PHD

Effects of growth and maturation on talent identification and selection in an elite youth football academy.

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Hill, Megan

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Effects of Growth and Maturation on Talent Identification and Selection in an Elite Youth Football Academy.

Megan Hill

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1. Hill, M., Scott, S., McGee, D., & Cumming, S.P. (2020). Coaches' Evaluations of Match Performance in Academy Soccer Players in Relation to the Adolescent Growth Spurt. *Journal of Science in Sport & Exercise.*
2. Hill, M., Spencer, A., McGee, D., Scott, S., Frame, M., & Cumming, S.P. (2020). The psychology of bio-banding: a Vygotskian perspective. *Annals of Human Biology, 47*(4), 328-335.
3. Hill, M., Scott, S., McGee, D., & Cumming, S.P., (2020), Are Relative Age and Biological Ages Associated with Coaches' Evaluations of Match Performance in Male Academy Soccer Players? *International Journal of Sports Science & Coaching.*

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Abstract

Talent identification and development pathways are confounded by relative age, adolescent growth, and biological maturation, where chronologically and biologically older players are provided with an advantage. While increases in size and improvements in speed, strength and power are advantageous for youth football players, the growth spurt can also increase injury risk and adversely affect motor coordination. Adolescence therefore presents a unique challenge for youth athletes and their coaches.

This thesis investigates how adolescent growth and maturation affects male youth academy football players and their coaches. Both quantitative and qualitative approaches are used to explore how coaches perceive, experience, and evaluate adolescent players. Coaches evaluations of players' match performances were significantly predicted by biological age in some age groups, where advanced maturity predicted a higher grade; however, chronological age did not significantly predict coaches match grades (study one). The adolescent growth spurt also influenced coaches' evaluations of performance, with grades declining from pre- to during- growth spurt, before increasing again post-growth spurt (study two).

These findings were advanced further by a mixed-methods longitudinal design, tracking adolescent boys and their respective coaches for 12 months to understand how coaches experience, perceive and manage growing and developing adolescent players (study three). Coaches perceived and described the adolescent growth spurt as problematic, with many players described as struggling with various signs and symptoms. Perceptions and expectations of players also differed by biological maturity status, where early maturing players were portrayed as physically dominant and provided greater opportunities for teams to win games, thus, coaches expectations were greater. Later maturing players, although technically and tactically advanced, had little impact on matches, thus, coaches explained it was harder for later maturing players to remain within the system. Finally, the competitive nature of the academy system further exacerbated the implications of adolescent growth and maturation within youth football; the importance of winning games influenced coaches' evaluations, game time, and selection opportunities.

The complexity of managing adolescent athletes was highlighted within this thesis. Further research and education within talent pathways are required to reduce biases associated with individual differences in biological maturity and the growth spurt.

List of Abbreviations:

AIC	Akaike Information Criterion
ASM	Athletic Skills Model
CIES	International Centre for Sports Studies
CPD	Continuing Professional Development
DBS	Disclosure and Barring Service
EM	Early Maturation
EPPP	Elite Player Performance Plan
EPL	English Premier League
FDP	Foundation Phase
GPS	Global Positioning System
LM	Late Maturation
LTAD	Long Term Athlete Development Model
NGB	National Governing Body
PHV	Peak Height Velocity
PWV	Peak Weight Velocity
PAH	Predicted Adult Height
PMA	Premier League's Performance Management Application
PDP	Professional Development Phase
RAE	Relative Age Effect
S&C	Strength and Conditioning
YDP	Youth Development Phase
YPD	Youth Physical Development Model

Introduction

Soccer is played by 21.5 million youth across the world (Rommers et al., 2019a). In England, the game is known as football, and is undoubtedly the highest participation team sport, with 2.49 million boys aged between five- and 15-years old participating (The Football Association, 2015). Within this group, around 10,000 boys are identified and recruited into professional football academies, with the aim of reaching the highest level of the game (Patel, Nevill, Cloak, Smith & Wyon, 2019). From as young as five years of age, players are recruited into highly competitive academies (Platts, 2012). Each year 1000 players are offered a contract within a professional academy between the ages of nine and 16 years of age (Platts, 2012), but of this very few attain a professional contract; Research suggests less than 1% of academy football players end up playing football for a living (Dowling, Reeves, Littlewood, Netsi & Richardson, 2018). Furthermore, in 2011, the English Premier League (EPL) was identified as having the second lowest number of home-grown players of the 'big five' leagues (EPL, Bundesliga, French Ligue, La Liga and Serie A) (Littlewood, Mullen & Richardson, 2011). Notions that English football academies were failing caused the EPL to address the shortcomings of football academies.

In 2012, the EPL introduced the Elite Player Performance Plan (EPPP), a new long-term strategy for elite youth development within the sport. The strategy was implemented to raise the standard of youth development and aid the transition of youth players to the highest level within English Football (Ames, 2017). Designed to provide holistic development, the programme promotes a player-led approach (Premier League, n.d.) while developing the four corners of the Football Associations curriculum; Physical, technical, social and psychological development (The Football Association, 2020). The aim of the EPPP is therefore, to create an effective and efficient talent identification programme to better recruit, develop and transition athletes through the programme into first team and International football (Premier League, 2012; Dowling et al., 2018).

The globalisation of football further encourages football academies to better identify and develop young players in return for financial rewards (Sarmento, Teresa Anguera, Pereira, & Araújo, 2018). Today, the game is characterised by the inflation of players wages, transfer fees, and the frequent movement of players across teams and leagues; thus, a football club's capacity to identify and develop players may guarantee a club's sporting and financial success (Sarmento et al., 2018; Williams & Reilly, 2000). Identifying young players with the potential to become elite and providing those players

with the most appropriate environment to fulfil this potential, has recently become a prominent issue in youth football (Williams & Reilly, 2000; Unnithan, White, Georgiou, Iga, & Drust, 2012; Sarmento et al., 2018). In England, a highly established footballing nation, there are high participation rates, a large talent pool and considerable financial and logistical resources to create an effective talent pathway (Bennett, Vaeyens & Fransen, 2019). Research shows however, a thinning supply of English youth players (Sagar, Busch & Jowett, 2010; Conn, 2017) and consequently, the interest and development of talent identification pathways have expanded (Williams & Reilly, 2000; Stratton, Reilly, Richardson & Williams, 2004; Unnithan et al., 2012; Sarmento et al., 2018).

Talent identification and development pathways are challenging and complex by nature; confounded on a global and individual level; by factors such as population size, talent pool, financial and logistical resources and coaching biases, location effects, the relative age effect (RAE) and individual differences in biological maturation respectively (Bennett et al., 2019). In the past, talent identification employed a solely subjective approach, where coaches and scouts used their personal opinion and assessment of players (Christensen, 2009; Day, 2011). Research suggests, however, subjective approaches to talent identification leads to inconsistencies and misjudgements (Williams & Reilly, 2000; Meylan, Cronin, Oliver & Hughes, 2010). Subsequently, there has been a push for talent identification and development pathways to use a science-based holistic system (Williams & Reilly, 2000; Vaeyens, Lenoir, Williams & Philippaerts, 2008), such as the EPPP. Common measures and indicators of potential within talent identification systems include anthropometrics, physiological factors, psychological characteristics, technical skills, and training history (Williams & Reilly, 2000; Meylan et al., 2010; Unnithan et al., 2012). Many of these factors, however, are influenced greatly by relative age and individual differences in biological maturity (Malina, Bouchard & Bar-Or, 2004a; Malina, Silva, Figueiredo, Carling & Beunen, 2012; Cumming, Lloyd, Oliver, Eisenmann, & Malina, 2017a; Johnson, Farooq & Whiteley, 2017).

Relative age and individual differences in biological maturity have been shown to independently impact player selection and performance in youth sport (Malina, Rogol, Cumming, Silva, & Figueiredo, 2015; Meylan et al., 2010; Sierra-Diaz, Gonzalez-Villora, Pastor-Vicedo, & Serra-Olivares, 2017). In youth football, like many sports, children are grouped according to chronological age with September 1st to August 31st being the cut-off dates each year; the difference in age between players in an age-group, limited to 12

months, is a concept known as relative age (Musch and Grondin, 2001). This difference in chronological age between two players born either end of the cut-off dates can result in differences in age-related experiences and development (Ward & Williams, 2003; Helsen, Van Winckel & Williams, 2005). Consequently, a considerable body of objective research shows an over-representation of players born at the start of the year begins in childhood and continues into adolescence (Helsen, Starkes & Van Winckel, 1998; Votteler & Honer, 2014; Sierra-Diaz et al., 2017).

Youth talent pathways are also challenged by individual differences in biological maturity (Malina et al., 2015; Cumming et al., 2017a). Biological maturation refers to the process of progression towards the mature state, defined in terms of status, timing and tempo, which is determined primarily by genetics (Malina et al., 2004a). Players of the same chronological age can vary greatly in terms of the timing and rate at which they develop and mature physically (Malina et al., 2015); which at the extremes has been shown to be as much as six years difference in biological age between two nine year old boys (Johnson, 2015). Research shows early maturing boys are more likely to be selected in youth football academies from early adolescence, around 11 years of age, aligned with the physical and athletic advantages gained in puberty (size, strength, speed, power) (Figueiredo, Goncalves, Silva & Malina, 2009a; Meylan et al., 2010; Johnson et al., 2017). In youth football, quantitative research shows there is a clear selection bias towards both chronologically older and biologically older players (Meylan et al., 2010; Johnson et al., 2017; Hill, Scott, Malina, McGee & Cumming, 2019), however, little research has explored why these biases continue to exist within talent pathways.

Globally, numerous football academies are trying to tackle the selection biases associated with relative age and biological maturity (Meylan et al., 2010; Mann & van Ginneken, 2017; Zuber, Zibung & Conzelmann, 2016), with football leading the way for other sports in this area (Cumming, 2018). However, famous cases often hit the headlines showing mistakes are still being made in relation to growth, maturation, and talent identification. Former England under-16 coach Kenny Swain suggested the FA believed they were "wasting time" on Marcus Rashford, as "…there were always question marks at the FA at the size of him" (Bate, 2016). Rashford is just one of many late maturing players who have been overlooked in talent identification systems; Kevin De Bruyne, Jesse Lingard and Harry Kane are other examples who struggled in their youth due to their delayed maturity, highlighting how maturation can confound talent identification (Bate, 2016; Doward, 2015). These famous cases represent a minority of late maturing

players who managed to remain in the system, and so many more players may have been excluded. Thus, more research, understanding and strategies are required to better identify and develop youth athletes.

The EPL and their EPPP initiative aims to better identify and develop youth footballers by educating, assessing, and monitoring adolescent growth and maturation (Lansley, 2016; Cumming, 2018). The strategy incorporates an extensive games programme, a series of battery physical performance tests, education, injury surveillance, and growth and maturation screening (Premier League, n.d.). The collection and assessment of this type of data has allowed the effects of maturation in youth footballers to be further explored through variables such as match running performance (Buchheit & Mendez-Villanueva, 2014; Gastin & Bennett, 2014), functional capacities (Malina, Eisenmann, Cumming, Ribeiro, & Aroso, 2004b; Vandendriessche et al., 2012), injury (Kemper et al., 2015; Wik et al., 2020) and selection biases (Johnson et al., 2017; Hill et al., 2019).

Academies within the EPPP are able to identify and recognise maturity status and determine specific stages of development such as the adolescent growth spurt (Ryan et al., 2018). The adolescent growth spurt, a rapid increase in stature occurring in all healthy adolescents around 14 years of age in boys, is also worthy of research and understanding (Malina et al., 2004a). There is a body of literature describing a period of adolescent awkwardness (Beunen & Malina, 1988; Quatman-Yates, Quatman, Meszaros, Paterno & Hewett, 2012), a peak increase in injury incidence (Read et al., 2018; Teunissen et al., 2020) and peak development of many physiological and functional attributes (Malina, Cumming, Morano, Barron & Miller, 2005; Philippaerts et al. 2006) aligned with the adolescent growth spurt. It is thus best practice to identify and adjust training load around the adolescent growth spurt to safeguard players from injury (Johnson, 2015; Lloyd & Oliver, 2012; Horobeanu, Jones & Johnson, 2017). However, the extent to which football academies understand, monitor, and adjust for the adolescent growth spurt is unknown.

Identifying and developing adolescent athletes is therefore a challenging task for any talent identification and development pathway. Youth scouts and coaches have to be aware of selection biases associated with individual differences in biological maturity and the relative age effect (RAE). Further, coaches need to understand and monitor the adolescent growth spurt in their players, where within one chronological age group, players may span pre-, during- and post-growth spurt (Johnson, 2015; Buchheit & Mendez-Villanueva 2014).

The importance of monitoring growth and maturation in adolescence is exacerbated by the increasing demands and competitiveness of the game. Around the pubertal phase, the game format changes; there is a shift from small-sided games to the adult format, where the pitch, ball and goal sizes increase, and the intensity and level of training and competition increases (Teunissen et al., 2020). Alongside this increasing intensity, talent selection decisions occur at 12, 14 and 16, where maturity associated differences in size and function are at their greatest, and the majority of players will experience their adolescent growth spurt (Malina et al., 2004a; Mills, Butt, Maynard, & Harwood, 2012). Understanding growth and maturity within talent identification pathways is vital in ensuring no athlete is overlooked, or equally, selected, for attributes in adolescence that will be attenuated in adulthood (Cumming et al., 2017a; Johnson et al., 2017). Youth coaches and talent selectors are therefore uniquely challenged, and little research has explored how they navigate and manage adolescence within football academies.

Although research recommends multidisciplinary approaches to talent identification and development, many talent pathways and academies still rely upon coaches' subjective evaluations (Christensen, 2009; Larkin & Reeves, 2018; Sieghartsleitner, Zuber, Zibung, & Conzelmann, 2019). While coaches' assessments are highly subjective, they are inherently holistic; a coach can integrate information on various factors and assess the player as a whole, such as technical skill, psychological ability, and familial support (Sieghartsleitner et al., 2019). The ability and expertise of a coach to integrate variables in their assessments means coaches evaluations show high prognostic validity, whereby coaches' assessments of players' game performance have been shown to be a strong predictor of later success in football (Zuber & Conzelmann, 2014; Sieghartsleitner et al., 2019). However, coaches' talent identification and evaluations can be swayed by personal feelings, intuition, and experiences (Lund & Soderstrom, 2017). How growth and maturation influences youth coaches' experiences and evaluations is relatively unknown, however. When the success of youth players reaching the next level of the game depends so heavily on a coach's assessment (Sieghartsleitner et al., 2019), it is important to understand how growth and maturation influence coaches' evaluations. This thesis aims to fill this gap in the literature around coach's knowledge, experiences and management of growth and maturation.

While existing research shows relative age and maturity associated selection biases for selection into talent pathways (Johnson et al., 2017; Hill et al., 2019), research

has yet to explore how relative age and individual differences in biological maturity impact players selected inside talent pathways. The original contribution of this thesis is to further understand how relative age and adolescent growth and maturation impact male youth academy football players. More specifically, it seeks to explore how youth academy coaches experience, perceive, evaluate, and understand this complex adolescent phase.

To understand the effects of growth and maturation within youth football academies, a biocultural approach is required. A biocultural approach considers the interactions of the biological and societal demands placed upon the growing and maturing individual; whereby the changes associated with puberty occur within a cultural context, both directly and indirectly affecting the individual (Malina et al., 2004a; Cumming et al., 2012; Mitchell, 2018). An integrative biocultural model takes into consideration sociocultural, biological, and environmental data (McElroy, 1990; Mitchell, 2018). In the case of this thesis, where the context is academy football, biological data may include data pertaining to growth and maturation status, sociocultural data may include coaches perceptions of players body and talent, and environmental data may consider the culture of academy football. This thesis therefore takes an interdisciplinary approach, to provide a more holistic understanding of how growth and maturation affects academy football players and their coaches. Combining both qualitative and quantitative measures over a series of studies, this body of work aims to further understanding of how adolescence, growth, and maturation impacts academy football and talent pathways.

The aim of this thesis is to understand the influence of growth and maturation on coaches' evaluations, perceptions, and management of male youth players within a professional football academy. More specifically, this thesis intended to add the coach's experiences and perceptions of adolescence, growth, and maturation to the literature. Utilising a mixed methods approach, this thesis aims to explore coaches' perceptions, evaluations, and experiences. Written in an alternative format, this thesis combines both published journal papers and traditional thesis chapters in order to best answer the research question: How does growth and maturation affect young players and their coaches within an elite youth football academy.

Chapter One: Literature Review:

Section 1: Puberty and Adolescence:

Puberty and adolescence are not the same. The definition of puberty is the period of rapid change leading to physical and reproductive maturation (Petersen & Taylor, 1980). In biology, puberty would be defined as a relatively short-term physiological event, comprising of the process of physical changes indicating the beginning of adolescence (Bogin, 2011). The physical developments during puberty such as changes in body shape and size, attainment of reproductive capacity and development of secondary sexual characteristics are triggered by hormonal changes (Tanner, 1962; Sugar, 1993). The onset of these complex changes is known as the process of adolescence (Blakemore, Burnett & Dahl, 2010). Adolescence is a much longer stage of the life cycle; it is marked by the onset of puberty until the onset of adulthood, comprising of physical, cognitive, and social maturation (Blakemore et al., 2010; Bogin, 2011).

To discuss the context of biological maturation and athletic performance, it is essential to first define and outline growth, maturation, and development. For humans to progress from conception to adulthood, puberty, growth, maturation, and development are essential processes. Although the terms growth, development and maturation are often used interchangeably, they refer to specific aspects of ontogenesis (Cameron, 2014). These processes have been systematically studied in a number of different disciplines for many years including anthropology, medicine, and more recently sport and exercise science (Malina et al., 2004a). This chapter will focus on the definition, measurement and importance of understanding puberty, growth, maturation, and development.

Growth:

Growth is a structural concept of the increasing size of the bodies' parts and as a whole. It is also the dominant biological activity for the first two decades of human life (Stratton et al., 2004; Malina et al., 2004a; Cameron and Bogin, 2012). Growth comes as a result of three underlying biological processes: hyperplasia, an increase in cell number, hypertrophy, an increase in cell size, and accretion, an increase in intracellular substances (Malina et al., 2004a).

Patterns of human growth are only understood because of previous longitudinal studies in which serial anthropometric measurements have been taken from children

(Sanders et al., 2017). Georges-Louis Leclerc, Compte de Buffon (1707-1788) published the growth of his friend's son, known simply as "De Montbeillard's son". Height measurements were taken around every six months from the boy's birth until he was 18 years old (1759-1777). The measurements were recorded in pieds, pouces, and lignes, the French units of the time, which correspond to approximately the present day's measure of a foot, an inch and the 12^{th} part of an inch respectively (Cameron & Bogin, 2012). In 1930, Richard Scammon published "the first seriatim study of human growth" using the measurements of De Montbeillards son reported in centimetres (Scammon, 1927). Compte de Buffon and Scammon's seminal work provide the starting point of postnatal growth research.

The first time human growth was presented in the form of a chart was accomplished by Scammon, by plotting the height achieved by De Montbeillards son at a number of ages, and subsequently joining the data points together (Scammon, 1927). This became known as the "height for age" or "height distance" curve (Cameron & Bogin, 2012) (Figure 1).

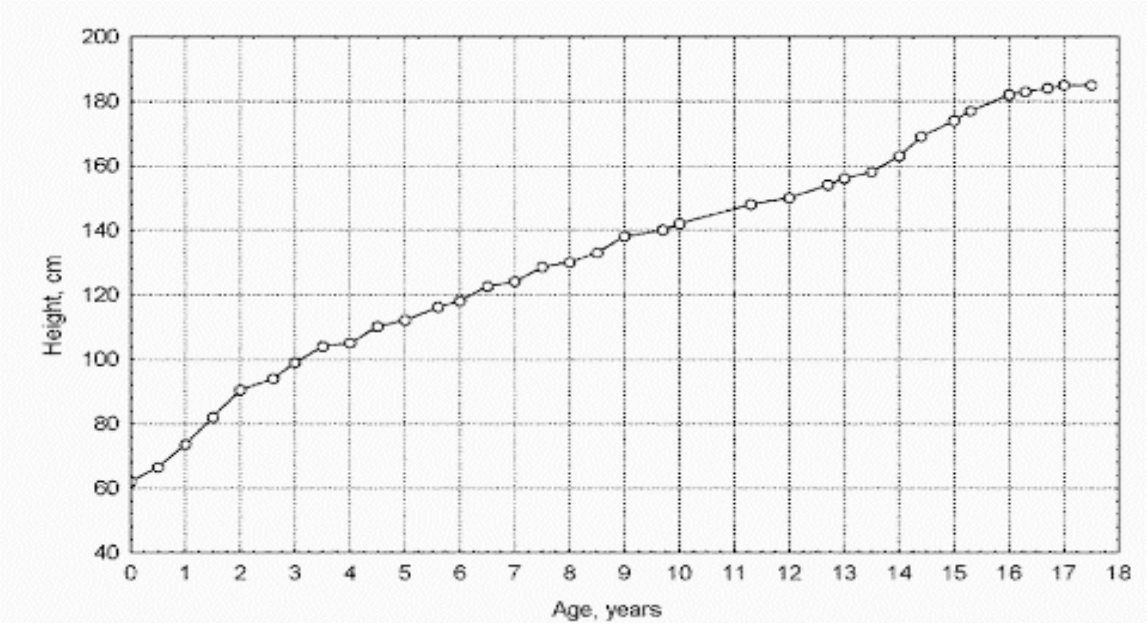

Figure 1: Height distance graph of De Montbeillard's son 1759-1777 (Source: Tanner 1962; Cameron & Bogin, 2012)

The resultant curve of De Montbeillards son (and any individual measured at intervals of six months or more), provides important information regarding human growth. The curve appears to be smooth, continuous, however not linear, and can be divided up into four phases (Cameron & Bogin, 2012). Infancy, the first phase, is characterised by rapid but deaccelerating growth, where children's heights can cross numerous growth percentiles as they grow. When an individual is in the childhood phase of growth they present a constant steady growth rate of five to seven centimetres per year, which tends to run parallel to percentiles, rather than cross them. The pubertal phase (the stage most relevant to this thesis) is characterised by rapid growth in the adolescent growth spurt of around eight to 14 centimetres per year. This is also the phase where timing, tempo and duration are most variable (Malina et al., 2004a). The fourth and final phase is characterised by very slow growth as individuals near adulthood. Although the majority of growth (more than 80%) occurs during infancy and childhood, the adolescent period is associated with being the most important in terms of physical changes (Cameron & Bogin, 2012).

As well as height for age curves, height data can be used to assess the rate of change in size creating "height velocity" curves (Tanner, 1951; Cameron & Bogin, 2012) (Figure 2 and 3). The curve requires age and height gained in centimetres per year. The resultant velocity curve reveals two distinct increases in growth rate or "growth spurts", the juvenile or mid-growth spurt occurring at age six to eight years, and the adolescent growth spurt occurring at 11-18 years (Cameron & Bogin, 2012). The juvenile growth spurt tends to occur around the same age, both within and between boys and girls, however, varies in magnitude. As with the juvenile growth spurt, the adolescent growth spurt also varies in magnitude, but also timing within and between the sexes. Boys have a slightly greater magnitude of adolescent growth spurt and enter this around two years later than girls, resulting in greater height (Malina et al., 2004a).

