Physical and Match Performance of Female Soccer Players

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Abbreviations

ICC = Intraclass Correlation Coefficient

MHR = Maximum Heart Rate

U11, U13, = Under 11, Under 13, etc.

Yo-Yo IRTL1 = Yo-Yo Intermittent Recovery Test Level 1

SD = Standard Deviation

SEM = Standard Error of Measurement

SDD = Smallest Detectable Difference

GPS = Global Positioning System

Glossary of Terms

GPS = a satellite navigation system that provides location and time information

Speed Zone 1 = Stationery and walking speed activity (0-6 km/h)

Speed Zone 2 = Jogging speed activity (6.1-8 km/h)

Speed Zone 3 = Low-Intensity running speed activity (8.1-12 km/h)

Speed Zone 4 = Moderate-Intensity running speed activity (12.1-15 km/h)

Speed Zone 5 = High-Intensity running speed activity (15.1-18 km/h)

Speed Zone 6 = Sprint speed activity (>18 km/h)

Total Distance Covered = The total distance covered within a soccer match

Percentage of Distance Covered within zone 1-6 = Percentage of distance covered across the 6 speed zones

Number of Entries in zone 1-6 = Total number of entries within the 6 different speed zones

Time Spent in zone 1-6 = The amount of time spent within each speed zone

Percentage of Time in zone 1-6 = Percentage of match time spent within each speed zone

Abstract

The English Football Association (FA) reported female soccer was the nation's number one team sport for female sport participation (1.38 m). There is no research on physical- and match- performance of female soccer players in England at the elite level and no investigations in to the new re-structure that the English FA made in 2011 for both senior and youth levels. Therefore, the overarching aim of this research thesis was to develop physical performance and match performance profiles of female soccer players in England across senior and youth players at both elite and non-elite levels of play.

All performance tests (body mass, height, body composition, 5-, 10-, and 20- m sprint time, agility 5-0-5 left- and right- time, countermovement jump height, depth jump rebound height, Yo-Yo IRTL1, Nordic hamstring lowers) assessed in study 1 showed "excellent to good" levels of between-session reliability (r= 0.724 – 0.996) and "excellent to good" levels of within-session reliability (r= 0.757 – 0.962), except for agility 5-0-5 right. Study 2 revealed the within-session match performance variables (distance covered and speed zone variables) used with the research thesis revealed "excellent" levels of reliability for all variables (r= 0.923 – 0.997), whilst the variation between two soccer matches indicated there were no significant difference present for all variables (p>0.05), except for the number of entries in zone 2 and the time spent in zone 1 (p>0.05). Both methodologies in study 1 and study 2 were implemented in subsequent studies.

Study 3 aimed to assess the physical performance of female youth soccer players and found the elite players demonstrated significantly greater performance across all physical assessments in comparison to non-elite players (p<0.05), with the exception of body mass and height (p>0.05). Body mass, height and Yo-Yo IRTL1 results were shown to increase

from U11 to U13 to U15 to U17, as well as decreasing across the age groups for sprint and agility times (study 3). When determining the match performance differences between elite and non-elite youth female soccer players, the elite players also displayed greater GPS match performance results than non-elite youth players; for example total distance covered (7893±1306 m vs. 5398±803 m), distance covered at zone -5 and -6 (574±228 m vs. 208±103 m and 347±187 m vs. 128±98 m) and the time spent stationary/walking (zone 1) (67±8 % vs. 80±6 %) ($p<0.05$) (study 4).

Study 5 investigated whether physical performance differs between playing positions and reported significant differences ($p<0.05$) between playing positions in elite youth female soccer players for physical performance variables such as Yo-Yo IRTL1, 10 m sprint, Nordic hamstring lowers and height ($p<0.05$).

When identifying the differences between starters and non-starters within physical and match performance data for senior female soccer players in study 6, there were multiple significant differences ($p<0.05$) present between these starting and non-starting players for body fat %, sprint and agility times. However, match performance results did not reveal any significant differences between groups ($p>0.05$). In contrast, study 7 aimed to assess the physical and match performance of senior female soccer players based on their level of play (league comparison) and highlighted elite soccer players demonstrated significantly greater Yo-Yo IRTL1 performance than sub-elite and non-elite players (1635±360 m vs. 1020±204 m and 1140±394 m), respectively ($p<0.05$). Match performance results also revealed elite players covered significantly greater distances at high-intensity and sprint speeds than sub-elite players (872±161 m vs. 658±190 m and 651±195 m vs. 410±193 m), respectively ($p<0.05$). Finally, the purpose of study 8 was to identify any differences of the final league position based on their physical performance assessments which revealed significant differences between groups for Yo-Yo IRTL1 showing the top two finishing teams had greater performance results than the team finishing in the bottom three (1083±400 m and 1140±394 m vs. 788±262). Moreover, the team finishing highest in the league were significantly faster over 5 m and 10 m sprint distances than the team finishing in the bottom three (1.07±0.04 s vs. 1.13±0.06 s and 1.87±0.06 s vs. 1.95±0.05 s).

To conclude, this research thesis outlines physical performance and match performance profiles of senior and youth female soccer players at both elite and non-elite levels of play in England and has highlighted the importance of physical conditioning for team success.

Chapter 1.0.

Introduction

1.1 Introduction to the research problem

During soccer matches, published data on female soccer demonstrates a high level of aerobic conditioning is required for the sport with average heart rates reported to be between 84-86% of the maximum heart rate (MHR) (Andersson et al., 2010; Krustrup et al., 2010) and the average total distances covered between 9,100-11,900 m (Andersson et al., 2010; Krustrup et al., 2010; Andersson et al., 2008; Mohr et al., 2008; Di Salvo et al., 2007; Hewitt et al., 2007; Krustrup et al., 2005). These aerobic soccer match specific variables are shown to be similar within male soccer data with the average percentage MHR between 85-87%, and the average distance covered ranging from 8,600-12,000 m (Wehbe et al., 2014; Andrzejewski et al., 2012; Lago-Penas et al., 2011; Andersson et al., 2010; Bradley et al., 2010; Krustrup et al., 2010; Rampinini et al., 2009; Andersson et al., 2008; Di Salvo et al., 2007; Hewitt et al., 2007; Krustrup et al., 2005; Mohr et al., 2003; Rahnama et al., 2002; Helgerud et al., 2001; Rienzi et al., 2000; Bangsbo et al., 1991). Although the performance within soccer is primarily associated with a player's aerobic endurance (due to the duration of the game, 90-minutes) (Mohr et al., 2003; Bangsbo et al., 1992), the performance, crucial moments and the outcome of a soccer match are dependent on the performance of decisive anaerobic activities such as sprinting, jumping, changing direction, duelling (Jullien et al., 2008; Little and Williams, 2007; Aziz et al., 2000).

A male soccer match is reported to consist of, on average. 250 brief intense anaerobic actions with repeated sprints occurring 39 times, sprinting every 9- seconds, with each lasting 2-4-

seconds (Bangsbo et al., 2006; McMillian et al., 2005; Stolen et al., 2005; Mohr et al., 2003; Reilly et al., 2000). Sprinting speed is also a key aspect within the sport contributing to soccer performance aspects such as obtaining possession, and scoring/ conceding goals (Reilly et al., 2000), and sprinting 1,025±150 m accounting for 1.4-3.0% of a game (Di Salvo et al., 2007; Mohr et al., 2003; Ali and Farrally, 1991). Further intense actions have been reported including 111 on the ball activities, jumping and changing direction 90-100 times at a 90-180 ° angle (Bloomfield et al., 2007). In comparison, female soccer matches show that players change the intensity of the activity 1326-1379 times during the 90 minutes (Mohr et al., 2008), with anaerobic variables such as the number of sprints and high-intensity bouts to be 20-27 and 125-154 times (Andersson et al., 2010; Mohr et al., 2008), respectively. This has been shown to equate to sprint distances totalling between 250-460 m and 1,300-1,680 m as high-intensity running (Andersson et al., 2010; Mohr et al., 2008), however in the context of the sport each high-intensity run and sprints will vary depending on the situation in a game. Sprint and high-intensity running speed zones were between 18.1-25 km/h and 15.1-18 km/h, respectively, for these particular studies (Andersson et al., 2010; Mohr et al., 2008). These decisive, anaerobic components associated with soccer (sprinting, striking the ball, turning, jumping, changing pace, cutting and accelerating and decelerating the body) are forceful and explosive and require near-maximum levels of muscular strength and power production (Chelly et al., 2009; Little and Williams, 2006; Stolen et al., 2005; Dupont et al., 2004; Inklaar, 1994).

It is important to state that the research on female soccer has produced normative data based on averages from a group of female soccer players. Individuals may demonstrate key physiology data which is greater or less than this average. Therefore, when applying practices in the field it is important to consider these individual differences.

A high level of conditioning is important within soccer for scoring or preventing goals from being scored, where players must be faster and more powerful than the opponent (Chelly et al., 2009). Although no studies have directly investigated the conditioning levels of female and male players through both physical- and match- performance assessments; research has indicated greater standard players cover greater high-intensity distance (2,430±140 m vs. 1,900±100 m and 1,680±90 m vs. 1,300±100 m), sprint distance (650±60 m vs. 410±30 m and 460±20 vs. 380±50 m) and the number of sprint bouts (39±2 vs. 26±1 and 30±2 vs. 26±1) than lower level players (Mohr et al., 2008; Mohr et al., 2003).

Rampinini et al. (2009) found that the top-5 finishing teams in Italian Serie A male league possessed significantly greater match performance than the bottom-5 teams for total distance with the ball, high-intensity distance with the ball and ball involvements, and successful passes, tackles and shots ($p<0.01$); yet the study did not investigate physical performance variables. Further findings by Wisloff et al. (1998) demonstrated the top-team in the male Norwegian Elite League possessed greater physical performance than the bottom-league team through maximal oxygen uptake (VO_2max) assessment (67.6±4.0 $mL·kg^{-1}·min^{-1}$ vs. 59.9±4.1 $mL·kg^{-1}·min^{-1}$), however, no comparisons were made through match performance assessments. Le Gall et al. (2008) did not include match performance variables within the research study, yet found male players with significantly greater performances within maximal anaerobic power, countermovement jump height and 10 m, 20 m, and 40 m sprint assessments at youth level reached a greater playing standard at senior level. Thus, even though studies may collectively indicate that a player's level of conditioning is associated with match performance, physical performance, success and level of play they reach; further individual research is required to directly investigate their combined relationship. More to this, these research studies (Rampinini et al., 2009; Le Gall et al., 2008; Wisloff et al., 1998) were investigations using male soccer players which highlights further the lack of research on female soccer.

1.2 Organisation of the thesis

FIFA recently reported a rapid growth of 29 million (32% increase) female soccer players worldwide within the past ten years (FIFA, 2012). However, although reports identify female soccer is one of the fastest growing sports in the world (Hong, 2003), research within this area is fairly limited and inconsistent, in terms of quality and quantity, when compared to male soccer research.

To the author's knowledge, Figure 1.1 displays the comparison of female soccer research and male soccer research, taken from Sport Discus database on October 2014 (search terms: female soccer; male soccer). The journal articles from the search showed 83% of the research papers on the physiological data (Physical Performance and 11v11 match variables) of soccer players were of male soccer players, with only 17% accounting for female soccer research; which supports the assertion that female soccer needs to be further investigated. Further analysis showed studies on USA female players were the greatest sample of all female soccer research (52%); Scandinavian countries second (20%); Australasia third (11%); England, Spain and Italy joint fourth (4%); and lastly Turkey and Germany (2%) (Figure 1.2).

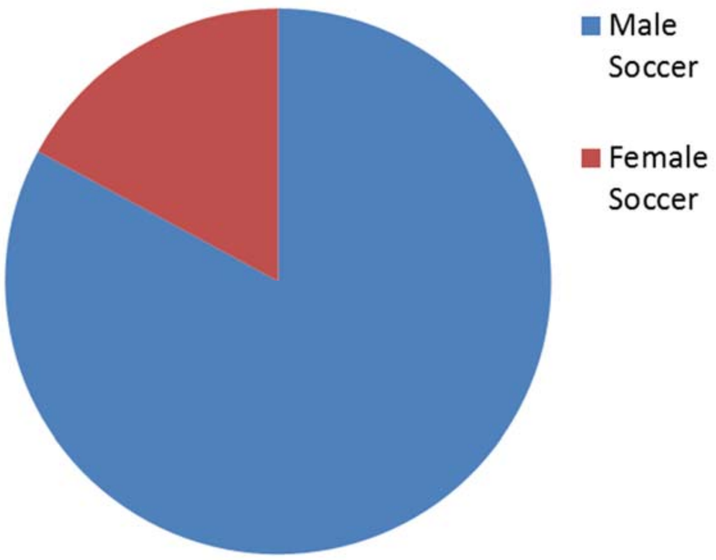

Figure 1.1. Comparison of the number of published soccer studies (Physical Performance and 11v11 match variables) in females (n=46) and males (n=223); October 2014

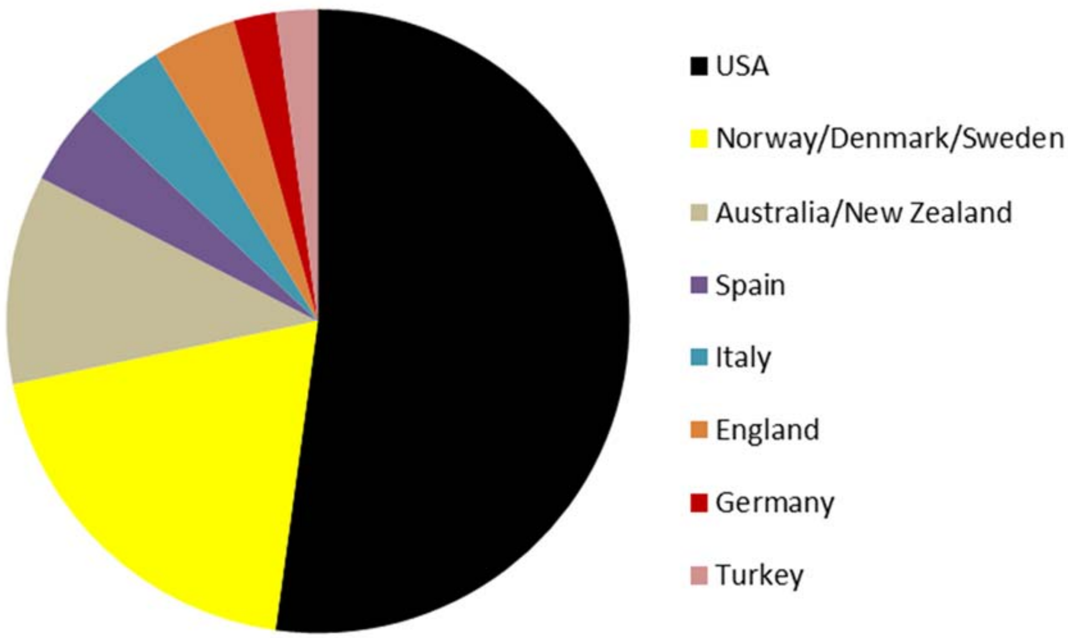

Figure 1.2. Chart showing the distribution of female soccer data (Physical Performance and 11v11 match variables) across the world; USA (n=24) vs. Norway/Denmark/Sweden (n=9) vs. Australia/New Zealand (n=5) vs. England (n=2) vs. Italy (n=2) vs. Spain (n=2) vs. Germany (n=1) vs. Turkey (n=1)

The English Football Association (FA) reported that female soccer is the nation’s number one team sport for female sport participation (1.38 m), and the third overall largest team sport in the nation, in terms of participation; only behind male soccer and male cricket. This status for female soccer within the country is great, however, more research and resources needs to be utilised for the elite level of the sport. The English FA recently restructured female soccer for both Senior and Youth level. Season 2011-2013 saw one league become professional (elite) with the remaining lower leagues maintaining amateur status. Season 2014/-2017 for the female senior game will see the two highest tiers (Women’s Super League 1 and Women’s Super League 2) become a professional (elite) league and separate from the amateur (non-elite) leagues (Figure 1.3).

Female youth soccer now has an elite pathway from the restructure of the English FA. Almost 60 centre of excellences were cut down to 31 elite female centre of excellences in the country three years ago, with 27 talent development centres bridging the gap between elite (centre of excellences) and non-elite (amateur grass root clubs) one year ago (Figure 1.4).

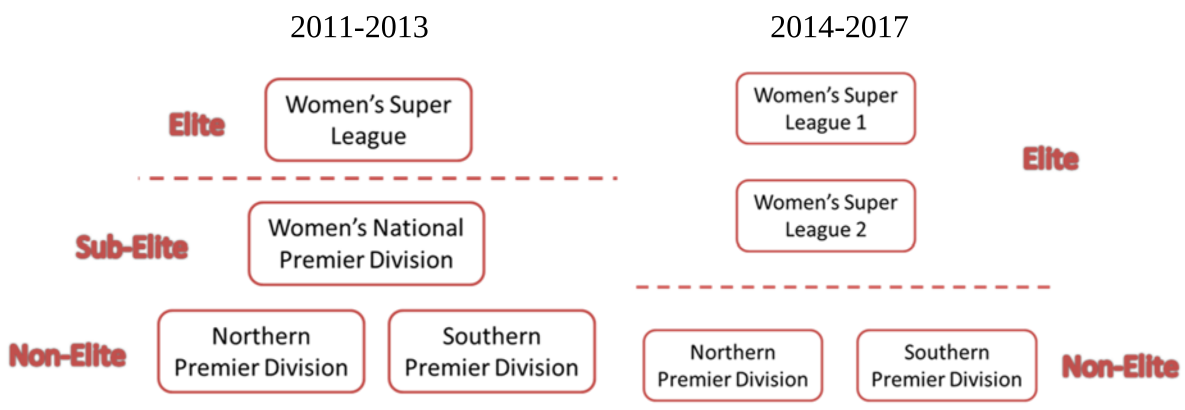

Figure 1.3. Structure of female soccer across the three highest leagues, in England (Senior)

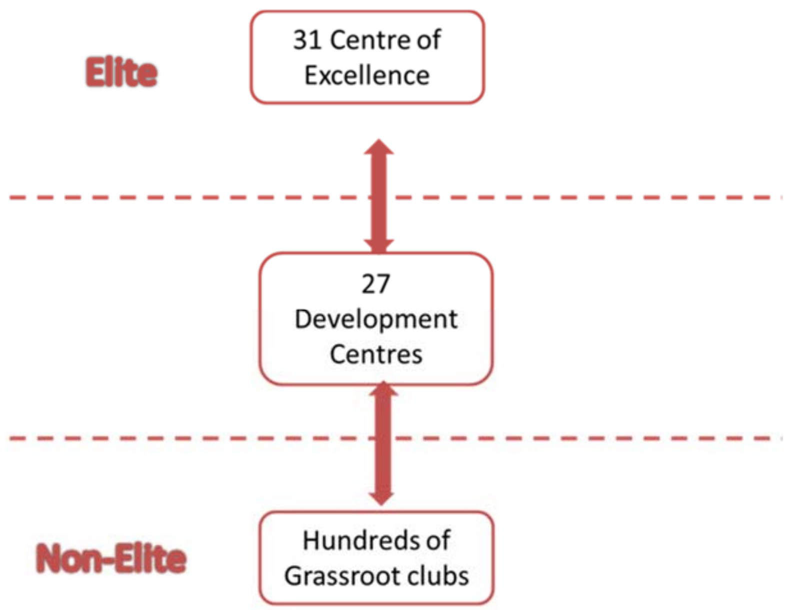

Figure 1.4. The current structure/hierarchy of female youth soccer in England

This restructure could optimise the development of elite players within England at both senior and youth level; however, no research has been carried out investigating the sport at the elite level in this country, only participation levels, at this point in time. With this in mind, the overarching aim of this research thesis is to develop physical- and match-performance profiles of female soccer players in England across senior and youth players at both elite and non-elite levels of play.

1.3. Research Objectives

a. Identify the reliability of specific assessment methods for physical performance tests (Chapter 3.0)

b. Determine the reliability of match performance assessment methods (Chapter 4.0)

c. Assess the physical performance of female youth soccer players (Chapter 5.0)

d. Determine the match performance differences between elite vs. non-elite youth female soccer players (Chapter 6.0)

e. Investigate whether physical performance differs between playing positions (Chapter 7.0)

f. Identify the differences between starters and non-starters within physical and match performance data for senior female soccer players (Chapter 8.0)

g. Assess the physical and match performance assessment data of senior female soccer players based on their level of play (league comparison) (Chapter 9.0)

h. Identify any differences of the final league position of female soccer teams based on their physical performance assessments (Chapter 10.0)

1.4. Research Questions

- ***a.*** Are the methods of assessing physical performance reliable? (Chapter 3.0)
- ***b.*** Are the methods of assessing match performance reliable? (Chapter 4.0)
- ***c.*** Does physical performance differ between elite and non-elite youth soccer players? (Section 5.1.1)
- ***d.*** Does physical performance differ across youth soccer age-groups? (Section 5.1.2)
- ***e.*** Does physical performance differ across age-groups at elite youth level? (Section 5.1.3)
- ***f.*** Does physical performance differ across age-groups at non-elite youth level? (Section 5.1.4)
- ***g.*** Are there any physical performance differences between youth elite and youth Non-elite soccer players at specific age-groups? (Section 5.1.5)
- ***h.*** Does match performance differ between elite and non-elite youth female soccer players at different levels of play? (Chapter 6.0)
- ***i.*** Are there any differences in physical performance profiles in elite youth female soccer players? (Chapter 7.0)
- ***j.*** Do physical and match performance results of senior female soccer players differ between starters and non-starters? (Chapter 8.0)
- ***k.*** Do physical and match performances differ between senior elite, sub-elite and non-elite female soccer players? (Chapter 9.0)
- ***l.*** Does physical performance contribute to final league position in a senior female soccer league? (Chapter 10.0)

Chapter 2.0.

Literature Review

The literature review includes a detailed overview of the current research methods and data of female soccer players across physical and match performance assessments. Sections 2.1-2.3 critiques the physical performance methods and results found in female soccer research and how these compare to male soccer players. Sections 2.4-2.5 identifies current soccer match performance methods and results within female soccer and compares the findings to male soccer players. Sport Discuss and Pubmed search engine databases were used to gather research for the literature review using the following search terms: female soccer; male soccer.

2.1. Conditioning Levels of Female Soccer Players Assessed Through Physical Performance Tests

A soccer player's absolute strength is beneficial for moving external objects (the ball and opposition players), whereas the level of relative lower-limb strength is suggested to be very important in relation to soccer-specific actions such as changing direction, running/sprinting, jumping and landing actions which can involve relative resultant forces between 1.65-4.22 times body mass (Wallace et al., 2010; Satro and Mokha, 2009; McBride et al., 2009; Hori et al., 2008; Barnes et al., 2007). It has been suggested a greater relative strength could provide greater acceptance of these high forces to optimise physical qualities such as jumping, sprinting, changing direction, and reduce risks to injury (Comfort et al., 2014; Comfort et al., 2012 a; Comfort et al., 2012 b; Chelly et al., 2010; Chelly et al., 2009; McBride et al., 2009; Hori et al., 2008; Ronnestad et al., 2008; Christou et al., 2006; Cronin and Sleivert, 2005; Wisloff et al., 2004; Hoff et al., 2002). To expand, McBride (2009) subdivided athletes into two groups; group -1 had maximal relative strength values less than 1.9 1RMkg/body mass (bm), while group -2 displayed maximal relative strengths greater than 2.1 1RMkg/bm. The study results revealed group -2 possessed significantly faster sprint performances over 40- and 10 yards. Whilst McBride et al. (2009) used back squat 1RM assessment methods to determine relative strength data, Hori et al. (2008) divided their subject groups in half based on the Australian rules football player's relative strength through front squat 1RM assessments. Hori et al. (2008) found similar findings to McBride et al. (2009) showing the 50% with greater relative strength scores had significantly greater countermovement jump height and faster sprint times than the remaining 50% with lower relative strength scores. These studies collectively highlight the importance of relative strength and its impact on physical performance qualities. The performance of these physical components can be the difference between scoring a goal by out-jumping an opponent with a header, sprinting faster than an opponent to get to the soccer ball first, or conversely conceding a goal by turning slower than the attacking opponent or absorbing landing forces slower than the opponent after an aerial duel; all these examples can ultimately contribute to the overall result of a soccer match. It is important to acknowledge that intervention training programs to improve an individual's relative strength must be appropriate for each individual. For example, it would be inappropriate for an individual to carry out heavy resistance training if they do not adopt the appropriate techniques and conditioning levels to carry this out safely. Training methods should be specific to each individual.

Soccer players with greater results in physical performance assessments have been reported to reach significantly greater standards of play, finish higher in competitive leagues, play in higher league division, start more matches and be retained at the club (Goto et al. 2013; Lago-Penas et al., 2011; Rampini et al. 2009; Gravina et al. 2008; Le Gall et al., 2008; Gil et al., 2007; Cornetti et al., 2000; Wisloff et al., 1998; Brewer and Davis, 1991; Gauffin et al., 1989). For instance, Le Gall et al. (2008) investigated physical performance results of male soccer players at French youth level over an eleven-year period and found the players with significantly greater physical performances subsequently played at a higher level (international and professional), whilst the players with significantly worse physical performance tests scores at youth level ended up playing soccer at a lower senior amateur level ($p<0.05$). These significant findings were present for maximal aerobic power, 40m sprint time and countermovement jump height. These findings are also supported by other research studies. Brewer and Davis (1991) showed 15 m and 40 m sprint performances were significantly faster in elite players than non-elite within English male soccer players ($p<0.05$). Moreover, Gauffin et al. (1989) reported players in the top divisions possessed significantly greater jump performance than the lower level teams, whilst Cornetti et al (2000) found the amateur players performed significantly worse in sprint and depth jump rebound height assessments when compared to elite and sub-elite player's results in French senior soccer leagues ($p<0.05$). Findings by Wisloff et al. (1998) support these findings demonstrating the higher placed team(s) in European leagues possessed a greater VO_2max than the bottom league team, while the researchers from Lago-Penas et al. (2011) found the successful teams had lower body fat compositions, greater performance in the physical tests, although, these findings were not statistically significant ($p>0.05$).

Even though these research studies may collectively indicate greater physical performance qualities could influence standards of play, final league position ranks, promotion or relegation, number of matches started, being retained or released from a club, they are all subsequent findings from male soccer. There has been no similar research carried out on female soccer at this point in time.

2.2. Physical Performance Tests: Female Soccer

2.2.1. Assessment of Jump Performance

The countermovement jump is a popular test used within female soccer to assess the physical performance of a player. The data results for the female soccer players are present within table 2.1, which shows large ranges between the data (21.0-53.1 cm). These female soccer studies have used various methods to assess countermovement jump (CMJ) height some of these include the use of arm swing while other protocols eliminate arm swing by insisting subjects jump with hands on their hips. The largest range between the studies was present for those who used arm swing protocols. The lowest data set, 21.0 cm, was reported within Larson-Meyer et al. (2000) who assessed countermovement jump height with arm swing within NCAA soccer players in a senior collegiate age group using standing reach jump (vertec) equipment methods. Nesser and Lee (2009) had the greatest data set, 53.1 cm, which was similar, in terms of the protocol (arm swing), equipment methods (standing reach jump, vertec), subject status (senior collegiate) and standard of play (NCAA), to that of Larson-Meyer et al. (2000). Yet, both studies display a 32.1 cm gap between them. If the soccer players utilise the full momentum of the arm swing this will optimise the height jumped, whereas a soccer player with poor arm drive during the swing and take-off phase of the jump may obtain lower results. Mujika et al. (2008) compared the use of both arm swing and hands on hips methods for female soccer players countermovement jump height and found differences of 5.4 - 4.7 cm between them. The lesser conditioned players demonstrating a lower ability to utilise arm swing in comparison to the greater conditioned players (4.7 cm vs. 5.4 cm), respectively (Mujika et al., 2008).

Female soccer research assessing countermovement jump height with no arm swing could contribute to a greater consistency between the studies. This is displayed between Haugen et al. (2012) and Shalfawi et al. (2013) studies. Haugen et al. (2012) found elite female soccer players from the Norway division jumped 28.5±4.1 cm with no use of arm swing (hands on hips) using AMTI force platform, sampling at 1000 Hz. While Shalfawi et al. (2013) similarly used soccer players from the Norway division, jumping with hands on their hips and found the mean height jumped to be 26.8±3.3 cm, also using AMTI force platform. However the sampling frequency was set to a lower rate of 100 Hz. The range between these studies (Shalfawi et al., 2013; Haugen et al., 2012) is considerably lower than the range displayed between Larson-Meyer et al. (2000) and Nesser and Lee (2009) (1.7 cm vs. 32.1 cm).

It is also important to note that greater sampling frequency have been found to produce greater variability in errors in comparison to greater sampling frequencies provide greater accuracy and lower variation in errors when assessing jump height performance on force platforms (Street et al., 2002; Vanrenterghem et al., 2001). Vanrenterghem et al. (2001) found greater variability in errors for lower sampling rates (50 - 100 Hz) in comparison to greater sampling frequencies (200 - 1000 Hz). However, further research showed sampling frequencies <1080 Hz under estimate jump height by 1.1-31%, thus suggesting jump height performance should be assessed with sampling frequencies >1080 Hz (Street et al., 2001).

The female soccer studies (Table 2.1) that used force platforms to assess jump height all utilised sampling frequencies <1080 Hz; leading us to question the validity of the performance data based on Street et al.'s (2001) findings.

When subject training status, assessment protocols, equipment methods and subject age are all matched between studies it is possible to state that arm swing produces inconsistent results with larger data result ranges, while no arm swing methods (hands on hips) provide greater consistency which have shown to display smaller data ranges between research studies. Further to this, studies have found armswing significantly increases the height jumped by 17.0-22.6% within squat jump and countermovement jump testing than when no armswing is used (Floria and Harrison, 2013; Domire and Challis, 2010; Hara et al., 2008). The use of armswing during vertical jump performance tests has reported to utilise the hip extensor muscles greater than when no armswing is used, thus contributing to an increased jump height (Domire and Challis, 2010). Hara et al. (2008) also found that the use of armswing contributes greater to the jump height than leg countermovement contribution (18% vs. 10%), respectively.

The female soccer countermovement jump data presented (Table 2.1) shows the different types of equipment used to assess countermovement jump height such as contact jump mat, optical timing system, force plate and vertec. Other studies have found the use of different equipment to assess countermovement jump could affect the reliability and the validity of the results with some equipment methods significantly under reporting or over estimating jump height scores more than other methods. Moir et al. (2008) found contact mats under reported (34%) when compared to assessment methods carried out on force plates, while Aragon-Vargas (2000) reported contact mats under estimated jump height in comparison to 3D motion analysis of centre of mass (-29%). Further research by Buckthorpe et al. (2012) reported similar results between laboratory force plate, portable force plate and belt mat devices (50.3±7.5 cm vs. 49.5±7.2 cm vs. 50.2±7.8 cm), whilst the vertec and contact mat devices were found to under report jump height in comparison to the actual laboratory force plate methods (47.9±7.9 cm and 38.6±6.5 cm vs. 50.3±7.5 cm), respectively. The female soccer research displayed within table 2.1 shows seven different types of testing equipment used to assess countermovement jump height. This could explain the large ranges between the data sets reported within the studies. However, because all seven types were not used and statistically compared within each study this makes it very difficult to indefinitely make the assumption that the large data ranges across female soccer research is due to contrasting testing equipment.

Some studies have assessed the reliability of the assessment methods used within their research, while others have not. Castagna and Castelli (2013) and Haugen et al. (2012) found very high within-study reliability Intraclass Correlation Coefficient (ICC) values ($r = 0.94$-0.97 vs. 0.97, $p<0.001$) with Shalfawi et al. (2013) reporting ICC scores of $r = 0.83$; suggesting a good level of reliability for the assessment of countermovement jump height. Larson-Meyer et al. (2000) found standard error measurement of their assessment methods to be just 1.27 cm. However, no other female soccer studies displayed, in table 2.1, assessed the reliability of their countermovement jump methods (Palmer et al., 2013; Rubley et al., 2011; Sjokvist et al., 2011; Krustrup et al., 2010; Campo et al., 2009; Nesser and Lee, 2009; Mujika et al., 2008; Polman et al., 2004).

Thus, due to the various protocols and testing equipment used throughout the studies assessing countermovement jump height for female soccer players, this makes it difficult to actually compare and contrast the actual data from each research study. Therefore a suggestion for a greater consistency of the countermovement jump methods is required when researching female soccer.

Haugen et al. (2012) investigated the differences between Norwegian National-team players, first division players and junior elite players, and found national team-players jumped 8-9% higher than first division and junior players (30.7±4.1 cm vs. 28.1±4.1 cm and 28.5±4.1 cm) ($p<0.05$), respectively. This suggests the soccer players at greater levels of play and greater ages produce significantly greater jump height performance results than those at lower levels of play and youth age. Palmer et al. (2013) supports this assumption by comparing elite female soccer players from NCAA division I team against females who were not athletically involved with playing soccer at high levels. The countermovement jump height of the soccer players was significantly greater when compared to the non-NCAA division I subjects (41.1 cm vs. 35.5 cm). Although Haugen et al. (2012) found significant differences between senior and youth players countermovement jump height, Castagna and Castellini's (2013) findings contradict this assumption showing no significant difference between jump height for international female soccer players at senior, under-19 and under-17 levels of play (31.6±4.0 cm vs. 34.3±3.9 cm vs. 29.0±2.1 cm), respectively ($p>0.05$).

It was previously shown how female soccer research was distributed across the world. USA research was shown to equate to 52% of the total number of female soccer studies, with Scandinavian, Spanish and Italian research making up 20%, 4% and 4%, respectively. Similar trends are present with the countermovement jump performances of the elite players from each country. Palmer et al.(2013) reported the greatest countermovement jump scores from USA (NCAA Div 1) soccer players in comparison to those from the top Danish League, Italian internationals, and players within the Spanish National First Division (41 cm vs. 35 cm vs. 30.2 cm vs. 28.9 cm), respectively. It could be possible to suggest that countries with more soccer research have optimised the conditioning level of their soccer players and have greater performing soccer players in physical tests like countermovement jump.

2.2.2. Assessment of Sprint Performance

The average sprint in a male soccer match has shown to be 3.5-6.3 m (Di Mascio and Bradley, 2013; Castagna et al., 2003) with nearly half (49%) of the total number of sprints in a match shorter than 10 m (Stolen et al., 2005), which would suggest 5 m acceleration time to be an important quality to each soccer player's match performance (Table 2.2). However, from the twelve research studies (Table 2.2), only Gabbett et al. (2008) reports data for 5 m sprint time for female soccer players. Thus, suggesting little research information exists on female soccer player's 5 m sprint time.

The assessment protocol and equipment used to measure sprint time have been found to affect data results. Studies have consistently shown dual-beam timing systems provide greater accuracy of sprint times than single-beam systems (Haugen et al., 2014; Earp, 2012; Cronin and Templeton, 2008; Yeadon et al., 1999; Dyas and Kerwin, 1995). A single-beam timing system involves just one beam that a subject must break through when sprinting while dual-beam timing systems contain two photocells set at different heights and requires both of these beams to be triggered simultaneously in order to register the split time. Whilst sprinting, if a subject breaks one beam with their arm using single-beam timing system and at the next timing gate break the beam with their torso this could increase the measurement error since the torso maybe 30 cm behind the leading arm. The dual-beam timing systems aim to solve the problem of beams being broken by a leading arm or thigh (Haugen et al., 2014; Earp, 2012; Yeadon et al., 1999).

It has also been suggested placing the timing gates at a height where only one body part can break the beam(s) improves the accuracy and reduces the errors involved whilst measuring sprint time. Yeadon et al. (1999) found the arms or torso broke the timing beam in only 14% of all reliability trials when photocells were mounted at hip height and 60% of all trials when photocells were situated 20 cm higher than the hips. However, Cronin and Templeton (2008) contradict these findings stating timing gates placed at hip height produce faster sprint times, thus greater errors, than photocells set at shoulder height due to the thighs breaking the beam before the upper body. These findings recognise the importance of being precise within the assessment methods of sprint performance.

A further important methodological detail to consider whilst assessing sprint time is the distance at which the subject starts sprinting behind the first timing light. If a subject starts on a pressure pad which starts the time as soon as the foot contact is removed they will record a slower sprint time to the next timing gate than if they start 50 cm or 1- metre behind the timing gate. The reason for this is that it allows the subject to generate a greater centre of mass velocity before they have even reached the first timing gate; the pressure pad trigger starts exclude this (Cronin et al., 2007; Kraan et al., 2001). This theory can also influence sprint time depending on the type of stance used on the research study’s start line. Cronin et al. (2007) found significant differences between three different sprint starts: split static start, parallel start and parallel false start with a backward step with right foot. The research results showed the parallel start was significantly the slowest time within male and female subjects but interestingly found parallel false start was significantly faster than the parallel start and the split static start (1.19±0.06 s vs. 1.28±0.06 s vs. 1.18±0.06 s), respectively. A possible reason for this is that the false step could enable a greater contribution from the stretch shorten cycle, resulting in higher force and power production than the opposing two methods (Kraan et al. 2001).

Acknowledging and standardising these assessment protocols ensure reliable results within the study, but also ensure reliability and accuracy between studies, particularly in the same research area. However, Cronin and Templeton (2008) recently commented on the lack of detail research fails to disclose within their assessment methods. For instance, the female soccer sprint time research (Table 2.2) fails to describe the type of start (e.g. 2-point start: split static stance, parallel start, parallel false start (with backward step); 3-point start) within 82% of all the studies (Shalfawi et al., 2013; Haugen et al., 2012; Oberacker et al., 2012; Sjokvist et al., 2011; Krustrup et al., 2010; Gabbett et al., 2008; Mujika et al., 2008; Sayers et al., 2008; Polman et al., 2004; Siegler et al., 2003), and 64% fail to describe the distance the subject started the sprint behind the first timing light (Shalfawi et al., 2013; Oberacker et al., 2012; Sjokvist et al., 2011; Krustrup et al., 2010; Nesser and Lee, 2009; Gabbett et al., 2008; Polman et al., 2004; Siegler et al., 2003). Sixty percent of the research studies assessing female soccer players sprint performance also failed to disclose the height at which the photocells were set at (Shalfawi et al., 2013; Oberacker et al., 2012; Sjokvist et al., 2011; Krustrup et al., 2010; McCurdy et al., 2010; Nesser and Lee, 2009; Gabbett et al., 2008; Polman et al., 2004). This lack of detail and standardisation of methods makes it difficult to reliably compare and contrast the results between each research study and evaluate female soccer player’s sprint performance.

To support this, the research studies (Table 2.2) use various equipment types to assess their soccer players sprint performance. Gabbett et al. (2008) reported within their methods that subjects were assessed using single-beam timings systems while Oberacker et al. (2012) disclosed the use of double-beam systems. All other studies, except McCurdy et al. (2010), failed to disclose whether the timing systems they used were single- or double- beam systems. Moreover, of the studies which disclosed the methodological information on the height of the photocells, there were contradictions present between them. Haugen et al. (2012) placed transmitters 140 cm off the ground, while Mujika et al. (2008), Sayers et al. (2008) and Siegler et al. (2003) situated photocells at 100 cm-, 200 cm-, and 25 cm- heights, respectively. Although each study assesses sprint times at different distances, it does increase the measurement errors and reduces the level of reliability between these studies (Yeadon et al., 1999; Dyas and Kerwin, 1995). Additional reductions in reliability between studies are present for those adopting different starting positions. Although Sjokvist et al. (2011), Gabbett et al. (2008), Sayers et al. (2008) and Polman et al. (2004) state the subjects started in a standing position (2- point) as part of their assessment protocol, they all fail to reveal the detail of what type of 2- point start. This type of detail has been suggested to be important as it can considerably influence sprint times ($p<0.05$) (Cronin et al., 2007; Kraan et al., 2001). McCurdy et al. (2010) was the only study to report the relevant detail of the 2- point stance (standing static split start with right foot lead). Furthermore, the start distances behind the first timing light were different between those studies which actually reported it in their methodology. Haugen et al. (2012), McCurdy et al. (2010) and Sayers et al. (2008) all began sprint times with subjects on the start line which eliminated any centre of mass velocity before the time begun, whilst Mujika et al.’s (2008) subjects started sprinting 3- metres behind the first gate which allowed greater velocities and force productions to occur before the time had begun.

Even though there is limited sprint performance data on female soccer players, the lack of consistency between the studies methods (Table 2.2) leads us to question the reliability of female soccer sprint performance data. Thus, suggestions for more research within this area is required but also a greater number of studies with consistent assessment protocols and disclosure of greater detailed methods so we can compare and contrast findings reliably.

