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Performance Profiling of Elite Youth Football Players

The effects of age on performance

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ABSTRACT

This study sought to investigate the whether the academy conformed to chronological and/or relative age effects and the effects of maturation in a review of performance tests. The data aimed to test whether relative age effects, are necessarily part of elite team sports alongside providing the club with an appropriate strategy for predicting physical performance. 93 elite male youth players (13.0 ± 1.9 years, 158.1 ± 15.7 cm, 48.7 ± 15.1 kg) spanning six squads, (U11, U12, U13, U14, U15 and U17) were involved in the study. Performance was assessed via tests of lower body power (CMJ), speed (10m and 20m tests), agility (505 test), and endurance (Yo-Yo IR1). Within each age category, participants were grouped based on their quartiles of birth and maturity status was assessed via anthropometrics. Analysis revealed significant differences between chronological age groups for all measured testing variables ($P<0.01$). No significant differences were observed between the U11, U12 and U13 squads in CMJ, 10m and 20m sprint alongside 505 times ($P>0.05$). However, the U14 to U17 had significantly better test results, for all measures, in comparison to the U11s. Significant differences in distance attained across all squads was only observed in the Yo-Yo IR1. Significant difference was witnessed between pre, circa and post groups ($P<0.01$). Circa-PHV and post-PVH groups produced significantly better results compared to pre-PHV. Furthermore, significant differences were found between circa-PHV and post-PHV groups across 10m, 20m and Yo-Yo IR1 ($P<0.05$), however no significant differences in 505 ($P=0.13$) and CMJ ($P=0.26$). Findings suggest the more mature/older players outperform their less mature/younger counterparts. It was also suggested that teams should compare players based on their maturational age rather than their chronological or relative ages to remove any bias in physical stature.

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ABBREVIATIONS

RAE – relative age effect

Q1 – 1st quartile

Q2 – 2nd quartile

Q3 – 3rd quartile

Q4 – 4th quartile

U11 – under 11

U12 – under 12

U13 – under 13

U14 – under 14

U15 – under 15

U17 – under 17

PHV – peak height velocity

CMJ – counter movement jump

LITERATURE REVIEW

INTRODUCTION

Within professional youth football, players are organised into specific squads by age. The most common way this is applied is through a chronological age grouping. Chronological age is calculated from a single time point away from an individual's date of birth, with the aim of creating an equal and fair competition, as well as participant development (Musch & Grondin, 2001). In Scottish football, players born between the 1st January and 31st December inclusively can play in the same age group.

Chronological age is calculated from a single time point away from an individual's date of birth. Sports tend to group their teams by chronological age, by applying specific cut off dates for inclusion in the team. The term 'relative age' refers to the differences in a chronological age group as a result of when they were born in the year (Barnsley et al., (1992). Studies looking at comparisons of birth dates among youth and senior athletes across a variety of sports have revealed skewed birth-date distributions favouring individuals born early in the selection year (Musch & Grondin, (2001). This phenomenon has been defined in the literature as the 'relative age effect' (RAE) (Barnsley et al., (1985). For there to be an established RAE, the sample of birth distribution must be different to that of the general population. Maturity or maturation is the timing and rate which a child starts to develop towards sexually mature state. Although all young people experience the same steps in the process of growth and development, some of them show maturational events earlier or later than their peers at the same chronological age (de Olivera et al., (2015). With many sports, RAE and maturation cause many problems. Currently Scottish football is investigating the structure of youth football, due to the national team failings to reach a major tournament since the 1998 World Cup. In youth football, especially in Scotland, the style of football requires a more physical ability aspect towards it rather than technical ability. As a result, football scouts sometimes mistake physical attributes for talent. This can in some cases, allow potential more technically adapt players to be lost from academy systems due to their lacking physical abilities. Therefore, the ability to potentially predict how players may eventually develop physically is of great importance. Youth academies carry out physical performance tests throughout the season usually to assess player's power, speed, agility and endurance.

The following review explores the research surrounding the different age related effects have on sport performance, particularly focussing on youth football. The effects of chronological age, relative age and maturity status will be investigated, discussing what they are, how they arise and looking closely at the effect they each have on performance, with the emphasis on how they affect physiological parameters such as speed, power, agility and endurance within testing and if these parameters can be used to predict future performance.

BACKGROUND OF FOOTBALL

Football (or soccer) is widely acknowledged to be the world's most popular sport (Giulianotti., (2012). Football's global governing body, the Fédération Internationale de Football Association (FIFA), has 211 national member associations, while its showcase tournament, the World Cup, is played every four years before worldwide television audiences. There has been a massive revenue growth over the last few years.

As recently as 2008/09 the total Premier League clubs' revenue was less than £2 billion. The £3 billion mark was passed in 2013/14 and Premier League clubs' aggregate revenue is likely to exceed £4 billion for the first time in 2016/17. (Deloitten., (2016). A review in 2016 by Deloitten summarised the current financial climate. Each Premier League match broadcast live in the UK will be worth £10.2m in domestic broadcast revenue. 25 years ago, the broadcast revenue by generated by all the First Division matches over the full season was £15 million. Therefore by half-time of the second Premier League game that is televised domestically in 2016/17, more broadcast revenue will have been generated over the course of an entire season. As a result, the financial incentives that can be gained in football have increased the need for elite clubs to perform and produce player's cable of competing at the highest level.

Football is the most popular sport in Scotland; it is played across many levels from recreational to professional. A study by SportScotland found that 52% of children between (8-15 years old) play football at least once a month. The Scottish Football Association has invested money into the re-structure of the youth game to try increase the amount of young players making it into the professional game.

DEMANDS OF FOOTBALL

What are the demands?

The physiological demands of football have been well researched across the professional game. Football requires a huge range of physical abilities, ranging from aerobic endurance to explosive power and repeated sprint ability. These abilities must also be combined with a technical proficiency, tactical awareness, psychological robustness, and fatigue resistance in order to attain high levels of success.

How are they monitored?

With advances in technology, such as global positioning systems (GPS) or stadium mounted camera systems (Prozone), teams can now monitor and relate match play load to create appropriate training protocols. These systems allow for the collection of a large variety of physical performance data, in relation to distance covered, in absolute and at a variety of different intensities, as well as max velocities and accelerations.

How have they changed?

In the professional game, outfield players will cover distances ranging from 10-12km depending on their position and goalkeepers approximately 4km across a 90 minute game (Stølen et al., (2005). However, distance covered is not a great marker of the physiological demands of football due to the majority of the distance covered by walking and low-intensity running (Bangsbo,. 2014). Research has suggested that the ability for players to perform high-intensity actions are becoming increasingly important in the game. Over the last few years the professional game has changed, a study by Bradley et al., (2014) investigated changes in the physical outputs of English Premier league players. They found that distances covered at high intensity (19.8–25.1 km/h) and sprint (> 25.1 km/h) have increased by over 30% over the last 7 seasons. Whilst players are now carrying out 80% more sprints, the total distance covered in the game has actually decrease by 2%. A study by Faude et al., (2012) The present results showed that straight sprints were the most dominant powerful action in decisive offensive situations in elite football. This suggests there is a need for players to be able to produce high intensity efforts if they wish to play at the top level

Are they the same in youths?

The aim of academies is to produce players that can play and compete at the first team level, physically, tactically and mentally. Therefore, once players reach a certain age, usually at U12 level in Scotland, teams will play 11v11 on a full-size pitch (but restricted in length but not width) with appropriate sized goals. This is to try build a tactical and technical awareness but to also to introduce a physiological adaptation which will serve them during their footballing career. As a result of playing on a restricted size of pitch, the physiological responses are different across the age groups. Harley et al., (2010) explored demands of match-play in U12 to U16 age-group football players. The study looked at total distance, high-intensity distance (>19.8km/h) and sprint distance (>25 km/h) in two professional English football clubs at five age-group levels (U12–U16). The study found that the U16 age-group covered significantly more absolute total distance (115.2 ± 15.8 $m.min^{-1}$), high-intensity distance (2481 ± 1044 m) and sprint distance (302 ± 184 m) than their youngest counterparts. Recently, Goto et al., (2015) examined the distances and speeds covered during match play for U11 to U16 English Premier League academy outfield players. The main finding of the study was that the total match distance covered by academy players and the distance covered at speeds faster than 21 km/h (sprinting) increased with age. There was an increase in running distance at high speeds between the U11 to U16 squads. With a strong relationship between running distance at high speeds and age, Goto et al suggested that an important characteristic of older academy players is their ability to cover increased distances at high speeds needed in the demands of the first team game.

TESTING

What are the standard tests?

Due to the complex physical nature of football, teams will often use a variety of different tests to assess player performance. Many of these tests are field based due to their specificity to the sport. Football clubs carry out physiological testing on their teams throughout different points of the season. With the demands of the game well understood, clubs use a variety of standard field-based tests to assess markers of power, strength, speed, agility and endurance. This review will describe the tests used by the football club's academy players and the rationale behind their use.

Players are tested to help clubs identify potential strengths and weaknesses in each player. The data can then be used to form the basis for the development of optimal training strategies. Svensson & Drust (2005) proposed further testing can then be used to evaluate the impact of these strategies on individual players, thereby evaluating the effectiveness of the programme. It also helps evaluate if players suit the type of profile they are looking for within the team.

Speed and Power Tests

Tests of speed and power are inherently linked most football related performance can be put down to the ability to produce force quickly (Newton et al., (1994). Players who get to the ball first and demonstrate agility and balance in attack and defence have a distinct advantage over opponents (Duthie et al., (2006).

10m and 20m sprints

Due to the nature of the game, high-speed actions during matches can be categorized into actions requiring acceleration, maximal speed, or agility. Acceleration is the rate of change in velocity that allows a player to reach maximum velocity in a minimum amount of time. To test this, teams will often get players to run as fast as they can, over a set variety of distances, depending on what areas of speed the club is looking to test. Testing over shorter distances, gives a representation of players ability to accelerate whilst longer distances are used to define top speed. The club use a test of 10m and 20m sprints to test the speed and acceleration of their academy players, due to the average sprint distance in football being approximately 17m (Little & Williams., (2005). The most common way to test speed/velocity is the time it takes a player to cover a set distance usually timed with dual-beam light gates. From this it is possible to work out how fast the player covers the selected distance using the equation:

Speed = Distance / Time

The reliability of the 10-m sprint time when using dual-beam light gates has been found to be approximately 0.02 seconds (≈1%). This method is the most common within football due to its relatively cheap cost and high reliability.

Countermovement Jump

A vertical jump height has been shown to be an appropriate way to assess lower body power and strength (Young et al., (2001). The neuromuscular performance of muscles have been shown to be similar in vertical jump and sprinting (Cormack et al., (2008), therefore in football where sprinting or ability to perform at high speed is important, it is sensible to assess players ability to jump. In football and at the club involved in the study, the countermovement jump (CMJ) is commonly used as an assessment tool.

Markovic et al., (2004) investigated the validity and reliability of a variety of numerous jump tests. They found that the countermovement and squat , were the most reliable and valid field tests for the estimation of explosive power of lower body power. The CMJ is a standing vertical jump which involves participants jumping upwards, with their hands on their hips. The reason hands are placed on hips is to eliminate the arm swing, which has been shown to give a gain of approximately 10% (Shetty et al., 1989), therefore giving a true reflection of the players' lower body power and strength.

