, 2012).

Match analysis also offers a key role in the developmental process – which has previously been mentioned as having a reciprocal relationship with talent identification. Figure 2.3, taken from Frank & Hughes (2004), illustrates where match analysis fits into the developmental process.

Figure 2.3. A schematic diagram illustrating how match (performance) analysis plays a role in the developmental process. Modified from Frank & Hughes, (2004)

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Different types of variables have been measured in soccer in order to determine successfulness. Figure 2.4 demonstrates the different classification of variables measured in soccer, including technical, tactical and biomechanical (Hughes & Franks, 2004). Technical skills have been measured on a basis of number of successful or non-successful passes, however to gain a true understanding of success, successfulness should be proposed as a ratio or percentage of successful events to overall total number of events. For example, to assess how effective a player is at scoring goals, a ratio might be produced showing number of goals per number of shots (Castellano *et al.*, 2012; Tenga *et al.*, 2010). However, to further increase the depth of analysis, assessing the right decision making process in a tactical sense would also be beneficial. For example, Player 1 scored 1 goal from 5 shots but had the opportunity to shoot 10 times, but it was deemed the correct tactical decision for the team to pass on the other 5 occasions as opposed to shoot (Hughes & Franks, 2004). Does this therefore suggest that player A is a better player because he plays within a team structure not solely as an individual?

Figure 2.4. Demonstrating the different classification of variables that have been used in the literature in soccer.

<i>Match classification</i>	<i>Biomechanical</i>	<i>Technical</i>	<i>Tactical</i>
Scores	Kicking	Passes to opposition	Passes/Possession
No. of shots on target	Ball projection velocity and spin	Tackles won and lost	Pace of attack
No. of shots off target	Kinematics and kinetics of kicking leg; Energy transfers	Shots off target	Shots
Corners etc.	Sequencing of joint actions	Dribbles	Tackles won and lost
Crosses etc.	Net joint forces and moments	Lost control	Passing distribution
	Throw in	On target crosses	Length of passes
	Ball release velocity	Off target crosses etc.	Dribbles etc.
	Kinematics of arms, including sequence of peak segment speeds.		
For a review see Hughes (1993).	For a review, see Lees and Nolan (1998); see also Putnam (1993).	For a review see Hughes (1993); see also Pettit and Hughes (2001).	For a review see Hughes (1993); see also Pettit and Hughes (2001).

Match analysis is a powerful process that distinguishes between different players of varying talent and ability, through assessing the successfulness of events within matches, rather than assessing players' ability in non-match settings.

2.6. Birth Date Distribution and the Relative Age Effect

A key area of discussion for talent identification is the Relative Age Effect (RAE) in soccer, and this is reflected in the wealth of research literature (Malina *et al.*, 2005; Helsen *et al.*, 2005; Jimenez *et al.*, 2008; Carling *et al.*, 2009; Hirose, 2009; Mujika *et al.*, 2009; Delorme *et al.*, 2010; Del Campo *et al.*, 2010; Vandendriessche *et al.*, 2012) where there seems to be a shift towards more players born in the first quartile of the year. This is based upon an age categorisation from 1st January to 31st December of the calendar year (excluding English based studies – 1st September to 31st August). The RAE indicates the age differences among individuals born in the same age group and the significances it can have on performance, and therefore talent identification (Jiménez and Pain, 2008). A phenomenon entitled the 'initial performance advantage' has been shown to be exploited by clubs in their identification and selection process due to the benefits of earlier developers (positive external and self-feedback, perceived increased competence and increased motivation and short-term performance; Helsen *et al.*, 2005). Jiménez and Pain (2008) have shown that players born later in the year inherent a greater disadvantage than the advantage gained by players born

earlier in the year. Moreover, they portrayed how the bigger and more successful clubs in Spain are characterised by having more players who were born in the January-April Period.

This early developmental process that clubs have been seen to favour is also accompanied by a preferentialism to an earlier maturational age (Malina *et al.*, 2005), where an increased psychological maturation age would accompany the initial performance advantage. An increased biological maturation could be seen as both an advantage and a disadvantage. In the short-term, performance maybe increased with an enhanced biological maturation, e.g. height and strength of a central defender. However in the longer-term, once the later developers have equalled in maturity, these earlier advantages would be lost, alongside potentially the successfulness in performance (Meylan *et al.*, 2010). This therefore wastes the critical and limited resources of the developmental process on players who have success based upon transient, not permanent parameters. This results in an ineffective developmental process; a categorisation in which all academies and centre of excellences endeavour to avoid.

2.7. Conclusions from previous research and implications for future research

In conclusion, talent identification is a difficult and complex process, however it has also been hampered by utilising inappropriate tests for both physiological and skill parameters (Meylan *et al.*, 2010; Ali, 2011). Furthermore, the ignorance of the relative age effect and other anthropometrical data have led to the loss and waste of the limited resources of the developmental process.

The significance of these evaluations, are the implications for nurturing and developing future potential. An ineffective talent identification process would particularly be detrimental to the national team, along with the professional leagues in which producing elite senior players have large financial gains.

In order to maximise the performance of academies and centre of excellences through increasing efficiency and productivity of the developmental process, the talent identification process must also be enhanced (Figure 2.1). The production of a systematic, objective and successful model could potentially reap vast rewards, both for national teams and professional clubs. Therefore, in producing such a model, physiological tests must be specific and valid to soccer, there must be tests for all physiological parameters and testing must happen over the course of a season to avoid the confounding variables of puberty and growth

factors (Meylan *et al.*, 2010). Table 2.4 illustrates a proposed battery of physiological tests that use objective tests and, where possible, specific tests for soccer.

Accordingly, skills tests, must test skills and not techniques, must be specific and fundamental to soccer, must assess open skills and must consider playing position by testing all skills. Anthropometric data must be used to avoid selecting early biological maturers on the basis of a deceived talent, and also used as guidance for thresholds for body composition.

Table 2.4. Proposed battery of physiological tests to use in talent identification. CMJ represents counter movement jump.

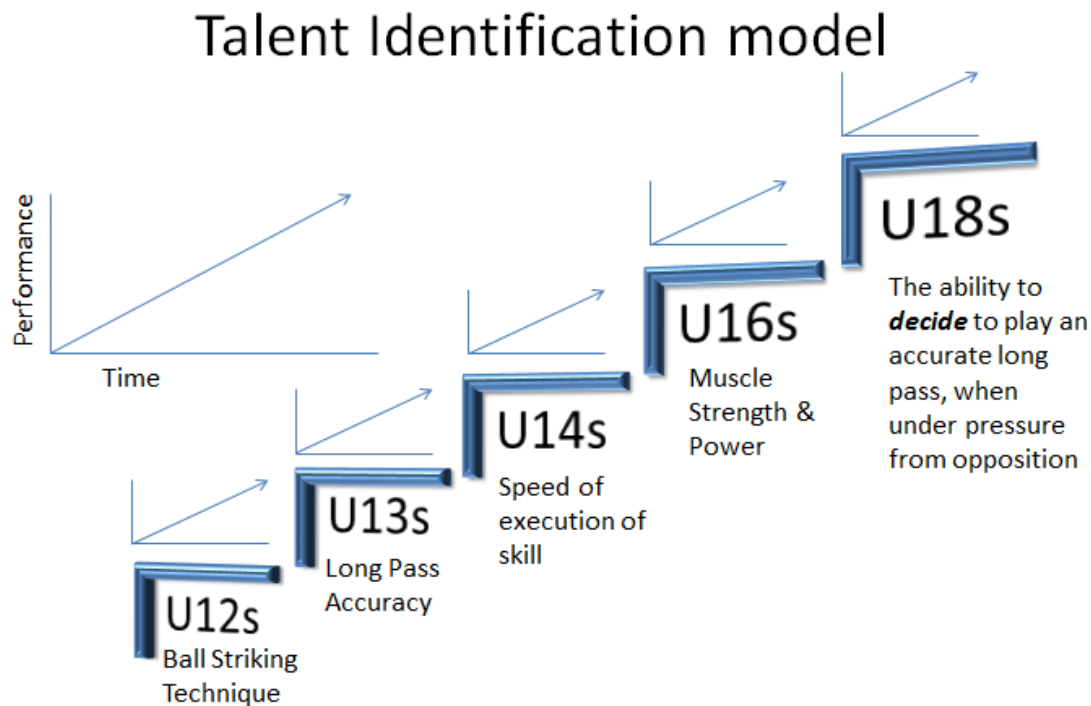
Physiological Parameter	Test(s) That should be used
Aerobic Power	Treadmill Test
Agility	Different agility test to measure all aspects of agility e.g. Change of direction factors, Perceptual factors, decision making factors etc.
Strength	Isokinetic Dynamometer & CMJ
Power	Counter Movement Jump & 5 Jump Tests
Anaerobic Power	Stationary & 'Flying' 5/15/30m Sprints
Body Composition	DEXA Scan & Skin Fold Analysis
Aerobic & Anaerobic Power	Yo-Yo Intermittent Recovery 2
Flexibility	Modified Back-Saver-Sit-Reach Test
Repeat Sprint Ability	Repeated Sprint Test

Studies discriminating between elite and sub-elite are insufficient in predicting future accomplishments, and provide little insight into the development process.

As an explanation, to become an elite soccer player you must have good ball control, in particular first touch control (Coelho *et al.*, 2010). However once in that elite bracket, ball control may not determine where in that bracket an individual may lie. It is possible that other variables may have more discriminatory power. Therefore a proposed talent identification procedure might establish the discriminating variables at each age range within an academy set up.

Figure 2.5 illustrates how a hypothetical series of thresholds that could be apparent in the composition of a talented player at the age of seventeen/eighteen. It shows that you have to collectively master each discriminatory variable at each level, and how these will together combine to form the discriminatory variable at seventeen/eighteen.

Figure 2.5. An overview of a proposed Talent Identification theory model overview



Additionally, as the figure shows, once the discriminatory variables can be established, a training programme can be implemented, whereby, over the time course of a season performance in those variables can be improved so that each player can move into the next age group successfully where the next discriminatory variable is the limiting factor. If this continues over time (across the time spent at an academy) all players can obtain the necessary individual variables needed to perform the discriminatory variables at an elite senior level. This talent identification model reiterates the reciprocal relationship between talent identification and talent development.

Lastly, some studies have used a multi-variate approach (Reilly *et al.*, 2000; Hoare & Warr, 2000; Wilson, 2009) however, they report their findings individually (physiological vs. skill vs. anthropometric), a better approach maybe statistically augmenting these variables together in order for greater discriminatory power to best predict on pitch performance.

Furthermore, the only way to determine a talent identification model as successful is to perform a longitudinal study. Studies employing these techniques are sparse. Hoare & Warr (2000) did conduct a longitudinal study, however they only followed the players they selected as ‘talented’ and therefore there is no control group to assess their talent identification process.

2.8. Aims and Hypotheses

The main aim of the current study is to investigate whether a multi-disciplinary talent identification model incorporating skill, physiological and anthropometric variables can predict on pitch performance (soccer ability) in elite youth soccer.

The first hypothesis is that the results from the skills tests will best predict on pitch performance. It is predicted that more skills test will predict or be correlated with on pitch performance than physical and anthropometric test results. This is because of the acknowledgement that the most important aspect of soccer is the successful execution of skill (Ali, 2011).

The second hypothesis is that any non-functional or non-specific tests – skill, physical and anthropometric - will not correlate with or predict on pitch performance.

3.0 Methods

3.1 Participants.

14 soccer players from the Coventry City F.C. Academy (mean \pm SD: age 17.4 ± 0.8 years, body mass 72.1 ± 1.2 kg, height 177.8 ± 5.7 cm, % body fat 9.0 ± 1.2 %) participated in the study. All players gave consent to be involved in the investigation that was granted ethical approval by the Coventry University Health and Life Sciences ethics committee (Appendix A).

3.2 Testing.

All participants completed a standardised 10-minute warm-up ahead of all testing, which was overseen by the sport scientist at the soccer club. The warm-up incorporated multi-directional movements, whole body movement exercises (e.g. squats, lunges etc), and a routine of static and dynamic stretches. Linear running started at low velocities and distances and gradually increased in both throughout the warm-up.

3.2.1. Anthropometric Testing.

Height (stretch stature; cm) and body mass (kg) were both determined using standard laboratory testing techniques (Seca 240 Stadiometer; Seca Scales 761, Hamburg, Germany, respectively). Body fat percentage was estimated using the equation from Withers *et al.*, (1987). The 7 site skinfold analysis included, biceps, triceps, subscapular, supraspinale, abdominal, front thigh and medial calf and was conducted in accordance with the technique from International Society of Advancement of Kinanthropometry (ISAK; Stewart *et al.*, 2001). This is because, Reilly *et al.*, (2009) demonstrated that the equation proposed had the highest correlation ($r=0.88$, $p<0.05$) with Dual-energy X-ray absorptiometry (DEXA) for elite Premier League professional soccer players.

3.2.2. Physiological Testing

All physiological data were collected in one session, where all participants completed the sprint testing followed by counter movement jump, and finished with the aerobic testing.

Counter Movement Jump (CMJ). This test was used to measure lower limb musculature power and was tested for using a 'Just Jump Mat' (Probotics, Alabama, USA), and was completed according to the method established by Bosco *et al.*, (1983). The highest of three jump attempts was used as the jump measurement (cm), and the use of arms were allowed. The rest time between each jump was dictated by the player when they felt they was ready to jump again (approximately 5 seconds).

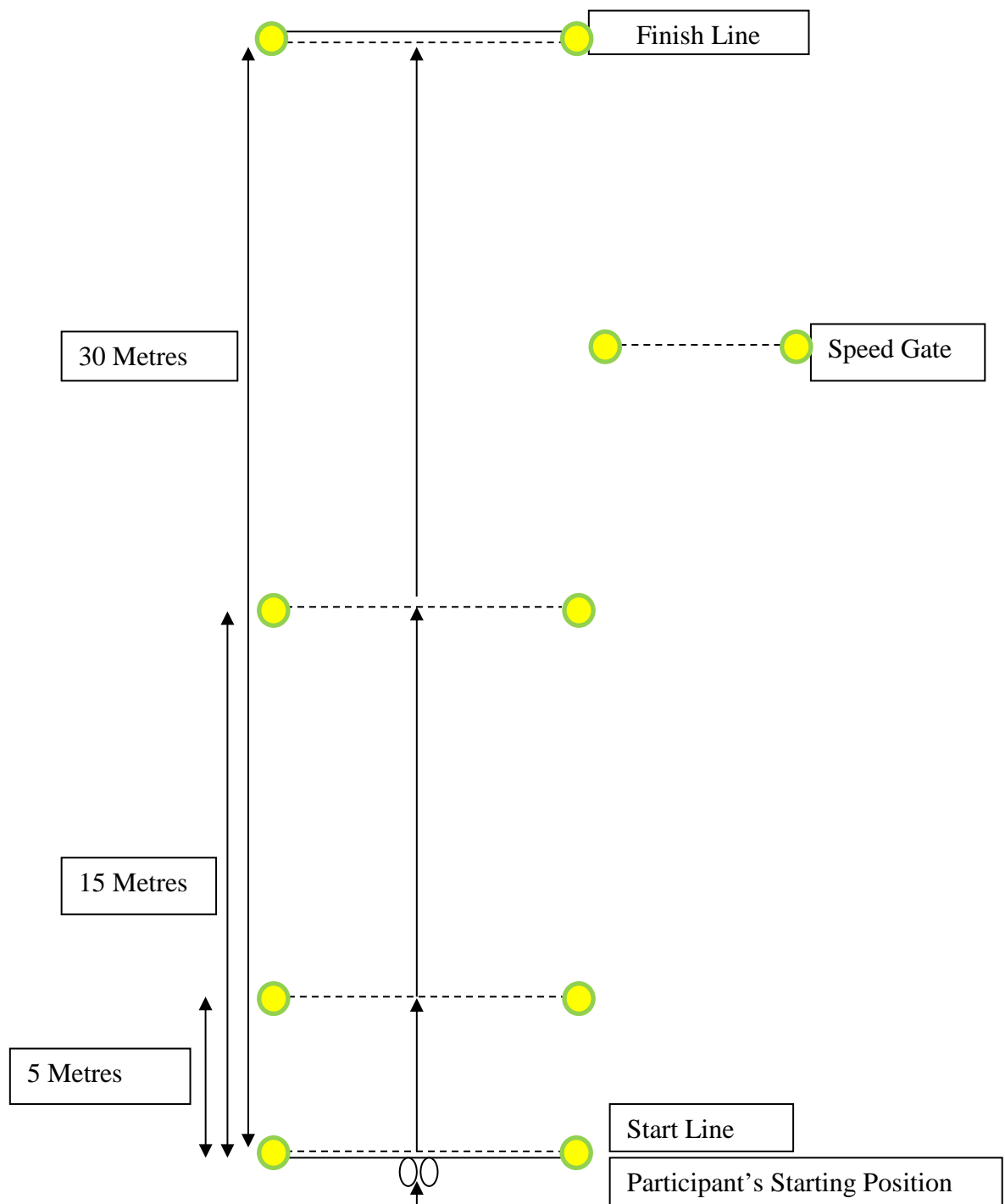
Aerobic Power (VO_{2MAX}) test. The Yo-Yo Intermittent Recovery Test Level 2 (Yo-Yo IRT2) was used to provide a measure of aerobic power. The estimate of VO_{2MAX} was calculated from the equation VO_{2MAX} (ml/min/kg) = IRT2 distance in meters x 0.0136 + 45.3; Krustup *et al.*, (2003). The Yo-Yo IRT2 was performed using a digital music player and speakers, and was completed in accordance with the protocol established by Bangsbo (1994). The test used a 20m shuttle with a 10 second rest period after each shuttle with incremental levels of intensity. A conversion sheet was used in order to calculate distance (meters) from the level reached in the test (Appendix B).

Anaerobic Power. Smart Speed Laser Gates (Fusion Sport, Brisbane, Australia) were used to measure the times of 5, 15 and 30 metre sprints (see Figure 3.1).

Figure 3.1 shows that participants started with both feet together in parallel (stationary), approximately 50cm behind the speed gate which minimised the possibility of breaking the beam and having to re-start the test. The participants started when they felt ready (i.e. not reacting to an external stimulus), and completed the 30 metre sprint as quickly as possible, breaking each speed gate on the way. Each participant completed the test 3 times, with the quickest result taken and recorded. The quickest time of any split from any of the 3 sprints were taken. E.g. the fastest 5m split time could have been from the 1st sprint, but the 15m and 30m could have come from the 2nd or 3rd sprints. Participants were asked to wait until they felt completely recovered before starting the next sprint trial, which was typically 2 -3 minutes.

Sprint Test Protocol

Figure.3.1: The layout of the anaerobic sprint tests



3.2.3. Skills Testing

There were 12 tests utilised in the study which determined soccer skill ability via passing accuracy, passing performance, shooting accuracy, juggling ability and dribbling speed abilities (Table 3.1). The testing was conducted in a circuit format, whereby a small group of players (2-3) started on one skills test and once that was completed they moved onto the next one, they continued to do this until they had completed all tests.