2.2.3. Assessment of One Repetition Maximum Strength

One repetition maximal (1RM) testing has commonly been used to assess the lower-limb strength of soccer players (Chelly et al., 2009; Wong et al., 2010; Nesser and Lee, 2009; Ronnestad et al., 2008; McMillian et al., 2005; Myer et al., 2005; Wisloff et al., 2004; Larson-Meyer et al., 2000). There are opposing methods used within these studies including assessments on fixed-weight machines (e.g. smith machines) and free-weight (e.g. barbell). Fletcher and Bagley (2014) and Langford et al.'s research demonstrated subjects produced greater (8-10.9%) 1RM scores from machine apparatus in comparison to free-weight (barbell) assessment methods, indicating that contrasting equipment methods can affect the resultant 1RM score. This could explain the data distribution of female soccer 1RM squat studies (Table 2.3) which shows the study using smith machine methodological protocols contains greater (22-33%) 1RM data than the other studies that used free-weight assessments (Nesser and lee, 2009; Myer et al., 2005; and Larson-Meyer et al., 2000).

The 1RM squat data produced has shown to differ depending on the squat depth of the subject (i.e., quarter squat, parallel, full squat), with shallower depths reported to produced greater 1RM outputs than deeper depths (Cotter et al., 2013; Drinkwater et al., 2012;

Blazevich et al., 2002). Cotter et al. (2013) statistically compared three different squat depths: above parallel, parallel and below parallel; and found significant differences between each depth ($p<0.001$). The lowest depth (below parallel) produced the lowest results, middle depth (parallel) produced the second greatest result and the highest depth produced the greatest result (125.28±4.34 kg vs. 129.97±4.82 kg vs. 150.42±4.92 kg), respectively. It is not possible to compare and contrast the squat depths used with the female soccer literature in table 2.3 due to the lack of methodological detail presented in the studies. There was only Myer et al.'s (2005) study which disclosed the squat depth used whilst assessing each soccer player's maximum squat strength (thigh parallel to the floor). The other studies presented in table 2.3 failed to disclose this important information. Larson-Meyer et al. (2000) stated "a safety bar was used to individually standardize adequate depth during the squat," while Nesser and Lee (2009) specified "all lifts were observed by the head coach to determine if it was an acceptable lift (i.e., proper depth, technique, etc)."

Myer et al. (2005) also disclosed further detail of their methodological assessment of maximum squat strength. They stated they used a submaximal strength test which was around a 5-rep max and used an existing equation to convert each score into a 1RM value (LeSuer et al., 1997; Wathan, 1994). This equation contained the following:

1RM = 100 x rep wt / [48.8+53.8 x exp (-0.075 x reps)]

The other studies (Table 2.3) were that of actual 1RM measurements (Nesser and Lee, 2009; Larson-Meyer et al., 2000). Positively, submaximal strength tests have been shown to accurately assess strength and predict 1RM, like that used in Myer et al.'s (2005) study. These particular studies reported mean differences of only 0-4% between true 1RM and predicted 1RM scores (Hetzler et al., 2010; Rontu et al., 2010; Reynolds et al., 2006; Pereira and Gomes, 2003). This implies it may not be necessary to subject athletes to maximum external loads whilst assessing a subject's maximum strength capabilities.

The reliability of the 1RM squat test has been questioned within the literature. Augustsson Ryman and Svantesson (2013) reported good ICC values (r= 0.85) for two trials of 1RM squat testing, yet disclosed statistical significant differences between two testing sessions (p=0.005). Ribeiro et al. (2014) contributes to these findings stating significant incremental (14.9-18.5%) 1RM squat values are present from testing trial 1 to trial 4 across all three experimental groups. These three experimental groups were divided based on their resistance training experience; novice (1- to 6- months); intermediate (7- to 12- months); advanced (13- to 24- months). However, the term 'resistance training experience' in this study was not described with great detail, with no indication of how often they trained or whether it was fixed-weight or free-weight experience. Both of these studies (Ribeiro et al., 2014; and Ryman Augustsson and Svantesson, 2013) included subjects who were detrained- or non-athletes with none or a small amount of resistance training experience which is irrelevant to the reliability of 1RM squat assessment within sports specific literature. To support this, McCurdy et al. (2004) conversely found trained female athletes had stronger ICC values than untrained females (r= 0.94 vs. r= 0.87), respectively. Larson-Meyer et al. (2000) found strong test-retest reliability 1RM squat scores for female soccer players who regularly performed resistance training programs. Myer et al. (2005) also supports these findings demonstrating a high test-retest reliability between 1RM squat testing sessions (r= 0.98) for female athletes. Thus, suggesting the 1RM squat test displays high levels of reliability when assessing athletes, rather than those of an untrained athletic status. Even though Faigenbaum et al. (2012) assessed 1RM power clean, the study reported high levels of reliability (r= 0.98) and only a 1% mean error difference between intra-reliability testing which were 3-7 days apart.

The problem is that the research procedure of 1RM testing of soccer players is often described imprecisely, with many studies more importantly, failing to assess the reliability of their own research methods (Chelly et al., 2009; Wong et al., 2010; Ronnestad et al., 2008; McMillian et al., 2005; Wisloff et al., 2004). Moreover, the reliability of 1RM assessment may be influenced depending on the regularity an athlete performs heavy load resistance exercises. For example, an athlete lifting heavy load regularly may contribute to a greater reliability of assessment methods than an athlete who does not have heavy load exercises within their training program. It is also worth noting that heavy load resistance training programs are not a commonplace in soccer, therefore, each player must have a level of experience with heavy resistance training before they perform 1RM tests for this assessment method to be safe for the individual. It can be suggested further research within this area must assess the reliability of their 1RM tests before publishing data within the literature and disclose the methodological and participant training information.

2.2.4. Assessment of Aerobic Performance

There are numerous different assessments used to determine female soccer player's aerobic performance (Green et al., 2013; Grieco et al., 2012; Oberacker et al., 2012; Ingebrigtsen et al., 2011; Sjokvist et al., 2011; Upton, 2011; Clark, 2010; Krustrup et al., 2010; Gabbett et al., 2008; Mujika et al., 2008; Miller et al., 2007; Krustrup et al., 2005; Polman et al., 2004) (Table 2.4). A large amount of these studies have used incremental treadmill tests to distinguish a female soccer player's VO_2max which measures the maximal level of oxygen consumption when a plateau is reached in spite of an increase in workload (Green et al., 2013; Grieco et al., 2012; Ingebrigtsen et al., 2011; Sjokvist et al., 2011; Krustrup et al., 2010; Miller et al., 2007; Krustrup et al., 2005). However, these methods are known to be expensive, time consuming in preparation, and can only assess one subject at one time, whereas it is possible to obtain information about a large number of athletes within a short time during Yo-Yo intermittent recovery (Yo-Yo IRT), which only require a tape measure, audio tape, stereo, speakers and cones for testing equipment at much lower costs (Bangsbo et al., 2008; Bangsbo et al., 2006; Bangsbo, 1994). These Yo-Yo IRT methods however represent a lower percentage (20%) of the studies displayed in table 2.4 (Oberacker et al., 2012; Mujika et al., 2008; Krustrup et al., 2005).

The Yo-Yo IRT was specifically designed by Bangsbo (1994) to evaluate the ability to repeat high-intensity running efforts over short distances and involves two parts: level 1 and level 2. The Yo-Yo IRT level 1 (Yo-Yo IRTL1) 'focuses on the capacity to carry out intermittent exercise leading to a maximal activation of the aerobic system,' whereas the Yo-Yo IRT level 2 (Yo-Yo IRTL2) assesses 'an individual's ability to recover from repeated exercise with a high contribution from the anaerobic system' (Bangsbo et al. 2008). The Yo-Yo IRTL1 involves two 20 m shuttle runs followed by 10- seconds of active recovery and involves four running bouts at 10-13 km/h, seven shuttles at 13.5-14 km/h and thereafter increases speed by 0.5 km/h every eight running bouts. The Yo-Yo IRTL2 test begins with four running bouts of 13-16 km/h, followed by seven bouts at 16.5-17 km/h and then continues to increase by 0.5 km/h every eight running bouts. Both of these tests end when the subject cannot maintain the required speed, thus the relevant level is recorded as their score. It is important to note that due to the nature of the speeds within Yo-Yo IRTL2 an individual with slower speeds may be penalised not because of the ability to recover from each high intense shuttle, but simply because they physically cannot run at a sufficient speed to make the beeps.

Some studies have reported strong relations between Yo-Yo tests and VO_2max (Ingebrigtsen et al., 2012; Rampinini et al., 2010; Rampinini et al., 2009), while others have shown the relationship between these two variables to be poor (Boullosa et al., 2013; Bradley et al., 2012; Karakoc et al., 2012; Wong et al., 2011; Rampinini et al., 2009). Ingebrigtsen et al. (2012) found high associations with VO_2max and Yo-Yo IRTL1 performance variables for both elite and sub-elite soccer players ($r= 0.76-0.73$, $p<0.01$). Two studies support these findings, Rampinini et al. (2009) and Rampinini et al. (2010), showing both studies Yo-Yo IRTL1 results strongly correlated with VO_2max ($r= 0.74$; $r= 0.74$) but in the latter study found Yo-Yo IRTL2 poorly correlated with VO_2max data ($r= 0.47$). Bradley et al. (2012), Karakoc et al. (2012) and Wong et al. (2011) found soccer player's Yo-Yo tests moderately correlated with VO_2max tests ($r= 0.68$; $r= 0.68$; $r= 0.56$), respectively. All these VO2max tests were performed using incremental treadmill assessments similar to Boullosa et al.'s (2013) methods, yet the researchers from this study found low associations with Yo-Yo IRTL1 performance ($r= 0.098$). Even though these studies may contradict each other's findings regarding the relationship between Yo-Yo and VO_2max performance, Bangsbo et al. (2008) created an equation from a linear regression graph containing 141 and 71 subject data sets for Yo-Yo IRTL1 and Yo-Yo IRTL2, respectively.

Yo-Yo IRTL1:

VO_2max = Yo-Yo IRTL1 distance (m) x 0.0084 + 36.4

Yo-Yo IRTL2

VO_2max = Yo-Yo IRTL2 distance (m) x 0.0136 + 45.3

These equations aimed to convert Yo-Yo IRT performance result into a VO_2max score. However, Bangsbo et al. (2008) themselves questioned the reliability of this conversion equation showing subjects with VO_2max data of 53 $mL \cdot kg^{-1} \cdot min^{-1}$ contained a substantial Yo-Yo result range of 1450-2600 m; suggesting this conversion is not accurate. Martinez-Lagunas and Hartman (2014) reinforced this assumption by assessing subjects within both Yo-Yo IRTL1 and treadmill (direct) methods of VO_2max. The Yo-Yo IRTL1 distance from Martinez-Lagunas and Hartman (2014) was converted to a VO_2max value for each subject using Bangsbo et al.'s (2008) equation allowing comparisons between the indirect and direct measures of VO_2max. The conclusions from the study reported Yo-Yo IRTL1 underestimated VO_2max data by 9.4%, thus inaccurately predicting actual VO_2max. Therefore, due to the sensitivity of the Yo-Yo tests and the opposing physiological demands it has to VO_2max tests, it may not be possible to accurately convert Yo-Yo IRT performance results into VO_2max values. This matter requires further attention so clearer conclusions can be made.

Further contradictions are present between VO_2max results and match performance results. Krustrup et al. (2003) reports found no significant correlations between high-intensity running in a game and VO_2max results ($r = 0.38$, $p > 0.05$), but stated VO_2max did correlate with the total distance covered within a game even though these correlations are relatively quite low ($r = 0.52$, $p < 0.05$). The findings were completely reversed within Krustrup et al. (2005) reporting significant correlations between high-intensity running variables and VO_2max ($r = 0.81$, $p < 0.05$), and poor insignificant correlations between total distance covered and VO_2max ($p > 0.05$). However what does remain consistent is the strong association Yo-Yo tests have with soccer match performance variables. Bradley et al. (2012) found the Yo-Yo test significantly correlated with high-intensity running activity in a soccer match ($r = 0.70$, $p < 0.05$). This was supported by Krustrup et al. (2005) who reported Yo-Yo IRTL1 significantly correlated with the amount of high intensity running performed in the last 5 minutes at the end of each half, the total distance covered and the total amount of high intensity running distance in a soccer match (r= 0.81, r= 0.56, r= 0.76; $p<0.05$), respectively. Further support from Krustrup et al. (2003) showed significant correlations with key soccer specific variables, total distance covered, high-intensity running and sprinting during a game (r= 0.53 – r= 0.58, $p<0.05$).

Furthermore, Yo-Yo IRT's have shown to have greater sensitivity to intervention training periods than VO_2max incremental treadmill testing. Krustrup et al. (2003) showed professional soccer players improved their Yo-Yo IRTL1 performance results by 31% from preseason preparation training to the start of the season, while VO_2max had only minor changes (7%). Additionally, Krustrup and Bangsbo (2001) reported a 23% increase in high intensity work during matches was associated with a 31% increase in Yo-Yo IRTL1 following a 12-week intervention.

Even though these studies suggest Yo-Yo IRT is more sensitive to training than VO_2max, it is important to state that studies using only VO_2max tests to assess pre- and post- training intervention results have found improvements in soccer player's VO_2max. Helgerud et al. (2001) found soccer player's VO_2max improved by 9.6% after an 8- week aerobic interval training program. Likewise, Chamari et al. (2005) showed 7.5% improvement in VO_2max from 65.3±5.0 to 70.7±4.3 $ml.kg^{-1}.min^{-1}$ after an 8-week aerobic interval training program. A similar training method used by Chamari et al. (2005) and Helgerud et al. (2001) was also performed in McMillian et al. (2005) finding VO_2max improvements of 9% after 10- weeks of intervention training. However, these studies did not use both VO_2max and Yo-Yo IRT within their research which makes it difficult to compare the two assessment methods. As previously stated, Krustrup et al. (2003) and Krustrup and Bangsbo (2001) did use both VO_2max and Yo-Yo IRT assessments to investigate the effect of an interventional training program and found Yo-Yo IRT to be the greater sensitive test for soccer players. Therefore, it makes it difficult to actually state Yo-Yo IRT is a more sensitive test for soccer players because these findings have come from just two studies, to the author's knowledge, thus it can be suggested to include both Yo-Yo IRT and VO_2max tests in further research to develop the findings from Krustrup et al. (2003) and Krustrup and Bangsbo (2001).

VO_2max testing may measure an individual's maximal oxygen consumption during exercise but its validity has been questioned to how it allows soccer players to cope with the changes in intensities during a match, thus a possible reason why it has correlated poorly with soccer match specific variables (Krustrup et al., 2005; Krustrup et al., 2003). An average female soccer match has shown to involve 1326-1379 changes in intensity where players are required to produce high intense bouts followed by lower intensity active recovery periods and repeated these series of movements whenever the game dictates it to happen (Mohr et al., 2008). By its design, the Yo-Yo IRT demonstrates these movements which are specific to those in team sports like soccer, unlike VO_2max treadmill based assessments.

2.3. Male vs. Female Soccer Players: Physiological Profile

The normative research data for female soccer players has shown to range from 21.0-53.1 cm and 28.4-41.1 cm for countermovement jumps height with and without arm swing, respectively (Table 2.1) (Castagna and Castellini 2013; Palmer et al., 2013; Shalfawi et al., 2013; Haugen et al., 2012; Sjokvist et al., 2011; Krustrup et al., 2010; Campo et al., 2009; Nesser and Lee, 2009; Mujika et al., 2008; Polman et al., 2004; Larson-Meyer et al., 2000). The majority of these scores are less than male soccer data apart from the NCAA Division I females scores in Nesser and Lee (2009) study (46.87-56.4 cm vs. 53.1 cm) (Nesser and Lee, 2009; Wong et al., 2010; Le Gall et al., 2008; Castagna et al., 2006; McMillian et al., 2005; Wisloff et al., 2004; Helgerud et al., 2001). In addition, female sprint data in table 2.2 are slower than the male soccer player’s sprint data for 20 m, 30 m and 40 m, respectively (3.20-3.59 s vs.3.00-3.12 s, 4.81-5.06 s vs. 4.00-4.22 s and 5.80 s vs. 5.35-5.55 s) (Needham et al., 2009; Till and Cooke, 2009; Wong et al., 2010; Gabbett et al., 2008; Dupont et al., 2004; Wisloff et al., 2004; Helgerud et al., 2001; Cornetti et al., 2000). In addition, the lower limb maximum strength data for female soccer players is less on both absolute and relative strength variables when compared to male soccer player’s scores (65.7-97.5 kg vs. 105-220 kg and 1.00-1.51 kg/bm vs. 1.77-2.95 kg/bm) (Table 2.3) (Chelly et al., 2009; Wong et al., 2010; Nesser and Lee, 2009; Ronnestad et al., 2008; McMillian et al., 2005; Myer et al., 2005; Wisloff et al., 2004; Larson-Meyer et al., 2000).

Table 2.1. Jump and hop performance research data for female soccer players

Physical Assessment	**Research**	**Subject status/ Number**	**Method**	**Score (cm)**
Counter-movement Jump (CMJ)/ Vertical Jump (cm)	Krustrup et al. (2010)	Danish Top League players / N=23	Hands on hips Jump Mat (Time It, Eleiko Sport)	35 ±1
	Castagna and Castellini (2013)	International Female Soccer Players (Italy)/ N=62	Hands on hips Portable Optical timing system (Optojump Next) Calculates flight time	30.2 ±3.5
	Larson-Meyer et al. (2000)	NCAA players/ N=14	With armswing Height measured from two hands over head to reach of vertical jump. Standing reach jump, Vertec	21.0 ±3.3
	Haugen et al. (2012)	Female Soccer Players (Norway) / N=194	Hands on hips AMTI Force Platform, amplified, sampling at 1000Hz	28.5 ±4.1 to 30.7 ±4.1
	Mujika et al. (2008)	Professional Female Soccer Players (Senior and Junior)/ N=34	Hands on hips Contact platform (Ergotester)	Senior: 32.6 ±3.7 Junior: 28.4 ±2
	Mujika et al. (2008)	Professional Female Soccer Players (Senior and Junior)/ N=34	With armswing Contact platform (Ergotester)	Senior: 38.0 ±4.8 Junior: 33.1 ±2.7
	Polman et al. (2004)	Elite players women's Northern Premier Division / N=36	With armswing Digital vertical jump meter (Takei) Belt connects to rubber plate, which subjects stand on, this measures the jump height	46.6 ±4.81
	Palmer et al. (2013)	NCAA Div I female soccer players / n=11	Hands on hips Jump mat (Just Jump) jump height based on flight time (ms)	41.1
	Rubley et al. (2011)	Female Soccer Players (USA) / N=16	1 step approach with armswing Vertec (standing vertical reach to measure jump height)	39.6 ±8.2
	Campo et al. (2009)	Elite players/ N=20	Hands on hips Jump Mat (Sport Jump system)	28.9 ±0.9
	Shalfawi et al. (2013)	Elite Female soccer players (Norway 2nd Div)/ N=20	Hands on hips AMTI force platform, amplified, sampling at >100Hz	26.8 ±3.3 to 29.9 ±5.6
	Sjokvist et al. (2011)	NCAA Div I female soccer players / N=14	With armswing Switch Mat (Robotics Inc)	49.3 ±8.3
	Nesser and Lee (2009)	NCAA Division I female players/ N=16	With armswing Vertec vertical reach height measuring device	53.1 ±9.4

Table 2.2. Female soccer player's sprint and agility performance research data

Physical Assessment	**Research**	**Subject status/ Number**	**Method**	**Score (s)**
Sprint Time (5 m)	Gabbett et al. (2008)	Female Soccer Academy, Australia / N=16	Dual-beam electronic timing gates (Swift performance). Standing start. Time measured to nearest 0.01 s	1.15 ±0.07 to 1.17 ±0.06
Sprint Time (10 m)	McCurdy et al. (2010)	NCAA Women Soccer Players N=15	Standing static split start with right foot lead. Sprint time measured by an accelerometer (attached to a waist belt) integrated with an electronic timing system	2.31 ±0.25
	Haugen et al. (2012)	Female Soccer Players (Norway) / N=194	Electronic timing equipment on 60x60 cm start pad. Transmitters placed 140 cm off ground. Infrared photocell (Biorun) Transmitter-reflectors1.6 m spacing 8 mm Mondotrack FTS surface	1.67 ±0.07 to 1.77 ±0.06
	Oberacker et al. (2012)	NCAA Div II female soccer players / N=19	Single beam photocells (Brower timing). Subjects preferred starting position. Indoor track- surface not disclosed	2.05 ±0.13
	Gabbett et al. (2008)	Female Soccer Academy, Australia / N=16	Dual-beam electronic timing gates (Swift performance). Standing start. Time measured to nearest 0.01 s	1.90 ±0.10 to 1.95 ±0.09
Sprint Time (15 m)	Mujika et al. (2008)	Professional Female Soccer Players (Senior and Junior)/ N=34	Infrared photocell gates (Timer S4) 5 m spacing and 1.0 m above ground level. Measured velocity not time (m/s) Start position 3 m behind first timing gate. Digital timer.	6.17 ±0.17 to 6.30 ±0.24 m/s
Sprint Time (20 m)	Oberacker et al. (2012)	NCAA Div II female soccer players / N=19	Single beam photocells (Brower timing). Subjects preferred starting position. Indoor track- surface not disclosed	3.51
	Shalfawi et al. (2013)	Elite Female soccer players (Norway 2nd Div)/ N=20	Infrared photocells (Newtest power timer portable system) measured to nearest 0.001 s	3.52 ±0.11 to 3.59 ±0.09

Sprint Time (20 m)	Sjokvist et al. (2011)	NCAA Div I female soccer players / N=14	Standing Start Electronic timing system (Brower)	3.58 ±0.19
	Gabbett et al. (2008)	Female Soccer Academy, Australia / N=16	Dual-beam electronic timing gates (Swift performance). Standing start. Time measured to nearest 0.01 s	3.20 ±0.14 to 3.30 ±0.14
Flying Sprint Time (20 m)	Siegler et al. (2003)	U.S. High school female players/ N=17	Electronic timer (Alge-Sports). Set at a 25 cm height. Concrete surface	3.00 ±0.15
Sprint Time (25 m)	Polman et al. (2004)	Elite players women's Northern Premier Division / N=36	Digital timing gates (Brower) Synthetic turf Standing start	4.12 ±0.13
	McCurdy et al. (2010)	NCAA Women Soccer Players/ N=15	Standing static split start with right foot lead. Sprint time measured by an accelerometer (attached to a waist belt) integrated with an electronic timing system	4.52 ±0.20
Sprint Time (30 m)	Krustrup et al. (2010)	Danish Top League players / N=23	Infrared light sensors (Time it; Eleiko Sport) precision of 0.01 s	5.06 ±0.06
	Sayers et al. (2008)	Professional female soccer players (USA) / N=20	Speed trap 2 automated timing device (Brower timing systems) Used pressure pad at start and two electronic timing gates Set at 2 m high from ground and 1 m apart	4.81 ±0.28
	Oberacker et al. (2012)	NCAA Div II female soccer players / N=19	Single beam photocells (Brower timing). Subjects preferred starting position. Indoor track- surface not disclosed	4.93 ±0.25
Sprint Time (40 m)	Nesser and Lee (2009)	NCAA Division I female players/ N=16	Speed trap II wireless timing system (Brower timing system) 3- point start stance	5.80 ±0.4
Agility Time (L-Shape)	Polman et al. (2004)	Elite players women's Northern Premier Division / N=36	Digital timing gates (Brower) Synthetic turf	Left: 6.05 ±0.10 Right: 6.17 ±0.10
Agility Time (4.5m-180°-4.5m)	Polman et al. (2004)	Elite players women's Northern Premier Division / N=36	Digital timing gates (Brower) Synthetic turf	2.62 ±0.13

Table 2.3. Female soccer player research data for maximum strength scores

Physical Assessment	Research	Subject status/ Number	Method	Score
1RM Squat Strength	Myer et al. (2005)	High school athletes/ n=45	Standard barbell Depth: thigh parallel to floor Was an 8rep max, which was converted to a predicted 1rep max score	Absolute: 65.7 ±1.9 kg Relative: 1.00 kg/bm
	Larson-Meyer et al. (2000)	American University players/ N=14	Smith Machine Depth not provided	Absolute: 97.5 ±10.0 kg Relative: 1.51 kg/bm
	Nesser and Lee (2009)	NCAA Division I female players/ N=16	Legend Strength Equipment Qualified coach who assessed “proper depth, technique etc”	Absolute: 75.8 ±14.0 Relative: 1.3 ±0.2 kg/bm

The VO_2max results from male soccer studies are also shown to be greater than the VO_2max from female soccer data in table 2.4 (58.4-63.4 vs. 44.2-57.6 $mL \cdot kg^{-1} \cdot min^{-1}$) (Wong et al., 2010; McMillian et al., 2005; Helgerud et al., 2001). The Yo-Yo IRTs are suggested to be a greater soccer-specific assessment as they mimic the workload and movements of a competitive match (Bangsbo et al., 2008; Krustrup et al., 2003; Krustrup and Bangsbo, 2001). Research in the Yo-Yo IRTL2 assessment has found female soccer data to be considerably lower than male soccer data (240-280 m vs. 591-1023 m) (Ingebrigsten et al., 2011; Krustrup et al., 2010; Thomassen et al., 2010; Rostgaard et al., 2008; Krustrup et al., 2006) (Table 2.4). Male soccer players are also shown to have greater Yo-Yo IRTL1 performance than female soccer players at senior level (1919-2414 m vs. 1224-1379 m); even youth male soccer players (under 9 and under 10) displayed greater performance within this test than senior females (1413-1427 m vs. 1224-1379 m), respectively.

Table 2.4. Aerobic capacity assessment data for female soccer players

Physical Assessment	Research	Subject Status/ Number	Method	Score
VO_2max (mL·kg^{-1}·min^{-1})	Clark (2010)	College and Adult recreational female players (U19) / N=32	12min running test. Distance covered (km) inputted into equation to calculate VO_2max. VO_2max = (22.351 x km run) – 11.288	57.27 ±1.59 mL·kg^{-1}·min^{-1}
	Gabbett et al. (2008)	Female Soccer Academy, Australia / N=16	VO_2max measured with multistage fitness test using equation described in a previous study	48.8 ±3.6 to 52.1 ±5.1 mL·kg^{-1}·min^{-1}
	Green et al. (2013)	Female Collegiate Soccer Players/ N=39	Laboratory assessment: motorised treadmill using continuous, incremental treadmill protocol Field assessment: Multi-stage test (20 m linear distance) and square route consisting of 20 m sides	41.8 ±3.1; 44.2 ±3.3; 49.6 ±3.9 mL·kg^{-1}·min^{-1}
	Grieco et al. (2012)	Female NCAA Div I Soccer Players / N=15	Incremental treadmill protocol, maintained 0° incline throughout. Start at 9 km/h speed and increase by 1 km/h every 2min until subject unable to maintain pace.	49.1 ±4.2 mL·kg^{-1}·min^{-1}
	Krustrup et al. (2010)	Danish Top League female players / N=23	Exhaustive incremental treadmill test	52.3 ±1.3 mL·kg^{-1}·min^{-1}
	Krustrup et al. (2005)	Elite female soccer players / N=14	Continuous, incremental treadmill protocol	49.4 mL·kg^{-1}·min^{-1}
	Miller et al. (2007)	Female Collegiate Soccer Players/ N=26	Continuous, incremental treadmill (motor driven) protocol	44.87 ±4.6 to 49.64 ±5.3 mL·kg^{-1}·min^{-1}
	Polman et al. (2004)	Elite players women's Northern Premier Division / N=36	20 m multi-stage shuttle run results converted into VO_2max score. Conversion not stated.	46.0 ±2.89 mL·kg^{-1}·min^{-1}
	Sjokvist et al. (2011)	NCAA Div I female soccer players / N=14	Continuous exhaustive incremental test on motorised treadmill. VO_2 measured using an automated metabolic measurement system (VacuMed model MX)	53.9 ±5.7 mL·kg^{-1}·min^{-1}

VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$)	Ingebrigtsen et al. (2011)	Elite Senior Female Soccer Players (Norway) / N=29	Continuous incremental protocol on treadmill (Rodby) with load increasing every 30 s using Sensor Medics model to obtain VO_2max scores.	50.7 ±4.96 to 5.4 ±5.7 $mL \cdot kg^{-1} \cdot min^{-1}$
	Upton (2011)	Female NCAA Div I Soccer Players / N=27	Does not state	46.1 ±4.6 $mL \cdot kg^{-1} \cdot min^{-1}$
Yo-Yo Intermittent Endurance Test Level 2	Krustrup et al. (2010)	Danish Top League players / N=23	2 x 20 m shuttles with 2.5 m recovery distance. 5 s recovery between each shuttle run.	1213 ±90m
Yo-Yo Intermittent Recovery Test level 1	Krustrup et al. (2005)	Elite female soccer players / N=14	2 x 20 m shuttles with 5 m recovery distance. 10 s recovery between each shuttle run.	1379 m
	Mujika et al. (2008)	Professional Female Soccer Players (Senior and Junior)/ N=34	2 x 20 m shuttles with 5 m recovery distance. 10 s recovery between each shuttle run.	Senior: 1224 ±255 m Junior: 826 ±160 m
Yo-Yo Intermittent Recovery Test Level 2	Oberacker et al. (2012)	NCAA Div II female soccer players / N=19	2 x 20 m shuttles with 5 m recovery distance. 10 s recovery between each shuttle run.	Level 18.2-18.3 ±4.6 Distance: 240-280 m

Potential reasons for the physical performance differences between female and male soccer players could be the level of conditioning females possess in relation to males. Research has shown females have lower neuromuscular control, hamstring strength, quadriceps to hamstring strength ratio, hip and knee flexion during landing than males (Myer et al., 2009; Chappell et al., 2007; Hewett et al., 2006; Hewett et al., 2005a; Hewett et al., 2005b; Zazulak et al., 2005; Ford et al., 2003). Further to this, the female soccer players will be exposed to circadian variations in oestrogen and progesterone throughout their menstrual cycle which cause fluctuations in their metabolism, thermoregulation, muscle contractile responses and endurance (Hewett et al., 2007; Bambaeichi et al., 2004; Stachenfeld et al., 2000; Philips et al., 1996; Sarwar et al., 1996; Bunt et al., 1990). However, the current research investigating the effect the menstrual cycle has on physical performance qualities is inconsistent. Some studies have reported no significant differences between physical performance variables and the phases of the menstrual cycle (Hertel et al., 2006; de Jonge et al., 2001; Gur, 1997; Lebrum et al., 1995), while others have demonstrated differences (Gordon et al., 2013; Greeves et al., 1999; Philips et al., 1996; Sarwar et al., 1996). Further inconsistencies are present between the literature which reported significant differences between the phases of the menstrual cycle and physical performance. For example, Sarwar et al. (1996) noted increased strength and reduced fatigability mid cycle while other research has found peak strength occurs mid-luteal phase (Greeves et al., 1999) or mid-follicular (Philips et al., 1996). Further contradictions were reported in Gordon et al. (2013) showing significant decrements in strength qualities during menses. Thus, it can be stated that more consistency is required within this research area.

In reference to female youth soccer player's physical performance pre-, during- and post-puberty, limited research has been explored. A critical period for the youth players is when they go through peak height velocity (PHV). PHV is where puberty begins and a rapid growth spurt commences resulting in a decline in motor coordination due to trunk and leg growing at different times. Sherar et al. (2005) reported this occurs on average at the age of 13.85- years for males and 11.58- years for females. However, not all individuals mature at the same rates so Sherar et al. (2005) found the early maturers hit PHV on average at 12.33- years for males and 10.30- for females, while late maturers go through PHV on average at 15.26- and 12.92- years for males and females, respectively. Therefore, in a soccer team PHV will not always occur at the same time due to each player maturing at different stages to each other.

The long-term athlete development (LTAD) model suggests neuromuscular efficiency is at its greatest pre-puberty and pre-PHV allowing accelerated adaptations to occur for skill, speed and suppleness. The model also states that an increase in hormonal responses post-puberty promotes strength and power related physical qualities. It is important to state that this model is based on a theory and lacks of empirical evidence to support the LTAD model's assumptions. For instance, Lloyd et al. (2011) reported no critical periods of accelerated adaptation between the age groups when assessing squat jump and countermovement jump performance of subjects at every year group from 7-years old to 16-years old. Lloyd et al. (2011) did however find a significant decline in performance between the ages of 10- and 11-years, and 11- and 12- years, which may be as a result of peak height velocity (PHV).

Research from Lloyd et al. (2011) did show interesting development patterns between the age groups for squat jump and countermovement jump performance of males based on their chronological age. Similar research from Vescovi et al. (2010) assessed female soccer player's physical performance between 12- and 21- years old, which based on Sherar et al.'s (2005) findings, is after PHV has occurred for the majority of these players (10.3 yrs). Therefore, this makes it difficult to analyse the physical performance of these female soccer player pre-puberty, during PHV, and post-puberty. Vescovi et al. (2010) did however find some interesting results from their research study.

2.4. Performance Assessments During Soccer Matches

Numerous methods have been developed over the last few decades which enable a soccer player's performance to be assessed during a competitive match. Some of these methods include time-motion analysis, global positioning systems (GPS), semi-automated computerised systems; which have enabled a physiological profile to be developed across standards of play (Lago-Penas et al., 2011; Andersson et al., 2010; Ayllon et al., 2010; Bradley et al., 2010; Rampinini et al., 2009; Mohr et al., 2008; Mohr et al., 2003), male and female sports (Goto et al., 2013; Silva et al., 2013; Dwyer and Gabbett, 2012; Harley et al., 2011) with special references to playing position (Wehbe et al., 2014; Andrzejewski et al., 2013; Di Mascio and Bradley, 2013; Vigne et al., 2013; Andrzejewski et al 2012; Gomez-Piriz et al., 2011; Lago-Penas et al., 2011; Andersson et al., 2010; Ayllon et al., 2010; Bradley et al., 2010; Dellal et al., 2010a; Gregson et al., 2010; Mohr et al., 2008; Mohr et al., 2003), and senior and youth levels (Wehbe et al., 2014; Andrzejewski et al., 2013; Di Mascio and Bradley, 2013; Goto et al., 2013; Silva et al., 2013; Vigne et al., 2013; Andrzejewski et al 2012; Dwyer and Gabbett, 2012; Gomez-Piriz et al., 2011; Harley et al., 2011; Lago-Penas et al., 2011; Andersson et al., 2010; Ayllon et al., 2010; Bradley et al., 2010; Dellal et al., 2010a; Gregson et al., 2010; Rampinini et al., 2009; Mohr et al., 2008; Mohr et al., 2003).

The common key variables assessed throughout the literature include the total distance covered, and the distance covered whilst walking, jogging, low-intensity running, moderate intensity running, high-intensity running and sprinting; with each category containing a specific speed zone. However, the speed zones across the literature are not normalised and remain inconsistent which hinders the value of normative data and makes it very difficult to compare and contrast data. Table 2.5 highlights that on average, Prozone contain greater sprinting speed zones than 80% of other methods (>25.2 km/h vs. 18- 24 km/h), suggesting research data using this method to assess match performance may be an under estimation of actual sprint performance.

Table 2.5. Showing the speed zone categories from senior soccer match research (male and female)

Research	**Walk (km/h)**	**Jog (km/h)**	**Low-Speed Run (km/h)**	**Moderate-Speed Run (km/h)**	**High-Speed Run (km/h)**	**Sprint (km/h)**
Di Mascio and Bradley (2013); Bradley et al. (2010); Gregson et al. (2010) **Prozone**	0.7 -7.1	7.2 -14.3	14.4 -19.7		19.8 -25.1	≥ 25.2
Andrzejewski et al. (2013); Andrzejewski et al. (2012); Lago-Penas et al. (2011) **Amisco Pro**	0 -11		11 -14	14 -19	19 -23	> 23
Dellal et al. (2010a) **Amisco Pro**					21 -24	> 24
Silva et al. (2013); Mohr et al. (2003) **Time motion analysis**	0.1 -6	6 -8	8 -12	12 -15	15 -18	18 -30
Andersson et al. (2010); Mohr et al. (2008) **Time motion analysis**	0.1 -6	6.1 -8	8.1 -12	12.1 -15	15.1 -18	18 -25
Vigne et al. (2013) **Time motion analysis**	≤ 5		5.1 -13	13 -16	16.1 -19	> 19
Rampinini et al. (2009) **SICS**					> 14	> 19
Owen et al. (2014) **GPS (Catapult, 5 Hz)**	0 -7.2	7.3 -14.3	14.4 -21.5		21.6 -25.2	> 25.3
Souglis et al. (2013) **GPS (Garmin)**	0 -7.15	7.16 - 11.39	11.40 - 13.79	13.80 - 19.31	19.32 - 24.14	≥ 24.15
Wehbe et al. (2014) **GPS (GPSports, 5 Hz)**	0.7 -7.1	7.2 -14.3	14.4 -19.7	19.8 -25.1		> 25.1

Speed zones have also differed between studies even though they used the same technology analysis software. The use of Amisco Pro in Dellal et al. (2010a) showed speed zones of 21-24 km/h and >24 km/h for high-intensity running and sprinting, respectively; whilst other multiple investigations show different high-intensity speed zones 19-23 km/h and sprint speed zones >23 km/h (Andrezejewski et al., 2013; Andrezejewski et al., 2012; Lago-Penas et al., 2011). It is important to note that the literature tends to report absolute values from the speed zones rather than normalising results, which may not reflect each player's individual work rate capabilities due to differences in sprint ability. For example, if a slow individual sprints to their full maximal speed, this may not be actually fast enough to register as a 'sprint' in the speed zones created. On the other hand, an individual who can sprint fast will find it easier to produce work rate values in the higher speed zone categories. In spite of this, absolute values allow us to compare players and other research with each other; normalising speed categories to each player's sprint ability would make these comparisons difficult and could allow a poorly conditioned player to appear considerably better than a greater conditioned player.

In addition, the use of different technological equipment and analysis software also limits the reliability between research data. Comparing soccer match performance assessment data from time-motion analysis (Silva et al., 2013; Vigne et al., 2013; Andersson et al., 2010; Mohr et al., 2008; Mohr et al., 2003; Helgerud et al., 2001), semi-automative computer systems (Andrezejewski et al., 2013; Di Mascio and Bradley, 2013; Andreezejewski et al., 2012; Lago-Penas et al., 2011; Bradley et al., 2010; Dellal et al., 2010a; Gregson et al., 2010; Rampinini et al., 2009) and GPS (Owen et al., 2014; Wehbe et al., 2014) methods may not be valid.

Due to the nature of the sport, research has reported coefficient of variation and ICC values for all match activity assessments with considerable large ranges (r=0.898-0.980, CV 1-13%) (Silva et al., 2013; Castagna et al., 2010; Castagna et al., 2003; Mohr et al., 2003; Helgerud et al., 2001). This large variability between the matches could be explained by the different opposition the team plays, different tactics performed on that particular day, different set of players in the starting 11, score of the game, the pressure on the outcome of the game.

Further inconsistencies between research data may exist due to different models of equipment, such as the GPS manufacturer (e.g. GPSports vs. Catapult), and various sampling frequencies available from each GPS merchant. Each GPS unit is created at a specific sampling frequency: the speed at which a GPS unit can collect movement information. Currently there are GPS units manufactured with sampling rates of 1-, 5-, 10- and 15-Hz with evidence that the lower sampling rates (1-Hz) provide a poor degree of inter-reliability when measuring athletic movement than the greater sampling rates (Johnston et al., 2012; Coutts et al., 2010). These assumptions could be made particularly for high intense activities such as high speed running and sprinting, particularly over short distances which have suggested to increase the level of error with GPS methodology (Johnston et al., 2012; Portas et al., 2010; Duffield et al., 2010). For example, if an individual sprints 5- metres in less than 1- second this may not be recorded in the lower sampling GPS units (1-Hz). Moreover, a female soccer match consists of 1326-1379 changes in activity and these changes happen at such a high intensity that a low sampling frequency (1-Hz), which samples just once per second, may miss a great amount of these changes in activity (Mohr et al., 2008). Whereas, a high sampling frequency GPS unit (5-15- Hz) is more likely to capture these changes in activity due to sampling >5 times per second. Portas et al. (2010) stated 5-Hz sampling frequency provides a lower range of error at higher speed intensities when compared to 1-Hz GPS frequencies (SEE: 2.2-4.4% vs. 1.8-6.8%) which also supports the findings that 1-Hz underestimates soccer-specific performance activity. Thus, it may be possible to suggest that a greater sampling frequency GPS unit (>1-Hz) would be more beneficial to use when assessing multiple interchangeable- and high- speed intensities involved in soccer.