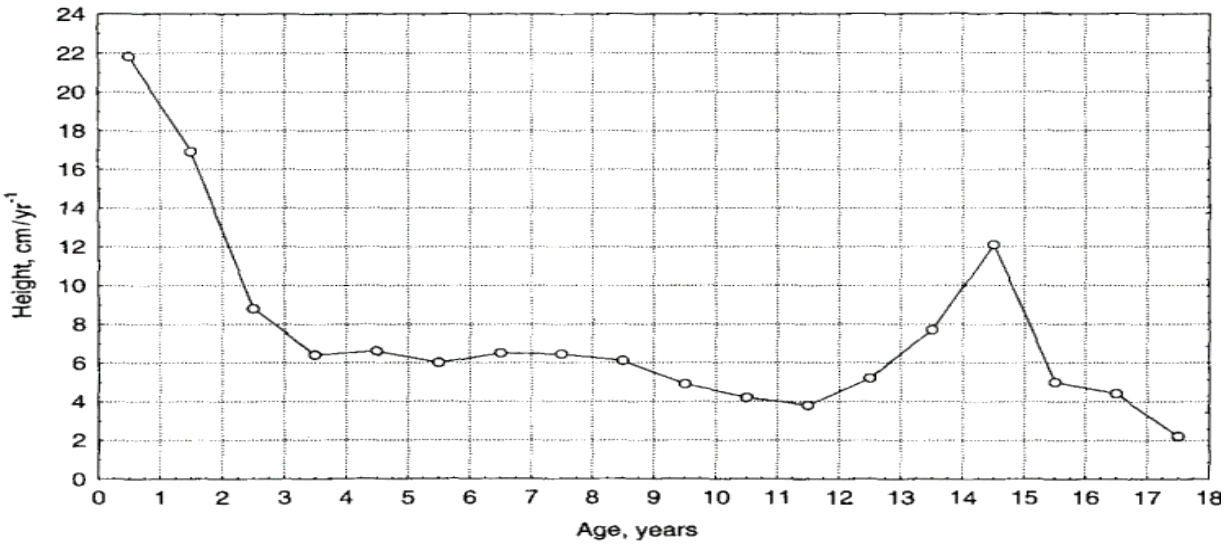

Figure 2: Velocity graph of De Montbeillard's son 1759-1777 (Source: Tanner, 1962; Cameron & Bogin, 2012)

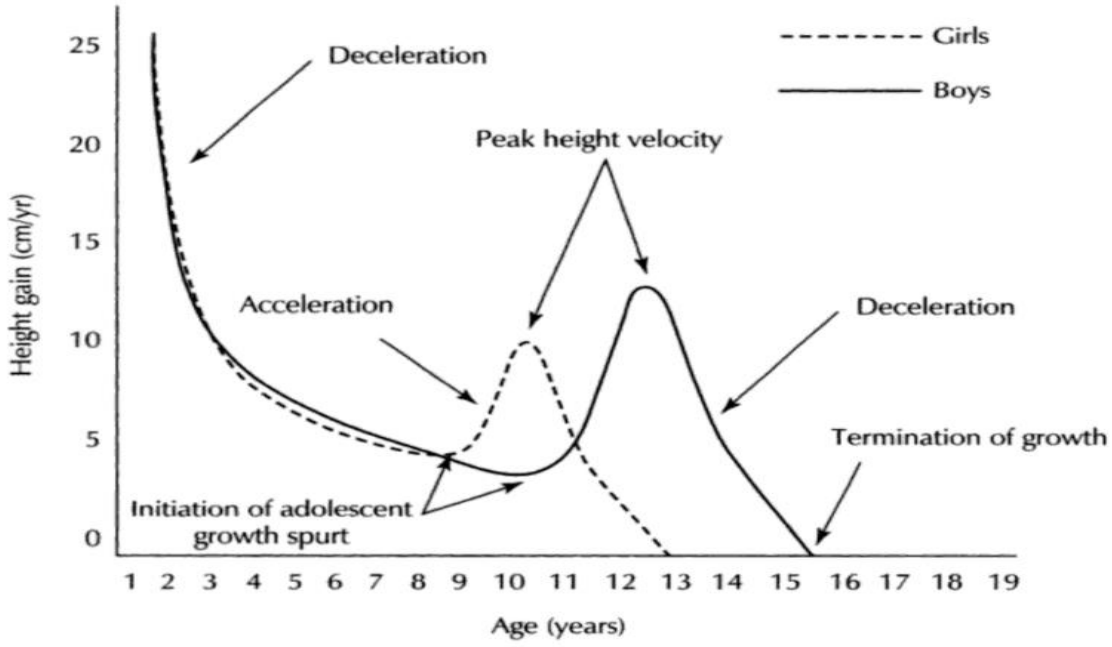

Figure 3: Height velocity curve for girls and boys (Source: Stratton et al., 2004)

Although this thesis focuses on general growth, it is of importance to be aware of the different growth of other tissues in the body. Scammon's systemic growth curves proposed four patterns of growth for the different tissues and systems (Cameron & Bogin, 2012). The four curves represent the growth pattern attained of lymphoid (lymph glands, tonsils, thymus etc.), neural (brain, nervous system, parts of the skull), genital (primary and secondary sex characteristics) and general tissue (height, weight, major organ systems) as a percentage of the total increment between birth and 20 years of age (Malina et al., 2004a). Figure 4 demonstrates that different tissues have different patterns and rates of growth, thus research on each tissue needs take place at the right time on the developmental pathway (Malina et al., 2004a; Cameron & Bogin, 2012)

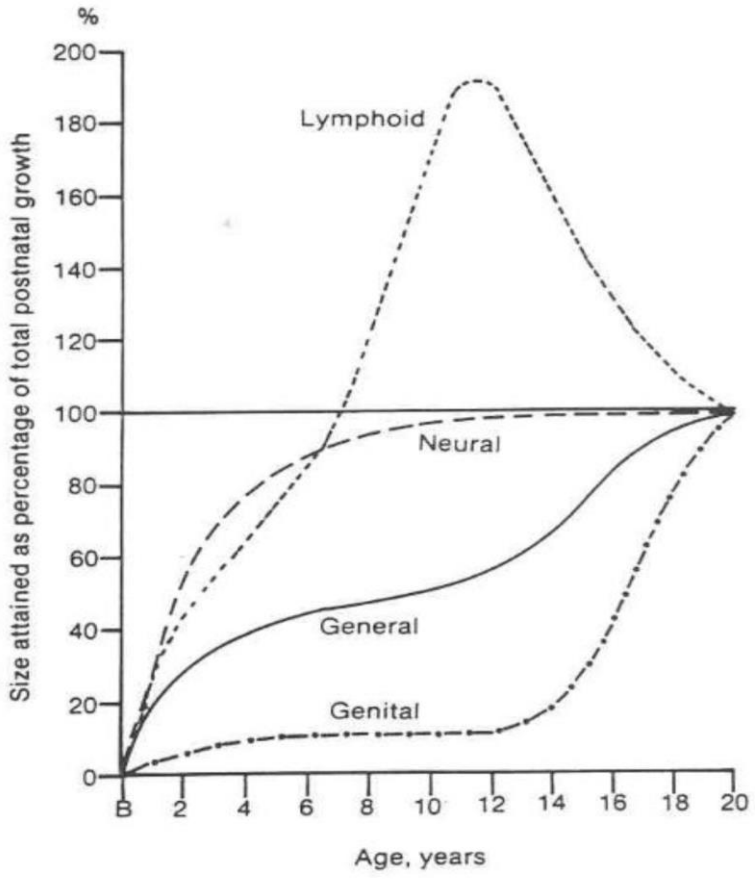

Figure 4: Scammon's systemic growth curves (Source: Malina et al., 2004a).

Post-natal growth follows a predictable pattern in all healthy children; however, there is considerable individual variability in timing and magnitude (Sanders et al., 2017). Thus, although individuals differ in final adult stature, the pattern of growth is alike for all healthy children around the world (Malina et al., 2004a). The pattern of growth for De

Montbeillards son, and all other healthy children, is a function of how frequently height data is collected, which in De Montbeillards son's case was around every six months (Cameron & Bogin, 2012, p.5). Data collected more frequently however provides more information on the nature of human growth; nonetheless, longitudinal studies with a high frequency of data collection are logistically not feasible, therefore few and far between (Cameron, 2014). The work of Dr Michele Lampl maybe the most notable. Lampl and colleagues assessed the growth in head circumference, height, and weight on a daily, twice weekly, and weekly basis for 31 children. They discovered growth in height was not a continuous phenomenon, rather it occurred in periods of saltation (short bursts of growth activity) and stasis (phases of no growth) (Lampl, Veldhuis & Johnson, 1992). The study of growth is therefore largely synonymous with measurement (Malina et al., 2004a).

Another notable study is the Fels Longitudinal Study, founded in 1929 in Ohio, designed to study childhood growth and development; the study continues to the present day with the children and grandchildren of the original participants enrolling into the study. This study has significantly contributed to the scientific literature, with numerous researchers and papers utilising the dataset (Roche, 1992; Whitaker et al., 2016). The creation of the Fels methodology to measuring skeletal maturation was also developed from the Fels dataset (see page 15) (Wright State University, 2019).

Measurement of Growth:

The two common measurements of growth are stature and body mass, or simply height and weight. Height is a linear measurement taken from the floor to the vertex of the skull, and weight is a measure of the mass of the body (Malina et al., 2004a). Standard procedure for measuring height is the stretch stature method, which involves the individual standing barefoot with feet together and heels, buttock and back touching the scale, with the head positioned in the Frankfort plane. A calibrated stadiometer is then used to measure height to an accuracy of 0.1cm. The assessor positions their hands along the jaw of the individual; the individual is instructed to take and hold a deep breath, through which the assessor applies upward lift through the mastoid processes (a feature on the temporal bone at the base of the skull and behind the ear). The assessor places the headboard of the stadiometer on the individual's vertex of the skull and reads the measurement. To measure weight, individuals stand barefoot on the centre of a weighing scale without support, distributing their weight equally between both legs (Stewart, Marfell-Jones, Olds, & Hans De Ridder, 2011). Diurnal variation occurs for both height

and weight however, with height decreasing by a centimetre or more over the course of the day and weight generally increasing by around 1kg for children dependent upon diet and physical activity over the day (Malina et al., 2004a; Stewart et al., 2011). Therefore, when assessing height and weight it is important to standardise measurement time, and where this is not feasible measurement time should be noted (Stewart et al., 2011).

Aside from height and weight, measures of limb circumferences, skinfold thickness and skeletal breadths provide information on the growth of other tissues (Malina et al., 2004a). Quality of measurement is of upmost importance in studies of human growth; standardised techniques and trained assessors are essential to obtain accurate and reliable data. It is important when obtaining any quantitative measure that procedures to minimise error are utilised (Ulijaszek & Kerr, 1999). Equipment requires frequent calibration and readings are checked for accuracy against objects of known weights (Malina et al., 2004a). Intra and inter-observer reliability, being the variability between repeated measures of the same individual by one observer and the variability between repeated measurements of the same individual by two or more observers respectively, is also often noted illustrating the imprecision and reliability of the measurement (Ulijaszek & Kerr, 1999). Importantly, errors in anthropometric measurement is unavoidable, but taking steps to reduce error and measuring imprecision (inter and intra observer reliability) permits confidence in results (Ulijaszek & Kerr, 1999).

Maturation:

Maturation is a process towards the mature state, which occurs in all tissues, organs and organ systems (Malina et al., 2004a). As with growth, maturity varies with each biological system or tissue considered; skeletal maturity is a fully ossified skeleton, sexual maturity is reproductive capability and somatic maturity is when growth in height is less than one centimetre per year (assumed adult height) (Malina et al., 2004a). Biological maturity varies across the different biological systems; thus, measurement depends upon which system is under investigation.

The control of human growth and maturation spanning the first two decades of life is a complex phenomenon, largely determined by genetics (Rowe, 2002; Van den Akker, Stein, Neale & Murray, 1987) but also influenced by the environment (Gluckman & Hanson, 2006; Cameron & Bogin, 2012). Environmental stressors, acute and chronic, can alter the process of maturation by either accelerating or delaying the process (Cameron &

Bogin, 2012). Stressors include prenatal and postnatal influences and dependent upon the stressor, maturity can be delayed or accelerated (Gluckman & Hanson, 2006; Belsky, 2019). Primarily however, the timing of puberty and maturation is genetically controlled (50-80%) (Loesch, Hopper, Rogucka, & Huggins, 1995; Palmert & Boepple, 2001).

To understand maturation, is important to note that chronological time and maturation are not equivalent. Put simply, in one chronological year, one does not mature by one year (Cameron & Bogin, 2012; Baxter-Jones, Eisenmann & Sherar, 2005). Chronological age is therefore not a valid indicator of biological maturation as individuals of the same age often vary in terms of their biological maturity (Malina et al., 2004a; Dorn, Dahl, Woodward & Biro, 2006). Maturation is often defined in terms of status, timing, and tempo. Maturation status refers to the state of maturation at the time of observation, maturation timing refers to when specific maturational events occur, whereas tempo refers to the rate of progression towards maturity (Malina et al., 2004a). Individuals often differ at a given point in time in terms of maturity status (level of maturity attained at that time), timing (when maturation events occur) and tempo (rate of maturation (Malina et al., 2004a).

Measurement of maturation:

Assessment and measurement are also fundamental to the study of human maturation. As already mentioned, chronological age is not a reliable indicator of biological maturity as individuals enter puberty at various ages and develop at varying rates (Malina et al., 2004a). Measurements can be used to identify maturation status, timing, and tempo. Maturity status measures reflect maturity of an individual at a fixed point in time; these measures can then be used to infer pubertal timing from a continuum by using standards and norms of the population (Dorn et al, 2006). Maturity timing and tempo can also be assessed by conducting repeated measures of maturity over a period of time (Mendle, 2014). Thus, when measuring biological maturation and categorising individuals it is pivotal to state the method and indicators being used for reference.

In order to measure and quantify maturity status and variation effectively, a number of maturity indicators have been identified. Maturity indicators are

> *"a definable and sequential change in any part or parts of the body that is characteristic of the progression of the body from immaturity to maturity" (*Cameron & Bogin, 2012, p520).

For a maturity indicator to be useful, it must conform to certain prerequisites:

- They must be present in all normal children of both sexes, universality.
- They must occur in a regular, definitive, and irreversible sequence.
- They must have the ability to discriminate between differing levels of maturity in children of the same chronological age.
- They must have good inter- and intra- observer reliability.
- They must be a valid indicator of maturity, thus reflect a genuine maturational change. (Cameron, 1997; 2015; Cameron & Bogin, 2012)

As already mentioned, measures of maturity differ according to the biological system considered. A number of different indicators of maturity exist primarily assessing that of skeletal, sexual and somatic maturity (Malina et al., 2004a), which will be discussed more closely in the next section. Research has concluded that when assessing biological maturation, the research question and focus should guide the choice of measurement (Dorn et al., 2006). The next section of this review discusses the protocol, logistics and strengths and weaknesses of various maturity measurements, with the primary focus on maturity measurement in boys.

1.2.1 Skeletal Maturity:

Assessing skeletal maturity is regarded as the most accurate and reliable measure of biological maturity status (Malina et al., 2004a; Dorn et al., 2006). Skeletal maturity, the only assessment that can be used in both childhood and adolescence, involves a radiograph of the hand and wrist that is then used to assess the skeletal maturity of the individual (Malina et al., 2004a). The left hand and wrist is a convenient location due to the many bones and epiphyses, which have an easily defined progression over time, within a small area limiting the exposure to radiation (De Sanctis et al., 2014; Nahhas, Sherwood, Chumlea & Duren, 2013). Although the radiation dose received, is less than 0.00017 millisievert (mSv) (equivalent to around one hour of natural background radiation in a large city centre), ethical issues remain (Huda & Gkanatsios, 1998; Public Health England, 2008; Johnson, Doherty & Freemont, 2009; Martin et al., 2011; Malina et al., 2015).

The changes to the bones within the hand and wrist are the maturity indicators used to provide the assessment, with the basis that an individual with more advanced maturity will display greater bone development and less cartilage than their less mature

peers (Baxter Jones et al., 2005). There are three maturity indicators in the bones providing the information on level of skeletal maturity attained at a given time. First is the initial appearance of the bone centres, signifying the first replacement of cartilage by bone. Second is the definition of the bones by gradual shape differentiation as the bones take up their adult form. The final indicator is the unison or fusion of the epiphyses with their respective diaphyses (Malina et al., 2004a, p.279).

Greulich-Pyle, Tanner-Whitehouse and Fels are three different methods that can be used to assess a hand-wrist radiograph. These methods provide a "skeletal age", an estimation of skeletal maturity, which is presented relative to the chronological age of the individual. Each method differs slightly in their reference samples, criteria and scoring system, thus skeletal age differs dependent on which method was applied (Malina et al., 2004a). Although skeletal assessment is seen as the best indicator of maturity, problems include the radiation dosage individuals are exposed to (although minimal), time and expense required and the lack of qualified and trained individuals (Malina et al., 2015; De Sanctis et al., 2014; Dorn et al., 2006; Malina et al., 2004a).

1.2.2 Sexual Maturity

Assessing sexual maturity is based upon the study of secondary sex characteristics as maturity indicators, thus, its use is limited to the pubertal phase of maturity (Malina et al., 2004a, p.284). The development of secondary sex characteristics reflects changes within the neuroendocrine system, and the maturation of the hypothalamic-pituitary gonadal and adrenal axes of the neuroendocrine system (Malina et al., 2015). Adrenarche is recognised as the earliest phase of puberty characterised by rising levels of androgen hormones, however no visible signs of puberty, and so is considered pre-pubertal. Gonadarche is characterised by further increases in hormones that lead to the maturation of the primary (testes and ovaries) and secondary sex characteristics and therefore an overt change (Dorn et al., 2006; Blakemore et al., 2010). Measurement of sexual maturation thus must begin in adolescence.

The most used criteria of assessing secondary sex characteristics are that of Tanner of hair (pubic and axillary), breast and genital maturation for girls and boys, respectively. Tanner divided the process of breast development into five stages (B1-B5), genetalia development into five stages (G1-G5), pubic hair development into five stages (P1-P5) and axillary hair development into three stages (A1-A3). In terms of maturity status, the first stage (B1, G1, P1, and A1) represents the pre-pubertal phase where no

development of each characteristic is observed. The last stage in each characteristic (B5, G5, P5, A3) represents the adult or mature state (Malina et al., 2004a, p.284; Dorn et al., 2006; Tanner, 1962).

Assessing secondary sexual characteristics using Tanner's criteria is deemed the gold standard of measuring pubertal status, however there are some limitations (Dorn et al., 2006). The scale was developed on a relatively small sample from one ethnic group (200 Caucasian boys and girls (Tanner, 1962) and assessing an individual's level of sexual maturity is often regarded as ethically moot due to the invasive nature of the assessment. The direct observation of the individual in a clinical setting is an intrusive procedure, which causes concern for those individuals involved, and difficulty in attaining consent. An alternative method occasionally used is a self-assessment method; after clear instruction, individuals enter a room and rate their own stage of sexual maturity by comparing themselves to a number of photographs or schematic drawings. The validity of self-assessment methods compared against direct observation with a clinician shows varying and inconsistent results; some research shows moderate to high correlations (0.59-0.92) (Matsudo & Matsudo, 1994; Malina et al., 2004a), whereas others show agreement between adolescent and clinician to be as low as 27% (Schlossberger et al., 1992; Schmitz et al., 2004).

Aside from Tanner's criteria of breast, genital and pubic hair, other secondary sex characteristics can also be used as maturity indicators. In boys, these include facial hair and voice changes rated on a four and three stage scale, respectively. In line with other maturity indicators, these are continuous processes where stages have been superimposed to help indicate level of maturity. These events tend to occur relatively late in puberty and this may explain their limited usage in studies of maturation (Malina et al., 2004a, p.292). As previously mentioned, the development of secondary sex characteristics is largely reflecting an increase in hormones and so clinical settings often utilise blood or saliva samples to indicate maturity status. This method also has limitations, however; not only is taking samples invasive, but many hormones have ultradian, circadian and monthly rhythms, meaning minute-by-minute, daily and monthly fluctuations, warranting consideration within research study designs (Dorn et al., 2006).

Other maturity indicators include age at menarche (first menstrual cycle), a clear and unambiguous indicator of sexual maturity status within females. Menarche however is a relatively late event in the pubertal phase (Gonadarche); therefore, it is not a good indicator of the onset of puberty as other pubertal changes would be underway (Coleman

& Coleman, 2002; Dorn et al., 2006). As a measure of maturity status in respect to a particular cohort however, age at menarche can be useful (Malina et al., 2004a). In adolescent males, age at spermarche has been used to categorise boys as pubertal (producing sperm) or prepubertal (not producing sperm) and is the counterpart of age at menarche. Age at spermarche seems to be a relatively early pubertal event, however, there is large variability (Dorn et al., 2006). The logistics and ethics of assessing spermarche complicate and limit the utility of this method (Cameron & Bogin, 2012, p.531).

1.2.3 Somatic maturity:

Neuroendocrine changes at puberty also result in changes in body size and composition. Pulses of growth hormone become consistent throughout the 24-hour day and the hormonal activation of the growth axis results in a linear growth spurt at around 12 in girls, and two years later for boys (Marshall & Tanner 1969, 1970; Malina et al., 2004a; Dorn et al., 2006; Blakemore et al., 2010). This growth spurt can be visualised on the height growth curve; the modulation at around 14 years of ages for boys is indicative of the adolescent growth spurt.

Maturity indicators have been derived from the growth spurt and as a result, somatic maturity can be estimated from longitudinal height data, spanning the adolescent growth spurt (Malina et al., 2004a). Multiple measures of height per year are necessary to completely capture the increase in growth velocity; further, linear growth in boys often continues into the late teens and early 20's, therefore it may be beneficial to prolong measurement (Parent et al., 2003; Dorn et al., 2006).

Maturity indicators derived from the growth curve are age at onset of the growth spurt, also known as take-off, and peak height velocity (PHV), the maximum rate of growth during the growth spurt. An estimate of maturity timing can be obtained using age at PHV, and tempo can be estimated using centimetres per year grown during PHV, if longitudinal height data is available (Malina et al., 2004a). Previously, individual's heights were plotted on a graph to identify when the peak in growth occurred. More recently, mathematical modelling of longitudinal individual height data is applied, facilitating the estimation and calculations of maturity timing (Malina et al., 2004a). The logistical difficulties in acquiring longitudinal height data spanning the adolescent growth spurt is a limitation of this method (Malina et al., 2015).

Non-invasive measures of estimating maturity status have become an increasingly common method perhaps due to their feasibility, however they still have limitations and should be applied with caution (Malina et al., 2004a; Malina et al., 2015; Cumming et al., 2017a). The first method, maturity offset, estimates the individual's number of years away from attaining PHV (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). Stature, sitting height, leg length and decimal age are inputted into the equation to provide an estimate of maturity timing (pre or post PHV) (Mirwald et al., 2002, Malina et al., 2015; Cumming et al., 2017a).

$$
\begin{aligned}
&Maturity\ offset\ (years)\\
&\quad = -9.236 + \left((0.0002708\ x\ (leg\ length\ x\ sitting\ height)\right)\\
&\quad + \left(-0.001663\ x\ (age\ x\ leg\ length)\right)\\
&\quad + \left(0.007216\ x\ (age\ x\ sitting\ height)\right)\\
&\quad + \left(0.02292\ x\ (mass\ by\ stature\ ratio\ x\ 100)\right).
\end{aligned}
$$

(Equation by Miwarld et al., 2002).

Research has questioned the validity and reliability of the maturity offset method (Mirwald et al., 2002). The method appears to be more useful nearer the time of PHV in average maturing boys with a narrow chronological age range (13-14.99 years), limiting its usefulness (Malina et al., 2015). Validation studies based on actual age at PHV revealed error for predicted ages were later for early maturing individuals, and earlier for late maturing individuals (Malina & Koziel, 2014a, 2014b; Malina et al., 2015). In view of that, research employing the maturity-offset method should be observed with caution (Cumming et al., 2017a).

Another maturity indicator of somatic maturity is percentage of predicted adult height attained. This method provides an indication of maturity status at the time of observation (Malina et al., 2015). To predict adult stature, most methods require the individual's skeletal age and therefore the limitations of assessing skeletal maturity transpire, thus limiting their suitability (Malina et al., 2004a). An alternative method was established to enable the prediction of adult height without requiring skeletal age. This method utilises the child's chronological age, height, weight, and mid-parent height (height of both mother and father divided by two) (Malina et al., 2004a; Malina et al.,

2015). The method, named the Khamis-Roche method, provides age-specific equations and standard errors (Khamis & Roche, 1994). Use of self-reported parental height increases the error in the prediction; however, adjustment equations can be applied to address overestimation (Epstein, Valoski, Kalarchian, & McCurley, 1995). The percentage error of the equation has been stated at 2.2cm (referring to the prediction of height for four to 17.5 years of age) (Khamis & Roche, 1994) and the method has been shown to have moderate concordance with maturity classifications based upon skeletal age (Malina, Dompier, Powell, Barron, & Moore, 2007). This method results in the expression of current height as a percentage of predicted adult height providing an estimate of maturity status. The higher the percentage of adult height attained, the more mature the individual (Malina et al., 2015). For instance, two boys of the same age and same height can have attained different percentages of adult height, where one boy is nearer to their predicted adult height (higher percentage) compared to the other (Malina et al., 2004a). Research has shown that PHV tends to occur approximately between 88-96% of predicted adult height; Evidence suggests the onset of the growth spurt occurs at around 88% of predicted adult height, PHV occurs around 91-92% of adult height, and growth slows to its pre-PHV velocity at 96% (Baxter-Jones, 2013; Cumming et al., 2017a; Parr et al., 2020).