The skills tests used are derived from associated research in this field (David *et al.*, 2013, unpublished), whereby the test reliability assessed using Pearson Correlation, r and the coefficient of variation CV , for the majority of the tests has been determined; *dribbling speed* ($r = 0.83$; $CV = 0.04$), *passing accuracy* ($r = 0.86$; $CV = 0.18$), *juggle duration* ($r = 0.89$; $CV = 0.30$) (David *et al.*, 2013, unpublished).

Passing Performance	Passing Accuracy	Shooting Accuracy	Dribbling Speed	Juggling Performance
Short Passing Right Angle	20m Passing Accuracy	20m Shooting Accuracy	Left Foot Only	Left Foot Only
Short Passing Wide Angle	35m Long Lofted Passing Accuracy		Right Foot Only	Right Foot Only
Wall Pass Performance			Alternate Feet	Alternate Feet

Table 3.1: Skills test used to determine soccer skill ability in Elite Youth Soccer Players

Passing performance

There were three tests that collectively signified passing performance; short-passing drill with rebound board (90° angle) using Techniques A & B and wide-angled passing drill with rebound board (130° angle) using Techniques A & B (see Figure 3.2) and Wall Pass Performance Test (Figure 3.3).

Short Passing; Right angle and wide angle

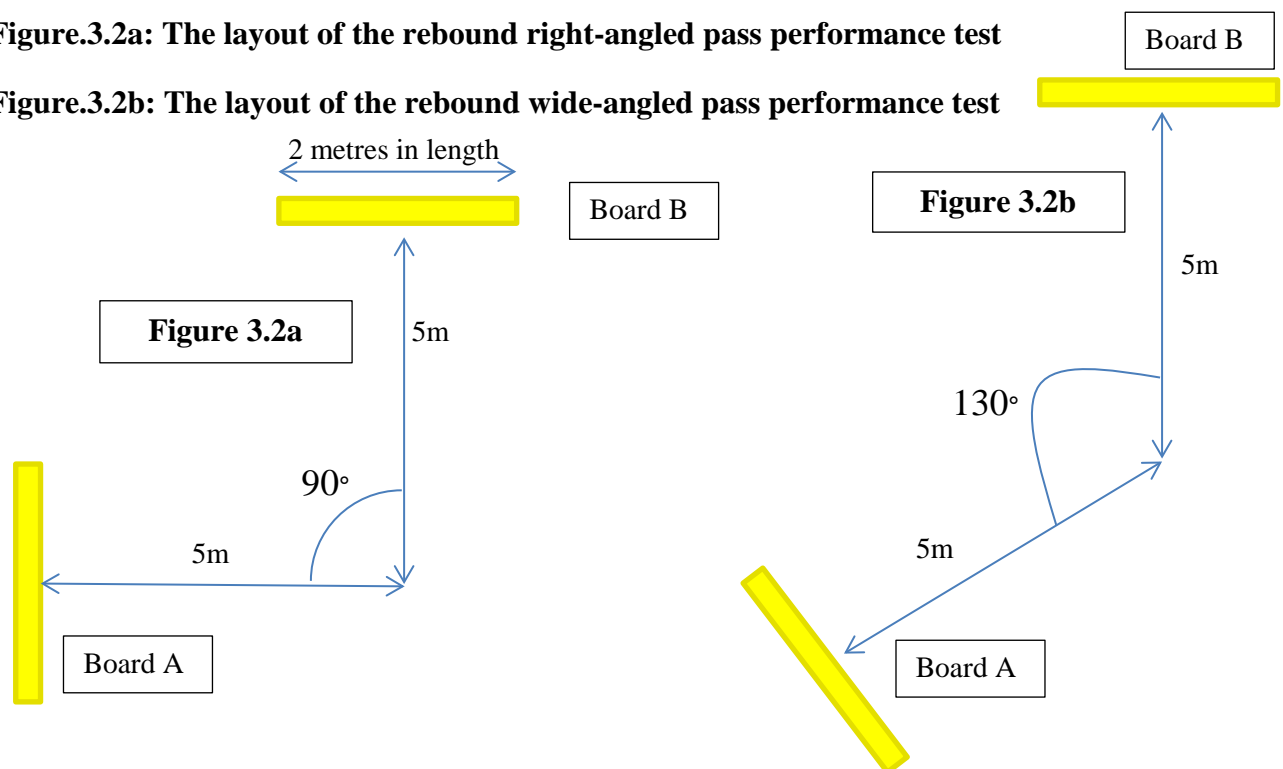
Figures 3.2a & 3.2b portray the structured layout of the passing performance tests at 90° and 130°. Both tests have the exact same protocol whereby each technique (A and B) was completed twice, and the time taken to complete 10 ‘cycles’ (Board A – Board B – Board A = 1 cycle) was recorded. The player only had 2 touches to play the ball between the rebound boards. Technique A was using one foot to receive the ball (control) and the other foot to make the pass to the rebound board. For example, when the ball came back off the right rebound board (Board B), the controlling touch to receive the ball had to be made with the left foot. Then, to pass the ball to the left rebound board (Board A), the pass had to be made with the right foot. The opposite feet were used for the opposite direction. The opposite feet were used for the opposite direction.

Technique B was using the same foot to control and pass the ball in one sequence. For example, when the ball came back from Board B, the controlling foot was the left foot and to pass the ball to Board A, the left foot was used. The right foot was used in the opposite direction.

Passing Performance Tests

Figure.3.2a: The layout of the rebound right-angled pass performance test

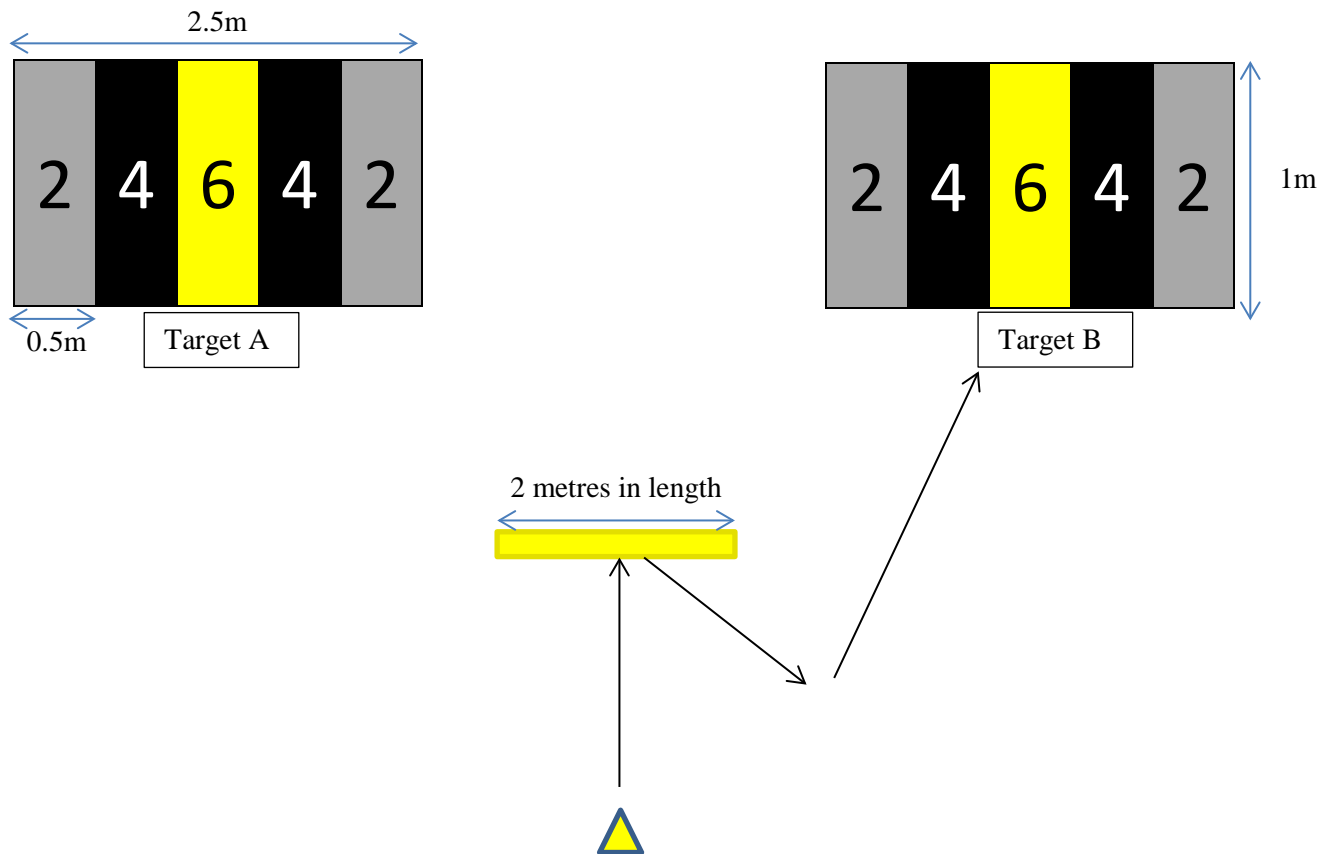
Figure.3.2b: The layout of the rebound wide-angled pass performance test



Wall Pass Performance Test

Figure 3.3 is the layout of the wall pass performance test. 45 seconds was the allocated time that participants had to score as many points as possible. The procedure was to start on the cone, pass the ball into the rebound board with the left foot and then pass the ball into the scoring target (Target B) with the right foot. The participants alternated between target A and B, therefore alternated which foot was used to pass the ball into the scoring target. If the line between two targets was hit, the average between the two numbers was given (e.g. between 6 + 4 = 5). For each point below the maximum (10) the player was missing the target by 0.25cm. The point of contact on the foot was the instep.

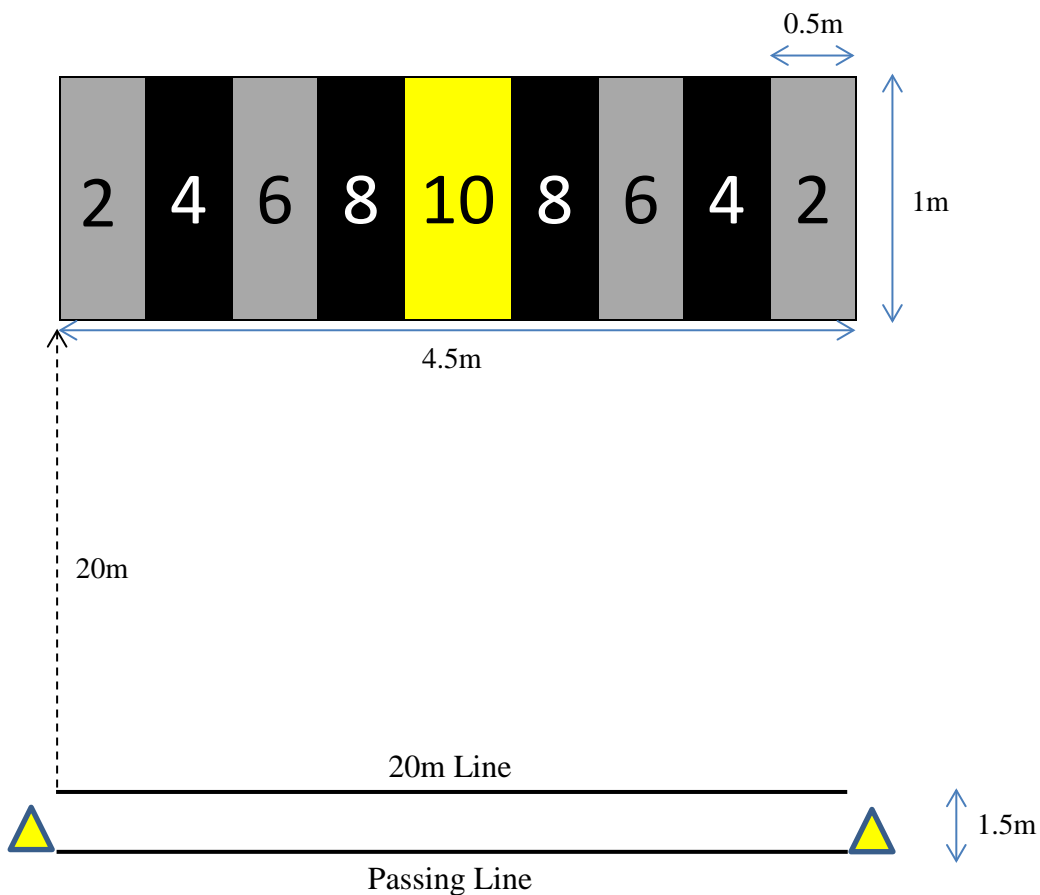
Figure.3.3: The layout of the wall pass performance test



Passing Accuracy Tests

Figure 3.4 illustrates the passing accuracy test over 20m. Each player had 14 passes with each foot at the scoring target. The participants rolled the ball out from their feet (~1m) over the passing line (but not over the 20m line) and executed a pass (one-touch) towards the scoring target – under the 1m height limit. The aim of the test was to score the highest number of points per kick (10). If the line between two targets was hit, the average between the two numbers was given (e.g. between 10 & 8 = 9). For each point below the maximum (10) the player had missed the target by 0.25cm. The point of contact on the foot was the instep.

Figure.3.4: The layout of the 20m passing accuracy test



Lofted Pass Accuracy Test

Figures 3.5a & 3.5b demonstrate the lofted pass accuracy test. The players played the ball approximately 1m in front of them with a single touch and then kicked the ball again, aiming for the target (Fig.3.5b). A score was given in relation to where the ball landed. The participants made 14 passes with each foot. The target was comprised of 5 concentric circles, whereby an outer circle had a 1m larger diameter than the inner, i.e. a 1m metre gap between each ring. Again, if the ball hit in between 2 scoring zones, the average of those two were given ($12 + 14 = 13$).

Figure.3.5a: The layout for the long lofted pass

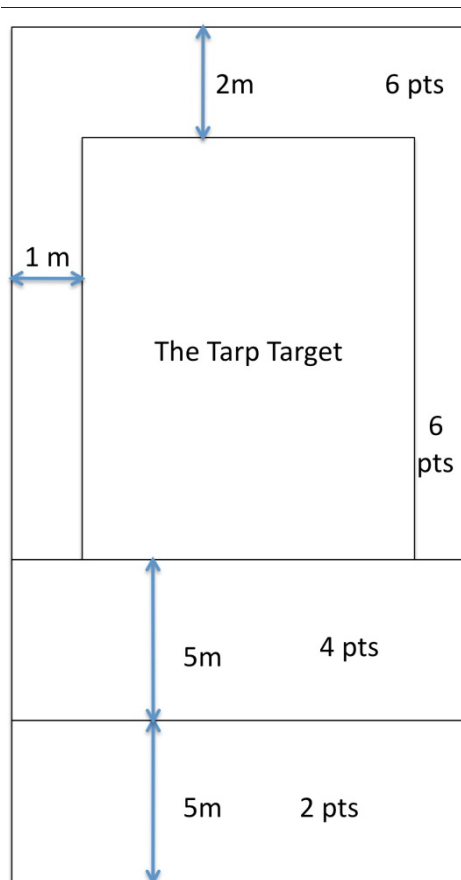
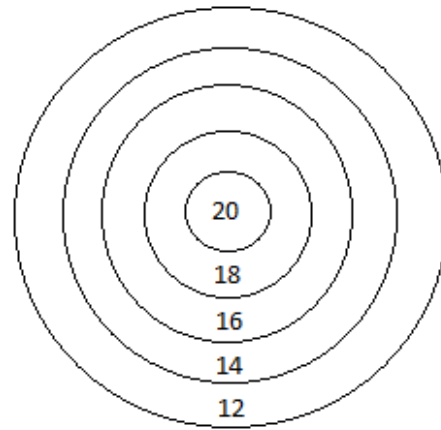


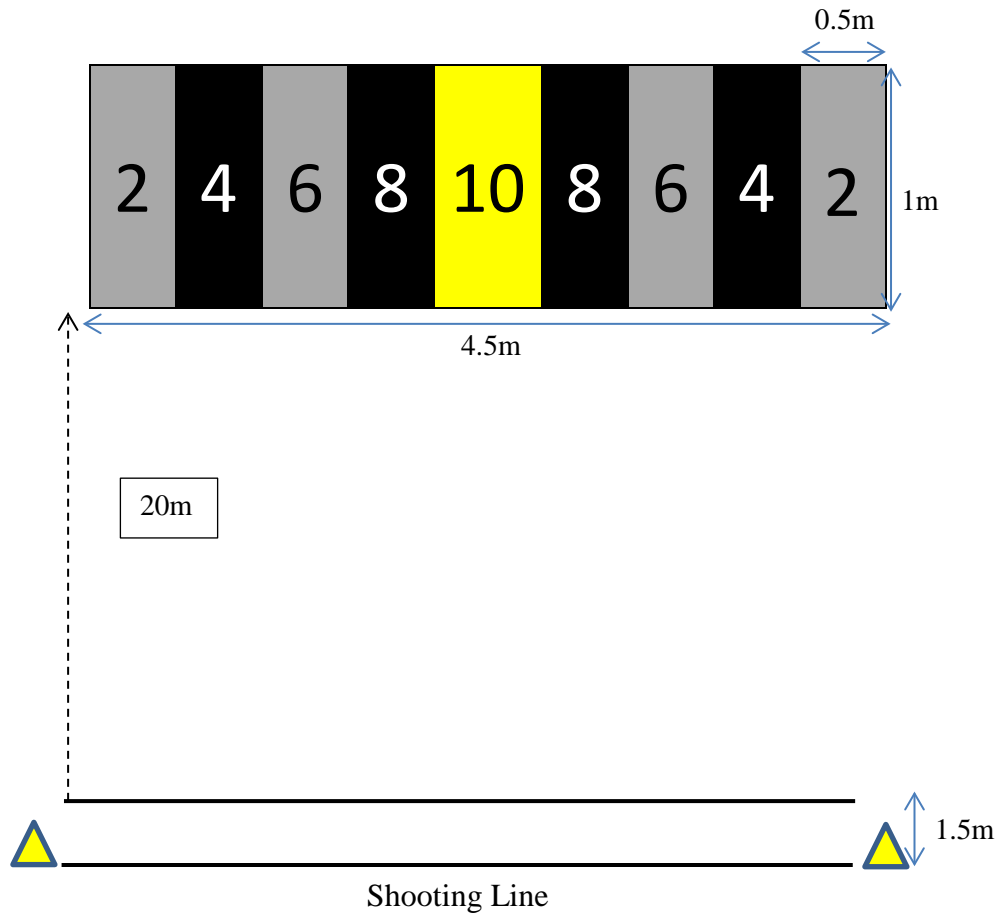
Figure.3.5b: The Tarp Target



Shooting Accuracy Performance

Figure 3.6 is the layout of the shooting accuracy test that was administered in the testing battery. The dimensions and protocols were the same as the passing accuracy test (Fig.3.3), the only difference however was that when striking the ball, the point of contact on the foot had to be from the 'laces' of the boot.