Agility Tests

505

Football by nature is not simply about the ability to perform high speed linear running movements, but it also requires high levels of agility. Agility doesn't have a clear definition in the literature but can but summarized as the ability to change direction rapidly but also the ability to change direction rapidly and accurately (Sheppard & Young (2006). There is an assortment of tests that football clubs can use to assess agility ability, from the T-test, Illinois test to the 505 agility test. In their review of the literature, Draper and Lancaster (1985) compared agility tests and concluded that the 505 test was the most valid test of agility due to its high correlation with acceleration in the turning phase of the test, but did not correlate highly with velocity. They deemed the Illinois agility test to be a less valid test than the 505 test, as it correlated strongly with top speed and less so with agility. Draper and Lancaster (1985) believed agility tests should be independent of top speed, and saw that acceleration in the 505 test was more related to the demands of a change of direction and re-acceleration. The 505 test consists of the participants running 10 m in a straight line and touch with the foot (right or left) on a line placed at 5 m from the speed gates, where they change direction and continue to run until crossing the starting point again.

Markers are placed at 5m points. The time is recorded from when the participants first run through the 5-m marker and stopped when they return through these markers (i.e., the time taken to cover the 5m up and back distance—10 m total). Reilly et al., (2000) suggests that agility tests could discriminate elite football players from other populations better than any other field test of strength, power, or flexibility. Also tests of agility should be assessed in conjunction with a single sprint tests to obtain a thorough indication of a player's speed capacity Little and Williams (2005). A review by Svensson and Drust on testing methods applied in football concluded that testing agility could be the best single indicator (over other field test for strength, power or flexibility) for overall footballing performance. Agility tests can discriminate elite football players from the general population and provide the best differentiation among non-players and elite and recreational performers**.**

Endurance

Yo-Yo IR1

Although footballers cover up to 10-12km (as stated earlier), the exercise is intermittent and made up of a variety of speeds. Therefore, the players need ability to repeatedly preform intense bouts of exercise. Thus, a test was developed by Jens Bangsbo, to help assess this measure of endurance. The Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1) is a football specific field test that maximizes the aerobic energy system through intermittent exertion. (Deprez et al., 2012), the Yo-Yo Intermittent Recovery Test Level 2 (Yo-Yo IR2) is more demanding on the anaerobic system (Ingebrigtsen et al., 2012). The test consists of 20-m shuttle runs with a gradual increase in speed, after a set of runs, players have a 10 second active rest period, and continue until they are unable to keep up with the required speed (Krustrup et al., 2006). The Yo-Yo IR1 consists of four running bouts at 10–13 km $km.h^{-1}$, seven at

13.5–14 km km.h^{-1}, and thereafter stepwise 0.5 km.h^{-1} speed increments every eight running bouts. The Yo-Yo IR2 test starts with four running bouts of 13–16 km.h^{-1}, seven bouts of 16.5–17 km.h^{-1}, and after that continues with stepwise increases of 0.5 km.h^{-1} every eight running bouts. At the club when academy players undergo performance testing, it more commonly the Yo-Yo IR1 that is used, mainly because younger squads do not have the physical capacity to maintain the starting high speed of the Yo-Yo IR2.

Studies have shown that performance in the Yo-Yo intermittent recovery test correlates well with the physical match performance of male elite footballers (Mohr et al.,(2003). Elite players covered 5% more distance during a match than moderate players. They also found the players within the elite group who performed better in the Yo-Yo test, also ran a greater amount of high speed running within the game, which has been indicated previously to be a key physical parameter for an elite level player. Interestingly they noted that positional differences in players also affected their Yo-Yo test score. Attackers and central defenders tended to cover less distance in matches, were found to have poorer Yo-Yo scores compared those players playing within midfield and full back positions.

AGE EFFECTS

CHRONOLOGICAL AGE

Introduction

Chronological age is calculated from a single time point away from an individual's date of birth. Sports tend to group their teams by chronological age, by applying specific cut off dates for inclusion in the team. Most cut off dates tend to allow a 12 month period defined as the "activity year" (Barnsley et al., 1992). In 1997, Fédération Internationale de Football Association (FIFA) implemented the cut-off date for youth football would be the January 1st to December 31st (Helsen et al., 2005) which still remain in place today (de Oliveira et al., (2015). Sporting bodies set these specific activity years with the aim of creating an equal and fair competition, as well as participant development (Musch & Grondin, 2001).

However chronological age grouping has its problems, as it can result in large age differences between teams depending on where they are born in the activity year. For example, with a 1st January cut-off date, those born shortly after this date (e.g. 5th January) are chronologically older than those born almost one year after the cut-off date (e.g. 30th December); however, both sub-sets are included in the same chronological age group (Vaeyens et al., 2005). Research has shown that chronologically older players are often over represented in football teams due to these cut off dates, and the effects are closely related to that of relative age. Sometimes players tend to be biologically ahead of their chronological age and can be classed as early-maturing individuals. A player who is considered to be "on-time" with their chronological age are classified as maturing at normal rate. Furthermore players who said to behind their chronological age are defined as late-maturing individuals (Lloyd et al., 2014). As a result the effects of different chronological ages can be closely linked to the other age effects.

Impact on Performance

Differences between different chronological age groups are well understood. Older players (e.g. U17 players) will have better performance scores in tests of speed, lower body power and endurance compared to that of a younger player (e.g. U11 players) due to the fact they are bigger, faster and stronger. Williams et al., (2011) investigated the difference in performance between U11-U16 players attending a centre of excellence at a professional English football club, during 10m and 30m sprints and lower body power testing via a CMJ. They found there was an overall improvement in performance variables of speed and jumps with age. However, performance variables showed no significant difference between players in the U12 and U13 teams. Conversely, players in the older age categories (U14, U15, and U16) were able to run significantly faster and jump significantly higher than all of their younger counterparts. Williams suggested that being relatively slow at the youngest age to being relatively fast at the oldest age, may reflect a bias toward more mature and physically developed players by the time players reach the U16 age group.

Conclusion

In conclusion, chronologically older players have been shown to perform better in testing, with faster times for sprints as well as greater jump scores. The literature does show that there is a cross-over between chronological age and other age related factors which provide this advantage or disadvantage.

RELATIVE AGE AND THE RELATIVE AGE EFFECT

Introduction

The difference in age between children born in the same year is referred to as 'relative age' (Helsen et al., (2012). The performance and participation consequences of relative age are known as 'relative age effects' (RAE) (Barnsley et al., (1992). Comparisons of birth dates in a vast amount of sports have shown skewed birth date distribution favouring individuals born in the early part of the selection year (Musch & Grondin., (2001). A difference of less than 12 months has been shown to be unimportant during adulthood, however it has been suggested that it could be extremely relevant during childhood (de Oliveira et al., (2015). For the RAE to be established it must show a skewed birth date distribution compared to that of the national average birth rate to the general population. When investigating relative age the literature tends to split the year into quartiles.

Prevalence

RAE is not unique in the sporting world. The first studies of RAE were carried out in education sector in the early 1960's. RAE in education is similar to sport, where older children have been suggested to achieve more academically than their younger classmates (Maddux (1980) & Diamond (1983). Large differences in relative age within education, have been shown to have a significant effect on children's cognitive development. Musch & Grondin., (2001). A potential reason for a RAE in education system is, much like sporting competitions, most systems follow a cut-off date structure, which determines which class you enter based on their chronological age. In Scotland the cut-off date for determining school entry is 1st March, with the academic year beginning in August. Children with birthdays between March-August must start school in the academic year during which they will become five years old, whereas children with birthdays in September to February can start in the August preceding their fifth birthday or defer for a year (Goodman et al., (2003). Large differences in relative age within education, have been shown to have a significant effect on children's cognitive development.

The idea that RAE could also appear in sport was first discussed by Barnsley et., (1985) & Grondin et al., (1984). Looking at Canadian youth ice hockey they noticed a skewed distribution of birthdates in competitive ice youth leagues a proposed a possible relationship between relative age and participation in sport which closely matched that of relative age and academic achievement. Barnsley argued that the higher age of children born early in the competition year gives them a competitive advantage over their younger peers. Since then RAE has been found to occur in a vast number of sports including baseball (Delorme et al., (2010), rugby (Till et al., (2010) and tennis (Baxter-Jones., (1995) (Mujika et al., (2009).

The prevalence of RAE within football is worldwide. Helsen et al., (2005) found that RAE occurred across Europe, they investigated the spread of birth rates in professional clubs and national team in Belgium, Denmark, England, France, Germany, Italy, The Netherlands, Portugal, Spain and Sweden. They reported that an over-representation of players born in the first quarter of the selection year (from January to March) for all the national youth selections at the under-15 (U-15), U-16, U-17 and U-18 age categories. The RAE is not just apparent in Europe, de Oliveria et al., (2015) and Massa et al., (2014) have both confirmed that the RAE exists in South American football, focussing most of the research on Brazilian youth football. van den Honert (2013) established that the RAE existed throughout football in all levels of Australian football. Sallaoui et al., (2013) and Williams (2010) found that there was a reverse RAE in regards to young African footballers, with a greater proportion born in the latter quarter of the year. The studies were both carried out at FIFA U17 World Cup competitions. A possible reason given for this was there could be a potential error in reporting actual dates of birth. As the study was carried out at an internationally accredited competition, they assumed that the dates of birth that they received were accurate. They claim that only about half the births for children under 1-year-old in African countries are actually registered. A study of vital registries in Cameroon indicates that only 33% of births could be confirmed by a birth certificate since the documents are held by the father (Ndong et al., (1994), thus there is a large room for error in reporting the actual dates of birth. However it is important to point out that this reverse RAE is not conclusive and further research is needed to clarify its existence.

The RAE effect is stronger in youth football than the professional adult game. Studies by Cobley (2008) and Vaeyens et al.,(2006), looking at the German Bundesliga and Belgian league respectively, found that the effect of the RAE decreases with increasing age. Reasons suggested for this are players born in the latter part of the year "catch up" physically with their peers at adult age (Mujika et al., (2009).

Why does it occur?

The occurrence of the RAE has been attributed to the large biological variability within chronological age groupings during youth sport. (Baxter-Jones, (1995). A review by Cobley et al, (2009) suggests that physical differences (i.e. a greater chronological age and likelihood of more advanced physical characteristics) are responsible for the RAE. A difference of less than 12 months has been shown to be unimportant during adulthood, however it has been suggested that it could be extremely relevant during adolescence (de Oliveira et al., (2015). This difference, particularly during the adolescence growth spurt, intensify physical and performance differences amongst individuals (Malina et al., (2007). As a result, relatively older children usually have an advantage over their younger peers due to exhibiting advanced physical characteristics and entering puberty earlier (Colbley et al. (2009). In most sports, greater body size, power and strength provided an advantage, therefore children who exhibit these characteristics at an early age are often considered to be talented by coaches and scouts (Helsen et al., (2012). This often leads to these players having the chance to reach higher quality teams, as a result of a developmental advantage rather than their level of proficiency, where they receive better coaching, training and play at a higher competition level (Wattieet al. 2008).

Impact on performance

Although the vast majority of research that has currently been carried out only looks to confirm the existence of the RAE within football, a few studies have investigated the effect that relative age and RAE has on physiological performance in testing. Relatively older players are thought to have a physical advantage, however the research would suggest that they don't result in a performance benefit.

de Oliveira et al., (2015) found that relative age had no influence on physical performance during jump, sprint and endurance testing of U-15 and U-17 Brazilian footballers. Although the research found no significant differences the authors did suggested that due to the lower level of competition, clubs involved would not have had such a rigid selection process compared that of more professional teams, which may have affected the results. Carling et al., (2009) research on elite U-14 French youth players, suggested that the players born earlier in the year did appear to perform better than their counterparts born in the latter part of the year, yet no significant differences were found. Carling did find that boys born in the earlier part of the year were physically larger, it has been known of some scouts to often mistake physical prowess for talent as taller players at a younger age often stand out. The study only investigated one age group (U14s) over an 11 year period, therefore it is difficult to make comparisons to other age groups. Deprez et al., (2012 & 2013) studied elite Belgian youths, found no significant differences in aerobic fitness (via the Yo-Yo IR1 test).