GPS units have been used across numerous research studies in order to detect physical demands and movements involved in sports such as rugby league (Austin and Kelly, 2014; Austin and Kelly, 2013; McLellan and Lovell, 2013; McLellan et al., 2011), rugby union (Suarez-Arrones et al., 2014; Cunniffe et al., 2009), long distance running (Nielsen et al., 2013), field hockey (Dwyer and Gabbett, 2012; Gabbett, 2010), futsal (Dogramaci et al., 2011), Australian rules football (Dwyer and Gabbett, 2012; Young et al., 2012), and other court and field-based sports (Vickery et al., 2014) with limited studies examining competitive soccer matches at senior level (Wehbe et al., 2014; Harley et al., 2011; Ayllon et al., 2010). These research studies investigating soccer match performance were published on Australian, Spanish and English male soccer teams at the elite level (Wehbe et al., 2014; Harley et al., 2011; Ayllon et al., 2010), respectively. These findings not only highlight the lack of published research on soccer match performance within England using GPS but it also identifies, at this point in time, there are no match assessments of female soccer using GPS methods.

2.5. Research on Male Soccer vs. Female Soccer

Match performance research in terms of gender comparison has shown to be similar in the total distance covered (8,600-12,000 m vs.9,100-11,900 m) during a match for males and females, respectively from semi-computerised, time-motion and GPS methodological assessments (Wehbe et al., 2014; Andrzejewski et al., 2012; Lago-Penas et al., 2011; Andersson et al., 2010; Bradley et al., 2010; Krustrup et al., 2010; Rampinini et al., 2009; Andersson et al., 2008; Di Salvo et al., 2007; Hewitt et al., 2007; Krustrup et al., 2005; Mohr et al., 2003; Rahnama et al., 2002; Helgerud et al., 2001) (Table 2.6, page 64). However, the sprinting distance (240-720 m vs. 250-460 m) and high-intensity distance (1,280-2,630 m vs. 1,300-1,680 m) in a match is reported to be greater for male than females soccer players (Wehbe et al., 2014; Andrzejewski et al., 2012; Lago-Penas et al., 2011; Andersson et al., 2010; Mohr et al., 2008; Mohr et al., 2003) (Table 2.6, page 64), respectively. To support this, when comparing the number of sprint bouts at elite and senior level, males performed greater totals than females (11.2-41 vs. 20-30) (Andrzejewski et al., 2012; Andersson et al., 2010; Gregson et al., 2010; Mohr et al., 2008; Mohr et al., 2003).Thus, it may be suggested female soccer players are able to produce similar volumes during a match in comparison to males, however, their high intensity and sprint performance are less than males.

Table 2.6. Normative data for match performance for female soccer players

Match Assessment	**Research**	**Subject Status/ Number**	**Score**
Average percentage of the Maximum Heart Rate	Krustrup et al. (2010)	Danish Top League players / N=23	86%
	Andersson et al. (2010)	Swedish and Danish Top class players/ N=17	84%
Blood Lactate	Krustrup et al. (2010)	Danish Top League players / N=23	1st half: 5.1 ±0.5 mmol.L 2nd half: 2.7 ±0.4 mmol.L
Distance covered (m)	Mohr et al. (2008)	National team players/ N=19 Elite players/ N=15	10,330 ±150 m 10,440 ±150 m
	Andersson et al. (2010)	Swedish and Danish Top class players/ N=17	9,900 ±1,800 m
	Krustrup et al. (2005)	Elite Danish players N=14	10,300 m
	Andersson et al. (2008)	International Swedish/ Danish players N=22	10,000 m 9,700 m
	Di Salvo et al. (2007)	International English players N=30	11,980 m
	Hewitt et al. (2007)	International Australian players N=6	9,140 m
High-intensity running distance (m)	Andersson et al. (2010)	Swedish and Danish Top class players/ N=17	1,530 ±100 m
	Mohr et al. (2008)	National team players/ N=19 Elite players/ N=15	1,680 ±90 m 1,300 ±100 m
Sprint distance (m)	Andersson et al. (2010)	Swedish and Danish Top class players/ N=17	250 ±570 m
	Mohr et al. (2008)	National team players/ N=19 Elite players/ N=15	460 ±20 m 380 ±50 m
Number of changes in activity	Mohr et al. (2008)	National team players/ N=19 Elite players/ N=15	1379 ±34 and 1326 ±24

Number of high-intensity runs	Mohr et al. (2008)	National team players/ N=19 Elite players/ N=15	154 ±7 and 125 ±7
	Andersson et al. (2010)	Swedish and Danish Top class players/ N=17	149 ±15 and 151 ±14
Number of sprint bouts	Mohr et al. (2008)	National team players/ N=19 Elite players/ N=15	30 ±2 and 26 ±1
	Andersson et al. (2010)	Swedish and Danish Top class players/ N=17	27 ±4 and 20 ±3

Summary

This chapter (2.0) included a detail overview of the current research methods and data of female soccer players across both physical and match performance assessments. The main considerations to take from the literature review were there appears to be a lack of research on female soccer players and there are considerable inconsistencies between the current research studies' methods. There is also a lack of methodological detail reported within the current research studies on female soccer player's physical performance which makes it difficult to compare and contrast the assessment data results. Chapters -3.0, -5.0, -7.0, -8.0, -9.0 and -10.0 aim to improve the quantity and quality of this within the female soccer literature.

The current speed zones measuring match performance are inconsistent which makes it difficult to compare and contrast the current data. The speed zones used within the match performance assessment chapters (4.0, 6.0, 8.0, 9.0) stay consistent with the greater quality, consistent research (Andersson et al., 2010; Mohr et al., 2008).

The use of lower sampling GPS units could provide a lower degree of inter-unit reliability when measuring athletic movement than greater sampling rates; with suggestions to use GPS units with sampling rate of >5Hz. There is a lack of data on match performance for female soccer players. In particular, there is limited published data using GPS methods to assess match performance within soccer in England, and there are no match assessments of female soccer using GPS methods. Chapters -4.0, -6.0, -8.0, and -9.0 aim to improve the quantity and quality of this within the female soccer literature by using 5 Hz GPS units.

2.6. Research Objectives

The overarching aim of this research thesis is to develop physical- and match- performance profiles of female soccer players in England across senior and youth players at both elite and non-elite levels of play.

a. Identify the reliability of specific assessment methods for physical performance tests (Chapter 3.0)
b. Determine the reliability of match performance assessment methods (Chapter 4.0)
c. Assess the physical performance of female youth soccer players (Chapter 5.0)
d. Determine the match performance differences between elite vs. non-elite youth female soccer players (Chapter 6.0)
e. Investigate whether physical performance differs between playing positions (Chapter 7.0)
f. Identify the differences between starters and non-starters within physical and match performance data for senior female soccer players (Chapter 8.0)
g. Assess the physical and match performance assessment data of senior female soccer players based on their level of play (league comparison) (Chapter 9.0)
h. Identify any differences of the final league position of female soccer teams based on their physical performance assessments (Chapter 10.0)

Chapter 3.0.

Are the methods of assessing physical performance reliable?

Introduction

One of the most important aspects about physical performance testing is the level of reliability each assessment attains through every single testing session. Assessing reliability of each testing method is vital as it allows us to determine whether those particular methods are reproducible with neither marked systematic nor random variation (Enoksen et al., 2009; Hopkins, 2000). The level of reliability an assessment method has could negatively or positively influence the ability to track changes in measurements (e.g. pre- and post-intervention training) and compare different subject groups. Therefore, it is important to distinguish what measurement errors can be accepted for practical use (Enoksen et al., 2009; Hopkins, 2000).

Female soccer research has demonstrated various methods whilst assessing physical performance variables (Table 2.1, page 50), which makes it difficult to compare each study's results. Countermovement jump height research studies (Buckthorpe et al., 2012; Moir et al., 2008; Aragon-Vargas, 2000) have shown how jump height can be misreported due to different equipment being used. Moir et al. (2008) found contact mats under reported (34%) when compared to assessment methods carried out on force plates, while Aragon-Vargas (2000) reported contact mats under estimated jump height in comparison to 3D motion analysis of centre of mass (-29%). Further research by Buckthorpe et al. (2012) reported similar results between laboratory force plate, portable force plate and belt mat devices (50.3±7.5 cm vs. 49.5±7.2 cm vs. 50.2±7.8 cm), whilst the vertec and contact mat devices were found to under report jump height in comparison to the actual laboratory force plate methods (47.9±7.9 cm and 38.6±6.5 cm vs. 50.3±7.5 cm), respectively. It is likely these differences may be due to the reliability of the equipment and methodologies used, and the varying calculations of jump height. For example, contact mat methods begin calculating jump height when the participant leaves the floor (end of take-off) and finishes on participant landing and does not take the first initial rise in centre of mass into account like 3D motion analysis methods. Another possible reason for the discrepancies in jump height results between the equipment methods may be due to the various landing techniques of the participants; some subjects will adopt a straight legged (hips and knees extended, and ankles plantar-flexed) landing, while others demonstrate a slightly crouched landing position (hips and knees flexed, and ankles dorsi-flexed) which has shown to contribute to differences of 2.3-2.8cm (Enoksen et al., 2009; Aragon-Vargas, 2000; Kibele, 1998).

Further to this, even the height at which the timing gate equipment are situated at, the distance the subject is behind the starting timing gate and the starting stance the subject has on the start line can all influence sprint time (Haugen et al., 2014; Earp, 2012; Cronin and Templeton 2008; Cronin et al., 2007; Kraan et al., 2001; Yeadon et al., 1999). For example, subject starting the sprint 1 -metre behind the start line benefits from utilising greater centre of mass velocities before the timing has begun, whilst a 0 –metre starting point does not (Cronin et al., 2007; Kraan et al., 2001). Differences in sprint start positions adopted contribute to variations in sprint performance results due to some starts promoting a false step mechanism, which enables a greater contribution from the stretch shorten cycle resulting in greater force and power production, thus faster sprint times (Cronin et al., 2007; Kraan et al. 2001). Another possible reason for the inconsistencies in sprint performance results could be due to the type of equipment used. A single-beam timing system involves just one beam that a subject must break through when sprinting while dual-beam timing systems contain two photocells set at different heights and requires both of these beams to be triggered simultaneously in order to register the split time. Whilst sprinting, if a subject breaks one beam with their arm using single-beam timing system and at the next timing gate break the beam with their torso this could increase the measurement error since the torso 30 cm behind the leading arm. The dual-beam timing systems aim to solve the problem of beams being broken by a leading arm or thigh (Haugen et al., 2014; Earp, 2012; Yeadon et al., 1999).

Limited performance data exists in female soccer players compared to their male counterparts (Figure 1.1, page 23) and a lack of consistency is reported between this limited number of female research methods (section 2.2), which ultimately leads us to question the current reliability of female soccer performance data. For example, only 1 out of the 11 sprint performance studies discussed in section 2.2 used the most accurate timing equipment (dual-beam timing system), 2- out of 4- studies standardised the starting stances on the start line, the other 5- studies did not report which stance was used, and only 4- out of the 11- studies reported the height at which the timing gates situated at. This highlights the variation of testing protocols used on female soccer players which makes it hard to compare and contrast the current data at present. Thus, suggestions for more research within this area is required but also a greater number of studies with consistent assessment protocols and disclosure of greater detailed methods so researchers can compare and contrast findings reliably. Therefore, the purpose of this chapter is to identify the reliability of specific assessment methods for physical performance tests.

Participants

Fourteen senior non-elite female soccer players (age: 23.8±1.7 yrs; body mass: 68.8±6.9 kg; height: 169.4±7.1 cm) from a Northern Premier Division team in England were recruited to take part in this reliability research study. All players were registered to the same club so that they followed the same weekly training regime. The study was carried out on the same day each week for three consecutive weeks to determine within and between session reliability of each assessment. Subjects who did not participate within each of the three reliability testing sessions were excluded from the study.

Protocol

Physical performance tests used within this study included body mass, height, body fat composition, Yo-Yo IRTL1, 5 m-, 10 m-, 20 m- sprint time, agility 5-0-5 for left and right legs, countermovement jump height, depth jump rebound height and Nordic hamstring lowers. Each test protocol was explained to each subject and the methods remained consistent across each assessment throughout the data collection process. The order of the physical tests were: body mass, height, body fat composition, countermovement jump height, depth jump rebound height, 20 m sprint, agility 5-0-5 left and right, Nordic hamstring lowers and Yo-Yo IRTL1. Each subject was given three minutes rest between each test, except the rest time between the Nordic hamstring lowers and the Yo-Yo IRTL1 was approximately ten minutes to allow the squad to finish the rest of the physical performance tests. The researcher gained permission from the relevant personnel at the soccer club, each participating subject provided written signed an informed consent and the study was approved by the University of Salford Research and Ethics Committee (HSCR13/46). Each subject was asked to stay hydrated and refrain from any activity on the day of the testing and eat no less than 3- hours before the testing. This was standardised across each testing session. Each testing session over the three weeks were carried out on the same day each week, the same time and in the same training facilities.

Body Mass

Subject's during this research studies had their body mass assessed using scales (Seca delta Model 707, Birmingham, UK). The subjects were instructed to remove footwear (football boots / trainers) and any heavy clothing (coats, jumpers, jackets). Body mass assessments were carried out over three separate occasions for three weeks (one week between each test bout) to assess the amount of change and calculate smallest detectable difference.

Height

The assessment of the subject's height was carried out using the height stadiometer (Seca 213, Leicester Height Measure). Each subject was asked to remove footwear and stand upright with their heels in contact with the bottom and back of the board of the stadiometer. Measurements were collected in centimetres. Each subject's height was assessed over three separate occasions for three weeks with one week between each testing bout.

Body Composition

Sum of skinfold and body fat composition percentage variables were calculated using a three-site skinfold (triceps, suprailiac and mid-thigh) measurement using Harpenden Skinfold Callipers (Baty International) and an age- and sex- specific formula:

% Body Fat = (0.41563 *x sum of skinfolds)* – (0.00112 *x square of the sum of skinfolds) +* *(*0.03661 x age) + 4.03653 (Jackson et al., 1980).

The three-skinfold sites from this study were also used in Terbizan et al. (2009) who reported no significant differences between these methods and seven-skinfold site methods ($p>0.05$). Other research has reported the high reliability from the three-skinfold site assessments from ICC statistical analysis, r= 0.996-0.999 (Loenneke et al., 2013; Bahamonde et al., 2009). All measurements were taken on the right side of the body, before exercise and by the same assessor (Clark et al., 2008; Heyward et al., 2002; Heyward and Stolarcyk, 1996). The body composition assessment was carried out on each subject on two separate occasions over two weeks, with one week between each testing bout.

Sprint

Sprint performance was measured over 5 m, 10 m and 20 m using timing gates (Brower SpeedTrap 2 Wireless Timing System) (Figure 3.1). These sprint distances were assessed as these are regularly performed in soccer, which are reflected in the literature (Chelly et al., 2010; Bangsbo, 1991). The timing system was single –beam which were situated at 95cm above the ground to allow the subjects to break the timing light at hip height and set up 1-metre apart between the transmitter and receiver (Yeadon et al., 1999). The subjects were instructed to perform three maximal effort sprint trials each with a 2-point split static stance on the start line and to keep accelerating until they had gone through the last pair of timing gates (20 m line) and 120- seconds between trials to allow full recovery. The start line was positioned 1- metre behind the first timing light (0m- line) to avoid a false trigger of the beam and to reduce the influence of a 'fly' time effect (Figure 3.1). This testing protocol was performed on three separate occasions over three weeks, with one week between each testing bout.

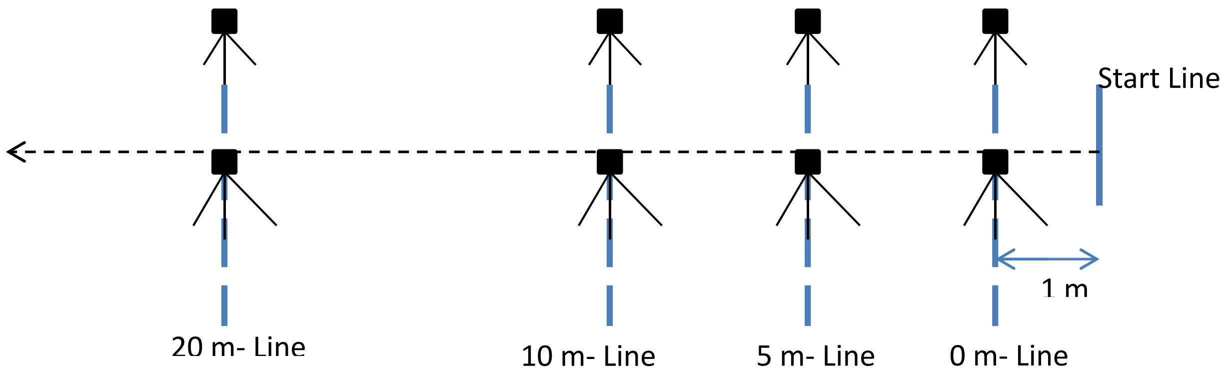

Figure 3.1. Sprint performance assessment set-up

Agility

Due to the high number of changes in direction within soccer (Bloomfield et al., 2007), the Agility 5-0-5 test (Figure 3.2) was used; which involves sprinting through the timing gate and forwards 5 m, turning 180 ° and sprinting back 5 m through the timing gate. Each subject was instructed to perform three trials on both left and right turns with 120- seconds rest given between each trial. Time measures were taken using timing gates (Brower SpeedTrap 2

Wireless Timing System) which were situated at 95 cm to allow the subjects to break the timing light at hip height, and were set up 1- metre apart.

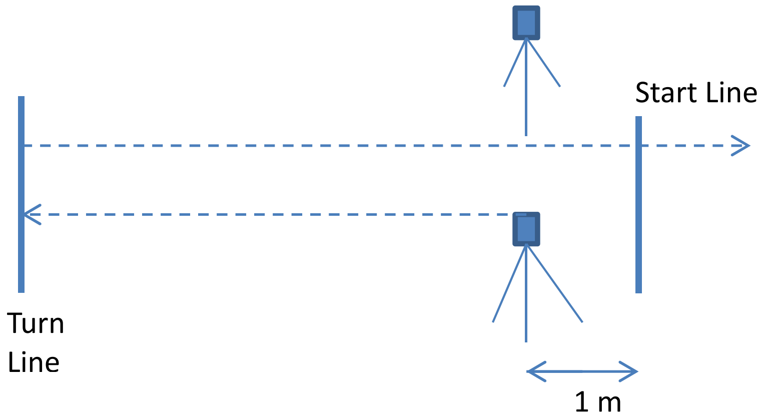

Figure 3.2. Showing the layout and protocol of the agility test

Each subject began the test in a static split, two-point stance and were instructed to perform each agility trial with maximal effort and to turn on the line and not to slow down until they had run back through the timing gates. If the subject did not hit the ‘turn line,’ they were instructed to take 120- seconds rest and complete that particular trial again. The start-line was positioned 1- metre behind the timing gates to avoid a false trigger of the beam and to reduce the influence of a ‘fly’ time effect. The agility 5-0-5 test was performed three times over three weeks with seven days separating each testing bout.

Countermovement Jump Height

Countermovement jump height was calculated using a contact mat (FSL Electronics Ltd, Northern Ireland) and FSL jump software (V1.01). Subjects were asked to stand on the mat with their feet hip width apart and their hands on their hips throughout the performance of the jump; take off, flight and landing (Figure 3.3). If the subject's hands were removed from their hips, that trial was discounted and the subject was asked to perform the trial again and reminded of the protocol. One practice trial was allowed prior to three maximum efforts with the maximum jump height taken as their best result. This testing protocol was performed on three separate occasions over three weeks, with one week between each testing bout.

Figure 3.3. Performance of the countermovement jump

Depth Jump Rebound Height

Depth jump rebound height was also calculated using a contact mat (FSL Electronics Ltd, Northern Ireland) and FSL jump software (V1.01). Subjects were asked to start the performance of the depth jump stood on the 30 cm step, with their feet hip width apart and their hands on their hips. All subjects were familiarised with the technique and instructions on how to perform the depth jump correctly (Figure 3.4). The subjects were asked to keep their hands on their hips throughout the depth jump performance and reminded if their hands were removed from their hips the trial would be dismissed and they would be asked to perform that trial again. One practice trial was allowed prior to three maximum efforts with the maximum jump height taken as their best result. The depth jump test was performed three times over three weeks with seven days separating each testing bout.

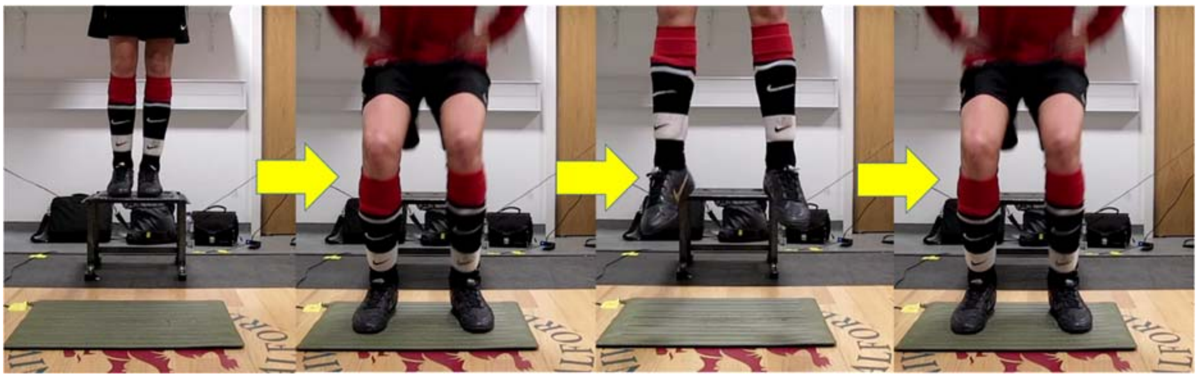

Figure 3.4. Performance of the depth jump

Nordic Hamstring Lowers: Break Point Angle

Nordic hamstring lowers is a hamstring specific exercise which has shown to improve the strength of the hamstrings by 11% and reduce the number of hamstring injuries in soccer players by 47% after a 10- week Nordic hamstrings training intervention (Mjolesnes et al., 2004; Askling et al., 2003). Hamstrings are vital in soccer and work hard through sprint related activity and deceleration type movements such as changing direction, stopping, landing etc.

The Nordic hamstring lowers in the present study were recorded using Casio Exlim-F1 camera (60- Hz) placed in the sagittal plane positioned 5 m away with a calibration trial recorded at the beginning of each testing session. Each subject was instructed to perform three maximal trials of the Nordic hamstring lowers after one sub-maximal practice trial. A sub-maximal practice trial was performed to ensure the correct technique and protocols were met: slow controlled speed of movement throughout, adopting a kneeling position with hips slightly flexed and the head, trunk and thigh falling forwards about the knee until they could no longer withstand the fall with the hamstring providing the main resistance against gravity (Sconce et al., 2015; Tansel et al., 2008) (Figure 3.5). To ensure loading was the same arms and hands were at the subject's side or across their chest and released to be used as a buffer for the fall, letting the chest touch the surface (Sconce et al., 2015; Mjolsnes et al., 2004).

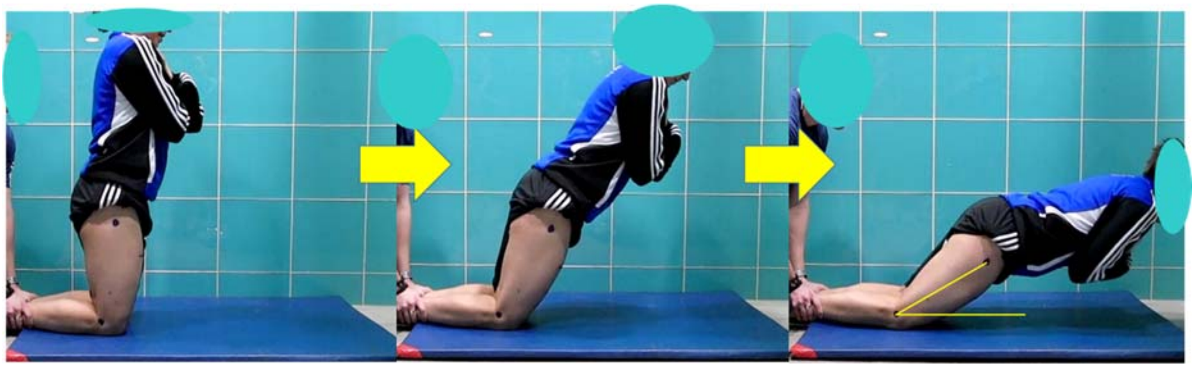

Figure 3.5. Nordic hamstring lowers assessment

Theoretically, the lower the break point angle the individual achieves, the greater the individual’s eccentric hamstring strength (Sconce et al., 2015). If the practice trial involved faults (e.g. trunk/hip flexed significantly, hands moved from across their chest/by their side before break point during eccentric phase) they were given the relevant coaching points so the three maximal attempts of the Nordic hamstring lowers were performed to a high technical standard. Because this test involved maximal eccentric strength of the hamstrings, 30- seconds rest was given between each trial to minimise the effects of fatigue.

This test was performed on three different occasions, with seven days separating each testing session. Markers were placed on the subject’s greater trochanter and lateral epicondyle, on the side of the body closest to the camera, and used to determine the break point angle when using Quintic Biomechanics software (9.03 v17). Break point angle was determined at the moment in time where the subject can no longer withstand the fall, and the angle measured from the Greater Trochanter (hip) to lateral epicondyle (knee) to the horizontal angle. The best Nordic break point angle result (lowest, closer to floor) for every athlete was taken from the three maximal trials and used as their score (Sconce et al., 2015).

A separate study, using this data, was performed to assess the intra-rater reliability of the researcher’s ability to measure the Nordic hamstring lowers break angle in Quintic Biomechanics software (9.03). This involved twenty-four subjects carrying out three trials of Nordic hamstring lowers and the researcher measuring each individual’s three trials, three times. The results of the ICC showed the researcher’s accomplished excellent intra-rater reliability (r= 0.972).

Yo-Yo Intermittent Recovery Test Level 1 (IRTL1)

The Yo-Yo IRTL1 involves repeated 2 x 20- metre runs (Figure 3.6: A to B to A) with 2 x 5-metres of recovery activity in between each high-tense bout of running. The 2 x 20-metre shuttle runs increase speed progressively which is controlled by audio bleeps from a tape recorder. The 2 x 5- metre of recovery activity (jog / walk) lasts 10-seconds and remains consistent throughout the test. The Yo-Yo IRTL1 consists of 4-running bouts at 10-13 km/h (0-160 m), 7-shuttle runs at 13.5-14 km/h (160-440 m) and subsequent continuous speed increments of 0.5 km/h after every 8- shuttle runs.(i.e. after 760 m, 1080 m, 1400 m, 1720 m, 2040 m, 2360 m etc.) (Krustrup et al., 2003). Strict rules were in place whereby if the subjects started to run past the start line (Figure 3.6: Line A) before the first 'beep,' at the start of each shuttle, they were given a start line warning: if they received two start line warnings they were automatically dismissed from the test. Similarly, if the subject's did not make it back to the finish line (Figure3.6: Line A) in time for the second 'beep,' they were issued with a finish line warning: if they received two finish line warnings they were asked to withdraw from the test. If subject's dropped out (without dismissal) or received a start line / finish line dismissal the last completed shuttle level was noted down as their Yo-Yo IRTL1 score. The Yo-Yo IRTL1 assessment was carried out on each subject on two separate occasions over two weeks, with one week between each testing bout.

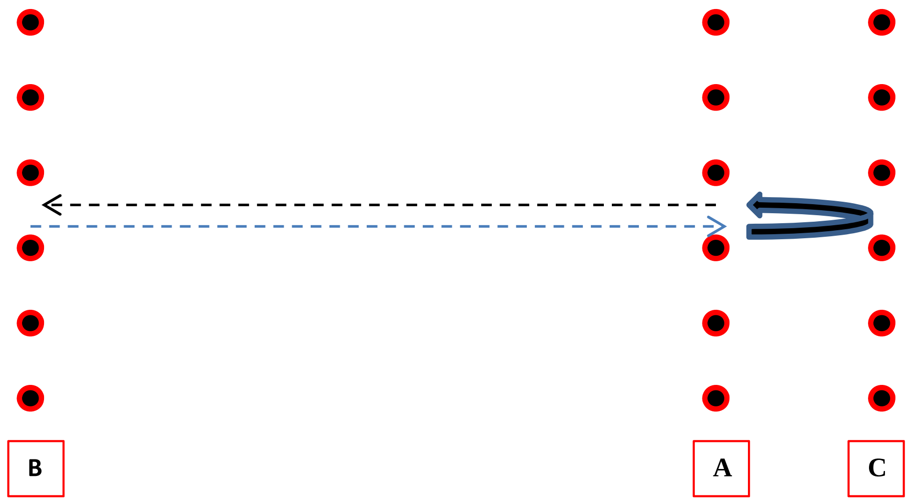

Figure 3.6. Yo-Yo Intermittent Recovery Test Level 1

Statistical Analysis

The methods in this section include a descriptive synopsis of the physical performance testing variables used within the research studies in Chapter -5, -7, -8, -9 and -10. The information involves the test protocols, procedures and testing equipment for each test. ICC analysis (absolute agreement) was performed for within- and between test reliability in SPSS (version 20.0) using Coppieters et al. (2002) criteria (Table 3.1). For those physical performance tests reported less than r=0.90 reliability, a repeated measures ANOVA (RMANOVA) was performed with bonferroni post-hoc analysis to assess if statistical differences were present between sessions or between trials. Alpha level was set at $p \leq 0.05$.

In order to establish random error scores (Munro and Herrington, 2011; Munro and Herrington, 2010) for within- and between- sessions SEM was calculated from the formula: (SD) * ($\sqrt{(1 - ICC}$)) (Thomas et al., 2005) and SDD was determined using the formula:

(1.96 * (√2)) * SEM) (Kropmans et al., 1999). It was important to identify the random error scores for each variable to allow practitioners to decide whether change in performance is significant, or within the error range (Kropmans et al., 1999).

Table 3.1. Coppieters et al. (2002) ICC value criteria

Rating	**ICC r value**
Poor	<0.40
Fair	0.40-0.70
Good	0.70-0.90
Excellent	>0.90

Results

Between Session

The ICC results to determine the between session- reliability of the physical performance assessments revealed excellent reliability for body mass, height, body composition, 5 m-, 10 m-, and 20 m- sprint times, Nordic hamstring lowers and Yo-Yo IRTL1, and good levels of reliability for agility left- and right- times, countermovement jump height and depth jump rebound height (Table 3.2), based on Coppieters et al. (2002) criteria (Table 3.1).

A repeated measures ANOVA (RMANOVA) was performed on the variables with only “good” levels of reliability which showed there was no significant differences ($p>0.05$) between each testing session for agility left and right times and depth jumps. However, countermovement jump height revealed significant differences ($p\leq0.05$) between testing sessions ($p=0.012$) with post hoc Bonferroni correction showing a greater jump height for testing session-3 when compared to test session-1 (30.8±2.5 cm vs. 28.4± 2.8 cm; $p=0.005$). There were no significant differences ($p>0.05$) between other testing sessions within the countermovement jump height assessment (test session-1 vs. test session-2 ($p>0.05$), test session-2 vs. test session-3 ($p>0.05$)).

ICC between-session reliability results are present within table 3.2, which shows the standard error of measurement (SEM) and smallest detectable difference (SDD) for each physical performance variable.

Table 3.2. 90% confidence intervals, SEM, SDD, SDD% of the mean, ICC and ICC reliability score for each physical performance assessment (between-session reliability)

	90% confidence intervals	**SEM**	**SDD**	**SDD% mean**	**ICC (r)**	**ICC Reliability**
Body Mass (kg)	0.985 – 0.998	0.59	1.65	3%	0.995	Excellent
Height (cm)	0.990 – 0.999	1.01	2.79	2%	0.956	Excellent
Sum of Skinfold (mm)	0.987 – 0.999	0.83	2.30	7%	0.996	Excellent
Yo-Yo IRTL1 (m)	0.860 – 0.990	104.6	290.1	18%	0.954	Excellent
5 m Sprint (s)	0.864 – 0.981	0.01	0.04	3%	0.944	Excellent
10 m Sprint (s)	0.835 – 0.977	0.0	0.1	4%	0.924	Excellent
20 m Sprint (s)	0.903 – 0.986	0.0	0.1	3%	0.960	Excellent
Agility 5-0-5 Left (s)	0.639 – 0.949	0.1	0.2	8%	0.816	Good
Agility 5-0-5 Right (s)	0.600 – 0.943	0.05	0.15	5%	0.837	Good
Countermovement Jump (cm)	0.456 – 0.917	1.65	4.59	16%	0.724	Good
Depth Jump (cm)	0.529 – 0.928	1.4	3.9	14%	0.799	Good
Nordics (°)	0.878 – 0.986	2.4	6.7	15%	0.957	Excellent

Within-Session

Further ICC results on within-session reliability of physical performance tests used within the study showed excellent reliability for 5 m- (r= 0.937), 10 m- (r= 0.915) and 20 m- (r= 0.962) sprint time and Nordic hamstring lowers (r= 0.944). Good levels of reliability were reported for 5-0-5 left time (r= 0.757), countermovement jump (r= 0.809), depth jump (r=0.857) and fair reliability for 5-0-5 right time (r= 0.560).

In order to assess whether statistical differences were present between the three trials for each left and right agility 5-0-5 test a RMANOVA was performed revealing significant differences were present between trials within the session ($p \leq 0.05$). Results from the post hoc Bonferroni correction showed significant differences ($p \leq 0.05$) were present between trial 1 versus trial 2 (2.88±0.12 s vs. 2.77±0.11 s, p=0.006) for agility right time; and trial 1 versus trial 3 (2.88±0.12 s vs. 2.75±0.10 s, p=0.009) for agility 5-0-5 left time. This statistical analysis demonstrates trial 3 contains greater performance when compared to trial 1 within the agility 5-0-5 left test. However, even though trial 2 had lower agility time (left) than trial 1, there were no significant difference and changes in performance ($p>0.05$) between trial 1 versus trial 3 (2.77±0.11 s vs. 2.75±0.10 s; p=1.000).

Similarly, within-session reliability of the countermovement jump height assessment was shown to be “good” (r= 0.809), based on Coppieters et al. (2002) criteria. In order to assess whether statistical differences were present between the three trials for the countermovement jump test a RMANOVA was performed. RMANOVA results reported significant differences were present ($p \leq 0.05$) between trials with post hoc Bonferroni correction identifying significant differences between trial 2 versus trial 3 (28.0±3.0 cm vs. 30.7±2.2 cm, p=0.003); which highlights there were improvements in performance in trial 3 when compared to trial 2.

However, there were no significant differences and changes in performance ($p>0.05$) between trial 1 versus trial 2 (29.4±2.8 cm vs. 28.0±3.0 cm, $p=0.338$) and trials 1 versus trial 3 (29.4±2.8 cm vs. 30.7±2.2 cm, $p=0.351$).

Discussion

The between-session reliability of the physical performance assessments revealed excellent reliability for body mass, height, body composition, 5 m-, 10 m-, and 20 m- sprint times, Nordic hamstring lowers and Yo-Yo IRTL1. While ICC results on within-session reliability of physical performance tests used showed excellent reliability for 5 m-, 10 m- and 20 m- sprint time and Nordic hamstring lowers.

For those physical performance variables which were considered to have good levels of between-session reliability: agility left- and right- times, countermovement jump height and depth jump rebound height; a RMANOVA with post hoc Bonferroni correction was performed. The results from the statistical analysis suggest that the countermovement jump assessment may improve with the testing sessions as the results showed testing session -3 produced significantly greater jump height scores than testing session -1. Therefore, in order to enhance reliability within future studies it may be beneficial to perform practice trials; where time permitting, a familiarisation testing session previous to the actual physical performance testing is carried out. This would only be applicable for players who had no/limited physical testing experience ($\leq$1 sessions).

Further statistical analysis was carried out on those physical performance variables which were categorised to have good- and fair- levels of within-session reliability: agility left- and right- time, and countermovement jump height. A RMANOVA with post hoc Bonferroni correction was performed which showed significant differences ($p \leq 0.05$) were present between trial -1 and trial -2 for agility right time, however there wasn't a significant difference present between trial -1 and trial -3. The agility 5-0-5 left time showed trial -3 had significantly lower time, thus greater performance, than trial 1 ($p \leq 0.05$), while trial -3 demonstrated greater improvements in performance than trial -2 within the countermovement jump height assessment ($p \leq 0.05$). These results suggest these particular assessments could produce inconsistent results across the three trials and it may be beneficial to carry out two or three practice trials prior to the three assessment trials within these particular tests.

These reliability results are similar to those reported in Shalfawi et al. (2013) which showed a 'good' level of ICC reliability (r=0.83) of the countermovement jump height test when assessing twenty second division Norwegian soccer players with no arm swing. Larson-Meyer et al. (2000) found SEM of their countermovement jump methods to be just 1.27 cm using fourteen NCAA soccer players, which is similar to the 1.65 cm reported in the present study. Both of these studies used similar sample sizes to the present study. On the other hand, Castagna and Castelli (2013) and Haugen et al. (2012) found 'excellent' levels of ICC reliability (r= 0.94-0.97) of countermovement jump assessment with standardised hand on hips protocol using sixty-two and one hundred ninety-two subjects, respectively. This possibly suggests that if a greater sample size was used within jump performance assessments this could have enhanced the reliability level from 'good' to 'excellent.'

The assessments with the smallest SDD percentage of the mean was the sprint performance tests (3-4%). The methodological detail within this study was established based on the practical findings from previous research which showed greater methodological testing accuracy of sprint performance (Haugen et al., 2014; Earp, 2012; Cronin and Templeton, 2008; Kraan et al., 2001; Yeadon et al., 1999; Dyas and Kerwin, 1995). The protocol includes timing gates set at 'hip' height (Yeadon et al., 1999), 95cm above the ground to allow the subjects to break the timing light at hip height and set up 1- metre apart between the transmitter and receiver (Yeadon et al., 1999), subjects starting 1-metre behind the timing gate with a 2-point split static stance (Cronin et al., 2007). The one recommendation not carried out was the use of dual-beam timing systems; due to cost and availability the present study used a single-beam timing system with greater care taken setting up the timing gates at hip height.

The number of sprint performance research assessing the real testing protocol detail to ensure the greatest accuracy of results is obtained far outweighs the number of similar investigations for the agility 5-0-5 test. The present study showed agility 5-0-5 testing demonstrated good to fair levels of reliability within- and between- session assessments, while sprint performance displayed excellent levels of reliability. Thus, it could be possible to suggest that more research needs to be carried out on the agility 5-0-5 test to improve the testing protocols, which may help improve the reliability levels.

This chapter aimed to identify reliable assessment methods for physical performance tests. On the whole, all testing protocols and methods were shown to have excellent or good levels of reliability for both between- and within-session reliability of assessments (Coppieters et al., 2002). Between session SDD results showed values of 3-4%, 5-8%, 14-16%, 18% and

15% for sprint-, changing direction- jump, aerobic- and eccentric hamstring strength-performance, respectively. These measurements are vital for future studies investigating the effect of an intervention training program or compare specific groups of athletes because it allows the researcher to identify whether significant differences are in fact present or whether these differences are actually a result of random error and lie within the SDD range. For example, when comparing pre- and post- training intervention results, the post 5 m sprint time result must greater than 3% to demonstrate a significant change in performance. Furthermore, Yo-Yo IRTL1 performances of two groups can only be deemed to be actually significantly different if there results differ by 290m (seven 20- m shuttle runs) (SDD: 18%).

The subject's (n=14) used within this reliability study were from a non-elite, amateur soccer team in the Women's Northern Premier Division who trained twice a week. Each testing session was carried out on the same day of the week for three consecutive weeks. From a squad size of twenty-six, twelve of the subject's data had to be discounted from the reliability study because they did not attend all three consecutive testing sessions, which resulted in a lower sample size than anticipated. Some of the reasons included not attending due to illness, injury and working commitments.