Figure.3.6: The layout of the shooting accuracy test

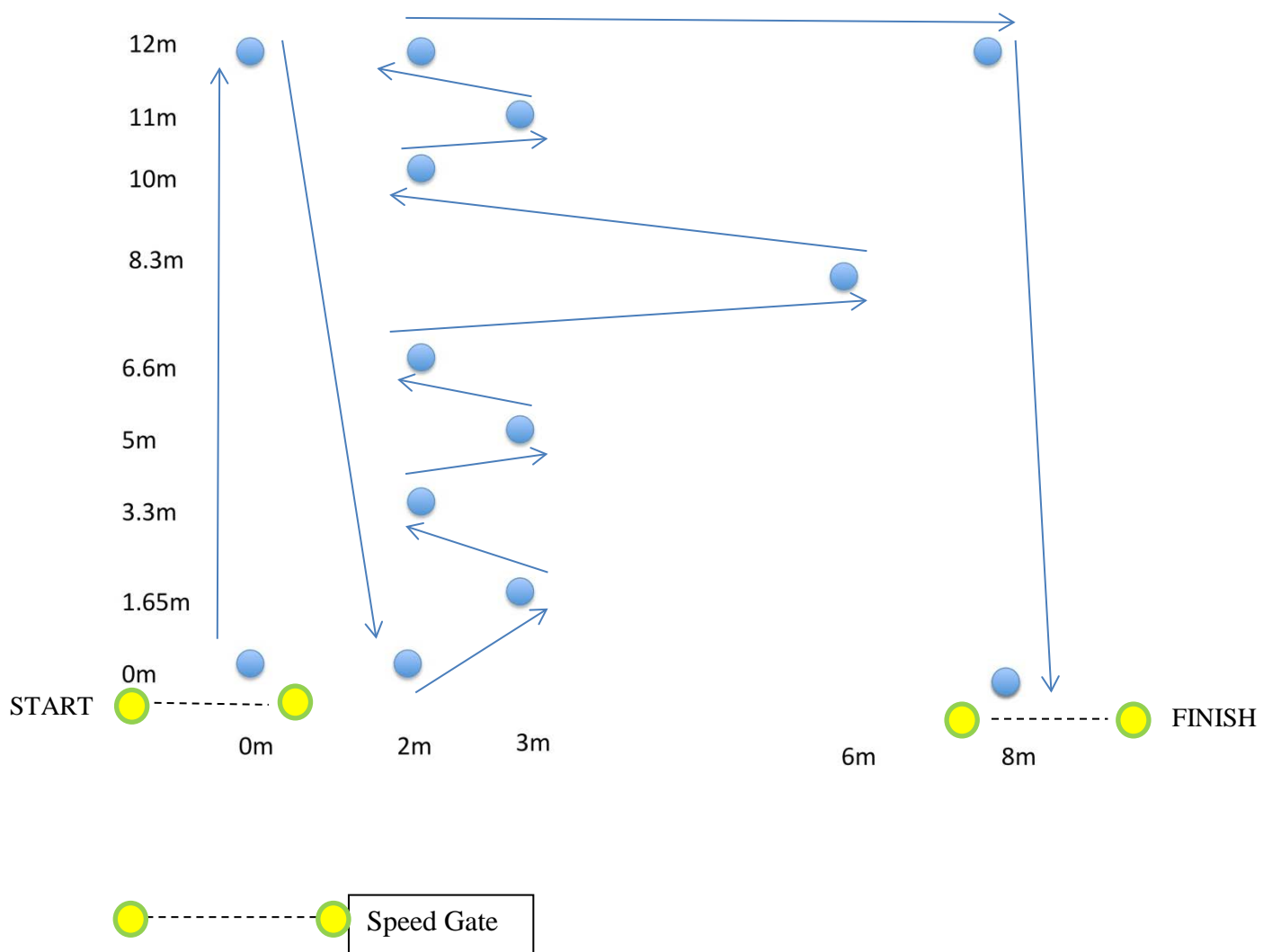


Dribbling and Performance

Figure 3.7 illustrates the dribbling performance test that the participants completed. The participants completed the course three times in the fashion that the arrows demonstrate.

They completed it once using only their right foot, once using only their left foot and a final time using both feet. Each trial was completed as quickly as possible using the same speed gates as the sprint test (Smart Speed Laser Gates; Fusion Sport, Brisbane, Australia).

Figure.3.7: The layout of the dribbling performance test.



Juggling Performance

There were 3 techniques to determine juggling ability; technique i): only using the right foot, technique ii): only using the left foot, technique iii): using both feet.

In the first two techniques, players were required to juggle the ball with only one foot and keep that foot in the air, and the other had to remain fixed and unmoved on the ground. The number of juggles that they player made with the correct foot was recorded. Mistakes were also counted, these included; when the desired kicking foot touched the floor, the ball touches the ground, the non-kicking foot swivels on the floor and the non-kicking foot moves position.

For the last technique, players had to use alternate feet to juggle with the ball. Players had to remain in a 1.5mx1.5m grid, the principles were still the same; number of juggles and number of mistakes were recorded. Number of juggles were only counted when the correct sequence was completed (left, right, left etc), the mistakes criteria was the same.

All participants had 60 seconds to juggle the ball in the air where all juggles and mistakes were recorded. A mistake would be recorded when; a) a player touches the ground with their kicking foot b) the ball touches the ground c) the non-kicking foot changes position on the ground d) the non-kicking changes direction (swivels) on the ground.

3.3 Match Analysis

11 Elite Youth Team (U17s & U18s) matches were analysed during the 2010-2011 season. These were recorded with a video camera (Sony Handycam HDR-CX250E) using a tripod, on top of a scaffold structure, with an elevated ground height of approximately 1.5m. Focus Software was used to analyse the games. Analysis of the games was completed using definition criteria for each action.

3.3.1. Definitions

The match analysis system implemented in the present study was used to distinguish frequency and success for on/around the ball events.

Actions were split up into events;

- i) Possession Events
- ii) Attacking Events
- iii) Free Kick & Dead Ball Situation Events

Each event was split up into outcomes

- i) Successful
- ii) Unsuccessful
- iii) Other – This option was deemed applicable in certain circumstances where the event could not be determined due

Table 3.2. Classification of possession events used in the match analysis system

Possession Event	Successful	Unsuccessful	Intercepted Pass
Short Pass – A pass in length that did not exceed ~15m, irrelevant to flight of ball	Where the intended receiver could have gained possession	Where the intended receiver could not have gained possession, including when the ball was played to an opposition player who did not have to move to receive the ball	Where the pass was intercepted where the opposition player had to move/adjust to intercept the pass

Long Floor Pass – A pass that exceeded 15m played on the floor	Where the intended receiver could have gained possession	Where the intended receiver could not have gained possession, including when the ball was played to an opposition player who did not have to move to receive the ball	Where the pass was intercepted where the opposition player had to move/adjust to intercept the pass
Long Lofted Pass – A pass that exceeded ~15m played in the air	Where the intended receiver could have gained possession	Where the intended receiver could not have gained possession, including when the ball was played to an opposition player who did not have to move to receive the ball	Where the pass was intercepted where the opposition player had to move/adjust to intercept the pass
One Touch Pass – A pass that consisted of only one touch (excluding head)	Where the intended receiver could have gained possession	Where the intended receiver could not have gained possession, including when the ball was played to an opposition player who did not have to move to receive the ball	Where the pass was intercepted where the opposition player had to move/adjust to intercept the pass

Distinguishing Between Events

A Successful pass was when:

- i) **The pass was accurate** (provided the receiver an opportunity to gain possession of the ball)
- ii) **And the speed of the pass was sufficient** (sufficient – the ball reached the receiver without interception, speed of the ball was not too quick as controlling the ball was unlikely).

Figure 3.8 shows the difference between an inaccurate pass (therefore an unsuccessful pass) and an accurate pass (intercepted). The differences here are that the unsuccessful pass never gave an opportunity for the receiver to gain possession where the intercepted pass could have given the receiver a chance of gaining possession. However, the interception could have been due to the defending qualities of the opposition team. These differences are important where the result is the same – the opposition has possession of the ball – however, the actions

leading to the event are different. Distinguishing between these events was important in ensuring the match analysis system was as accurate as possible. Intercepted actions were either a result of a pass not having sufficient velocity or due to the qualities of the defending team.

Figure 3.8. The difference between an intercepted pass and an unsuccessful pass:

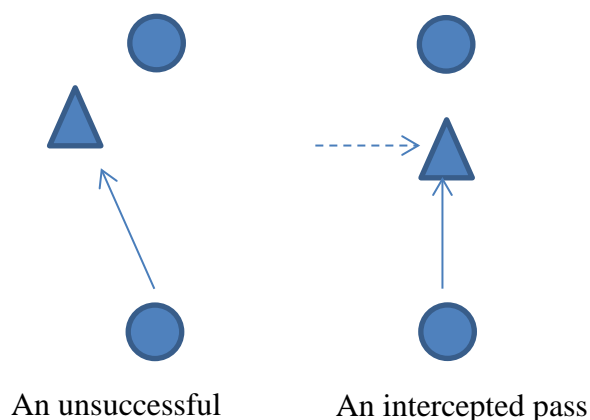


Table 3.3 Classification of attacking events used in the match analysis process

Attacking Events	Successful	Unsuccessful	Goal
Shot Inside the Box – Any attempt that was at goal with any part of the body except the head within the box	The shot was on-target (excluding the frame of the goal)	The shot was off target – including the framework of the goal	A goal is scored directly from the shot
Shot Outside the Box - Any attempt that was at goal with any part of the body except the head from the outside the box	The shot was on-target (excluding the frame of the goal)	The shot was off target – including the framework of the goal	A goal is scored directly from the shot
Dribble – Any run with the ball with the intention to beat an opponent	The player remained in possession of the ball	The player lost possession of the ball	N/A

Cross – A ball played into the penalty area from a wide area (with the aim of creating a goal scoring opportunity) regardless of the flight of the ball	The ball played created a goal-scoring opportunity	The ball played in did not create a goal-scoring opportunity	
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Table 3.4. Classification of free-kick and dead ball situation events used in the match analysis process

Free Kick & Dead Ball Situations	Successful	Unsuccessful	Intercepted	Goal
Penalty Shot – Shot from the penalty spot from an awarded penalty	The shot was on-target (excluding the frame of the goal)	The player lost possession of the ball	Where the cross was intercepted form an opposing player	A goal was scored directly from the shot
Free-Kick Cross – A ball played into the penalty area from a wide area (with the aim of creating a goal scoring opportunity) regardless of the flight of the ball	The ball played created a goal-scoring opportunity	The ball played in did not create a goal-scoring opportunity	Where the cross was intercepted form an opposing player	A goal was scored directly from the shot
Free-Kick Pass – A restart of play (free-kick) where the player attempts to pass to a team-mate	Where the intended receiver could have gained possession	Where the intended receiver could not have gained possession, including when the ball was played to an opposition player who did not have to move to receive the ball	Where the pass was intercepted form an opposing player	Where the pass was intercepted where the opposition player had to move/adjust to intercept the pass
Free-Kick Shot –	The shot was on-	The shot was off-	N/A	A goal was

A restart of play with an intended shot at goal	target (excluding the framework if the goal)	target (including the framework of the goal)		scored directly from the shot
Corner Pass – Restart of play from the corner with an attempted pass – not directly played into the penalty area	Where the intended receiver could have gained possession	Where the intended receiver could not gain possession, including when the ball was played to an opposition player who did not have to move to receive the ball	Where the pass was intercepted from an opposing player	Where the pass was intercepted where the opposition player had to move/adjust to intercept the pass
Corner Cross – Restart of play from the corner when the player crosses the ball into the penalty area regardless of the flight of the ball	The played ball reached the penalty area and produced a goal scoring opportunity	The played ball did not produce a goal scoring opportunity	Where the cross was intercepted from an opposing player	N/A

A success for each player for each action was calculated ($((\text{Total number of actions for an event} - \text{total number of unsuccessful outcomes for that event}) / \text{Total number of actions for an event}) * 100$). Total number of actions was calculated from total number of actions minus the total number of intercepted actions (where applicable). This was because of the speed of the analysis system and the inability to determine whether the outcome was due to defending qualities of the opposing team or the pass did not have sufficient speed or accuracy.

After collecting data for all the match variables listed above, some variables were eliminated from the rest of the study. This was based upon the infrequent occurrence of the event. The variables that were included in the current study were; (possession events) short pass, one touch pass, long floor pass and long lofted pass (attacking events) shot inside the box, shot outside the box, cross, dribble (free kick and dead ball situations) free kick cross, long lofted free kick pass, free kick shot, corner cross.

Repeatability of the match analysis system was measured by duplicating two games out of the 11 youth soccer games. Each double set of data was then correlated together. An average of the correlations was then given as the repeatability factor for the match analysis system.

Statistical Analysis. SPSS (Statistical Package for Social Sciences; Illinois, USA) was used as the statistical software. Age independent residuals were calculated for the variables that significantly correlated with age and were used in all subsequent correlation and regression analysis. A Pearson Correlation Coefficient was used to correlate between variables, with an accepted statistical significance of $p < 0.05$. Multiple Linear Regression Analysis was used with the variables that significantly correlated with overall match success which determined what variable(s) best predicted overall match success.

The relationship between variables was what this study was interested in, hence why a Pearson Correlation Coefficient was administered. The investigation of this study was completed within an elite soccer setting, whereby application of sports science research is integrated within an identification and development programme. The results of this study must be able to be reinvested into the field environment, such that the level of statistics applied is within the realms of that of sports scientists working as practitioners in talent identification. Whilst other statistical tests – for example, principal component analysis – would have dealt with potential problems of correlation between independent variables, interpretation of the results would have been more complex, therefore limiting the potential application of the analysis used in the study by practitioners and thus the impact of the study within elite soccer settings would have been diminished.

4.0 Results

Table.4.1: Anthropometric Data of the players used in this study, N = 14

	Height (cm)	Body Mass (kg)	Body Fat %
Mean	179.2	73.6	9.0
Standard Deviation	6.3	7.0	1.2

4.1. Effects of Age on Performance

As age was potentially a confounding variable, the relationship between age and each performance variable was investigated. Four variables were significantly correlated with age. Short Pass Success significantly correlated with age ($r = 0.588$, $p=0.014$; Fig.4.1). 5m and 15m Sprint times were significantly correlated with age ($r = 0.499$, $p=0.024$; Fig.4.2; $r = 0.552$, $p=0.013$; Fig.4.3), as was YoYo IRT2 ($r = 0.735$, $p=0.001$; Fig.4.4). Therefore to remove the confounding effects of age, age residuals were calculated and used, for each of these variables, in all subsequent correlation and regression analysis.

Figure 4.1. Relationship between the age of players used in the study and short pass success N = 14 individuals, $r = 0.588$, $p=0.014$

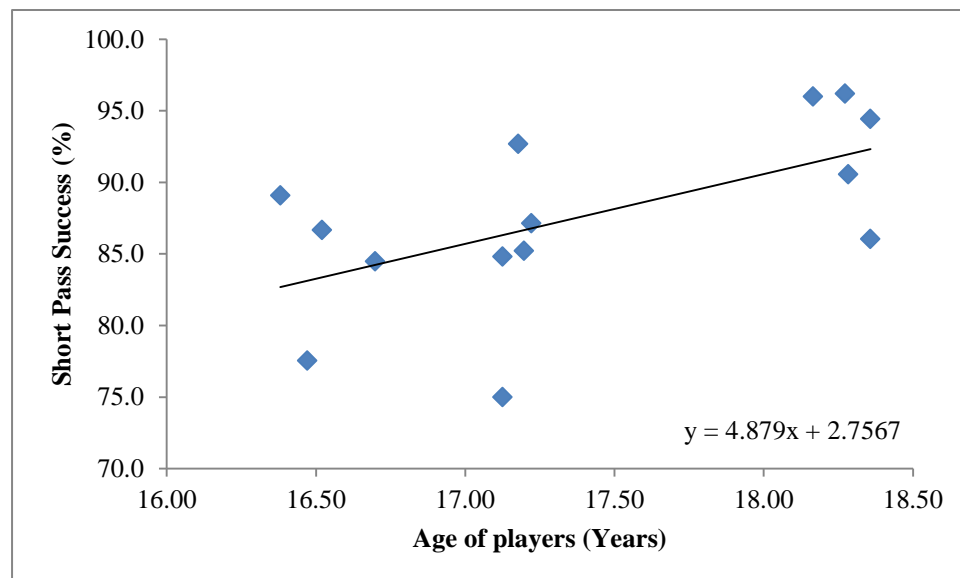


Figure 4.2. Relationship between the age of the players used in the study and 5m sprint times, N = 14 individuals, $r = 0.499$, $p = 0.024$

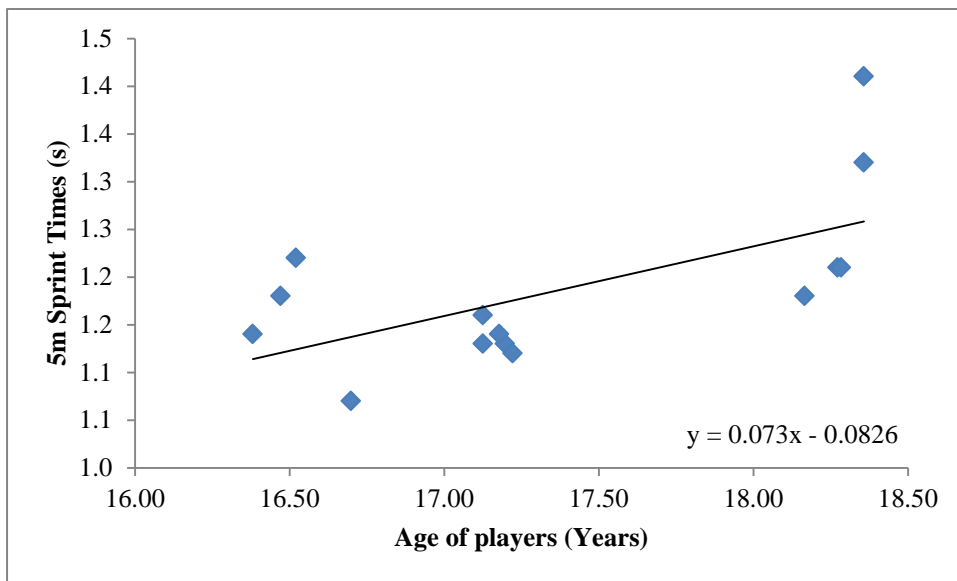


Figure 4.3. Relationship between the age of the players used in the study and 15m sprint times, N= 14 individuals, $r = 0.552$, $p = 0.013$