In elite youth football, within a specific age-group, a higher chronological age is not associated with a better Yo-Yo IR1 performance which suggests that the relative age of the players does not provide a significant advantage in terms of football-specific endurance), vertical jump performance or speed over 5m and 30m.

Once again the only trend was players on the 1st quartile were found to be taller and heavier. Deprez did note that these physical/performance advantages found in the relatively older player were diminished as players began the maturational growth towards adult stature, which levelled off the differences found at younger ages.

Conversely, Gil et al. (2014) observed greater performance scores of youth players (aged between 9-10) born in the first quartile in a Spanish county. These first quartile players were found to have faster times in the agility and speed tests over 30 meters. Gil also tested markers of endurance capacity (Yo-Yo IR1) and lower body CMJ and found players performed better in these tests however it was shown not to be statistically significant. Gil did also find the first quartile players were also taller and heavier which has been previously been observed in the research before.

It is therefore possible to hypothesis that players born in the latter part of the year are not always at a disadvantage compared to those born in the early part and RAE does not potentially affect player performance at elite clubs, and that elite football training may remove the effect.

A notable observation was that the differences diminished when players grew older, resulting in smaller effect sizes. Several reasons might account for this observation. First, each player will eventually reach the adult stage and achieve full maturation, levelling off the differences existing in the younger age groups. Second, youth athletes differ in timing and tempo of development, growth and maturation, demonstrating large inter-individual differences in anthropometrical characteristics and physical capacities, independent of the birth quarter the player is born in. Finally, drop-out of injured players and selection policies in favour of players with similar anthropometrical characteristics and physical capacities could result in more homogeneous birth quarters when players grow older.

Possible Solutions

Despite all the research that has been carried out the RAE over the last few decades, its prevalence is still large in youth football (Helsen et al., (2012). Proposed solutions have been to rotate the cut-off date which only results in shifting the problem to other months in the year. Recently the introduction of “future teams” like in Belgium. They have recently created U16-F and U17-F ‘future’ teams in addition to the regular U16 and U17 teams which mainly consist of ‘later maturers’ (Helsen et al., (2012). Whether or not this will have an impact on the RAE is yet too been seen in the research.

Conclusion

In conclusion, the effect relative age and RAE have on football is well established in some aspects. Players born in the earlier part of the year tend to be overrepresented in many clubs around the world, predominately down to their greater physical appearance. However from the few studies published, it would appear that these older players don't perform any better than the relatively younger players. As with most studies of relative age there was once again an overrepresentation of players born in the earlier quartiles. It is therefore difficult to make real conclusions about whether or not relative age has an effect on performance. Potential reason for this could be the level of competition may remove the effect. Further research is needed to investigate whether or not relative age and its effects, do affect player physiological performance in testing.

MATURITY

Introduction

Another factor which can affect player performance is biological maturation/maturity status. The adolescent growth spurt is the timing and rate which a child starts to develop towards sexually mature state, commonly defined as puberty. This period of time causes dynamic changes in physiological capabilities, physical parameters and sexual characteristics of the individual involved (Pearson et al., (2006). Everyone tends to change physically during puberty, usually by increasing in size and mass. Also enhancements in neural function, multi-joint coordination, changes in muscle architecture, and increases in muscle power occur. This has been related to the rise in circulating concentrations of testosterone and growth hormone as a result of the onset of puberty (Malina et al., (2004).

Although all young people experience the same steps in the process of growth and development, some of them show maturational events earlier or later than their peers at the same chronological age. (de Olivera et al., (2015). The adolescent growth spurt varies considerably in timing, tempo and duration among individuals (Philippaerts et al., (2006). This leads to some children who can be more or less mature for their chronological age. Biological maturity can vary as much as 3 years in individuals of the same chronological age (Gastin et al., (2013). Within single-year chronological age groups, boys and girls advanced in maturity (sexual, skeletal, age at peak height velocity) are, on average, taller and heavier than peers who are average (on time) or delayed (late) in maturity status (Malina et al., (2005). Research has shown that boys who are advanced in biological maturity (or early maturers) are generally better performers than their later maturing peers mainly due to their greater physical presence (Philippaerts et al., (2006).

Measuring Maturity

During the adolescent growth spurt, the skeletal, sexual and neuro-endocrine systems all undergo changes. A players biological maturity is commonly defined by the measurements of the skeletal age (analysis of bones), sexual age (based on the development of reproductive system) and somatic age (determined by stature). Measuring maturity can be a challenging for a vast amount of reasons. Firstly the timing and tempo of growth varies between individuals (Beunen et al., (1992). As a result of this, one off assessments of maturity status can sometimes be misinterpreted. Therefore it is useful to carry out longitudinal monitoring to regularly update a players maturity status. Each of the three systems measured have their advantages and disadvantages.

Skeletal Age

Skeletal maturation involves development of cartilaginous structures into fully developed bones (Lloyd et al., (2014). Assessment of skeletal age is classed as the gold standard method within the literature when measuring the maturation status of a person. It uses x-rays or radiographs of the left wrist to determine the age of an individual. Therefore only trained individuals such as radiographers, can perform this method of assessment. The bone age refers to the degree of biological maturation in relation to the development of skeletal tissue (Malina (2011). There are a number of methods used to asses skeletal age; Greulich-Pyle method (Greulich et al., (1959), Tanner-Whitehouse (TW) method (Tanner et al., (1975) and the Fels method (Roche et al., (1988).

Greulich-Pyle method: Is an 'atlas-based' technique where radiograph of child's left wrist is compared against reference x-ray plates of varying levels of skeletal maturation. The skeletal age is then determined by which x-ray closely reflects the scanned wrists. For example, if the x-ray of a 10-year-old boy matches closely with the reference plate x-ray of a 12 year old, then his skeletal age would be determined as 12 and he would be deemed to be maturing early (Lloyd et al., (2014). This method is based on the concept that bone matures at a uniform rate however this is not always the case.

Tanner-Whitehouse (TW) method: This method has been revised a few times since its original proposal. It looks at either 13 or 20 bones in the wrist and hand. Each bone is categorized into a stage score (stage A to stage H/I) which then given a maturation score and the cumulative score is converted to a skeletal age value (Satoh., (2015).

Potential problems with this method are it is a fairly difficult and time-consuming process, with a degree of individual decision making when analysing the bones.

Fels method: The Fels method is based on maturity assessments of the radius, ulna, carpals, metacarpals and the phalanges. Each bone is graded to age and the sex of the individual. Using specific software, skeletal age and standard error of estimate are then calculated. Like the TW method, the Fels method is again a complex and time consuming process. The ability of the assessment tool to provide an estimated standard error within the measurement is obviously of benefit for the long-term tracking of biological maturation in children and adolescents (Lloyd et al., (2014).

Overall, although skeletal age is considered the gold standard method of determining biological maturity, it is a very costly and time consuming method. Also the need for specialist equipment and assessors, mean it is sometimes not a practical method of measurement, especially within most youth football clubs. There is also the ethical view of subjecting children to needless radiation. A review by Malina (2011) stated that with modern technology, exposure to radiation from an x-ray is minimal, 0.001 millisievert (mSv), which is less than natural background radiation.

Sexual Age

Sexual age refers to the degree of biological maturation towards a fully functional reproductive system. There are a couple of methods that can be used to asses sexual age, the Tanner Criteria (Tanner (1962) and the age at menarche. The age of menarche relates to the age at which a female has their first menstrual period. It therefore can't be applied to male youth football. The Tanner Criteria method is an intrusive method of testing and can only be carried out by trained clinicians, once both parent and the child involved have given consent. The criteria uses observations of the development of secondary sexual characteristics (genitals - males, breasts - females and pubic hair – males and females), which are then compare against 5 stages of growth (Tanner (1962). Stage I is defined as prepubertal, Stages II and III are defined as early pubertal, Stage IV is defined as late pubertal, and Stage V is considered fully mature. Potential shortcomings of the Tanner Criteria are the inability to differentiate children within each stage, it is unable to provide an insight into the speed a child is going through maturation and it can also only be applied when a child is going through the pubertal phase of growth (Lloyd et al., (2014). As a result, measuring sexual age is not particularly feasible within a youth academy setting due to its invasiveness and the need for trained clinicians.

Somatic Age

Due to the issues surrounding measuring skeletal and sexual age, many football youth academies tend to measure somatic age. The degree of overall growth in stature is referred to as the somatic age. Commonly used measures that can determine somatic age include; assessments of longitudinal growth curves, prediction of peak height velocity (PHV) and predictions/percentages of adult stature (Malina (2011). With the onset of sexual maturation, skeletal growth is stimulated by increased endocrine function, which releases different levels of hormones such as estrogen, testosterone, insulin-like growth factor 1, and growth hormone. This can be observed through changes in the size and length of stature and limbs. The longitudinal collection of anthropometric measurements, are non-invasive and allow growth curves to be established. From these curves, the age at which PHV will potentially occur can be predicted. PHV is the age at which maximum growth occurs (Stratton et al., (2013), typically occurs at around the ages of 12 in females and 14 in males (Malina et al., 2004). Youths' who are early maturing, can exhibit PHV up to a year or more before the average age, meanwhile those who are later maturers can be as far as a year behind the average. An average mature enters PHV at the predicted average age (Baxter-Jones et al., 2005). Within a youth football academy setting, it is important to longitudinally track anthropometric measurements. During maturation players can potentially be at a greater risk of suffering an injury (Malina., (2010). Sometimes it is not possible to track a child's measurements. In this case PHV can be predicted using equations developed by Mirwald et al., (2002). The equation takes into consideration the different rates of the growth in the body. The equation require the attainment of chronological age (years and months), body mass, standing height, and seated height, which can be used to determine years from PHV for a male or female at any given single point in time. The estimation in years has a standard error of approximately 6 months.

Impact on Performance

Maturity can have an effect on performance. Performance differences among maturity (measured via the Tanner criteria) groups are apparent by 13 years of age and tend to be greatest at 14 and 15 year (Malina et al. (2004). Players who are more mature (radiographs of the left wrist and Mirwald measurement of PHV) generally tend to outperform their less mature counterparts in physiological performance testing (Buchheit et al., (2014). Figueriredo et al., (2009) examined the effect maturity had on physical markers of performance, football skills and goal orientation across 5 Portuguese clubs U11-U14 teams. Maturity status was established by skeletal age, via radiographs of the left wrist. They then used the Fels method to estimate how mature each player was. The performance testing involved the Yo-Yo IR 1, vertical jump ability (CMJ and SJ), an agility and anaerobic fitness test. They found that early maturers in the U13-U14's teams tended to perform better in the vertical jump tests, with no such trends apparent in the U11-U12. Interestingly they found that later maturers performed better in the Yo-Yo IR1 test across all teams, however it was suggested that this may have been down to the low number of late maturers which caused an uneven distribution within the squad. It has been suggested that the performance benefits were potentially linked to a lower body mass found in later matures, resulting in a lower energy cost of running.