General Maturity Changes:

The dynamic process from immature to mature consists of many measurable landmarks. Aside from linear growth and the development of secondary sex characteristics, other changes are occurring concurrently. Adolescence and puberty is a time of significant increase in weight, where 50% of adult body weight is gained. Peak weight velocity (PWV) occurs around the time of PHV, with average increases in weight approximately 9 kilograms per year; for girls PWV follows PHV by 6 months averaging 8.3kg per year (Tanner, 1989; Rogol, Clark & Roemmich, 2000). Increases in bone mineral content, muscle mass and fat occur under the influence of the gonadal steroid hormones and growth hormone (Rogol et al., 2000). Android (apple) and gynoid (pear) patterns of fat distribution begin to develop in late adolescence due to changes in fat distribution (Rogol et al., 2000). Skeletal changes result in wider shoulders and hips for males and females respectively (Cameron & Bogin, 2012). Increased testosterone in boys means they also experience a substantial increase in growth of bone and muscle, as well as a loss of fat in the limbs. This reduction in fat and simultaneous increase in muscle mass coincides with the occurrence of PHV and thus increased strength (Rogol et al.,

2000). By the end of adolescence, these changes lead to an obvious sexual dimorphism where males are larger and stronger (Cameron & Bogin, 2012).

Development:

Development, a term used synonymously with growth and maturation, is a broader concept comprising of biological and behavioural contexts (Malina, 2014; Malina et al., 2004a). The biological context refers to the differentiation and specialization of cells, mainly occurring prenatally, but continues until body systems are fully functional (Malina et al., 2004, p.5). The behavioural context considers the cultural setting of the individual and refers to the acquisition and refinement of a number of behaviours. Social, emotional, and cognitive competence are often used when talking about an individual's development (Malina et al., 2004a; Malina, 2014).

Section 2: Influence of Growth and Maturation on athletic performance:

The three processes discussed, growth, maturation, and development, are dominant in the first two decades of an individual's life (Malina et al., 2004a). The biological phenomena of growth and maturation do not occur separately from development and the interaction of the three is important to consider (Malina et al., 2004a). The interaction of these three distinct processes varies across childhood and adolescence, between individuals, and across different population groups (Malina, 2014). Several developmental components such as social experiences, perception of oneself/perceptions from others, self-esteem and personal identity are influenced by maturity; consequently, children and adolescents must be viewed bio-culturally (Malina et al, 2004a; Mitchell, 2018).

Adolescents must also be viewed as individuals, because although all children undergo the same pattern of growth, achieve the same developmental landmarks and have the same end goal of maturity, individuals of the same chronological age vary greatly in terms of timing and tempo of maturation (Cameron & Bogin, 2012; Malina et al., 2004a). As already mentioned, chronological age and biological age are not interchangeable, age has been said to be only marking the passing of time (Wohlwill, 1973; Dorn et al., 2006). Chronological age determined according to the calendar year, and biological age determined by their level of maturity, can therefore differ by several years (Malina et al., 2004a). This variation in maturity has been shown to be up to six years in difference

between two boys, both nine years old (measured using the Fels method of assessing skeletal maturity (Johnson et al., 2009; Johnson et al., 2017). Although this is an extreme difference, it supports the notion that children of the same chronological age vary greatly in terms of their biological maturity.

Traditionally, for education and sport, children are grouped within their chronological age. It was anticipated this would reduce large differences in age, provide age related development, fair competition, and therefore equal chances for success (Musch & Grondin, 2001; Helsen et al., 2005). However, as seen, children of the same age differ greatly in terms of their maturity and development. In one age group some individuals will mature in advance of their chronological age (early maturing) whereas some will mature in delay of their chronological age (late maturing); others will have a similar biological age to their chronological age (on-time/average maturing) (Malina et al., 2004a, p.7). The traditional method of grouping individuals within their chronological age group for school and sports, is therefore questioned when individuals within the age groups vary greatly in terms of their biological maturity.

2.1 Influence of growth and maturation on athletic performance:

Individual differences in the timing of maturation can easily be distinguished within a group where individuals are of the same chronological age. Early maturing boys experience a more intense adolescent growth spurt which results in greater pubertal gains of height, weight, and lean mass (Cumming et al., 2017a; Malina et al., 2004a). This presents the early maturing individual an athletic advantage in terms of strength, speed, power, and size (Cumming et al., 2017a; Malina, 2014). Maturity-associated differences in size and function are at their greatest during adolescence (around 11 to 14 years) and so at these particular ages, large differences in performance between early and late maturing boys emerge. In adulthood, these maturity-associated advantages become negligible (Malina et al., 2015; Cumming et al., 2017a) and in some cases are reversed (Lefevre, Beunen, Steens & Renson, 1990). Growth and maturation therefore directly influence athletic performance, where early maturers outperform their later maturing peers (Buchheit & Mendez-Villanueva, 2014; Malina et al., 2004b; Malina et al., 2004a).

Research has shown athletic performances in adolescence are influenced directly by individual differences in maturity timing. Performances on standardised tests generally increase with age, however at the onset of adolescence boys' performances show a marked improvement (Malina et al., 2004b; Malina, 2014). Lefevre and colleagues (1990)

showed early maturing boys outperformed their on time and late maturing peers in several motor performance tasks. They tracked the performances of a number of Belgian boys from 12 to 17 years of age and found the results were influenced by maturity timing, with early maturers performing the best and late maturers the worst (Malina et al., 2004a) (Figure 5). For many talent predicting tasks, i.e. speed, agility, power, endurance and dribbling, there is a maturity-associated gradient in which early maturing players tend to outshine their peers (Meylan et al., 2010; Malina et al., 2015; Malina et al., 2004b; Vaeyens et al., 2006).

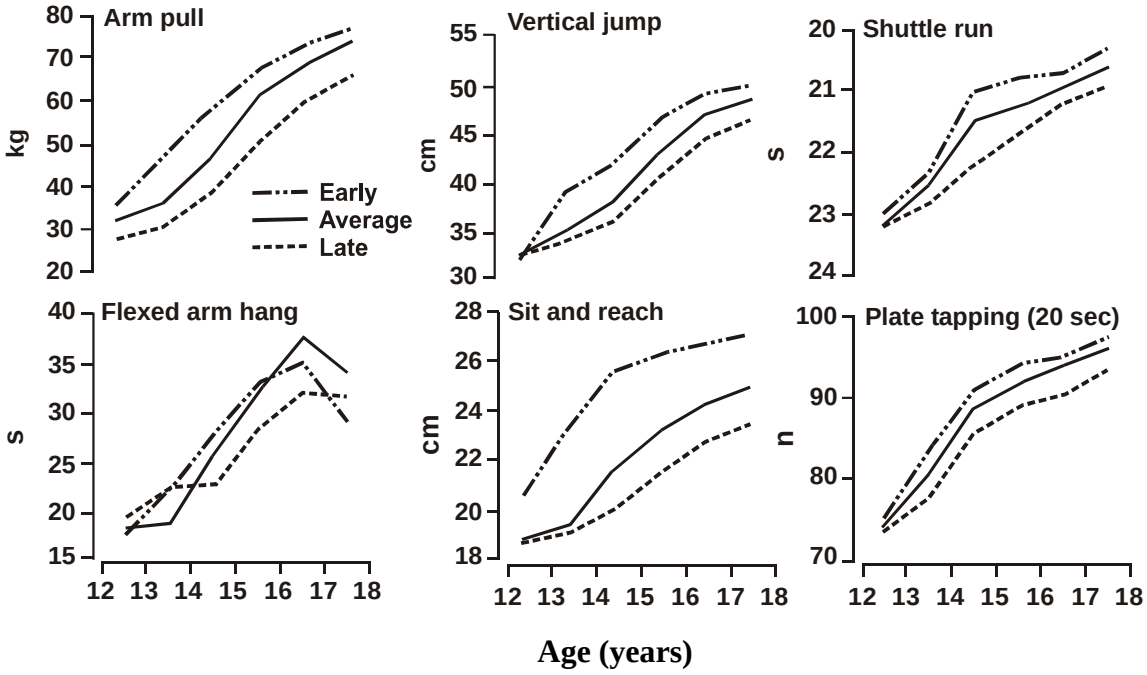

Figure 5: Mean motor performances of early, on time and late maturers (Source from: Malina et al., 2004a; Lefevre et al., 1988).

Growth and maturation also indirectly effects the individual. Early maturing boys often present a more adaptive motivational profile; boys who advance earlier than their peers tend to have higher perceptions of their strength, fitness, sporting competence and even attractiveness (Cumming et al., 2011, 2012, 2017a). Not only do individual differences in maturity timing affect the perceptions of the athlete themselves, it also influences the perceptions from others around them. Early maturing athletes display a social stimulus value, where their increased size provides the perception that they are physically suited for a sport (Dorn et al., 2006; Malina et al., 2015). This social stimulus value affects the treatment, evaluation, and interactions the individual is subjected to (Malina, 2014; Malina et al., 2015).

The direct and indirect effects of individual differences in timing of maturation has great implications on the sport and the athlete (Cumming et al., 2017a). Firstly, early maturing boys tend to be more attracted to sports such as football, rugby, basketball, and ice hockey, because greater size, speed and strength are seen as advantageous (Cumming et al., 2017a). Secondly, early maturing boys are more likely to be selected into these sports because of their physical qualities and functional characteristics (Cumming et al., 2017a). Finally, early maturing boys in these sports are more likely to be encouraged, rewarded, acquire more playing time, and given more opportunities to specialist resources, coaching and leadership positions (Cumming et al., 2017a; Bloom & Sosniak, 1985). A body of research has shown this bias in the selection and success of early maturing adolescent athletes, which will be discussed further in the succeeding sections (Beunen & Malina, 1988; Johnson et al., 2017; Malina et al., 2015; Malina et al., 2000; Patel et al., 2019).

Individual differences in growth and maturation not only contribute to performance differences, inequity in selection and competition, but also injury risk (Cumming et al., 2017a). Risk of injury is the nature of all sport, however, for athletes delayed in maturation, competing with and against larger, stronger, and faster players, there is an increased injury risk (Cumming et al., 2017a). Equally, athletes undergoing their adolescent growth spurt are suggested to be susceptible to growth-related injuries (Kemper et al., 2015; van der Sluis et al., 2014; van der Sluis, Elferink-Gemser, Brink & Visscher, 2015). Two common disorders often seen in youth football are associated with the beginning and end of the adolescent growth spurt (Malina et al., 2004a). Sever's, a disorder associated with heel pain tends to occur just before the adolescent growth spurt, whereas pain under the knee is symptomatic of Osgood Schlatter's disease peaking during the growth spurt (Cumming et al., 2017a; Price, Hawkins, Hulse, & Hodson, 2004). A prospective epidemiological study of injuries suffered within English football academies found Osgood Schlatter's and Sever's accounted for 5% of the total injuries sustained over two years. Between the ages of 11 and 13 however, these two disorders accounted for 13.8% of injuries with Osgood Schlatter's peaking in the under 13/14-year age group and Sever's in the under 11 age group (Price et al., 2004). Thus, understanding growth and maturation is valuable for football clubs to effectively treat, manage and even prevent injuries associated with the growth spurt (van der Sluis et al., 2014; van der Sluis et al., 2015).

2.2 Adolescent Awkwardness:

A fascinating question pertains to the topic; does the onset of puberty and the growth spurt make a young person clumsier? During adolescence and the adolescent growth spurt, children are often described as “gawky”, “lanky” and “gangly” and this period seems to be associated with a level of clumsiness. Adolescent awkwardness is a matter of discussion for sports coaches, researchers, and parent’s alike, understanding if, why and how this awkwardness can be measured (Reynolds, 2011). Within the literature, the term adolescent awkwardness is widely used, yet the consensus as to whether the phenomena exists and how to detect it is commonly debated. Despite a lack of scientific evidence, it is thought for some individuals the growth spurt is associated with a temporary disruption of motor coordination (Beunen & Malina, 1988).

Adolescent awkwardness has been a deliberated and researched phenomenon from as early as 1922 to the present day with inconsistent findings (Homburger, 1922 as seen in Beunen & Malina, 1988; Quatman-Yates et al., 2012; Baker, Cobley, Schorer & Wattie, 2017). Many researchers advocate that adolescent awkwardness exists and suggest monitoring growth rates and performance (Beunen & Malina, 1988; Lloyd & Oliver, 2012; Tanner, 1989). Tanner suggested adolescents experience a temporary six-month awkwardness as they struggle to sense their change in physical proportions and adjust to their new long limbs (Tanner, 1989). Philippaerts and colleagues analysed awkwardness in a sample of adolescent soccer players compared to general adolescent boys and found performance on most tests improved with age; a decline in performance on a 30-metre dash was attributed to adolescent awkwardness, where the highly skilled boys showed the biggest decrease in performance (2006). Other research concurs that individuals who were highly skilled before undergoing the growth spurt tend to be the individuals who show the biggest decrement in performance (Beunen & Malina, 1988). There is therefore some evidence to suggest a possible period of adolescent awkwardness for elite young athletes.

On the other hand, a number of studies have shown evidence against the notion of awkwardness, where no plateau or decrement in performance was recorded (Davies & Rose, 2000; Malina et al., 2005). Measuring adolescent awkwardness is problematic however, due to strength, speed and power increasing with age, thus any awkwardness may be masked by general improvements occurring with age and experience (Malina et al., 2005). Quatman-Yates et al., suggest the inconsistent results may be due to past

research focusing on motor skill performances rather than sensorimotor function (2012). Adolescent awkwardness is clearly an area requiring further research.

2.3 Maturity Biases:

Elite athletes possess specific physical characteristics suited to their sport. Early research in the area tried to understand whether these elite athletes acquired these characteristics from the intensive training or whether the sport selected individuals because of these preferred attributes (Baxter-Jones, Helms, Maffulli, Bainespreece, & Preece, 1995). The initial literature proposed that exercise increased the growth rates in athletes (Thompson, 1917; Baxter-Jones et al., 1995), however recent studies suggests it is early maturation that is selected for within certain sports (Malina, Meleski & Shoup, 1982).

Early maturing athletes have been shown to be overrepresented in a number of sports (Malina et al., 1982). Research in the 1950's showed a bias towards boys advanced in maturity in the 10 to 12-year-old Baseball Little League World Series (Hale, 1956). Research in male ice-hockey showed selected players in a group of 14-15-year olds tended to be taller, heavier and more mature (using age at PHV as the indicator of biological maturity) (Sherar, Baxter-Jones, Faulkner & Russell, 2007). Early maturing athletes also tend to be selected for in many other sports such as swimming (Baxter-Jones et al., 1995; Malina, 1994), tennis (Baxter-Jones et al., 1995), basketball (Torres-Unda et al., 2013), rugby (Till, Cobley, O'Hara, Cooke & Chapman, 2014) and alpine ski racing (Muller, Muller, Hildebrandt, & Raschner, 2016).

The systematic bias for early maturing athletes does not occur in all sports, however. Late maturing boys are preferentially selected over early maturing athletes in gymnastics (Baxter-Jones, 1995; Malina et al., 2013) and long-distance running (Malina et al., 2015). For girls, a similar gradient is also seen for both gymnastics (Baxter-Jones, 1995; Malina et al., 2013), long distance running, figure skating, diving (Malina et al., 2015) and ballet (Mitchell, Haase, Malina, & Cumming, 2016). Extreme cases of late maturation have been shown in ballet, gymnastics, and figure skating with delayed onset of maturation being not only desirable but practically necessary (Ryan, 1995).

> *"She never suspected her career would be destroyed from the inside, by her own body and the coach she once adored. Sometime during her fifteenth year, Kristie's body began to change. Despite the intense physical work and delayed menarche,*

her body grew and rounded. At 4 feet 11 inches, she saw her weight creep from 88 pounds to 92 pounds and then to 98 pounds. Karolyi [coach] turned against his star pupil, as if her growth were a betrayal".
(Ryan, Little Girls in Pretty Boxes, 1995, p113).

2.4 Maturity Biases within Football:

A plethora of research within youth football also confirms a bias towards early maturing athletes (Meylan et al., 2010). Research with 135 elite youth football players found mean skeletal age (Fels) to be higher than mean chronological age, indicating advanced maturity status for many of the players (Malina et al., 2000). The proportion of later maturing players within this sample also decreased with increasing chronological age (Malina et al., 2000). Similarly, research conducted in England and Qatar by Johnson et al concurred, finding biological maturity status (Fels method) had a strong influence over selection and the systematic bias towards early maturers increased with age (2017). Maturity biases emerge around 11 years of age, coinciding with puberty and the associated athletic gains such as speed, strength, and power (Meylan et al., 2010). A number of other studies have also found the systematic bias towards early maturing athletes to increase with age and competitive level, thus late maturing athletes become further under represented at the older ages (Hirose, 2009; Figueriedo et al., 2009a; Meylan et al., 2010).

A number of studies have assessed maturity status of youth footballers and various functional capacity or skill-based tasks. One study assessed the stage of pubic hair development based on Tanners criteria (1962) and the 69 Portuguese youth footballers spanned the whole spectrum of Tanners stages (PH1-PH5); 9%, 30% and 28% of which were in stages PH1, PH4 and PH5 respectively (Malina et al., 2004b). Thus, with more than a quarter of the group classified as biologically mature (PH5) this is more evidence to demonstrate the bias towards early maturing adolescent players (Malina et al., 2004b). This study also showed biological maturity status significantly influenced the functional capacity of the players (Malina et al., 2004b). Stage of biological maturity significantly influenced a jump, speed, and aerobic task, where players in the latter stages of maturation performed better (Malina et al., 2004b). Figuerideo et al (2009b) also found Portuguese elite youth football players were chronologically and biologically (skeletally) older and performances in functional capacities were better than the club and dropout players. Another study showed selected football players were early maturing, taller, heavier, ego

orientated and performed better in tasks of explosive power, repeated sprints, and ball control (Coelho E Silva et al., 2010). In terms of match performance, early maturing 15-year-old elite footballers presented greater locomotor and match running performances than their later maturing peers (Buchheit & Mendez-Villanueva., 2014). There is therefore substantial evidence that early maturing athletes perform better in talent predicting tasks and are therefore selected over their later maturing peers in youth football (Meylan et al., 2010).

Biological maturity not only influences selection into the team but also playing position. Research has shown a link between maturity, anthropometrics and physiological characteristics and the various playing positions (Malina et al., 2000; Gil, Gil, Ruiz, Irazusta, & Irazusta, 2007; Meylan et al., 2010). The literature suggests forwards and defenders (including goalkeepers) are more advanced in maturity than midfielders (Malina et al., 2004b; Towlson et al., 2017). Maturity, and crucially greater anthropometrics seem to bias both entry into the team and subsequent position allocation; coaches and scouts need to understand the effects of growth and maturation in adolescence before signing and allocating players positions (Towlson et al., 2017). Late maturing players are less likely to be selected on to the team, and less likely to be selected for pivotal positions (Cumming et al., 2017a).

The systematic exclusion of later maturing players is a flaw within the football academy system. Disregarding both average and later maturing athletes shrinks the pool in which talent scouts can select from, leaving only early maturing athletes available for selection; this is highly flawed when maturity status becomes irrelevant after adolescence (Johnson et al., 2017; Burgess & Naughton, 2010). Ostojic and colleagues prospectively followed 55 14-year-old Serbian male football players and found proportionally late maturing boys were at a higher chance of achieving the highest professional status; in absolute terms however, late maturing boys were still less likely to be represented at the adult level (2014). Lefevre et al found early maturing boys significantly outperformed later maturing boys in motor performance tests; these same boys were followed up at 30 years of age and for most of the motor performance tests, the later maturing individuals had not only caught up the once early maturers but also for some tasks had significantly overtaken them (1990). Research therefore suggests performances in adolescence are often not what is observed at the adult level.

Given a chance to remain in the system, late maturing players can and do reach elite levels. Late maturing players eventually catch up to their early maturing teammates

in regards to their growth and maturation, but importantly their athletic potential is suggested to be greater due to the hurdles and challenges faced throughout adolescence; this theory is known as the underdog hypothesis (Krogman, 1959; Gibbs, Jarvis & Dufur, 2011). To overcome the physical disadvantages, late maturing athletes develop greater psychological profiles and present greater technical and tactical skills in order to remain competitive (Malina et al., 2015; Zuber et al., 2016; Cumming et al., 2017a). Although scientific evidence to support this is limited (Malina et al., 2015), a number of famous case studies exist to demonstrate this. One being the very successful Tottenham and England striker and Captain Harry Kane, who as a child had a tough journey through the academy system. After release from both Arsenal and Watford for his lack of physicality, he signed for Tottenham's academy aged 11 where he also struggled due to his immaturity.

> *"Young players are examined minutely, from saliva tests to agility exercises, but data-driven certainties do not take into account human nature or the idiosyncrasies of physical maturation. Harry Kane maybe lauded, on t-shirts and in song, by Spurs fans as "one of our own" but as an immature 14-year-old, the youngest in his age group, he was close to being dis-owned. The in-house jokes about his lack of speed, physical definition and agility, which was 30 percent lower than his peers, have even reached England manager Gareth Southgate". (Calvin, 2017).*

Other current players have experienced similar journeys. Gareth Bale for example was *"a skinny boy from an external development centre in Bath, who earned his Southampton scholarship by a single vote"* (Calvin, 2017, p.36). Nathaniel Clyne, another later maturing player struggled to make his mark in academy football.

> *"Nathaniel Clyne…scored six goals on trial as a winger at the age of ten, but Arsenal rejected him because he was supposedly too small. Spurs were similarly blinkered…excelled at Crystal Palace, made his Premier League debut for Southampton, and was sold to Liverpool for £12.5 million in July 2015". (Calvin, 2017, p.6).*

After adolescence, the maturity-associated differences in size and function are attenuated and sometimes reversed, and yet many players have already been cut based upon their adolescent development. The early maturing youngsters who achieved the initial success have often failed to develop other skills, due to a reliance on their physical

nature, and thus are ill prepared for competition with equally mature peers (Cumming et al., 2017a). Presumptions and expectations surrounding early maturing athletes' success at the adult level are often not met (Cumming et al., 2017a).

Research has shown selection procedures within academy football are biased by a player's current physicality and maturity rather than their long-term potential. The nature of selecting the more physically mature players may come from the desire for immediate success rather than the continuing development of potential players (Augste & Lames, 2011). Former Manchester United Manager Sir Alex Ferguson recognised these pitfalls and commented on the risk in selecting players based on their adolescent maturity.

> *"The biggest risk was that we had erred in our assessment of a particular boy and could have used his spot to work with a more talented youngster. We had to wait a little longer to see the potential in some boys, because not everyone's physique develops at the same rate".* (Ferguson, 2015, p260).

2.5 Strategies to combat Individual Differences in Maturity:

There is clear evidence to show in many sports, including football, that maturity biases are problematic. As mentioned, individual differences in the timing of maturity has great impact on young athletes in terms of their development, training, injury risk, and talent identification. Numerous talent identification and talent development models have been developed, considering adolescence and differences in biological maturity (Balyi & Hamilton, 2004; Balyi, Way & Higgs, 2013; Ford et al., 2011; Lloyd & Oliver, 2012). It is accepted that children are not "miniature adults" and thus, various models have aimed to address the importance of child development within long term models (Faigenbaum et al., 2011; Lloyd & Oliver, 2012).

The Long Term Athlete Development Model (LTAD) by Balyi and colleagues was one of the first models to account for the maturational status of children; the model aimed to utilise "windows of opportunity" within the development years where children are most sensitive to training-induced adaptations (2004; 2013). The LTAD model has been criticised however for being driven by theory rather than empirical evidence (Ford et al., 2011; Lloyd & Oliver, 2012). The Youth Physical Development Model (YPD) by Lloyd and Oliver was proposed to provide a logical evidence-based approach to developing young athletes (2012). The YDP model provides practitioners with when and

why each fitness component should be emphasised and highlights the need for individualised training to account for individual differences in maturity status (Lloyd & Oliver, 2012). Finally, the Athletic Skills Model (ASM) focuses upon talent development from adolescence to adulthood, emphasising physical literacy and appropriate training exercises for each phase of child development (Wormhoudt, Savelsbergh, Teunissen & Davids, 2017). These talent development models which many National Governing Bodies (NGB) advocate, aim to better develop athletes through adolescence, recognising individual differences in growth and maturation.