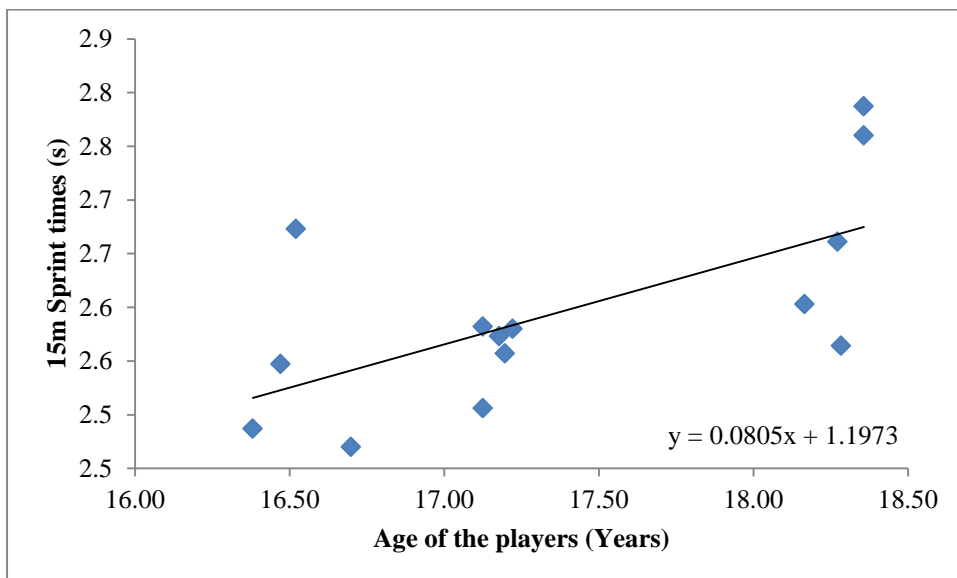
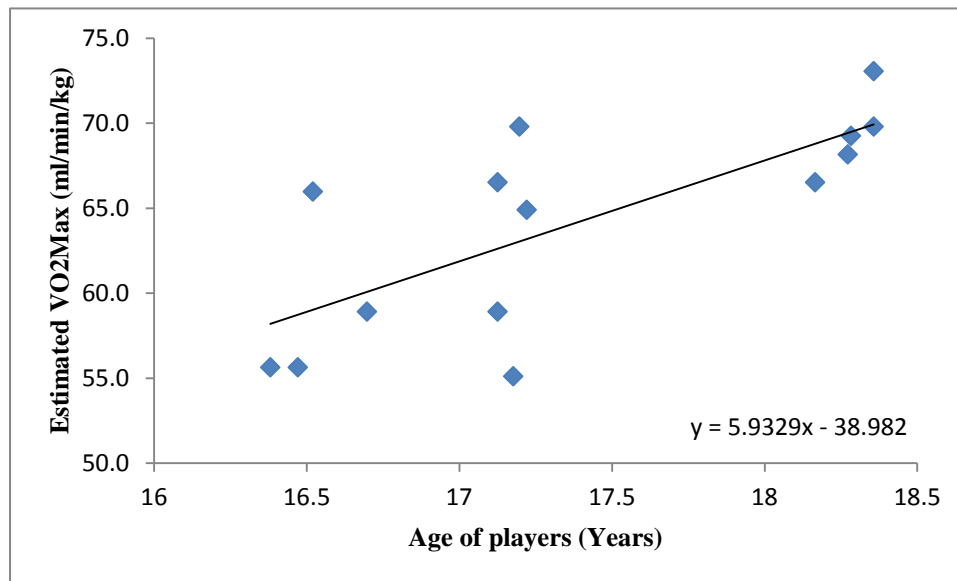


Figure 4.4. Relationship between the age of the players used in the study and estimated VO₂Max derived from YoYo IRT2 Levels N = 14 individuals, $r = 0.735$, $p = 0.001$



4.2. Relationships within physical fitness tests:

A summary of the physical fitness performance data is provided in Table 4.2.

Table.4.2: Physiological data of the players used in this study, N = 14

	5m (secs)	15m (secs)	30m (secs)	CMJ (cm)	Estimated VO ₂ MAX (ml/min/kg)
Mean	1.19	2.60	4.42	46.0	64.1
Standad Deviation	0.09	0.09	0.13	5.3	6.1

15m sprint times were significantly positively correlated with 5m ($r = 0.817$, $p < 0.00$; Fig.4.5) and 30m sprint times ($r = 0.605$, $p = 0.011$ Fig.4.6) but 5m and 30m sprint times were not significantly correlated ($r = 0.127$, $p = 0.333$)

Jump Height was significantly negatively correlated with 15m ($r = -0.493$, $p = 0.037$; Fig.4.7) and 30m ($r = -0.562$, $p = 0.018$; Fig.4.8) sprint times but not 5m sprint time ($r = -0.295$, $p = 0.153$).

YoYo IRT2 performance was not significantly correlated with any variable 5m ($r = 0.203$, $p = 0.243$), 15m ($r = 0.206$, $p = 0.239$), 30m ($r = 0.306$, $p = 0.144$) sprint times, Jump Height ($r = -0.285$, $p = 0.161$).

Figure 4.5. Relationship between 5m and 15m Sprint Time in academy soccer players.

N=14 individuals; $r=0.817$, $p<0.00$. The line was fitted using regression analysis

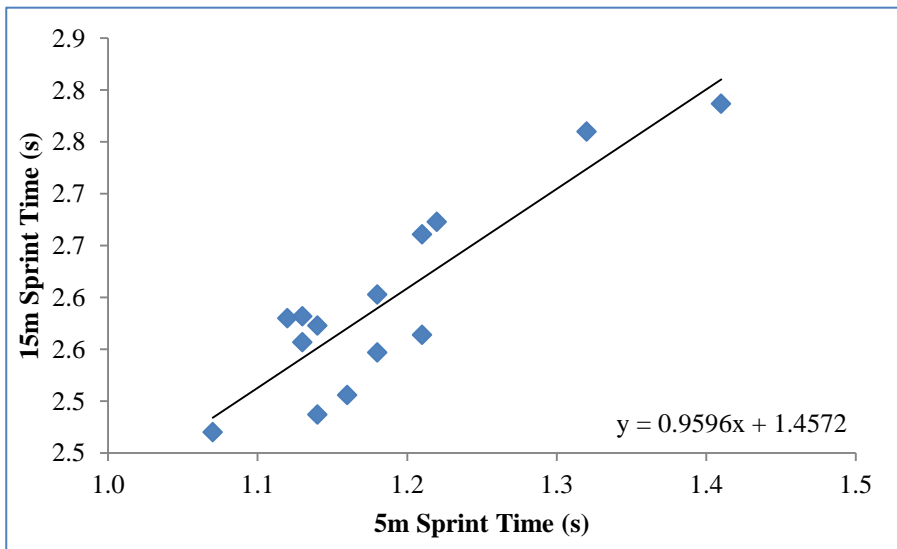


Figure 4.6. Relationship between 15m and 30m sprint times in academy soccer players

N=14 individuals; $r=0.605$, $p=0.011$

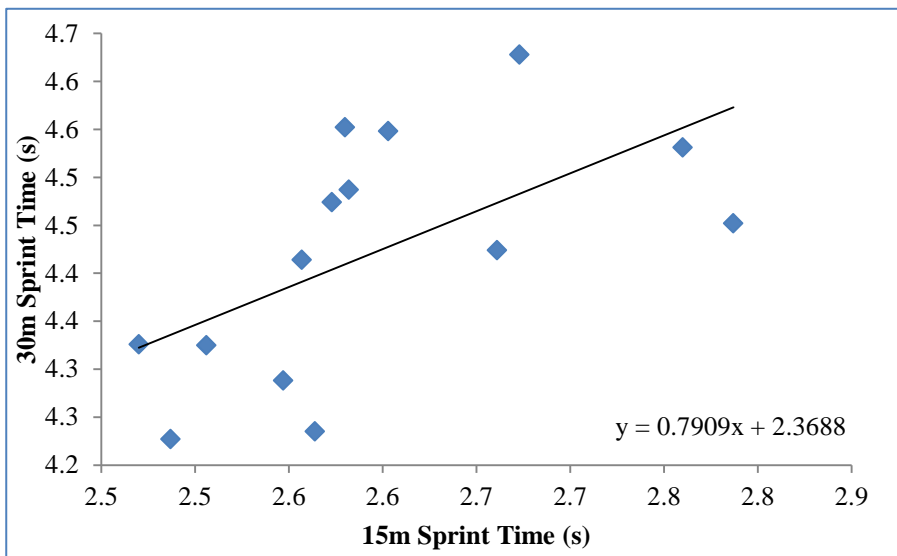


Figure 4.7. Relationship between jump height and 15m sprint time. N=14 individuals, $r=-0.493$, $p=0.037$

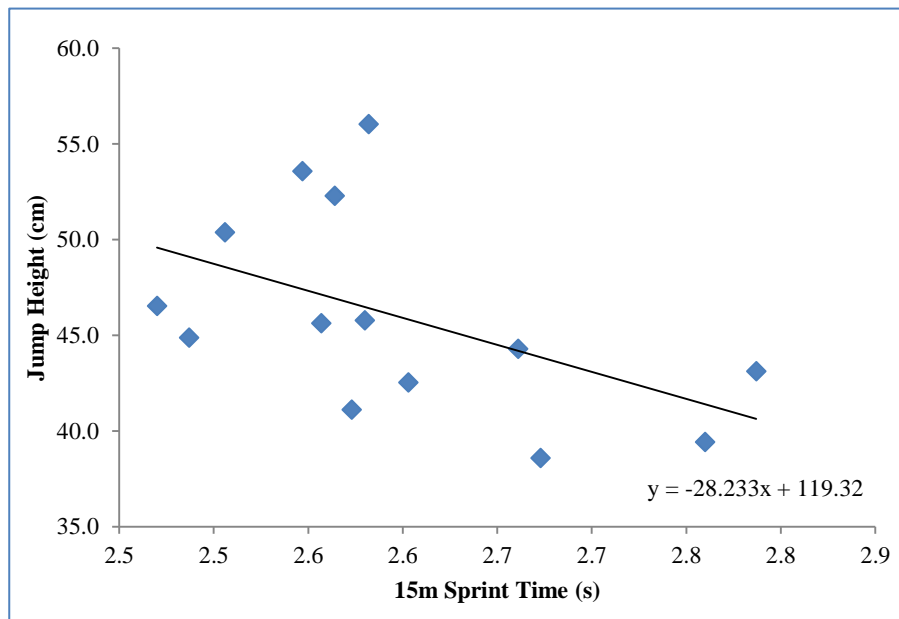
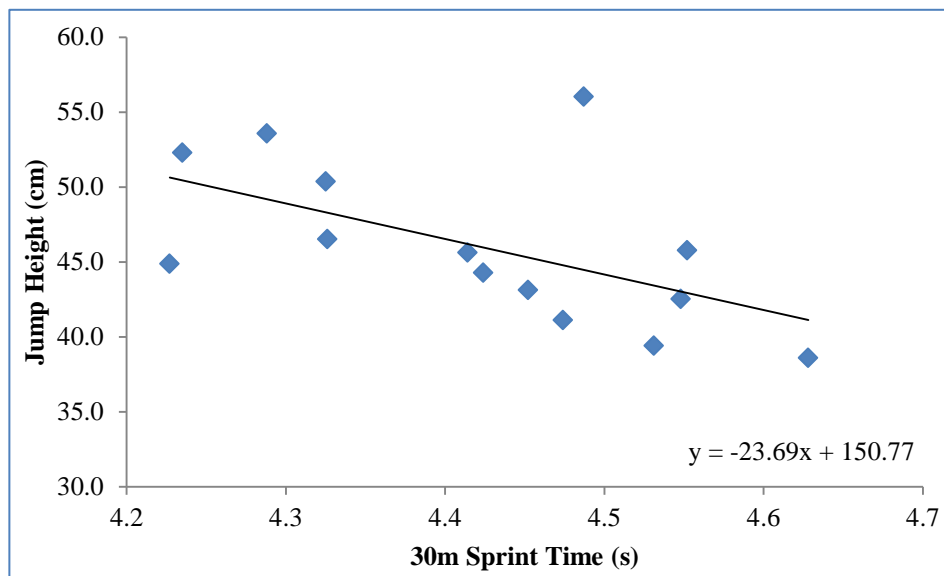


Figure 4.8. Relationship between jump height and 30m sprint time. N=14 individuals $r=-0.562$, $p=0.018$



4.3. Relationships within Skills Tests:

A summary of the skills data is provided in Table 4.3.

Table.4.3: Football skills result data, N = 14

	Passing 20m (Points)	Passing 35 m (Points)	Wall-Pass (Points)	Rebound Board - Right-angled (Points)	Rebound Board - wide angled (Points)	Shooting 20m (Points)	Alternate Juggle Average (Points)	Juggle-Left Foot (points)	Juggle_right Foot (Points)	Dribbling Time Both Feet (Points)	Dribble-Left Foot (Points)	Dribble_right Foot (Points)
Mean	6.0	6.1	12.6	50.3	51.0	4.8	49.0	17.7	19.4	24.2	27.2	26.4
SD	0.8	1.5	3.4	4.6	4.2	1.1	36.3	39.2	23.1	1.2	2.5	2.4

The 20m Passing Test results were significantly positively correlated with 3 out of the other 4 skills tests, based upon passing; 35m Passing Test ($r=0.721$, $p=0.001$; Fig.4.9), Wall Pass Test ($r=0.666$, $p=0.003$; Fig.4.10) and Rebound Board-Wide Angle Test ($r=-0.501$, $p=0.024$; Fig.4.11).

35m Passing Drill, Wall-Pass, Rebound Wide Angle or Rebound Right Angle did not have any other significant results within the battery of skills tests.

Figure 4.9. Relationship between 20m passing test performance and 35m passing test performance N=13 individuals, $r=0.721$, $p=0.001$

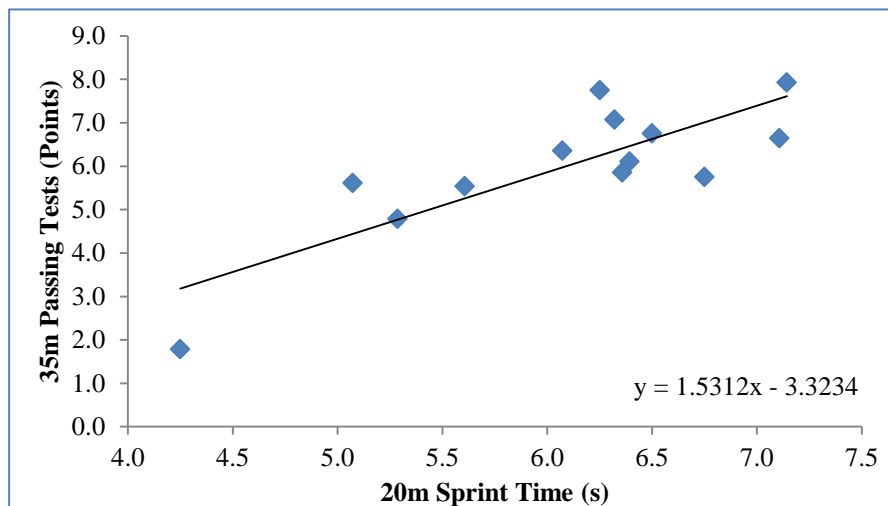


Figure 4.10. Relationship between 20m passing test performance and the wall-pass test performance N=13 individuals $r=0.666$, $p=0.003$

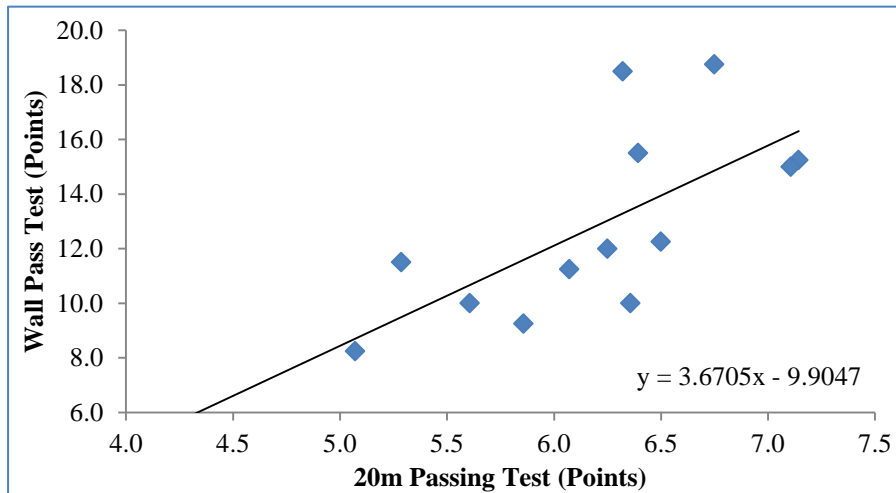
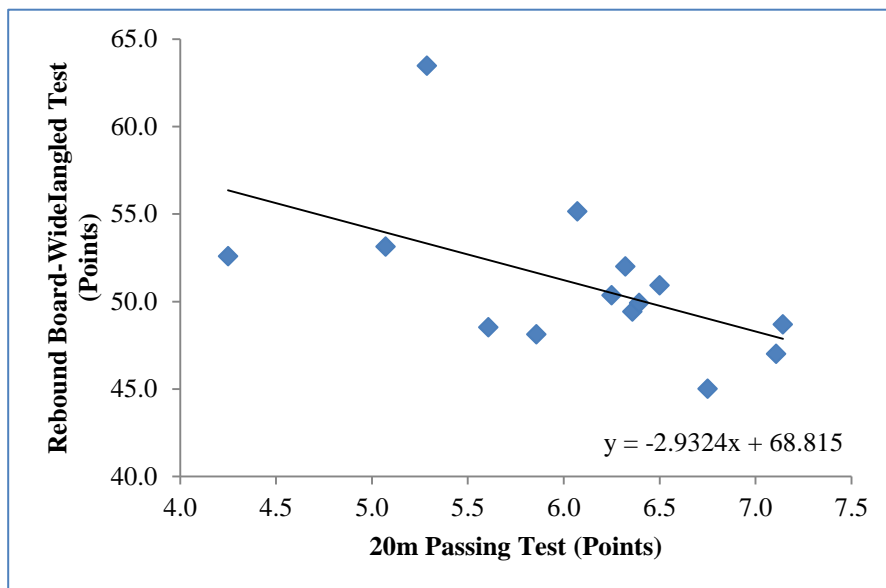


Figure 4.11. Relationship between 20m passing test performance and rebound board-wide angled test performance N= 14 individuals, $r=-0.501$, $p=0.024$



4.4. Relationships within match analysis measures (Success)

A summary of the match performance data is provided in Table 4.4.

Table 4.4. Match Analysis data for each variable recorded,

	SUCC %	Corner Cross %	Cross %	Dribble %	Free Kick Cross %	Free Kick Shot %	Headed Pass %	Headed Shot %	Long Floor Pass %	Long Lofted Free Kick Pass %	Long Lofted Pass %	One Touch Pass %	Penalty Shot %	Short Pass %	Shot Inside the Box %	Shot Outside the Box %	Event Per Hour (h-1)
Mean	69.1	70.5	30.4	83.2	42.0	61.1	68.0	36.7	80.3	54.1	51.6	77.5	50.0	87.6	46.0	24.4	25.9
SD	9.8	18.1	26.4	21.0	42.5	53.6	18.7	35.8	11.8	34.1	12.4	7.9	70.7	6.3	35.7	30.5	11.9

Short Pass success was significantly positively correlated with 2 out of the other 3 match analysis measures; Long Lofted Pass ($r=0.550$, $p=0.026$; Fig.4.12) and One-Touch Pass ($r=0.577$, $p=0.015$; Fig.4.13).