The female soccer players will be exposed to circadian variations in oestrogen and progesterone throughout their menstrual cycle which cause fluctuations in their metabolism, thermoregulation, muscle contractile responses and endurance (Hewett et al., 2007; Bambaeichi et al., 2004; Stachenfeld et al., 2000; Philips et al., 1996; Sarwar et al., 1996; Bunt et al., 1990). Research has suggested these circadian variations throughout the menstrual cycle significantly affect physical performance qualities (Gordon et al., 2013; Greeves et al., 1999; Philips et al., 1996; Sarwar et al., 1996), whilst other studies have reported no significant differences between physical performance variables and the phases of the menstrual cycle (Hertel et al., 2006; de Jonge et al., 2001; Gur, 1997; Lebrum et al., 1995). With the reliability study in this research thesis assessing females over three consecutive weeks this could lead to different physical performance results at each testing session. However, due to the inconsistencies across the literature in this research area this was not monitored during the experimental reliability study but is important to note as a possible limitation to this reliability research study.

Conclusion

The full methodological detail of each of these physical performance tests were highly researched to ensure the greatest level of reliability could be obtained. The reliability of the physical performance assessments were shown to have excellent or good reliability for both between- and within-session reliability of assessments. This suggests the methodological detail of each assessment is appropriate to be used within future studies and the SDD measurements of each of these tests allows practitioners to decide whether changes in performance between- or within- groups are significant, or within the error range. Although reliability was ‘good,’ for the agility 5-0-5 and countermovement jump tests, an additional trial may be required in the testing protocols.

Chapter 4.0.

Are the methods of assessing match performance reliable?

Introduction

Over the last few decades numerous methods have been developed to assess performance within a competitive soccer match. These methods include the use of time-motion analysis (Silva et al., 2013; Vigne et al., 2013; Andersson et al., 2010; Mohr et al., 2008; Mohr et al., 2003), global positioning systems (GPS) (Owen et al., 2014; Souglis et al., 2013; Wehbe et al., 2014), semi-automated computerised systems (Andrzejewski et al., 2013; Di Mascio and Bradley, 2013; Andrzejewski et al., 2012; Lago-Penas et al., 2011; Bradley et al., 2010; Dellal et al., 2010a; Gregson et al., 2010); all of which have enabled a physiological profile to be developed across standards of play, at both youth and senior level, for each playing position, and across both male and female players. However, the use of these different technologies and analysis software limits the reliability between the current soccer research data, thus comparing soccer match performance assessment data from time-motion analysis, semi-automative computer systems and GPS methods may not be valid.

Further inconsistencies may exist between GPS research data due to the use of different of equipment manufacturers, such as GPSports vs. Catapult, and the various sampling frequencies available from each GPS merchant. Each GPS unit is created at a specific sampling frequency: the speed at which a GPS unit can collect movement information. Currently there are GPS units manufactured with sampling rates of 1-, 5-, 10- and 15- Hz with evidence that the lower sampling rates (1-Hz) provide a poor degree of inter-reliability when measuring athletic movement than the greater sampling rates (Johnston et al., 2012;

Coutts et al., 2010). These assumptions could be made particularly for high intense activities such as high speed running and sprinting, particularly over short distances which have suggested to increase the level of error with GPS methodology (Johnston et al., 2012; Portas et al., 2010; Duffield et al., 2010). For example, if an individual sprints 5- metres in under 1-second this may not be recorded in the lower sampling GPS units (1- Hz). Portas et al. (2010) stated 5- Hz sampling frequency provides a lower range of error at higher speed intensities when compared to 1- Hz GPS frequencies (SEE: 2.2-4.4% vs. 1.8-6.8%) which also supports the findings that 1- Hz underestimates soccer-specific performance activity. Thus, it may be possible to suggest that a greater sampling frequency GPS unit (>1- Hz) would be more beneficial to use when assessing multiple interchangeable- and high- speed intensities involved in soccer.

Due to the nature of the sport, research has reported coefficient of variation and ICC values for all match activity assessments with considerable large ranges (r= 0.898-0.980, CV 1-13%) (Silva et al., 2013; Castagna et al., 2010; Castagna et al., 2003; Mohr et al., 2003; Helgerud et al., 2001). This large variability between the matches could be explained by the different opposition the team plays, different tactics performed on that particular day, different set of players in the starting eleven, score of the game, the pressure on the outcome of the game. This study aimed to identify the within-session (inter-unit) reliability (section 4.1.1) and the typical variation observed between matches (section 4.1.2).

Protocol

Each subject was provided with a 5-Hz GPS unit (GPSports/ SPI Pro X II), which was worn in between the shoulder blades in a custom-made undergarment (GPSports). These GPS units were switched on twenty minutes before the actual session start time to allow a suitable period for the unit to 'lock-on' to the satellites (Harley et al., 2011).

GPS variables used within the research study were:

- Distance covered variables

  Total distance covered, distance covered at zone 1 – zone 6, percentage of distance covered at zone 1 - zone 6.

- Speed zone variables

  Number of entries in speed zones 1-6, total time spent at speed zone 1 –zone 6, percentage of time spent at speed zone 1 –zone 6.

GPS speed zones (see Glossary of Terms and Abbreviations, page 14 and 15) were adopted and consistent with speed ranges within Andersson et al. (2010) and Mohr et al. (2008).

4.1.1. Within-session reliability

Participants

Eight youth female soccer players (age: 14.4±0.5 yrs; body mass: 46.6±7.2 kg; height: 158.6±5.9 cm) from a centre of excellence in England were recruited to take part in the within-session reliability research study. The within-session reliability study involved each subject wearing two vest garments, with one GPS unit in each slot, for their normal training session. Strict procedures were in place prior and post training session to ensure GPS units used for the same player were kept together so comparisons of the data could be made for each subject. The researcher gained permission from the relevant personnel at the soccer club, each participating subject provided written signed an informed consent and the study was approved by the University of Salford Research and Ethics Committee (HSCR13/46). Each subject was asked to stay hydrated and refrain from any activity on the day of the testing and eat no less than 3- hours before the testing.

Statistical Analysis

ICC statistical analysis was used on the data to assess the reliability between the GPS units for each separate GPS variable using SPSS (version 20). ICC values were interpreted based on Coppieters et al. (2002) criteria (Table 3.1, page 82): Excellent reliability r= >0.90; good reliability r= 0.70-0.90; fair reliability r= 0.40-0.70; poor reliability r= <0.40. From this, standard error of measurement (SEM) and smallest detectable difference (SDD) could be calculated in order to establish random error scores (Munro and Herrington, 2011; Munro and Herrington, 2010). While SEM was calculated from the formula: (SD) * ($\sqrt{(1 - ICC})$) (Thomas et al., 2005) and SDD was determined using the formula: (1.96 * ($\sqrt{2}$)) * SEM) (Kropmans et al., 1999). The effect size was calculated using the formula: $ES = \frac{\bar{X}_1 - \bar{X}_2}{SD_{\text{control}}}$, (Vincent and Weir, 2012).

Results

The SEM, SDD and the results of the ICC analysis are present in table 4.1.

GPS Distance covered variables:

Based on the criteria of Coppieters et al. (2002) and the ICC scores (Table 3.1, page 82), it suggests all distance covered variable GPS assessments consist of excellent reliability. This includes total distance covered, distance covered at zone-1, -2, -3, -4, -5 and -6, and the percentage of the total distance covered at zone -1, -2, -3, -4, -5, -6 (Table 4.1). ICC for all variables were statistically significant ($p<0.001$).

GPS Speed Zone variables:

Results from the ICC for speed zone variables compared to the Coppieters et al. (2002) criteria (Table 3.1, page 82) show all speed zone variable assessments between the GPS units share excellent reliability. This includes the number of speed zone entries at zone -1, -2, -3, -4, -5, -6, the time spent at speed zone -1, -2, -3, -4, -5, -6 and the percentage of time spent at speed zone -1, -2, -3, -4, -5, -6 (Table 4.1). ICC for all variables were statistically significant ($p\leq0.001$).

Table 4.1. SEM, SDD and ICC values for all distance covered GPS variable assessments

	SEM	**SDD**	**SDD% mean**	**ICC (r)**	**ICC Reliability**
Total Distance Covered (m)	13.34	36.97	1%	0.997	Excellent
Distance Covered at Zone 1 (m)	5.58	15.46	1%	0.996	Excellent
Distance Covered at Zone 2 (m)	5.25	14.54	4%	0.977	Excellent
Distance Covered at Zone 3 (m)	6.69	18.53	6%	0.981	Excellent
Distance Covered at Zone 4 (m)	1.28	3.54	3%	0.994	Excellent
Distance Covered at Zone 5 (m)	6.45	17.87	16%	0.979	Excellent
Distance Covered at Zone 6 (m)	0.94	2.60	6%	0.993	Excellent
Percentage of total distance covered at Zone 1 (%)	0.07	0.20	2%	0.989	Excellent
Percentage of total distance covered at Zone2 (%)	0.02	0.04	3%	0.974	Excellent
Percentage of total distance covered at Zone 3 (%)	0.05	0.14	8%	0.970	Excellent
Percentage of total distance covered at Zone 4 (%)	0.01	0.02	3%	0.993	Excellent
Percentage of total distance covered at Zone 5 (%)	0.10	0.27	14%	0.974	Excellent
Percentage of total distance covered at Zone 6 (%)	0.04	0.11	10%	0.984	Excellent
Number of Entries in Zone 1	3.21	8.91	9%	0.972	Excellent
Number of Entries in Zone 2	6.87	19.05	13%	0.961	Excellent

Number of Entries in Zone 3	4.84	13.40	12%	0.972	Excellent
Number of Entries in Zone 4	0.97	2.69	4%	0.993	Excellent
Number of Entries in Zone 5	0.83	2.31	11%	0.984	Excellent
Number of Entries in Zone 6	0.35	0.97	27%	0.966	Excellent
Time Spent in Speed Zone 1 (min)	0.00	0.00	1%	0.995	Excellent
Time Spent in Speed Zone 2 (min)	0.06	0.16	3%	0.980	Excellent
Time Spent in Speed Zone 3 (min)	0.08	0.21	12%	0.964	Excellent
Time Spent in Speed Zone 4 (min)	0.00	0.00	3%	0.995	Excellent
Time Spent in Speed Zone 5 (min)	0.00	0.00	13%	0.979	Excellent
Time Spent in Speed Zone 6 (min)	0.00	0.00	7%	0.995	Excellent
Percentage of Time at Speed Zone 1 (%)	0.17	0.46	1%	0.977	Excellent
Percentage of Time at Speed Zone 2 (%)	0.08	0.23	7%	0.923	Excellent
Percentage of Time at Speed Zone 3 (%)	0.09	0.25	13%	0.950	Excellent
Percentage of Time at Speed Zone 4 (%)	0.01	0.02	3%	0.993	Excellent
Percentage of Time at Speed Zone 5 (%)	0.03	0.09	15%	0.973	Excellent
Percentage of Time at Speed Zone 6 (%)	0.00	0.00	9%	0.989	Excellent

4.1.2. Variation between-sessions

Participants

Eighteen outfield elite soccer players (age: 24.6±3 yrs; body mass: 65±8.6 kg; height: 169.3±7.5 cm) from a women's super league were recruited for the between-session reliability research study to investigate the typical variations between performances during a soccer match. This between-session reliability study involved each subject wearing a GPS unit during a 90-minute soccer match on two separate occasions. Seven to fourteen days separated the two data sets that were collected and each match was carried out on the same home soccer pitch, at the same time of day and against similar standard of opponent in league competition (women's super league standard teams). The data was only collected on the subjects who started the game and played the full 90 minutes of the soccer game. Therefore, if a player was substituted and did not play the full duration of the game the data was discounted. The researcher gained permission from the relevant personnel at the soccer club, each participating subject provided written signed an informed consent and the study was approved by the University of Salford Research and Ethics Committee (HSCR13/46).

Statistical Analysis

Statistical analysis of the data was carried out using SPSS (version 20). Normality of data was confirmed using a Shapiro Wilks test. To assess the variation between the two soccer matches, a paired samples t-test was performed.

Effect size was also calculated using the formula: $ES = \frac{\bar{X}_1 - \bar{X}_2}{SD_{\text{control}}}$, (Vincent and Weir, 2012). The effect sizes were interpreted using Cohen's (1988) criteria: 0.10 = small, 0.30 = moderate, 0.50 = large.

Results

The results from the paired samples t-test show there were significances differences ($p<0.05$) between the two soccer matches for variables: number of entries in zone 2 ($p=0.040$), and time spent in speed zone 1 ($p=0.041$) (Table 4.2). There were no other significant differences present within any other GPS variable ($p>0.05$). The results showed a small effect size for distance covered at zone -1 and -5, percentage of total distance at zone -3, and -5 and time spent in zone 4; moderate effect size for distance covered at zone -3, and -4, percentage of total distance covered at zone 1, number of entries at zone -3, -4 and -5, time spent in zone -3, -5 and -6; and large effect size for total distance covered, distance covered at zone -2 and -6, percentage of total distance at zone -2, -4 and -6, number of entries in zone -1, -2 and -6, time spent in zone -1 and -2 (Table 4.2).

Table 4.2. The variation between soccer matches from the paired samples T-test results for each GPS match performance variable

GPS Variable	Session 1 Mean ±SD	Session 2 Mean ±SD	t	P	Effect Size
Total Distance Covered (m)	10254.1 ±491.1	10013.4 ±658.9	1.777	P=0.099	0.41
Distance Covered at Zone 1 (m)	2475.6 ±407.3	2505.6 ±399.9	-0.503	P=0.626	-0.08
Distance Covered at Zone 2 (m)	3787.3 ±448.3	3579.0 ±427.0	2.035	P=0.062	0.47
Distance Covered at Zone 3 (m)	2197.0 ±473.3	2104.6 ±440.0	1.211	P=0.248	0.21
Distance Covered at Zone 4 (m)	1378.7 ±207.3	1441.7 ±241.4	-0.954	P=0.360	-0.28
Distance Covered at Zone 5 (m)	382.9 ±186.5	360.6 ±105.2	0.497	P=0.628	0.15
Distance Covered at Zone 6 (m)	32.7 ±32.2	21.8 ±9.2	1.071	P=0.301	0.46
Percentage of total distance covered at Zone 1 (%)	24.4 ±5.2	25.4 ±5.5	-1.259	P=0.264	-0.20
Percentage of total distance covered at Zone 2 (%)	36.8 ±3.2	35.6 ±2.6	1.382	P=0.158	0.42
Percentage of total distance covered at Zone 3 (%)	20.4 ±4.0	20.8 ±3.4	-0.672	P=0.588	-0.10

Percentage of total distance covered at Zone 4 (%)	13.4 ±1.8	14.3 ±1.7	-1.553	P=0.179	-0.50
Percentage of total distance covered at Zone 5 (%)	3.7 ±1.8	3.6 ±1.0	0.154	P=0.739	0.10
Percentage of total distance covered at Zone 6 (%)	0.3 ±0.3	0.2 ±0.1	0.265	P=0.282	0.47
Number of Entries in Zone 1	1233 ±117	1167 ±109	2.042	P=0.061	0.57
Number of Entries in Zone 2	1713 ±102	1613 ±118	2.272	P=0.040 #	0.84
Number of Entries in Zone 3	701 ±101	662 ±111	1.979	P=0.068	0.37
Number of Entries in Zone 4	252 ±29	242 ±33	0.804	P=0.440	0.34
Number of Entries in Zone 5	49 ±25	45 ±11	0.791	P=0.441	0.25
Number of Entries in Zone 6	5 ±5	3 ±1	1.185	P=0.240	0.57
Time Spent in Speed Zone 1 (min)	59 ±6	62 ±4	-2.495	P=0.041 #	-0.58
Time Spent in Speed Zone 2 (min)	34 ±4	32 ±3	1.802	P=0.081	0.60
Time Spent in Speed Zone 3 (min)	12 ±3	11 ±2	1.297	P=0.127	0.29

Time Spent in Speed Zone 4 (min)	6 ±1	6 ±1	-0.127	P=0.750	0.15
Time Spent in Speed Zone 5 (min)	1.2 ±0.7	1.0 ±0.3	0.130	P=0.446	0.30
Time Spent in Speed Zone 6 (min)	0.1 ±0.1	0.1 ±0.1	-0.810	P=0.580	0.30

 # Significant difference between the two soccer matches ($p \leq 0.05$)

Discussion

The within-session reliability (same subject wearing two different units at the same time) showed excellent reliability across every variable assessed, based on Coppieters et al.'s (2002) criteria. These reports suggest the GPSports units are reliable equipment for assessing soccer match performance. Previous research has found significant differences / variations between different types of GPS units (Johnston et al., 2014; Buchheit et al., 2013) ($p<0.05$), however when assessing the reliability of the exact same GPS unit, like the present study, reports have demonstrated high levels of reliability for each variable (Johnston et al., 2014; Johnston et al., 2012). Johnston et al. (2012) showed the outputs from two 5-Hz GPS units (Catapult MinimaxX) were not significantly different and obtained high reliability for total distance, distance covered at each speed zone, time spent at each speed zone, number of speed zone entries, which were similar to the present study ($p>0.05$). However, although not significant, other studies (Johnston et al., 2014; Johnston et al., 2012) have found that as the speed of movement increased so did the level of error which led to a reduction in the level of reliability; which contradict those reported in the present study with high-intensity running and sprinting activity (speed zone -5 and -6) demonstrating similar levels of reliability to lower speed zones (r= 0.966-0.993 vs. r= 0.923 vs. 0.996), respectively.

As reported, all GPS variables assessed between-units demonstrated 'excellent' levels of reliability with low error ranges (SDD% of mean) (Coppieters et al., 2002). The within-session, between unit SDD results showed differences of 0.01-0.16%, 0.02-0.14%, 0.04-0.27%, 0.01-0.13% and 0.01-0.15% for total distance covered at speed zone -1 to -6, percentage of total distance at speed zone -1 to -6, number of entries in speed zone -1 to -6, time spent in speed zone -1 to -6 and the percentage of time spent in speed zone -1 to -6, respectively. These measurements not only show low levels of random error, which supports the quality of the data collection protocol, but they are also vital for future match performance studies. These future investigations such as assessing the effect an intervention training program has had or comparing different groups of athletes; allow the researcher to identify whether significant differences are in fact present or whether these "significant differences" are actually a result of random error and lie within the SDD range. For example, if a researcher is comparing the means of the total distance covered pre- and post- training intervention, based on the results from the present study, the post result must be outside the SDD range (0.01%) for this to demonstrate an actual significant change in performance.

There are many variables which could influence the variability between soccer matches such as the tactics played on the day, the opponent's tactics, the opponents physical and/or technical output, the environment, the score of the game, etc. Mohr et al. (2003) found low coefficient of variation between male soccer matches using time-motion analysis methods, reporting only a 9.2% variation for high-intensity running distance. Gregson et al. (2010) showed higher coefficient of variation between male soccer matches within an 8-week period (22.0-38.9%) and between two seasons (17.7-30.8%) using Prozone assessment methods of high intensity activity. In contrast, Rampinini et al. (2007) found the lowest levels of coefficient of variation (6.8-14.4%) using similar data collection methods of high intensity activity (Prozone), however the variation between the two matches assessed were against the same opposition; which was one of the factors discussed that could influence the variability between matches. These studies only reported coefficient of variation between matches for high speed running activity and failed to disclose lower speed zone activity variation similar to the present study (speed zone 1 to 4). Rampinini et al. (2007) reported the effect size for between match variation for total distance covered (0.35) and very high intensity running distance (0.41), which are similar to those displayed in the present study for total distance covered (0.41) and distance covered at speed zone 6 (0.46). However, the effect size in the present study for speed zone 5 is considerably lower than Rampinini et al.'s (2007) study (0.15 vs. 0.42).

Effect size was used in order to assess the level of magnitude of the difference between the two competitive soccer matches (between-session variation). The results showed a small effect size for distance covered at zone -1 and -5, percentage of total distance at zone -3, and -5 and time spent in zone 4; moderate effect size for distance covered at zone -3, and -4, percentage of total distance covered at zone 1, number of entries at zone -3, -4 and -5, time spent in zone -3, -5 and -6; and large effect size for total distance covered, distance covered at zone -2 and -6, percentage of total distance at zone -2, -4 and -6, number of entries in zone -1, -2 and -6, time spent in zone -1 and -2 (Table 4.2) (Vincent and Weir, 2012). To the author's knowledge, this is the first female soccer study to demonstrate the variation between soccer matches and the results are essential for future studies. For example, total distance covered in speed zone 5 displayed an effect size of 0.15, which suggests that when assessing match performance between different groups or pre- and post- training interventions, the difference between the means has to be greater than 0.15, otherwise the difference is trivial, even if it is statistically significant ($p<0.05$). Similarly for the variables with moderate/large effect sizes, such as time spent in speed zone 5 (0.30), the differences between means (between groups or pre- and post- training interventions) must be greater in order for the results to be significant ($p<0.05$).

This chapter shows the inter-reliability of the GPS units are excellent and the intra-variation of soccer match performance is low which ensures reliable methodologies are used within research studies in chapter -6, -8, and -9. There were significant difference between matches for two variables: number of entries in zone -2 and time spent in zone -1, therefore, extra caution should be taken if significant differences are present for these variables in future studies.

Even though 5-Hz GPS sampling frequencies were found to provide lower range of error at high speed intensities in comparison to lower sampling frequencies (1-Hz) and showed lower level of error in the present study; greater GPS sampling frequencies are recommended for assessing high intense athletic movement such as sprinting (Johnston et al., 2012; Coutts et al., 2010; Duffield et al., 2010; Portas et al., 2010). Therefore, it would have been beneficial for the present study to use GPS sampling rates >5-Hz; however, the 5-Hz GPS equipment was only available at the time the data collection took place due to cost and resource availability.

Conclusion

This chapter aimed to meet the needs of objective *b*: to determine the reliability of match performance assessment methods. In summary, the within-session reliability (same subject wearing two different units at the same time) showed excellent reliability across every variable assessed, based on Coppieters et al.'s (2002) criteria. Furthermore, the between match variation results showed there were no significant differences between the two soccer matches assessed apart from two variables: number of entries in zone- 2 and time spent in zone- 1.

Chapter 5.0.

Physical Performance of Youth Female Soccer Players

Introduction

A football player's absolute strength is beneficial for moving external objects (the ball and opposition players), whereas, relative strength is suggested more applicable for controlling their own body weight through accelerating and decelerating actions which can reach forces of 1.65-4.22 times body mass (Wallace et al., 2010; Satro and Mokha, 2009; Barnes et al., 2007). Some of these accelerating and deceleration actions have been assessed within Le Gall et al.'s (2008) research study. Le Gall et al. (2008) investigated physical performance results of male soccer players at French youth level over an eleven-year period to see which players upon graduation were successful in attaining a professional contract. The research findings identified the players with significantly greater physical performances subsequently played at a higher level (international and professional), whilst the players who performed significantly worse at physical performance tests at youth level were later reported to be playing soccer at a lower amateur level ($p<0.05$). These significant findings were present for maximal aerobic power, 40 m sprint time and countermovement jump height. These findings are supported and contradicted by other research studies. Brewer and Davis (1991) supports Le Gall et al.'s (2008) findings showing 15 m and 40 m sprint performances were significantly faster in elite players than non-elite within English male soccer players ($p<0.05$). Moreover, Gauffin et al. (1989) showed vertical jump performance were significantly greater in the top two divisions than the lower level teams, while Cornetti et al. (2000) on the other hand found the amateur players performed significantly worse in sprint and depth jump rebound height assessments when compared to elite and sub-elite players in French senior soccer ($p<0.05$). Although these findings suggest the physical performance of soccer players may contribute to the level of play a soccer player achieves, no research has been carried out on female youth soccer (to the author's knowledge) comparing elite and non-elite players. It is worth noting that research studies have assessed physical performance differences directly between senior females, youth females and male soccer players but no comparisons within female youth soccer players (elite vs. non-elite), to the author's knowledge. Therefore, the aim of this chapter was to assess the physical performance of female youth soccer players (objective *c*). Chapter 5.0 investigates the physical performance results of youth soccer players. Section 5.1 displays results directly comparing all elite players against non-elite players (all data elite vs. all data non-elite). Section 5.2 presents the results from statistical analysis comparing all age groups against each other (all data: U11 vs. U13 vs. U15 vs. U17), with section 5.3 and section5.4 completing the same analysis for elite level and non-elite standard, respectively. And lastly, section 5.5 investigates the interaction between age groups and standards; where elite players were directly compared against non-elite players at each age group (e.g. U11 elite vs. U11 non-elite; U13 elite vs. U13 non-elite etc.).

Participants

Two hundred and fifteen female youth players were recruited to take part in this study. One hundred and forty-one subjects were signed players from girl's centre of excellence teams (Elite: age 14.6±1.9 yrs; body mass: 52.9±9.9 kg; height: 159.5±15.1 cm), while seventy-four subjects were part of a girl's grass roots football club (Non-Elite: age: 14.1±2.1 yrs; body mass: 48.9±9.9 kg; height: 154.7±10.7 cm) which were classed as a non-centre of excellence standard. Figure 1.4 (page 25) shows the youth female soccer structure of which these two groups were taken from. The groups were matched based on the number of times a week they trained and the proportions of playing positions.

Age groupings were split into under 11 years (U11: n=9 vs. n=18), under 13 years (U13: n=12 vs. n=17), under 15 years (U15: n=55 vs. n=21) and under 17 years (U17: n=65 vs. n=18) for elite and non-elite, respectively.

Protocol

The elite soccer players were tested on a separate occasion from the non-elite group of players. Physical performance assessments used within this study included body mass, height, Yo-Yo IRTL1, 5 m sprint time, 10 m sprint time, 20 m sprint time, agility 5-0-5 left time, agility 5-0-5 right time, countermovement jump height, depth jump rebound height and Nordic hamstring lowers. The methodological detail (pages 71-81) and reliability of each of these tests was assessed within chapter 3 (page 68). Each test was explained in detail to each subject and methods remained consistent across each assessment throughout the data collection process. The researcher gained permission from the relevant personnel at both elite and non-elite teams and each subject/ parent/ guardian signed an informed consent form after the study was approved by the University of Salford Research and Ethics Committee (HSCR13/46). Each subject was also asked to stay hydrated and refrain from any activity on the day of the testing and eat no less than 3- hours before the testing. This was standardised across each testing session.

Statistical analysis

All statistical analysis was performed in SPSS for windows version 20 (Chicago, Ill). All parameters were checked for their conformity to normal distribution through a Shapiro Wilks test. Each dependent variable was analysed using a 4 x 2 factorial ANOVA for the factors of age group and level (non-elite vs. elite). Independent sample t-tests with a bonferroni adjustment for multiple comparisons was used to locate any significant differences. Significance was set at $p \leq 0.05$.

5.1. Results

5.1.1. Does physical performance differ between elite and non-elite youth soccer players? (Main Effect)

Results from the statistical analysis are present within table 5.1. These findings reveal there was a significant difference ($p \leq 0.05$) between the two groups of soccer players across all variables, excluding body mass (power = 0.142) and height (power = 0.137) variable assessments ($p > 0.05$). Table 5.1 shows the elite players demonstrated greater Yo-Yo IRT L1 distance ($p \leq 0.001$; power = 1.000), countermovement jump height ($p \leq 0.001$; power= 0.956) and depth jump rebound height ($p \leq 0.001$; power = 0.987); and significantly faster 5 m sprint time ($p \leq 0.001$; power = 1.000), 10 m sprint time ($p \leq 0.001$; power = 1.000), 20 m sprint time ($p \leq 0.001$; power = 1.000), agility 5-0-5 time left ($p=0.028$; power = 0.597) and right ($p=0.05$; power = 0.496) ($p \leq 0.05$).

Table 5.1. Mean and SD for each physical age for elite and non-elite players

Variable	Mean ±SD	
	Elite (n=141)	**Non-Elite (n=74)**
Body Mass (kg)	52.9 ±9.9	48.9 ±9.9
Height (cm)	159.5 ±15.1	154.7 ±10.7
Yo-Yo IRT L1 distance (m)	1561 ±534 **	536 ±256
5 m Sprint (s)	1.06 ±0.10 **	1.15 ±0.08
10 m Sprint (s)	1.86 ±0.17 **	2.04 ±0.14
20 m Sprint (s)	3.34 ±0.30 **	3.73 ±0.31
Agility 5-0-5 Left (s)	2.68 ±0.24 **	2.89 ±0.18
Agility 5-0-5 Right (s)	2.68 ±0.23 **	2.89 ±0.18
Countermovement Jump (cm)	30.3 ±3.8 **	24.7 ±4.5
Depth Jump (cm)	29.8 ±3.9 **	22.9 ±5.0

** significant difference between elite and non-elite $p < 0.01$

5.1.2. Does physical performance differ across youth soccer age-groups? (Main Effect)

The results from the statistical analysis with post-hoc analysis identified significant differences ($p \leq 0.05$) between groups for body mass, height, Yo-Yo IRTL1 result, 5 m, 10 m and 20 m sprint times, and agility 5-0-5 left and right assessments (Table 5.2).

Under 11:

Post hoc analysis identified U11 players were significantly different ($p \leq 0.05$) to other age groups within variables body mass, height, Yo-Yo IRTL1, 5 m-, 10 m-, 20 m- sprint time assessments (Table 5.2). From mean comparisons between the groups, the results reveal U11's had a significantly lower body mass and height than U13, U15 and age groups, respectively ($p=0.002$, $p \leq 0.001$, $p \leq 0.001$; power = 1.000 and $p \leq 0.001$, $p \leq 0.001$, $p \leq 0.001$; power = 1.000) ($p \leq 0.05$). The U11s also had a significantly greater ($p \leq 0.05$), thus slower time, than U13, U15 and U17 age groups at 10 m ($p=0.010$, $p \leq 0.001$, $p \leq 0.001$; power = 1.000) and 20 m ($p=0.001$, $p \leq 0.001$, $p \leq 0.001$, power = 1.000) sprint distances. U11s also possessed significantly slower sprint times at 5 m assessments when compared to U15 and U17s ($p \leq 0.001$, $p \leq 0.001$; power = 1.000) and lower Yo-Yo IRTL1 results distances than U17 players ($p=0.010$; power = 0.798) ($p \leq 0.05$).

Table 5.2. Mean and SD of each physical performance variable for each age group

Variable	Mean ±SD			
	Under 11	Under 13	Under 15	Under 17
Body Mass (kg)	37.6 ±7.9 *b #c ~d	45.6 ±9.6 †a ~d	50.5 ±7.6 †a ~d	57.5 ±7.1 †a *b #c
Height (cm)	140.0 ±6.9 *b #c ~d	152.4 ±7.5 †a †c ~d	159.5 ±5.6 †a *b ~d	164.8 ±7.0 †a *b #c
Yo-Yo IRT L1 distance (m)	537 ±385 ~d	675 ±403	918 ±409	1299 ±671 †a
5 m Sprint (s)	1.20 ±0.08 #c ~d	1.15 ±0.07 #c ~d	1.09 ±0.05 †a *b	1.06 ±0.09 †a *b
10 m Sprint (s)	2.14 ±0.15 *b #c ~d	2.03 ±0.11 †a #c ~d	1.93 ±0.07 †a *b	1.89 ±0.12 †a *b
20 m Sprint (s)	3.96 ±0.29 *b #c ~d	3.72 ±0.25 †a #c ~d	3.49 ±0.16 †a *b	3.40 ±0.20 †a *b
Agility 5-0-5 Left (s)		2.94 ±0.13 #c ~d	2.75 ±0.11 *b	2.72 ±0.16 †a *b
Agility 5-0-5 Right (s)		2.93 ±0.14 #c ~d	2.73 ±0.14 *b	2.70 ±0.14 †a *b
Countermovement Jump (cm)	24.6 ±4.8	26.1 ±3.8	26.8 ±3.7	27.8 ±4.7
Depth Jump (cm)			25.9 ±3.4	27.6 ±5.7
Nordics (°)		51 ±9	46 ±10	45 ±14

†a significant difference from U11 age group ($p\leq0.05$)

*b significant difference from U13 age group ($p\leq0.05$)

#c significant difference from U15 age group ($p\leq0.05$)

~d significant difference from U17 age group ($p\leq0.05$)

Under 13:

Further post hoc analysis revealed the U13 players were significantly different ($p\leq0.05$) to other age groups for the variables of body mass, height, 5 m-, 10 m- and 20 m- sprint time, and agility 5-0-5 left and right assessments. From the mean comparisons between the groups revealed U13s had a significantly greater body mass than U11 players, but a lower body mass than U17s ($p=0.002$, $p\leq0.001$; power = 1.000) ($p\leq0.05$) (Table 5.2). Results also revealed the U13 players had significantly greater height than U11s and significantly lower height than U15 and U17 players ($p\leq0.001$, $p=0.001$, $p\leq0.001$; power = 1.000), respectively ($p\leq0.05$). U13s also had a significantly greater ($p\leq0.05$), thus slower time, than U15 and U17 age groups, and faster times than U11s at 10 m ($p=0.001$, $p=0.003$, $p=0.010$; power = 1.000) and 20 m sprint distances ($p\leq0.001$, $p\leq0.001$, $p=0.001$; power = 1.000), respectively. The U13 age group possessed significantly slower sprint times at 5 m sprint, agility 5-0-5 left and right assessments when compared to U15 and U17s, respectively ($p=0.004$, $p=0.002$; power = 1.000; and $p\leq0.001$, $p\leq0.001$; power = 1.000; and $p\leq0.001$, $p\leq0.001$; power = 1.000) ($p\leq0.05$).

Under 15:

Bonferroni post hoc analysis revealed the U15s were significantly different ($p \leq 0.05$) to other age groups for the variables body mass, height, 5 m-, 10 m- and 20 m- sprint time and agility 5-0-5 left and right assessments. From mean comparisons between the groups in table 5.2, the results show the U15 players had a significantly greater body mass than U11s and lower body mass than U17s ($p \leq 0.001$, $p = 0.008$; power = 1.000) whilst post hoc analysis also identified U15s had significantly greater height than U11s and U13s but lower than U17s players ($p \leq 0.001$, $p = 0.001$, $p = 0.029$; power = 1.000), respectively ($p \leq 0.05$). Post hoc analysis also revealed U15 players had significantly lower ($p \leq 0.05$), thus faster, sprint times than U11 and U13 age groups at 5 m-, 10 m- and 20 m- sprint times ($p \leq 0.001$, $p = 0.004$; power = 1.000; $p \leq 0.001$, $p = 0.001$; power = 1.000; $p \leq 0.001$, $p \leq 0.001$; power = 1.000), respectively. Moreover, U15s possessed significantly faster agility 5-0-5 left and right times than U13 players ($p \leq 0.001$; power = 1.000; $p \leq 0.001$; power =1.000) (Table 5.2) ($p \leq 0.05$).

Under 17:

Post hoc analysis results also showed the U17 soccer players were significantly different ($p \leq 0.05$) to other age groups within variables body mass, height, Yo-Yo IRTL1 result, 5 m-, 10 m- and 20 m- sprint time and agility 5-0-5 left and right assessments. Mean comparisons between the groups reveal the U17s had a significantly greater body mass than U11s, U13s, and U15s, and greater height than U11s, U13s and U15s, respectively ($p \leq 0.001$, $p \leq 0.001$, $p = 0.008$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$, $p = 0.029$; power = 1.000) ($p \leq 0.05$) (Table 5.2). The U17s also had a significantly greater Yo-Yo IRTL1 result than the U11s ($p = 0.010$; power = 0.798) and a lower, thus faster sprint time over 5 m-, 10 m, and 20 m- distances than U11s and U13s ($p \leq 0.001$, $p = 0.002$; power = 1.000; and $p \leq 0.001$, $p = 0.003$; power = 1.000;

and $p \leq 0.001$, $p \leq 0.001$; power = 1.000) ($p \leq 0.05$). The U17s also had significantly lower, faster agility 5-0-5 times than U11s and U13s for left and right assessments, respectively ($p \leq 0.001$, $p \leq 0.001$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$, p = 1.000) (Table 5.2) ($p \leq 0.05$).

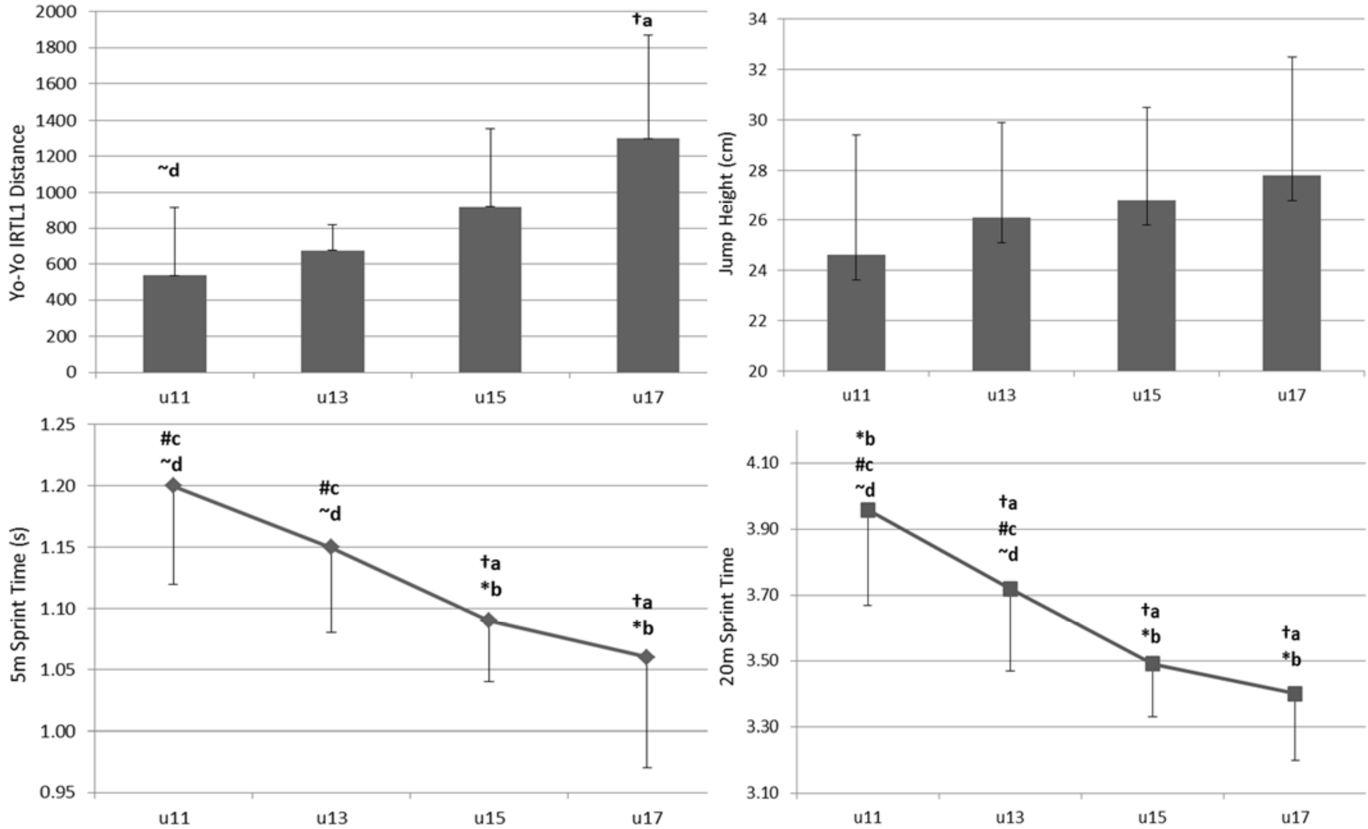

Figure 5.1. Results of physical performance assessments for Yo-Yo IRTL1, CMJ, 5 m- and 20 m- sprint time. †a significant difference from U11 age group; *b significant difference from U13 age group; #c significant difference from U15 age; ~d significant difference from U17 age group, ($p \leq 0.05$)

5.1.3. Does physical performance differ across age-groups at elite youth level?

The one way ANOVA with bonferroni pairwise comparison identified significant differences ($p \leq 0.05$) between groups within body mass, height, Yo-Yo IRTL1 result, 5 m, 10 m and 20 m sprint times, and agility 5-0-5 left and right assessments (Table 5.3).

Under 11:

Post hoc analysis identified U11s players were significantly different ($p \leq 0.05$) to other age groups within variables body mass, height, Yo-Yo IRTL1 result, 5 m-, 10 m- and 20 m- sprint time assessments (Table 5.3). Mean comparisons between the groups reveal U11's had a significantly lower body mass ($p \leq 0.001$, $p \leq 0.001$, $p \leq 0.001$; power = 1.000) and height ($p \leq 0.001$, $p \leq 0.001$, $p \leq 0.001$; power = 1.000) than under 13s, under 15s and under 17s, respectively ($p < 0.05$). Moreover, the U11s had a significantly lower Yo-Yo IRTL1 result than the U17 age group ($p = 0.007$; power = 0.798) and a greater, thus slower sprint time over 5 m-, 10 m, and 20 m- distances than U15s and U17s ($p = 0.036$, $p = 0.000$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$; power = 1.000) ($p \leq 0.05$).