Another strategy proposed to combat maturity differences is bio-banding (Cumming et al., 2017a). The nature of bio-banding is to group children based on their physical and biological age rather than their chronological age. The first suggestion of this in sport came from Krogman, who suggested assessments of maturity should be considered when evaluating and selecting players for the 1957 Baseball Little League World Series (Krogman, 1959). Combat sports such as boxing and judo group their athletes based on age and weight criteria, as extreme disparities in size is deemed unfair and unsafe (Cumming et al., 2017a). Grouping athletes by their maturity status could therefore have several benefits for both early and late developers such as reduced injury risk, competitive equity, and aid in meritocratic selection decisions (Cumming et al., 2017b). Early research reviewing players experiences of bio-banding suggest early maturing players found the games to be more physically challenging and the style of play challenged their technical and tactical ability. Late maturing players found the game to be less physically challenging and valued the opportunity to prove their technical, tactical, and psychological qualities (Cumming et al., 2017a; Bradley et al., 2019). Further research examining bio-banding is warranted however (Cumming et al., 2017a; 2017b).

Section 3: Relative Age Effect:

As well as evidence for a maturity bias within youth sport, a bias towards chronologically older athletes is also evident within the literature. This phenomenon, coined the Relative Age Effect (RAE), has been studied in education and sports, spanning childhood to adulthood (Sierra-Diaz et al., 2017). It is often assumed the individuals born at the beginning of the selection year are not only chronologically the oldest, but also biologically (Baxter-Jones, 1995); however, it has to be noted the two are separate concepts (Cumming et al., 2017a). Relative age is defined by a child's date of birth, whereas maturity is essentially genetically driven and therefore a child can be early

maturing and yet born later in the year, or vice versa (Malina, 2014; Cumming et al., 2017a). RAE and maturity are therefore separate phenomena, independently influencing performance and selection, thus they must be treated separately (Cumming et al., 2017a; Hill et al., 2019; Towlson et al., 2017).

As mentioned previously, to create a level playing field, provide age-related development and reduce large differences in age, children and adolescents tend to be grouped by their chronological age. Simply, schools and sports stipulate cut-off dates, which becomes the selection year for that age group. For example, the English education and English youth football selection year is classified as 1st September to August 31st; the 13-year-old age group is therefore individuals whose thirteenth birthday falls between these two dates (Helsen et al., 2005).

The difference in age between a player born at the beginning of the selection year and a player born at the very end of the selection year is known as relative age. Just under one-year difference (or 364 days) in age is the maximum difference in relative age in any age group. Although this magnitude is smaller than is often seen in maturity differences in an age group (Johnson et al., 2017), it still results in significant differences between the eldest and youngest individuals (Musch & Grondin, 2001). Consequences of the relative age difference is known as the RAE (Musch & Grondin, 2001).

Organising children into these chronological age groups often results in differences between the youngest and oldest within the group. Research has shown not only differences in age, but also physical, emotional, cognitive, and anthropometric differences (Helsen et al., 2005). Level of experience as a function of age is another factor in chronological age grouping. The oldest players in the age group have simply been alive for longer and therefore have more experiences than a child born 12 months later (Ward & Williams, 2003; Helsen et al., 2005). Although at the adult level this seems negligible, level of experiences in children born 12 months apart can differ remarkably (Helsen et al., 2005). For these reasons, chronologically older children in the age group often experience an initial performance advantage, which likely increases both intrinsic and extrinsic motivation compared to later born individuals (Helsen et al., 2005). Increased motivation and greater perceived competence likely encourages relatively older individuals to develop further, in comparison to relatively younger individuals (Cobley, Baker, Wattie & McKenna, 2009a). Thus, relatively older children within an age group have an advantage over later born children, affecting both academic and athletic performances (Musch & Grondin, 2001).

A large body of research has provided substantial evidence to confirm RAE's within education. The difference in age between the oldest and youngest individuals within one school year group has consistently shown a difference in level of attainment regardless of gender, school subject (Massey, Elliot & Ross, 1996), assessment type (Bell, Massey & Dexter, 1997) or education stage (Bell & Daniels, 1990; Cobley, McKenna, Baker, & Wattie, 2009b). Relatively older children (born closest to the cut-off date) achieve considerably higher and are more likely to be identified as gifted and talented (Cobley et al., 2009b). On the other hand, relatively younger individuals tend to be classified with academic problems, and have poorer attendance, thus achieve less than their older peers (Musch & Grondin, 2001; Cobley, Abraham & Baker, 2008).

3.1 Relative Age Effects in Sport:

The first RAE's identified in a sporting context were established in ice hockey. Grondin et al found a skewed birthdate distribution towards players born early in the sporting year in professional ice hockey (1984). Barnsley, Thompson and Barnsley concurred finding an over-representation of ice hockey players born in the first quarter of the sporting year selected to represent Canadian provincial and national teams (January to March) (1985). Even more recently, Sherar et al found the birth date distribution of selected ice hockey players aged 14-15 to be positively skewed with the majority born early in the selection year (2007). This over-representation of athletes being born early in the selection year has been established in a number of sports such as swimming, tennis (Baxter-Jones, 1995), volleyball (Grondin et al, 1984), cricket (Edwards, 1994), baseball (Thompson, Barnsley & Stebelsky, 1991) and many more (Delorme & Raspaud, 2009; Muller et al., 2016; Sherar et al., 2007).

Typical RAE patterns, where individuals tend to be born early in the sporting year, are not seen in all sports, however. In some sports such as golf, the RAE has not been identified (Côté, Macdonald, Baker, & Abernethy, 2006). In gymnastics, the effect seems to be reversed (Baxter-Jones, 1995). Finally, in sports where physicality is less influential on performance, or where athletes are grouped according to their size, the RAE has not been identified (Delorme, 2014). The RAE in women's sports has received considerably less attention than male sports and warrants further enquiry (Musch & Grondin, 2001; Sierra-Diaz et al., 2017).

3.2: Relative Age Effects in Football:

Research pertaining to the RAE in male soccer has received considerable attention across the world for a number of years (Musch & Grondin, 2001). The first investigation in soccer by Barnsley, Thompson and Legault, found an over representation of players born in the first months of the selection year of the under 17 and under 20 1990 World Cup players (1992). Across the globe, Dudink investigated the RAE in the top two soccer leagues in the Netherlands and the top four English soccer leagues and found a significant over representation of players born in the first quarter of the selection year (1994). Significant RAE's were also found in the top professional leagues in Belgium, France (Verhulst, 1992), Germany, Japan, Brazil, and Australia, many of which have different cut-off dates for the selection year (Musch & Hay, 1999). Substantial evidence from around the world therefore suggests a RAE exists within male soccer (Sierra-Diaz et al., 2017).

Research has investigated the RAE in football within a number of different contexts such as playing position, age, and level of playing (Sierra-Diaz et al., 2017). The RAE is more evident for certain positions within football, where defenders have been consistently observed to be the most over-represented by relatively older players (Romann & Fuchslocher, 2013; Sierra-Diaz et al., 2017). Helsen, Starkes, and Van Winckel studied the RAE in youth football and found the players who were identified as talented were more likely to be born at the beginning of the selection year (1998). This effect began as young as six years of age (Helsen et al., 1998), reinforcing that relative age and maturity are independent constructs, as maturity effects would not be observed until around 11 years of age (Malina et al., 2015). The selected relatively older players were subsequently more likely to succeed in football, compared to their relatively younger peers who tended to drop out of the sport as early as 12 years old (Helsen et al., 1998). Importantly, this suggests children are dropping out of youth football due to their late date of birth within the selection year, and therefore talent identification within football appears not to be meritocratic. The over representation of relatively older players remains even in adult teams, when the associated relative age advantages during childhood have subsided (Cobley et al., 2009a). This could be explained by the "self-fulfilling prophecy"; in childhood the chronologically older are falsely defined as the most talented (because of the initial age-related advantages), evoking specific treatment for those older players

which creates the initial false judgement to be correct (Hancock, Adler & Cöté, 2013; Gladwell, 2008).

Despite the overwhelming research confirming the occurrence of RAE within football over the years, recent research suggests the effect remains (Sierra-Diaz et al., 2017). One study investigated the RAE in professional football across Europe over a ten-year period and found no change in the RAE across this time (Helsen et al., 2012). This perhaps could be attributed to the lack of work conducted in combating these RAE's (Wattie, Schorer & Baker, 2015; Mann & van Ginneken, 2016). Recently strategies to combat RAE have been tested, such as quarter four trial days and age-ordered shirt numbers, but further research and development is necessary (Mann & van Ginneken, 2016; Hibernian Media., 2016).

Section 4: Context of Elite Youth Football

In order to understand the complex nature of talent identification and evaluation in adolescence, it is important to understand the academy environment. This next section reviews the key factors that influence the academy culture, including the structure of academy football and the Elite Player Performance Plan (EPPP).

4.1 Football Academies:

The primary role of a football academy is to select, develop and nurture young potential into future sporting stars. Football clubs invest substantial amounts of money, time, and resources into identifying and developing young talented football players, with the aim for them to reach professional first team football (Vaeyens et al., 2006). Recently however, questions surrounding the process of identifying and nurturing these young athletes during the adolescent years have arisen. In spite of the substantial investments into youth football, very few young English players are reaching professional status within the English Premier League (EPL) (Sagar et al., 2010). The thinning supply of English youth footballers coming through the academy system allowed the notion that football academies were failing, to hit the headlines (Sagar et al., 2010; Conn, 2017; Magowan, 2015).

Football academies are special training schemes set up and funded by professional clubs to develop young players to play at the professional level. Scouting and recruitment begins from as young as five years of age (Platts, 2012) however players join academies

at nine years of age through to 16 years of age on school-boy terms (part-time). Training three or four times a week and fixtures on weekends, players are continuously evaluated, with a retention or release decision every two years at the end of the season. At 16, players are either offered a two year full-time contract (scholar) or are released (Mills et al., 2012). Despite over 1000 players a year between the ages of 9 and 16 being contracted to professional football academies, a minority succeed to professional status (Platts, 2012; Mills et al., 2012).

Youth elite football is notoriously competitive, where 90% of those who join an academy setting fail at attaining the professional level (Mills et al., 2012; Williams, 2009). Only 10% of players offered a scholarship at 16 attain a professional contract at 18; Of those who are successful at 18, only one in four remain in the professional game after their 23rd birthday (Anderson & Miller, 2011). Despite the increasing numbers of boys within the English academy system (around 12,000), the number of first team opportunities for these boys has been decreasing year after year (Conn, 2017).

Research and statistics continue to illustrate the shortcomings of English football academies (James, 2010; Dowling et al., 2018; Poli, Ravenel & Beeson, 2018). The CIES Football Observatory revealed progression from academy to first team is poor, with only 14.1% of EPL first team players competing for the club they trained at (Poli, Ravenel & Besson, 2018). Of Premier League footballers, 59.9% are employed from overseas (Magowan, 2015), suggesting promoting young academy graduates is not a priority. The concerns surrounding employment of overseas players has not gone unnoticed; Calvin wrote,

> *"Academy products are easily disposable. Some are kept as 'bodies' to service anaemic under-21 and under-23 teams; most are allowed to wither on the vine, since home-grown players are deemed to lack the lustre of ready-made foreign players".* (Calvin, 2017, p.15.)

The concerns regarding the import of foreign players and decline of youth progressing to the elite stage triggered the EPL to implement a new strategy: The EPPP.

Introduced in 2012, the EPPP aimed to improve and increase the development of home-grown players. The plan utilises a multi-disciplinary platform comprising of the "four corners"; physical, psychological, social/emotional, technical and tactical development to better educate and inform recruitment, development and transition through the academy (Premier League, 2012; Dowling et al., 2018). The EPPP also

encompasses a national injury surveillance project, national benchmark fitness testing, bio-banding, and growth and maturation screening (Premier League, 2012). As part of the EPPP, football academies are audited to ensure they are meeting the expected 'good practice' components and awarded a category rating from 1-4 with one being elite. This process change provided a new holistic approach to talent identification and development within youth football (Premier League, 2012).

The EPPP created a number of guidelines for clubs to follow. Academies could recruit young players from the age of four into a club training programme, however players cannot be signed until nine years of age. From there, they enter the first stage of player development, the Foundation Phase (FDP) until they are 12 years old. Players then go through their first career transition into the Youth Development Phase (YDP) for the under 13's through to under 16's. The final development stage is the Professional Development Phase (PDP) for the under 17's to the under 23's. Players can transition all the way through the successive age groups, be released, and new players can be recruited in. Talent identification and development is thus continually applied throughout the academy to aid the club in making selection, retention, and release decisions at all ages.

4.2 Talent Identification and Development Models:

Talent identification, the "process of recognising current participants with the potential to excel within a particular sport" has thus become increasingly important to ensure the contracts, resources and coaching goes to the players with the most promise (Vaeyens et al., 2008). Traditional cross-sectional models of talent identification, however, seem to exclude many young children from participating in elite sport (Vaeyens et al., 2008). It is acknowledged that the nature of identifying talented young footballers is a complex issue and so the multidisciplinary holistic approach within the EPPP is a step in the right direction for elite youth football (Meylan et al., 2010; Vaeyens et al., 2008).

Interest and research in talent identification and development has greatly expanded in recent years (Williams & Reilly, 2000; Stratton et al., 2004; Unnithan et al., 2012; Sarmento et al., 2018). Talent identification processes have shifted from a scouts and coaches' subjective assessment of a player to a more sport-science based holistic system of assessing talent in youth football (Williams & Reilly, 2000; Unnithan et al., 2012). Although the coach's 'eye' is useful in talent identification, research shows when used in isolation it can result in misjudgements and inconsistencies, thus sport science

contributions are recommended to add objectivity to identification decisions (Unnithan et al., 2012). The coach's subjective opinion on player performance, however, remains to be utilised as a key indicator of potential and ability (Larkin & Reeves, 2018; Sieghartsleitner et al., 2019).

The importance of the coach's 'eye' and their ability to judge criteria for success should not be undervalued (Thomas & Thomas, 1999). Youth coaches play a significant role in the talent identification process, applying their knowledge, experience, and intuition alongside objective multi-disciplinary measures to assess talent (Williams & Reilly, 2000; Day, 2011). Within games and training, coaches can assess talent holistically, by observing their players across multiple domains such as physical, technical, tactical, and psychological skills (Sieghartsleitner et al., 2019). Coaches are also a key stakeholder in deciding if players are selected, retained, relaesed and offered scholarhsips; however reserach focused upon the youth football coaches perceptions and experiences of the talent pathway are minimal (Mills et al., 2012). Specifically, how adolescence, growth and maturation influence coaches' perceptions and experiences of talent identification and development is lacking.

Under the EPL's EPPP initiative, the close monitoring of growth and maturation is now recommended in youth football academies (Premier League, 2012). As seen throughout, growth and maturation directly and indirectly influences player development and selection (Cumming et al., 2017a). It is therefore of upmost importance for coaches and scouts to understand growth, maturation, and development in order to tackle the RAE and maturity biases. It is of equal importance, however, for both the parents and players to understand this pubertal stage. The athlete, parent, and coach together, are key to understand all aspects of how growth, maturation, and development influence player's experiences within youth football. As can be seen in the following quote education and understanding growth and maturation can be valuable in making decisions within youth football.

> *"To educate those clubs who reject a boy for a sudden lack of physical co-ordination when a simple conversation with his mother would have elicited the information he had grown an inch in three weeks"* *(Calvin, 2017, p.25)*

Some research has explored how age and maturity status influence selection into an academy setting (Meylan et al., 2010; Johnson et al., 2017; Hill et al., 2019). It is equally important however, to understand how age, growth and maturity continue to manifest

inside the ‘selected’ academy environment. Aligned with the quote above, it is important for the talent development pathway to continually consider how growth and maturation is influencing youth coaches.

4.3 Southampton Football Academy:

Southampton Football Club are proud advocates of the EPPP and their ctageory one academy status confirms their reputation. The long list of academy graduates who achieved first team status within the Premier League and gained England caps is also verification of Southampton’s success. Gareth Bale, Adam Lallana, James Ward-Prowse, Theo Walcott and Alex Oxlade Chamberlain are just some of the footballing stars to triumph through the Southampton academy. With the help of this research, the club aim to further understand how growth and maturation affects their players and their practices. Southampton Football Club already have a good understanding of maturation as is shown in the following quote:

> *“Alex was a slender kid at 14 and his scholarhsip was in question. But he was so techincally good that aged 16 we got him to play down an age group. A year on he had his growth spurt, become a powerful athlete and six months later was in the first team”.*
> *Les Reed – Southampton’s Club Executive Director (Premier League, 2013)*

This thesis aims to further research and understand the area of growth and maturity within Southampton’s Football Academy from the coach’s perspective. It is imperative to understand how growth and maturity influences the youth coaches’ perceptions, evaluations, and experiences of managing adolescent athletes because they are a key stakeholder in the talent pathway within academy football.

Study One

Commentary

A significant body of research has investigated the impact of the RAE and biological maturation upon selection into youth football academies (Meylan et al., 2010; Sierra-Diaz et al., 2017; Johnson et al., 2017). Research shows a selection bias and a consequential over-representation of both chronologically older and biologically older players within academies; evidence shows relative age and biological maturity selection biases operate independently (Johnson et al., 2017; Hill et al., 2019).

The systematic exclusion of both chronologically and/or biologically younger players is problematic within talent identification pathways (Malina et al., 2015; Johnson et al., 2017; Patel et al., 2019). Younger and late maturing players are being continually excluded from entering talent pathways based upon attributes in which they have no control over (relative age and maturity status) and which are redundant in adulthood (Cumming et al., 2017a; Hill et al., 2019). Talent identification models influenced by RAE and biological maturation are thus, ineffective, and inefficient (Hill et al., 2019).

It is known that the RAE and maturation selection biases simultaneously impact selection into youth football, but very few studies have investigated the impact of both (Johnson et al., 2017; Hill et al., 2019; Patel et al., 2019). Further, research investigating if relative age and biological maturity continues to influence the selected players inside football academies is limited. It is important to know if individual variation in chronological age and biological maturity continues to influence the selected players inside academy programmes; coaches evaluations and selection and release decisions within the talent pathway, may be influenced by relative age and biological maturation, alike recruitment. This study aimed to understand the degree to which variance in relative age and biological maturity influenced coaches' perceptions of game performance within a youth football academy. This is relevant to this thesis as it aims to understand how relative age and biological maturity continues to impact youth football players inside football academies.

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Are Relative Age and Biological Ages Associated with Coaches' Evaluations of Match Performance in Male Academy Soccer Players?									
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Candidate's contribution to the paper (provide details, and also indicate as a percentage)	The candidate contributed to / considerably contributed to / predominantly executed the… Formulation of ideas: 80% of idea and research question came from the candidate Design of methodology: 90% of design and methodology by candidate with guidance and input from supervisory team. Experimental work: 80%- Much of the data was already collected. Candidate collated and cleaned the dataset and carried out data analysis Presentation of data in journal format: 90%- written by candidate; edited and redrafted with supervisory team.								
Statement from Candidate	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature.								
Signed	[redacted] Megan Hill					**Date**	19/10/2020		

Are Relative Age and Biological Ages Associated with Coaches' Evaluations of Match Performance in Male Academy Soccer Players?

Abstract:

Talent identification and selection in soccer has been shown to be confounded by individual differences in relative age and biological maturation. Limited research has however, investigated whether these effects are reflected in coaches' evaluations of performance. This study investigated relative and biological age associated differences in coach perceptions of performance in a professional soccer academy across four seasons. The performances of 279 male players were evaluated on a 4-point Likert-scale. Multi-level modelling was used to examine predictive relationships between biological age, chronological age, result, and opposition of game, on match grades. Result of the games was a statistically significant predictor of players perceived performance in every age-group; category of opposition was only significant in the under 13 and 14 age-groups. Biological age significantly predicted players perceived performance grades in the under 10, 14 and 15 age-groups, whereby advanced maturity predicted a higher grade. Across all age-groups, a relative age effect was observed, however age half was not a significant predictor of perceived performance grade in any age-group. Coaches evaluations of match performance appear to vary in accordance with maturity, opposition, and result of game. Academy staff should recognise and account for individual differences in biological maturation when retaining and releasing players.

Keywords: Soccer, talent identification, evaluation, maturation, relative age.

Introduction:

The identification and development of young soccer players is a primary objective of professional soccer academies. [1] Professional soccer academies scout and recruit talented players from increasingly young ages. [2] Those identified as talented are invited to join development programmes and/or academies and benefit from greater investment in their development and access to professional coaching and sports science/medicine support. [3, 4] The literature surrounding talent identification advocates for a holistic approach, considering the athlete's physical, technical, and psychosocial attributes. [5]

Two factors known to impact player selection and retention in academy soccer are relative age and biological maturity.[6, 7] Relative age is the difference in chronological age between the oldest and youngest individuals within an age group determined by date of birth and age group cut off dates. Athletes born close to the sporting cut-off date (September 1st in English soccer) are chronologically almost one year older than their peers born at the end of the sporting year (August 31st). In contrast, biological maturation refers to the process of progression towards the mature state, defined in terms of status, timing and tempo.[8] Children of the same chronological age have been shown to vary by as much as five to six years in skeletal (i.e., biological) age. [3, 9] Individual variation in maturation is determined by a combination of hereditary (i.e., genes) and, to a lesser extent, environmental factors (e.g., stress). [10, 11] Thus, it is entirely possible for the oldest athlete within a competitive age group to also be the least mature within his or her cohort, and vice versa. [7] In support of this contention, recent research observed that relatively younger male players were more likely to be advanced in maturation for their age. [12]

Relative age and biological maturity are often considered and treated as synonymous. They do, however, exist and operate independent of one another. [4] The relative age effect (RAE), whereby older players are disproportionally represented and retained in youth soccer, can be observed from early childhood and is relatively stable through adolescence. [7, 13, 14] Whereas some studies have reported a reversal of the RAE in adulthood; an equal, if not greater number, of studies have reported no such reversal or, at most, a small attenuation in the effect. [15] In contrast, the selection bias towards players advanced in maturity emerges with the onset of puberty (approximately 11 to 12 years of age) and generally increases with age and level of competition. [3, 8] Given the independent nature of these phenomenon's, it is logical to assume that the RAE and

maturity selection biases arise from and be governed by different factors and, thus, may require independent solutions.

The physical and athletic advantages (i.e., greater size, lean mass, speed, power, and strength) of advanced maturation are well documented in boys' soccer. [6, 16, 17] Most of this evidence is, however, limited to tests of strength, speed and power using standardised testing batteries. Advanced maturation has also been shown to contribute towards more successful performance on a range of different skills tests, though to a smaller degree. [18] The extent to which these advantages are also observed in relation to in game performance is, as of yet, unclear. Some studies have investigated the influence of biological maturity on match performance but have assessed physical capacity through speed zones [19] and match running performance [20], rather than performance as a whole. Although standardised performance testing and objective data collected through Global Positioning System (GPS) can aid the practitioner's understanding on player's ability and potential, it may not reflect the quality of the individual's technical or tactical attributes. [21, 22, 23] Accordingly, Malina recommended that further studies are needed to understand variation in performance associated with maturity, which need to include a broader variety of performance measures than traditional standardised testing [17].

The 'coach's eye' is considered to be an essential part of the talent identification process; skilled, knowledgeable, and experienced coaches and scouts are often employed to recognise potential athletes, with physiological testing results used to support the subjective assessment of talent. [1, 21] In addition to the player's inherent attributes (i.e., skill, performance, knowledge, technical & tactical awareness), coaches' evaluations of talent in soccer have been shown to be influenced by a multitude of factors including intuition, experiences, personal preference and philosophy, and the sporting culture. [23] Coaches' evaluations of player performance across games also play a central role in the process of deciding whether players are recruited, retained, or released. The physical and athletic advantages associated with advanced relative age and/or biological age may also act to influence coaches' perceptions of talent. [4, 24]

Primary scientific literature promotes multi-dimensional models of talent identification; however, the coaches' subjective assessment of game performance continues to be used as a core indicator of ability and future potential. [26, 27] The coach's observation of match game performances provides a holistic measure of performance, as players are able to show a variety of their talent and skills. Early maturing players are able to display their strength, speed, and power and therefore tend to dominate the game

physically, [4, 28] whereas later maturing individuals are more likely to display their technical and tactical ability (i.e. decision making, awareness) which are all deemed important qualities for success. [29] Coaches can use and integrate the information from a number of different domains shown in a game to judge the player as a whole.[27] The coach's perceptions of their player's performances is crucial, therefore a holistic approach to evaluating performance, such as game observations, is required. As previously noted, it is often the coach's decision as to whether a player is selected or released from a talent programme, thus evaluating if relative age and biological age influence the coach's perceptions of performance throughout adolescence is imperative.