Philippaerts et al., (2006) also used skeletal age (via the TW method) to estimate maturity in a young Belgian football team. Early maturers performed better in the vertical jump (up to 10 centimetres higher) and 30m sprint (0.8 seconds faster) scores. It is suggested that maximal gains in muscular strength and power occur, on average, after peak height velocity, early maturers could potentially be able to utilise this extra muscle to improve performance.

Similar results were found by Buchheit et al (2013 & 2014) within a group of highly trained youth players. They found that that more mature players had faster times during sprint tests. The only difference was both of Buchheit studies used the equation by Mirwald et al., (2002) to estimate maturity which could be deemed less accurate compared to that of the TW method.

Conclusion

The literature out at the moment does show the effect that maturity can have on performance. Biological maturity effects the skeletal, sexual and neuro-endocrine systems leads to changes in physiological capabilities, physical parameters and sexual characteristics. This leads to an increase in height and mass along with the changes in muscle power. As a result the more mature players tend to perform better in some aspects of testing such as jump height and sprinting due to these physical gains.

SUMMARY

The RAE is well established in some aspects of football. Research has shown that players born in the earlier part of the year tend to be overrepresented in many clubs around the world, which has been predominately been put down to their greater physical appearance. Even though RAE has been investigated for many years the problem does not seem to have disappeared and in some cases, is getting worse. However from the few studies published looking at performance testing, it would appear that these older players don't perform any better than the relatively younger players. Further research is needed to investigate whether or not relative age and its effects, do actually affect player physiological performance in testing. Also the literature does show the effect that maturation status can have on performance. The effect biological maturity has on the bodily systems has been shown to increase height and mass of players along with gains in muscle power. This results in the more mature players within the same chronological age group performing better in some aspects of testing such as jump height and sprinting. Chronologically older players have been shown to perform better in testing, with faster times for sprints and also greater jump scores. The literature suggests that there is a cross over between chronological age, relative age and maturity status factors which may all play a part in affect player performance.

RESEARCH ARTICLE

INTRODUCTION

Within professional youth football, players are organised into specific squads by age. The most common way this is applied is through a chronological age grouping. Chronological age is calculated from a single time point away from an individual's date of birth, with the aim of creating an equal and fair competition, as well as participant development (Musch & Grondin, 2001). In Scottish football, players born between the 1st January and 31st December (inclusive) can play in the same age group. Chronological age is calculated from a single time point away from an individual's date of birth. Sports tend to group their teams by chronological age, by applying specific cut off dates for inclusion in the team. The term 'relative age' refers to the differences in a chronological age group as a result of when they were born in the year (Barnsley et al., (1992). Studies looking at comparisons of birth dates among youth and senior athletes across a variety of sports have revealed skewed birth-date distributions favouring individuals born early in the selection year (Musch & Grondin., (2001). This phenomenon has been defined in the literature as the 'relative age effect' (RAE) (Barnsley et al., (1985). For there to be an established RAE, the sample of birth distribution must be different to that of the general population. Maturity or maturation is the timing and rate which a child starts to develop towards sexually mature state. Although all young people experience the same steps in the process of growth and development, some of them show maturational events earlier or later than their peers of the same chronological age (de Olivera et al., (2015). Currently Scottish football is investigating the re-structuring of youth football, due to the national team failings to reach a major tournament since the 1998 World Cup. In youth football, especially in Scotland, the style of football requires a more physical ability aspect towards it rather than technical ability. As a result, football scouts have been sometimes known to mistake physical prowess on the field for talent. This can in some cases, allow potentially more technically adapt players to be missed or on occasions lost, from the academy systems due to their lack of physical stature. As a result of this, academies have started to pay more attention to where players are in terms of PHV. Alongside this, youth academies carry out physical performance tests throughout the season to assess player’s power, speed, agility and endurance. Therefore, if there was a way to potentially predict how players may eventually develop physically it could help prevent youth academies from realising players too early.

The aim of this present study was to assess whether the academy conformed to chronological and/or relative age effects and investigate the effects of maturation, by reviewing the clubs’ battery of performance tests. In performing this analysis, the data will test whether relative age effects, although common, are necessarily part of elite team sports. From this, the study will also try to provide the club with an appropriate strategy for predicting physical performance.

METHODS

Participants

The data was collected from 93 male youth players (13.0 ± 1.9 years, 158.1 ± 15.7 cm, 48.7 ± 15.1 kg) registered with an elite youth Scottish football academy (6 Star Club Academy Scotland rating – highest rating available) during the 2014/15 season. The participants were grouped by their chronological age into six squads, under 11 (U11; n= 19), under 12 (U12; n= 12), under 13 (U13; n= 17), under 14 (U14 n= 14), under 15 (U15; n= 15) and under 17 (U17; n= 16). Players in the U11, U12, U13 and U14 players in the squads participated in 3 x 1.5 h of football training per week with one competitive match. The U15 and U17 squads participated in 4 x 1.5 h of football training per week, 1.5 h of strength and conditioning training with one competitive match. All participants and their parents/guardians provided written informed consent and all procedures were granted approval by the University of Glasgow Ethics Committee.

Experimental Design

Within each age category, participants were grouped according to their quartiles of birth and maturity status. Quarter 1 (Q1) contained months (January to March), quarter 2 (Q2) (April to June), quarter 3 (Q3) (July to September) and quarter 4 (Q4) (October to December). The General Registrar's Office for Scotland provided data on the number of births within the general population, by month, for all relevant years. Expected birth date distributions for the population of interest will be calculated from this information.

Each participant’s maturity was predicted by using the non-invasive method outlined by Mirwald et al. (2002). This required measurement of standing height, seated height and body weight. The equation identified the number of years, to or from, each participant is to their individualized peak height velocity (PHV).

Peak Height Velocity = -9.236 + 0.0002708 x (Leg Length x Seated Height) - 0.001663 x (Age x Leg Length) + 0.007216 x (Age x Seated Height) + 0.02292 x (Weight / Height)

Figure 1. Equation of PHV by Mirwald et al,. (2002)

PHV is a key reference point for biological maturity where once it is attained, biological maturity is assumed to be achieved. Standing height was measured to the nearest 0.01 m using a stadiometer (Seca Height Measure 213) whilst seated height was measured with participants seated on the base of the stadiometer placed upon a box. Body mass was recorded to the nearest 0.1 kg using a set of electronic scales (Seca Scales 770). Afterwards participants were divided into three groups based upon how many years away to or from PHV. Specifically, players were classed as pre-PHV (n=57) (greater than 1.0 year away from PHV), circa-PHV (n=22) (between -1.0 and +1.0 years to and from PHV) and post-PHV (n=14) (greater than +1.0 from PHV).

Following these anthropometric measurements, participants underwent physiological testing on an indoor 3G pitch. Firstly participant’s lower body power was tested by a countermovement jump (Cormack et al., (2008). Each participant carried out 2 x counter movement jumps (CMJ) with the “Just Jump” mat. Each jump involved the participant stepping onto the mat, bending knees to a self-selected depth whilst keeping hands on hips, jumping upwards and landing onto the mat. Each player was given a suitable rest period of 45 seconds between jumps, with the highest jump recorded. Participants then underwent the modified 505 agility test (shortened from 15m to 10m, to make it a more football specific movement) (Sheppard et al., (2006). This test aims at evaluating the capacity of the participants ability to quickly change direction. Markers were set up at 5 and 10 m from a line marked on the ground. The participants ran from the 10 m marker toward the line (run in distance to build up speed) and through the 5 m markers, turned on the line, and run back through the 5 m markers. The time was recorded from when the participants first run through the 5-m marker and stopped when they return through these markers (i.e., the time taken to cover the 5 m up and back distance—10 m total). The participants were instructed to not overstep the line by too much, as this would increase their time. The participants run 10 m in a straight line and touch with the foot (right or left) on a line placed at 5 m from the speed gates, where they change direction and continue to run until crossing the starting point again. The time spent in the 5 m was measured by photoelectric timing gates (Browser Timing Systems) and considered for analysis. Each participant performed 2 attempts, and the best score was recorded. Proceeding this, each participant underwent 3 x 20 m sprints with photoelectric timing gates (Brower Timing Systems) placed at 0, 10 and 20 m to evaluate their speed. Each sprint started 0.5 m behind the first timing gate, to ensure the first movement forward eliminated variations in participant starting techniques with the fastest trials were recorded. Lastly the participant's endurance was tested by the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1). Each participant has their own running lane, marked by cones, approximately 2m in width. From theses, corresponding cones are placed 20m away. Another cone placed 5 m behind the finishing line marked the running distance during the active recovery. The test consists of repeated 2 x 20-m runs back and forth between the starting, turning, and finishing line at progressively increased speed, controlled by audio bleeps from a portable speaker. Between each running bout, the participants have a 10-s active rest period, consisting of 2 x 5 m of jogging. When the participants twice have failed to reach the finishing line in time, the distance covered is recorded and represents the test result (Krustrup et al., (2003).

Statistical Analysis

All results are presented as mean± standard deviation. Data were analysed using SPSS statistics package (IBM SPSS Statistics 21). All data were assessed for normality of distribution according to the Shapiro-Wilk's test. Statistical comparisons between squads' and maturity groups' height, weight, APHV, maturation status, CMJ, 10 and 20 sprint time, 505 agility time and Yo-Yo IR1 distance were performed according to a one-way between-groups analysis of variance (ANOVA). Where significant differences of the ANOVA were present, *post-hoc* analysis with a Bonferroni adjustment were carried out to show which squads differed from each other. For non-normal data, post-hoc analysis was performed using Mann-Whitney U Test. Significance was accepted at $P<0.05$

RESULTS

A significant difference was found for all measured variables (P<0.01). For height and weight, the U11 and U12 squads were significantly smaller and lighter than the U14, U15, and U17s (Table 1). Furthermore, the U11s were shorter and lighter than the U13s, and the U13s were significantly different in height (P<0.01), but not weight (P = 0.09) than their U14 counterparts. The U11 squad reach peak height velocity earlier than all the other squads on average, significant differences were shown across all squads bar the U12 squad. Significant differences in maturity offset were observed between all squads. Those within the U13, U14, U15 and U17, displayed a greater offset in maturity than those in the squad beneath and the U11.

An unequal spread of birth date across the squads was observed (Table 2) with a higher proportion of players born in the first quartile (Q1) (January-March) than the last quartile (Q4) (October-December) for each squad. 58.5% of the total academy players were born in the Q1 of the year, compared to almost a quarter of participants born in the Q2. However, there are more Q4's in the U13 and U14 squads than Q3, which does not conform to the expected distribution for a relative age effect.

There was a larger proportion of players classed as pre-PHV (61.3%) compared to those circa-PHV (23.7%) and post-PHV (15.1%) (Table 3). The U11 and U12 squads are exclusively made up of pre-PHV players, whereas within the U14s and U15s mixture of pre- and circa-PHV is observed (Table 3). In comparison the U17 squad had the highest number of, and were predominately made up of, post-PHV players.

A significant difference was found between groups for all measured testing variables (*P*<0.01). No significant differences were observed between the U11, U12 and U13 squads in the CMJ, 10m sprint, 20m sprint and 505 agility tests (*P*>0.05) (Table 4).

However, the U14, U15, and U17 squads had significantly higher CMJ scores, produced faster sprint times and covered greater distance in the Yo-Yo IR1 test in comparison to the U11s. Significant differences showed that U11 were out performed by U14, U15 and U17 (P<0.05 for all) squads across the CMJ, 10m sprint, 20m sprint, 505 agility and Yo-Yo IR1. For the Yo-Yo IR1, significant differences in the distance covered were observed across all squads (Table 4). Furthermore, between the U13 to U14 and the U15 to U17 squads, significance was observed across all the tests (P<0.05). No such differences were observed between the U14 to U15 squads (P>0.05) excluding the 20 m sprint test (P=0.04).