Table 5.3. Mean and SD for each physical performance variable at each age group for the elite female soccer players

Variable	Elite: Mean ±SD			
	Under 11	Under 13	Under 15	Under 17
Body Mass (kg)	35.6 ±6.3 *b #c ~d	45.6 ±11.4 †a ~d	50.3 ±7.5 †a	57.0 ±7.1 †a *b
Height (cm)	138.8 ±7.5 *b #c ~d	151.2 ±8.0 †a #c ~d	158.9 ±5.9 †a *b ~d	164.9 ±7.2 †a *b #c
Yo-Yo IRT L1 distance (m)	1053 ±379 ~d	1234 ±141 ~d	1422 ±434 ~d	1760 ±570 †a *b #c
5 m Sprint (s)	1.13 ±0.05 #c ~d	1.12 ±0.05 #c ~d	1.07 ±0.06 †a *b ~d	1.04 ±0.06 †a *b #c
10 m Sprint (s)	2.01 ±0.12 #c ~d	1.97 ±0.08 #c ~d	1.88 ±0.09 †a *b ~d	1.83 ±0.07 †a *b #c
20 m Sprint (s)	3.71 ±0.23 #c ~d	3.55 ±0.16 #c ~d	3.38 ±0.17 †a *b ~d	3.28 ±0.11 †a *b #c
Agility 5-0-5 Left (s)		2.93 ±0.12 #c ~d	2.69 ±0.09 *b	2.66 ±0.10 *b
Agility 5-0-5 Right (s)		2.93 ±0.15 #c ~d	2.69 ±0.09 *b	2.66 ±0.13 *b
Countermovement Jump (cm)	27.9 ±3.9	29.1 ±2.5	30.6 ±4.5	30.2 ±3.3
Depth Jump (cm)			30.0 ±4.1	30.0 ±3.8
Nordics (°)		51 ±9	46 ±10	45 ±14

†a significant difference from U11 age group ($p \leq 0.05$) *b significant difference from U13 age group ($p \leq 0.05$) #c significant difference from U15 age group ($p \leq 0.05$) ~d significant difference from U17 age group ($p \leq 0.05$)

Under 13:

Further post hoc analysis revealed the U13 players were significantly different ($p<0.05$) to other age groups within variables body mass, height, Yo-Yo IRTL1 result, 5 m-, 10 m- and 20 m- sprint time and agility 5-0-5 left and right assessments (Table 5.3). Mean comparisons between the groups show U13s had a significantly lower body mass ($p \leq 0.001$; power = 1.000) than U17s and lower height ($p=0.003$, $p \leq 0.001$; power = 1.000) than U15s and U17s ($p \leq 0.05$). However, the U13s possessed greater values in comparison to U11s ($p \leq 0.001$, $p \leq 0.001$) for body mass and height assessments. Moreover, the U13s had a significantly ($p \leq 0.05$) lower Yo-Yo IRTL1 result than U17 age group ($p=0.05$; power = 0.798) and a greater, thus slower sprint time over 5 m-, 10 m, and 20 m- distances than U15s and U17s ($p=0.029$, $p \leq 0.001$; power = 1.000; and $p=0.009$, $p \leq 0.001$; power = 1.000 and $p=0.009$, $p \leq 0.001$; power = 1.000). The U13s also had significantly greater, slower agility 5-0-5 left and right times than U15s and U17s, respectively ($p \leq 0.001$, $p \leq 0.001$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$; power = 1.000) (Table 5.3) ($p \leq 0.05$).

Under 15:

Bonferroni post hoc correction revealed the U15s were significantly different ($p \leq 0.05$) to other age groups within variables body mass, height, Yo-Yo IRTL1 result, 5 m-, 10 m- and 20 m- sprint time and agility 5-0-5 left and right assessments (Table 5.3). Mean comparisons between the groups demonstrate the U15 soccer players had a significantly greater body mass ($p \leq 0.001$, $p \leq 0.001$; power = 1.000) and height ($p \leq 0.001$, $p=0.003$; power= 1.000) than U11s and U13s, but lower values in comparison to U17s ($p \leq 0.001$, $p \leq 0.001$) ($p \leq 0.05$). Moreover, the U15s had a significantly lower Yo-Yo IRTL1 results than U17s age group ($p=0.002$; power = 0.798) and a lower, thus faster sprint time over 5 m-, 10 m, and 20 m- distances than U11s and U13s ($p=0.036$, $p=0.029$; power = 1.000; and $p \leq 0.001$, $p=0.009$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$; power = 1.000) but greater, slower times than U17s players ($p \leq 0.001$, $p \leq 0.001$ and $p \leq 0.001$) ($p \leq 0.05$). The U15s also had significantly ($p \leq 0.05$) lower, faster agility 5-0-5 times than U13s for left and right assessments, respectively ($p \leq 0.001$; power = 1.000, and $p \leq 0.001$; power = 1.000) (Table 5.3).

Under 17:

Post hoc analysis also showed the U17 players were significantly different ($p \leq 0.05$) to other age groups within variables body mass, height, Yo-Yo IRTL1 result, 5 m-, 10 m- and 20 m- sprint time and agility 5-0-5 left and right assessments (Table 5.3). The U17s had a significantly greater body mass than U11s and U13s and greater height than U11s, U13s and U15s, respectively ($p \leq 0.001$, $p \leq 0.001$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$ and $p \leq 0.001$; power = 1.000) ($p \leq 0.05$). Moreover, the U17s had a significantly greater Yo-Yo IRTL1 result than U11s, U13s and U15s age groups ($p=0.007$, $p=0.05$ and $p=0.002$; power= 0.798) and a lower, thus faster sprint time over 5 m-, 10 m, and 20 m- distances than U11s, U13s and U15s

($p \leq 0.001$, $p \leq 0.001$, $p \leq 0.001$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$ and $p \leq 0.001$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$ and $p \leq 0.001$; power = 1.000) ($p \leq 0.05$). The U17s also had significantly ($p \leq 0.05$) lower, faster agility 5-0-5 times than U13s for left and right assessments, respectively ($p \leq 0.001$; power = 1.000; and $p \leq 0.001$; power = 1.000).

5.1.4. Does physical performance differ across age-groups at non-elite youth level?

The results from the ANOVA with bonferroni post hoc correction revealed significant differences ($p \leq 0.05$) between groups within body mass, height, Yo-Yo IRTL1 result, 5 m-, 10 m- and 20 m- sprint times, agility 5-0-5 left and right and countermovement jump and depth jump rebound height assessments (Table 5.4).

Under 11:

Bonferroni post hoc analysis showed the under 11 players were significantly different ($p \leq 0.05$) to other age groups within variables body mass, height, Yo-Yo IRTL1 result, 5 m-, 10 m- and 20 m- sprint times, agility 5-0-5 left and right times and countermovement jump assessments (Table 5.4).

The results from the bonferroni post hoc analysis revealed the U11s soccer players had a significantly lower body mass than U15s and U17s and lower height than U13, U15s and U17s, respectively ($p \leq 0.001$, $p \leq 0.001$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$ and $p \leq 0.001$; power = 1.000) ($p \leq 0.05$). Moreover, the U11s had a significantly lower Yo-Yo IRTL1 result than U15 and U17 age groups ($p=0.002$, $p=0.002$; power = 0.798) and a greater, thus slower sprint time over 5 m-, 10 m, and 20 m- distances than U13, U15 and U17 players ($p=0.005$, $p \leq 0.001$ and $p \leq 0.001$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$ and $p \leq 0.001$; power = 1.000, and $p=0003$, $p \leq 0.001$, $p \leq 0.001$; power = 1.000) ($p \leq 0.05$). The U11s agility 5-0-5 left time was significantly ($p \leq 0.05$) greater, thus slower than U15s and U17s while right assessments were significantly slower than U13s, U15s and U17s, respectively ($p \leq 0.001$, $p \leq 0.001$;

power= 1.000; and p=0.003, p$\leq$0.001 and p$\leq$0.001; power = 1.000). Lastly, U11s had a significantly lower countermovement jump than U15s (p=0.027; power = 0.136) (p$\leq$0.05).

Under 13:

Post hoc analysis also revealed U13 players were significantly different (p$\leq$0.05) to other age groups within the following variables: body mass, height, Yo-Yo IRTL1 result, 5 m-, 10 m- and 20 m- sprint time and agility 5-0-5 left and right assessments.

From mean comparisons between the groups, the results reveal U13s had a significantly lower body mass (p=0.015, p$\leq$0.001; power = 1.000) and height (p$\leq$0.001, p=0.004; power = 1.000) than U15s and U17s, but greater values in comparison to U11s for height assessments (p$\leq$0.001) (Table 5.4) (p$\leq$0.05). The U13 soccer players also had a significantly lower Yo-Yo IRTL1 result than the U17 age group (p=0.018; power = 0.798) and a greater, thus slower sprint time over 5 m-, 10 m, and 20 m- distances than U15 and U17 players (p=0.004, p=0.003; power = 1.000; and p$\leq$0.001, p$\leq$0.001; power = 1.000; and p$\leq$0.001, p$\leq$0.001; power = 1.000) but faster times than U11 players, respectively (p=0.005, p$\leq$0.001 and p=0.003) (p$\leq$0.05) (Table 5.4). The U13s also had significantly greater, slower agility 5-0-5 left and right time than U15s (p$\leq$0.001; power = 1.000; and p$\leq$0.001; power = 1.000), but faster time than the U11 players within agility 5-0-5 right assessments (p=0.003) (p$\leq$0.05).

Table 5.4. Mean and SD for each physical performance variable at each age group for the non-elite female soccer players

Variable	Non - Elite: Mean ±SD			
	Under 11	**Under 13**	**Under 15**	**Under 17**
Body Mass (kg)	38.6 ±8.6 #c ~d	45.5 ±7.7 #c ~d	53.7 ±6.3 †a *b	55.7 ±5.3 †a *b
Height (cm)	140.6 ±6.8 *b #c ~d	153.4 ±7.3 †a #c ~d	161.1 ±4.6 †a *b	162.3 ±5.9 †a *b
Yo-Yo IRT L1 distance (m)	364 ±180 #c ~d	445 ±182 ~d	657 ±195 †a	651 ±318 †a *b
5 m Sprint (s)	1.24 ±0.06 *b #c ~d	1.17 ±0.08 †a #c ~d	1.10 ±0.05 †a *b	1.11 ±0.06 †a *b
10 m Sprint (s)	2.20 ±0.13 *b #c ~d	2.08 ±0.11 †a #c ~d	1.95 ±0.07 †a *b	1.96 ±0.08 †a *b
20 m Sprint (s)	4.09 ±0.23 †b †c †d	3.85 ±0.24 †a †c †d	3.53 ±0.15 †a †b	3.51 ±0.17 †a †b
Agility 5-0-5 Left (s)	3.06 ±0.19 #c ~d	2.96 ±0.13 #c ~d	2.75 ±0.10 †a *b ~d	2.85 ±0.15 †a *b #c
Agility 5-0-5 Right (s)	2.96 ±0.10 *b #c ~d	2.92 ±0.13 †a #c	2.75 ±0.10 †a *b ~d	2.85 ±0.12 †a #c
Countermovement Jump (cm)	23.0 ±4.6 #c	24.8 ±3.5	27.4 ±3.5 †a ~d	22.8 ±5.1 #c
Depth Jump (cm)		22.5 ±4.5	25.8 ±3.7 ~d	20.0 ±5.3 #c

†a significant difference from U11 age group ($p \leq 0.05$)

*b significant difference from U13 age group ($p \leq 0.05$)

#c significant difference from U15 age group ($p \leq 0.05$)

~d significant difference from U17 age group ($p \leq 0.05$)

Under 15:

Further post hoc analysis demonstrated the U15 players were significantly different ($p \leq 0.05$) to other age groups within variables body mass, height, Yo-Yo IRTL1 result, 5 m-, 10 m- and 20 m- sprint time and agility 5-0-5 left and right, and countermovement and depth jump height assessments (Table 5.4).

From mean comparisons between the groups, the results reveal U15s had a significantly ($p \leq 0.05$) greater body mass and height than U11 and U13 age groups, respectively ($p \leq 0.001$, $p=0.015$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$; power = 1.000) (Table 5.4). Moreover, the U15s had a significantly ($p \leq 0.05$) greater Yo-Yo IRTL1 result than U11 age group ($p=0.002$; power = 0.798) and a lower, thus faster sprint time over 5 m-, 10 m-, and 20 m- distances than U11s and U13s, respectively ($p=0.005$, $p \leq 0.001$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$; power = 1.000 and $p \leq 0.001$, $p \leq 0.001$; power = 1.000). The U15s also had significantly lower, faster agility 5-0-5 times than U11s, U13s and U17s for left and right assessments, respectively ($p \leq 0.001$, $p \leq 0.001$, $p=0.05$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$, $p=0.037$; power = 1.000) ($p \leq 0.05$). Lastly, U15s possessed significantly greater countermovement jump height performance than U11s and U17s ($p=0.027$, $p \leq 0.001$; power = 0.136), and greater depth jump rebound height than U17s ($p \leq 0.001$; power = 0.128) ($p \leq 0.05$).

Under 17:

Bonferroni post hoc analysis also identified U17 soccer players were significant different ($p \leq 0.05$) to other age groups within variables body mass, height, Yo-Yo IRTL1 result, 5 m-, 10 m- and 20 m- sprint time and agility 5-0-5 left and right, and countermovement jump and depth jump assessments (Table 5.4).

From mean comparisons between the groups, the results show U17s had a significantly greater body mass and height than U11s and U13s ($p \leq 0.001$; power = 1.000; and $p \leq 0.001$, $p=0.004$; power = 1.000), respectively. The U17s players also had a significantly greater Yo-Yo IRTL1 result than U11 and U13 players ($p \leq 0.001$, $p=0.018$; power = 0.798) and a lower, thus faster sprint time over 5 m-, 10 m-, and 20 m- distances and agility 5-0-5 left and right times than U11s and U13s ($p \leq 0.001$, $p=0.003$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$; power = 1.000; and $p \leq 0.001$, $p \leq 0.001$; power = 1.000), respectively ($p \leq 0.05$). Alternatively when compared to the U15 players, U17 players possessed significantly greater, thus slower agility times on left and right ($p=0.05$; $p=0.037$), respectively ($p \leq 0.05$). Lastly, the U17s also had lower countermovement jump and depth jump rebound height performances were lower in U17 players when compared to the U15 players ($p \leq 0.001$; power = 0.136; and $p \leq 0.001$; power = 0.128) (Table 5.4) ($p \leq 0.05$).

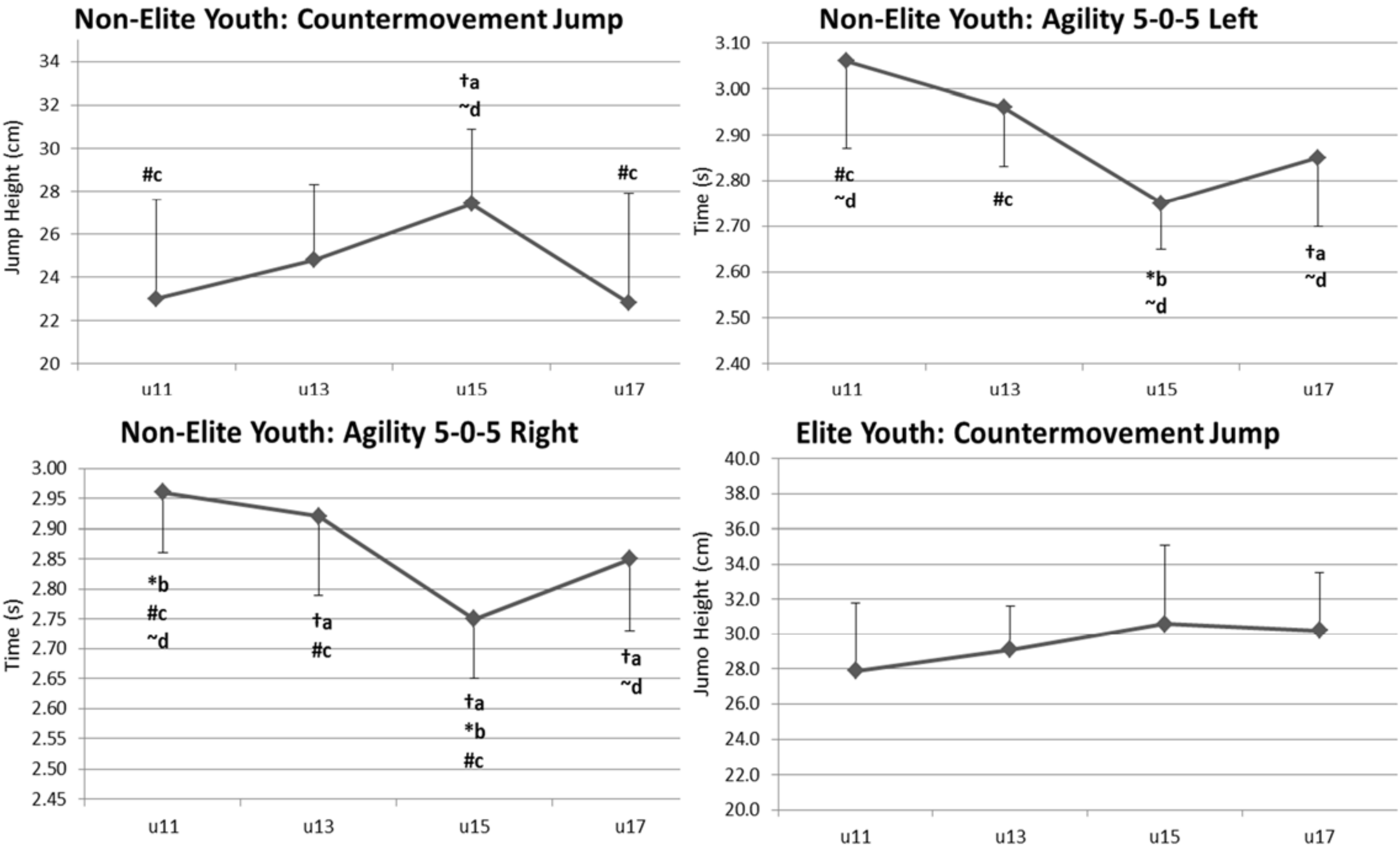

Figure 5.2. Showing the results from the CMJ, agility 5-0-5 left and right tests for non-elite players, and CMJ test results from elite female soccer players. †a significant difference from U11 age group; *b significant difference from U13 age group; #c significant difference from U15 age; ~d significant difference from U17 age group, ($p \leq 0.05$)

5.1.5. Are there any physical performance differences between youth elite and youth non-elite soccer players at specific age-groups? (Interaction)

Under 11s Elite vs. Non-Elite:

The independent samples t-test results comparing U11 age band elite and non-elite soccer players revealed significantly better performances in the elite players within Yo-Yo IRTL1 test ($p \leq 0.001$; power = 0.461), 5 m sprint time ($p \leq 0.001$; power = 0.857), 10 m sprint time ($p=0.028$; power = 0.839), 20 m sprint time ($p=0.028$; power = 0.860) (Table 5.5). There were no significant difference ($p>0.05$) between groups within body mass (power = 0.697), height (power = 0.265) and countermovement jump (power = 0.697) assessments (Table 5.5).

Table 5.5. Mean and SD for each physical performance variable for U11 elite and non-elite female soccer players

Variable	Under 11 Age Group: Mean ±SD	
	Elite (n=9)	Non Elite (n=18)
Body Mass (kg)	35.6 ±6.3	38.6 ±8.6
Height (cm)	138.8 ±7.5	140.6 ±6.8
Yo-Yo IRT L1 distance (m)	1053 ±379 *	364 ±180
5 m Sprint (s)	1.13 ±0.05 *	1.24 ±0.06
10 m Sprint (s)	2.01 ±0.12 #	2.20 ±0.13
20 m Sprint (s)	3.71 ±0.23 #	4.09 ±0.23
Countermovement Jump (cm)	27.9 ±3.9	23.0 ±4.6
* significant difference between elite and non-elite $p<0.01$ # significant difference between elite and non-elite $p\leq0.05$		

Under 13s Elite vs. Non-Elite:

The result findings show significant differences within Yo-Yo IRTL1 test ($p\leq0.001$; power = 0.461), and 20 m sprint time ($p=0.028$; power = 0.860) (Table 5.6). There were no significant difference ($p>0.05$) between groups for body mass (power = 0.697) and height (power = 0.265) and 5 m sprint (power = 0.857), 10 m sprint time (power = 0.839), agility 5-0-5 left (power = 0.437) and right (power = 0.547), and countermovement jump (power = 0.697) assessments.

Table 5.6. Mean and SD for each physical performance variable for U13 elite and non-elite female soccer players

Variable	Under 13 Age Group: Mean ±SD	
	Elite (n=12)	**Non-Elite (n=17)**
Body Mass (kg)	45.6 ±11.4	45.5 ±7.7
Height (cm)	151.2 ±8.0	153.4 ±7.3
Yo-Yo IRT L1 distance (m)	1234 ±141 *	445 ±182
5 m Sprint (s)	1.12 ±0.05	1.17 ±0.08
10 m Sprint (s)	1.97 ±0.08	2.08 ±0.11
20 m Sprint (s)	3.55 ±0.16 *	3.85 ±0.24
Agility 5-0-5 Left (s)	2.93 ±0.12	2.96 ±0.13
Agility 5-0-5 Right (s)	2.93 ±0.15	2.92 ±0.13
Countermovement Jump (cm)	29.1 ±2.5	24.8 ±3.5
* significant difference between elite and non-elite $p<0.01$		

Under 15s Elite vs. Non-Elite:

The results from the independent samples t-test comparing U15 age band elite and non-elite soccer players revealed significant differences within Yo-Yo IRTL1 test ($p\leq0.001$); power = 0.461), 10 m sprint time ($p\leq0.001$; power = 0.839), 20 m sprint time ($p\leq0.001$; power = 0.860), and depth jump ($p\leq0.001$; power = 0.976) (Table 5.7). There were no significant difference ($p>0.05$) between groups for body mass (power = 0.697) and height (power =

0.265), 5 m-sprint time (power = 0.857), agility 5-0-5 left (power = 0.437) and right (power = 0.547) and countermovement jump (power = 0.697) assessments.

Table 5.7. Mean and SD for each physical performance variable for U15 elite and non-elite female soccer players

Variable	**Under 15 Age Group: Mean ±SD**	
	Elite (n=55)	**Non-Elite (n=21)**
Body Mass (kg)	50.3 ±7.5	53.7 ±6.3
Height (cm)	158.9 ±5.9	161.1 ±4.6
Yo-Yo IRT L1 distance (m)	1422 ±434 *	657 ±195
5 m Sprint (s)	1.07 ±0.06	1.10 ±0.05
10 m Sprint (s)	1.88 ±0.09 *	1.95 ±0.07
20 m Sprint (s)	3.38 ±0.17 *	3.53 ±0.15
Agility 5-0-5 Left (s)	2.69 ±0.09	2.75 ±0.10
Agility 5-0-5 Right (s)	2.69 ±0.09	2.75 ±0.10
Countermovement Jump (cm)	30.6 ±4.5	27.4 ±3.5
Depth Jump (cm)	30.0 ±4.1 *	25.8 ±3.7
* significant difference between elite and non-elite $p<0.01$		

Table 5.8. Mean and SD for each physical performance variable for U17 elite and non-elite female soccer players

Variable	Under 17 Age Group: Mean ±SD	
	Elite (n=65)	**Non-Elite (n=18)**
Body Mass (kg)	57.0 ±7.1	55.7 ±5.3
Height (cm)	164.9 ±7.2	162.3 ±5.9
Yo-Yo IRT L1 distance (m)	1760 ±570 *	651 ±318
5 m Sprint (s)	1.04 ±0.06 *	1.11 ±0.06
10 m Sprint (s)	1.83 ±0.07 *	1.96 ±0.08
20 m Sprint (s)	3.28 ±0.11 *	3.51 ±0.17
Agility 5-0-5 Left (s)	2.66 ±0.10 *	2.85 ±0.15
Agility 5-0-5 Right (s)	2.66 ±0.13 *	2.85 ±0.12
Countermovement Jump (cm)	30.2 ±3.3 *	22.8 ±5.1
Depth Jump (cm)	30.0 ±3.8 *	20.0 ±5.3
* significant difference between elite and non-elite $p<0.01$		

Under 17s Elite vs. Non-Elite:

The results from the independent samples t-test identified significant differences within Yo-Yo IRTL1 test ($p \leq 0.001$, power = 0.461), 5 m sprint time ($p \leq 0.001$; power = 0.857) 10 m sprint time ($p \leq 0.001$; power = 0.839), 20 m sprint time ($p \leq 0.001$; power = 0.860), agility 5-0-5 left ($p \leq 0.001$); power = 0.437) and right ($p \leq 0.001$; power = 0.547), countermovement jump ($p \leq 0.001$); power = 0.697) and depth jump ($p \leq 0.001$; power = 0.976) assessments (Table

5.8). There were no significant difference ($p>0.05$) between groups for body mass (power = 0.697) and height (power = 0.265) tests.

Summary of Results

To summarise Elite player’s had significantly greater Yo-Yo IRTL1 distance, countermovement jump height and depth jump rebound height than non-elite players ($p<0.01$) [5.1.1]. Elite player’s also had significantly lower (faster) 5 m-, 10 m- and 20 m- sprint times, and agility 5-0-5 left and right times than the non-elite players ($p<0.01$). There was no significant differences reported for body mass and height variables ($p>0.05$) [5.1.1].

Specific trends across the age groups were observed, with the performance improving across all physical performance variables as age-groups increased (5.1.2). There were significant differences present between the age-groups for body mass, height, Yo-Yo IRTL1 distance, 5 m-, 10 m-, and 20 m- sprint times and agility 5-0-5 left and right times ($p \leq 0.05$). There were no significant differences between age groups for countermovement jump height, depth jump rebound height and Nordic hamstring lowers ($p>0.05$) [5.1.2].

There were also clear trends across the age groups in relation to their performance within the physical assessments for elite players; as the age-groups increased, performance within the physical tests improved (5.1.3). There were significant differences present between the age-groups for variables body mass, height, Yo-Yo IRTL1 distance, 5 m-, 10 m-, and 20 m- sprint times and agility 5-0-5 left and right times ($p \leq 0.05$) [5.1.3]. There were no significant differences between age groups for countermovement jump height, depth jump rebound height and Nordic hamstring lowers ($p > 0.05$) [5.1.3].

There were significant differences present between the age-groups for non-elite players for variables body mass, height, Yo-Yo IRTL1 distance, 5 m-, 10 m-, and 20 m- sprint times, agility 5-0-5 left and right times, countermovement jump height and depth jump rebound height ($p \leq 0.05$). Like all-players (5.1.2) and elite players (5.1.3) there were specific trends displayed between age-groups and performance. However, this was not demonstrated for all variables. Non-elite players displayed trends dissimilar to all players and elite players for Yo-Yo IRTL1, 5 m- and 10 m- sprint times, agility 5-0-5 left and right times, countermovement jump height and depth jump rebound height (5.1.4).

Elite U11 players possessed significantly greater performance for Yo-Yo IRTL1, and lower, thus faster times for 5 m-, 10 m- and 20 m- sprint times than non-elite players (5.1.5). There were no significant differences between groups for body mass, height and countermovement jump height assessments ($p > 0.05$).

Elite U13 players had significantly greater Yo-Yo IRTL1 distance and lower 20 m sprint time than non-elite players (5.1.5). No other significant differences between the groups were reported for any other variable ($p > 0.05$).

The elite U15 players displayed significantly greater performance results than non-elite players for Yo-Yo IRTL1, 10 m- and 20 m- sprint, and depth jump rebound height variables (5.1.5). There were no other significant differences present for any other variable ($p > 0.05$).

Elite U17 players had significantly greater performance for Yo-Yo IRTL1, countermovement jump height and depth jump rebound height variables compared to non-elite players (5.1.5). Elite players also had significantly lower, thus faster performance at 5 m-, 10 m-, and 20 m-sprint times, and agility 5-0-5 left and right times than non-elite players. There were no significant differences between groups for body mass and height assessment variables ($p>0.05$).

Discussion

The purpose of this chapter was to assess the physical performance of female youth soccer players (objective *c*).

The main findings from section 5.1.1 showed elite youth soccer players had greater Yo-Yo IRT L1 distance, countermovement jump height and depth jump rebound height and significantly faster 5 m sprint time, 10 m sprint time, 20 m sprint time, agility 5-0-5 time left and right turns than the non-elite players ($p \leq 0.05$). Although the tests and testing protocols differed to the present study, Vaeyens et al. (2006) found similar results between elite and non-elite youth male soccer players. The male elite players in this particular research study demonstrated significantly greater performances in vertical jump height, static bent arm hang, sprint and endurance shuttle run tests in comparison to non-elite players (Vaeyens et al., 2006) ($p<0.05$). On the other hand, Le Gall et al. (2008) found the only differences between the groups at youth level were countermovement jump height and 40 m sprint time assessments. Le Gall et al. (2008) found no significant differences between international (elite) and amateur (non-elite) players for variables10 m and 20 m sprint which contradicts the results from section 5.1.1. Reilly et al. (2000) however found elite male youth soccer players performed faster 5 m sprint times than non-elite players (1.04±0.03 s vs. 1.07±0.06 s) similar to the findings of the present section (5.1.1); however, the differences were not significant ($p>0.05$). All other physical performance tests in Reilly et al. (2000) identified elite players had significantly greater performances than non-elite players ($p<0.05$) which supports the results from the present study.

The analysis between age groups U11 vs. U13 vs. U15 vs. U17 across physical performance tests found significant differences for Yo-Yo IRTL1, 5 m-, 10 m- and 20 m- sprint times, and agility 5-0-5 left and right times. Even though all groups were not all significantly different to each other, the trends for every variable showed increases in performance as the age groups increased. The U17s were better at the tests than U11, U13 and U15 players; the U15s were better at each test in comparison to U11 and U13 players; and the U13s performed to higher level in all physical tests when compared to U11s players (Figure 5.1, page 117).

This was also similar for the comparisons for all variables between the age groups for elite players only with the exception of countermovement jump (Figure 5.2, page 128) which showed the U17s performed poorer than U15 players. All other variables showed progressive improvements in physical performance for each test from U11s up to U17 age groups. This trend is also true for non-elite players in section 5.1.4 from U11 to U15 age groups. However, the non-elite trends for all variables (except 20 m sprint) contradict those findings in sections 5.1.2 (all players) and 5.1.3 (elite players) showing the U17s performing worse in physical assessments (Figure 5.1, page 117).

Long term athletic development research has demonstrated that an individual will improve physical qualities as they develop through biological maturity (Lloyd et al., 2011; Vescovi et al., 2010; Sherar et al., 2005), however when a female athlete reaches near full biological maturation around U17 ages these biological changes slow down. Therefore, after full maturation is achieved, a female athlete's ability to continue to improve their physical qualities will be determined by their adaptations to training. Therefore, possible reasons for the different rates of changes between U15 and U17 for elite and non-elite players (Figure 5.1, page 117; and Figure 5.2, page 128) could be due to the types of conditioning each group does. Elite players at centre of excellence soccer teams have a sport scientist and physiotherapist leading conditioning programs with the players at least once a week which may influence the physical improvements from U15 to U17 age groups. Whereas non-elite players receive no conditioning support from their club which may be a possible reason why these players do not improve their physical performance from U15 to U17.

Vescovi et al. (2010) supports the findings within section 5.1.2 (all players) and 5.1.3 (elite players) identifying the older group (18-21 yrs) as the highest performing age group, and the youngest age group (12-13 yrs) as the least. These speed, power and change of direction assessments were also found to include significantly differences between the female soccer age groups which is similar to the reports in the present study. Russell and Tooley (2011) found similar trends within youth male soccer players showing improvements in performance physical assessments from under-14 (U14) to under-16 (U16) to under-18 (U18) players; with significant differences reported for 15 m sprint, 30 m sprint, countermovement jump, VO_2max variables ($p<0.05$).

On the whole, the findings from section 5.1.5 showed the elite players performed better than the non-elite players in all physical assessments; with exception of agility 5-0-5 test for U13s. The elite U11 players were significantly better across Yo-Yo IRTL1 and 5 m-, 10 m- and 20 m- sprint assessments than the U11 non-elite players ($p \leq 0.05$). The elite players performed significantly better than non-elite players in variables Yo-Yo IRTL1 and 20 m sprint time for U13 age groups, and for Yo-Yo IRTL1, 10 m sprint, 20 m sprint and depth jump assessments within the U15 age group ($p < 0.001$). The U17s results showed the elite players performed to a significant greater standard than the non-elite players for all physical performance assessments: Yo-Yo IRTL1, 5 m-, 10 m-, 20 m- sprint times, agility 5-0-5 left and right times, countermovement jump height and depth jump rebound height ($p < 0.001$). The findings from the present study support those reported in section 5.1.1 and Reilly et al. (2000), even though Reilly et al. (2000) used U16 youth male soccer players. Reilly et al. (2000) found elite players performed better than sub-elite players with differences significant for variables 15 m-, 25 m-, 30 m- sprint, VO_2max and vertical jump tests. Vaeyens et al. (2006) did use male youth age groups which were more alike to those used in section 5.1.5. They found elite players were faster than non-elite players at U13, U14, U15 and U16, obtained greater power at U14, U15 and U16, and greater aerobic performance at U15 and U16 ($p < 0.05$). Alternatively, even though Le Gall et al. (2008) did not compare elite and non-elite players, they did find elite players with significantly greater physical performance results at youth level played at a greater level of player compared to those who had lower physical performance assessment results ($p < 0.05$). With the previous literature findings and the results from this chapter it may be possible to suggest that when technical and tactical abilities are matched, elite female youth soccer players could play at a greater level of play based on their greater physical performance capabilities.

There could be multiple reasons why the elite players in this research possess greater physical performances in numerous tests and achieved the greater levels of play whilst non-elite players did not. One possible reason could be that the elite players have participated in a greater number of training hours than the non-elite players, which has shown to be contribute to greater performance levels (Memmert et al., 2010; Weissensteiner et al., 2008; Baker et al., 2006; Duffy et al., 2004; Hodges et al., 2004; Baker et al., 2003; Helsen et al., 1998). Further possible reasons may be that many of the elite players achieved greater levels of play by participating in more sports than soccer while non-elite players specialise in just soccer much earlier, however the research on early specialisation is contradicted between sports. For instance, super-elite athletes in sports such as platform diving, gymnastics and figure skating all achieved greater levels of performance than elite athletes due to early specialisation in their sport (Gullich and Emrich, 2014; Law et al., 2008). However, other evidence suggests that super-elite athletes in sports such as soccer, tennis, field hockey and other Olympic sports performed greater volumes of practice in other sports, started later in their main sport and specialised later than elite athletes (Gullich, 2014; Gullich and Emrich, 2014; Hornig et al., 2014; Carlson, 1988).

In hind sight, it would have been beneficial to get the youth soccer players to fill out a questionnaire about their current level of activity, past and present. For example, how many other sports do they play as well as soccer, how many hours of each sport have they completed each week since they very first began playing sport. This could have given an improved insight into possible reasons why the elite and non-elite players presented key differences across physical performance tests at each age group.

It would have also been valuable to collect all physical testing data for all variables at each assessment occasion, however, due to time and facility restrictions not all tests could be performed. For example, data could not be collected for Nordic hamstring lowers when assessing non-elite players due to the lack of facilities at their training ground.

In England, female youth soccer matches and training practices are played in chronological age groups at both elite and non-elite levels which was a reason why the investigations of youth soccer players were split into chronological age groups. However, it would have been beneficial to assess each player's maturation qualities using Sherar et al.'s (2005) equations to gain biological age and age from peak height velocity (PHV) data and link this to the physical performance results. This is a consideration for future research.

Conclusion

In summary, the main findings from this chapter suggest elite soccer players obtain greater physical performances than non-elite players at youth level. Thus, this may allow the assumption that not only are elite soccer players playing at the highest level because of their technical and tactical abilities, but could they also have been signed or retained at this high level because of their greater physical performance. On the other hand, it could be possible that non-elite players may not be able to play at a high level because of their lack of physical performance qualities, or are they playing soccer at a low level due to poorer soccer abilities, or a combination of both?

Chapter 6.0.

Does match performance differ between elite and non-elite youth female soccer players at different levels of play?

Introduction

Multiple match performance analysis methods have been constructed over the last few decades, including time-motion analysis, semi-automated computerised systems and global positioning systems (GPS). These methods have been used to determine match performance in senior male and female soccer matches within numerous research studies (Owen et al., 2014; Wehbe et al., 2014; Andrzejewski et al., 2013; Di Mascio and Bradley 2013; Silva et al., 2013; Souglis et al., 2013; Vigne et al., 2013; Andrzejewski et al., 2012; Lago-Penas et al., 2011; Andersson et al., 2010; Bradley et al., 2010; Dellal et al., 2010a; Gregson et al., 2010; Rampinini et al., 2009; Mohr et al., 2008; Mohr et al., 2003). Eighty-one percentage of these research studies constitute the use of time-motion analysis and semi-automated computerised system methods whilst only 19% are of GPS analysis methods. All 19% of GPS analysis methods were studies investigating male soccer, none to the author's knowledge have been used to determine senior female soccer performance. Also, no studies have investigated soccer match performance using GPS methods within youth female soccer players, to the author's knowledge. This leads us to assume there is a lack of research on female soccer and leads us to consider more research is needed within this area; thus, the purpose of this research study was to investigate the differences in match performance, through GPS analysis, between elite and non-elite soccer players at youth standards of play.

Chapter 6.0 aims to determine the match performance differences between elite vs. non-elite youth female soccer players (objective *d*). This chapter involves the use of the GPS methods used in chapter 4.0 (page 91) in order to detect soccer match performance variables of youth female elite players and non-elite players.

Participants

Thirty-four under-15 (n=13) and -17 (n=21) players from centre of excellence clubs and amateur/ grass roots clubs were recruited to take part in this research study (age: 15.9±0.6 yrs; body mass: 56.8±5.2 kg; height: 164.9±6.3 cm). Twenty-two subjects were players at centre of excellence clubs (elite) while the remaining twelve subjects in the study were players from a grassroots/amateur club (non-elite). Figure 1.4 (page 25) demonstrates the female youth soccer structure in England to demonstrate where the two sets of soccer players were sampled from.

Protocol

Match performance (GPS) methods were carried out during this study using distance covered- and speed zone- variables. All methodological detail and the reliability of these methods and testing equipment were shown to have an excellent level of reliability in chapter 4.0 (page 91) (r= 0.950-0.997), based on Coppieters et al. (2002) criteria. The researcher gained permission from the relevant personnel at both the elite and the non-elite teams and each subject/ parent/ guardian signed an informed consent form, after the study was approved by the University of Salford Research and Ethics Committee (HSCR13/46). Data for this study was collected from competitive league matches and only included if the subject had played the full 80-minutes of the soccer match, all other data which were less than 80-minutes was immediately discarded.

Statistical Analysis

Statistical analysis was performed on the data using SPSS (version 20). All parameters were checked for their conformity to normal distribution through a Shapiro Wilks test. An independent samples t-test was carried out to identify if differences between elite and non-elite youth soccer players exist across distance covered variables and speed zone variables. Significance level was set at $p \leq 0.05$.

Results

Distance Covered Variables:

The results from the independent samples t-test show the elite players demonstrated a significantly greater total distance covered ($p \leq 0.001$), distance covered at zone -2 ($p=0.004$), -3 ($p \leq 0.001$), -4 ($p \leq 0.001$), -5 ($p \leq 0.001$), -6 ($p \leq 0.001$) and percentage of the total distance at zone -3 ($p \leq 0.001$), -4 ($p \leq 0.001$), -5 ($p \leq 0.001$), -6 ($p=0.006$) than the non-elite players (Table 20). It was also shown that the non-elite players possessed a significantly greater ($p \leq 0.05$) percentage of total distance covered at zone 1 ($p \leq 0.001$) than elite players. There were no other significant differences between groups for any other distance covered variables ($p>0.05$).