Research investigating the impact of relative age and biological age upon coaches' evaluations of performance are limited. Biological maturation has previously been shown to influence coaches' predictions of long-term potential in under-16 Australian male soccer players.[30] Coaches were asked to rate each player's long term potential in terms of the level of competition they will attain; results demonstrated that later maturing players were perceived to have a significantly lower long-term potential than their average and early maturing teammates.[30] This study used a cross-sectional rating of potential, in a group of under 16's. [30] As soccer is a sport that selects for early maturing boys from eleven years of age, it is possible that the sample in this study may not have had the appropriate range of early, on time and late maturing players required to fully understand the associations between maturity and coach perceptions of ability/potential [3, 8]

In light of the previous discussion, the purpose of the current investigation is to understand the degree to which variance in relative age and biological age influences coaches' perceptions of game performance in elite youth soccer players who play for an English Premier League Soccer Academy (Southampton Football Club). Assuming that older relative and biological age afford a performance advantage in youth soccer, it was predicted that both of these variables would be positively associated with coach evaluations of match performance. That is, relatively older and more mature players would receive higher match ratings than their younger and/or late maturing peers, respectively. Given that coach evaluations of player performance may be confounded by the game outcome and standard of opposition, these variables were examined in parallel with differences in biological and relative age.

Method:

Participants:

Participants included male academy players registered and playing for the under-9 to under-16 age groups at Southampton Football Club between July 2014 and June 2018. Players were divided into chronological age groups of 12-month bands, beginning in September and ending in August. Data was collected from all academy games within this time (tournaments excluded). Within this period, 279 participants were included, however many players participated in multiple games over the four seasons and therefore 13199 data points were collected. For a game to be included within the analysis, the player must have played over 40 minutes in the game, thus the final number of data points analysed was 12272 from 279 athletes.

Relative Age (Age-Half):

A player's birthdate and date of game was used to calculate their decimal age for each game. Within each team (age group) playing every game, players were ordered in terms of their chronological age and split into two halves. The players in the top half (coded as 0) represented the oldest and the players in the bottom half (coded as 1) the youngest. This was carried out to understand where a player was positioned in their team in terms of their chronological age. Birth quarter was also collected, with September, October and November coded as birth quarter 1, December to February as birth quarter 2, March to May as birth quarter 3 and June, July and August coded as birth quarter 4 to understand relative age.

Biological Age (%PAH z-score):

Biological maturity status was estimated using percentage of predicted mature adult height attained at the time of observation. [31] Among children of the same chronological age, children who are estimated to be closer to their adult height (higher percentage) are more advanced in maturation compared to those further away from their predicted adult height. To predict adult height, the Khamis-Roche method was used which requires current age, height and weight of the player and mid-parent height (i.e. the biological parents mean height). [31] The median error bound for this Khamis-Roche method between the actual height and that of the predicted adult height is 2.2cm for males between the ages of 4 to 17.5 years. [31] For the age groups used within this study, 9 to 16 years old, the lowest 50% error was 1.3cm for the 16year olds, and the highest 50% error was 2.8cm for the 14-year olds. [31] Trained academy sports scientists used standardised procedures to measure height and weights of the player (around every 12 weeks). Parents self-reported their heights, which were subsequently adjusted for overestimation. [32]

For each game, the most recent estimate of biological maturity status was utilised. To be included the nearest measurement of biological maturity status had to be within the six months before the game. If a player missed a measurement and therefore didn't have a measurement within the six months before the game, their biological maturity status was coded as missing for that game; if a player's biological maturity status could not be estimated (no biological parent height) their biological maturity status was coded as missing. For every game, a z-score was created using percentage of predicted adult height to understand where each player was positioned in their team in terms of their biological maturity.

Match Grade, Result and Opposition:

As part of normal procedures in Southampton's soccer academy, every player has their performance evaluated and graded by their coach. Grades range from one to four, with one representing not at academy standard; two, approaching academy standard; three, meeting academy standard and four, exceeding academy standard; standards are outlined by the academy relative to what is expected at each age group. Consequently, for every game a player has participated in they have a corresponding match grade indicating their performance (to be included in the analysis, the player must have played over 40 minutes in the game). Opposition teams were coded according to the Premier League Academy category status, with the standard of the opposing team rated from 1-4, with 1 being the most elite and 4 the least elite opposition (local grass-root teams). Result of each game was also coded as loss (0), draw (1) and win (2).

Ethics:

When players register with Southampton Football Club's academy, they, and their parents/guardians' consent to routine collection of data. This also includes consent to the potential use of this data for research and publication purposes. All measurements of height and weight were taken on a voluntary basis and participants had the right not to be assessed. The Research Ethics Approval Committee for Health of Bath University (REACH) approved this research study and the right to use the retrospective anonymous data.

Statistical Methods:

Data was inputted and analysed using IBM SPSS (version 23; SPSS Inc, Chicago, USA). Descriptive statistics were conducted looking at means and standard deviations of

chronological age, match grades and percentage of predicted adult height. A series of multi-level models (i.e. hierarchical linear modelling) using maximal likelihood estimation were conducted to examine the predictive associations between biological maturity status, relative age, result and opposition and the performance match grade amongst. Separate analyses were conducted for each age group. In accordance with processes outlined by Field (2005) a stepwise approach was employed whereby potential predictors of match performance were entered in stages and the comparative fit of successive models was evaluated at each stage. [33] Model fit was evaluated using the Akaike Information Criterion (AIC). [34] The AIC was chosen as the index of model fit as it provides a better estimate of comparative fit across models, is more conducive to model parsimony, and less likely to generate an overfitted model. The baseline Model (Model 1) included only the dependent variable (i.e., match grade). A random intercept model accounting for the nesting of repeated measures across individuals was then tested (Model 2). In the next model, the slopes describing the predictive association of maturation, age-half, opposition status, and match outcome upon match performance were entered as fixed factors (Model 3). In the final model (Model 4), the slopes were allowed to vary for age-half, result and opposition status. Biological maturation remained as a fixed factor in the final model as it was entered as a continuous and non-categorical variable.

Results:

Descriptive statistics for chronological age, match grade, and percentage of predicted adult height are reported in Table 1. The descriptive statistics shows the mean values for chronological age and biological age increases with successive age groups. For percentage of predicted adult height, the standard deviation generally increased with age up to the under 15 age group (with the exception of the under 11 age group). Mean match grades generally decreased with age and standard deviations remained fairly consistent across the age groups. The relative age effect, when expressed by birth quarters, 47.6% of all players were born in birth quarter 1 (September-November); corresponding percentages of players born in the other birth quarters were 22.6% in birth quarter 2, 17.0% in birth quarter 3 and 12.8% in birth quarter 4 (June to August).

Table 1: Descriptive statistics showing means and standard deviations of chronological age, biological age (%PAH) and match grade and across the age groups.

		Chronological Age		**Match Grade**			**Biological Age (% of PAH)**	
	n	M	SD	M	SD	*n*	M	SD
Under 9	*1684*	8.99	0.39	2.49	0.63	*1642*	74.73	1.89
Under 10	*1608*	9.91	0.45	2.50	0.63	*1566*	77.35	1.90
Under 11	*1609*	10.90	0.47	2.48	0.63	*1577*	80.31	1.83
Under 12	*1658*	11.86	0.48	2.49	0.62	*1658*	83.00	2.04
Under 13	*1836*	12.89	0.49	2.29	0.71	*1828*	86.87	2.52
Under 14	*1580*	13.92	0.54	2.25	0.68	*1552*	91.28	2.81
Under 15	*1213*	14.80	0.50	2.21	0.71	*1182*	95.15	2.03
Under 16	*1084*	15.72	0.55	1.93	0.71	*1052*	97.64	1.39

Table 2: Multi-level Model explaining biological maturation (%PAH z-score) and chronological age (age half- oldest or youngest halves) relative to teammates on performance match grade.

Multilevel models	β	SE	*F*	*P*	95% CI
Under 9					
Intercept	2.16	0.10	498.2	**.000**	1.97, 2.35
Match Result	0.16	0.02	96.8	**.000**	0.13, 0.19
Opposition Status	-0.03	0.02	2.8	.097	-0.07, 0.01
Biological Age	0.03	0.03	1.4	.234	-0.02, 0.10
Age Half	0.01	0.06	0.1	.810	-0.10, 0.13
Under 10					
Intercept	2.10	0.09	498.9	**.000**	1.91, 2.28
Match Result	0.13	0.02	52.5	**.000**	0.09, 0.16
Opposition Status	-0.01	0.02	0.2	.643	-0.04, 0.03
Biological Age	0.06	0.03	4.2	**.040**	0.00, 0.11
Age Half	0.08	0.05	2.7	.100	-0.02, 0.18
Under 11					
Intercept	2.16	0.09	604.6	**.000**	2.00, 2.33
Match Result	0.14	0.02	70.6	**.000**	0.11, 0.18
Opposition Status	-0.02	0.02	0.8	.386	-0.06, 0.02
Biological Age	0.03	0.03	1.4	.233	-0.02, 0.08
Age Half	0.01	0.05	0.1	.792	-0.08, 0.10
Under 12					
Intercept	2.15	0.09	604.6	**.000**	1.98, 2.32
Match Result	0.13	0.02	75.6	**.000**	0.10, 0.16
Opposition Status	0.01	0.02	0.1	.724	-0.03, 0.04
Biological Age	0.00	0.03	0.0	.876	-0.05, 0.06
Age Half	-0.00	0.05	0.0	.989	-0.09, 0.09
Under 13					
Intercept	1.81	0.09	376.2	**.000**	1.62, 1.99
Match Result	0.22	0.02	165.6	**.000**	0.19, 0.25
Opposition Status	0.06	0.02	17.2	**.000**	0.03, 0.09
Biological Age	0.01	0.03	0.1	.806	-0.05, 0.06
Age Half	-0.07	0.05	2.00	.161	-0.17, 0.03
Under 14					
Intercept	1.71	0.09	376.0	**.000**	1.54, 1.89
Match Result	0.27	0.02	224.6	**.000**	0.23, 0.30
Opposition Status	0.05	0.02	8.3	**.004**	0.02, 0.08
Biological Age	0.09	0.03	10.7	**.001**	0.04, 0.14
Age Half	-0.04	0.05	0.9	.356	-0.14, 0.05
Under 15					
Intercept	1.67	0.11	233.7	**.000**	1.46, 1.89
Match Result	0.29	0.02	166.9	**.000**	0.25, 0.33
Opposition Status	-0.01	0.02	0.1	.723	-0.05, 0.03
Biological Age	0.16	0.03	24.6	**.000**	0.10, 0.22
Age Half	-0.01	0.06	0.0	.889	-0.13, 0.11
Under 16					
Intercept	1.4	0.11	181.2	**.000**	1.97, 2.35
Match Result	0.22	0.02	91.0	**.000**	0.13, 0.19
Opposition Status	-0.01	0.03	0.1	.789	-0.07, 0.01
Biological Age	0.06	0.03	3.5	.063	-0.02, 0.09
Age Half	0.01	0.06	0.1	.831	-0.10, 0.13

CI= Confidence Interval; **Bold**=*P*<0.05

Match Result= Win (2), draw (1), loss (0). Opposition Status= 1-4 (most to least elite). Biological age= %PAH Z-score. Age Half= top half (0), bottom half (1).

Across all of the age groups, Model 3 was statistically significant and provided the best degree of model fit. That is, allowing the slopes to vary relative to result, standard of opposition, or age half did not result in any improvements to model fit. As such, Model 3 was treated as the final Model in all age groups. The Estimated Mean coefficients (β), standard error estimates (SE), significance (*p*) and 95% confidence intervals (CI) associated with the best fitting Model is presented in Table 2. Consideration of the main effects associated with Model 3 demonstrated that advanced maturation was positively associated with higher ratings of match performance in the U10, U14 and U15 age groups. Relative age (age half) was, however, unrelated to coach evaluations of match performance in any of the age groups. Game outcomes were positively associated with ratings of match performance in all of the age groups. That is, coaches awarded higher ratings of match performances when the game outcomes were more positive (i.e., draws and wins, versus losses). Finally, opposition status was associated with superior rating of match performance in only the U13 and U14 age groups, with players in these age groups being awarded higher match ratings when competing against poorer opposition level academies.

Discussion:

The purpose of this study was to investigate the degree to which variance in relative age and biological age among players was related to coaches' evaluations of player match performances in academy soccer. Multilevel modelling, controlling for match outcome, standard of opposition and nesting of data within individuals revealed that advanced biological maturation was associated with more positive coach evaluations of match performance in the U10, U14 and U15 age groups. That is players who matured in advance of their peers were considered to performed better. Advanced maturation was not significantly associated with coaches' evaluations of performance in the U9, U11 through to U13 and the U16 age groups. Contrary to expectation, relative age was unrelated to coach evaluations of match performance in all of the age groups.

Although there are no existing studies to directly compare the result of the current investigation, the findings from this study are generally consistent with those examining the impact of biological maturation upon player selection and performance in Academy soccer. [3, 5, 35] As previously noted, from the onset of puberty early maturing players have consistently been shown to outperform their later maturing peers on most tests of physical fitness and, to a lesser degree, skill performance. [4, 16, 17] During competition, early

maturing players have also shown to reach higher peak speed, cover greater distance at speed, and engage in more singular and repeated instances of high intensity activity.[19, 20, 36, 37, 38, 39] A selection bias toward early maturing players is also evident from the onset of puberty, generally increases in magnitude with age and competitive level. [3, 6, 40] Accordingly, it is not surprising that the physical and athletic advantages associated with advanced maturity are also reflected in coach evaluations of game performance in some of age groups.

The failure to observe an association between relative age and coach evaluations of match performance is somewhat surprising, given that a relative age effect in this sample was previously documented.[35] It is well established that relative age plays an important role in the selection and recruitment of academy players. [13, 14] The degree to which relative age impacts player performance following entry into the academy system is, however, less clear. Research examining the associations between relative age and physical fitness/aptitude in academy players have generally shown little to no association between the constructs of interest. [41] That is, once in an academy setting relative age has limited bearing upon player performance and/or retention. This may be due to a number of factors including limited variance in relative age within the academy population and/or differences in the performance characteristics or attributes of relatively old and young academy players. Extreme differences in chronological age are contained to one year within a single age group, and with results showing a disproportionate number of players to be born in the first half of the competitive year, extreme differences in relative age are limited. Further, aligned with the underdog theory, the limited number of relatively younger born athletes selected into academy systems, need to possess superior physical, technical and psychological attributes in order to remain competitive. [4, 42, 43.]

Result of the game was found to be statistically significant in all age groups, with coaches awarding higher performance grades to players when the team were more successful. In terms of opposition, when the opposing team were classified as a weaker opponent (a lower category classification), perceived performance grades were higher and statistically significant in the under 13 and under 14 age groups only. It is not surprising coaches perceive greater performances from their players when they are winning or playing seemingly poorer oppositions; either the team performed better thus higher performance grades were warranted or the success of the game biases coaches' perceptions positively.

It is also important to note the general decrease in performance grades with chronological age as seen in Table 1. This may reflect the increase in competition and expectations with advanced age or poor performances against opposition teams with a more pronounced maturity selection bias than the sampled academy population.[35] Further, decrements in performances grades with age may reflect the adolescent growth spurt. Results showed associations between match grade and maturity in the Under 11 through to Under 13 age groups failed to reach significance; early maturing players in these age groups may have any advantages of advanced maturation mitigated by the challenges experiences with the growth spurt. Research has shown the adolescent growth spurt can present significant challenges in terms of increased risk of injury and adolescent awkwardness factors such as coordination, mobility, and skill execution. [4, 38, 44, 45, 46, 47] Additionally, in the older age groups, players advanced in maturity have overcome growth-related challenges, have acquired the maturity-associated advantages and as some researchers and coaches suggest, got "their growing out of the way". [48]

The findings of this study have practical implications for those working within youth soccer academies. When identifying, selecting and/or evaluating players; awareness and consideration of differences in biological maturity is important. As shown, maturity is positively associated with coach's player evaluations, which play an important role in selection, retention, and release decisions. Ideally, when selection decisions are made, players should be evaluated in order of maturation; doing so would provide decision makers with the context and awareness of where a player is in their development, but also may draw attention to the individual differences in maturity influencing coaches performance grades. Further, it may be beneficial to understand whether a player is experiencing their growth spurt when making selection decisions based upon performance grades. Future studies should assess the influence of the growth spurt on match grades, as well as the reliability and validity of assessing players via a match grade.

Limitations of this study should be noted. First, the results of this study are specific to one professional academy and may not generalise to other academies or grassroots competition. For example, the degree to which coaches place value upon physical and/or athletic aptitude may vary relative to the level of competition, coaches' understanding and awareness of growth and maturation, and or the academies underlying philosophy of player development. The measure of performance used in this research is also reliant on a single item evaluating performance that is scored on a continuum from 1 to 4. While this method has ecologically validity (i.e., it is the system currently used to

evaluate match performance), information regarding the validity and reliability of this scale as a measure of performance is lacking. Further, the reliability of this scale is limited by the single item and the relatively small number of response items. This limitation is further compounded when you consider that the majority of the performance grades awarded fall within the middle response categories, liming variation on this scale (match grades of 2's and 3's). Reliability is generally higher for scales or items that provide and utilise a greater number of response categories. Lower levels of reliability can attenuate effects, making associations or differences look smaller than they are in reality. Future research should seek to validate and determine the reliability of this measure of performance.

According to our findings, a player's biological maturity status within their team can influence the coaches' perception of their performance for some age groups. Positive match outcomes are also associated with higher perceived performance ratings. This study provides further support for sport practitioners and coaches to understand maturation continues to affect an individual's development and not just their selection into a sport. [18]

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Study Two:

Commentary:

Research shows the RAE and biological maturation impact selection into youth sports, including football (Meylan et al., 2010; Sierra-Diaz et al., 2017). The previous study assessed the degree to which variance in relative age and biological maturation influenced coaches' perceptions of game performance within a youth football academy. Findings showed biological maturity significantly impacted a player's perceived performance grade in the under 10, 14 and 15 age groups, whereby, advanced maturity was associated with a higher match grade. Chronological age was, however, not a significant predictor of match grade in any of the age groups. Further, descriptive statistics found coaches evaluated performance grades generally decreased with chronological age; this was hypothesised to reflect the increase in competition and associated expectations with advancing age, but potentially also the adolescent growth spurt. For the under 11 to under 13 age groups, associations between maturity and match grade failed to reach significance; early maturing players in these age groups are likely to be experiencing their adolescent growth spurt and thus may be challenged by adolescent awkwardness and injuries (Beunen & Malina, 1988; Malina et al., 2004a; Kemper et al., 2015).

Youth coaches are uniquely challenged, because one chronological age group can present players ranging from pre-, during, to post-growth spurt (Buchheit and Mendez-Villanueva 2014; Cumming et al. 2017a). Previous research has shown that the adolescent growth spurt increases the development of peak and functional attributes (Philippaerts et al. 2006), increases the susceptibility of injuries (McKay, Cumming & Blake, 2019), and potentially triggers a period of adolescent awkwardness (Beunen & Malina, 1988). Importantly for coaches, these changes associated with the growth spurt will be occurring at different times for their players dependent upon maturity timing. It is unknown how the adolescent growth spurt impacts subjective coaches' evaluations of player performance in academy football; this study aims to fill this gap within the literature. It is important to understand how the adolescent growth spurt influences the coach's evaluations as coaches are key stakeholders in selection, retention, and release decisions. This is relevant to this thesis as it aims to understand how the adolescent growth spurt, and maturity timing influences coaches' perceptions and evaluations in academy football.

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Statement from Candidate	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature.				
Signed	[redacted] Megan Hill		**Date**	19/10/2020	

“Coaches’ Evaluations of Match Performance in Academy Soccer Players in relation to the Adolescent Growth Spurt”

Abstract:

Individual differences in biological maturation present challenges for coaches involved with youth soccer players. Youth in the same chronological age group vary in terms of stage of maturity (pre, circum- and post-pubescent) and rate of growth, but how this affects coaches’ evaluations of player performance is unknown. The aim of this study was to compare youth soccer coaches’ evaluations of players match performances before, during and post growth spurt in a professional English soccer academy across four seasons. 278 male soccer players in the under-9 to under-16 age-groups had their performances evaluated by their coach on a 4-point Likert scale. For each game, players were categorised by their maturity status estimated using percentage of predicted adult height at the time of observation. A one-way ANCOVA controlling for the level of opposition and game outcome revealed that coaches’ evaluations declined from the pre- to during growth spurt stages, however, this was only significant in the under 12 age-group. Further, coaches’ evaluations increased again in the post-growth spurt stage, although only significant in the under 15 age-group. Coaches evaluations of player performance appear to vary in accordance with stage of maturity and rate of growth. Practitioners in youth soccer should understand the extent to which maturity status may adversely impact performance and consider this when making talent selection decisions.

Keywords: Soccer, maturity, growth, adolescence, evaluation

Introduction:

Traditionally, academy soccer players train and compete in groups dictated by their chronological age (e.g., Under 11 years, Under 12 years). Children of the same age can, however, demonstrate significant variation in biological maturity with some individuals entering puberty well in advance or delay of their same age peers (Malina et al. 2019). Children of the same age have been shown to vary by as much as five to six years in terms of skeletal age, an established proxy of maturation in youth (Johnson et al. 2009).

Individual differences in biological maturation present significant challenges for those involved in the identification and development of talented young athletes (Cumming et al. 2017). Within any single year age group, a coach will have to manage, train and evaluate players who vary markedly in size, athleticism, and stage of maturity (i.e., pre-, circum-, & post-pubescent) (Buchheit and Mendez-Villanueva 2014; Cumming et al. 2017). Although children can demonstrate marked variation in the timing of maturation, the pattern of growth is generally the same for all healthy children (Sanders et al. 2017). It occurs distal to proximal, so the extremities undergo growth first (feet, hands and head), followed by the arms and legs, the length and then the width of the trunk (Anderson and Twist 2005, Malina et al. 2004; Viru et al. 1999).

Growth in childhood is steady and predictable, with boys and girls gaining approximately five to seven centimetres and two to three kilogrammes per year from early- to late-childhood (Malina et al. 2004; Rogol et al. 2000; Tanner 1989). In childhood, growth in stature is disproportionally greater in the extremities (i.e. arms and legs) than the torso resulting in physique that has comparatively greater leg length (Cameron and Bogin 2012; Malina et al. 2004). Gains in mass during childhood result from both fat and fat-free mass, with modest increases in lean mass and slight reductions in relative fat mass (Malina et al. 2004). Improvements in physical fitness are also modest, with steady, predictable, and linear improvements in speed, strength, power, and aerobic capacity (Beunen and Malina 1988). Whereas children who mature in advance of their peers tend to be taller and heavier than their same age peers, they typically do not demonstrate marked advantages in athleticism (Malina et al. 2004).

Individual differences in biological maturation have greater consequence at the onset of puberty (Malina et al. 2015). The age at which children enter puberty is highly variable and determined by hereditary (i.e., genetic) and environmental/behavioural factors (e.g., stress, physical activity, nutrition) (Cameron and Bogin 2012). The

hormonal changes mark the onset of puberty, occur on average, around 9 to 10 years of age in males. The more overt and physical changes associated with puberty (i.e., changes in secondary sex characteristics, growth spurt) do not, however, emerge until approximately 11 to 12 years of age (Malina et al. 2004). The pubertal growth spurt is the most salient feature of puberty and characterised by rapid increases in stature then, approximately 3 to 6 months later, mass (Malina et al. 2004; Rogol et al. 2000). Peak height velocity (PHV), the most rapid point of growth in stature, occurs at approximately 14 years of age in boys yet varies relative to timing (Beunen and Malina 1988; Malina et al. 2004; Marshall and Tanner 1970). Whereas early maturing boys may achieve PHV at 11 or 12 years of age, late maturing boys may not experience PHV until 16 or 17 years of age. Mean values for growth in stature at PHV generally fall between 8 to 14 centimetres per year (Malina et al. 2004), though tend to be greater in early maturing males. Due to the saltatory (i.e., episodic) nature of growth, it is not uncommon to record notably higher growth rates, especially if a child is assessed on a more frequent basis (Beunen and Malina 1988; Marshall 1971). During puberty, growth is predominantly in the upper torso. Peak gains in mass (PWV) typically occur 3 to 6 months following PHV and are largely attributable to gain in lean mass. Rates of growth in mass during puberty approximate 10-12kg per year, though vary across individuals (Rogol et al. 2000). As with stature, early maturing boys experience greater pubertal gains in lean mass than their late maturing peers (McKay et al. 2019). After PHV and PWV, growth velocity in stature decreases, ceasing when adult (i.e., mature) stature is attained (Cameron and Bogin 2012). By the end of the growth spurt all body parts return to proportion.