Similar trends in height and weight were observed across the quartiles of each squad (Figure 2 & 3). Players born in Q1 appeared to be the tallest and heaviest in the U15 and U17 squads. Little difference was noted in height and weight between quartiles amongst the younger squads, with exception to the Q3 in the U12 squad.

CMJ height did not appear to show a specific trend (Figure 4), other than players born in the latter quartiles of the U14 to U17 squads appeared to produce higher scores. The U13 squad showed little variation in jump height across all quartiles tested. Overall, 10m and 20m sprint times appeared to follow similar patterns as can be seen in Figure 5 and 6. Players born in the Q4 of the U11 to U13 produced the slower times compared to those relatively older players. Results in the 505-agility test (Figure 7) mirrored the findings in the 10 and 20m sprint times. It was observed that those born in Q1 covered more distance in the Yo-Yo IR1 (Figure 8) in the U11, U12, U13 and U15 squads. There was also a lack of variation amongst the other quartiles in the above mentioned squads. As can be seen in Figure 9, players born in Q1 appeared to be more physically mature, within the U11, U14, U15 and U17 squads. Q1's in these squads appeared to be closer to PHV compared to the other quartiles.

Significant difference was observed between pre, circa and post groups ($P<0.01$). The circa and post group were greater in height and weight compared to the pre-group ($P<0.01$) (Table 5). Likewise, players in the post PHV group were statistically different in physical attributes compared to the circa group ($P<0.01$). Similarly, circa and post groups produced significantly better results across the performance testing compared to those pre PHV. Furthermore, significant differences were also witness between circa and post groups across 10m, 20m and Yo-Yo IR1 ($P=<0.05$), however no significant differences in 505 ($P=0.13$) and CMJ ($P=0.26$) were found.

Table 1. Participant characteristics (Mean ± SD) across the six chronological age groups

Squad	Age (years)	Height (cm)	Weight (kg)	APHV (years)	Maturity Offset (years)
U11 *(n=19)*	10.5±0.2	142.4±5.9	33.7±4.2	13.9±0.3	-3.4±0.3
U12 *(n=12)*	11.4±0.3	145.1±7.1	36.2±5.0	14.3±0.3	-2.8±0.4
U13 *(n=17)*	12.4±0.3	151.1±8.0*	41.1±6.7*	14.6±0.6*	-2.1±0.6*†
U14 *(n=14)*	13.4±0.3	160.9±9.8*†	48.3±7.7*	14.7±0.5*	-1.3±0.6*†
U15 *(n=15)*	14.6±0.2	171.1±10.3*†	59.4±10.7*†	14.7±0.7*	0.1±0.7*†
U17 *(n=16)*	15.9±0.5	179.5±4.6*†	70.6±6.7*†	14.5±0.5*	1.4±0.6*†
Total *(n=93)*	**13.0±1.9**	**158.1±15.7**	**48.7±15.1**	**14.4±0.6**	**-1.4±1.8**

* denotes significantly different from U11and U12; † denotes significantly different from the age group below. (P<0.05)

Table 2. Participant spread across quartile ranges

Squad	**Q1 (%)**	**Q2 (%)**	**Q3 (%)**	**Q4 (%)**
U11 *(n=19)*	12 (63.2)	3 (15.8)	3 (15.8)	1 (5.3)
U12 *(n=12)*	7 (58.3)	3 (25)	1 (8.3)	1 (8.3)
U13 *(n=17)*	9 (52.9)	4 (23.5)	1 (5.9)	3 (17.6)
U14 *(n=14)*	6 (42.9)	4 (28.6)	1 (7.1)	3 (21.4)
U15 *(n=15)*	9 (60)	4 (26.7)	2 (13.3)	0 (0)
U17 *(n=16)*	12 (70.6)	3 (17.6)	1 (5.9)	1 (5.9)
Academy Total *(n=93)*	**55 (58.5)**	**21 (22.3)**	**9 (9.6)**	**9 (9.6)**

Table 3. Participant spread across maturity status

Squad	**Pre PHV (<1 year) (%)**	**Circa PHV (±1 year) (%)**	**Post PHV (>1 year) (%)**
U11 *(n=19)*	19 (100)	0 (0)	0 (0)
U12 *(n=12)*	12 (100)	0 (0)	0 (0)
U13 *(n=17)*	16 (94.1)	1 (5.9)	0 (0)
U14 *(n=14)*	9 (64.3)	5 (35.7)	0 (0)
U15 *(n=15)*	1 (6.7)	14 (93.3)	0 (0)
U17 *(n=16)*	0 (0)	2 (12.5)	14 (87.5)
Academy Total *(n=93)*	**57 (61.3)**	**22 (23.7)**	**14 (15.1)**

Table 4. Participant physical performance scores in chronological age groupings

Squad	CMJ (cm)	10m (sec)	20m (sec)	505 (sec)	Yo-Yo IR1 (m)
U11 *(n=19)*	39.5±6.3	2.00±0.09	3.52±0.15	2.49±0.07	1035.8± 275.2
U12 *(n=12)*	39.6±4.3	1.96±0.06	3.44±0.09	2.47±0.08	1229.1±260.5*
U13 *(n=17)*	39.6±3.4	1.98±0.08	3.49±0.17	2.45±0.09	1376.5±392.2*
U14 *(n=14)*	45.7±4.6*†	1.90±0.08*†	3.29±0.13*†	2.34±0.10*†	1723.3±377.7*†
U15 *(n=15)*	47.2±5.0*	1.82±0.09*	3.16±0.15*†	2.28±0.06*	1626.7±332.5*
U17 *(n=16)*	51.0±4.2*†	1.73±0.06*†	2.99±0.09*†	2.22±0.07*†	1978.5±312.2*†
Average *(n=93)*	**43.5±6.5**	**1.90±0.12**	**3.33±0.24**	**2.38±0.13**	**1464.4±453.1**

* denotes significantly different from U11; † denotes significantly different between the age group below. (*P*<0.05)