Table 6.1. Mean and SD of each distance covered variable for elite and non-elite female youth soccer players

Variables	**Elite** **Mean ±SD**	**Non-Elite** **Mean ±SD**
Total Distance Covered (m)	7893 ±1306 #	5398 ±803
Distance Covered at Zone 1 (m)	2992 ±408	2942 ±140
Distance Covered at Zone 2 (m)	853 ±214 #	609 ±222
Distance Covered at Zone 3 (m)	2139 ±607 #	1077 ±370
Distance Covered at Zone 4 (m)	989 ±365 #	425 ±173
Distance Covered at Zone 5 (m)	574 ±228 #	208 ±103
Distance Covered at Zone 6 (m)	347 ±187 #	128 ±98
Percentage of total distance covered at Zone 1 (%)	39 ±7 #	56 ±8
Percentage of total distance covered at Zone 2 (%)	11 ±2	11 ±3
Percentage of total distance covered at Zone 3 (%)	27 ±4 #	19 ±4
Percentage of total distance covered at Zone 4 (%)	12 ±3 #	8 ±3
Percentage of total distance covered at Zone 5 (%)	7 ±2 #	4 ±2
Percentage of total distance covered at Zone 6 (%)	4 ±2 #	2 ±2
# significant difference between groups ($p \leq 0.05$)		

Speed Zone Variables:

Statistical analysis results from the independent samples t-test showed the elite players performed a significantly greater number of entries in zone -1 ($p=0.004$), -2 ($p \leq 0.001$), -3 ($p \leq 0.001$), -4 ($p \leq 0.001$), -5 ($p \leq 0.001$) and -6 ($p \leq 0.001$) than non-elite players Table 6.2). Moreover, elite players spent a significantly greater time in speed zone -2 ($p=0.016$), -3 ($p \leq 0.001$), -4 ($p \leq 0.001$), -5 ($p \leq 0.001$), -6 ($p \leq 0.001$), yet significantly less time in speed zone -1 ($p=0.038$), when compared to non-elite players. Non-elite players demonstrated a significantly greater percentage of time in speed zone -1 ($p \leq 0.001$) when compared to elite players, however elite players had significantly greater percentage of time at speed zone -2 ($p=0.041$), -3 ($p \leq 0.001$), -4 ($p \leq 0.001$), -5 ($p \leq 0.001$) and -6 ($p \leq 0.001$).

Table 6.2. Mean and SD of each speed zone variable for elite and non-elite female youth soccer players.

Variables	**Elite** **Mean ±SD**	**Non-Elite** **Mean ±SD**
Number of Entries in Zone 1	548 ±132) #	387 ±160
Number of Entries in Zone 2	892 ±223 #	558 ±224
Number of Entries in Zone 3	717 ±232 #	358 ±157
Number of Entries in Zone 4	371 ±161 #	153 ±82
Number of Entries in Zone 5	164 ±77 #	60 ±34
Number of Entries in Zone 6	45 ±28 #	16 ±11
Time Spent in Speed Zone 1 (min)	58 ±7 #	64 ±8
Time Spent in Speed Zone 2 (min)	7 ±2 #	5 ±2
Time Spent in Speed Zone 3 (min)	13 ±4 #	7 ±2
Time Spent in Speed Zone 4 (min)	5 ±2 #	2 ±1
Time Spent in Speed Zone 5 (min)	2 ±1 #	1 ±0.5
Time Spent in Speed Zone 6 (min)	1 ±1 #	0.5 ±0.5
Percentage of Time at Speed Zone 1 (%)	67 ±8 #	80 ±6
Percentage of Time at Speed Zone 2 (%)	8 ±2 #	7 ±2
Percentage of Time at Speed Zone 3 (%)	15 ±4 #	9 ±3
Percentage of Time at Speed Zone 4 (%)	5 ±2 #	3 ±1
Percentage of Time at Speed Zone 5 (%)	2.6 ±1.0 #	1.0 ±0.6
Percentage of Time at Speed Zone 6 (%)	1.3 ±0.6 #	0.6 ±0.4
# significant difference between groups ($p \leq 0.05$)		

Discussion

The purpose of this study was to investigate the differences in match performance, through GPS analysis, between elite and non-elite soccer players at youth standards of play. The results showed the elite players had significantly greater total distance covered, distance covered at zone-2, -3, -4, -5, -6 and percentage of the total distance at zone -3, -4, -5, -6 than the non-elite players ($p \leq 0.05$). The non-elite players possessed a significantly greater ($p \leq 0.05$) percentage of total distance covered at zone 1 than elite players, while elite players obtained a greater number of entries in zone -1, -2, -3, -4, -5 and -6 than non-elite players highlighting a greater number of changes in activity ($p \leq 0.05$). Moreover, elite players were shown to spend a significantly greater time in speed zone -2, -3, -4, -5, -6, yet significantly less time in speed zone -1 (stood still/walking), when compared to non-elite players ($p \leq 0.05$). Non-elite players demonstrated a significantly greater percentage of time in speed zone -1 when compared to elite players, however elite players had significantly greater percentage of time at speed zone -2, -3, -4, -5 and -6.

Comparisons of distance covered between the elite players and non-elite players showed the elite players covered 46% (2495 m) greater distance during the 80-minute youth soccer match. This difference between elite and non-elite is greater than identified in previous soccer match performance studies investigating different playing levels. Mohr et al. (2003) demonstrated a 5% (530 m) difference between top class players and moderate level player’s total distance within male soccer match performance. Similar trends were reported in female senior soccer data: Andersson et al. (2010) identified international level players covered 2% (200 m) more of the total distance compared to domestic league players, however all players within this study were playing at a relatively high elite level. Conversely, Mohr et al. (2008)

found top class players (elite), and high level players (sub-elite) which were playing in sub-elite leagues. The total distance covered differences within Mohr et al. (2008) study were closer to those in this present chapter; 28% greater for the elite team.

Moreover, in terms of high intensity activities, the elite players covered greater distance at higher intensities than non-elite players. The crucial moments and the outcome of a soccer match is dependent on the performance of decisive high intensity activities (Jullien et al., 2008; Little and Williams, 2007; Aziz et al., 2000). Even though both groups played the same duration, the elite players covered 175% (366 m) more high-intensity running (zone 5) and 171% (219 m) more sprinting (zone 6) distance than non-elite players ($p \leq 0.05$). Not only did the elite players cover more distances at these high intensity levels, they also performed 173% (104) and 181% (29) more high-intensity and sprint bouts than non-elite players, respectively ($p \leq 0.05$). Similar to the results in the present study, Andersson et al. (2010) and Mohr et al. (2008) found the higher level players covered significantly 16% and 24% greater sprint distances than the lower level players, respectively. Further research from Mohr et al. (2003) showed male soccer players covered 650 m (58%) more sprinting distance at top class level (elite) than the moderate level players (non-elite) ($p<0.05$). Even though these research studies support the trends shown within the present study, the difference between elite and non-elite youth players in this study are much greater than the differences between level of plays within other male and female soccer match performance research. This suggests the gap between elite and non-elite players at youth level in English soccer is much greater than the levels within other senior female and male soccer match performances. It is important to note however, that although the speed categories for sprint (zone -6) were matched at 18 km/h, all the other studies used time motion analysis to obtain their data while the present study used GPS methods (Andersson et al., 2010; Mohr et al., 2008; Mohr et al., 2003).

The great differences between the two sets of youth players for high intense match performance variables in the present study could be explained by the activities performed at the lowest speed level (zone -1). The results reported the non-elite players spent 80% of the 80 minute soccer match stood still or walking, which was 13% (6- minutes) more than the elite players. Assumptions could be made from these data sets that the elite youth players may recover faster between the high-intense activities and require less recovery time (walking/ stationary activity), while the non-elite youth players require greater recovery from the high intense bouts hence, 80% of their 80-minute soccer match performance carried out either walking or stood still.

From the present study's findings, it can be assumed that elite players are physically performing to a greater standard during soccer matches in comparison to non-elite players. It is important to highlight that the elite youth players are not too far behind elite senior soccer players across numerous variables, while non-elite youth players are considerably behind. Andersson et al. (2010) and Mohr et al. (2008) demonstrate the high levels of physical match performance involved during senior soccer (Figure 6.1) such as greater distance covered, greater sprint distances and less time spent walking and stood stationary. It is worth noting that even though the youth elite players match duration was only 80-minutes, they did perform 97 m more sprint distances than the Swedish and Danish elite senior female players in Andersson et al. (2010) who performed in a 90-minute soccer match (347 m vs. 250 m).

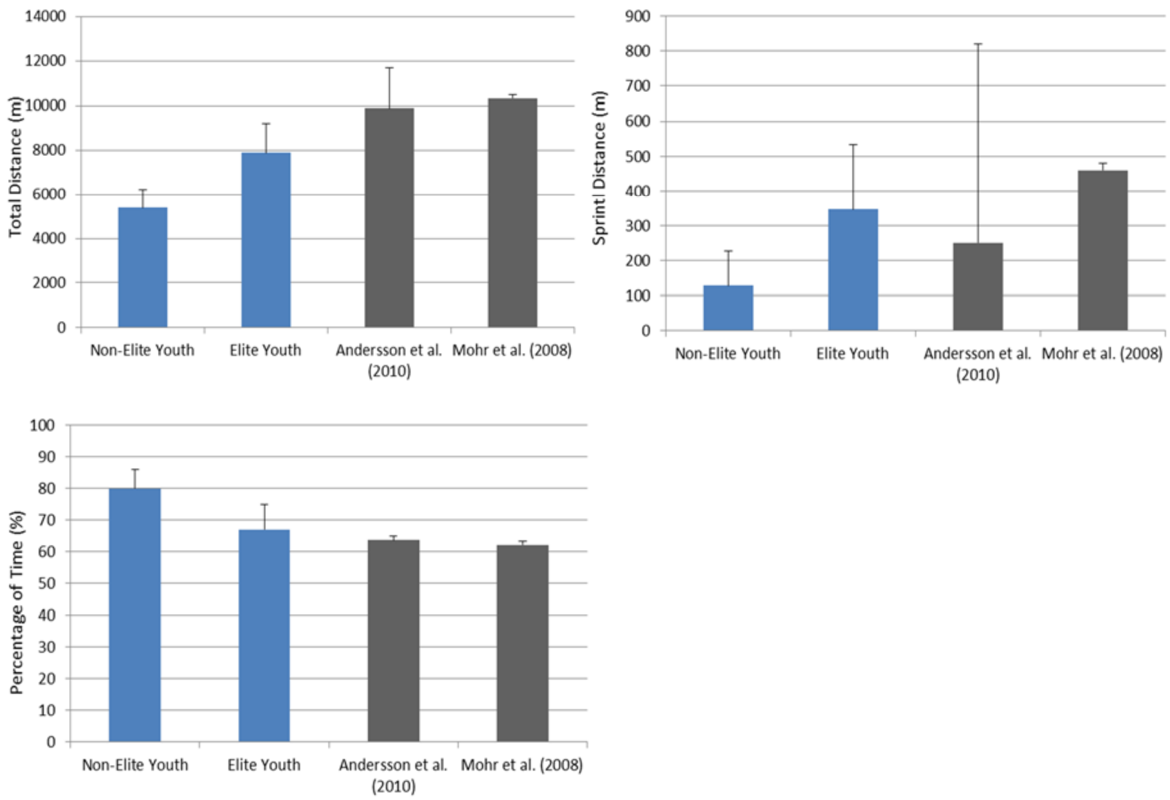

Figure 6.1. Showing youth elite and non-elite soccer players against the existing research across total distance, sprint (zone 6) distance and percentage of time in zone -1 (stationary/walking) variables

It is possible that these youth elite soccer players could enhance their performance within a soccer match even further through the use of appropriate training methods. Helgerud et al. (2001) found the 4x4 interval training (4 sets of 4 mins work, with 3 mins rest between sets) carried out twice a week for 8-weeks improved the total distance covered by 24% and increased the total number of sprints performed during a match by 100%. Based on these findings, the elite soccer players could improve their total distance covered from 7893 to 94712 m and their number of sprints from 45 to 90. After this type of training intervention program, the elite soccer players could be displaying greater total distance covered performance in an 80-minute match compared to Australian international players who perform in a 90-minute soccer match (Table 2.6, page 64) (Hewitt et al., 2007). Therefore, by carrying out this form of training it gives the female youth soccer players a greater chance of meeting the demands of a senior female soccer match and possibly setting the greater levels of match performance variables in female soccer.

These elite youth soccer players are performing at the sufficient level to compete at an elite level when they become a senior player, especially when you compare them to non-elite players. However, they must adapt to the 90-minute duration of senior soccer matches and continually progress to achieve the highest match performances possible. It is also important to note that the data within Andersson et al. (2010) and Mohr et al. (2008) is just normative, not the optimal; therefore match performance targets for these current elite youth soccer players must be greater than those reported to ensure female soccer grows considerably at both youth and senior levels.

When match performance was assessed, each outfield soccer player was asked to wear a GPS unit each throughout the duration of the soccer match. The only data recorded was that of the full soccer match duration. If a soccer player did not play for the full match duration (80 minutes), their data was discarded from the study. This was out of the researcher's control for reasons such as the player being substituted by the coach, an injury to the player which stopped further participation to the match etc. If these instances had not happened and each player had played the full duration for each match within the research data collection process, it would have benefited the data sample size.

There was a consistent method used to assess match performance within the studies. However, external influences may have affected each match assessment; such as the opponent, the environment (weather, crowd influence etc), the tactics the opponents used, the tactics each of the assessed team used etc. All of which could have influenced the results.

Conclusion

In summary, elite youth soccer players perform to a greater performance level during competitive soccer matches in comparison to non-elite players. The results from the GPS match performance assessments indicated youth elite players were substantially better than the non-elite players across numerous distance covered variables and speed zone variables.

Chapter 7.0.

Are there any differences in physical performance profiles in elite youth female soccer players?

Introduction

Female soccer match data has demonstrated a high level of aerobic and anaerobic conditioning is required for the sport (Andersson et al., 2010; Krustrup et al., 2010; Andersson et al., 2008; Mohr et al., 2008; Di Salvo et al., 2007; Hewitt et al., 2007; Krustrup et al., 2005). Mean data reports average heart rates between 84-86% MHR (Andersson et al., 2010; Krustrup et al., 2010) and the average total distances covered between 9,100-11,900 m (Andersson et al., 2010; Krustrup et al., 2010; Andersson et al., 2008; Mohr et al., 2008; Di Salvo et al., 2007; Hewitt et al., 2007; Krustrup et al., 2005). Even though the performance within soccer is primarily associated with a player’s aerobic endurance (due to the duration of the game, 90-minutes) (Mohr et al., 2003; Bangsbo et al., 1992), the performance, crucial moments and the outcome of a soccer match are all dependent on the performance of decisive anaerobic activities (Jullien et al., 2008; Little and Williams, 2007; Aziz et al., 2000). These decisive, anaerobic soccer components (sprinting, striking the ball, turning, jumping, changing pace, cutting and accelerating and decelerating the body) are forceful and explosive and require near-maximum levels of muscular strength and power production (Chelly et al., 2009; Little and Williams, 2006; Stolen et al., 2005; Dupont et al., 2004; Inklaar, 1994). Research in a female soccer match reports players change the intensity of the activity 1326-1379 times during the 90- minutes (Mohr et al., 2008), with anaerobic variables such as the number of sprints and high-intensity bouts to be 20-27- and 125-154- times (Andersson et al., 2010; Mohr et al., 2008), respectively. This has shown to equate to sprint distances between 250-460 m and 1,300-1,680 m as high-intensity running distances (Andersson et al., 2010; Mohr et al., 2008).

These studies reporting female soccer data all show the group mean, however, only Andersson et al. (2010) and Mohr et al (2008) compared the differences each playing position exerts in a soccer match. Andersson et al. (2010) found midfielders covered significantly greater total distance and high intensity running distances than defenders in senior International soccer matches (10,600±300 m vs. 9,500±900 m and 1920±200 m vs. 1,300±100 m), respectively ($p<0.05$). However there were no other significant differences between variables in international matches and domestic league matches (senior). Due to the low sample size of forward players (n=3), this playing position was not included within the statistical calculations. Mohr et al. (2008) on the other hand included all outfield players within the statistical analysis. This study also included only senior players and showed defenders ran significantly less high intensity running than midfielders and attackers (1,260±110 m vs. 1,650±110 m and 1,630±100 m), respectively ($p<0.05$). Furthermore, attackers were found to sprint a significantly greater distance than defenders in a soccer match (520±30 m vs. 330±50 m).

Haugen et al. (2014), Dillern et al. (2012) and Ingebrigtsen et al. (2011) showed differences between positions within physical performance assessment results. Dillern et al. (2012) and Ingebrigtsen et al. (2011) both found no significant differences between positions for VO_2max variable but found significant differences between positions for velocity at anaerobic threshold. Dillern et al.'s (2012) post hoc analysis revealed midfielders and attackers demonstrated a significantly greater velocity at anaerobic threshold than goalkeepers (10.0±0.6 km/h vs. 7.9±1.1 km/h and 9.3±1.1 km/h vs. 7.9±1.1km/h; p=0.032), respectively. Whilst Ingebrigtsen et al. (2011) found the defenders had a significantly greater velocity at anaerobic threshold than goalkeepers (10.10±0.99 km/h vs. 8.37±0.67 km/h; p=0.04). Haugen et al. (2012) alternatively assessed anaerobic variables and found there were no significant differences between playing positions for jump assessments but showed only 20 m sprint velocity to be the only significant variable to be different between positions. The study showed forwards significantly sprinted 3-4% faster than midfielders ($p<0.001$) and goalkeepers (p=0.003), while defenders sprinted 2% faster than the midfield players (p=0.019).

All these studies comparing playing positions within soccer matches and physical performance assessments include senior soccer players; except for Haugen et al. (2012) who included a sample of soccer players ranging from 15- to 35- years of age. No studies, to the author's knowledge, have assessed the differences between female playing positions for youth only players within a soccer match and physical performance assessments. Therefore, the purpose of this chapter is to investigate whether physical performance differs between playing positions (objective *e*).

Participants

One hundred and eighty-three youth elite female soccer players were recruited from centre of excellences to take part in this study (age: 15.1±0.7 yrs; body mass: 54.2±8.0 kg; height: 162.3±7.2 cm).These players were from the U15 and U17 age groups at these elite academies and consisted of goalkeepers (n=15), defenders (n=70), midfielders (n=58), forwards (n=40).

Protocol

Physical performance tests used within this study included body mass, height, body fat composition, Yo-Yo IRTL1, 5 m, 10 m, and 20 m sprint times, agility 5-0-5 left time, agility 5-0-5 right time, countermovement jump height, depth jump rebound height and Nordic hamstring lowers. The methods and reliability of each of these tests was assessed within chapter 3 (page 68). Each test protocol was explained to each subject and the methods remained consistent across each assessment throughout the data collection process. The researcher gained permission from the relevant personnel at the soccer clubs and each participating subject signed an informed consent form after the study was approved by the University of Salford Research and Ethics Committee (HSCR13/46).

Subjects were all asked to complete the studies consent forms after an overview of the assessment protocols were given. Each subject was asked to stay hydrated and refrain from any activity on the day of the testing and eat no less than 3- hours before the testing. This was standardised across each testing session.

Statistical Analysis

Statistical analysis of the data was carried out using SPSS (version 20). Normality of data was confirmed using a Shapiro Wilks test. A one-way ANOVA with post hoc Bonferroni analysis was used to assess the differences between playing positions at elite youth level (goalkeepers vs. defenders vs. midfielders vs. forwards). Significance level was taken at $p \leq 0.05$.

Results

Results from the one-way ANOVA revealed significant differences between playing positions for body mass ($p=0.001$), height ($p<0.001$), Yo-Yo IRTL1 ($p<0.001$), 10 m sprint ($p=0.005$), 20 m sprint ($p=0.008$), agility 5-0-5 right ($p=0.032$) and Nordic hamstring lowers ($p=0.009$) variables (Table 7.1).

Goalkeepers:

Results from the Bonferoni post hoc analysis showed goalkeepers had a significantly greater height than midfielders ($p=0.002$) and greater body mass than defenders ($p=0.016$) and midfielders ($p=0.001$). Goalkeepers had significantly lower Yo-Yo IRTL1 distances than defenders, midfielders and forwards ($p<0.001$). Goalkeepers were also significantly slower in the 10 m-($p=0.005$) and 20 m- ($p=0.006$) sprint assessments than the forwards, and significantly slower than the midfield players at 10 m sprint times ($p=0.034$) ($p\leq0.05$). Further analysis showed the goalkeepers had a significantly slower agility 5-0-5 right time than defenders ($p=0.029$) and forwards ($p=0.034$) and had a significantly greater Nordic hamstring lower break angle than midfield and forward players ($p=0.007$) ($p\leq0.05$). There were no other significant differences for any other variables and playing positions ($p>0.05$).

Defenders:

Bonferroni post hoc analysis results revealed defending players had significantly lower body mass than goalkeepers (p-0.016) and greater height than midfielders ($p=0.042$) ($p\leq0.05$). Defenders also had a significantly ($p\leq0.05$) greater Yo-Yo IRTL1 distance than goalkeepers ($p<0.001$). Further analysis showed defenders were significantly faster within agility 5-0-5 right assessments than goalkeepers ($p=0.029$). There were no other significant differences for any other variables and playing positions ($p>0.05$).

Midfielders:

Results from the post hoc statistical analysis showed midfielders had significantly lower body mass than goalkeepers ($p=0.001$) and were significantly smaller than goalkeepers ($p=0.002$), defenders ($p=0.042$) and forwards ($p<0.001$) ($p\leq0.05$). Midfielders were shown to have significantly greater Yo-Yo IRTL1 distance ($p<0.001$) and significantly lower Nordic break angle than goalkeepers ($p=0.020$), respectively ($p\leq0.05$). There were no other significant differences for any other variables and playing positions ($p>0.05$).

Table 7.1. Mean and SD for each playing position across each physical performance variable

Variables	Mean ±SD			
	Goalkeepers	**Defenders**	**Midfielders**	**Forwards**
Body Mass (kg)	60.8 ±5.3 †d †m	53.7 ±8.8 †g	51.9 ±6.8 †g	56.2 ±7.3
Height (cm)	166.6 ±7.9 †m	162.4 ±7.2 †m	159.0 ±6.4 †g †d †f	165.8 ±5.7 †m
Sum of Skinfold (mm)	45.1 ±8.5	47.4 ±11.4	43.0 ±10.7	41.9 ±15.0
Body Fat Composition (%)	19.2 ±3.5	20.1 ±4.7	18.3 ±4.4	17.9 ±6.2
Yo-Yo IRT L1 Distance (m)	771 ±249 †d †m †f	1488 ±514 †g	1681 ±529 †g	1701 ±459 †g
5 m Sprint (s)	1.07 ±0.05	1.07 ±0.07	1.05 ±0.06	1.05 ±0.06
10 m Sprint (s)	1.92 ±0.08 †m †f	1.87 ±0.09	1.86 ±0.08 †g	1.84 ±0.07 †g
20 m Sprint (s)	3.44 ±0.15 †f	3.35 ±0.17	3.33 ±0.14	3.29 ±0.12 †g
Agility 5-0-5 Left (s)	2.74 ±0.09	2.70 ±0.10	2.68 ±0.12	2.70 ±0.12
Agility 5-0-5 Right (s)	2.78 ±0.12 †d †f	2.68 ±0.13 †g	2.69 ±0.12	2.67 ±0.10 †g
Countermovement Jump (cm)	27.9 ±4.6	29.9 ±4.6	28.9 ±3.8	31.0 ±4.0
Depth Jump (cm)	29.1 ±4.9	29.2 ±4.5	28.8 ±3.8	30.1 ±3.5
Nordics (°)	57 ±8 †m †f	46 ±12	44 ±12 †g	41 ±13 †g

†g significant difference from goalkeepers ($p \leq 0.05$)

†d significant difference from defenders ($p \leq 0.05$)

†m significant difference from midfielders ($p \leq 0.05$)

†f significant difference from forwards ($p \leq 0.05$)

Forwards:

Bonferroni post hoc results from the statistical analysis identified the forward players were significantly taller in height than the midfielders ($p<0.001$). Further results showed forwards had a significantly greater Yo-Yo IRTL1 distance ($p<0.001$), and lower Nordic break angle ($p=0.007$) than goalkeepers ($p \leq 0.05$). Forward players were also the fastest position over 5 m, 10 m and 20 m sprint times, but only significantly($p \leq 0.05$) faster than goalkeepers for only 10 m ($p=0.034$) and 20 m ($p=0.006$) sprint assessments. Forwards also had the faster agility 5-0-5 right time with significant differences ($p \leq 0.05$) only to goalkeepers ($p=0.034$).

Discussion

The main findings from this chapter reports significant differences between playing positions for variables: Yo-Yo IRTL1, 10 m sprint time, 20 m sprint time, agility 5-0-5 right and Nordic hamstring lowers ($p<0.05$). Significant differences between playing positions for sprint times and agility times are all comparable with the findings from Gil et al. (2007). Gil et al. (2007) discovered forwards were significantly faster ($p<0.05$) than goalkeepers during agility testing, just like the results in this chapter. The present study also found the forwards were faster than goalkeepers and defenders, like Gil et al. (2007) ($p<0.05$; $p<0.001$, respectively), though the present study only found significant differences between forwards and goalkeepers for 20 m sprint ($p \leq 0.05$). However, Gil et al. (2007) did use different testing methods for sprint (30 m sprint) and agility (30 m with 10 cones) assessments and male soccer players from the Spanish Leagues.

Haugen et al. (2012) used the same sprint distance (20 m) as the present study and found female soccer player forwards were significantly ($p=0.003$) 4% faster than goalkeepers, which is comparable to the results in this study. Although Haugen et al. (2012) did also find the forwards and defenders were significantly faster than midfield players ($p<0.001$; $p=0.019$, respectively). On the other hand, when assessing youth male soccer players Pivovarnicek et al. (2013) found no significant differences between playing positions for sprint performance. However the number of subjects in this study was considerably lower than the sample size in the present study (Total: n=18 vs. 183; Goalkeepers: n=2 vs. 15; Defenders: n=4 vs. 70; Midfielders: n=7 vs. 58; Forwards: n=5 vs. 40).

There is limited research comparing Yo-Yo IRTL1 scores between playing position’s. Only Cihan et al. (2012) and Lago-Penas et al. (2014), to the author’s knowledge, assessed the difference between positions for the Yo-Yo IRTL1. Pivovarnicek et al. (2013) found male goalkeepers had significantly ($p<0.05$) lower performance within the Yo-Yo IRT level 2 whilst similarly, Lago-Penas et al. (2014) discovered male goalkeepers had significantly ($p<0.05$) lower Yo-Yo IRTL1 performance than all other playing positions. These two studies present comparable trends to the results in the present study. The results in this chapter showed goalkeepers to have significantly lower Yo-Yo IRTL1 distances than defenders, midfielders and forwards. Alternatively, Cihan et al. (2012) found male goalkeepers only had significantly lower Yo-Yo IRTL1 performance than midfield players, with midfielders also having significantly greater results than defenders and strikers (forwards). Due to the lack of Yo-Yo IRTL1 representative research for each playing position

Cihan et al. (2012) used Bangsbo et al.'s (2008) conversion equation to turn the Yo-Yo IRTL1 scores into VO_2max values; which is researched in greater depth in soccer playing positions. Table 7.2 includes the Yo-Yo IRTL1 results from this chapter converted to VO_2max values using Bangsbo et al.'s (2008) equation:

VO_2max = Yo-Yo IRTL1 distance (m) x 0.0084 + 36.4.

Table 7.2. Converted Yo-Yo IRTL1 results into VO_2max values for each soccer playing position

	Goalkeepers	**Defenders**	**Midfielders**	**Forwards**
VO_2max ($ml.kg^{-1}.min^{-1}$)	42.9	48.9	50.5	50.7

Dillern et al. (2012) assessed VO_2max (treadmill testing) results of each playing position from Norwegian third female soccer division (n=32) and found no significant differences between all playing positions ($p>0.05$). Similarly, Haugen et al. (2014) found no significant difference between female soccer positions for VO_2max results (treadmill testing) using similar sample sizes to this chapter's subject sample size (n=199 vs. n=183). However, the results from this chapter do show significant differences ($p<0.001$) between soccer playing positions using the soccer specific aerobic assessment designed by Bangsbo et al. (2008). Previous female soccer match data has demonstrated differences do occur between playing positions within key variables such as total distance covered and high intensity running distances. Which possibly leads us to suggest if aerobic assessments such as Yo-Yo IRTL1 are more commonly sensitive to the performance output of each playing position (Lago-Penas et al., 2014; Pivovarnicek et al., 2013; Cihan et al., 2012), then this greater soccer specific assessment should be used in the future instead of treadmill VO_2max testing.

The main findings from this chapter revealed significant differences between playing positions for Yo-Yo IRTL1, 10 m sprint time, 20 m sprint time, agility 5-0-5 right and Nordic hamstring lowers ($p<0.05$). The outfield playing positions (defenders, midfielders, forwards) performance a significantly greater Yo-Yo IRTL1 distance than the goalkeepers ($p<0.05$). The Yo-Yo IRTL1 test involves two 20 m shuttle runs followed by 10- seconds of active recovery and involves four running bouts at 10-13 km/h, seven shuttles at 13.5-14 km/h and thereafter increases speed by 0.5 km/h every eight running bouts. This specific activity is something that the goalkeepers do not get exposed and is not specific for the demands of the playing position, whereas outfield players will perform similar movements to the Yo-Yo IRTL1 during every training sessions and soccer match. This could also explain the significant differences present for the 10 m sprint time and 20 m sprint time between the goalkeepers and some of the outfield positions. It is possible to suggest that the goalkeepers may have recorded significantly slower 10 m sprint time than midfielders and forwards ($p<0.05$) and significantly slower 20 m sprint time than forwards ($p<0.05$) because the positional demands of a goalkeeper do not require them to make numerous 10 m and 20 m sprints throughout training and soccer matches. Further to this, a goalkeeper will perform shorter sprints and explosive jump movements, similar to the outfield playing positions, thus this could be the reason why there were no significant differences between playing positions for 5 m sprint time and jump height tests.

From this discussion, when assessing a player’s physical performance is it appropriate to test a physical variable which does not correspond to the demands of their playing position? For example, if the physical demands of a goalkeeper do not require them to have perform 20 m shuttle runs and 20 m sprints should they be assessed for Yo-Yo IRTL1 and 20m sprint tests? Would it be more applicable to assess their sprint time over 10 m, or create positional specific tests for a goalkeeper which match the demands of their position?

Following on from this, if a team's style of play is to "press" the opponent when they have the ball in their half where the team's forwards and the midfielders will be required to perform 20 m sprints continuously at a high intensity, the physical demands of these forward and midfield players would be different to if a team's style of play is to sit back and block and build play and only required to perform 5 to 10 m sprints with multiple changes in direction. The first team would possess greater performances in the 20 m sprint and Yo-Yo IRTL1 tests and poorer agility 5-0-5 times, while the second team could produce poorer 20 m sprint time and Yo-Yo IRTL1 distance and faster agility 5-0-5 times. These reasons could account for the lack of significant differences between outfield players in the physical performance tests. This is something to consider in the future when assessing players physical performance's from different soccer clubs.

Further to this, when working with a team it could be important to train the players based on the soccer team's style of play. The example of the soccer team who "pressed" the opponent in their half when they had the ball and performed 20 m sprints throughout the game at high intensity would require training intervention programs which specifically aimed to improve aerobic qualities (the ability to recover from each high intense bout) and sprint performance (Comfort et al., 2014; Comfort et al., 2012 a; Comfort et al., 2012 b; Dellal et al., 2010b; Wong et al., 2010; Chelly et al., 2009; McBride et al., 2009; Hori et al., 2008; Ronnestad et al., 2008; Sporis et al., 2008; Christou et al., 2006; Chamari et al., 2005; McMillian et al., 2005; Wisloff et al., 2004; Hoff et al., 2002; Helgerud et al., 2001).

This study includes comparisons of each youth soccer playing position and how they differed in terms of their physical performance assessment results. From this, a feedback document was produced which identifies descriptive boundaries based on a soccer player's testing result data: i.e. what is good, above average, below average or poor (Table 11.3, page 221). There was a great sample size for each playing position which allowed the data to be split into 4 groups: goalkeeper, defender, midfielder and forwards. If the data sample size had been even greater it would have been highly beneficial to break the groups into more playing positions: For example, goalkeeper, full back defender, central defender, centre midfielder (defending), centre midfielder (attacking), centre forward, wide midfielder/forward. Moreover, it would have been beneficial to construct the same analysis for the match performance assessment. For example, what is good, above average, below average or poor for each distance covered and speed zone variable. However, because many soccer players did not participate in the soccer match for the full duration those data samples were discarded. Thus, the overall sample size was not large enough to perform similar statistical analysis in this study.

Conclusion

In summary, the research in this chapter identified differences exist between positions within physical performance assessments, with significant differences for sprint performance (10 m and 20 m), Yo-Yo IRTL1 distances, agility 5-0-5 (right) times and Nordic hamstring lowers break point angle. These findings suggest position specific training interventions could be utilised in order to optimise the performance and meet the demands of each playing position.

Chapter 8.0.

Do physical and match performance results of senior female soccer players differ between starters and non-starters?

Introduction

There is limited research comparing the results of physical performance between starting and non-starting soccer players. Silvestre et al. (2006) found male starting soccer players to have similar results to non-starting players across all physical performance variables except for total body power production assessments. Also, out of all six separate bouts of testing across the season Kraemer et al. (2004) only found the starters to be different from non-starting players in the fifth set of testing, showing a significant 4.3% and 13.8% decrease in sprint speed and vertical jump performance when compared to the previous four testing sessions. There were no other differences for any other variables within this study. On the other hand, Manson et al. (2014) more recently assessed international (New Zealand) elite female soccer players and found the starters to have significantly greater maximal aerobic velocity, relative peak vertical force during sprint performance and absolute and relative eccentric leg strength from isokinetic assessments than non-starting players at U17 level, respectively (18.9±0.40 km/h vs. 18.2±1.2 km/h; 23.7±1.92 $N.kg^{-1}$ vs. 21.6±2.02 $N.kg^{-1}$; absolute: 165±39.3 $N.m^{-1}$ vs. 120±34.7 $N.m^{-1}$; relative: 2.81±0.57 $N.m^{-1}$ vs. 2.09±0.60 $N.m^{-1}$). Commonly, Jenkins et al. (2013) also found starters to have greater eccentric strength than non-starting players on isokinetic physical performance assessments in USA female soccer.

Other research carried out on starting and non-starting soccer players has been based on body composition, body load and hormonal responses (McLean et al., 2012; Haneishi et al., 2007; Kraemer et al., 2004).

Although research has been carried out on starters and non-starters within physical performance assessments, there is a lack of data on match performance assessment comparisons. There has been research published on elite and non-elite soccer player comparisons from different teams and/or levels of play, however to the author's knowledge, match performance assessments have not been compared with starters and non-starters within the same female soccer club. Therefore the aim of this study is to directly compare starters and non-starters across physical and match performance assessments within English Soccer players.

8.1.1. Physical Performance of Senior Female Soccer: Starters vs. Non-Starters

Participants

One hundred and fifteen players were recruited from female soccer clubs in the Women's National Premier League and the Women's Northern Premier Division to take part in this study. Sixty-four of those assessed were regular first team players (Starters) and the remaining fifty-one subjects were reserve team players (Non-Starters) (Starters: age: 24.5±4.2 yrs, body mass: 59.6±6.3 kg, height: 165.0±5.1 cm; Non-Starters: age: 21.5±5.6 yrs, body mass: 58.9±8.2 kg, height: 160.1±6.5 cm). The positional types of the starting players included one goalkeeper, twenty-five defenders, seventeen midfielders and twenty-one forwards; whilst the non-starting players included one goalkeeper, nineteen defenders, nineteen midfielders and twelve forwards.

Protocol

Physical performance assessments used within this study included body mass, height, body fat composition, Yo-Yo IRTL1, 5 m sprint time, 10 m sprint time, 20 m sprint time, agility 5-0-5 left time, agility 5-0-5 right time, countermovement jump height, depth jump rebound height and Nordic hamstring lowers. The methodological detail and reliability of each of these tests was assessed within chapter 3 (page 68). Each test was explained in detail to each subject and methods remained consistent across each assessment throughout the data collection process. The researcher secured permission from the relevant personnel at the soccer clubs and each subject signed an informed consent form after the study was approved by the University of Salford Research and Ethics Committee (HSCR13/46).

Subjects were all asked to complete the studies consent forms after an overview of the assessment protocols was given. Each subject was asked to stay hydrated and refrain from any activity on the day of the testing and eat no less than 3- hours before the testing. This was standardised across each testing session.

Statistical Analysis

Statistical analysis of the data was carried out using SPSS (version 20). All parameters were checked for their conformity to normal distribution through Shapiro Wilks test and a Levene's test for assumption of equality of variances was performed. An independent samples t-test was used to assess whether significant differences occurred between starters and non-starters. Significance level was set at $p \leq 0.05$.

Results

Results from the independent samples t-test showed significant differences ($p \leq 0.05$) between first team and reserve team across variables body fat%, 10 m sprint, 20 m sprint, agility 5-0-5 left and right tests and countermovement jump. Comparisons of group means (Table 8.1) showed the starters possessed significantly less body fat % ($p=0.003$), faster 10 m sprint ($p=0.014$) and 20 m sprint time ($p=0.006$), faster agility 5-0-5 left- ($p=0.006$) and right- times ($p=0.023$) and a greater countermovement jump height ($p=0.025$) than the non-starters. However, there were no significant differences ($p>0.05$) between squad groups for any other variables from the statistical analysis of the data.

Table 8.1. Mean and SD of starters and non-starters across Physical Performance assessment variables

Variable	Mean ±SD	
	Starters	**Non-Starters**
Body Mass (kg)	59.6 ±7.6	58.9 ±7.5
Height (cm)	165 ±6.9	160 ±21.7
Body Fat (%)	20.2 ±4.7 *	24.4 ±7.6
Yo-Yo IRT L1 distance (m)	1087 ±369	997 ±380
5 m Sprint (s)	1.07 ±0.05	1.09 ±0.06
10 m Sprint (s)	1.87 ±0.07 #	1.91 ±0.09
20 m Sprint (s)	3.32 ±0.13 *	3.41 ±0.17
Agility 5-0-5 Left (s)	2.66 ±0.12 *	2.74 ±0.17
Agility 5-0-5 Right (s)	2.66 ±0.14 #	2.73 ±0.15
Countermovement Jump (cm)	27.8 ±4.0 #	26.0 ±4.0
Depth Jump (cm)	27.0 ±4.4	25.6 ±4.0
Nordics (°)	52 ±11	53 ±8

* Significant difference between groups ($p<0.01$)

Significant difference between groups ($p \leq 0.05$)

8.1.2. Match Performance (GPS) of Starters and Non-Starters at Senior Female Soccer

Participants

Thirty players were recruited from female soccer clubs in the Women's Northern Premier Division to take part in this study. Eighteen played in the first team leagues (starters: age: 23.3±3.8 yrs, body mass: 58.9±6.8 kg, height: 166.5±5.0 cm) while the remaining twelve subjects participated in the reserve team league (non-starters: age: 22.4±5.9 yrs, body mass: 62.3±7.4 kg, height: 162.3±6.2 cm).

Protocol

Match performance (GPS) methods were carried out during this study using distance covered- and speed zone- variables. All methodological detail and the reliability of the GPS match performance methods and testing equipment were shown to have an excellent level of reliability in chapter 4.0 (page 91) (r= 0.950-0.997).The researcher gained permission from the relevant personnel at the soccer clubs and each subject participating in the study signed written consent. The study was approved by the University of Salford Research and Ethics Committee (HSCR13/46). Data for this study was collected from competitive league matches and only included if the subject had played the full 90-minutes of the soccer match, all other data which was less than 90-minutes was removed from the data collection sample. On a separate day and >7days after the physical testing match performance assessments were performed.

Subjects were all asked to complete the studies consent forms after an overview of the assessment protocols were given. Each subject was asked to stay hydrated and refrain from any activity on the day of the testing and eat no less than 3 hours before the testing. This was standardised across each testing session.

Statistical Analysis

Statistical analysis was performed on the data using SPSS (version 20). Levene's equality of variances test was used along with a Shaprio Wilks normality test. All data was normally distributed ($p>0.05$) and met the assumption of equality of variances. An independent samples t-test was carried out to investigate the differences between the starters and non-starters across distance covered variables and speed zone variables (glossary of terms and abbreviations, page 14 and 15). Significance level was set at $p\leq0.05$.

Results

The results from the independent samples t-test revealed, there were no significant differences between the starters and non-starters for all distance covered- and speed zone-variables ($p\leq0.05$) (Table 8.2 and Table 8.3).