Aligned with the adolescent growth spurt is the peak development of many physiological and functional attributes (Malina et al., 2005; Pearson et al. 2006; Philippaerts et al. 2006; Teunissen et al., 2020). Longitudinal research has shown improvement in various tests of functional capacity vary relative to the timing of the adolescent growth spurt (Beunen and Malina 1988). The rate of improvement of limb speed occurs 18 to 24 months before PHV, flexibility increases 6 months before PHV and strength and power increases 6 to 12 months after PHV (Beunen et al. 1988; Stratton and Oliver 2014). The development of these attributes is associated with PHV, however with the variability in the timing and tempo of growth and maturation, means there is a consequential variability in the development of physical and physiological characteristics within a group (Malina et al. 2005). As a result, the comparison of players test scores according to chronological age is greatly confounded by differences in pubertal timing.

Importantly, elite level football requires highly developed physical characteristics such as speed, power, and agility (Stolen et al. 2005; Williams and Reilly 2000). Thus, growth and maturity should be considered when evaluating players and making talent identification decisions (Cumming et al. 2017).

The physical and athletic benefits associated with puberty in males are well documented (Buchheit and Mendez-Villanueva 2014; Cumming et al. 2017; Malina et al. 2004; Meylan et al. 2010). What is less clear, however, is the extent to which these changes may also adversely impact athletic performance. Adolescent awkwardness is a concept that has been proposed and widely debated within the field of paediatric exercise. The phenomenon, first described by Homburger in 1922 (Homburger, in Beunen and Malina 1988), refers to a temporary disruption in neuromuscular control and proprioceptive ability that coincides with the adolescent growth spurt (Beunen and Malina 1988; Lloyd et al. 2014). Research by Hirtz and Starosta found 90% of boys showed clear, often considerable, impairment of coordination aligned with their growth spurt (2002). Awkwardness has been attributed to a combination of factors including rapid and asynchronous change in body size, composition and physique, reductions in mobility, flexibility and coordination, marked changes in strength and power, and developmental changes in how the brain assimilates and processes information about body positioning (John et al. 2018; Quatman-Yates et al. 2012; Viel et al. 2009). Anecdotally, growing teenagers are often described as clumsy and awkward in their movements. There is, however, limited empirical evidence to support this concept or an associated decline in athletic performance (Davies and Rose 2000; Malina et al. 2005). This lack of evidence may, however, be due to the complex and transient nature associated with both identifying and measuring the phenomena (John et al. 2018) and a lack of longitudinal research investigating changes in performance during adolescence. That said, emerging evidence suggests at least a plateau or decline in tasks requiring balance and coordination during the growth spurt, especially in boys (Beunen and Malina 1988; Ryan et al. 2018; Quatman-Yates et al. 2012). Speed (30m sprint time) has also been shown to be impaired in the year preceding PHV, potentially due to the growth spurt commencing in the lower limbs (Philippaerts et al. 2006). That said, despite a strong body of evidence, the concept of ‘adolescent awkwardness’ is generally accepted within the coaching community, especially in sports and activities that require fine motor control and/or enhanced mobility and flexibility (Beunen and Malina 1988).

Another concern pertaining to the pubertal growth spurt is that children are more vulnerable to certain types of injury during this stage of development (Caine et al., 2014; Froholdt et al., 2009; Quatman-Yates et al. 2012; van der Sluis et al. 2014). Risk factors that are unique to this adolescent phase include vulnerability of growth plates, differences in biological and chronological age, and an asynchrony between bone lengthening and mineralisation (Caine et al. 2014). Peak weight velocity (PWV), the maximum rate of increase in body mass, occurs shortly after PHV (Rogol et al. 2000), where muscle mass increases rapidly with a consequential increase in forces the athlete can produce. Adolescent awkwardness, or a decline in motor coordination, and an increase in forces produced means athletes may also increase susceptibility to injury during puberty (van der Sluis et al. 2014; Wik et al. 2020). Growth related disorders such as Osgood Schlatter and Sever's disease cause pain in the knee and the heel respectively and are often seen in youth playing sports who are during and beginning their growth spurt respectively (Price et al. 2004). Thus, players experiencing PHV are particularly vulnerable to pain and traumatic injuries (van der Sluis et al. 2014).

The adolescent growth spurt and the accompanying changes may adversely impact playing performance in academy soccer. Players undergoing their adolescent growth spurt experience several changes and affects in which players pre or post growth will not be facing to the same extreme. Youth in their growth spurt will be experiencing advancements in their physical capabilities but may also be experiencing awkwardness and pain or injury associated with their increased growth. Research has shown performances in physical testing scores to be affected by this adolescent growth spurt (Philippaerts et al. 2006). Although physical testing scores are a valuable tool for talent identification, a coach's subjective opinion of players' match performances is pivotal in whether young players are retained or released (Day 2011; Lund and Soderstrom 2017; Williams and Reilly, 2000). It is, therefore, important to understand if this adolescent phase of accelerated growth influences coaches' evaluations of game performance.

In light of the previous discussion, the purpose of this investigation is to consider the impact of the adolescent growth spurt upon coach evaluations of player performance in academy soccer. Consistent with the concept of adolescent awkwardness, it is hypothesised that coaches' evaluations of player 'match performances' will vary relative to their stage of development. More specifically, it is expected that players will receive poorer match grades during the growth spurt than pre- and post-growth spurt.

Method:

Participants:

The sample for this study was made up of under-9 to under-16 age group players registered for a category one Premier League Football Academy between July 2014 and June 2018. Data was collected from all academy games within this period (tournaments and games where a player played less than 40 minutes game time were excluded). Within this period, 278 participants were included, however many players participated in multiple games over the four seasons and therefore multiple data points per player were collected.

Through the process of registering with the Premier League Football academy, individual players and their parents/guardians provide written informed consent to the routine collection of data and the potential use of this data for research purposes. All measurements of height and weight were taken on a voluntary basis and participants had the right to not be assessed. The Research Ethics Approval Committee for Health of Bath University (REACH) approved this research study and the right to use the retrospective data.

Biological Maturity:

Percentage of predicted mature adult height attained at the time of observation was the estimate of biological maturity status used (Roche et al. 1983). Within a chronological age group, players with a higher estimated percentage of predicted adult height are assumed to be more mature than players with a percentage more removed from their predicted adult height. The Khamis-Roche method was used to predict adult height, utilising current age, height and weight of the player and the biological parents' mean height (Khamis-Roche et al. 1994). The median error bound for the Khamis-Roche method between actual height and predicted height is 2.2 cm for males aged 4 to 17.5 years (Khamis-Roche et al. 1994). Height and weight of the players was measured every 12 weeks by trained academy sports scientists following standardised procedures. Self-reported parents' height was adjusted for overestimation; parents tend to overestimate their height when self-reporting and so the corrective equations by Epstein and colleagues were applied (Father's adjusted height =7.12 +(0.953 x reported height in cm and

Mother's adjusted height =5.88 + (0.955 x reported height in cm) (Epstein et al. 1995; Faigenbaum et al. 2019).

For each game, the nearest estimate of biological maturity status was utilised (to be included, this measure had to be within six months of the game). The players percentage of predicted adult height attained at the time of observation was then expressed as pre-pubertal, pubertal (during the growth spurt) and late pubertal (post-growth spurt) for each game. Percentages of predicted adult height between 86 and 95% were classified as "circa" or during the growth spurt (Baxter-Jones 2013; Cumming et al. 2017; Sanders et al. 2017). Percentages lower than 86% and greater than 95% were recorded as pre- and post-growth spurt, respectively.

Match Grade, Result and Opposition:

As part of normal procedures within the football academy, all players have every performance assessed and graded by their age-group coach on a scale of one to four. Criteria for grades are outlined by the academy as per what is expected per age group; Coaches grade each player from 1 to 4, depending on whether they performed below academy standard, approaching academy standard, meeting academy standard and exceeding academy standard respectively. Accordingly, for every game a player participates, they have a corresponding match grade of one to four indicating their coaches perception of performance (for the match grade to be included in the analysis a player must have played for 40 minutes or more to ensure the coach had a good representation of their performance).

Equally, opposition and result of each game across the seasons were recorded. Opposition teams were coded using Premier League Academy Category Status, with the standard of the opposition rated from 1 to 4, with 1 being most elite and 4 being grassroots. Result of each game was coded as a win, loss, or a draw. Previous research has shown result and opposition status to influence coach ratings of player performances.

Statistical Methods:

Data was inputted and analysed using IBM SPSS (version 23). A chi-square test was used to compare the match grades of players across the biological maturity groups. A one-way ANCOVA was conducted to determine a statistically significant difference between the levels of biological maturity (pre, during or post growth spurt) on match grades while

controlling for the opposition status and result of that game; this was conducted for the overall sample and for each individual age-group separately. Effect sizes were calculated and interpreted using Cohen's guidelines and significance was set at $p<0.05$ (Cohen, 1988).

Results:

A one-way ANCOVA was conducted to determine statistically significant differences in match performance across the different biological maturity groups. It should be noted the assumption for homogeneity of variance was violated for the Under 15 age-group, and thus result should be interpreted with some caution; analysis continued due to large sample sizes and controlling for the covariates (result and opposition) was important to the analysis.

Table 3: Table to show descriptive statistics across age groups

	Chronological Age			**Match Grade**		**% of PAH**		
	n	M	SD	M	SD	*n*	M	SD
Under 9	*1684*	8.99	0.39	2.49	0.63	*1642*	74.73	1.89
Under 10	*1608*	9.91	0.45	2.50	0.63	*1566*	77.35	1.90
Under 11	*1609*	10.90	0.47	2.48	0.63	*1577*	80.31	1.83
Under 12	*1658*	11.86	0.48	2.49	0.62	*1658*	83.00	2.04
Under 13	*1836*	12.89	0.49	2.29	0.71	*1828*	86.87	2.52
Under 14	*1580*	13.92	0.54	2.25	0.68	*1552*	91.28	2.81
Under 15	*1213*	14.80	0.50	2.21	0.71	*1182*	95.15	2.03
Under 16	*1084*	15.72	0.55	1.93	0.71	*1052*	97.64	1.39

The descriptive statistics show the mean and standard deviations for chronological age, percentage of predicted adult height, and match grade for every age group (Table 3). Mean chronological age and percentage of predicted adult height increased with successive age groups. Mean match grade generally decreased as age groups advanced.

The Chi-square result showed a significant association between maturity timing and match grade ($X^2(6)=702.8$, $p<.001$) (Table 4). More specifically, lower match grades were overrepresented in the post growth spurt and during growth spurt groups. For the total sample, the ANCOVA showed a statistically significant effect of growth spurt status

on match grade after controlling for the opposition and result of the game (F (3,10856) 188.85, p=0.000, partial eta squared=.03). Subsequent pairwise comparisons indicated that the adjusted mean values for match grade were significantly lower for the during growth spurt group than the pre-growth spurt group and for the post-growth spurt group than the during growth spurt group.

The ANCOVA showed a statistically significant effect of growth spurt status on match grade after controlling for the opposition and result of that game for the under 12's and under 15's (Table 5). For the under 12's the average mean match grade was significantly higher for the players in the team who were pre-growth spurt (F (3,) 15.53, p=0.000). Similarly, within the under 13's the average mean match grade was higher for the players pre-growth spurt compared to the players who are playing during their growth spurt; however, this was non-significant (p=0.087). For the under 15's however, the average mean match grade was higher for players post growth spurt, compared to players during their growth spurt ((F (3,1079) 25.851, p=0.000).

Table 4:Table to show frequency of match grade classifications by biological maturity status.

Maturity Status	**Match Grade (Expected Frequency)**			
	1 (10.29%)	***2 (45.45%)***	***3 (42.67%)***	***4 (1.59%)***
Pre-Growth (<86%)	5.41%	41.88%	50.73%	1.97%
During Growth (86-95%)	13.65%	50.30%	35.00%	1.04%
Post-Growth (>95%)	23.03%	47.76%	27.79%	1.42%

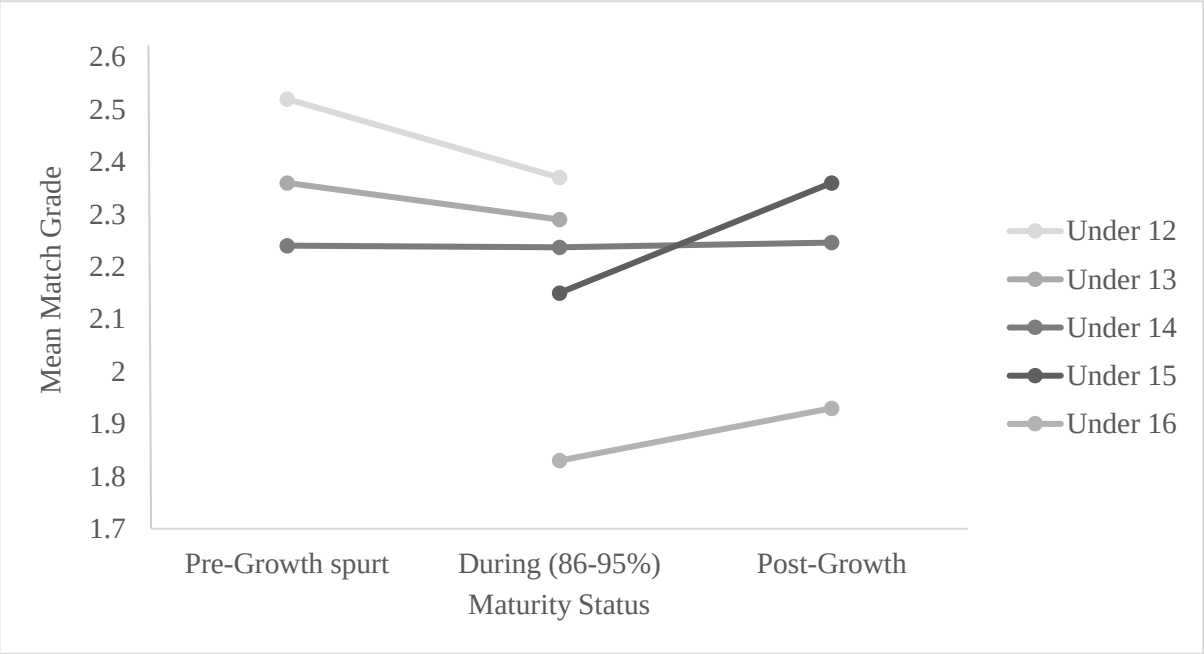

Figure 6: Graph to show mean match grades across the different maturity statuses within each age group (age-groups only included if more than 20 classified in each maturity group).

Table 5: ANCOVA for mean match grade by maturity status for U9-U16 age groups showing adjusted mean match grades.

	Mean Match Grade					
Age Group	Pre-Growth (n)	During (86-95%) (n)	Post-Growth (n)	F	*P*	η_p^2
Under 9	(1503) 2.50					
Under 10	(1356) 2.51					
Under 11	(1377) 2.48	(13) 2.58		0.33	.564	.000
Under 12	(1220) 2.52	(293) 2.37		15.53	**.000**	.010
Under 13	(348) 2.36	(1260) 2.29		2.94	.087	.002
Under 14	(32) 2.24	(1412) 2.24	(20) 2.25	0.00	.996	.000
Under 15		(674) 2.15	(409) 2.36	25.85	**.000**	.023
Under 16		(93) 1.83	(851) 1.93	1.87	.172	.002

Bold=Significant at <0.05.

Discussion:

The purpose of this investigation was to compare youth soccer coaches' evaluations of players' match performance before, during and after the growth spurt. Controlling for opposition status and match outcome, coaches' evaluations of match performance appeared to decline from the pre- to mid-growth spurt phases, before increasing again post-growth spurt. Although there was a general trend towards a reduction in match performance through the mid-growth spurt stage, it should be noted that the maturity associated differences in coaches' evaluations of match performance only achieved statistical significance in the under 12 and under 15 years age-groups (Figure 6). Equally, it is important to note that the effect sizes associated with these differences were generally small. That said, these differences may have been attenuated due to the limited range of the scale for assessing match performance (i.e., four-point scale) and limited variation in the responses of the coaches. That is, the majority of match grades awarded were either twos and threes, with markedly less scores of one or four being given. While the differences in under 13 and 16's age groups follow the trend, of superior performance pre- and post-growth spurt, they did not achieve statistical significance. In contrast, the coaches' evaluations of match performance did not vary relative to maturation status in the U14's age group. This may, however, reflect the fact that the majority of all players in this age group were categorised as mid-growth spurt.

The observation that coaches' evaluations of player match performance declined on entry to the growth spurt and then increased post-growth spurt is line with the concept of 'adolescent awkwardness'. That is, that the rapid changes in size, form and function that accompany the pubertal growth spurt may adversely impact athletic performance during this phase of development (Beunen and Malina 1988). As previously noted, the concept of adolescent awkwardness is generally accepted within the coaching community, despite a lack of empirical evidence (Lloyd et al. 2013; Philippaerts et al. 2006; Ryan et al. 2018). Researchers suggest specific aspects of motor control may be affected during the rapid adolescent growth spurt, such as neuromuscular control, postural stability, and interlimb/intersegmental coordination (John et al. 2018; Quatman-Yates et al. 2012). Furthermore, regressions in neuromuscular control, postural stability and interlimb coordination will influence important attributes required in football such as speed, agility, and balance (John et al. 2018). Adolescents situated in mid-puberty and experiencing their adolescent growth spurt may therefore have disturbances to their motor

patterns influencing their ability to perform in matches. Hirtz and Starosta suggest the impairment of rhythm, kinetic differentiation and coordination may appear immediately aligned with the growth spurt or with a one-year delay (2002). This one-year delay in coordination may also explain the lower match grades in the post-growth spurt group (Table 5). Equally, expectations of athlete's post-growth spurt may be higher and could explain the perceived lower performance grades. Players pre-growth spurt have not been exposed to these challenges yet; players post-growth spurt have overcome these growth-related challenges and got their growing out of the way (Mitchell et al., 2016).

Although it has been argued the "coaches eye" would struggle to pick up on such small regressions in motor control (Quatman-Yates et al. 2012), the results of the current investigation suggest maturity associated decrements in performance related to the growth spurt are reflected in coaches' evaluations of match performance. The extent to which coaches are aware how the growth spurt adversely impacts player performance is, however, unclear, and worthy of further consideration. As match performance grades are routinely used to inform decision in player selection and retention meetings, it is important that those involved in the decision processes recognise the extent to which maturational status may adversely impact player performance. A player who is not performing well or has experienced a sudden dip in performance may be struggling with the challenges associated with adapting to the changes associated with the growth spurt. It is equally important that the coaches consider how growth-related declines in performance may impact players from a psychological perspective. The need to feel and demonstrate competence is a primary driver of intrinsic and adaptive motivation. A failure to meet these needs may result in frustration, maladaptive coping behaviours, and amotivated behaviour (Nicholls 1984). Accordingly, coaches and practitioners should seek to educate players on the impact of growth upon performance, adapt training programmes accordingly, and help them adjust their expectations during this stage of development, supporting them through the adjustment process.

Anecdotal evidence illustrates the challenges associated with evaluating player ability and future potential during the growth spurt. As an academy player, Gareth Bale experienced a dip in performance through the adolescent growth spurt (James, 2014). As a late developer, this dip in performance coincided with a period where most of his contemporaries had already passed through this phase. As such, his performance relative to his peers were notably poorer. At this timepoint, questions were raised with regards to whether or not he should be retained or released due to his stagnating progress.

Recognising that Gareth was currently in the middle of his growth spurt and the potential challenges this may present, Academy talent selectors decided to retain him; though the decision was only secured by a single vote (Calvin, 2017, p.36). With careful adaptation of his training programme and continued support Gareth was able to successfully transition through this phase and go on to become one of the United Kingdom's most expensive transfers when he eventually joined Real Madrid. Although Gareth Bale was retained within the academy system, it is possible that many talented players experiencing similar challenges may have been de-selected from academies as a result of growth-related dips in performance. Accordingly, academy practitioners should consider growth rate and maturity status when evaluating players and making decisions pertaining to electing/releasing adolescent players.

The first age group to include players categorised as mid-growth spurt was the under elevens. The majority of the players in this age group were, however, categorised as pre-growth spurt. Although the initial onset of puberty for boys occurs around 9 to 10 years of age, the pubertal growth spurt in boys is a relatively late occurring event (Malina et al. 2004; Marshall and Tanner 1970). Coupled with the observation that the selection bias towards early maturing boys does not emerge until approximately 11 to 12 years of age, the relatively small number of boys categorised as during growth-spurt in this age group is to be expected. Those boys categorised as mid-growth spurt in this age group can, by nature of their age and maturation status, are more likely to be early maturing. As one would expect, the proportion of players categorised as mid and post-growth spurt increases sequentially through the age groups. Of particular interest, the under 14 age group was the only cohort in which players of all maturity categories were represented. This suggests this is the age group in which coaches can expect the greatest variances in growth and maturation. This finding is consistent with the observation that mean age for PHV in boys approximates 13.8 to 14 years of age, and this value is likely to be skewed in soccer due to a disproportional representation of early maturing boys (Malina et al. 2004). Despite the greater range of maturational status observed in this age group, the majority of the boys in the under 14's were categorised as being in the mid-growth spurt group, with a smaller number of boys designated to be pre- and post-growth spurt. By the under 16 group, the majority of players were identified as post-growth spurt, with a smaller number of players categorised as mid-pubertal. Those players categorised as mid-growth spurt in this age group are more likely to be late maturing for their age (Malina et al. 2004).

Limitations of the study should be noted. Firstly, results of this study are based on one professional football academy and thus may not generalise to other football academies with different coaching values and understanding of the influence of growth and maturity on young players. Another limitation within the current study is the method used to assess match performance. Match grade is a single item evaluation of performance on a small scale (1-4) and to date, lacks evidence to support its validity and reliability. That said, the item does present high ecological validity, in that it is the current method utilised by the coaches in this academy system to evaluate player performance and development. It should also be noted that coaches typically restricted the majority of their evaluations to scores of 2 and 3, with comparatively few players receiving scores of 1 and 4 (Table 4). While restricted sample variance in the variable of interest limits the sensitivity of the analyses and generalisability of the findings (Lakes 2013), it does, paradoxically, make the observation of a maturity associated dip in performance even more surprising. If more sensitive measures of performance were employed the impact of the growth spurt upon player performance may be even greater. Accordingly, future research should seek to examine the impact of the growth spurt upon performance using a diverse and more sensitive range of the methods and measures, including longitudinal, observational, and mixed methods designs. Research to determine the validity and reliability of the match grades system is also warranted. Finally, the method used to detect the growth spurt, is an estimation of when the growth spurt is expected to occur. The percentage bracket of 86% to 95% of predicted adult height was used as this has been shown to be in line with when the majority of youth would experience the growth spurt (Sanders et al. 2017). Finally, it should be noted that the impact of the growth spurt upon player performance through the growth spurt is likely to be highly individualised. It is likely that many of the players categorised as mid-growth spurt may not have experienced plateaus or declines in performance. Future research should also utilise growth velocity to further validate the growth spurt.

In line with our findings, a player's stage of maturity status and growth rate can influence coaches' perceptions of their performances in some age groups. Generally, players in mid-puberty, experiencing their adolescent growth spurt were perceived to perform lower than their peer's pre-growth spurt. Academy coaches and practitioners should understand the possible detrimental effects of growth and maturity for some players and consider this when making selection and retention decisions. Finally, it is important to recognise that not all individuals will experience growth related decrements

in performance during puberty and how each individual adapt to change during this stage of development will vary (Hirtz and Starosta 2002). Although some research has shown 90% of boys face trouble with coordination in the growth spurt, some individuals may see no decrements in performance and others may see improvements (Hirtz and Starosta 2002). Nevertheless, the results of this study suggest that puberty is a developmental stage in which potential growth-related decrements in performance are more likely to observed.