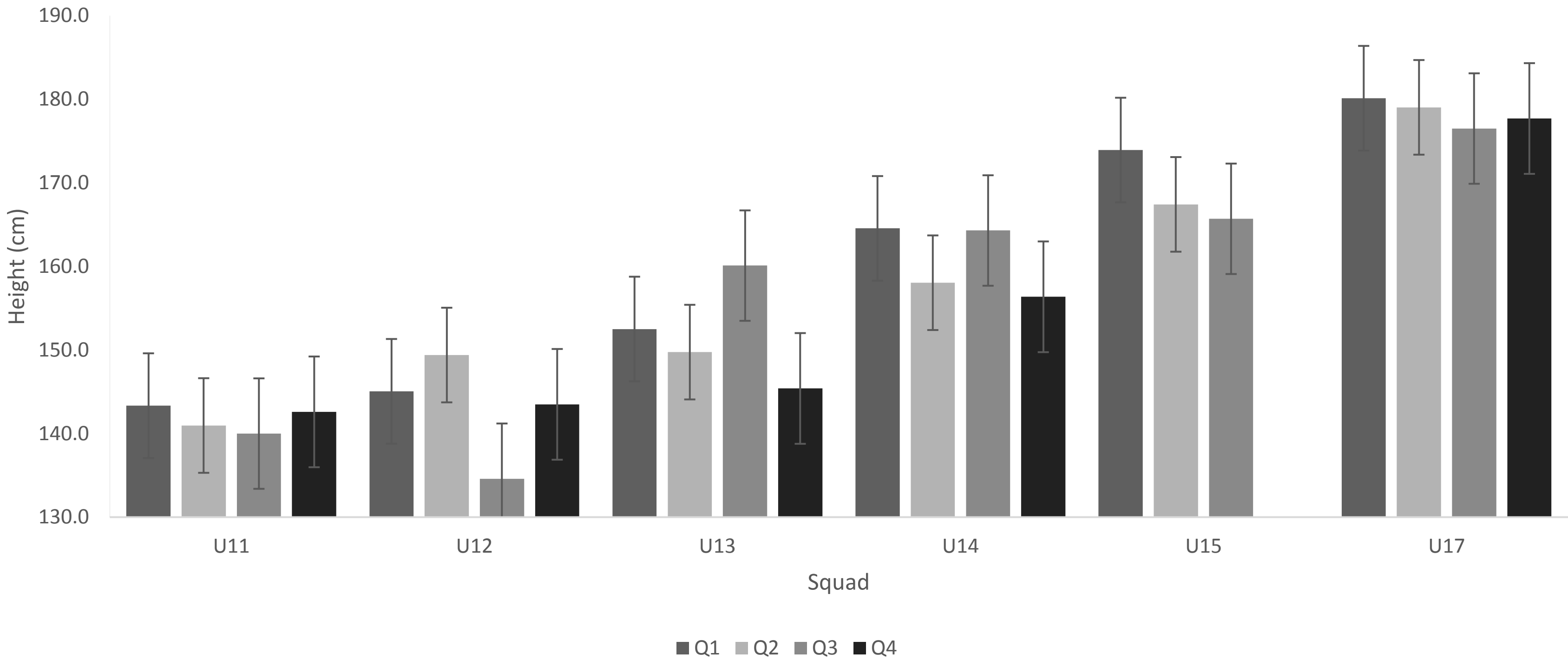

Figure 2. Mean height (centimetres) of each quartile across the squads

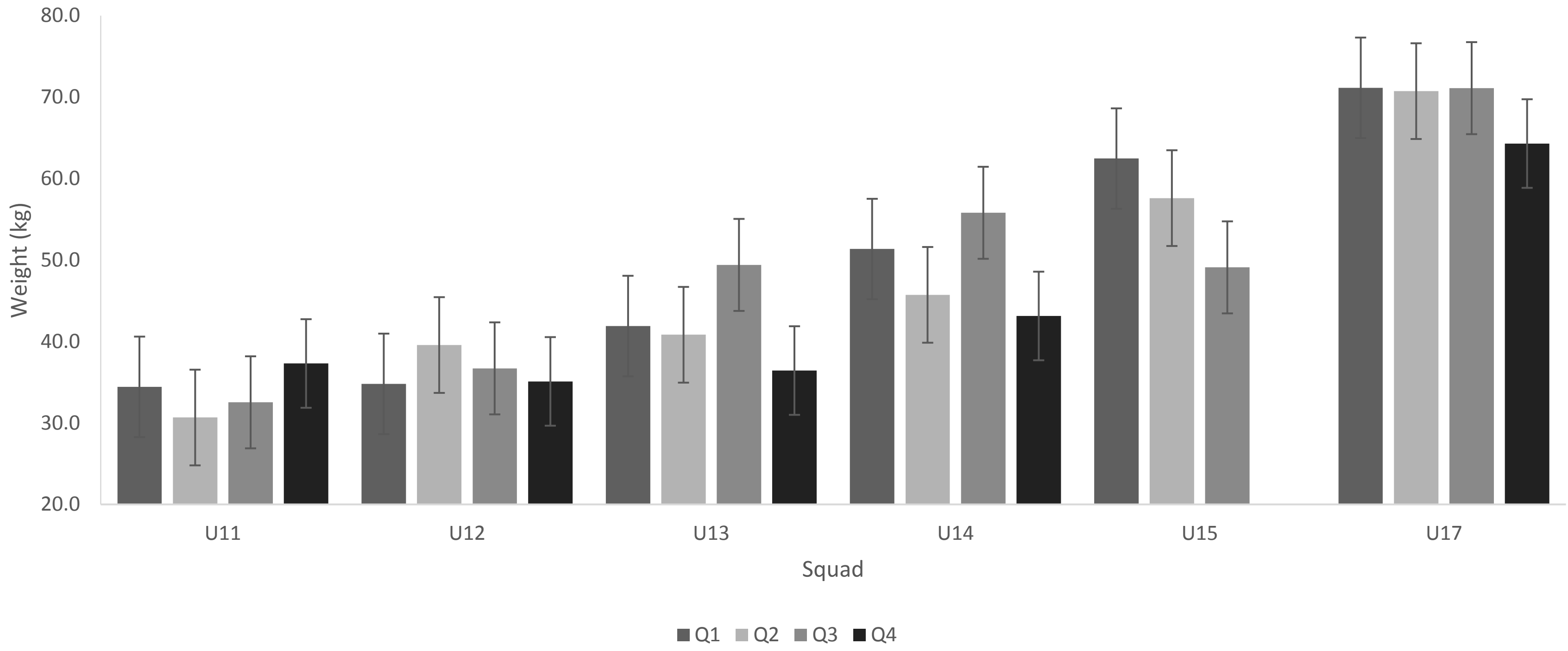

Figure 3. Mean weight (kilograms) of each quartile across the squads

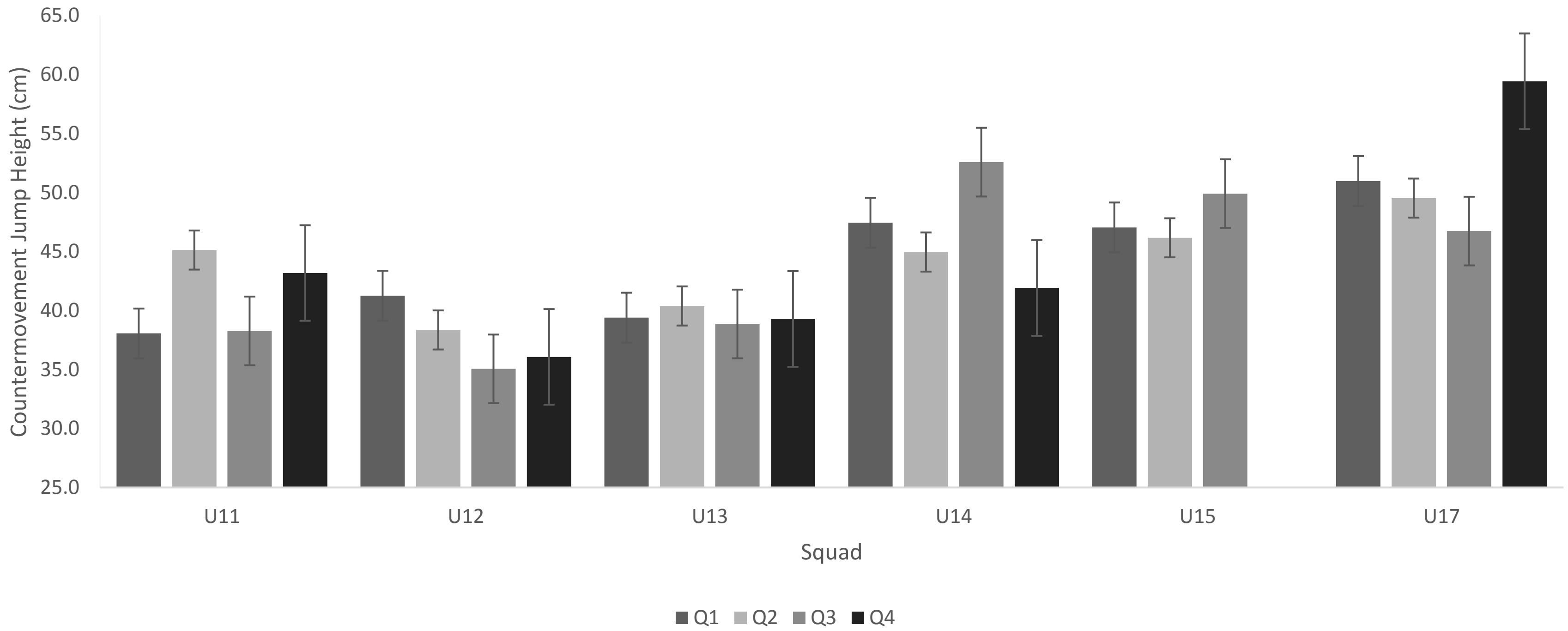

Figure 4. Mean countermovement jump height (centimetres) for each quartile across the squads