There were no significant relationships between Long Floor Pass and any other match analysis measure. Long lofted pass and one-touch pass didn't have any significant relationship with any other variable (apart from short pass success).

Figure 4.12. Relationship between short pass success and long lofted pass success
N=13 individuals, $r=0.550$, $p=0.026$

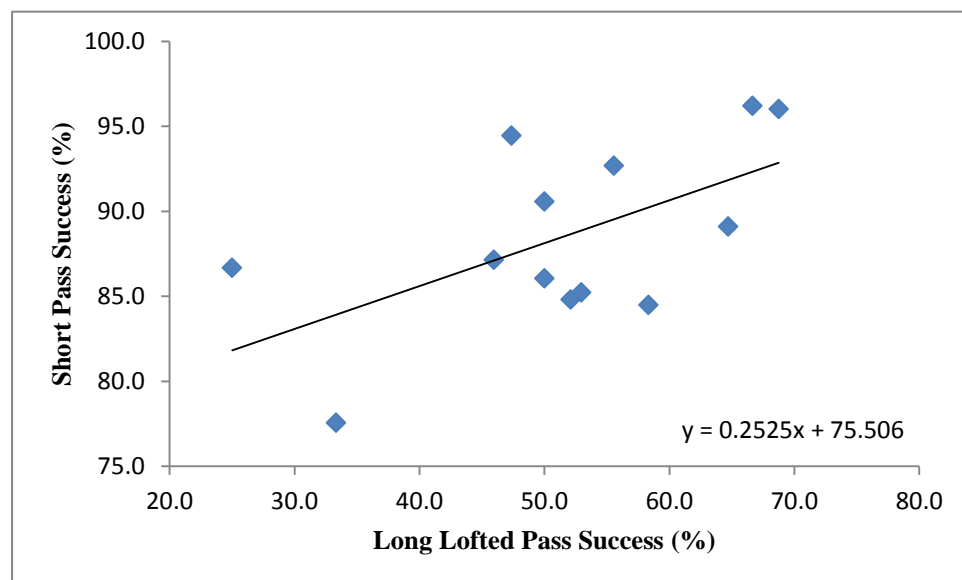
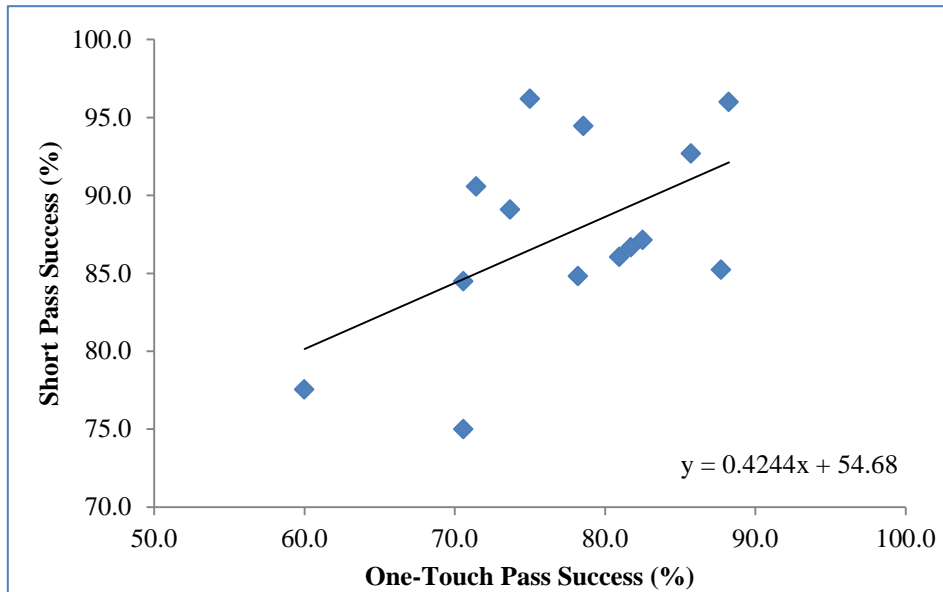


Figure 4.13. Relationship between short pass success and one-touch pass success
N=14 individuals, $r=0.577$, $p=0.015$



4.5. Relationships between match analysis measures and skill tests

Successfulness of short passing in the match analysis correlated significantly with the shortest passing skills test (20m, $r=0.754$; $p=0.001$; Fig.4.14), but no other skills tests. Long floor pass in the match analysis correlated significantly with rebound board-right angled ($r= -0.565$, $p=0.028$; Fig.4.15) and was almost significantly correlated with rebound board-wide angled ($r= -0.447$, $p=0.055$) but was not significant with any other skills tests.

One-touch pass in the match analysis significantly positively correlated with 20m passing test ($r=0.688$, $p=0.003$; Fig.4.16), 35m passing test ($r=0.552$, $p=0.025$; Fig.4.17) and the wall-pass test ($r=0.524$, $p=0.033$; Fig.4.18).

Long lofted pass was the only match analysis variable that didn't correlate with a skills test and rebound board-wide angles was the only skills test that didn't correlate with a match analysis variable.

Figure 4.14. Relationship between short pass success and 20m passing test performance
 N= 14 individuals, $r=0.754$; $p=0.001$

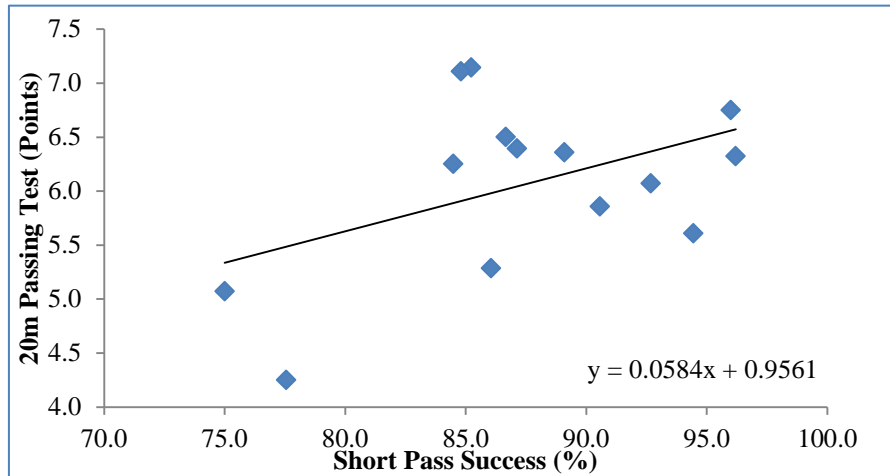


Figure 4.15. Relationship between long floor pass success and rebound board-right angled test performance
 N = 14 individuals, $r= -0.565$, $p=0.028$

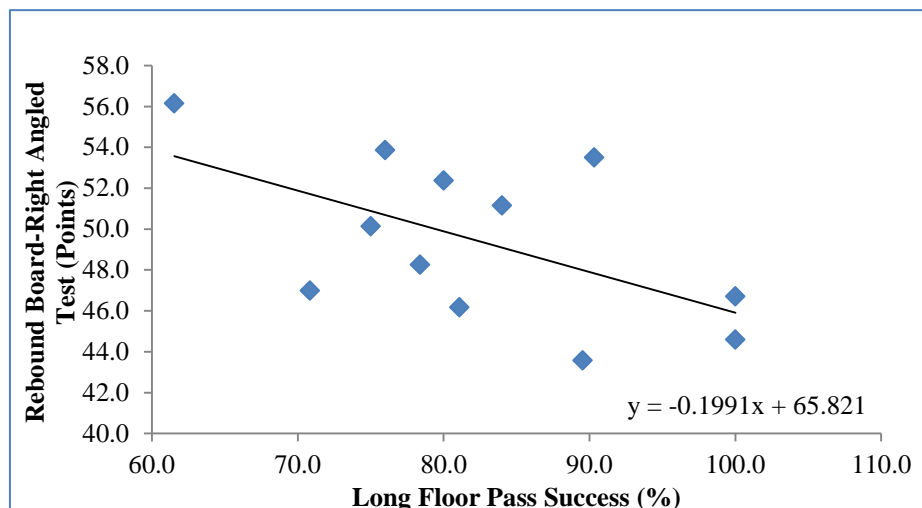


Figure 4.16. Relationship between one-touch pass success and 20m passing test performance
 N = 14 individuals, $r=0.688$, $p=0.003$

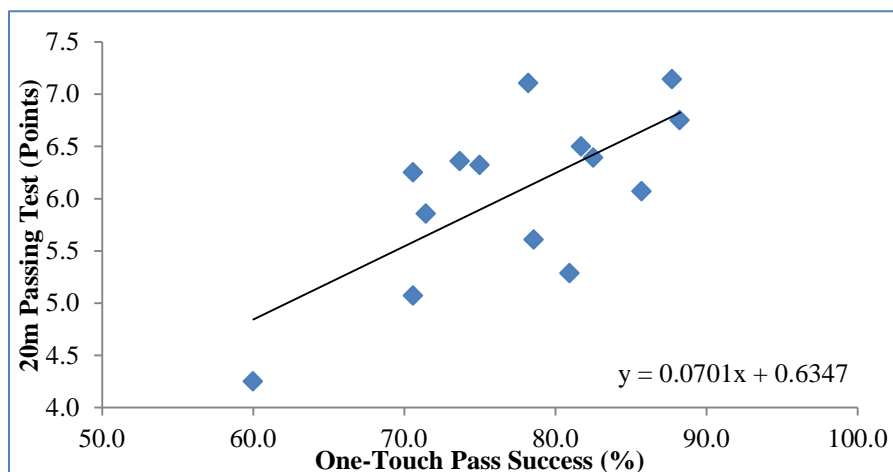


Figure 4.17. Relationship between one-touch pass success and 35m passing test performance N = 13 individuals, $r=0.552$, $p=0.025$

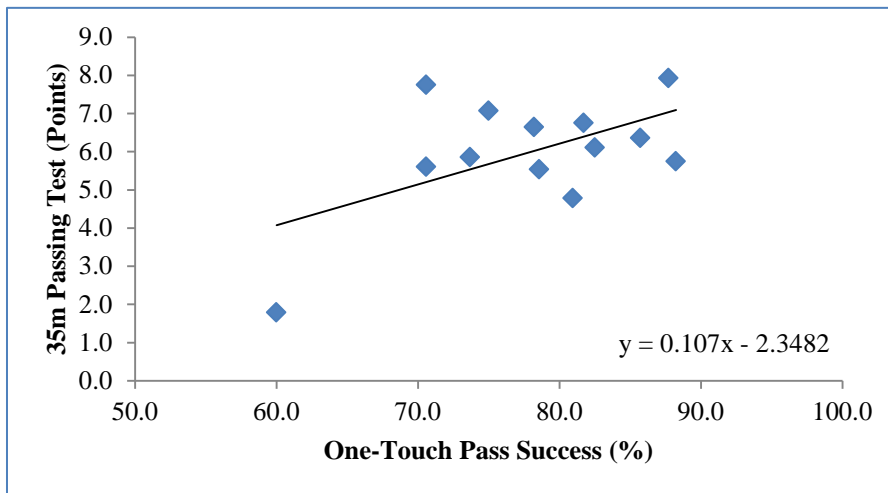
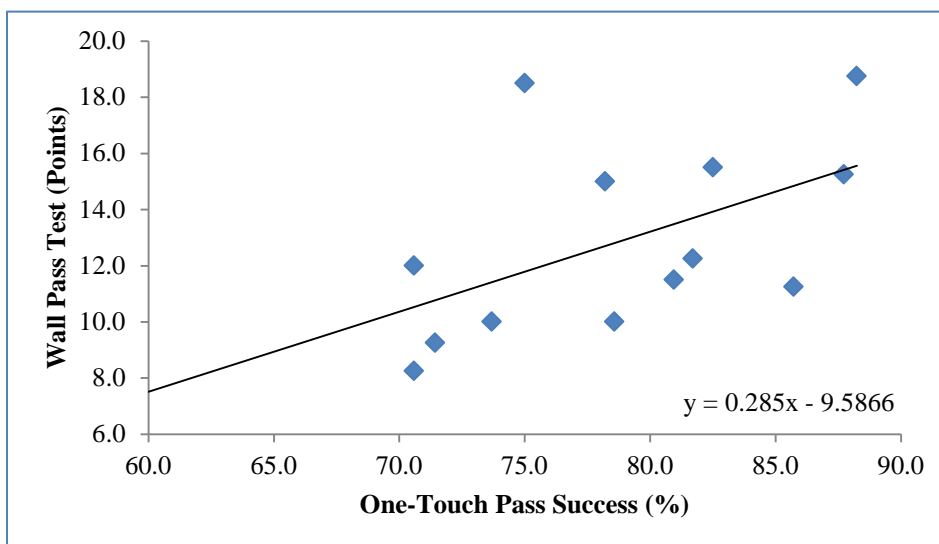


Figure 4.18. Relationship between one-touch pass success and wall pass test performance N = 13 individuals, $r=0.524$, $p=0.033$



4.6. Prediction of on Pitch Performance

4.6.1. From Physical Tests;

Jump Height significantly correlated with overall match success ($r = -0.619$, $p = 0.035$; Fig.4.19). 30m sprint time significantly correlated with overall match success ($r = 0.467$, $p = 0.035$; Fig.4.20) but 5m and 15m did not ($r = 0. -0.113$, $p = 0.350$; $r = 0.066$, $p = 0.411$) No other physical fitness variable correlated significantly with overall match success.

Figure 4.19. Relationship between Jump height and overall success N = 14 individuals, $r = -0.549$, $p = 0.021$

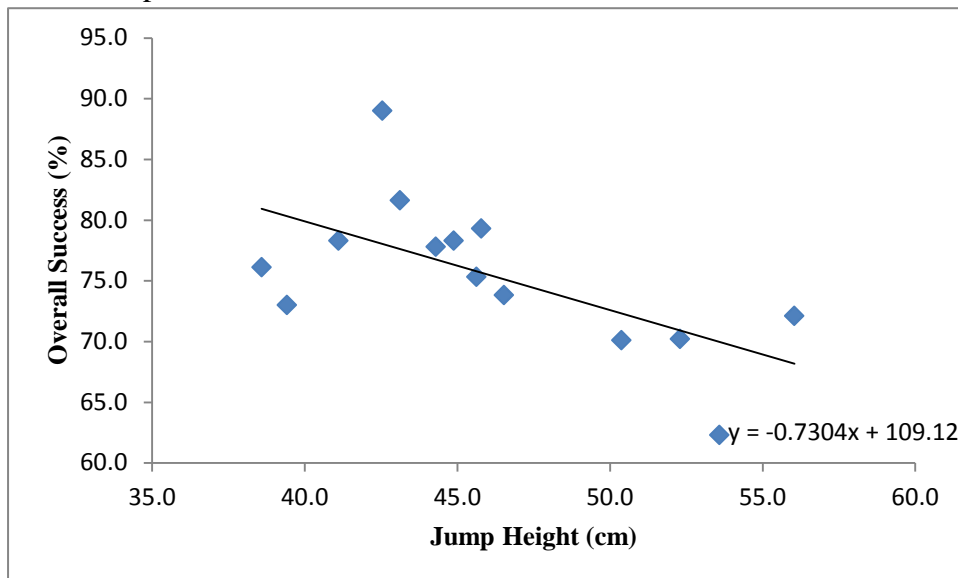
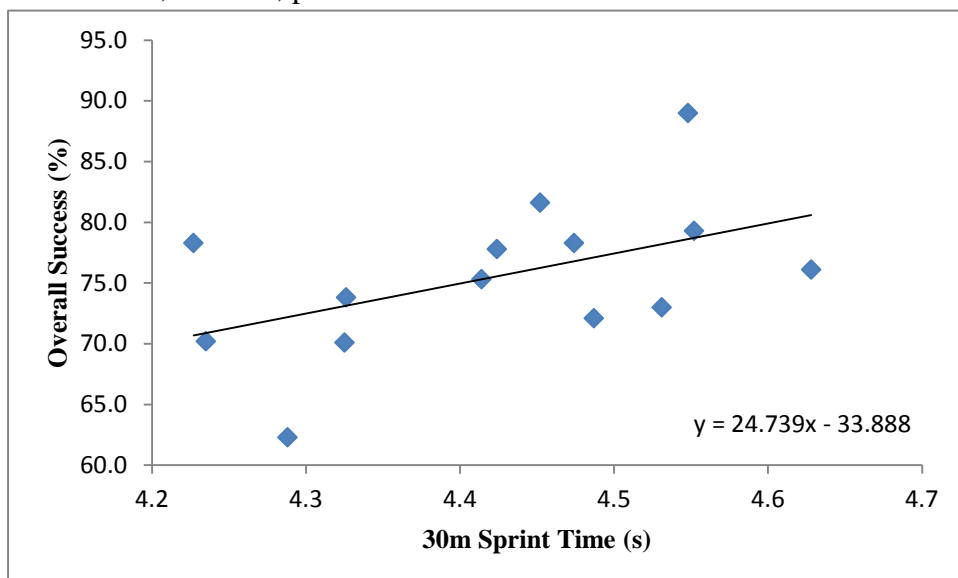


Figure 4.20. Relationship between 30m Sprint Time and overall success N = 14 individuals, $r = 0.467$, $p = 0.035$



4.6.2. From Skills Tests;

Only one passing test significantly correlated with overall match success; 20m Passing Test ($r=0.754$, $p=0.001$; Fig.4.21), with Wall-Pass Test almost significantly correlating ($r=0.471$, $p=0.052$).

Dribbling time with the right foot correlated with overall success ($r= -0.528$, $p=0.026$; Fig. 4.22) but not Dribbling time with the left foot ($r= -0.124$, $p=0.337$) or Dribbling time with both feet ($r=0.410$, $p=0.093$).

Alternate Juggling also correlated significantly with overall success ($r=0.682$, $p=0.01$; Fig.4.23).

Neither of the Rebound Board passing tests correlated significantly with overall success (Wide-Angled; $r= -0.285$, $p=0.162$. Right-Angled; $r=0.052$, $p=0.436$). Nor did 20m shooting ($r=0.359$, $p=0.103$).