Table 8.2. Mean and SD for starters and non-starters across each distance covered match performance variable

Variables	Starters	Non-Starters

	Mean ±SD	Mean ±SD
Total Distance Covered (m)	8906 ±1000	8550 ±1015
Distance Covered at Zone 1 (m)	3318 ±300	3330 ±338
Distance Covered at Zone 2 (m)	938 ±172	993 ±183
Distance Covered at Zone 3 (m)	2396 ±538	2276 ±434
Distance Covered at Zone 4 (m)	1151 ±386	1065 ±419
Distance Covered at Zone 5 (m)	658 ±190	563 ±311
Distance Covered at Zone 6 (m)	410 ±193	323 ±195
Percentage of total distance covered at Zone 1 (%)	38 ±6	40 ±7
Percentage of total distance covered at Zone 2 (%)	11 ±8	12 ±3
Percentage of total distance covered at Zone 3 (%)	27 ±4	26 ±2
Percentage of total distance covered at Zone 4 (%)	13 ±3	12 ±4
Percentage of total distance covered at Zone 5 (%)	7 ±1	6 ±3
Percentage of total distance covered at Zone 6 (%)	5 ±2	4 ±2

Table 8.3. Mean and SD for starters and non-starters across each speed zone match performance variable

Variables	**Starters**	**Non-Starters**

	Mean ±SD	**Mean ±SD**
Average Speed (m/s)	1.6 ±0.2	1.6 ±0.2
Maximum Speed (m/s)	7.0 ±0.7	7.2 ±0.9
Number of Entries in Zone 1	637 ±112	602 ±85
Number of Entries in Zone 2	1035 ±168	949 ±134
Number of Entries in Zone 3	846 ±191	737 ±197
Number of Entries in Zone 4	451 ±138	368 ±171
Number of Entries in Zone 5	192 ±54	150 ±80
Number of Entries in Zone 6	50 ±16	41 ±24
Time Spent in Speed Zone 1 (min)	61 ±5	62 ±6
Time Spent in Speed Zone 2 (min)	8 ±1	9 ±2
Time Spent in Speed Zone 3 (min)	15 ±3	14 ±3
Time Spent in Speed Zone 4 (min)	6 ±2	5 ±2
Time Spent in Speed Zone 5 (min)	2 ±1	2 ±1
Time Spent in Speed Zone 6 (min)	1 ±1	1 ±1
Percentage of Time at Speed Zone 1 (%)	66 ±6	67 ±6
Percentage of Time at Speed Zone 2 (%)	9 ±1	9 ±2
Percentage of Time at Speed Zone 3 (%)	16 ±3	15 ±3
Percentage of Time at Speed Zone 4 (%)	6 ±2	5 ±2
Percentage of Time at Speed Zone 5 (%)	2.7 ±0.7	2.3 ±1.3
Percentage of Time at Speed Zone 6 (%)	1.3 ±0.6	1.1 ±0.7

Discussion

The main findings from this chapter reports significant differences between starters and non-starters for the following physical performance variables: body fat%, 10 m sprint, 20 m sprint, agility 5-0-5 left and right tests and countermovement jump ($p \leq 0.05$). It's worth noting that starting players did have better performances than non-starting players across all physical performance tests but differences were not significant within Yo-Yo IRTL1, 5 m sprint time, depth jump rebound height and Nordic hamstring lowers ($p > 0.05$). These findings are different to those found in Silvestre et al. (2006) who found male soccer starting players had similar performance results to non-starting players (except for one variable: total body power production), although they did use different physical performance tests than the ones used in this study (vertical jump height (with no countermovement), Yo-Yo intermittent endurance test level 2, 9.1 m sprint time and 36.5 m sprint time).

More commonly, studies by Manson et al. (2014) and Jenkins et al. (2013) found significant differences between starters and non-starters within their physical performance assessment variables ($p < 0.05$). Manson et al. (2014) reported New Zealand female starters had significantly greater maximal aerobic velocity, relative peak vertical force during sprint performance and absolute and relative eccentric leg strength ($p < 0.05$) and Jenkins et al. (2013) also found USA female starters to have greater eccentric strength than non-starting players. Whilst these studies used isokinetic testing methods to assess eccentric hamstring strength between starters and non-starters, it is difficult to compare the findings to the Nordic hamstring methods used in this chapter; even though these two assessments have shown to correlate (Sconce et al., 2015). Furthermore, Manson et al. (2014) found significant differences between starters and non-starters for aerobic assessments whilst the present study found the differences to be non-significant; it is also difficult to compare these findings as Manson et al. (2014) used 30:15 intermittent fitness test whilst this chapter used Yo-Yo

IRTL1 methods. The 30:15 intermittent fitness test involves a 30-second shuttle run interspersed with a 15-second active recovery period, where the running speed begins at 8 km/h and increases 0.5 km/h for every 30-second shuttle run completed. Whereas, the Yo-Yo IRTL1 involves two 20 m shuttle runs followed by 10- seconds of active recovery and involves four running bouts at 10-13 km/h, seven shuttles at 13.5-14 km/h and thereafter increases speed by 0.5 km/h every eight running bouts.

The Yo-Yo IRTL1 has also shown to have strong relationships with key match performance variables. Bradley et al. (2012) demonstrated the Yo-Yo test significantly correlated with high-intensity running activity in a soccer match ($r = 0.70$, $p<0.05$). Krustrup et al.'s (2005) findings support this reporting that Yo-Yo IRTL1 significantly correlated with the amount of high intensity running performed in the last 5 minutes at the end of each half, the total distance covered and the total amount of high intensity running distance in a soccer match ($r = 0.81$, $r = 0.56$, $r = 0.76$; $p<0.05$), respectively. Further research from Krustrup et al. (2003) showed significant correlations with key soccer specific variables: total distance covered, high-intensity running and sprinting during a game ($r = 0.53$ – $r = 0.58$, $p<0.05$). Whereas, at this point in time there has been no research carried out to investigate the 30:15 intermittent fitness test's relationship with soccer match performance variables.

It could be likely that with an intervention training program, these physical performance variables could improve, which could lead to further improvements in performance in a soccer match. It has been suggested that improvements in relative strength could provide physical qualities such as jumping, sprinting, changing direction (Comfort et al., 2014; Comfort et al., 2012 a; Comfort et al., 2012 b; Chelly et al., 2010; Chelly et al., 2009; McBride et al., 2009; Hori et al., 2008; Ronnestad et al., 2008; Christou et al., 2006; Cronin and Sleivert, 2005; Wisloff et al., 2004; Hoff et al., 2002). Numerous studies have demonstrated the positive effect a resistance training program has on physical performance variables such as sprinting, agility and jump performance (Campo et al., 2009; Meylan and Malatesta, 2009; Wong et al., 2010; Nunez et al., 2008; Perez-Gomez et al., 2008; Christou et al., 2006). However at this point in time, no studies have investigated the effect a resistance training intervention program has on both physical and match performance in female soccer players. By improving a soccer players physical performance qualities, this could subsequently improve their performance in a soccer match. Helgerud et al. (2001) has assessed the effect an aerobic training intervention program has on male youth soccer players using aerobic test measures (running economy, lactate threshold and the running speed at lactate threshold) and on soccer match performance variables such as total distance covered, the number of sprints performed and on the ball involvements. However, other research studies have demonstrated improvements in aerobic qualities following an aerobic training intervention program but have not investigated the effect their intervention program has in a soccer match (Dellal et al., 2010b; Sporis et al., 2008; Chamari et al., 2005; McMillian et al., 2005; Hoff et al., 2002; Helgerud et al., 2001). Therefore, this prompts a need for further research in this area.

For future reference it is possible to suggest that more research and maybe a greater sample size of players needs to be collected in order to address objective *f*: identify the differences between starters and non-starters within physical and match performance data for senior female soccer players. However, there could be other key reasons to why particular players are starters or non-starters. For example, a player with high technical, tactical and physical ability could be playing in the reserves (non-starter) due to other issues such as poor attitude, not attending training sessions, suspension, returning from injury. Therefore, this could influence future research even with a greater sample size.

Conclusion

In summary, the starters were significantly faster at 10 m sprint, 20 m sprint, agility 5-0-5 left and right tests, had greater countermovement jump heights and leaner body fat % than non-starters ($p \leq 0.05$). The results from the match performance assessment variables did not show any significant differences present between groups, however, the data did show the starters covered a greater total distance, high-intensity running and sprint distance (zone -5 and -6), percentage of time in zone 5 and zone 6 speeds, and number of high intensity runs and sprints than non-starters, however, these differences were not significant ($p > 0.05$). It is difficult to compare the result findings against other research studies assessment of match performance variables for starting and non-starting players because there are none available in the soccer literature, to the author's best knowledge. Furthermore, comparisons between starters vs. non-starters may be more difficult due to differences in the opposition and importance of the game (i.e., first team vs. reserve league).

Chapter 9.0.

Do physical and match performances differ between senior elite, sub-elite and non-elite female soccer players?

Introduction

2011 saw the English football association (FA) form a new professional league (women's super league) to run through the summer season (May-September). In order to be accepted within this league the English FA selected eight teams who could meet the business plan criteria (e.g. facilities, funding, player salaries, staff resources) and sustain these for at least three seasons. These teams included Arsenal Ladies FC, Liverpool Ladies FC, Lincoln Ladies FC, Doncaster Rovers Belles FC, Everton Ladies FC, Birmingham Ladies FC, Chelsea Ladies FC, and Bristol Academy Ladies FC. After these three seasons each team would have to reapply along with other new enthusiastic teams. The other lower two leagues in the hierarchy (Figure 1.3, page 25) would remain a winter league with the seasons running from September to April. This research study was performed during the second Women's Super League season (2011), and within the 2011/12 season for the Women's National Premier League and Women's Northern Premier Division teams.

Male soccer research has shown strong findings when investigating physical performance results of elite and non-elite standards. Gauffin et al. (1989) showed vertical jump performance were significantly greater in the top two divisions (elite) than the lower level teams (non-elite), while Cornetti et al (2000) found the amateur (non-elite) players performed significantly worse in sprint and depth jump rebound height assessments when compared to elite and sub-elite players in French senior soccer ($p<0.05$). Similar results have been shown in female senior soccer research. Haugen et al. (2012) found National players (elite) to be significantly 2% faster than first division (sub-elite) and 5% faster than second division teams (non-elite) in 0-20 m sprint times ($p<0.05$). These elite (National) players also jumped 9% higher than sub-elite players within countermovement jump height assessments. Even with standards of play more closely matched, Mohr et al. (2008) found top class players (national players) demonstrated a significantly greater number of high intensity runs and sprint bouts, and a significantly greater time spent at high-intensity running and sprinting than high level players (elite players from the top Danish and Swedish leagues) ($p<0.05$).

Even though these studies collectively indicate physical and match performance assessment results differ between players at elite and non-elite levels of player, to the author's knowledge, no research has been carried out comparing elite vs. non-elite players in English female soccer players.

The aim of this study is to compare physical and match performances between female soccer from the Women's Super League (elite), Women's National Premier League (sub-elite) and Women's Northern Premier Division (non-elite) (objective *g*).

9.1.1. Physical Performance Among Different Leagues Tiers: Elite vs. Sub-Elite vs. Non-Elite Senior Female Soccer Players

Participants

Thirty-four players were recruited from female soccer clubs in the Women's Super League (elite, n=9), Women's National Premier League (sub-elite, n=14) and the Women's Northern Premier Division (non-elite, n=11) to take part in this study (mean ± SD age, body mass and height was; 24.6±3.2 yrs, 58.9±8.1 kg, 164.2±6.8 cm, respectively).

Protocol

Physical performance assessments used within this study included body mass, height, body fat composition, Yo-Yo IRTL1, 5 m sprint time, 10 m sprint time, 20 m sprint time, agility 5-0-5 left time, agility 5-0-5 right time, countermovement jump height and depth jump rebound height. The methodological detail and reliability of each of these tests was assessed within chapter 3 (page 68). Each test protocol was explained to each subject and the methods remained consistent across each assessment throughout the data collection process. The researcher gained permission from the relevant personnel at the soccer clubs and each participating subject signed an informed consent form after the study was approved by the University of Salford Research and Ethics Committee (HSCR13/46).

Subjects were all asked to complete the studies consent forms after an overview of the assessment protocols was given. Each subject was asked to stay hydrated and refrain from any activity on the day of the testing and eat no less than 3- hours before the testing. This was standardised across each testing session.

Statistical Analysis

Statistical analysis of the data was carried out using SPSS (version 20). All parameters were checked for their conformity to normal distribution through Shapiro Wilks test. A one-way ANOVA was used to assess significant differences between the three team levels, with a bonferroni post-hoc test used to locate subsequent significant differences. Alpha level was set at $p \leq 0.05$.

Results

The results from the one-way ANOVA showed significant differences ($p \leq 0.05$) between groups for Yo-Yo IRT L1 distance and depth jump rebound height (Table 9.1). Bonferroni post hoc analysis revealed the elite players had a significantly greater Yo-Yo IRT L1 distance than both sub-elite (p=0.004) and non-elite players (p=0.012). The sub-elite players were also shown to have a significantly ($p \leq 0.05$) greater depth jump rebound height than non-elite players (p=0.02) There were no other significant differences reported between groups for any other variables (p>0.05).

Table 9.1. Mean and SD of elite, sub-elite and non-elite soccer players physical performance results

Variable	League Comparison: Mean ±SD		
	Elite (n=9)	**Sub-elite (n=14)**	**Non-elite (n=11)**
Body Mass (kg)	56.2 ±8.1	60.4 ±8.1	59 ±8.3
Height (cm)	164.1 ±7.7	164.3 ±6.0	164.3 ±6.5
Body Fat%	22.5 ±6.5	21.1 ±4.9	20.2 ±5.5
Yo-Yo IRT L1 distance (m)	1635 ±360 *b #c	1020 ±204 †a	1140 ±394 †a
5 m Sprint (s)	1.06 ±0.06	1.07 ±0.05	1.08 ±0.05
10 m Sprint (s)	1.90 ±0.09	1.84 ±0.06	1.88 ±0.09
20 m Sprint (s)	3.37 ±0.14	3.30 ±0.11	3.32 ±0.16
Agility 5-0-5 Left (s)	2.64 ±0.10	2.59 ±0.12	2.63 ±0.09
Agility 5-0-5 Right (s)	2.66 ±0.11	2.59 ±0.11	2.61 ±0.10
Countermovement Jump (cm)	28.8 ±1.6	30.4 ±3.4	28.2 ±3.1
Depth Jump (cm)	28.0 ±4.7	30.5 ±2.2 #c	26.8 ±3.0 *b

†a significant difference from Elite ($p \leq 0.05$)

*b significant difference from Sub-Elite ($p \leq 0.05$)

#c significant difference from Non-Elite ($p \leq 0.05$)

9.1.2. Match Performance Among Different Leagues Tiers: Elite vs. Sub-Elite vs. Non-Elite Senior Female Soccer Players

Participants

Thirty-four players were recruited from female soccer clubs in the Women's Super League (elite, n=9), Women's National Premier League (sub-elite, n=14) and the Women's Northern Premier Division (non-elite, n=11) to take part in this study (mean ± SD age, body mass and height was; 24.6±3.2 yrs, 58.9±8.1 kg, 164.2±6.8 cm, respectively).

Protocol

Match performance methods were carried out during this study using GPS to assess distance covered- and speed zone- variables. The reliability results of these methods and testing equipment and methodological detail were shown to have an excellent level of reliability in chapter 4.0 (page 91) (r= 0.950-0.997). The researcher acquired permission from the relevant personnel at the elite, sub-elite and non-elite soccer clubs and each subject signed an informed consent. The study was approved by the University of Salford Research and Ethics Committee (HSCR13/46). The data collected for this study was that of full 90-minutes duration from a competitive league match. All other data from the soccer match which was less than 90-minutes were removed from the data sample.

Statistical Analysis

Statistical analysis of the data was carried out using SPSS (version 20). All parameters were checked for their conformity to normal distribution through Shapiro Wilks. A one-way ANOVA was used to assess if statistical significant differences were present between the three standards of play, with a Bonferroni post hoc correction used to distinguish where, if any, differences occurred. This statistical assessment was performed on distance covered variables and speed zone variables (glossary of terms and abbreviations, page 14 and 15). Significance level was set at $p \leq 0.05$.

Results

Distance Covered Variables:

The results from the one-way ANOVA revealed significant differences between groups for total distance covered ($p=0.012$), distance covered at zone-2, -5 and -6 ($p=0.032$; $p=0.006$; $p=0.012$), and the percentage of total distance covered at zone-5 and -6 ($p=0.010$; $p=0.047$), respectively ($p \leq 0.05$).

Bonferroni post hoc analysis identified the elite standard players possessed significant greater total distance covered ($p=0.021$), distance covered at zone -2 ($p=0.044$), -5 ($p=0.005$) and -6 ($p=0.009$), and percentage of total distance at zone -5 ($p=0.008$) and -6 ($p=0.047$) than sub-elite players, respectively (Table 9.2). There were no other significant differences between standard of play for any other distance covered variables ($p>0.05$).

Table 9.2. Mean and SD for each group's match performance results

Variable	Mean ±SD		
	Elite (n=9)	Sub-Elite (n=14)	Non-Elite (n=11)
Total Distance Covered (m)	9811 ±738	9717 ±751 #	8906 ±1000
Distance Covered at Zone 1 (m)	3164 ±175	3318 ±300	3352 ±242
Distance Covered at Zone 2 (m)	1079 ±145	938 ±172 #	1049 ±100
Distance Covered at Zone 3 (m)	2674 ±400	2396 ±538	2698 ±490
Distance Covered at Zone 4 (m)	1371 ±200	1151 ±386	1364 ±242
Distance Covered at Zone 5 (m)	872 ±161	658 ±190 #	772 ±171
Distance Covered at Zone 6 (m)	651 ±195	410 ±193 #	482 ±317
Percentage of total distance covered at Zone 1 (%)	35 ±5	38 ±6	35 ±4
Percentage of total distance covered at Zone 2 (%)	11 ±1	11 ±2	11 ±1
Percentage of total distance covered at Zone 3 (%)	27 ±3	27 ±4	28 ±4
Percentage of total distance covered at Zone 4 (%)	14 ±1	13 ±3	14 ±2
Percentage of total distance covered at Zone 5 (%)	9 ±1	7 ±1 #	8 ±1
Percentage of total distance covered at Zone 6 (%)	7 ±2	5 ±2 #	5 ±3
# significantly different to Elite players ($p\leq0.05$)			

Speed Zone Variables:

The results from the one-way ANOVA revealed significant differences between groups for speed zone variables: average speed (p=0.024), maximum speed (p=0.030), number of entries in speed zone -1 and -2 (p=0.001; p=0.012), time spent in speed zone -2 and -5 (p=0.020; p=0.014), and percentage of time spent in speed zone -5 and -6 (p=0.009; p=0.007), respectively ($p \leq 0.05$).

Statistical analysis from the Bonferroni post hoc correction revealed the elite players possessed significantly greater average speed (p=0.028), maximum speed (p=0.034) and time spent in zone -2 (p=0.038) and -5 (p=0.024), and percentage of time spent in zone -5 (p=0.008) and -6 (p=0.006) than non-elite players, respectively (Table 9.3). Moreover, sub-elite soccer players displayed significantly ($p \leq 0.05$) greater number of entries in zone -1 (p=0.001) and -2 (p=0.009) than non-elite soccer players. There were no other significant differences between groups across any other speed zone variable assessments ($p > 0.05$) (Table 9.3).

Table 9.3. Mean and SD for the speed zone match performance variable for elite, sub-elite and non-elite female soccer players

Variable	**Mean ±SD**		
	Elite (n=9)	**Sub-Elite (n=14)**	**Non-Elite (n=11)**
Average Speed (m/s)	1.75 ±0.13	1.75 ±0.10	1.57 ±0.18 #
Maximum Speed (m/s)	7.88 ±0.78	7.13 ±0.45	7.04 ±0.70 #
Number of Entries in Zone 1	638 ±155	846 ±51	637 ±112 *
Number of Entries in Zone 2	1096 ±243	1281 ±66	1035 ±168 *
Number of Entries in Zone 3	935 ±197	957 ±170	846 ±191
Number of Entries in Zone 4	504 ±104	529 ±86	451 ±138
Number of Entries in Zone 5	228 ±48	222 ±61	192 ±54
Number of Entries in Zone 6	65 ±15	60 ±28	50 ±16
Time Spent in Speed Zone 1 (min)	57 ±4	56 ±8	61 ±5
Time Spent in Speed Zone 2 (min)	9 ±1	9 ±1	8 ±1 #
Time Spent in Speed Zone 3 (min)	16 ±2	16 ±3	15 ±3
Time Spent in Speed Zone 4 (min)	6 ±1	6 ±1	6 ±2
Time Spent in Speed Zone 5 (min)	3 ±1	3 ±1	2 ±1 #
Time Spent in Speed Zone 6 (min)	2 ±1	1 ±1	1 ±0.5
Percentage of Time at Speed Zone 1 (%)	61 ±4	63 ±4	66 ±6
Percentage of Time at Speed Zone 2 (%)	9 ±1	9 ±1	9 ±1
Percentage of Time at Speed Zone 3 (%)	17 ±2	17 ±3	16 ±3
Percentage of Time at Speed Zone 4 (%)	7 ±1	6 ±1	6 ±2
Percentage of Time at Speed Zone 5 (%)	3.4 ±0.6	3.0 ±0.6	2.7 ±0.7 #
Percentage of Time at Speed Zone 6 (%)	2.1 ±0.6	1.5 ±0.9	1.3 ±0.6 #

* significantly different to Sub-Elite players ($p \leq 0.05$)

significantly different to Elite players ($p \leq 0.05$)

Discussion

The aim of this study was to assess physical and match performances of elite, sub-elite and non-elite female soccer players. The results from the physical performance assessments showed significant differences do occur between these groups of female soccer players within Yo-Yo IRTL1 distances and within depth jump rebound height.

In comparison to other studies the present study's physiological performance assessment results were competitive. Elite, sub-elite and non-elite 5 m sprint times from the present study were considerably lower, thus faster, than those reported in Gabbett et al. (2008) (1.06-1.08 s vs. 1.15-1.17 s). The 10 m sprint times from this chapter were faster than other senior female soccer research (Oberacker et al., 2012; McCurdy et al., 2010; Gabbett et al., 2008) (1.84-1.90 s vs. 1.90-2.31 s), except Haugen et al.'s (2012) Norwegian player's 10 m sprint time (1.67 s). Sprint times over a 20 m distance from the present studies results were faster than all other senior female soccer data (Shalfawi et al., 2013; Oberacker et al., 2012; Sjokvist et al., 2011)

(3.30-3.37s vs. 3.51-3.59 s), with exceptions to Gabbett et al.'s (2008) Australian soccer players (3.20-3.30 s).

The results from the match performance assessments showed significant differences between the elite, sub-elite and non-elite female soccer players for total distance covered, distance covered in zone -2, -5 and -6, the percentage of distance covered at zone -5 and -6, the number of entries in zone -1 and -2, the time spent in zone -2 and -5, and the percentage of match time in zone -5 and -6.

As stated in previous chapters, the match performance data on female soccer is limited. The female soccer players in Andersson et al. (2010) and Mohr et al. (2008) demonstrated high-intensity running distances (zone -5 and zone -6) between 1300-1680 m which were all greater than sub-elite and non-elite players. However, only the National team players in Mohr et al.'s (2008) study were shown to have greater total high-intensity running distance than elite players (1680 m vs. 1523 m). The elite soccer player's sprint distances (zone -6) within the present study were greater than all female soccer player's data in Andersson et al. (2010) and Mohr et al. (2008) (651 m vs. 250-460 m). Additionally, the actual number of high-intensity runs and sprint bouts were greater for the elite players in this chapter than those reported by Andersson et al. (2010) and Mohr et al. (2008) (283 vs. 125-154; and 65 vs. 20-30). It is important to note that Andersson et al. (2010) and Mohr et al. (2008) did assess match performance through time-motion analysis methods while the present study used GPS methods to assess match performance. However, the studies were matched in terms of speed zone categories which allow valid comparisons to be made between these research studies.

Another area lacking across senior female soccer research is the Yo-Yo IRTL1. The Yo-Yo IRTL1 results for the elite players within this chapter were shown to be considerably greater than those in Mujika et al. (2008) and Krustrup et al. (2005) (1635 m vs. 1224-1379 m). However, the Yo-Yo IRTL1 results from these two studies were greater than sub-elite and non-elite players within the present study (1224-1379 m vs. 1020-1140 m).

The results showed the highest group (elite) performed significantly greater during the Yo-Yo IRTL1 compared to the two lower standard groups (sub-elite and non-elite). When the Yo-Yo IRTL1 distance is converted into VO_2max values using Bangsbo et al.'s (2008) equation, the difference between the values were shown to be 4.1-5 $ml.kg^{-1}.min^{-1}$ (Table 9.4). These values are similar to those reported by Wisloff et al. (1998). It has been stated that a difference in around 6 $ml.kg^{-1}.min^{-1}$ between teams, in terms of distance covered, is suggested to be similar to having an extra player on the field (Hoff, 2005; Wisloff et al., 1998).

Table 9.4. Converted Yo-Yo IRTL1 results into VO_2max values for each soccer player group

	Elite	**Sub-Elite**	**Non-Elite**
VO_2max ($ml.kg^{-1}.min^{-1}$)	50.1	45	46

Research studies have demonstrated how an appropriate training intervention can improve VO_2max values to those reported by Wisloff et al. (1998). McMillian et al.'s (2005) training program involved soccer players completed a soccer specific dribbling track twice a week, for a 10-week period. Each session involved 4-sets of high-intensity work periods (90-95% of MHR) of 4-minutes separated by lower intensity activity (jog: 70% MHR). The VO_2max improved by 6.4 $ml.kg^{-1}.min^{-1}$ after the 10-week interventional training period. Helgerud et al. (2001) used similar methods and found improvements of 6.2 $ml.kg^{-1}.min^{-1}$. However, Helgerud et al.'s (2001) training study involved 8-weeks of training, running on an incline treadmill, with a lower recovery intensity (50-60% MHR) than McMillian et al. (2005).

The assumption that a difference of around 6 $ml.kg^{-1}.min^{-1}$ between teams, in terms of distance covered, is similar to having an extra player on the field (Hoff, 2005; Wisloff et al., 1998) is subsequently supported from the results displayed in section 8.2: Match performance among different leagues tiers: Elite vs. Sub-Elite vs. Non-Elite senior female soccer players. The greatest Yo-Yo IRTL1 distance difference was between elite and sub-elite players (1635±360 m vs. 1020±204 m), respectively. These two groups were also found to have a significantly different total distance covered (elite: 9811±738 m vs. sub-elite: 9717±751 m), with elite players also demonstrating significantly greater sprint distance and total high intensity running distances (zone -5 and zone -6) (651±195 m vs. 410±193 m; and 1523 m vs. 1068 m), respectively ($p \leq 0.05$).

The Yo-Yo IRTL1 is specifically designed to measure the athlete's ability to recover between each high intense shuttle (x2), with shuttle speeds progressing at each level. The results from this chapter do show the importance of soccer players having a high aerobic capacity and a high ability to recover quickly between each high intense sprint and the impact it can have on match performance and more importantly could contribute to the level of play female soccer players reach. The main suggestions from this study for female soccer players wanting to achieve a higher level of play would be for them to focus on improving their physical capabilities through appropriate intervention training which could improve their physical performance and performance within a soccer match (Turner et al., 2013).

Helgerud et al. (2001) also highlighted how a specific interval training program can affect physical performance, and positively transfer into soccer match performance after an 8-week period. The physical performance results from their study showed significant improvements in running economy (6.7%), lactate threshold (16%) and the running speed at lactate threshold (21.6%), respectively. These improvements transferred into match performance with significant improvements in the total distance covered (20%), number of sprints performed (100%), the number of involvements with the ball (24.1%) on the soccer pitch. If the elite, sub-elite and non-elite soccer players from the present study carried out Helgerud et al.'s (2001) 8-week training intervention their total distance covered performance would increase from 9811 m to 11773 m, 9717 m to 11660 m, 8906 m to 10687 m; and their number of sprints would improve from 65 to 130, 60 to 120 and 50 to 100, respectively. However, it is important to note that the rates of improvement from this intervention training method were average measures of the group of subjects (male youth soccer players) used within this research study. Therefore, female senior individuals from this research study may respond differently to the average rates of improvement with some players responding with lower rates of improvement, others possibly improving at greater rates.

These proposed improved values for elite and sub-elite soccer players would be greater than all previous match performance data, except for Di Salvo et al. (2007) (Table 2.6, page 64). A second bout of the intervention training could see elite and sub-elite players produce greater match performance values than all the previous female soccer match performance research (Table 2.6, page 64). Thus, suggestions would be to carry out similar forms of training to improve both physical- and match-performance and aim to set new high standards in female soccer.

Numerous anaerobic training studies have also demonstrated the positive effects strength and power conditioning training have on soccer-specific performance variables such as sprinting, agility and jump performance (Campo et al., 2009; Meylan and Malatesta, 2009; Wong et al., 2010; Nunez et al., 2008; Perez-Gomez et al., 2008; Christou et al., 2006).Whilst similarly, aerobic-specific tests have shown to significantly improve after aerobic training programs (Dellal et al., 2010b; Sporis et al., 2008; Chamari et al., 2005; McMillian et al., 2005; Hoff et al., 2002; Helgerud et al., 2001). Therefore, it is essential to carry out these forms of intervention training on female soccer players in order to improve their physical levels of conditioning.

When match performance was assessed, each outfield soccer player was asked to wear a GPS unit each throughout the duration of the soccer match. The only data recorded in the chapters was that of the full soccer match duration. For example, senior soccer match duration was 90-minutes; youth soccer match duration was 80-minutes; therefore if a soccer player did not play for the full match duration, their data was discarded from the study. This was out of the researcher's control for reasons such as the player being substituted by the coach, an injury to the player which stopped further participation to the match etc. If these instances had not happened and each player had played the full duration for each match within the research data collection process, it would have benefited the data sample size for each chapter which assessed match performance.

Although each chapter had large enough sample sizes to carry out the appropriate statistical analyses, it would in hindsight been great to get more data in each study. For example, this study included players from two teams from each soccer league to assess the differences of elite, sub-elite and non-elite female soccer players from different leagues; it would have been even better if every team's players from those three divisions were tested within this study. However, due to time, funding and the soccer clubs (especially from the Women's Super League) carrying out their own physical testing this was no possible. Other limitations are consistent with previous chapters which used same methodology.

Conclusion

To summarise, there were differences between the players in the elite, sub-elite and non-elite leagues within both physical performance assessments and match performance assessments. Key variables were shown to have significant differences between groups (elite vs. sub-elite vs. non-elite) for Yo-Yo IRTL1 distances, depth jump performance, total distance covered, distance covered at zone -2, -5 and -6, the percentage of total distance covered at zone -5 and -6, average speed, maximum speed, number of entries in speed zone -1 and -2, time spent in speed zone -2 and -5, and percentage of time spent in speed zone -5 and -6 ($p \leq 0.05$). These findings highlight the importance of physical conditioning; therefore, if soccer players strive to play at greater levels or soccer teams from the lower leagues want to get promoted not only do they probably need to improve their soccer abilities but they should also aim to improve their player's physical performance qualities through training interventions.

Chapter 10.0.

Does physical performance contribute to final league position in a senior female soccer league?

Introduction

Performance within a soccer match has been primarily associated with a player's aerobic endurance (due to the duration of the game, 90-minutes) (Mohr et al., 2003; Bangsbo et al., 1992); however, the actual performance, crucial moments and the outcome of a soccer match is dependent on the acquisition of decisive anaerobic activities (Jullien et al., 2008; Little and Williams, 2007; Aziz et al., 2000). These decisive, anaerobic soccer components (sprinting, striking the ball, turning, jumping, changing pace, cutting and accelerating and decelerating the body) are forceful and explosive and require near-maximum levels of muscular strength and power production (Chelly et al., 2009; Little and Williams, 2006; Stolen et al., 2005; Dupont et al., 2004; Inklaar, 1994) and have reported to contribute to key soccer match principles such as obtaining possession, scoring goals, conceding goals, preventing goals from being conceded (Reilly et al., 2000).

Comparative research has been carried out on male soccer teams in the same league. Rampinini et al. (2009) found the top-5 finishing teams in Italian Serie A league possessed significantly greater total distance, high-intensity distance, ball involvements and successful passes, tackles and shots than the bottom-5 teams. Findings by Wisloff et al. (1998) support this assumption demonstrating the higher placed team(s) in European leagues possessed a greater VO_2max than the bottom league team(s), while Apor (1988) reported the ranking of four teams in the Hungarian top soccer division reflected the same ranking order of the team mean VO_2max values. Lago-Penas et al. (2011) studied teams who finished in the top half of the league (successful teams) and compared them with teams finishing in the bottom half of the league. The researchers from this study (Lago-Penas et al., 2011) found the successful teams to have lower body fat compositions, greater performance in the physical tests and were more muscular, however, these findings were not statistically significant ($p>0.05$).

Even though these research studies suggest the final league position of the soccer teams could be influenced by the team's physical conditioning status, no research has been carried out on female soccer (to the author's knowledge). Thus, chapter 10.0 includes a research study which investigates whether the final league position is influenced by each team's physical performance results. This chapter compares the physical performance assessment results of the first positioned team, second positioned team, mid-table positioned team and a team finishing in the bottom three (all in the same league) against each other. The study aims to identify any differences of the final league position of female soccer teams based on their physical performance assessments (objective *h*).

Participants

Forty-nine players were recruited from female soccer clubs in the Women's Northern Premier Division to take part in this study (age: 22±4.6 yrs, body mass: 60.2±8.2 kg, height: 163.5±6.8 cm). Between eleven and thirteen players (regular starters) were assessed from four different soccer teams within the Women's Northern Premier Division. One team finished in first position (1PT) and achieved promotion, the second team (2PT) came in second place, the third team finished mid-table (MTP) and the fourth team finished the league within the bottom three positions (B3P).

Protocol

Physical performance tests used within this study included body mass, height, body fat composition, Yo-Yo IRTL1, 5-, 10- and 20- m sprint times, agility 5-0-5 left and right times, countermovement jump height, depth jump rebound height and Nordic hamstring lowers. The methodological detail and reliability of each of these tests was assessed within chapter 3 (page 68). Each test protocol was explained to each subject and the methods remained consistent across each assessment throughout the data collection process. The researcher gained permission from the relevant personnel at the soccer clubs and each participating subject signed an informed consent form. The study was approved by the University of Salford Research and Ethics Committee (HSCR13/46).

Subjects were all asked to complete the studies consent forms after an overview of the assessment protocols were given. Each subject was asked to stay hydrated and refrain from any activity on the day of the testing and eat no less than 3- hours before the testing. This was standardised across each testing session.

Statistical Analysis

Statistical analysis of the data was carried out using SPSS (version 20). Normality of data was confirmed using a Shapiro Wilks test. A one-way ANOVA with post hoc bonferroni analysis was used to assess whether significant differences occurred between soccer teams within the Women's Northern Premier Division. Significance level was taken at $p \leq 0.05$.

Results

Results from the one-way ANOVA showed significant differences ($p \leq 0.05$) between groups within variables: Yo-Yo IRTL1 distance, 5 m sprint time, 10 m sprint time, and agility 5-0-5 time left and right (Table 10.1).

Table 10.1. Mean and SD of each team's physical performance result

Variable	League Position Comparison: Mean ±SD			
	1PT	2PT	MTP	B3P
Body Mass (kg)	59.0 ±7.7	59.2 ±8.3	61.4 ±5.6	63.3 ±6.6
Height (cm)	164.2 ±7.6	164.3 ±6.5	155.4 ±45.7	167.6 ±4.2
Body Fat (%)	18.9 ±3.1	20.2 ±5.5	22.1 ±6.1	23.1 ±4.2
Yo-Yo IRT L1 distance (m)	1083 ±400 ~d	1140 ±394 ~d		788 ±262 †a *b
5 m Sprint (s)	1.07 0.04 ~d	1.08 ±0.05	1.08 ±0.05	1.13 ±0.06 †a
10 m Sprint (s)	1.87 ±0.06 ~d	1.88 ±0.09	1.89 ±0.07	1.95 ±0.05 †a
20 m Sprint (s)	3.32 ±0.11	3.32 ±0.16	3.37 ±0.17	3.43 ±0.12
Agility 5-0-5 Left (s)	2.69 ±0.08	2.63 ±0.09 #c	2.80 ±0.18 *b	
Agility 5-0-5 Right (s)	2.67 ±0.09 #c	2.61 ±0.10 #c	2.86 ±0.19 †a *b	
Countermovement Jump (cm)	26.3 ±4.0	28.2 ±3.1	28.3 ±4.7	29.2 ±3.7
Depth Jump (cm)	25.3 ±4.7	26.8 ±3.0	28.1 ±4.5	28.4 ±4.8
Nordics (°)	53 ±12	57 ±7	51 ±7	48 ±7

†a significant difference from 1st position ($p \leq 0.05$); *b significant difference from 2nd position ($p \leq 0.05$); #c significant difference from Mid-table position ($p \leq 0.05$); ~d significant difference from Bottom 3 position ($p \leq 0.05$)

1st positioned team (1PT):

Post hoc analysis showed that the 1PT players had a significantly greater Yo-Yo IRTL1 distance ($p=0.05$), faster 5 m and 10 m sprint times ($p=0.013$ and $p=0.016$) than the B3P players. Moreover, the 1PT players had a significantly lower, thus faster agility 5-0-5 time, right turn only ($p=0.007$) than MTP team.

2nd positioned team (2PT):

Post hoc analysis showed the 2PT players had a significantly greater Yo-Yo IRTL1 distance than the B3P players ($p=0.05$). Moreover, the 2PT players had a significantly lower, thus faster agility 5-0-5 left ($p=0.016$) and right time ($p\leq0.001$) than the MTP team.

Mid-table positioned team (MTP):

Post hoc analysis shows MTP team had significantly greater, thus slower agility 5-0-5 left time than 2PT players ($p=0.016$) and slower agility right time than 1PT and 2PT ($p=0.007$ and $p\leq0.001$), respectively.

Bottom 3-positioned team (B3P):

Post hoc analysis reveals the B3P team had significantly lower Yo-Yo IRTL1 distance than 1PT and 2PT players ($p=0.05$). Also, B3P sprint times at 5 m ($p=0.013$) and 10 m ($p=0.016$) were significantly greater, thus slower than 1PT players ($p\leq0.05$).

There were no other significant differences between groups for any other variable ($p>0.05$).

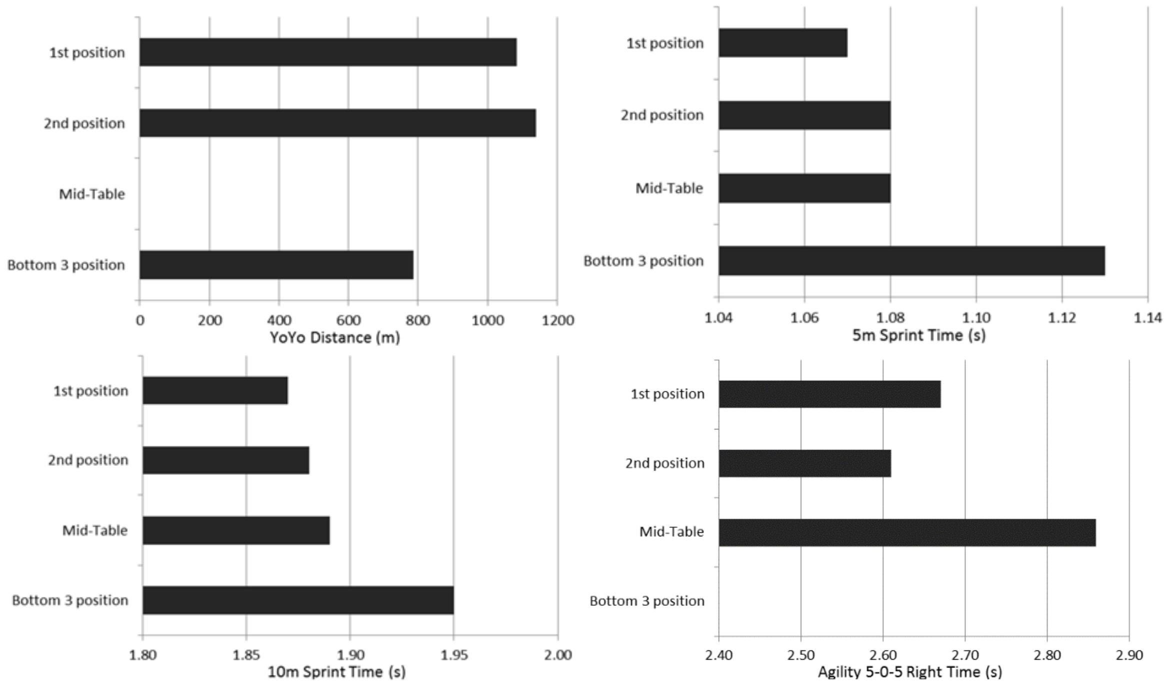

Figure 10.1. Each soccer team's Yo-Yo IRTL1 distance, 5 m sprint time, 10 m sprint time and agility 5-0-5 right time results in relation to final league ranking

Discussion

The purpose of this study was to identify whether physical performance contributed to final league position in a senior female soccer league. The results from the physical performance assessments showed there were significant differences between the teams. The 1st positioned team (1TP) and the 2nd positioned team (2TP) had significantly greater Yo-Yo IRTL1 results than a bottom -3 positioned team (B3P) (1083±400m and 1140±394m vs. 788±262m) ($p \leq 0.05$) (Figure 10.1, page 205). These findings are similar to Wisloff et al. (1998) and Apor et al. (1988) who both found aerobic capacity influenced the final league position in male soccer. This leads us to assume soccer teams with greater aerobic conditioning could be more likely to finish higher in their league than those teams with lower levels of aerobic conditioning (Figure 10.1, page 205). Soccer teams should apply research based intervention programs to improve their player's aerobic conditioning.