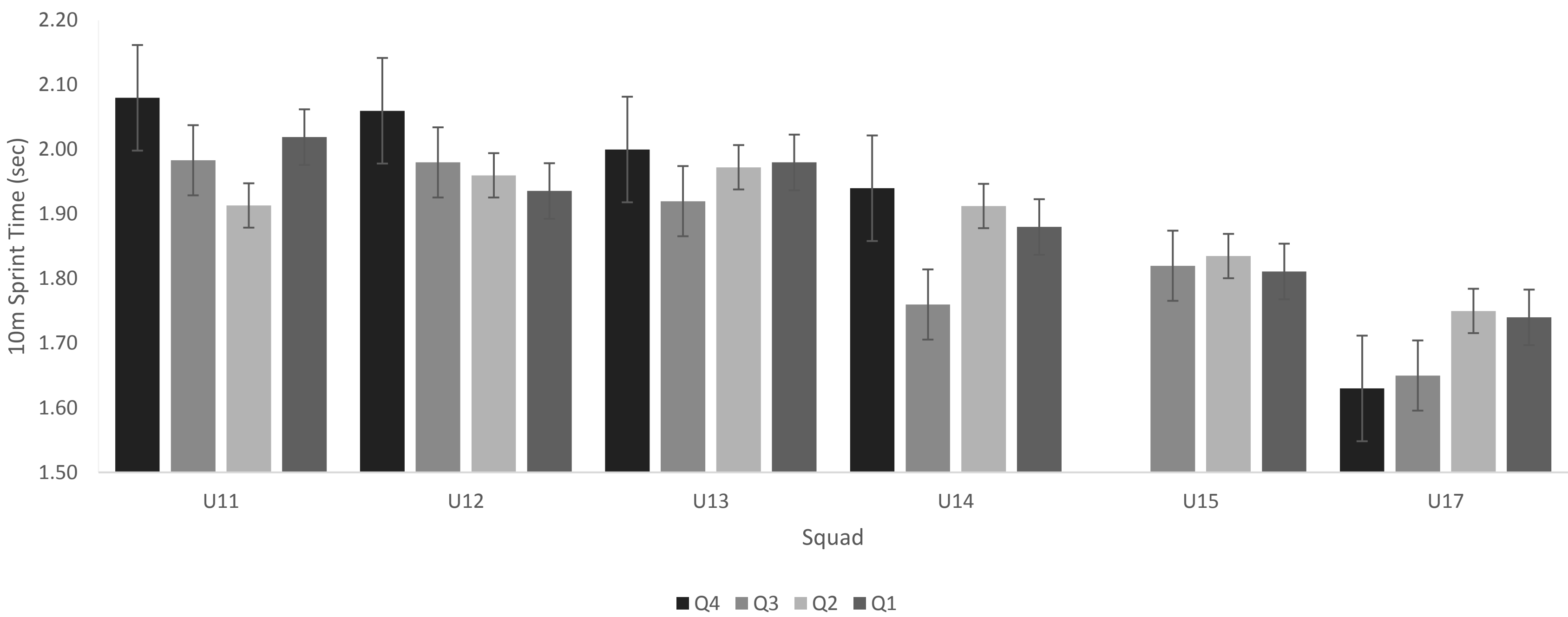

Figure 5. Mean 10 meter sprint time for each quartile across the squads

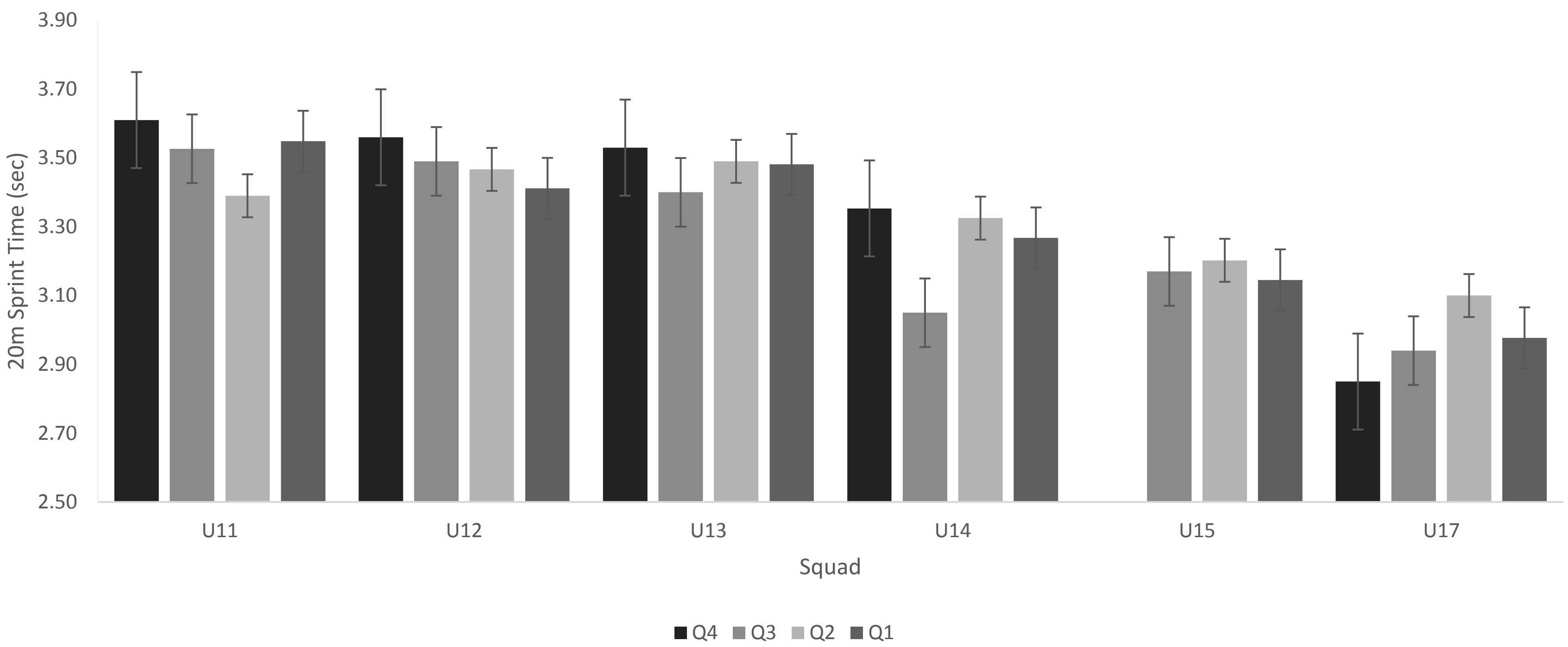

Figure 6. Mean 10 meter sprint time for each quartile across the squads

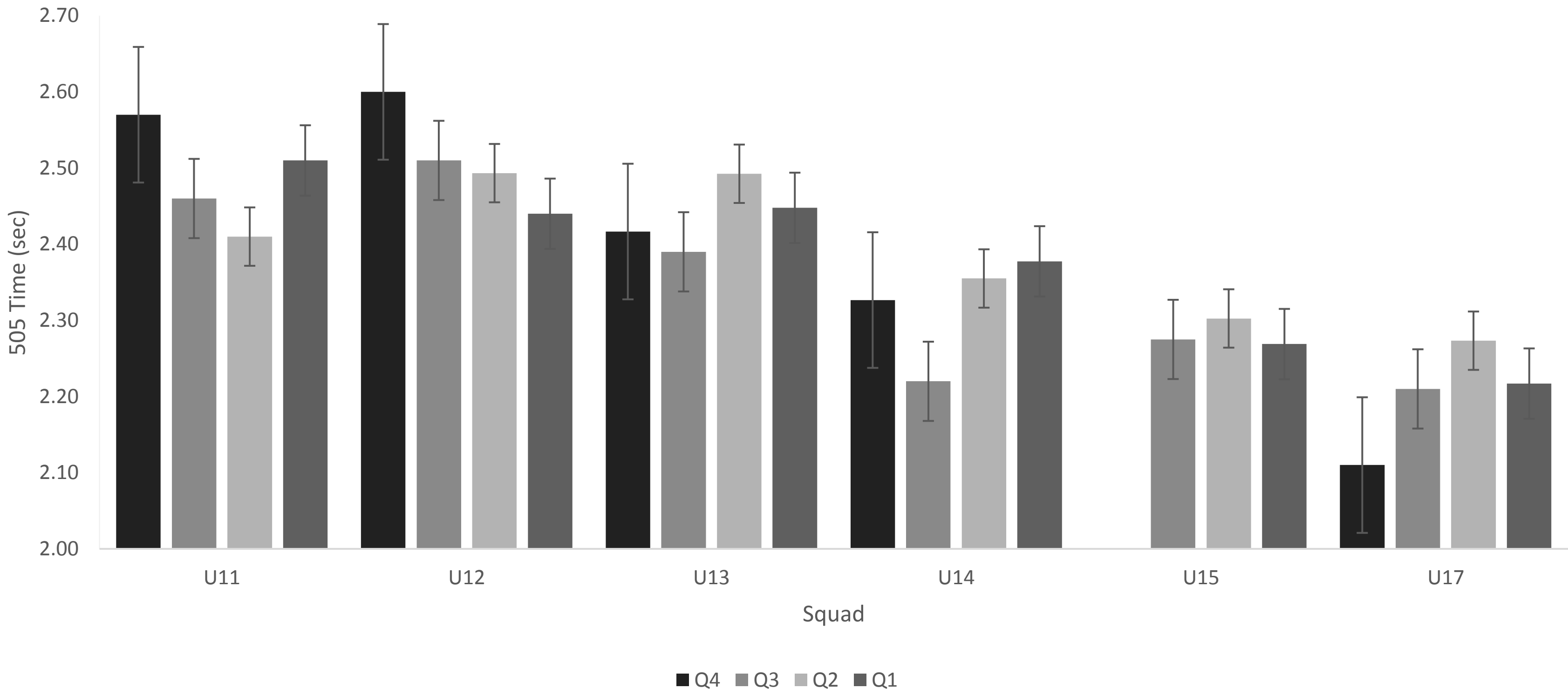

Figure 7. Mean 505 agility time for each quartile across the squads

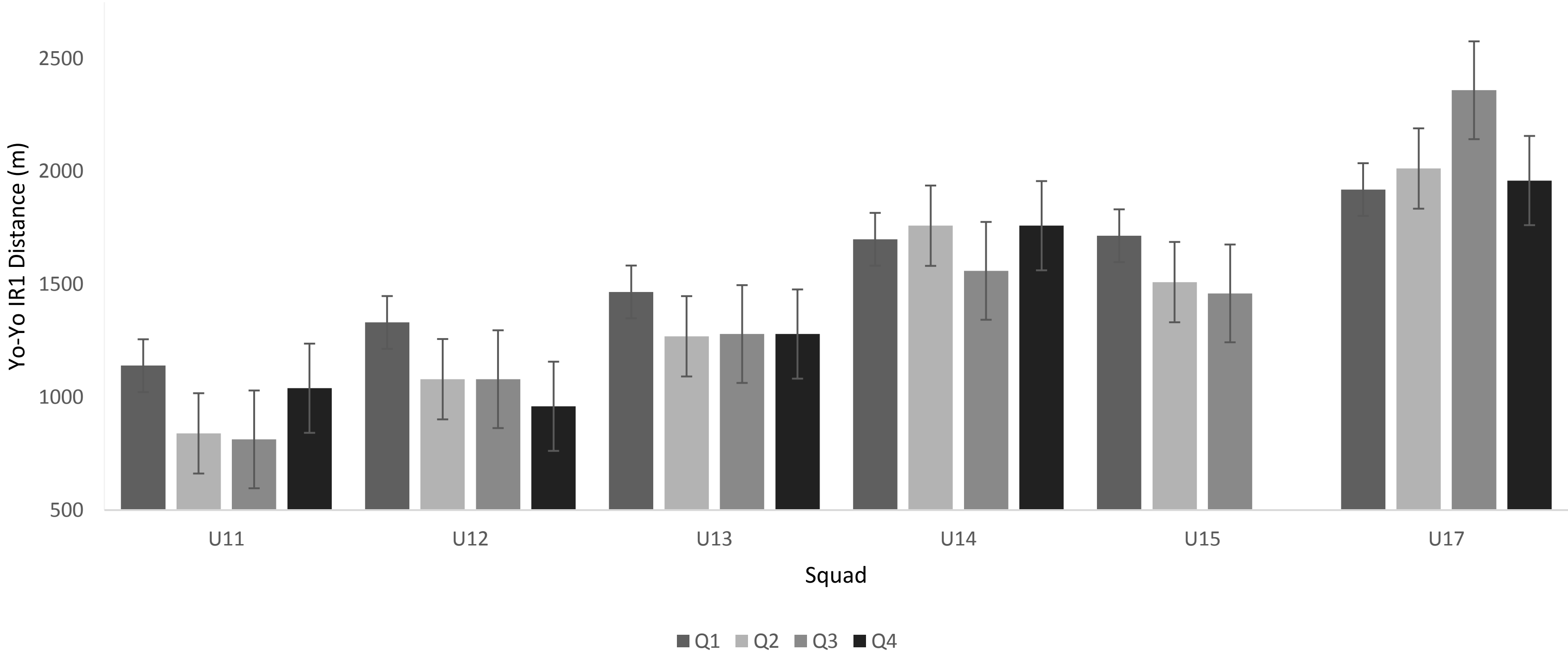

Figure 8. Mean Yo-Yo intermittent recovery level 1 in meters for each quartile across the squads

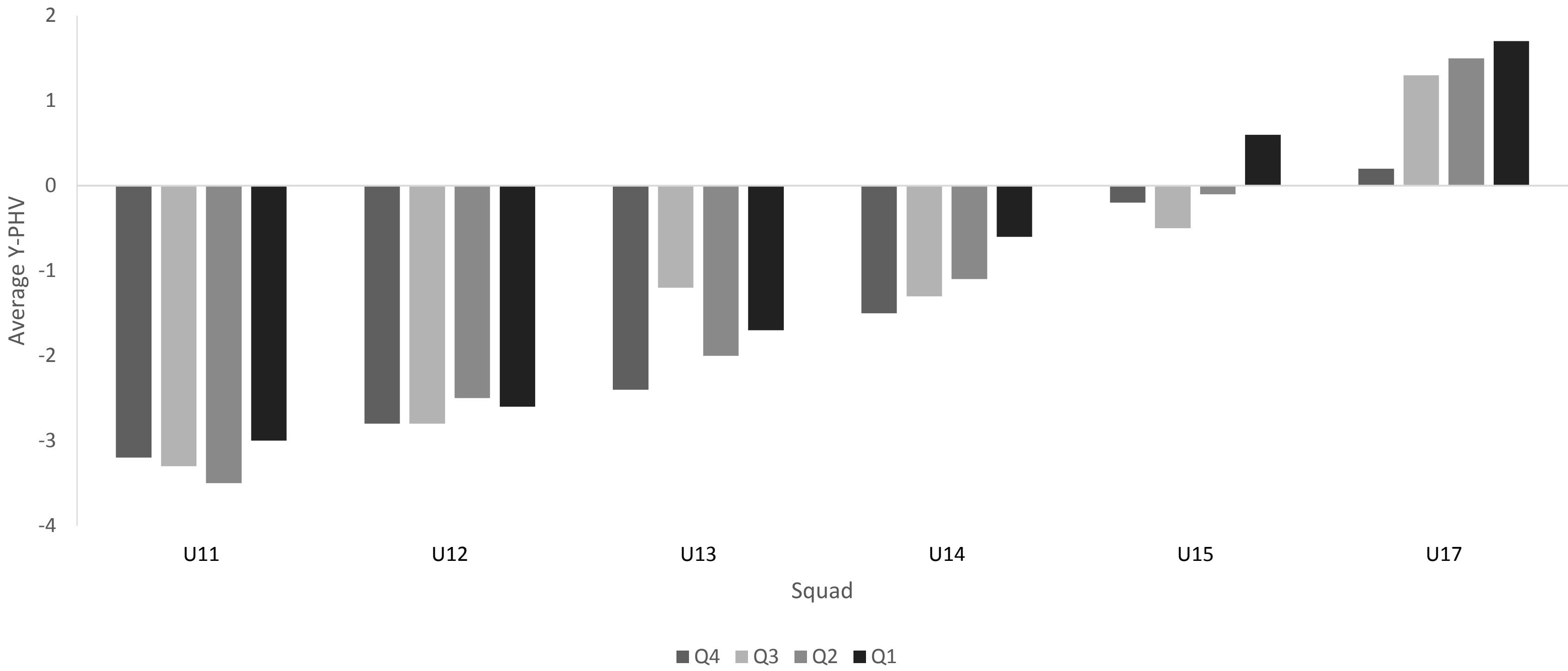

Figure 9. Mean years from PHV (-/+) across each quartile in each squad

Table 5. Participant physical and performance characteristics (Mean ± SD) across the 3 maturation age groups

Squad	Height	Weight	CMJ (cm)	10m (sec)	20m (sec)	505 (sec)	Yo-Yo IR1 (m)
Pre *(n=57)*	**147.1 ± 7.5†**	**33.7 ± 6.2†**	**40.3 ± 4.8†**	**1.97 ± 0.08†**	**3.47 ± 0.15†**	**2.45 ± 0.09†**	**1306.9 ± 390.7†**
Circa *(n=22)*	**172.8 ± 7.2**	**60.2 ± 8.7**	**47.6 ± 4.7**	**1.82 ± 0.07**	**3.16 ± 0.13**	**2.30 ± 0.09**	**1588.6 ± 442.4**
Post *(n=14)*	**179.8 ± 5.0*¤**	**71.1 ± 5.6*¤**	**50.7 ± 4.1¤**	**1.73 ± 0.06*¤**	**3.00 ± 0.09*¤**	**2.23 ± 0.06*¤**	**2014.6 ± 300.0*¤**

† denotes significantly different from the Pre-Circa (*P*=<0.05); * denotes significantly different from the Circa-Post (*P*=<0.05); ¤ denotes significantly different from the Pre-Post (*P*=<0.05)

DISCUSSION

The main findings of the present study were that firstly, performance across all testing variables was directly linked to age, with each age scoring higher/faster than their younger counterparts from the U11 squad up. Secondly, for stage of maturation a hierarchical order of Post-PHV>Circa-PHV>Pre-PHV was reported for all performance variables. Furthermore, a relative age effect was observed with 58% of players being born in Q1, and over 80% of total players born in Q1 and Q2 combined.