Figure 4.21. Relationship between Overall success and 20m passing test N=14 individuals, $r=0.754$, $p=0.001$

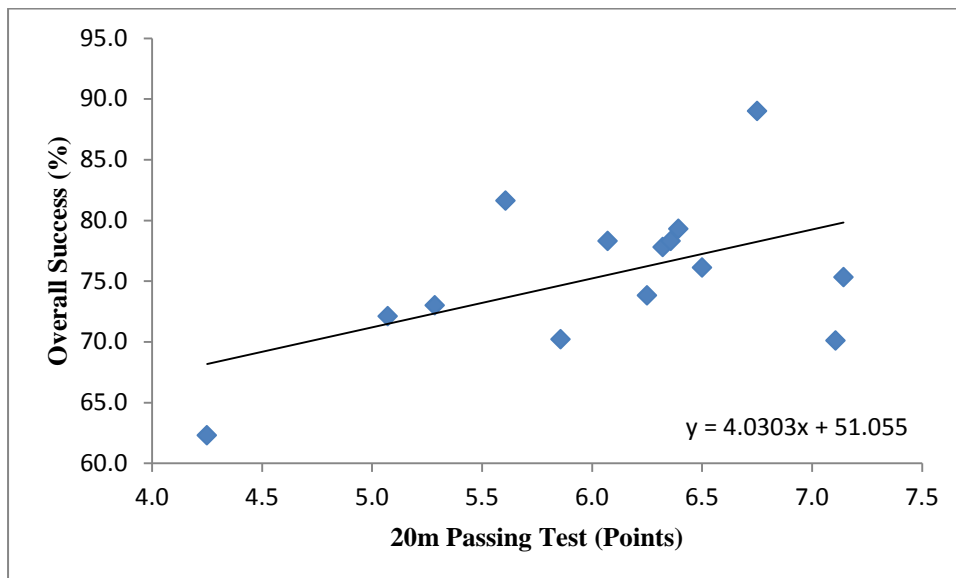


Figure 4.22. Relationship between Overall success with dribbling times with the right foot N = 14 individuals, $r = -0.528$, $p = 0.026$

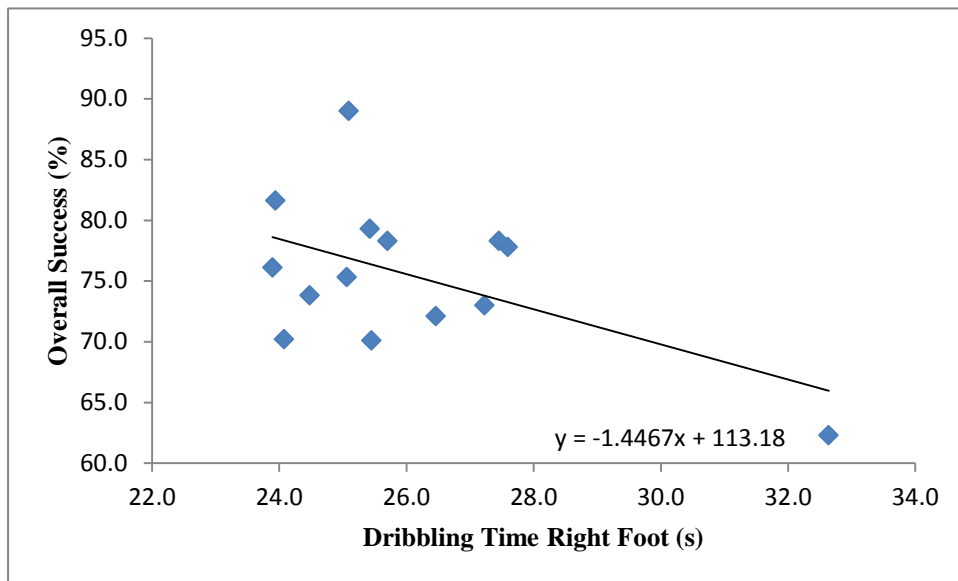
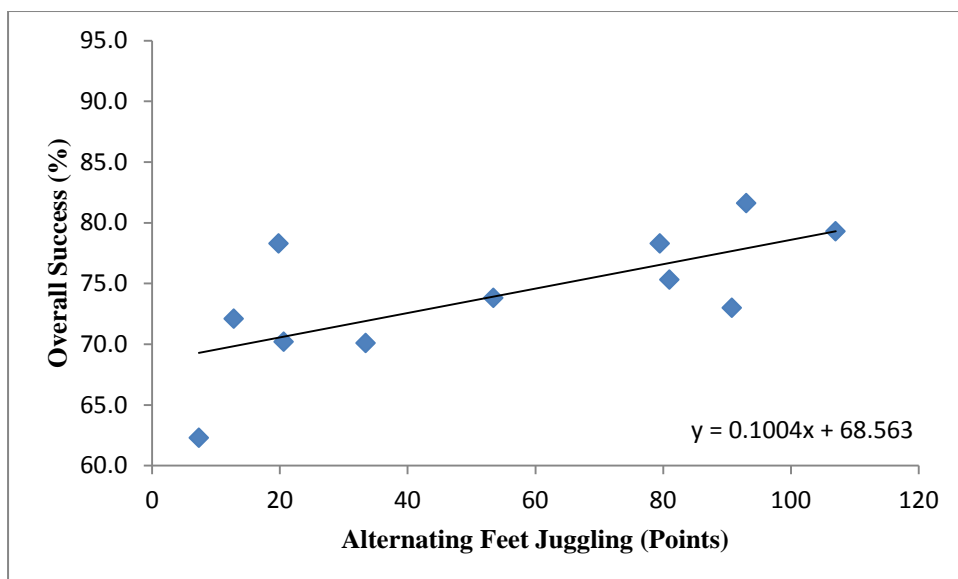


Figure 4.23. Relationship between Overall success and alternating feet juggling test performance N = 11 individuals, $r = 0.682$, $p = 0.01$



4.6.3. From Match Analysis;

The success of 3 on pitch skills significantly correlated with overall success; Long Lofted Pass success ($r=0.512$, $p=0.037$; Fig.4.24), One Touch Pass success ($r=0.726$, $p=0.002$; Fig.4.25), and Short pass success ($r= 0.735$, $p=0.001$; Fig.4.26).

Figure 4.24. Relationship between Overall success and long lofted pass success
N = 13 individuals, $r=0.512$, $p=0.037$

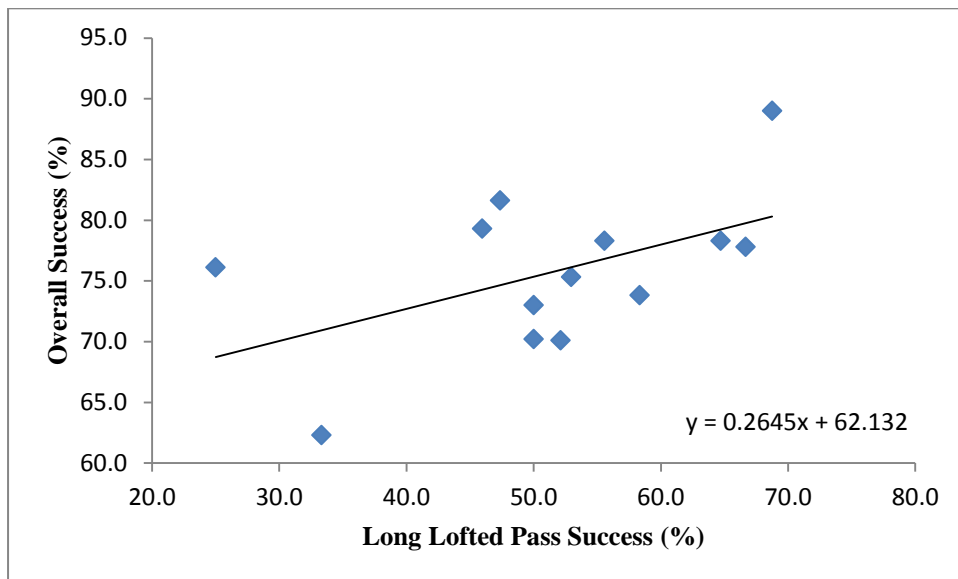


Figure 4.25. Relationship between Overall success and One-touch pass success

N = 14 individuals, $r=0.726$, $p=0.002$

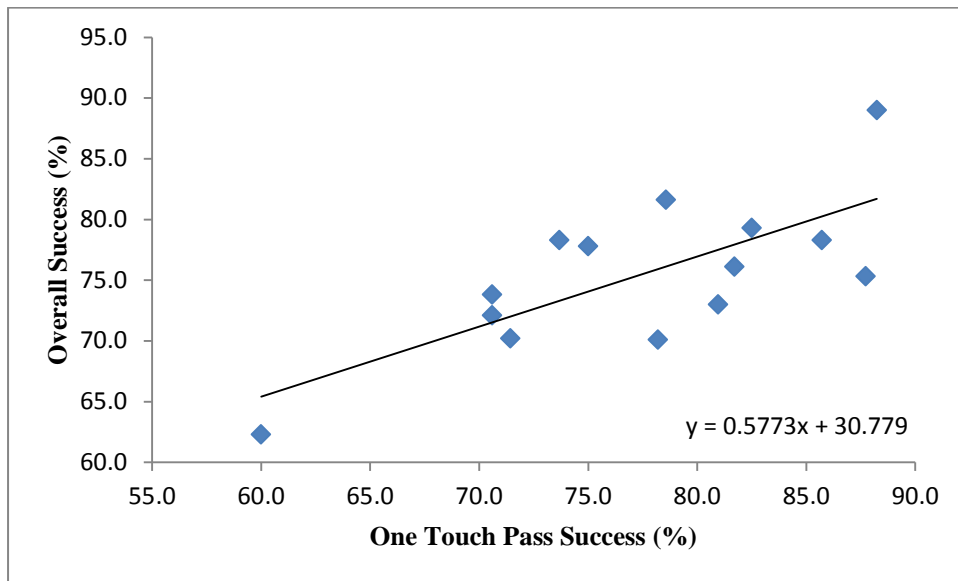
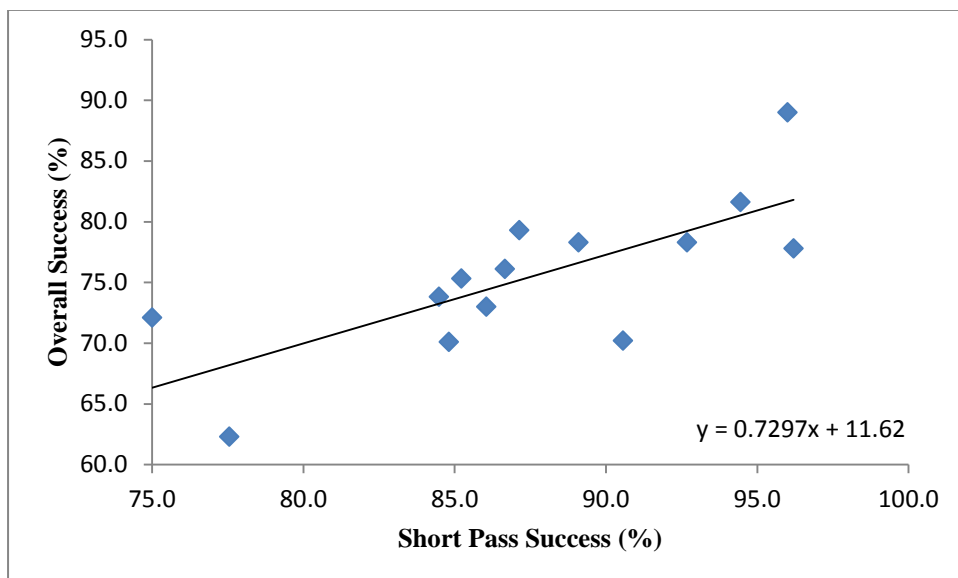


Figure 4.26. Relationship between Overall success and short pass success

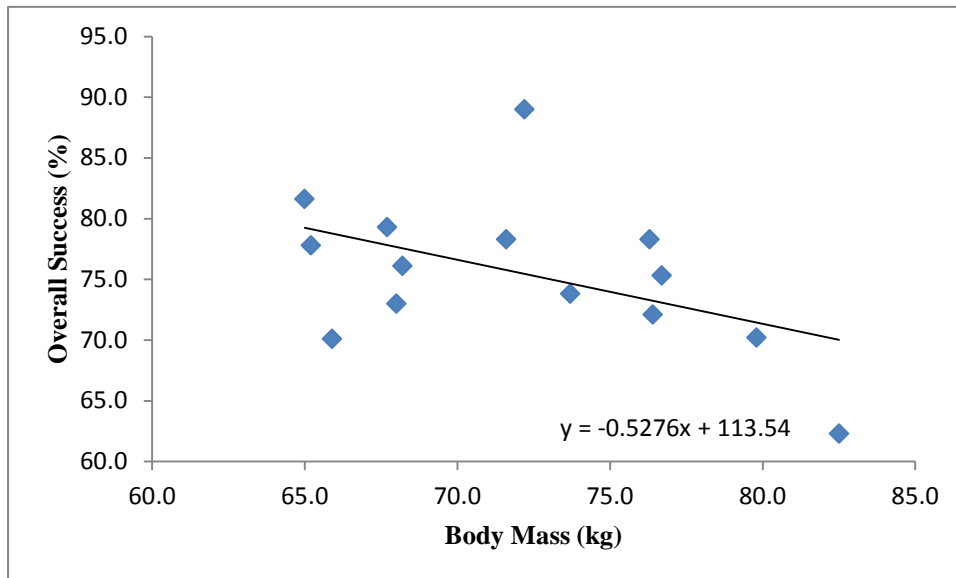
N = 14 individuals, $r = 0.735$, $p=0.001$



4.6.4. From Anthropometrics

Body Mass was significantly correlated with overall success ($r = -0.477$, $p = 0.042$; Fig.4.27).

Figure 4.27. Relationship between Overall success and body mass N = 14 individuals, ($r = -0.477$, $p = 0.042$)



4.7. Multiple regression analysis

Multiple regression analysis was used to determine which anthropometric, physical fitness or skills test variable, or combination of variables, could best be used to predict variation in overall match success between academy soccer players. The 20m Passing Test was the best predictor of overall match success (adjusted $r^2 = 0.499$, $p = 0.009$), explaining 49% of the variation in overall match success.

4.8. Summary of results

The best predictor of overall success was the 20m passing test (adjusted $r^2 = 0.499$, $p = 0.009$). Variables that significantly correlated with overall success (in order of strength of correlation) included 20m passing test ($r = 0.754$, $p = 0.001$), juggling with alternate foot ($r = 0.682$, $p = 0.01$), jump height ($r = -0.549$, $p = 0.021$), body mass ($r = -0.477$, $p = 0.042$), 30m sprint time ($r = 0.467$, $p = 0.035$) and dribbling performance using the right foot ($r = 0.409$, $p = 0.083$).

5.0 Discussion

5.1 Main Findings

The main aim of the present study was to investigate whether selected skills, anthropometric and physical fitness tests could be used to predict variation between soccer players in overall success in soccer matches. The thinking behind such an approach is that any field tests that can predict on pitch success would be useful in talent identification. The main hypothesis of the present study was that the variable that best predicted overall success in matches would be a skills test. Overall success was determined by calculating the total number of successful events as a percentage of the total number of events.

In agreement with the main hypothesis, the variable that best predicted overall success in matches was the 20m passing test. The other part of the main hypothesis of the present study was that more skills tests would significantly correlate with overall success than physical and anthropometric measures. In total there were six variables that significantly correlated with overall match success (three of which were skills tests); 20m passing test, dribbling time with the right foot, alternate juggling, jump height, 30m sprint time and body mass.

The second hypothesis of the current study was that non-specific/functional tests would not significantly correlate or predict overall success in matches. The results of the present study does not support this hypothesis as alternate feet juggling significantly correlated with overall success.

5.2. Comparisons of Data

The participants that were used in the study show similar anthropometric and physiological characteristics to players that have been used in previous investigations (Table 5.1.)

Table 5.1. Illustrating the anthropometric and physiological similarities between the current study's participants and previous study's participants

Variable	Current Study (Means)	Previous Literature (Means)
Height (cm)	179.2±6.3	169 – 183cm - Stølen <i>et al.</i> , (2005) (Review)
Body Mass (Kg)	73.6±7.0	64 – 82Kg - Stølen <i>et al.</i> , (2005) (Review)
Body Fat (%)	9±1.2	10.6 Reilly (2000) 10.9-12.1 9Largo-Penas <i>et al.</i> , (2011)
CMJ Height (cm)	46±5.3	39.3 - 61 Stølen <i>et al.</i> , (2005) (Review)
30m Sprint Time (s)	4.42±0.13	4.00±0.2 (Wisloff <i>et al.</i> , (1998) 4.45±0.04 Mohr <i>et al.</i> , (2003)
(Estimated) VO ₂ MAX (mL/min/kg)	64.1±6.1	57.4±4.0 Impellizzeri <i>et al.</i> , (2004) – 69.8±6.6 MacMilan <i>et al.</i> , (2005)

5.3. Why did skills test correlate well with overall success?

Firstly, the current study is in conjunction with the abundance of previous literature of many years that has presented findings that skills tests and technical abilities – measured in a diverse number of ways - can distinguish between soccer players of varying ability (Rosch *et al.*, 2000; Reilly *et al.*, 2000; Vaeyens *et al.*, 2006; Ali *et al.*, 2007; Russell *et al.*, 2010).

The primary finding of the 20m passing test best predicting performance conforms to the many studies that have also found passing to be a fundamental and crucial skill to obtain in order to become successful and to develop into an elite soccer player (Rosch *et al.*, 2000; Ali *et al.*, 2007; Russell *et al.*, 2010).

In particular dribbling has previously been found to be a discriminating variable between elite and non-elite players (Reily *et al.*, 2000; Huijgen *et al.*, 2009). The current study illustrates further the importance of dribbling with the novel finding that it has discriminated between individual players *within* an elite soccer population. What is interesting however, is that in the present study only the right foot dribbling performance correlated with overall match success and not the left foot dribbling performance. What this suggests is that the majority of the players were right footed and used more right footed actions in the games. This lateral dominance has been previously found in the literature (Carey *et al.*, 2001; Grouios *et al.*,

2002). However, match analysis data was not collected to determine which foot players used and therefore the current study cannot support this explanation.

The fact that in the present study juggling with alternate feet was significantly correlated with overall success in matches, suggests that ball control is an important ability to possess in order to be successful in match play in soccer. The present study's ball juggling results also complement the dribbling times (despite not being significantly correlated) as one test is controlling the ball in a relatively static body position (i.e. not moving with the ball on a pitch), with the other mastering the ball in a dynamic movement around a dribbling course set out on an astrofurf pitch. I.e. although players do not juggle balls within a match, ball juggling provides an indication of the ball control skills that underlie skills used within a match situation. The ability to master and manipulate the ball has been previously shown to distinguish between elite and non-elite populations in soccer. Rosch *et al.*, (2000) found that dribbling was the most powerful skill variable in distinguishing between adult players of different skills standards, and in youth players (14-18 years) juggling also significantly differed between different levels of groups.

It was hypothesised that skills test variables would best predict overall on pitch performance (overall success in matches). This was based upon the wealth of previous research literature which has investigated into establishing the differences between varying standard of players using skills tests (Reilly *et al.*, (2000); Rosch *et al.*, (2000); Waldron and Worsfold (2010); Russell *et al.*, (2010); Huijen *et al.*, (2009); Vaeyens *et al.*, (2006). Conclusions from the array of literature demonstrating that skills are a vital function of being an elite soccer player and the fact that the current match analysis system only involved assessing skills related events and did not look at measuring any physical aspects of on pitch performance, explains why skills tests best correlated with overall success in the current study.