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Study Three

Commentary

The aim of this study was to explore and better understand how the adolescent growth spurt impacts youth football players within professional academies. The previous two studies of this thesis objectively assessed how the coach's subjective evaluations were influenced by firstly, relative age and biological maturity, and secondly, the adolescent growth spurt. Findings showed advanced biological maturity predicted higher performance evaluations from coaches in some age groups, and performance grades dipped when players were categorised as circa-growth spurt.

The majority of studies investigating maturation in football have focused upon the impact of maturity status or timing upon athletic performance (Malina et al., 2004b; Philippaerts et al., 2006; Figueiredo et al., 2009b). There is comparatively little research investigating the impact of the adolescent growth spurt, and the few research articles that have, focused upon injury incidence and burden (Wik et al., 2020; van der Sluis et al., 2015), rather than performance. Considering the previous studies within this thesis and the limited understanding of knowledge of this phenomenon there was a need to explore the impact of the growth spurt in greater and broader detail. The ideal method to study and examine the impact of the adolescent growth spurt is to longitudinally track players as they go through their growth spurt, to better understand how changes in growth, impact performance and coaches' perceptions and evaluations.

This longitudinal mixed-methods study aimed to understand youth football coaches' perceptions, experiences, and management of male adolescent football players. The mixed-methods approach allows for both a rich, deep understanding to coaches' experiences while allowing for convergence and triangulation with quantitative measures of growth, maturity, and performance. This is particularly relevant to the aim of this thesis of understanding the wider impact of adolescent growth and maturation in football academies.

Introduction

Academy football is a high-pressured competitive environment for young athletes (Sagar et al., 2010; Mills et al., 2012). Young players face a range of personal and interpersonal challenges affecting their development and overall experience (Richardson, Gillbourne & Littlewood, 2004). Aside from facing the challenges of academy football in general, young players must also navigate through the passage of adolescence (Dorn et al., 2006; Dahl, 2004). Although adolescence presents opportunities for young athletes, increased size, strength, speed, power, and higher cognitive functioning; it is also characterised by an increased risk for development of maladaptive behaviours, injury and adolescent awkwardness (Dahl, 2004; Malina et al., 2004a; Blakemore et al., 2010). Adolescent football players are, therefore, presented with unique changes and challenges.

Adolescence is a process that is marked by the onset of complex changes comprising physical, cognitive, and social maturation occurring between childhood and adulthood (Blakemore et al., 2010). All normal healthy individuals will experience adolescence and the associated changes, however young people encounter adolescence and develop at different rates and times (Malina et al., 2004a; Dorn et al., 2006). Individual variation in the age at which puberty occurs is considerable, and children of the same chronological age can differ by several years in terms of their biological maturity status (Johnson et al., 2009; Malina et al., 2004a). The most salient and observable change in adolescence, resulting from the onset of puberty, is the adolescent growth spurt; PHV is the most rapid point of growth in stature and occurs in boys around 14 years of age, however varies relative to maturity timing (Marshall & Tanner, 1970; Cameron & Bogin, 2012). Boys who mature early may attain PHV around 11 or 12 years of age, compared to late maturing boys who undergo PHV at 16 or 17 years old. Coaches of a single age-group are therefore presented with children of the same chronological age, but at varying stages of biological development; coaches must therefore manage children pre- circum- and post-PHV (Buchheit & Mendez-Villanueva, 2014; Cumming et al., 2017a).

The adolescent growth spurt is particularly relevant in the context of youth sport. Boys in PHV experience rapid increases in stature, growing around eight to fourteen centimetres per year; this growth rate is significantly higher than the childhood rate of growth of around five to seven centimetres per year (Malina et al., 2004a). The saltatory nature of growth, however, means substantially higher growth rates are not uncommon, particularly if growth measurements are taken on a regular basis (Marshall, 1971; Beunen

& Malina, 1988; Teunissen et al., 2020). Three to six months after PHV, PWV, the most rapid point of growth in mass occurs; individuals gain approximately nine kilograms in PWV compared to increases of two to three kilograms in childhood (Rogol et al., 2000; Malina et al, 2004a). Alongside the marked increases in height and weight in adolescence, boys experience increases in muscle mass and bone accretion, skeletal changes resulting in wider shoulders, and increases in levels of testosterone (Rogol et al., 2000; Malina et al., 2004a). Boys who mature early tend to experience greater pubertal gains in height and weight, lean muscle mass and bone accretion compared to their later maturing peers (Cheng et al., 1999; McKay et al., 2019). The timing of the adolescent growth spurt and the associated changes in size and body composition therefore have important implications in youth sport.

The functional benefits associated with puberty and maturation are well established in males (Malina et al., 2004a; Meylan et al., 2010). Research has shown the peak development of many physiological and functional attributes is aligned with PHV (Malina et al., 2005; Teunissen et al., 2020); Objective data shows early maturing boys are stronger, faster, and more powerful, and generally outperform their later maturing peers in physical tasks (Beunen & Malina, 1988; Malina et al., 2004b; Coelho E Silva et al., 2010; Malina, 2014; Cumming et al., 2017a; Buccheit & Mendez-Villanueva., 2014). Due to the variability in the timing of PHV, there is a resultant variability in the development of physical characteristics within an age-group (Philippaerts et al., 2006; Malina et al., 2005; Teunissen et al., 2020). Further, early and late maturing athletes will thus require different training regimes and loads (Lloyd & Oliver, 2012). This presents a unique challenge for coaches of adolescents. Coaches will encounter players of varying maturity stages (i.e. pre- circa- and post-PHV) and must accommodate for this in training sessions (Lloyd & Oliver, 2012; Cumming et al., 2017a). The YPD Model, encompassing athletic development from early childhood to adulthood, emphasises the need for individualisation of training programmes when working with adolescents of varying maturity statuses (Lloyd & Oliver, 2012).

Variation in the timing of maturity-associated changes and the adolescent growth spurt, also present challenges for coaches in terms of evaluating talent (Malina et al., 2004a; Vaeyens et al., 2006; Lovell et al., 2015; Cumming et al., 2017a; Study One and Two). Talent identification and evaluation of youth athletes is superimposed on the demands of growth and maturation, where individual differences in maturity status directly and indirectly influence the talent identification process (Cumming et al., 2012;

Cumming et al., 2017a). The advantage of early maturing athletes in physical and functional attributes described previously, represents the direct effects of growth and maturation upon athletic success (Cumming et al., 2017a). Comparison of physical testing scores of early and late maturing athletes in the same age-group, is directly confounded by differences in maturity timing, making evaluations difficult. The indirect effects reflect the management of adolescent athletes by their coaches and youth sport programme (Cumming et al., 2017a). The athlete's body and attributes hold a social stimulus value (Cumming, Eisenmann, Smoll, Smith & Malina, 2005), where players who are deemed most likely for success are offered more opportunities, coaching and resources (Bloom & Sosniak, 1985; Cumming et al., 2017a; Vaeyens et al., 2008). Consequently, research has shown there is a selection/exclusion gradient in many sports including football, around the time of puberty and the growth spurt, that increases with age and competitive level (Malina, 2009; Figiueredo et al., 2009a; Meylan et al., 2010; Malina et al., 2015; Johnson et al., 2017).

In youth football, data shows there is a large over-representation of early maturing boys in academies (Malina et al., 2004b; Figueredo et al, 2009a; Carling, Le Gall & Malina, 2012; Johnson et al., 2017; Hill et al., 2019). However, it is well established that early maturing players have maturity-associated advantages in adolescence, that in adulthood will be diminished or even reversed (Lefevre et al., 1990). Discriminating against late maturing players is known to reduce the talent pool from which players can be selected (Johnson et al., 2017). Strategies to reduce these maturity biases are currently being tested and trialled (Cumming et al., 2017a; Cumming et al., 2017b; Abbott, Williams, Brickley & Smeeton, 2019; Bradley et al., 2019; Reeves, Enright, Dowling & Roberts, 2018). Despite the large body of research explaining the influence of maturity status in academy football, the selection biases remain (Johnson et al., 2017; Hill et al., 2019; Bennett et al., 2019).

Youth coaches are also presented with unique challenges related to adolescent players such as growth-related injuries and adolescent awkwardness (Beunen & Malina, 1988; Quatman-Yates et al., 2012). Aside from biological maturity status, athletes experiencing their adolescent growth spurt are also more vulnerable to injuries (Quatman-Yates et al., 2012; Price et al., 2004; Kemper at al., 2015; Dupré & Potthast, 2020; Van Der Sluis et al., 2014; Rommers et al., 2019b). The increased rate of growth, vulnerability of growth plates, and differences in biological and chronological age increase the injury risk in this adolescent phase (Caine, Purcell & Mafulli, 2014; Kemper et al., 2015). Some

research also suggests adolescent awkwardness, a temporary period of motor coordination disruption coinciding with the adolescent growth spurt, may increase the likelihood of injuries (Van der Sluis et al., 2014; Wik et al., 2020). Adolescent awkwardness is a highly debated phenomena in youth sport, with current research showing conflicting results (Beunen & Malina, 1988; Davies & Rose, 2000; Hirtz & Starosta, 2002; Quatman-Yates et al., 2012; John, Rahlf, Hamacher & Zech, 2018). Within youth sport contexts, adolescent awkwardness is an accepted theory, which also appears to affect sport performance, especially for high performers (Study Two; Beunen & Malina et al., 1988). Selection and exclusion decisions may therefore also be affected by the potential problems associated with undergoing the growth spurt (Study Two). Youth coaches consequently face unique challenges when managing, coaching, and evaluating adolescent athletes.

It is well acknowledged in the literature that youth sport programmes identifying and developing talented young athletes, should measure and monitor growth and maturity status (Williams & Reilly, 2000; Johnson, 2015; Cumming et al., 2017a). As described, the adolescent growth spurt and maturity timing have major implications for coaches in terms of training and evaluating their players, in this particularly vulnerable phase (Cumming et al., 2017a; Lloyd & Oliver, 2012). In youth sport, coaches are a key stakeholder, who play a pivotal role in athlete development, talent evaluation and selection/retention decisions (Baker, Schorer & Wattie, 2018; Williams & Reilly, 2000). Research shows however, growth and maturity status influences coaches' perceptions (Cumming et al.. 2017a; Vaeyens et al., 2006). Quantitative research suggests that coaches perceive early maturing football players to be better performers (Study One; Cripps, Hopper & Joyce, 2016), with greater potential (Cripps et al., 2016); research has also shown that the adolescent growth spurt may also negatively affect coaches perceptions of performance, regardless of maturity status (Hill et al., 2020; Study Two). It is, therefore, imperative to understand coaches' perceptions of adolescent athletes pertaining to growth and maturation when they play such a key role with athletes, and more broadly within talent identification systems. With the objective of football academies to select, develop and nurture young athletes into professional players (Vaeyens et al., 2006), it is important for coaches to understand the implications of the adolescent growth spurt and maturity timing, for academies to be efficient and effective.

To gain a more comprehensive understanding of how adolescence and the growth spurt influence elite youth athletes and coaches' perceptions, a more explorative approach

is required. Objective quantitative studies dominate the current literature; very few qualitative studies have been conducted exploring how changes associated with adolescence impact young athletes (Mitchell et al., 2016). Although it is pivotal to understand quantitively if these selection and performance differences exist, exploratory qualitative work can explore how and why these biases manifest. With greater understanding of how the adolescent growth spurt and maturity timing affect both the player and the coach, youth sport programmes may be able to better develop players through adolescence and potentially mitigate some of the maturity associated selection biases. Therefore, the aim of this study was to understand youth football coaches', perceptions, experiences, and management of male adolescent football players. It is important to understand when youth players undergo their adolescent phase, how do their coaches perceive and navigate their athletes through this experience?

Methodology

Study Design:

This study applied a longitudinal mixed methods approach to understand youth football coaches' perceptions, experiences, and management of male adolescent football players through the adolescent growth spurt. Both quantitative and qualitative data were collected simultaneously over the 12-month study period, in three phases. The data was then analysed and combined to provide a deep contextualised understanding of coaches' experiences of managing adolescent football players.

Mixed methods research is an approach for conducting research that involves collecting, analysing, and integrating or mixing quantitative and qualitative research and data into one longitudinal study (Cresswell, 2003). Both qualitative and quantitative approaches are used in this instance to triangulate, look for convergence or corroboration by using different methods, and for complementarity, using results from one method to elaborate or clarify results from a different method (Cresswell, 2003; Tashakkori & Teddlie, 2010). The mixed methods approach employed in this study was used to draw upon then benefits of both quantitative and qualitative data in order to best tackle the research question.

As noted, the purpose of this study was to monitor and follow adolescent football players through their growth spurt and understand how coaches perceive and manage adolescent changes. Accordingly, this study involved quarterly quantitative measures of youth players maturity status, growth velocities, game time and match performance. Alongside this, interviews were conducted every four months with the youth football coaches to understand their experiences, changing perceptions and management of their respective players. Both approaches were then combined to further understand the complex phenomena of growth and maturity in adolescence in a youth football context. Player growth, maturity and performance data for each quarter were mapped onto the qualitative comments the coaches provided, generating a deeper, contextualised understanding.

Sample:

The sample included youth players and their respective coaches from Southampton Football Club. The under 12 to under 16 age groups from Southampton Football Club's academy were the youth sample for this study. Participants were current registered players

at the club at the time of the study. These age groups form the Foundation Development Phase (FDP) (U12) and the Youth Development Phase (YDP) (U13-U16) of the academy, where players take part in the day release programme (education and football training on site at least one day a week). Recruitment of these age groups reflects the ages of experiencing maturation, the adolescent growth spurt (Malina et al., 2004a) and logistically were easier to access due to the day release programme.

Coaches from Southampton Football Academy were the selected sample for the qualitative methodology. The coaches working with the under 12-16 age groups were invited to take part in the study; Each age group had a head coach and an assistant coach. Eleven coaches fit this criterion, and nine agreed and consented to take part. Not all coaches participated in every phase of the study. Overall, five focus groups and eight interviews were conducted across the study.

Due to the continuously changing nature of academy football and the longitudinal nature of the study, the sample evolved throughout. During the study period, some players were released from the academy and several players entered into the academy system, therefore many participants left and enrolled into the study at various points. The inclusion criteria thus specified males aged 11-17 years registered and attending Southampton Football Club's academy programme, as well as the respective football coaches of the under 12 to under 16 teams. The overall sample comprised nine male coaches and 98 male youth football players.

Procedures:

The data collection followed a series of steps with two distinct yet integrated methodologies 1) quantitative measures of maturity, growth velocities and game time/performance grades and 2) qualitative enquiry into coach's experiences and management of players in this adolescent period. The procedure, methods and logistics were created in collaboration with Southampton Football Club to ensure the availability of the academy coaches, players, and the researcher across the footballing season, in addition to gaining buy in from the collaborator/funder. Data collection commenced in January 2019 and was completed by January 2020. This methodology section will describe both the quantitative and qualitative procedures (See Figure 7 for a procedural plan).

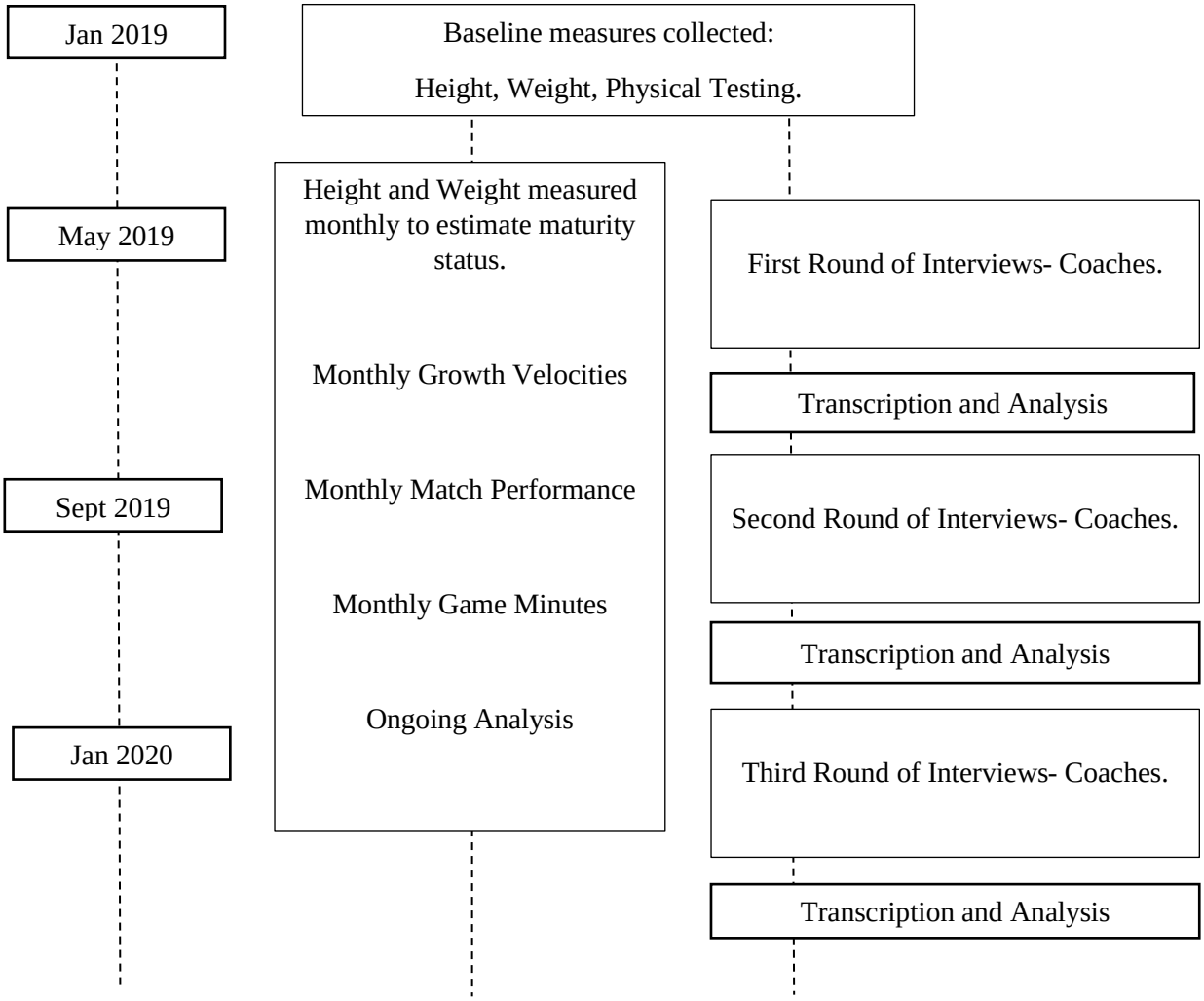

Figure 7: Procedures followed for data collection.

Procedures- Quantitative:

Growth Velocities and Maturity Status:

All players in the U12 to U16 age-groups attend a day release programme (on Tuesdays and/or Wednesdays throughout the season) in which data collection of height and weight took place. Each age-group were informed as to when on their timetable this would occur to ensure measurement time was standardised throughout the study (starting on the 29th January 2019) (See Table 6).

Table 6: Time of monthly measurement for each age-group

Age-Group:	**Time of Measurement:**
Under 12	Tuesday 10.30am
Under 13	Wednesday 10.45am
Under 14	Wednesday 11.00am
Under 15	Wednesday 9.00am
Under 16	Tuesday 9.00am

Every player in each team had their height and weight measured and recorded by the researcher and the sport scientist associated with that team. Participants wore their training kit and socks when being measured. Height was measured using a calibrated stadiometer and the stretch stature method and weight was measured using a weighing scale. Measurements were recorded on both a hard copy and electronically. This procedure was repeated monthly (Johnson, 2015); monthly measurements were conducted for a number of reasons. Firstly, more frequent monthly measures allowed the risk of large pieces of missing data to be eliminated. If players missed a measurement for illness, away matches or tours, their previous monthly measures were utilised. This allowed for a more comprehensive dataset. Secondly, monthly measures allowed for reliability and greater confidence in the quarterly measurements used for the study. Height and weight measurements were taken to enable the calculation of growth velocities and estimation of biological maturity. If players did not attend the day release programme for any reason (holiday, illness, away matches etc) their measurement for that month was recorded as missing. Finally, monthly measures of height and weight provided continual up to date measures of changes in the athlete due to a growth spurt; accuracy of measurement was extremely important due to the frequent nature of the measurement (Johnson, 2015).

Growth velocities were calculated by taking away the previous measurement of height and weight from the latest or current measurement and multiplied by the elapsed time between the two measurements. Growth velocities were calculated monthly and also for each phase of the study (January 2019 to April, May to September, October to January 2020). If a player was not present for the dates of the phase (e.g. Jan and April) their nearest monthly measurement was used, and growth velocities were adjusted accordingly

(e.g. Feb-April). Date of measurement was always noted so calculations could be conducted accurately.

Biological maturity was estimated using percentage of predicted adult height at time of observation (Khamis & Roche, 1994). The median error bound for the Khamis-Roche method between actual height and predicted height is 2.2 cm for males aged 4 to 17.5 years (Khamis & Roche, 1994). The estimate used the latest measure of the players age, height and weight and their mid-parent height (biological height of both mother and father divided by two) (Malina et al., 2004a) to provide frequent updated measures of percentage of predicted adult height at time of observation for each phase of the study. Parental heights were self-reported and adjusted for overestimation using corrective equations by Epstein and colleagues (Father's adjusted height =7.12 +(0.953 x reported height in cm and Mother's adjusted height =5.88 + (0.955 x reported height in cm) (Epstein et al., 1995). Each updated percentage of predicted adult height attained at the time of observation was then expressed as pre-pubertal, pubertal (during the growth-spurt) and late pubertal. Percentages of predicted adult height between 86 and 95% were classified as "circa" or during the growth spurt (Baxter-Jones, 2013; Cumming et al. 2017a; Sanders et al. 2017). Percentages lower than 86% and greater than 95% were considered as pre- and post-growth spurt respectively, which has been shown to correctly estimate 96% of players who were in their growth spurt (Parr et al., 2020).

Game Time and Performance:

Normal procedures at Southampton Football Club involve the routine collection and recording of game time and game performance. Game time simply involves recording the minutes each player played in every game across the year. This data is stored on the Premier League's Performance Management Application (PMA), from which data was extracted for the purposes of this research.

As well as game time, each player receives a subjective performance grade for every game they participate in. This is assessed by their age-group coach and grades range from one to four. Grades represent whether players are below (1), approaching (2), meeting (3) or exceeding (4) the academy standard. This data is also stored on the Premier League's PMA and was extracted for the purposes of this research.

Across the study period, game time and game performance grades were collected and collated into an excel file. For each phase of the study (January 2019 to April, May to September, October to January 2020) overall game time was calculated (all game

minutes added together to see how many minutes played over the four-month period) and an average match performance grade was created (an average performance measure over each four-month period).

Thus, an excel file was created with player identification number, date of birth and age-group, which measures of height, weight, growth velocity, maturity status estimate, game time and average game performance grade were continually added to (See Figure 7 for a detailed procedural plan of how data was collected). A simple descriptive analysis with means and standard deviations were conducted to reflect the growth, maturation, and performance characteristics of the sample.

Ethics:

Prior to any data collection, approval for this research was sought and granted from the University of Bath Research Ethics Approval Committee for Health (unique reference: EP 18/19 002) (REACH, BATH, 2019). Additionally, the objectives, rationale and procedures of the study were explained to the Football Projects and Innovation Board at Southampton Football Club for further approval.

With the players included in this sample being minors (under 16), informed parental consent was required. Informed consent was obtained from the parents on the induction day at the start of the season when they registered their child into the academy for the season. All of the data collected for this study on the players, were already routine measurements taken by the club, so consent was obtained to use this data anonymously within research and for publication. As the players participating were under the age of 16, the researcher obtained a DBS certificate. Players had the right to refuse measurement, however height and weight measurements were a routine part of academy life and so there were no refusals.

Procedures: Qualitative Methodology:

This part of the study applies a qualitative approach utilising qualitative case study methodology, semi-structured interviews and thematic analysis. Qualitative research aims to investigate a phenomenon through individuals who have directly experienced the phenomenon, appreciating their unique viewpoints which can only be fully understood within the context of their worldview and experience (Castleberry and Nolen, 2018). Semi-structured interviews were used to obtain experiential accounts from youth football coaches about their experiences, perceptions, and management of adolescent football

players. Inductive thematic analysis was used to identify, analyse, and report patterns and themes within the data (Braun and Clarke, 2006). Inductive, or 'bottom-up' thematic analysis is data-driven, whereby the qualitative data is not forced into pre-existing codes or driven by the researcher's theoretical interest (Braun & Clarke, 2006). However, researchers cannot free themselves of their experiences, knowledge, and theoretical and epistemological commitments, thus it is acknowledged it is impossible for researchers to be purely inductive (Braun & Clarke, 2012). Finally, case studies are presented for exploring the coach's experiences, perceptions, and management in different contexts, for individual players, utilising both the qualitative and quantitative data (Houghton, Murphy, Shaw & Casey, 2015).