One of the most successful training interventions which meets the 6 $ml.kg^{-1}.min^{-1}$ improvements suggested by Wisloff et al. (1998) is the 4x4 interval training format. These training methods have shown to improve VO_2max by 6.2-6.4 $ml.kg^{-1}.min^{-1}$ over an eight to ten week period (McMillian et al., 2005; Helgerud et al., 2001).

Further physical performance differences were found between the teams in that same soccer league. The 1TP and the 2TP had significantly lower (faster) 5 m sprint times than the B3P and the 1TP also had a significantly faster 10 m sprint time than the B3P, respectively (1.07±0.04 s and 1.08±0.05 s vs. 1.13±0.06 s; and 1.87±0.06 s vs. 1.95±0.05 s) ($p \leq 0.05$). Furthermore, the 1TP and 2TP had significantly lower (faster) agility 5-0-5 right times than MTP (2.67±0.09 s and 2.61±0.10 s vs. 2.86±0.19s), while the 2TP were significantly faster than MTP in the agility 5-0-5 left test (2.63±0.09 s vs. 2.80±0.18 s). These findings suggest that soccer teams with greater anaerobic performance levels may finish higher in their league than those teams with lower levels of anaerobic performance (Figure 10.1, page 205).

Numerous anaerobic training studies have showed how these anaerobic performance variables can be improved through the appropriate strength and power conditioning training interventions (Campo et al., 2009; Meylan and Malatesta, 2009; Wong et al., 2010; Nunez et al., 2008; Perez-Gomez et al., 2008; Christou et al., 2006).Whilst similarly, aerobic-specific tests have shown to significantly improve after aerobic training programs (Dellal et al., 2010b; Sporis et al., 2008; Chamari et al., 2005; McMillian et al., 2005; Hoff et al., 2002; Helgerud et al., 2001). Thus, female soccer teams must apply these research based intervention programs to improve their player’s anaerobic conditioning and increase the chances of becoming successful in their domestic league.

These result outcomes allow the assumption that a team with greater anaerobic physical performance could finish higher in the league than a team, in the same league, with a collective lower anaerobic physical performance. These trends are comparable to those in Lago-Penas et al. (2011) who found the teams in the top half of the league (successful teams) had greater performance in the physical tests than the teams finishing in the bottom half of the league (unsuccessful teams). However, unlike the present study, the differences between those teams were found to be not statistically significant ($p>0.05$).

Although this study had large enough sample sizes to carry out the appropriate statistical analyses, it would in hindsight been great to get more data in each study. This study involved the assessment of soccer team's physical performance qualities from the same league and investigating whether this affected the overall league ranking. It was unfortunate that all physical tests were not carried out. Whilst assessing the soccer team which finished in the bottom-3 position the testing time available ran out which meant we could not assess the players within the agility 5-0-5 tests. Also, the soccer players from the team finishing mid-table decided they did not want to do the Yo-Yo IRTL1 assessment which is why they did not have any data for this particular test and no statistical comparisons could be made to the other soccer teams in the same soccer league. Even though this study produced interesting results from the physical performance assessments, it would have been interesting to assess the match performance as well. However, due to time restrictions and teams not being 100% comfortable wearing the GPS unit, as they felt the equipment would influence the soccer match result, this was not carried out. Other limitations are consistent with previous chapters which used same methodology.

Conclusion

Overall, the research showed significant differences between the teams within the same league and the trends show the higher finishing league teams had better physical performance results than the team finishing lower in the league. This was particularly present for aerobic, sprint speed and change of direction ability variables: Yo-Yo IRTL1, 5 m sprint, 10 m sprint, and agility 5-0-5 left and right tests. These findings emphasise the importance of physical conditioning for female soccer players; thus, if female soccer teams aim to be successful in their domestic league they must aim to improve their player's physical performance qualities through training interventions as well as improving their soccer ability.

Chapter 11.0.

Discussion

11.1. Realisation of aims and objectives

The overarching aim of this research thesis was to develop physical performance and match performance profiles of female soccer players in England. The following objectives were assessed:

a. **Identify the reliability of specific assessment methods for physical performance tests (Chapter 3.0)**

The physical tests assessed for their reliability in chapter 3 were body mass, height, body composition, Yo-Yo IRTL1, 5 m-, 10 m- and 20 m- sprint times, agility 5-0-5 left and right turn times, countermovement jump height, depth jump rebound height and Nordic hamstring break point angle. This study demonstrated all testing protocols and methods had excellent levels of within- and between- session reliability (Coppieters et al., 2002).

b. **Determine the reliability of match performance assessment methods (Chapter 4.0)**

The GPS match performance variables were assessed in chapter 4 for their inter-unit reliability and inter-variation. This study demonstrated all testing protocols and methods had excellent levels of inter-unit reliability for and low variation between competitive soccer matches excluding number of entries in zone -2 and time spent in zone -1.

c. **Assess the physical performance of female youth soccer players (Chapter 5.0)**

Elite youth soccer players had greater Yo-Yo IRT L1 distance, countermovement jump height and depth jump and significantly faster 5 m sprint time, 10 m sprint time, 20 m sprint time, agility 5-0-5 time left and right turns than the non-elite players ($p \leq 0.05$). Specific trends across the age groups were observed, with the performance improving across all physical performance variables as age-groups increased (5.1.2). There were significant differences present between the age-groups for body mass, height, Yo-Yo IRTL1 distance, 5 m-, 10 m-, and 20 m- sprint times and agility 5-0-5 left and right times ($p \leq 0.05$). There were no significant differences between age groups for countermovement jump height, depth jump rebound height and Nordic hamstring lowers ($p > 0.05$) [5.1.2]. Like section 5.1.2, as the age-groups increased the performance within the physical tests also improved. There were significant differences present between the age-groups for variables body mass, height, Yo-Yo IRTL1 distance, 5 m-, 10 m-, and 20 m- sprint times and agility 5-0-5 left and right times ($p \leq 0.05$). There were no significant differences between age groups for countermovement jump height, depth jump rebound height and Nordic hamstring lowers ($p > 0.05$). There were significant differences present between age-groups for all variables assessed: body mass, height, Yo-Yo IRTL1 distance, 5 m-, 10 m-, and 20m- sprint times, agility 5-0-5 left and right times, countermovement jump and depth jump rebound height ($p \leq 0.05$). Specific trends across the age groups were observed, with the performance improving across all physical performance variables as age-groups increased from U11 to U15. However, the non-elite trends for all variables (except 20 m sprint) showed the U17s performing worse in physical assessments than U15 players. Section 5.1.5 found elite players performed better than the non-elite players in all physical assessments at each youth age-group; with exception of agility 5-0-5 test for U13s. The elite U11 players performed significantly better at Yo-Yo IRTL1 and 5-, 10- and 20 m- sprint assessments than the U11 non-elite players ($p \leq 0.05$). The elite players were also significantly better than non-elite players in variables Yo-Yo IRTL1 and 20 m sprint time for U13 age groups, and for Yo-Yo IRTL1, 10 and 20 m sprint and depth jump assessments within the U15 age group ($p < 0.001$). The U17s results showed the elite players performed to a significantly greater standard than the non-elite players for all physical performance assessments ($p < 0.001$) except body mass and height variables ($p > 0.05$).

d. Determine the match performance differences between elite vs. non-elite youth female soccer players (Chapter 6.0)

Elite players had significantly greater total distance covered, distance covered at zone-2, -3, -4, -5, -6 and percentage of the total distance at zone -3, -4, -5, -6 than non-elite players ($p \leq 0.05$). The non-elite players possessed a significantly greater ($p \leq 0.05$) percentage of total distance covered at zone 1 than elite players, while elite players obtained a greater number of entries in zone -1, -2, -3, -4, -5 and -6 than non-elite players ($p \leq 0.05$). Moreover, elite players were shown to spend a significantly greater time in speed zone -2, -3, -4, -5, -6, yet significantly less time in speed zone -1, when compared to non-elite players ($p \leq 0.05$). Non-elite players demonstrated a significantly greater percentage of time in speed zone -1 when compared to elite players, however elite players had significantly greater percentage of time at speed zone -2, -3, -4, -5 and -6.

e. **Investigate whether physical performance differs between playing positions (Chapter 7.0)**

The main findings revealed significant differences between playing positions for variables: Yo-Yo IRTL1, Nordic hamstring lowers, 5-0-5 right, 10 and 20 m sprint times ($p \leq 0.05$). Forwards and defenders were significantly faster ($p \leq 0.05$) than goalkeepers during 5-0-5 right testing. The forwards were also reported to be faster than goalkeepers and midfield players over 10 m sprint distances, but only faster than goalkeepers in 20 m sprint distance ($p \leq 0.05$). The results also showed goalkeepers had significantly lower Yo-Yo IRTL1 than defenders, midfielders and forwards and greater, thus worse, break point angle during Nordics assessment than midfield and forward players ($p \leq 0.05$).

f. **Identify the differences between starters and non-starters within physical and match performance data for senior female soccer players (Chapter 8.0)**

The results from the match performance assessment variables did not show any significant differences present between the groups, although the starters covered a greater total distance, high-intensity running and sprint distance (zone -5 and -6), percentage of time in zone 5 and zone 6 speeds, and number of high intensity runs and sprints than non-starters, these were not significant ($p > 0.05$). This was the first study, to the author’s knowledge, to compare starters and non-starters in female soccer. Physical performance results showed starting players were significantly faster at 10 m sprint, 20 m sprint, agility 5-0-5 left and right tests, had greater countermovement jump heights and leaner body fat % than non-starters ($p \leq 0.05$).

g. **Assess the physical and match performance assessment data of senior female soccer players based on their level of play (league comparison) (Chapter 9.0)**

The group from the highest tier (elite) performed significantly greater during the Yo-Yo IRTL1, average speed, maximum speed, time spent in speed zone -2 and -5, and percentage of time spent in speed zone -5 and -6 than non-elite players ($p \leq 0.05$). Elite players also had significantly greater Yo-Yo IRTL1, total distance covered, distance covered at zone-2, -5 and -6, the percentage of total distance covered at zone-5 and -6 compared to sub-elite players ($p \leq 0.05$).

h. **Identify any differences of the final league position of female soccer teams based on their physical performance assessments (Chapter 10.0)**

The 1st positioned team (1TP) and the 2nd positioned team (2TP) performed significantly greater at the Yo-Yo IRTL1 than a bottom- 3 positioned team (B3P) (1083±400 m and 1140±394 m vs. 788±262 m) ($p \leq 0.05$). No other significant differences were reported ($p > 0.05$).

11.2. General discussion

At present, because there is a lack of female youth soccer research, there is limited normative data which makes it hard to know how good or how poor the results are from physical performance tests. Therefore, data boundaries linking to categories have been constructed from the research studies to help coaches and players understand what the player's physical performance status is and how it actually compares to others. No other piece of female soccer research has produced these types of boundaries that can be utilised in youth soccer clubs. Table 11.1 (page 219) shows what results are good, above average, below average and poor at each youth age group for each physical test, for non-elite youth soccer players, whilst Table 11.2 (page 220) displays this for the elite youth players and Table 11.3 (page 221) shows what results are good, above average, below average and poor at each age group for each physical test, based on their playing position.

The performance categories and the data boundaries are also displayed in table 11.4 (page 222) for each playing level at senior level: elite, sub-elite and non-elite female players. It was also important to carry this out for female senior soccer clubs in the English leagues so they can utilise this and see how their soccer players compare to others. For example, do teams from the non-elite leagues have players who would produce poor performances at the elite level? If teams were aiming for promotion to the elite leagues and their players were poor physical performers then they may decide that intervention training programs are needed to improve the player's physical qualities. Another key reason for producing these categories for senior female soccer is it gives the youth players a target and something aim higher than.

For variables Yo-Yo IRTL1, countermovement jump and depth jump, categories were created as follows:

- Good: > +1 standard deviation
- Above average: Mean to +1 standard deviation
- Below average: Mean to -1 standard deviation
- Poor: < -1 standard deviation

For variables 5 m-, 10 m- and 20 m- sprint time, agility 5-0-5 left and right, and Nordic hamstring lowers break point angle, the performance boundaries were generated with:

- Good: < -1 standard deviation
- Above average: Mean to -1 standard deviation
- Below average: Mean to +1 standard deviation
- Poor: > +1 standard deviation

Table 11.1. The performance categories and the data boundaries for non-elite youth female soccer players

		u11- non elite	u13- non elite	u15- non elite	u17- non elite
YoYo IRTL1 (m)	Good	> 544	> 627	> 852	> 969
	Above Average	365 - 544	446 - 627	658 - 852	652 - 969
	Below Average	184 - 364	263 - 445	461 - 657	333 - 651
	Poor	< 184	< 263	< 462	< 333
5m Sprint (s)	Good	< 1.18	< 1.09	< 1.05	< 1.05
	Above Average	1.18 - 1.23	1.09 - 1.16	1.05 - 1.09	1.05 - 1.10
	Below Average	1.24 - 1.30	1.17 - 1.25	1.10 - 1.15	1.11 - 1.17
	Poor	> 1.30	> 1.25	> 1.15	> 1.17
10m Sprint (s)	Good	< 2.07	< 1.97	< 1.88	< 1.88
	Above Average	2.07 - 2.19	1.97 - 2.07	1.88 - 1.94	1.88 - 1.95
	Below Average	2.20 - 2.33	2.08 - 2.19	1.95 - 2.02	1.96 - 2.04
	Poor	> 2.33	> 2.19	> 2.02	> 2.04
20m Sprint (s)	Good	< 3.86	< 3.61	< 3.38	< 3.34
	Above Average	3.86 - 4.08	3.61 - 3.84	3.38 - 3.52	3.34 - 3.50
	Below Average	4.09 - 4.32	3.85 - 4.09	3.53 - 3.68	3.51 - 3.68
	Poor	> 4.32	> 4.09	> 3.68	> 3.68
Agility 5-0-5 Left (s)	Good	< 2.87	< 2.83	< 2.65	< 2.70
	Above Average	2.87 - 3.05	2.83 - 2.95	2.65 - 2.74	2.70 - 2.84
	Below Average	3.06 - 3.25	2.96 - 3.09	2.75 - 2.85	2.85 - 3.00
	Poor	> 3.25	> 3.09	> 2.85	> 3.00
Agility 5-0-5 Right (s)	Good	< 2.86	< 2.79	< 2.65	< 2.73
	Above Average	2.86 - 2.95	2.79 - 2.91	2.65 - 2.74	2.73 - 2.84
	Below Average	2.96 - 3.06	2.92 - 3.05	2.75 - 2.85	2.85 - 2.97
	Poor	> 3.06	> 3.05	> 2.85	> 2.97
Countermovement Jump (cm)	Good	> 27.6	> 28.3	> 30.9	> 27.9
	Above Average	23.1 - 27.6	24.9 - 28.3	27.5 - 30.9	22.9 - 27.9
	Below Average	18.4 - 23.0	21.3 - 24.8	23.9 - 27.4	17.7 - 22.8
	Poor	< 18.4	< 21.3	< 23.9	< 17.7
Depth Jump (cm)	Good		> 27	> 29.5	> 25.3
	Above Average		22.6 - 27	25.9 - 29.5	20.1 - 25.3
	Below Average		18 - 22.5	22.1 - 25.8	14.7 - 20.0
	Poor		< 18	< 22.1	< 14.7

Table 11.2. The performance categories and the data boundaries for elite youth female soccer players

		u11- Elite	u13- Elite	u15- Elite	u17- Elite
YoYo IRTL1 (m)	Good	> 1432	> 1375	>1856	> 2330
	Above Average	1054 - 1432	1235 - 1375	1423 - 1856	1761 - 2330
	Below Average	674 - 1053	1093 - 1234	988 - 1422	1200 - 1760
	Poor	< 674	< 1093	< 988	< 1200
5m Sprint (s)	Good	< 1.08	< 1.07	< 1.01	< 0.98
	Above Average	1.08 - 1.12	1.07 - 1.11	1.01 - 1.06	0.98 - 1.03
	Below Average	1.13 - 1.18	1.12 - 1.17	1.07 - 1.13	1.04 - 1.10
	Poor	> 1.18	> 1.17	> 1.13	> 1.10
10m Sprint (s)	Good	< 1.89	< 1.89	< 1.79	< 1.76
	Above Average	1.89 - 2.00	1.89 - 1.96	1.79 - 1.87	1.76 - 1.82
	Below Average	2.01 - 2.13	1.97 - 2.05	1.88 - 1.97	1.83 - 1.90
	Poor	> 2.13	> 2.05	> 1.97	> 1.90
20m Sprint (s)	Good	< 3.55	< 3.39	< 3.21	< 3.17
	Above Average	3.55 - 3.70	3.39 - 3.54	3.21 - 3.37	3.17 - 3.27
	Below Average	3.71 - 3.87	3.55 - 3.71	3.38 - 3.55	3.28 - 3.39
	Poor	> 3.87	> 3.71	> 3.55	> 3.39
Agility 5-0-5 Left (s)	Good		< 2.81	< 2.60	< 2.56
	Above Average		2.81 - 2.92	2.60 - 2.68	2.56 - 2.65
	Below Average		2.94 - 3.05	2.70 - 2.78	2.67 - 2.76
	Poor		> 3.05	> 2.78	> 2.76
Agility 5-0-5 Right (s)	Good		< 2.78	< 2.60	< 2.53
	Above Average		2.78 - 2.92	2.60 - 2.68	2.53 - 2.65
	Below Average		2.94 - 3.08	2.70 - 2.78	2.67 - 2.79
	Poor		> 3.08	> 2.78	> 2.79
Countermovement Jump (cm)	Good	> 31.8	> 31.6	> 35.1	> 33.5
	Above Average	28.0 - 31.8	29.2 - 31.6	30.7 - 35.1	30.3 - 33.5
	Below Average	24 - 27.9	26.6 - 29.1	26.1 - 30.6	26.9 - 30.2
	Poor	< 24	< 26.6	< 26.1	< 26.9
Depth Jump (cm)	Good			> 34.1	> 33.8
	Above Average			30.1 - 34.1	30.1 - 33.8
	Below Average			25.9 - 30.0	26.2 - 30.0
	Poor			< 25.9	< 26.2
Nordics (°)	Good		<42	< 36	< 31
	Above Average		50.9 - 42	45.9 - 36	44.9 - 31
	Below Average		51.0 - 60	46.0 - 56	45.0 - 59
	Poor		> 60	> 56	> 59

Table 11.3. The performance categories and the data boundaries for the playing positions of youth female soccer players

		Goalkeepers	Defenders	Midfielders	Forwards
YoYo IRTL1 (m)	Good	> 1020	> 2002	> 2210	> 2160
	Above Average	772 - 1020	1489 - 2002	1682 - 2210	1702 - 2160
	Below Average	552 - 771	974 - 1488	1152 - 1681	1242 - 1701
	Poor	< 522	< 974	< 1152	< 1242
5m Sprint (s)	Good	< 1.02	< 1.00	< 0.99	< 0.99
	Above Average	1.02 - 1.06	1.00 - 1.06	0.99 - 1.04	0.99 - 1.04
	Below Average	1.07 - 1.12	1.07 - 1.14	1.05 - 1.11	1.05 - 1.11
	Poor	> 1.12	> 1.14	> 1.11	> 1.11
10m Sprint (s)	Good	< 1.84	< 1.78	< 1.78	< 1.77
	Above Average	1.84 - 1.91	1.78 - 1.86	1.78 - 1.85	1.77 - 1.83
	Below Average	1.92 - 2.00	1.87 - 1.96	1.86 - 1.94	1.84 - 1.91
	Poor	> 2.00	> 1.96	> 1.94	> 1.91
20m Sprint (s)	Good	< 3.29	< 3.18	< 3.19	< 3.17
	Above Average	3.29 - 3.43	3.18 - 3.34	3.19 - 3.32	3.17 - 3.28
	Below Average	3.44 - 3.59	3.35 - 3.52	3.33 - 3.47	3.29 - 3.41
	Poor	> 3.59	> 3.52	> 3.47	> 3.41
Agility 5-0-5 Left (s)	Good	< 2.65	< 2.60	< 2.56	< 2.58
	Above Average	2.65 - 2.73	2.60 - 2.69	2.56 - 2.67	2.58 - 2.69
	Below Average	2.74 - 2.83	2.70 - 2.80	2.68 - 2.80	2.70 - 2.82
	Poor	> 2.83	> 2.80	> 2.80	> 2.82
Agility 5-0-5 Right (s)	Good	< 2.66	< 2.55	< 2.57	< 2.57
	Above Average	2.66 - 2.77	2.55 - 2.67	2.57 - 2.68	2.57 - 2.66
	Below Average	2.78 - 2.90	2.68 - 2.81	2.69 - 2.81	2.67 - 2.77
	Poor	> 2.90	> 2.81	> 2.81	> 2.77
Counter-movement Jump (cm)	Good	> 32.5	> 34.5	> 32.7	> 35.0
	Above Average	28.0 - 32.5	30.0 - 34.5	29.0 - 32.7	32.0 - 35.0
	Below Average	23.3 - 27.9	25.3 - 29.9	25.1 - 28.9	27.0 - 31.0
	Poor	< 23.3	< 25.3	< 25.1	< 27.0
Depth Jump (cm)	Good	> 34.0	> 33.7	> 32.7	> 33.6
	Above Average	29.2 - 34.0	29.3 - 33.7	28.9 - 32.6	30.2 - 33.6
	Below Average	24.2 - 29.1	24.7 - 29.2	25.0 - 28.8	26.6 - 30.1
	Poor	< 24.2	< 24.7	< 25.0	< 26.6
Nordics (°)	Good	< 49	< 34	< 32	< 28
	Above Average	49 - 56	34 - 45	32 - 43	28 - 40
	Below Average	57 - 65	46 - 58	44 - 56	41 - 54
	Poor	> 65	> 58	> 56	> 54

Table 11.4. The performance categories and the data boundaries for senior female soccer players

		Senior Non-Elite	Senior Sub-Elite	Senior Elite
YoYo IRTL1 (m)	Good	> 1534	> 1224	> 1995
	Above Average	1141 - 1534	1021 - 1224	1636 - 1995
	Below Average	746 - 1140	816 - 1020	1275 - 1634
	Poor	< 746	< 816	< 1275
5m Sprint (s)	Good	< 1.03	< 1.02	< 1.00
	Above Average	1.03 - 1.07	1.02 - 1.06	1.00 - 1.05
	Below Average	1.08 - 1.13	1.07 - 1.12	1.06 - 1.12
	Poor	> 1.13	> 1.12	> 1.12
10m Sprint (s)	Good	< 1.79	< 1.78	< 1.81
	Above Average	1.79 - 1.87	1.78 - 1.83	1.81 - 1.89
	Below Average	1.88 - 1.97	1.84 - 1.90	1.90 - 1.99
	Poor	> 1.97	> 1.90	> 1.99
20m Sprint (s)	Good	< 3.16	< 3.19	< 3.23
	Above Average	3.16 - 3.31	3.19 - 3.29	3.23 - 3.36
	Below Average	3.32 - 3.48	3.30 - 3.41	3.37 - 3.51
	Poor	> 3.48	> 3.41	> 3.51
Agility 5-0-5 Left (s)	Good	< 2.54	< 2.47	< 2.53
	Above Average	2.54 - 2.62	2.47 - 2.58	2.54 - 2.63
	Below Average	2.63 - 2.72	2.59 - 2.71	2.64 - 2.74
	Poor	> 2.72	> 2.71	> 2.74
Agility 5-0-5 Right (s)	Good	< 2.51	< 2.48	< 2.55
	Above Average	2.51 - 2.60	2.48 - 2.58	2.55 - 2.65
	Below Average	2.61 - 2.71	2.59 - 2.70	2.66 - 2.77
	Poor	> 2.71	> 2.70	> 2.77
Countermovement Jump (cm)	Good	> 31.3	> 33.8	> 30.4
	Above Average	28.3 - 31.3	30.5 - 33.8	28.9 - 30.4
	Below Average	25.1 - 28.2	27 - 30.4	27.2 - 28.8
	Poor	< 25.1	< 27	< 27.2
Depth Jump (cm)	Good	> 29.8	> 32.7	> 32.7
	Above Average	26.9 - 29.8	30.6 - 32.7	28.1 - 32.7
	Below Average	23.8 - 26.8	28.3 - 30.5	23.3 - 28.0
	Poor	< 23.8	< 23.3	< 23.3

Previous authors have suggested a ‘window of opportunity’ exists where physical qualities are more sensitive to adaptation than at any other time in an individual’s athletic development (Balyi and Hamilton, 2004). The long-term athlete development (LTAD) model suggests skill, speed and suppleness can be enhanced pre-puberty where neuromuscular efficiency is at its greatest, allowing accelerated adaptations to occur. The model also states strength and power related physical qualities can be optimised the most post-puberty due to increased hormonal responses. It is important to state that this model is based on a theory and lacks of empirical evidence to support the LTAD model’s assumptions.

For example, Lloyd et al. (2011) assessed squat jump and countermovement jump performance of subjects at every year group from 7-year olds to 16-year olds, and reported no critical periods of accelerated adaptation between the age groups. Lloyd et al. (2011) did however find a significant decline in performance between the ages of 10- and 11- years, and 11- and 12- years, which may have resulted from the presence of peak height velocity (PHV). PHV is where puberty begins and a rapid growth spurt commences resulting in a decline in motor coordination due to trunk and leg growing at different times. Sherar et al. (2005) reported this occurs on average at the age of 13.85- years for males and 11.58- years for females. However, not all individuals mature at the same rates so Sherar et al. (2005) found the early maturers hit PHV on average at 12.33- years for males and 10.30- for females, while late maturers go through PHV on average at 15.26- and 12.92- years for males and females, respectively. Therefore, in a soccer team PHV will not always occur at the same time due to each player maturing at different stages to each other.

A long term research study needs to carried out to distinguish where exactly these ‘window of opportunities’ occur. Individual player’s need to be assessed each year from a young age of 6- or 7-years old until they are over 18-years of age and tracked each year based on their skeletal age, not on their chronological age. It is important to track players based on their skeletal age and the years from PHV because each soccer player will mature at different times, some will be average maturers, others maybe early- or late- maturers. However, the problem with a proposed twelve year study is that not every soccer player that was assessed at 7-years old will still be playing soccer at 18-years of age which will limit the sample size. Also unless the researcher has full control over each player’s training then it will be difficult to distinguish if a ‘windows of opportunity’ has been utilised. For example, some players may have intervention speed training 3-years before PHV causing improvements in speed performance, whilst others never had any form of intervention speed training and did not improve significantly.

Research from Lloyd et al. (2011) did show interesting development patterns between the age groups for squat jump and countermovement jump performance of males based on their chronological age. Similar research from Vescovi et al. (2010) assessed female soccer player’s physical performance between 12- and 21- years old, which based on Sherar et al.’s (2005) findings, is after PHV has occurred for the majority of these players (10.3 yrs). Therefore, the findings from Vescovi et al. (2010) will not allow assessments of the physical performance of the female soccer players pre-puberty, how it was affected during PHV, and their performance post-puberty. The research study in chapter 5.0 began assessing players at the under-11 age group, which include 9- and 10- year olds. This particular study does allow analysis of how physical performance was affected around PHV by assessing players from 9- years old to senior level.

Vescovi et al. (2010) did however find some interesting results from their research study. They discovered performance rapidly improved from the 12-13 year old to 15-17 year old players for 9.1m speed test, countermovement jump height and agility assessments. The researchers also found smaller gains in performance were observed after the age of 16 years old. These findings are similar to those from chapter 5.0.

Figure 11.1 (page 226) and Figure 11.2 (page 227) demonstrate these trends in performance from chapter 5.0 for elite and non-elite players, respectively. On the whole, it seems to show that the greatest changes in physical performance and where they could be more sensitive to adaptation is from U11 to U15 age groups. After the age of U15, there were minimal changes present. Therefore, it could be possible to suggest the best time to influence physical performance and for players to achieve their athletic potential could be between the chronological ages of 9 – 15 years. It may also be possible to state that after the age of 15- years old that physical performance is harder to influence and athletic potential is more difficult to fulfil.

Figure 11.1. The trends of each physical performance assessment from U11 to U17elite age groups and the link to the top three senior leagues

Figure 11.2. The trends of each physical performance assessment from U11 to U17 non-elite age groups and the link to the top three senior leagues

Figure 11.1 (page 226) demonstrates the trends of the age groups and how this tracks onto the non-elite, sub-elite and elite senior levels. It is important to highlight that the U17 elite youth players have greater physical performance than the senior players playing in elite, sub-elite and non-elite soccer leagues for over half of the assessments (Yo-Yo IRTL1 and 5 m-, 10 m- and 20 m- sprint times). Based on these findings, this leads us to believe the U17 elite players are ready and more than capable to play at senior elite level based on their physical qualities. However, figure 11.2 (page 227) displays the trends of non-elite youth age groups and how this leads on to senior soccer suggesting the jump from non-elite youth soccer, in terms of physical performance, could be too great for these youth players due to their physical performance being considerably poorer than all three senior levels.

As these elite U17 players become senior players in the next few years this could hopefully impact on the senior leagues and improve the physical performance at these leagues. Then it is vital the U15 players improve as they become U17 players, more than the previous U17s; U13 players improve even more than the U15s etc. If the physical performance qualities of female soccer in England are to improve at senior levels the greatest way to do this could be at youth levels especially because this may be the greatest 'window of opportunity' to improve in physical performance qualities (Figure 11.1, page 226; Figure 11.2, page 227).

These findings lead us to suggest that as the youth soccer players age increases, so too does their physical performance. Therefore, if we know that a soccer player's physical performance improves as their chronological age increases there is a point to be made that we need to be patient with the younger players.

Further to this, these younger players could carry out specific intervention training programs to help improve their physical qualities. Studies such as Helgerud et al. (2001) highlighted how a specific interval training program can affect physical performance, and positively transfer into soccer match performance after an 8-week period. The physical performance results from their study showed significant improvements in running economy (6.7%), lactate threshold (16%) and the running speed at lactate threshold (21.6%), respectively. These improvements transferred into match performance with significant improvements in the total distance covered (20%), number of sprints performed (100%), the number of involvements with the ball (24.1%) on the soccer pitch. Further training methods (4x4 interval training format) have shown to improve VO_2max by 6.2-6.4 $ml.kg^{-1}.min^{-1}$ over an eight to ten week period of high-intensity interval training (McMillian et al., 2005; Wisloff et al., 1998). Thus, suggestions would be to carry out similar forms of training to improve both physical performance and match performance.

Numerous anaerobic training studies have demonstrated the positive effects strength and power conditioning training have on soccer-specific performance variables such as sprinting, agility and jump performance (Campo et al., 2009; Meylan and Malatesta, 2009; Wong et al., 2010; Nunez et al., 2008; Perez-Gomez et al., 2008; Christou et al., 2006).Whilst similarly, aerobic-specific tests have shown to significantly improve after aerobic training programs (Dellal et al., 2010b; Sporis et al., 2008; Chamari et al., 2005; McMillian et al., 2005; Hoff et al., 2002; Helgerud et al., 2001).

Even though these research studies (Campo et al., 2009; Dellal et al., 2010b; Meylan and Malatesta, 2009; Wong et al., 2010; Nunez et al., 2008; Perez-Gomez et al., 2008; Sporis et al., 2008; Chamari et al., 2005; Christou et al., 2006; McMillian et al., 2005; Hoff et al., 2002; Helgerud et al., 2001) have shown how specific interventional training programs improve physical performance qualities, there are no compulsory practices soccer players must carry out.

The English FA and FIFA highly recommend female soccer players use FIFA 11+ as part of their training regime. However, FIFA 11+ is aimed to be an injury prevention programme carried out in the warm up before soccer training twice a week and part of the programme performed prior to matches. It includes a series of low-intensity warm up exercises such as hip range of movement ("over the gate/close the gate"), lateral side stepping and forwards and backwards running. Even though backwards running accounts for only 3.6-3.9% of soccer match (Mohr et al., 2008). There are no other athletic movements associated with soccer within this program such as decelerating (stopping), travel and transition movements, drop step turns, split step accelerating techniques, maximum velocity sprints over 30 m, 1v1 footwork. There are however some strength, plyometric and balance exercises within the programme. These include balancing on one leg throwing and catching the ball with a partner, single leg squats, 10-12 continuous reps of Nordic hamstring lowers and squat with toe raise. The "plyometric" exercises in this program involve jumping with instructions to hold the landing position for 1-second before the next rep. Although this may improve the level of control through these exercises, it isn't actually a "plyometric" exercise. Plyometric exercises involve foot contact times equal to or less than 0.25 seconds which can help soccer players produce maximal amounts of muscular forces in a short amount of time (NSCA, 2008; Schmidtbleicher, 1992). Thus, these types of movements may accommodate the poorly conditioned soccer players who require these basic level exercises however, this may not provide the stimulation required for high conditioned soccer players. This poses the question: How does FIFA 11+ program aim to improve the very elite players and how does FIFA 11+ make the elite players become even more elite? Further to this, the exercises do not seem to reflect the demands and the intensities involved in soccer, thus, unlikely to improve maximal physical qualities such as sprinting, turning/cutting, jumping etc. A soccer player must be able to control their own body through soccer-specific accelerating and decelerating actions (Wisloff et al., 1998); as these actions can reach forces of 1.65-4.22 times body mass (Wallace et al., 2010; Satro and Mokha, 2009; Barnes et al., 2007). If soccer players can cope with these high forces and produce greater results in physical performance assessments they are likely to have greater opportunities reaching higher standards of play, finishing higher in competitive leagues, playing in higher league division, starting more matches and being retained at a club (Goto et al. 2013; Lago-Penas et al., 2011; Rampini et al. 2009; Gravina et al. 2008; Le Gall et al., 2008; Gil et al., 2007; Cornetti et al., 2000; Wisloff et al., 1998).

11.3. Conclusion

There is much that can be done within female soccer in England which could help optimise performance within both physical and match components. This research thesis includes different twelve research studies assessing five-hundred and seventeen senior and youth female soccer players to meet specific objectives which has provided a greater understanding into the physical performance and match performance of female soccer in England.

Although the findings from this research thesis have provided a greater insight into the female sport, there is still a massive need in this area to work on youth soccer player's athletic development to improve the game physically as the female game is considerably far behind males. It has been discussed previously in the literature review (chapter 2.0, page 28) how male soccer players perform better in physical performance assessments; they are stronger, aerobically fitter and faster than females. It is important female soccer players become better conditioned and improve their physical performance through appropriate intervention training programs, which could bridge the gap closer between female and male soccer.

The overall findings collectively reveal greater performances are displayed within female soccer players playing at the elite levels of play and in the most successful teams; which allows us to suggest that if we can improve physical and match performance qualities to greater levels this could help improve the standard of female soccer within England so they can endeavour to compete against the best players/teams in the world. However, to do this, more intervention training needs to be carried out in female youth and senior soccer in England and research studies to track these inventions also needs to be completed.

This research has begun to analyse the conditioning levels of female soccer players in England through physical and match performance assessment. However, at present this is only data, results and suggestions documented on paper. These findings need to live in the real world, make positive changes to the players and count for something constructive to aid the success of female soccer players within this country. The female soccer teams need to specifically working with youth players, who are ultimately the next generation, and aiming to improve their physical qualities as well as technical and tactical elements. It is important that the English FA supports soccer teams at both non-elite and elite levels to help female soccer promote greater performance and bridge the gap closer to the male sport. At present, this gap is too large. The volume and the quality of training is very different. For example, an U15 female team and an U15 male team at the same soccer club in North West, England provides two training sessions a week and a thirty minute physical conditioning session for their female players, and four training sessions a week and sixty minutes of physical conditioning sessions a week for their male players. Furthermore, the soccer coach at the male youth team has to obtain at least a level 4 (A- license) coaching qualification whereas the female team needs to have a level 3 qualification (B- license). Therefore, if a male youth soccer player is receiving coaching from a greater qualified soccer coach, performing double the amount of physical conditioning sessions and is training twice as much as a female soccer player then these factors only highlight further reasons why the gap between female and male soccer could be so large.

Female soccer players in England must be able to compete with the best soccer players around the world in the domestic leagues and at international level. Therefore, suggestions for a further restructure in the female game is essential if the next generation of youth soccer players are to improve on that of the current generation of players (which were tested in this research thesis). The findings from this research thesis highlight specific areas which need to be implemented and it is important that these live in the real world every day.

11.4 Recommendations for future research

It would be beneficial to female soccer if the current studies from this thesis were developed further and utilised with skeletal age and age from PHV and investigate this in more depth. Which poses a question: do female youth soccer player's chronological age significantly differ to their skeletal age and do the trends across skeletal ages differ to those in figure 11.1 (page 226) and figure 11.2 (page 227).

Recommendations to those working in female youth soccer would to be patient and wait for the later maturing players to develop physically or maybe put them through physical intervention training programmes and allow the improvements to happen with time. It is important to note that some players have low levels of athletic potential, while others have high levels and I believe this is a research area that definitely needs investigating in female youth soccer. Further research questions include:

- If a youth soccer player is very good technically and tactically at soccer but not quite there from a physical performance perspective, should they be released?
- What if this player has high levels of athletic potential or they were a late maturer and their skeletal age is significantly lower than their chronological age or they were playing in the same team as players who were all early maturers with a skeletal age considerably greater than their chronological age, which makes the less developed player's physical qualities stand out even more as poor?
- How do we know that after peak height velocity or when the skeletal ages of the players balances out at senior levels that their physical performance will not be greater than other elite female soccer players?
- Further research questions need to be derived from this: Are late maturing players released more than early maturing players?
- Are players being signed/ released due to their soccer ability or does maturation status influence these decisions?
- If we improved the physical performances of non-elite players would this improve their chances playing at elite youth level?
- If an elite player's physical performance becomes poor in comparison to other youth players in their age group, are they released from elite levels of play by the soccer coaches (who specialise in technical aspects and tactics) and thus have to play at the lower non-elite level?
- If we were to re-test the elite and non-elite players at senior and youth soccer teams in three years, would the physical performance and match performance results differ to those in this research thesis?

Other research questions could be proposed based on the findings from this research thesis: With the appropriate physical intervention training, does the rate of improvement from 9-15 years become greater than if an intervention was carried out (intervention vs. control measure)? Do different intervention training programs work better than others within sensitive ‘windows of opportunity’ to optimise physical performance?

Finally, we trust elite soccer players are playing at the highest level because of their technical and tactical abilities, but have they also been signed or retained at this high level because of their greater physical performance? Could it also be possible that non-elite players may not be able to play at a high level because of their lack of physical performance, or are they playing soccer at a low level due to poorer soccer abilities, or a combination of both? Other areas to consider going forwards could assess the emotional intelligence, psychological profiles and motivational orientations: Do these psychological themes in a soccer player influence the level of play they achieve? Are the elite players present higher levels of confidence, mental toughness and resilience and make key decisions at high pressure moments? These interesting findings could provoke even further investigations into this research area.

The overarching aim of this research thesis was to develop physical performance and match performance profiles of female soccer players in England. Due to lack of research in female soccer this research thesis has not only met the aim and the outcomes from the research studies successfully but has given greater insight into the different directions further research could be explored.

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