5.4. Why didn't physical fitness tests correlate well with overall match success?

The results of the present study suggest that the most important physical variable to determine overall success in soccer matches is lower body anaerobic muscle power (jump height - Fig.4.19 and 30m sprint time - Fig.4.20). These results have been found in the literature before (Hoare & Warr, 2000; Counter Movement Jump Height, Kalapotharakos *et al.*, 2006; vertical jump, Malina *et al.*, 2007; Coelho *et al.*, 2010).

The current study suggests that there is a difference between the acceleration part of the sprint testing and the countermovement jump test, which has previously been reported to have similar powerful physical parameters (Stølen *et al.*, 2005). The present study contradicts this as neither 5m nor 15m sprint times correlated with CMJ height, yet CMJ height significantly correlated with 30m sprint time, suggesting variation in the 30m sprint times and countermovement jump height are due to similar physical parameters. To further the discrepancy between the current study and previous literature, Reilly *et al.* (2000) has found that 15m sprint times were the best speed discriminator between elite and non-elite groups which is inconsistent to the current study as neither 5m nor 15m sprint times significantly correlated with overall success in matches. Furthermore, it has previously been reported that the most frequent length of sprints in soccer is 5-15m (Di Salvo *et al.*, 2010), suggesting muscle power and acceleration are important for the movement requirements of soccer and making it more surprising that in the present study, 30m sprint time was the only sprint time that significantly correlated with overall success. It is impossible to state that the present study suggests that maximum velocity is more of an important variable for talent identification than acceleration, as the current method did not directly measure this variable.

5.4.1 Relative Age Effect and Maturity

Some of the variables that were measured in the present study, were significantly correlated with age; Short Pass Success, 5m and 15m Sprint times and the YoYo IRT2. This suggests that physical variables are subject to biological maturity which has been found in the literature on numerous occasions (Meylan *et al.*, 2010; Pearson *et al.*, 2006). However, it also suggests that the ability to pass the ball is affected by age, which would imply that experience and years of playing, affect how players perform in actual match play in elite youth soccer. This seems a reasonable suggestion as the population of the current study was a youth soccer team that was comprised of two age groups (U17s & U18s) where some players could have played over 12 months more soccer at that standard. Vantinen *et al.*, (2010) found that there were significant differences in soccer skills (dribbling and passing) between 10-14 year olds. However, literature more specific to this age range contradicts the present study's findings as Malina *et al.*, (2005) found that age contributed to relatively little variation in ball control (ball juggling), dribbling (9x9m square dribbling track) and passing (distance of 9m) soccer skills.

What should be noted however is that in the current study, age did not significantly correlate with overall success in match play, which suggests that despite some variables being affected by age, these variables may not be that important in dictating successfulness in matches in elite youth soccer. This is confirmed as only one of the variables that significantly correlated with age, significantly correlated with overall success.

The main reason however to why physical tests did not correlate with overall success as well as skills tests is primarily due to the match analysis system not measuring any physical related events.

The aim of the present investigation was to predict soccer ability in matches through a multi-disciplinary battery of tests. Despite the current match analysis system not measuring any physical related events, physical tests results still significantly correlated with overall success, suggesting some physical parameters are sensitive enough to distinguish *within* an elite youth soccer population. This therefore implies the importance of physical parameters, in particular lower body muscular power, within a Talent Identification model in soccer.

As mentioned in the literature review, and supported by the results of the current study, physiological variables can play a key role in the Talent Identification of soccer players and only soccer specific physiological variables should be tested for, with only soccer specific tests for those variables being used (Svensson & Drust, 2005), as discussed in the following sections.

5.4.2 VO_{2MAX}

Aerobic capacity was estimated for in the present study due to the distances covered in matches (10-13km; Stølen *et al.*, 2005), relationship with involvements with the ball (Helgerud *et al.*, 2001) and the fact that increased aerobic capacity increases the player's capacity to recover from sprints (Tomlin & Wenger 2001).

In the current study VO_{2MAX} was estimated using a soccer specific intermittent recovery test (YoYo IRT2) - it could have been tested for using an incremental speed protocol conducted on a treadmill that would have given a more accurate reading of the maximal amount of oxygen that the body can utilise. However, previous findings have demonstrated that increases in the YoYo IRT2 are not mirrored in VO_{2MAX} tests, suggesting that the YoYo IRT2 is more sensitive than standard laboratory tests of aerobic performance, to

improvements in soccer specific fitness (Bangsbo, 1994) and therefore supports the choice of test in the current study.

The present study suggests that variation between elite soccer players in overall success is not dependent on VO_{2MAX} . It has been suggested that there is a threshold that needs to be reached for soccer players and once this has been reached there does not need to be a focus on aerobic capacity (Clarke *et al.*, 2008). The present study supports the threshold idea as estimated VO_{2MAX} was significantly correlated with age but not overall success. The data suggests that the older players in the group have developed an advanced aerobic capacity as it is needed at playing at that age group standard and they have played at that standard for an additional season. Previous literature supports the current study by suggesting that aerobic capacity may distinguish between elite and non-elite soccer players but not within an elite population (Vaeyens *et al.*, 2006; Malina *et al.*, 2007).

5.4.3 Anaerobic Power

Anaerobic power was assessed for in the present study due to the nature of shorter sprints in soccer (Di Salvo *et al.*, 2010) and it is a variable that has directly distinguished between standard of play in youth soccer players and has also been used to predict the chances of progressing onto advanced levels in soccer (Le Gall *et al.*, 2010).

Sprint testing is the predominant anaerobic power test for assessing anaerobic power in football players (Svensson & Drust, 2005). The distances of the sprints used in this study were 5m, 15m and 30m due to research such as Mohr *et al.*, (2003) stating that the average sprint duration in soccer is approximately 2-4 seconds. However, it is unknown whether maximum velocity was reached during this test. A longer sprint with more split times would have confirmed maximum velocity (Little & Williams, 2005). Additionally, usage for non-stationary starts should be considered to increase the validity of sprint testing, as standing still only incorporates 4.6% of purposeful movements in a soccer match (Bloomfield *et al.*, 2007).

What the present study does support is the notion that key factors within matches are dictated by more anaerobic events than aerobic events (Lehance *et al.*, 2009), as measures of aerobic performance in the present study were not significantly correlated with overall success in matches. The literature is divided upon the importance of aerobic power in soccer and the effects of this variable in match situations. Helgerud *et al.*, (2001) demonstrated the importance of the aerobic system as they stated that by increasing the aerobic endurance by

two weekly session of interval training (4x4 mins, 3mins recovery between sets) for 8 weeks, increased $\text{VO}_{2\text{MAX}}$, lactate threshold and running economy which resulted in increased involvements on the ball in matches (labelled as “*all situations where a player is in contact with the ball or in direct pressure on an opponent in possession of the ball*”). In contrast, Clarke *et al.*, (2008) argues against the importance as they illustrated that aerobic capacity has been shown to fluctuate over the course of the season and the changes between in-season and off-season values of $\text{VO}_{2\text{MAX}}$ are minimal and non-significant in soccer players.

5.4.4 Muscle Power

Muscle power was tested for in this study as specific soccer movements such as jumping and accelerating depend on muscle power generation (Mohr *et al.*, 2003) and muscle power output has previously been shown to be useful in distinguishing between standards of playing levels in soccer (Sprint times, Cometti *et al.*, 2001; Jump height, Kalapoharatos *et al.*, 2006).

Muscle power was tested for, in the present study using a counter-movement jump test. There are different variations of the counter movement jump (using arms and not using arms), however to increase the ecological validity of the test so that it is more soccer specific, the use of arms were included, as it has been shown to be incorporated in the technique of jumping in soccer for such specific soccer actions, such as heading the ball (Paoli *et al.*, 2012).

5.5. Why didn't Anthropometric tests correlate well with overall match success?

Body mass was the only anthropometric variable that significantly correlated with overall success; which stated that the lighter players performed better in soccer games. This study did not look at positional differences within elite youth soccer players, however this anthropometric result could suggest that certain positions are more successful in games than others. The best predicting skill variable was 20m passing, and three out of four passing events correlated with overall success (short pass, one-touch pass and long lofted pass success). This suggests that passing was a key variable in elite youth soccer matches. In previous literature, it has been shown that midfielders in the premier league make the most passes (Bloomfield *et al.*, 2007) and defenders and strikers in the premier league are heavier than midfielders (Bloomfield *et al.*, 2005). Thus, it can be postulated that midfielders in this study were more successful in soccer matches than defenders and strikers. This cannot be confirmed however, due to the present study not taking positional differences into account.

As only one out of the three anthropometric variables significantly correlated with overall success, the present study suggests that anthropometric variables are not key variables in distinguishing within elite youth populations, and therefore are not as useful as other variables for talent identification models in soccer. The primary reason for this evaluation from the current study's results is due to the match analysis variables including variables that are independent of physical stature. Furthermore elite youth soccer players have been shown to share similar anthropometric data. In the present study there were very similar body compositions and therefore there is very little variation (Mean 9%, SD 1.2). Reilly *et al.*, (2000), Kalapotharakos *et al.*, (2006) and Largo-Penas *et al.*, (2011) all found that percentage of body fat discriminated between elite and non-elite groups, however it is likely that body fat percentage is not a sensitive enough variable to use to distinguish within an elite population group, as shown in this study.

Actions in games that would benefit from certain anthropometric measures would be events more suited to contact related events; defending or heading events (Largo-Penas *et al.*, 2011). For example, if two different players had similar jump heights, however one was 30cm taller than the other, the taller player would generally find it less difficult to defend in certain situations, from crosses, corners, and long lofted passes for example. Also, defenders encounter more physical contact (Bloomfield, 2007), therefore being taller and heavier would also suggest being stronger, which could be more important in certain situations.

All anthropometric tests were carried out in accordance with the methodologies of the International Society of Advancement of Kinanthropometry (ISAK). Ideally, laboratory tests such as hydrostatic weighing or a DEXA Scan would be used to determine body composition, due to their accuracy and precision (Ellis, 2000, Norgan, 2008). However, skinfold measurements and the estimation of whole body composition equations have been established to be as valuable as a three compartmental model including a DEXA Scan in estimating mean fitness of groups and to be the best field test for estimating fat % of individuals (Fuller *et al.*, 1992; in Norgan, 2008).

In summary, anthropometric variables are not as powerful as other variables at distinguishing between player success in elite youth soccer players, within an elite population. From the results of the current study and the results from previous research, it could be proposed that anthropometric variables are best suited to talent identification models that concentrate on distinguishing between elite and non-elite not within an elite population.

5.6. Skills Tests Evaluation

The aim of using skills tests was to replicate match play in a way that can objectively assess a player's ability, to indicate how an individual will perform in actual match play, and therefore be implemented into a talent identification process.

However, when comparing some skills test to actual match play there are many discrepancies, which means that these tests lack validity and therefore the results of these tests may not be truly representative of soccer match play. Any tests that are used in talent identification models should be specific and sensitive, as players are subject to systematic and similar training programmes and it is therefore more difficult and complex to distinguish between elite level players (Le Gall *et al.*, 2010). The tests used in the current study are defined as 'closed skills' tests; these are tests that can be described as predictable and in a stable environment (Knapp, 1977). Skills in soccer match play however, would be described as the opposite; 'open skills' where the environment is unstable and unpredictable (Knapp, 1977). The vital difference here is that closed-skills tests measure technique and not skill. A substantial part of soccer match play is composed of 'open skills' due to the inclusion of opposition. Therefore, open skills tests evolves the test from assessing techniques to assessing skills, as a skill is specific to the demands of a situation, whereby in soccer, situations are continually changing. Another example includes using a dynamic skill instead of a static skill. A 'dead ball' situation (static skill) is less representative of a match situation (Reilly *et al.*, 2000; Hoare & Warr, 2000; Rösch *et al.*, 2000; Vaeyens *et al.*, 2006) compared to a moving ball (Ali *et al.*, 2007) or a dynamic ball release system (Russell *et al.*, 2010). By introducing pressure, a time limit and a moving ball component, there is increased difficulty and increased ecological validity of the skill. As more skilful players perform skills quicker (Ali *et al.*, 2007) there will be an increased variance in the results. Sacrificing either speed or precision in order to maximise or preserve the other, is an occurrence coined by Fitts and Posner (1967, sourced from Russell *et al.*, 2010) as the 'speed-accuracy trade-off'. An increased variance in results due to taxing a skill more would also be down to the relationship between coordination, control and skill, where coordination is the ability to augment movement system components in a goal-directed activity, and control is the ability to change motor patterns that coordination is needed for. For example, kicking requires coordination of different limbs and different parts of these limbs, and control is needed when applying varying forces or velocities to these movements. Skill is involved in such actions as angling the foot to change the trajectory of ball flight, or to apply spin etc (Newell, 1985 & Turvey,

1990; sourced in Davids *et al.*, 2000). Players need to be able to have the correct motor patterns available when changing velocities and forces, to cater for certain situations, for example being hurried or in awkward positions due to opposition.

As table 5.2 illustrates, older studies do not use skills tests that activate the speed-accuracy mechanism.

Table 5.2: Overview of the differences of methodologies in passing and shooting skill testing

Authors	Static/ Dynamic Test	Pressure/ No Pressure	No/Time Limit	Closed/ Open Skill Test	Subjective/ Objective
Reilly <i>et al.</i> , (2000)	Static	No Pressure	No Time Limit	Closed Skill Test	Objective
Hoare & Warr (2000)*	Dynamic	No Pressure	No Time Limit	Closed Skill Test	Subjective
Rösch <i>et al.</i> , (2000)	Static & Dynamic	No Pressure	No Time Limit	Closed Skill Test	Objective
Vaeyens <i>et al.</i> , (2006)	Static	No Pressure	No Time Limit	Closed Skill Test	Objective
Ali <i>et al.</i> , (2007)	Dynamic	No Pressure	Time Limit	Open Skill Test	Objective
Russell <i>et al.</i> , (2010)	Dynamic	No Pressure	Time Limit	Open Skill Test	Objective
Waldron & Worsfold (2010)	Dynamic	Pressure	Time Limit	Open Skill Test	Objective

* Passing Only

In the present study, some skills test did use a time presence, others however did not, and no skill test in this study used opposition (Table 5.3). This is referring to the ‘Task Constraints’ of the Dynamical Systems Theory of performing and practice. The tests used in this study standardised ‘Environmental Constraints’ (weather, surface conditions, size of area etc) to prevent the results being confounded by these variables. However without, task constraints influencing the skills tests (tactical pressures, oppositional pressures, rules of the game etc) the ecological validity of the tests applied diminishes and therefore the likelihood of distinguishing variation between an already elite population, also dwindle. Tests that have less demanding circumstances do not fully represent the environment in which the players are accustomed to perform, and therefore will never have the power to fully elicit the variations within a tightly bound population. Out of the three skill test variables, which significantly correlated to overall success in the present study, two had time constraints (dribbling time with the right foot and alternate juggling). Contradictory however to the dynamical systems theory, a simple passing test – without a time constraint or opposition (task constraints) - was the best variable for predicting overall match performance in this study. This illustrates the value that closed-skills tests can have in the field setting.

Table 5.3: Illustrating how many tests used a time measure or opposition

Test	Time Measured	Opposition
20m Passing	×	×
35m Lofted Pass	×	×
Dribbling Tests	✓	×
Juggling Tests	✓	×
Shooting Test	×	×
Wall – Pass Test	✓	×
Rebound Board Tests	×	×

The 20m passing test best predicted on pitch overall success (Fig.4.21), whereby the results of the 20m passing test explained 49% of the variance in overall success. This illustrates that the technique used in the 20m passing test is an important aspect of overall success in soccer. This shows the value of closed skills tests, especially in a field setting, despite their limitations. It would be interesting however, to investigate the same tests with either a pressure from opposition or a time limit on the test to see whether this could explain more than 49% of the variance in overall success.

The difficulty of having an opponent in a skills test is the repeatability of that external variable. If different players were used as opponents, it is not possible to say that all opponents are of the same standard. Furthermore, even if the same person was used for every test, you could not guarantee the player could perform at the same standard for every repetition of the test.

Newer studies also include more aspects of a skill, for example Russell *et al.*, (2010) incorporated perceptual awareness and a decision making aspect by using light cues in both their passing and shooting tests. Ali *et al.*, (2007) used the Loughborough Soccer Passing Test and the Loughborough Soccer Shooting Test (LSPT & LSST) which also incorporated more aspects of a complete skill by the tests utilising players' abilities to pass, control and pass/shoot the ball at specific targets. Both the Russell *et al.*, (2010) and the Ali *et al.*, (2007) methods have been shown to be reliable and valid measures of passing and shooting ability.

However, no attempt has been made to correlate results of these tests with match performance in soccer.

The performance and results of skills tests also depend on some physical attributes (Rampinini *et al.*, 2008; Stone & Oliver, 2009; Vantinen *et al.*, 2010). In the present study's case, the long lofted pass and the dribbling tests involved a high degree of physical performance (long lofted pass – lower body muscular strength and power; dribbling time - speed and acceleration). However, although a high level of fitness is an advantage, not all elite athletes are elite games based sports-people, it is therefore the ability to apply the levels of fitness a player may have to the execution of a particular skill or technique that is essential (Malina *et al.*, 2005).

It is important to note however, that the environment in which these types of tests are used in soccer, is in a field environment whereby complicated controls and protocols would be difficult to implement (Svensson & Drust, 2005), especially when performing these tests with large numbers of players. Complicated protocols in a field environment would be difficult to manage and control and would possibly be too time consuming, therefore decreasing the repeatability of tests and subsequently producing inconsistent findings. There is a balance that talent identification models need to have, whereby they need to be accurate and valid for the sport to be able to distinguish within elite populations but also be able to be successfully implemented in field environments and still be reliable and precise. The 20m passing test used in the current study shows that tests that are not fully open and not fully representative of actual match play, can still predict approximately half of the variation in on pitch performance (overall success in matches). These findings support the theory that tests that are both easy to use and easy to perform can still be powerful in the TID process.

The aim of the present study was to establish variables that could predict soccer ability in matches for elite youth soccer players. The skills test results suggest that passing accuracy over 20m is an important skill to obtain in order to be successful within an elite youth soccer population. Furthermore, the ability to dribble quickly (with the right foot) and the ability to control the ball with alternate feet off the floor, are also important skill traits to have.

5.7 Match Analysis Evaluation

Match analysis was used in this study as the overall performance variable, in which the reliability of the match analysis in the present study was ($r=0.899$, $p<0.001$).

Through multiple regression analysis, this study determined that the 20m passing test explained more of the inter-individual variance in overall success in matches than any other variable tested. This could be down to the fact that passing variables success made up on average 87% of overall success per player, of which the short pass variable as an individual variable on average made up 36% of overall success per player. This therefore may reduce the importance placed upon passing as a key variable for on pitch performance in elite youth soccer players, which the current study's results propose.