One of the aims of the study was to investigate whether differences existed in performance testing regarding chronological age and/or relative.

Research tells us that with as players undergo go sexual maturation they increase in size and mass (Malina et al., (2005), reflected within the results of this study. There was a significant difference found between squads' anthropometric measurements. The U11 displayed significant differences across height, weight, APHV and maturity offset compared to all squads bar the U12 (Table 1). The expected age for maturation has been noted between the ages of 13.8 to 14.2 years (Malina et al., 2004) which is where the largest observed difference in height is typically seen. This was the case in this study as the largest difference in height between age groups was was seen between the U14 to U15 squad ($P<0.01$). The players in this academy were found to be taller on average compared to some of their European counterparts, playing in Belgium (Vayens et al., (2006), Portugal (Malina et al., 2004), England (Reilly et al., 2000). They were found to be alike to players at an elite level at a club based in France (Carling et al., 2009).

The physiological demands of football are multifactorial (Stølen et al., 2005). The present study investigated measurements of physical performance, lower body power, sprinting speed, agility and endurance. The technical components of football, which fundamentally includes a player's physical fitness (speed, agility, explosive power) and motor (passing, dribbling, shooting) abilities, can enable coaches to differentiate between the standard players within a team (Williams et al., 2011). The neuromuscular performance of muscles, in regard to muscle recruitment and force production, have been shown to be similar action in vertical jumping and sprinting (Cormack et al., (2008). The increase in high intensity running that has been witnessed in the game over the last few seasons (Bradley et al., (2014) displays the importance of sprinting or ability to perform at high speed is important, therefore it is sensible to assess players ability to jump alongside sprinting performance.

The countermovement jump (CMJ), is a reliable measure and is relatively simple test to carry out. Despite the lack of variation between the U11, U12 and U13 squads (Table 4), the results do show significant difference as the squad age increases in CMJ height. The large difference in comparing those player in the U13 to U14 suggest that maturation may have an impact on player development.

Similar trends were witnessed across the 10m, 20m and 505 agility test scores, where the younger squads were significantly slower compared to those older squads. The only test that showed a progressive and significant difference across each squad was the Yo-Yo IR1 test, where each squad was able to cover more distance in the test than the squad younger. Previous literature has shown the importance for players to have an aerobic capacity. The majority of sfootball matches are decided by the high-intensity movements (Faude et al., (2012), players not only need the ability to reach these speeds, but the ability to repeatedly produce them when required without hindering their performance. Similar improvements in Yo-Yo IR1 performance across chronological age grouping were found by Deprez et al., (2012). A possible reason for this marked ability within the older squads could be down to older squads playing 90 minute games which aids the development of an aerobic capacity allowing players to run for longer before fatigue sets in.

Furthermore, as players get older, in theory they develop more efficient movement patterns, therefore older players and better adapt to changing direction more efficiently than younger players. Older players can also control their running speed which allows them to pace themselves better which could account to the difference in Yo-Yo scores.

Previous work has confirmed the worldwide presence of a RAE within youth football, so it was likely that it would be found within this Scottish academy also. The results indicate there is an over representation of players across the overall academy born in the first three months of the year (58.5%) than those born at the end of the year (9.6%) (Table 2). For the relative age effect to be confirmed, the age spread must be different to the of the population average. Players in this study were born between 1998-2004, when compared to the general population spread there was a clear relative age effect occurring. The birth-rate of the general population was found to be evenly spread at approximately 25% across each quartile of the birth year thus confirming the RAE within the academy.

RAE was effect was seen across all squads involved in the study, showing that even players as young as 10 and 11 born latter stages of the year were less likely to be selected into an elite youth set up. The only squads not to fully conform to the RAE were the U13 and U14, this is not surprising as you would expect to see a largest variation of physical maturity being around the PHV starts to occur. The RAE effect is stronger in youth football than the professional adult game. Research in German Bundesliga (Cobley (2008) and Belgian league (Vaeyens et al., (2006) respectively, found that the effect of the RAE decreases with increasing age. By the time youth players are up for selection for the senior level of the squad, differences in physical attributes have disappeared and players born in the latter part of the year have "caught up" physically with their peers at adult age (Mujika et al., (2009). This would suggest that the spread across the quartiles should be edging potentially towards a more equal distribution as the players get older. This isn't seen in this study with over 70% of U17's players were born within the first quartile (Table 2). Possible reasons for this could be that a lack of players within the latter quartiles had potentially not developed earlier than their counterparts and therefore had not remained in the academy system. Interestingly though, there doesn't appear to be a great difference in height in the U17 squad (Figure 1), which does suggest those born in the latter stages have caught up.

Another potential reason is a change in culture within football. Although the RAE has been researched for numerous years, the financial windfall that one promising young talented footballer can potentially bring to clubs these days mean academies are under growing pressure to scout the very best before their rivals do. In Scotland the earliest squad that players can be signed to in a professional academy is U11. This provides the first opportunity for scouts to spot and capture players the deem as talented, however they still mistake physical prowess as talent rather than their technical ability.

The study also investigated whether the club conformed to the typical relative age effects and how it related to performance. Typically, relatively older children usually have an advantage over their younger peers due to exhibiting advanced physical characteristics (Colbley et al. (2009), in the case of this study that does not conform to the traditional bias. Players born in the first quartile don't appear to always be the biggest in stature (Figure 1) when compared to those within their peer groupings which is not typically expected. Research by Deprez (2012) and Carling (2009) both found that on average Q1's tended to be larger than their younger counterparts. The Q1s were larger than the Q4's across the academy, which could be down to the low numbers in the last quartile due to them being physically less mature and were released before PHV occurred. Although there is an apparent relative age effect occurring at the club, the testing performance does not reflect this to a certain extent. There were no real noticeable differences in countermovement jump, 10 and 20m sprint and 505 between quartiles across all squads. This casts doubt on the hypothesis that relatively older players outperform those that are relatively younger. Figures 2 to 8 show that the players within those the first quartiles were not always the best performers. Players born in the latter squads were in some cases able to match if not better the performance of their teammates. It was noticed that these players tended not to differ greatly in physical stature compared to the rest of the squad, so it could be suggested they were early maturing which allowed them to physically compete with other members of the same squad. The only squad to show typical relative age testing performance were the U12s, where those players born in Q1 outperform the relatively younger counterparts across all the tests. When Q1's are compared to the Q4's they do outperform them across the age groups, excluding the U17s.

The study demonstrations the differences in anthropometry and performance when players were grouped according to their maturity status. Previous studies have group players into two groups based "more mature" or "less mature", however this study split players into 3 groups, pre (<1 year from PHV), circa (year to and from PHV) and post (>1 year from PHV). This allowed a greater insight into where within the academy, players were in terms of years to maturation. The use of the equation developed by Mirwald et al. (2002) was selected due to its practical application within a football setting and its high reliability (Mendez-Vallanueva et al. (2013). Physical performance markers of strength, speed and power usually develop and improve with maturation (Williams et al., (2011), Vayens et al., (2006), Buchheit et al., (2010). Players who were post-PHV were significantly taller and heavier than those circa and pre-PHV (Table 5). Similarly, players post-PHV produced faster sprint times in the 10m and 20m test, a greater change of direction ability resulted in quicker 505 agility times combined with an increased distanced covered in the Yo-Yo IR1. Equally similar significant differences (P=<0.05 for all) were noted between pre-PHV vs circa-PHV all anthropometric and physical tests, which shows more mature players do produce better scores in performance testing, tying into the notion that chronologically older players are more likely to be more physically mature than their younger counterparts.

A lack of a significant difference noted between the circa-PHV and post-PHV regarding the countermovement jump. Although there was a significant difference chronologically between the U15-U17 squads, whom made up the majority of the circa-PHV and post-PHV group (Table 3), it was hypothesised that the reason was in relation to the U15-U17 squads participated in specific strength and power-based gym sessions weekly. As previously mentioned the neuromuscular performance of muscles has been shown to be similar in vertical jump and sprinting so it would have been expected to potentially see the same differences reflected in the 10m and 20m sprint testing, however it wasn't the case. Therefore, it is difficult to say if the effect was purely down to a maturational effect or that they had gained this lower leg power from gym-based sessions. Other studies have investigated jump height within elite youth footballers, Reily et al., (2000), it was found the players jumped higher in tests of CMJ compared to the elite players within this academy. The players involved in the study were smaller on average which suggests they have an increased power to weight ratio which could account for the increased jump height.

However, knowing that maturation and maturity would appear to have a large influence on performance and selection. RAE is still very common across most football academies across the globe. The physical demands of playing football in some countries has allowed players who are physically advanced in maturity but not technically gifted as others, to remain within the system longer than smaller but technically advanced players.

It is difficult to draw conclusions about predicting performance from the data that was collected in this study. Although it is clear to see that as players get older there is an apparent increase in performance. Ideally the study would track players who produced the fastest sprints, highest jumps and covered the most distance at a young age (pre-PHV) and follow them through the following years up to post-PHV and see if they were still the best compared to the squad or if they produced test performances that were in line with the rest of the squad. It is important to note that due to the nature of football, that a good performance in physical testing does not equal to footballing ability. These abilities must also be combined with a technical proficiency, tactical awareness, psychological robustness, and fatigue resistance to attain high levels of success.

LIMITATIONS

A limitation to the study was the fact it was only carried out using a single seasons data, this therefore only allows a snapshot into what could potential occurring within the academy. At the time of writing there was only a small sample size of available data to use. One of the reasons was down to a variety of differing testing protocols being used within the club over past seasons. However, there is now potential to carry on a future study using the same testing protocol described within this study, which should hopefully allow the club a greater understanding into the potential effects that relative age and maturation on their players. Another major limitation in the study was down to the nature of the RAE. Low player numbers were reported across the latter quartiles (Q3-Q4) in squads. A longitudinal study would to be able to track certain players who are performing above those of a similar biological maturity, but due to the nature of football, testing performance does not always relate to an on-field performance and as a result there is no guarantee these players would remain in the system.

CONCLUSION

In conclusion the aim of this present study was to review the academies performance testing and assess whether they conformed to chronological and/or relative age effects, whilst also investigating the effects of maturation. In performing this analysis, the data tested whether relative age effects, although common, were necessarily part of elite team sports. From this, the aim was to try to provide the club with an appropriate strategy for predicting physical performance. From the results, the club do indeed conform to the typical trends found in a chronological grouping. Significant differences were found across all the anthropometric and performance markers of speed, lower body power, agility and endurance between the U11 and U17 squads. Although there did appear to be an apparent relative age effect within this study, the players investigated did not conform to the expected results. Relatively older players within each squad did not appear to differ compared to those relatively younger. The study did show that players post-PHV (i.e. mature) are significantly different to players pre-PHV and circa-PHV on most physical performance markers. In terms of prediction of performance, the study was unable to provide a clear insight, due to the data available. It would be suggested that clubs compared players in terms of maturation rather than relative or chronological age. As a result, there is the potential for the club to more effectively manage and protect relatively younger/less mature players, allow them to develop and reach their physical potential before releasing them based on height which was previously the norm. For this to occur there needs a change in the way coaches and scouts deliberate about players and focus on technical ability rather than physical competence.

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