Match analysis might not be a fully accurate measure of overall performance in an elite youth academy setting. Elite youth academy soccer is a developmental environment, whereby players are encouraged to play in formations, positions, and styles that might not directly suit their most effective style of play. For example, an individual that is very accurate and consistent at playing long lofted passing over 35m might be asked to play in positions where that skill cannot be executed and might be asked to play shorter floor passes. Therefore, in such a situation the match analysis will pick up a decreased success, which may not portray the player's correct level of talent.

However, 20m passing test results also significantly correlated with dribbling success, free kick cross success, one touch pass success and short pass success as well as significantly correlating with 3 out of the other 4 passing tests used in the present study. What this suggests is that if a player is repeatedly accurate at passing over 20m they are in general successful at many of the other skills tests and many of the on pitch success. However, passing events made up the majority of overall success within the match analysis and therefore skews the data to be more biased towards passing than other variables.

There are many aspects of overall match performance that were not included in the match analysis criteria. For example, no receiving aspects were included within the match analysis. The requirements to control a pass from one player to another will vary. However due to the criteria of the match analysis system, as long as that pass is accurate and of a speed to reach the required target, without being excessively fast, it is determined a successful pass. The quality of the controlling touch is an aspect that has previously distinguished between different levels of performance in soccer (Coelho *et al.*, 2010). Furthermore, the quality of a player's first touch can determine what options they have afterwards. For example, if a player is predominantly right footed, an ideal first touch to control a pass would leave the ball in front of the player, with the ball on the right-hand side of the player. This would allow a pass

in all directions in front of the player, opposed to the first touch leaving the ball on the left-hand side of the player and therefore making a pass to the right with the right foot impossible without a further touch.

Additionally, the match analysis system used in this study does not take into account the speed at which the skill is being executed. A 10m pass under a time limit would test the skill of that pass more than not having a time limit, in accordance to the speed accuracy trade-off. As previously mentioned, players of higher abilities execute skills quicker whilst maintaining accuracy, opposed to players of lesser abilities (Ali *et al.*, 2007).

Furthermore, this current match analysis system only dealt with attacking actions and not defensive actions. Broadly, any action can be described as either an offensive or defensive action. Throughout the team the primary responsibilities of the type of players change from defending to attacking (defenders, →, strikers). Only simply looking at one of the two main aspects (attacking), will leave more defensively minded players at a disadvantage. This is a major weakness of the match analysis system used in this study.

Position specific differences are also important factors to be considered, and is a factor that was missed out in the current match analysis system. For example as previously discussed, the ability to control the ball with the first touch is important (Coelho *et al.*, 2010) and this increases in importance when receiving the ball while under direct pressure from the opposition. A striker or a centre midfield player would receive the ball in these sorts of conditions more often than a centre back or a full back. So a striker that has a high pass success but a very poor receiving the ball under pressure success, would still be determined to be a successful player in the current match analysis system, which might not truly represent their actual overall success.

To further that argument, not every player might have the same profile in the same position; and there might be a need to have different variations in the same position. For example, one striker might be the type of player that runs in behind the opposition defence because he has a high maximum velocity. However, another striker might be very strong and tall and therefore plays in front of the opposition defensive line and receives the ball and 'holds' off opponents. They could both be as effective as the other with the same success at their specific roles, however this would not be determined with the current match analysis system.

All events in the current match analysis system are regarded as having the same weighting in terms of importance. However, in certain positions, certain actions become more or less important (Dellal *et al.*, 2010). For example, it is more important for a striker to have a high shooting success than a defending player to have a high shooting success (Bloomfield *et al.*, 2007). Therefore the power of this match analysis system to distinguish between the levels of players would be greater if there was a position specific weighting factor for position specific variables. This could be based upon the primary aims and responsibilities of that position. For example, a striker's main variable would be shots on target or goals scored success, whereas a midfield's main variable might be pass success (Bloomfield *et al.*, 2007).

Furthermore, the current match analysis system dictated that for a pass to be successful it had to "give the receiving player a chance to gain possession", i.e. a combination of correct speed and accuracy or a slower pass and less accuracy (to allow the receiving player to move into the line of the pass). However, a player that has more accuracy in their passing could pass to a specific foot depending on the situation. For example, if a player is marked, there is an increased chance of the team maintaining possession if the pass is played to the right hand side of the player if the opposition player is on the left hand side, due to the increased difficulty for the opposing player to win the ball back. Or a player could be running into a specific space so the pass needs to be a specific speed and executed accurately into that space. The current match analysis technique does not distinguish between the fine differences in accuracy and therefore fails to fully distinguish between all levels of talent between players. For example, a pass that is on the floor (when arriving at the receiving player) is easier to control than a pass that might bounce a metre in front of the receiving player or approach them at a raised height. These types of limitations become even more important when trying to distinguish within an elite population where the differences between players can be relatively small.

Other discussion points include a 'successful' event (e.g. pass) that leads to an unsuccessful or *less* successful event. For example, if a pass is accurate but raised off the floor and passed to a part of the body that requires more than one touch, could lead to a subsequent unsuccessful event such as a missed pass/shot opportunity. However the original pass was still labelled as successful and the second failed action was labelled as unsuccessful. For the second action to be successful it could have to require more 'skill' and even if the event was unsuccessful, it might actually demonstrate more skill than the first pass.

The match analysis system also does not take in account the direction of a pass. A player could have a 100% pass success, however every pass could be in a sideways or backwards direction. In some cases this could be the only option in order to keep possession and the best choice of direction. However, if every player only passed sideways or backwards, a goal would never be scored. Soccer has to be considered as a forward playing game as the goals are in front of each team. A player that makes a successful forward pass should be given more credit than a player not making a forward pass. This is because a forward pass can be a more difficult pass to make. This is because a forward pass might require more accuracy and a specific speed of pass simply because there is less space as there are more opposition players, and a player that doesn't have the ability to do that might choose to play an easier pass to prevent giving away possession. Additionally, if the ability to receive the ball from a pass is poor, and requires further touches it could reduce the number of options available to pass and take a longer time. By taking a longer time to control the ball, a potential pass might be missed. This might have been the best choice of pass in that certain situation. Additionally taking longer time to control the ball and requiring more than one touch allows the opposition a greater chance to win the ball back.

When analysing a player's action, it is impossible to determine what the initial intent of that action was. For example, player A played a pass to player C and it was determined a successful pass, however player A's actual intention was to play the pass to player B. These few incidences that happen in a game mean that the level of precision and reliability of the match analysis technique is slightly weakened. This limitation fits within the same discussion point as the skills testing where there must be a balance between practicality and the accuracy of the match analysis system. The system that was used in the present study could have been more accurate however, for TID models and for use in the soccer environment setting, it needs to be able to be simple, practical and repeatable (Svensson & Drust, 2005).

The ability of the player to choose the correct action in a situation is not quantified in the current match analysis system. There is often more than one option to choose from when in possession of the ball, however choosing the 'correct' or the best option in a desired situation warrants more credit than not choosing the correct/best option. This would correspond with the ability to 'see' all opportunities, relating to the importance of perceptual awareness in soccer (Williams, 2000; Ward & Williams, 2003; Ali, 2011). Not only having good perceptual skills, but the ability to see all options, and the ability to make the correct decision

is vital (Vaeyens *et al.*, 2007). A simple success format in a match analysis system will not identify these variables.

In summary, the current match analysis method was used in order to assess soccer ability as a reference for skill, physical and anthropometric data to predict. The match analysis system was heavily weighted towards passing events and therefore the data is skewed towards players and playing positions that pass more than other players/positions (midfielders; Bloomfield *et al.*, 2007). However, establishing a complex, accurate and precise system whilst in a soccer field setting proposes many difficulties. In order for a match analysis system to be repeatable, it needs to be less complex and therefore not every variable in soccer matches will be assessed. The current match analysis system was repeatable and therefore proposes a value in a soccer field setting, and therefore illustrates its usefulness in talent identification and development processes.

5.8. What battery of tests should be used in the future to discriminate between players within an elite soccer population?

There were certain variables that were not tested for in the current study, and these need consideration when evaluating the current study and for future investigation into distinguishing between players within an elite population in soccer.

Many variables have been used in other talent identification models, where only 3 physiological variables were tested for in this study, and therefore other physical variables that need to be considered are; agility, muscle strength and repeated sprint ability.

5.7.1. Agility

One variable that was not measured in the battery of tests in this study was agility. Agility is a key physiological variable in team sports as it can become vital in performing key tasks such as defending and beating an opponent (Young & Wiley, 2010). It is heavily related to key movement variables mentioned earlier (jumping, tackling, turning, dribbling etc; Mohr *et al.*, 2003) and has previously been shown to be a key discriminating variable in talent identification models (Reilly *et al.*, 2000).

Agility has proven to be a difficult variable to measure, as there is not a general consensus on the correct methodological design for a test, mainly due to the various neurophysiological and physiological factors that agility is comprised of (Svensson & Drust, 2005). Recent tests of

agility, coined ‘reactive tests of agility’ (Sheppard *et al.*, 2006) overcome this limitation as the participant has sport specific stimuli to react to and therefore need to make a decision to enable a change of direction. A sport specific cue is vital in the inclusion of an agility test due to the ‘anticipation effect’ where a decrease in decision time has been seen to be apparent (Young & Wiley, 2010).

Considering previous literature and the concept of measuring agility, it is deemed that it might better suit a talent identification model that distinguishes between elite and sub-elite opposed to being used to differentiate within an elite population in soccer. Therefore it was the correct decision for the current study not to include this variable. Furthermore, as the current study focused specifically upon on the ball attacking events and not any physically related events and it would have therefore been unlikely that agility would have predicted or significantly correlated with overall success in soccer matches.

5.7.2. Maximum Strength

Maximum strength has been used in talent identification models because of its importance in the nature of specific movements in soccer (Bloomfield *et al.*, 2007) and because it has distinguished between different standards of soccer (Togari *et al.* 1988; sourced in Stølen *et al.*, 2005,).

Maximum strength can be tested in the field and in the laboratory. One repetition maximums can be determined in the field however, despite the increased validity, a safer, more controlled environment might be preferred. Isokinetic Dynamometry in a laboratory setting is often the more preferred approach (Svensson & Drust, 2005).

Alongside agility, maximum strength may be best suited to a talent identification model that has a different goal to the one used in the existing study. This is due to the complexities in testing for the variable and as the current study’s match analysis system did not concentrate upon physically related events.

5.7.3. Maximum Velocity

As 30m sprint time was the only anaerobic power variable to correlate with overall success, analysis of maximum speed warrants further investigation in future talent identification models. Moreover, it is important to include different tests for acceleration, maximum speed

and agility as research has shown that they are all independent variables as they only share 39% common variance (Little & Williams, 2005).

5.7.4. Repeated Sprint Ability

Repeated sprint ability (ability to perform short-duration sprints (<6 s) with a short recovery time (< 30 s); Mujika *et al.*, 2009) has been shown not to be affected by age. Therefore, this variable warrants investigation as to whether it discriminates between and/or within soccer populations, as repeated sprints are frequently used in soccer matches (Mujika *et al.*, 2009).

5.7.5. Perceptual Awareness

Perceptual awareness has been shown to become more important in older ages of youth soccer (Vantinen *et al.*, 2010) and has been a popular area of research in soccer (Ward & Williams 2003) and has previously been linked with talent identification (Williams, 2000). Therefore implying the increased importance for this variable to be used in future talent identification models. More recent tests of skill in soccer have used perceptual tasks in order to make the tests more valid for soccer with an intention of increasing the ability to separate players within an elite population (Russell *et al.*, 2010). This again addresses the problem between accuracy and ability to test in the field. Based upon the literature this is a variable that could have been included in the current TID model.

5.7.6. Psychology in Talent Identification

A major criticism of this study was that it did not include any aspects of measuring or assessing psychological variables. Previous research has suggested that psycho-behavioural skills are the key indicators of an individual's capacity to develop - more so than physical and or performance variables (Abbott & Collins, 2002). Furthermore, ego orientation opposed to task orientation has also been shown to be a powerful discriminating variable (Reilly *et al.*, 2000; Coelho *et al.*, 2010), however more recent research has also questioned the importance of psychological variables in talent identification models (Figueiredo *et al.*, 2009).

Psychological parameters have been shown in the literature to be a vital part of sport expertise acquisition (Abbott & Collins, 2002; Vaeyens *et al.*, 2008) in particular goal commitment, engagement in coping behaviours, and seeking social support have shown to differentiate between soccer players that become professional from those that do not (Yperen, 2009).

It is considered that the present study should have included psychological testing and it should also be included in future TID models regardless of the goal of the talent identification model.

5.7.7. Other variables this talent identification model should take into consideration

Tactical elements have been shown to vary between different standards of players (Kannekens *et al.*, 2009) and the importance of training tactical knowledge has also been advised and discussed in the literature (Memmert, 2010). This might be key in distinguishing between two elite players that are very similar technically, however vary in their ability to affect games. Two different strikers of similar technical on the ball skills may become different due to their movement in order to receive the ball. For example, one striker might be better at not being marked by a defender ('losing' the defender) and therefore creates more opportunity to score or help to score goals.

To conclude for future research a future battery of tests must be multi-disciplinary as nothing individually will ever solely predict talent on its own (Williams & Reilly, 2000), however only certain variables should be used in accordance with the aims and objectives of a specific talent identification model.

5.8. Summary of findings

The current study succeeded in significantly being able to explain the variance in soccer match performances using a variety of tests in the domains of skill, physical and anthropometric variables. The best predicting variable was 20m passing accuracy, and other variables that were shown to have significant relationships with overall success were; dribbling ability with the right foot, alternate juggling, 30m sprint time, jump height and body mass.

The current study tested for variables and excluded others with the intention of distinguishing within an elite population and not between populations. For future TID models, it should be noted that more variables than what the current study used should be adopted in order to fully maximise the ability to distinguish between players in an elite population including; maximum velocity, repeated sprint ability and perceptual and psychological variables.

5.9. Practical Applications & use of results in Talent Identification Models

This study would not be able to successfully predict future soccer performance, however it has given an insight to what is required to be successful at an elite youth soccer level (16-18 years). As proposed in the review of literature, assessing current performance through successfulness of events in soccer matches, aids in long term talent identification processes. It would be logical to suggest that in order to be successful at 20m passing, a player would need to have the ability to be successful at passing at a shorter distance first. Therefore, a key talent identification variable at a younger age could be accuracy at a shorter distance passing drill of maybe 10-15m. Furthermore, as juggling significantly correlated with overall success, yet is not an action that is performed regularly in soccer, suggests that there is a cross over between the qualities that are required to be successful for both. Therefore, it would again be logical to presume ball control could be a variable that could predict future accomplishments at an elite youth level. This applies to all variables that significantly correlated with overall success in the present study (30m sprint time, dribbling performance and counter movement jump height).

In accordance, it would be recommended that the development process of youth elite academy players should concentrate on 20m passing accuracy and ball control in both static and dynamic domains, as these variables predicted or significantly correlated with overall success in elite youth academy soccer matches.

Additionally, sports scientists should look to implement anaerobic power interventions, with the specific intention of increasing jump height and decreasing sprint time over longer distances (30m) as opposed to the most frequent length of sprints (5-10m) in soccer match play, as suggested in previous literature.

6.0. References

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Appendix A – Informed consent form

FOR STUDENT PROJECTS AND STUDENT PLACEMENTS IN THE DEPARTMENT OF BIOMOLECULAR AND SPORT SCIENCES COVENTRY UNIVERSITY

NAME OF STUDENT Oliver Morgan

NAME OF UNIVERSITY SUPERVISOR Dr. Rob James

COURSE TITLE Masters by Research Sport Science

TITLE OF RESEARCH PROJECT

The Use of Skill, Physiological and Anthropometric Variables to Predict Soccer Ability in Elite Youth Soccer Players

Thank you for agreeing to help one of our students with their research work. This form explains what you will be asked to do. If you have any questions about this please ask the student.

By signing this form you agree to take part in the study. However, please note that you are free to stop taking part at any time.

PURPOSE OF THE RESEARCH

The purpose of this research is to investigate whether on-pitch soccer performance can be predicted using individually or collectively different variables through a multivariate battery of tests including; skills tests, physiological tests and anthropometric tests.

PARTICIPATION IN THIS RESEARCH WILL INVOLVE

In taking part in this study you will be asked to confirm your gender, age and if you are able to participate in physical activity. Additionally you will be asked for your consent so filming of matches that you will be participating in over the season can occur. Furthermore, during the season you will be asked to complete physiological tests, skills tests and anthropometrical tests. The skills testing will incorporate a number of different skills ranging from passing to dribbling. The physiological tests will include such tests as sprinting and jumping, and the anthropometrical tests will include such measurements as height and weight.

FORESEEABLE RISKS OR DISCOMFORTS

The physiological tests are maximal tests and therefore discomfort might be felt afterwards to recover as the tests will require maximal exertion and effort. The level to which players will exert themselves will be to their discretion and at no point will they be forced to carry on if they want to stop the testing procedure.

BENEFITS TO THE SUBJECT OF PARTICIPATION

The results of the present study could elicit findings that could modify training and the developmental process. The benefits of this study might therefore be enhancement of the developmental process, which hopefully lead to increased performances of players during soccer matches.

WHAT WILL HAPPEN TO YOUR DATA

Any data/ results from your participation in the study will be used by Oliver Morgan as part of their project work. The data will also be available to Dr Rob James and Mr Mark Noon. This piece of work may also be published in scientific works, but your name or identity will not be revealed. If you wish to attend a debrief at the end of the study to discuss your data and how it was used this can be arranged with the researcher

All data will be kept confidential and the 1998 Data Protection Act will be strictly adhered to ensure subject's rights are protected.

Oliver Morgan is available to answer any questions or queries that you may have.
oliver.j.morgan@hotmail.co.uk Telephone Number - 07961209947

Additionally, questions can be directed towards Dr. Rob James -
rob.James@coventry.ac.uk

If you have any questions about your rights as a participant or feel you have been placed at risk you can contact Dr. Rob James

I confirm that I have read the above information. The nature, demands and risks of the project have been explained to me.

I have been informed that there will be no benefits/ payments to me for participation
I knowingly assume the risks involved and understand that I may withdraw my consent and discontinue participation at any time without penalty and without having to give any reason.

Subject's signature _____ Date _____

Investigator's signature _____ Date _____

Signature of Parent/ Guardian _____ Date _____

The signed copy of this form is retained by the student and at the end of the project passed on to the supervisor. A second copy of the consent form should be given to the subject for their own reference.

Appendix B – Conversion Sheet YoYoIRT2

Conversion sheet from level reached in the Yo-Yo IRT2 to distance completed (meters) in order to calculate $\text{VO}_{2\text{MAX}}$ with the equation $\text{VO}_{2\text{MAX}}$ (ml/min/kg) = IRL2 distance in meters $\times 0.0136 + 45.3$ (Krustrup *et al.*, 2003). Taken from www.bangsbosport.com

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