The aim of the interviews was to generate an understanding of how youth football coaches experience, perceive, and manage their adolescent players. Interviews were designed to explore the coach's experiences of their players adolescent growth spurt and implications of maturity status. For example, "How do you recognise a player is going through the adolescent growth spurt", "Do you feel the adolescent growth spurt changes players?", "What are the implications of differences in maturity status between players?" (See Appendix A for Interview Schedule). Further, the quantitative data surrounding performance, maturity status and growth rate were also used to drive and shape the interviews with the coaches; the objective data collected monthly was continually analysed in order to shape the interview questioning.

Some head coaches opted to complete the interview separately to their assistant coach; for these age-groups two separate interviews were conducted with each coach for that phase. In other age groups head coaches wanted to conduct the study together with their assistant and so some age groups had one focus group per phase of the study (semi-structured interview schedule remained the same).

Researcher Positionality:

Researcher membership in the group and or area of interest is important to all approaches of qualitative research; the researcher plays a direct and active role in both data collection and analysis, thus their position and status cannot be ignored (Dwyer & Buckle, 2009). Researchers are increasingly stating their position within the group/topic of interest as an insider or an outsider (Dwyer & Buckle, 2009). If the researcher is an insider, they share characteristics, a role, or experiences with the group of interest and thus are considered a member of the group; In comparison, an outsider researcher is someone who has little

commonality to the group of participants (Dwyer & Buckle, 2009). More recently, researchers argue that the researcher takes on multiple positionings within a study and is neither fully inside or outside, but rather on a continuum of "insiderism and outsiderism" (Milligan, 2016; Thomson & Gunter, 2010). This continuum considers both how the researcher views themselves in the research process but also how the researcher is viewed and positioned in the project by the participants themselves (Milligan, 2016).

Qualitative researchers actively participate in the research process whereby it is impossible to remain a complete outsider; thus, researchers occupy the space between insiders and outsiders (Dwyer & Buckle, 2009). In this study, the researcher holds a unique position. The researcher was brought into the football club as a Doctoral student at the start of the investigation but was also considered an employee of the club. The researcher was therefore immersed in the culture and environment in which the research took place. Immersion is an important approach in qualitative research, as it enables the researcher to be on the "inside" of the field under investigation (Hammersley & Atkinson, 2003; Woodward, 2008). The researcher wore the club kit and was present at the training ground often (site of investigation). The young players saw the researcher as a member of staff, and the employees of the club (including the participants) positioned the researcher as a member of staff and research consultant. The researcher was present at the training ground even when not data collecting, for example attending training, meetings, home and away matches and even a club tour. Thus, although the participants were fully aware that the researcher's role in the club was to undertake this investigation, their continued presence at the club meant they were seen as part of the group/team and therefore a level of trust was built. Equally, as a white woman in a male dominated environment the researcher did not share all characteristics with the sample of participants. The participants understood the researcher's line of enquiry and considered them to be a sport scientist for example, but not a coach or an expert of the football culture. The researcher was therefore seen as a member of the wider group (insider of the football club), however an outsider of the sub-culture of the coaching world.

Philosophical Worldview/Epistemologies:

A researcher's philosophical worldview influences the research process and what the researcher brings to a study, thus their epistemology should be identified at the outset (Creswell, 2003). This research is framed by a pragmatic worldview. Pragmatism is a problem-orientated philosophy, whereby researchers focus on how best to answer the research question by using a range of methods and approaches (Rossman & Wilson,

1985). Researchers therefore have the choice to draw from both quantitative and qualitative approaches to best understand the problem (Creswell, 2003). Mixed methods research involves the collection, analysis, and synthesis of both quantitative and qualitative data to better understand a research topic or problem (Creswell & Plano Clark, 2011). Pragmatism has been identified as the appropriate paradigm for mixed methods researchers (Creswell & Plano Clark, 2011; Creswell & Creswell, 2018). Quantitative purists align with assumptions based upon a positivist worldview, whereas qualitative purists align with interpretivism (Johnson & Onwuegbuzie, 2004; Creswell & Creswell, 2018). The goal of mixed methods, drawing upon the benefits of both quantitative and qualitative research, aligns with pragmatism in order to provide the best opportunity to answer research questions (Johnson & Onwuegbuzie, 2004). Pragmatism and a mixed methods approach was employed in this study to explore how growth and maturation in adolescence impacts academy footballers and their coaches; This research question requires a pragmatic approach to explore this complex topic.

Qualitative Procedure:

The interview schedule was designed to explore youth football coaches' experiences, perceptions, and management of adolescent football players, with particular interest in factors such as maturity biases and the adolescent growth spurt.

The interviews were designed to be mutually beneficial; serving both to aid the research and to generate an opportunity for the reflection and learning of the participant. A pilot was conducted in advance of the study to test the interview schedule. Strength and Conditioning (S&C) coaches at the football club were used to trial the interview questions. This led to some amendments of the interview schedule, mainly regarding the language used in the questioning to ensure coach understanding. For example, scientific language such as PHV was modified to lay language such as growth spurt.

The interviews began with the coach describing their experiences of their team and players over the current study period. This allowed the participant to relax into the interview and subject matter but also provide insightful data regarding coach perceptions and understanding of their players. After a general discussion surrounding the players in their respective age group, the researcher then used the interview schedule to continue the interview with content questions (Creswell, 2003) (See Appendix A).

Interviews were conducted face to face at Southampton Football Club's Staplewood Training Ground. Only the coach/coaches in the interview and the

researcher were present in the meeting room. Interviews ranged in time from 47 minutes to one and a half hours and were recorded, enabling rich and detailed data to be collected.

Interviews were recorded using a dictaphone to capture the data. Interviews were transcribed into written form in order to be studied in detail, coded and analysed (Bailey, 2008). Transcription was completed by the primary researcher for data protection and as the first key step of data analysis. Although transcribing is a lengthy task, it allows the researcher to immerse and become familiar with the dataset and is an important first step in data analysis; transcribing involves repeated listening and re-reading of the dataset providing the transcriber with a thorough understanding (Braun & Clarke, 2006). This familiarity with the dataset allows the researcher to pay attention to what is actually there, facilitating ideas that emerge in the analysis (Bailey, 2008).

In line with ethics, anonymity was maintained in the transcripts with participants names and identifiable details removed (Bryman, 2004). Participants were renamed Coach 1- Coach 9 for the presentation of the findings. Any names, teams, or places which posed a risk to anonymity were removed from the transcripts.

Ethics:

Participants were provided with an information sheet via email. After agreeing to take part in the study an interview date and time was organised. At the start of the interview participants received a printed version of the information sheet and were given an opportunity to ask questions about the study. Written consent forms were then provided with a signature indicating consent to take part. For the subsequent phases of the study, verbal rolling consent was required.

Potential ethical issues were anticipated prior to the research commencing. This enabled any issues in data collection to be managed effectively (Guillemin & Gillam, 2004). For example, although unlikely, procedures were in place if participants became distressed of if they disclosed any information which suggested either they or their players were in harm or danger. The ethical procedures in place were developed in accordance with confidentiality and the ethical policies of both the University of Bath and Southampton Football Club. A reflexive stance was also adopted throughout this study. In reflexive research, the investigator regularly reflects upon their actions and position within the research process and analysis of the data (Guillemin & Gillam, 2004). Reflexivity

bridges the gap between procedural ethics and ethics in practice and acknowledges researcher effect and researcher positionality (Guillemin & Gillam, 2004).

Data Analysis:

Thematic analysis is seen as a foundational method for qualitative analysis, which can provide rich, detailed, and complex accounts of data (Braun & Clarke, 2006; Nowell et al., 2017). Thematic analysis is a method for identifying, analysing, reporting and often interpreting patterns, or themes, within data (Braun & Clarke, 2006; Boyatzis, 1998). Often in qualitative research, the process of analysis is lacking; themes are often said to 'emerge' from the dataset, denying the role of the researcher in identifying, selecting, and reporting themes of interest (Braun & Clarke, 2006). Themes are created by the researcher to represent some level of patterned response or meaning, and so researcher judgment is required to determine themes (Braun & Clarke, 2006). In this study, the researcher actively participated in the research process by immersing in the environment over the study period and acknowledging their positionality.

This study applied a 'bottom up' or inductive thematic analysis, driven by the dataset rather than pre-existing codes (Braun & Clarke, 2006). It is acknowledged, however, no researcher can be purely inductive, freeing themselves of any experience, knowledge and epistemological commitment (Braun & Clarke, 2006).

To conduct this study the six steps of thematic analysis by Braun and Clarke were employed (2006). The first step of data analysis was familiarisation with the data. Listening to the recordings of the interviews and transcribing the data allowed for the researcher to engage in familiarisation (Braun & Clarke, 2006). Once immersed in the data, the researcher began re-reading the transcripts and manually coding the data. The researcher identified anything of interest within the raw data by highlighting sections and adding comments to the transcripts to mark initial codes. The next phase of analysis involved arranging the initial codes into broader potential themes and sub-themes which the codes relate to. Themes were then reviewed and revised to ensure coherence and their accurate reflection of the data before defining and naming each theme. Throughout the coding and thematic analysis process, meetings for discussions and verification of the themes with the supervisory team were carried out. Themes were then analysed in further detail; what story did each theme tell and how did the theme fit with the others and the overall research question? Sub-themes were identified to give structure and to offer hierarchy of meaning within the data (Braun & Clarke, 2006). Finally, the researcher

began the write-up, reporting the complex story of the data through each individual theme and sub-themes.

Credibility:

It is important to ensure qualitative research is deemed legitimate and trustworthy (Nowell et al., 2017). This research employed the widely accepted criteria of credibility, transferability, dependability, and confirmability by Lincoln and Guba (1985), similar to the established quantitative tests of validity and reliability. Credibility refers to the fit between researcher's interpretation of the participants original view (Nowell et al., 2017). To ensure credibility in this study, the researcher utilised member checking, where the findings of the research were presented back to the sample. After data analysis was complete, the themes and sub-themes were reported back to the coaches as a collective, to ensure data interpretation accurately represented their views. Coaches were allowed to challenge the interpretation of the data in this meeting. This process enables participants to confirm credibility to the research (Lincoln & Guba, 1985; Korstjens & Moser, 2018). In this meeting, there was agreement between the participants and the researcher's interpretation, and coaches used this meeting to explore the interpretations further.

A reflexive approach to this research is also integral in ensuring the transparency and quality of the research (Korstjens & Moser, 2018). The researcher must acknowledge their pre-conceived assumptions and be reflexive about their role in the collection, analysis, and interpretation of the data (Korstjens & Moser, 2018). Throughout the study, the researcher kept reflexive notes, where annotations and thoughts from the interviews through to transcription were recorded (Korstjens & Moser, 2018); this enables the researcher to construct interpretations and question how those interpretations arose, "what do I know" and "how do I know what I know" respectively (Guillemin & Gillam, 2004). Alongside the raw data and transcripts, reflexive notes offer an audit trail to illustrate how interpretations of the data were made. This enables the reader to track the research journey and follow the same procedures to arrive at a similar or comparable conclusion (Nowell et al., 2017).

Data Synthesis: Case Studies and Mixed Methods Approach:

The quantitative and qualitative data were collected simultaneously over a period of 12 months. For each individual player, their growth, maturity status, and game time/performance were recorded over the three phases of the study. The qualitative data collected over the same three phases was recorded and analysed. The data were then

combined to gain further understanding and context. Finally, data were synthesised to culminate in case studies. A mixed methods design was employed to draw upon the benefits of both quantitative and qualitative research, and to provide a rich, complex approach to tackle the research question (Tashakkori & Teddlie, 2010). The researcher also had access to gather both quantitative and qualitative data in a hard to reach elite sample (Creswell & Creswell, 2018). Although time consuming to collect and analyse both forms of data, it was thought the simultaneous collection of the data (See Figure 7) in a convergent mixed methods design was the best approach to answer the research question.

Case study methodology is a comprehensive approach to describing and exploring complex issues, where the researcher is interested in the phenomenon and the context in which it occurs (Houghton et al., 2015). The case studies in this study originate from the thematic analysis. The case studies produced provide a combination of both the qualitative and quantitative data to further illustrate the themes in specific players and coaches. Case studies were collected inductively, whereby both quantitative and qualitative data were collected, analysed, and combined, to create multiple case studies based upon the data integration (Creswell & Creswell, 2018). The combination of the qualitative and quantitative data allowed for the corroboration of the coaches' experiences and perceptions to better understand the manner in which changes in growth and maturation in adolescence influence performance and perceptions and the dynamic nature of this relationship. See Table 7 for an example of how the longitudinal data was recorded and combined.

Table 7: Example of how data were recorded and synthesised for each player.

Player	**Jan-April 2019**	**May-Sept 2019**	**Oct-Jan 2020**
Player ID (Birth Quarter) Age Group	"Coaches Interviews" Growth Velocity over this period: % Predicted adult height at start and end of period: Match grade over this period: Game time over this period:	"Coaches Interviews" Growth Velocity over this period: % Predicted adult height at start and end of period: Match grade over this period: Game time over this period:	"Coaches Interviews" Growth Velocity over this period: % Predicted adult height at start and end of period: Match grade over this period: Game time over this period: Released or retained:

Results and Discussion

Descriptive statistics are presented in Table 8, 9, and 10. Table 8 shows the mean, standard deviation, and range of players growth velocities over time for each age group. The mean growth rate values in this study varied over time and across the age groups, which is consistent with other studies that have documented no clear or consistent pattern of growth velocities within adolescence (Teunissen et al., 2020). Descriptive statistics for percentage of predicted adult height over time for each age group are shown in Table 9. As expected, mean percentage of predicted adult height increases over time and over successive age groups. Table 10 shows descriptive statistics for coach evaluated match grades over time for each group. Grades generally decreased as age groups increased; a finding similar to that shown in study one and two of this thesis (Hill et al., 2020).

Under 16 players were removed from this descriptive analysis due to the high frequency of missing data, and a selection and release decision in this age group meant many players were released from the academy and therefore left the study.

Table 8: Descriptive statistics for growth velocity over time by age group in cm/year.

Age Group	Sample size (n)	January-April 2019			May-September 2019			October-January 2020		
		$\bar{x}$	SD	range	$\bar{x}$	SD	range	$\bar{x}$	SD	range
Under 12	16	5.90	1.94	6.70	6.84	2.23	7.68	10.62	2.70	9.83
Under 13	22	8.81	2.81	8.57	6.22	3.14	9.61	8.77	3.81	14.50
Under 14	15	8.05	3.01	10.01	7.31	3.61	10.71	4.56	2.48	6.09
Under 15	18	5.80	2.98	10.06	2.52	1.79	5.81	2.52	2.19	6.08

$\bar{x}$ = mean, SD= standard deviation

Table 9: Descriptive statistics for percentage of predicted adult height over time by age group (%)

Age Group	Sample size (n)	January-April 2019			May-September 2019			October-January 2020		
		$\bar{x}$	SD	range	$\bar{x}$	SD	range	$\bar{x}$	SD	range
Under 12	16	87.40	2.69	8.6	88.35	2.71	9.1	90.14	2.72	9.0
Under 13	22	88.48	1.58	6.7	89.53	1.63	6.8	91.06	2.07	5.6
Under 14	15	93.53	1.59	4.7	95.04	1.39	3.8	95.84	1.49	4.3
Under 15	18	97.02	1.96	6.4	97.71	1.71	6.3	98.45	1.44	4.8

$\bar{x}$ = mean, SD= standard deviation

Table 10: Descriptive statistics for coach evaluated performance grades over time by age group (match grade of 1-4).

Age Group	Sample size (n)	January-April 2019 $\bar{x}$ (SD)	May-September 2019 $\bar{x}$ (SD)	October-January 2020 $\bar{x}$ (SD)
Under 12	16	2.50 (0.28)	2.78 (0.07)	2.79 (0.15)
Under 13	22	2.64 (0.23)	2.49 (0.32)	2.32 (0.36)
Under 14	15	2.44 (0.31)	2.45 (0.23)	2.63 (0.19)
Under 15	18	2.37 (0.30)	2.17 (0.27)	2.30 (0.39)

$\bar{x}$ = mean, SD= standard deviation

The experiences of academy football coaches managing and navigating their players through the adolescent growth spurt were characterised by three main themes (see Figure 8). (1) Growth as a 'condition', with four sub-themes: (1.1) 'having growth', (1.2) perceived signs and symptoms, (1.3) management and treatment, (1.4) implications for selection, retention, and release. (2) Advantages, disadvantages and performance expectations of maturity status and timing of the growth spurt, comprising of four sub-themes: (2.1) The advantages and disadvantages of early maturation, (2.2) the advantages and disadvantages of late maturation, (2.3) different performance expectations associated with maturity status, (2.4) the implications for selection, retention and release. (3) Player development within institutional constraints, with three sub-themes describing the context of managing and developing adolescent footballers in a competitive environment: (3.1) Player development versus winning, (3.2) conflict of potential versus performance, (3.3) player development within academy constraints.

Each theme and sub theme are subsequently discussed and selected quotations from participants are presented. Case studies are also presented to provide detailed examples of selected themes and sub-themes. Case studies present rich detail, context, and data around one player within the academy which signifies and expands on one or more of the sub-themes in greater detail. Further quotations can also be seen in Appendix B.

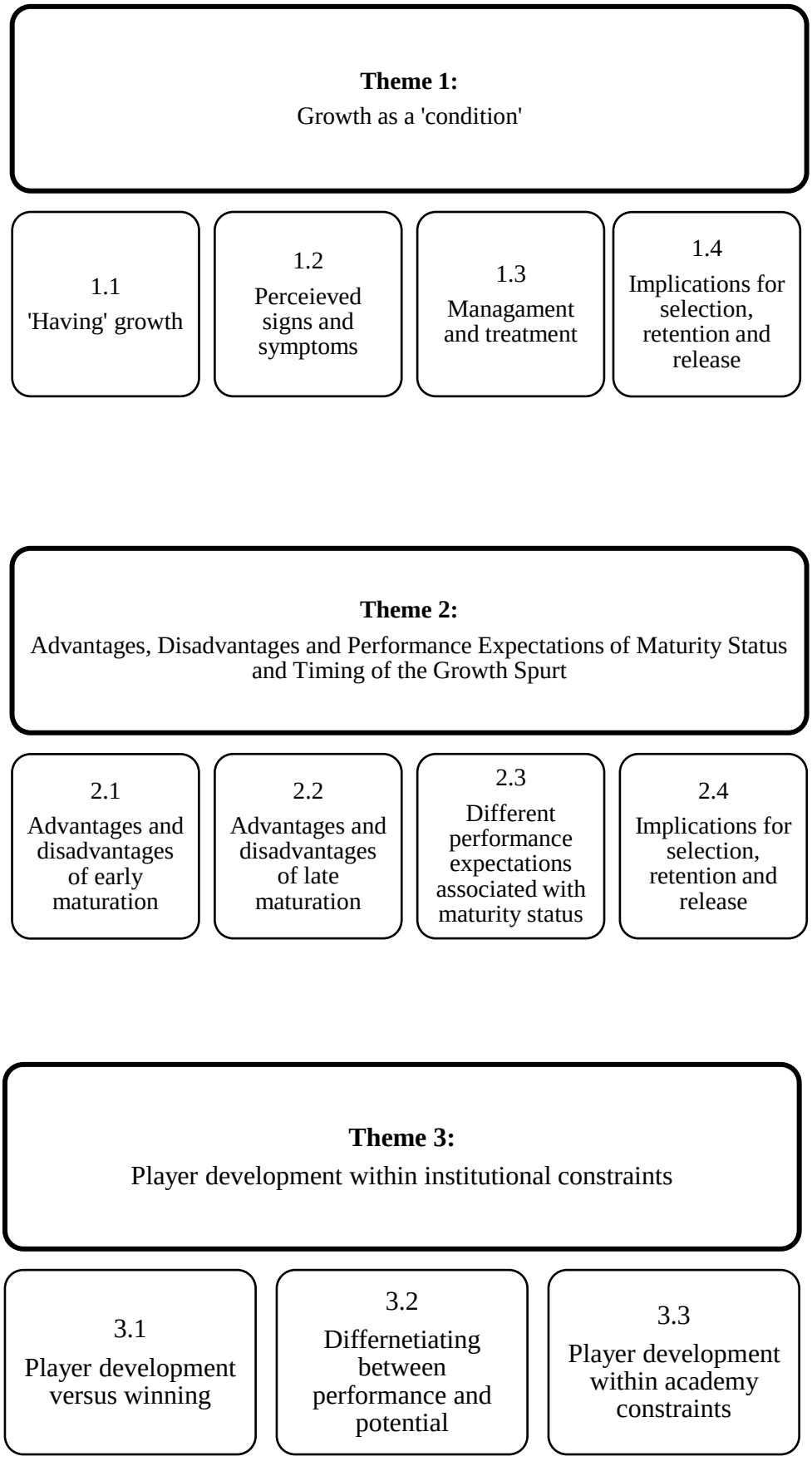

Figure 8: Hierarchy of themes characterising coaches' experiences of managing adolescent football players

Theme 1: Growth as a ‘Condition’

The experiences of academy football coaches managing and navigating their players through the adolescent growth spurt were characterised by three themes.

The first theme, growth as a ‘condition’, explores how coaches perceive the adolescent growth spurt. Coaches describe growth and the indicators of growth in the same way a medical condition is described with signs and symptoms. The adolescent growth spurt is not a medical condition or disease, however the coach’s descriptions frame growth as problematic for many players. Not all players were described to suffer from the growth spurt due to the complex idiosyncratic nature; case studies throughout this study demonstrate the huge variation and idiosyncratic nature of growth. However, coaches presented a range of views and three clear sub-themes and case studies are presented below (see Figure 9 for a hierarchy of the theme).

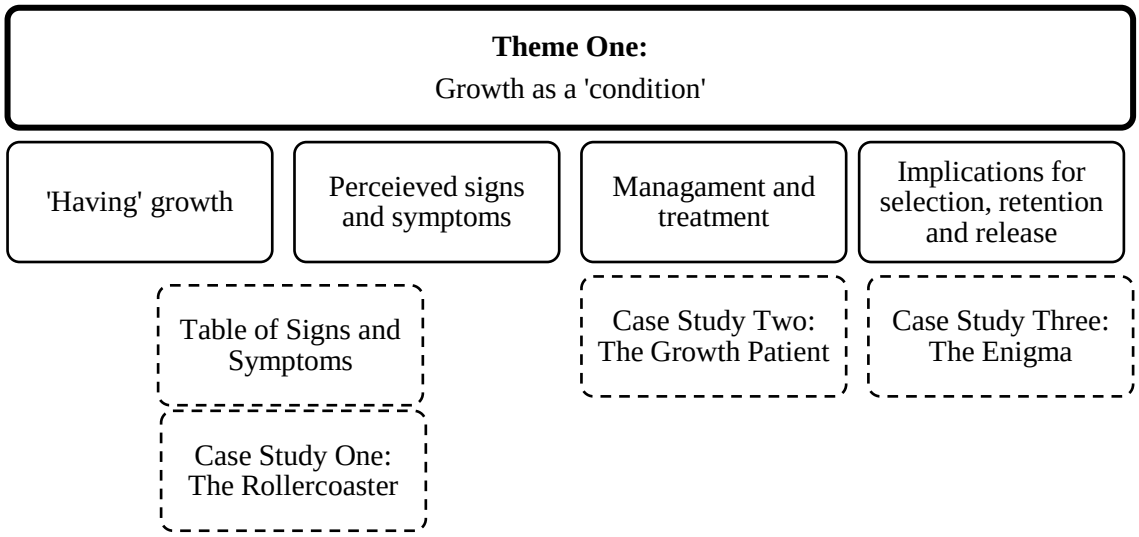

Figure 9: Hierarchy of theme characterising growth as a 'condition'.

1.1: "Having" Growth

Coaches discussed their experiences of managing and observing players through adolescence, many of whom were experiencing the adolescent growth spurt. Coaches identified the players they understood to be growing and described growth in the manner that a medical condition or disease would be described, even though growth is an essential, inevitable process that all adolescents experience, not 'contract'. This theme, growth as a 'condition', outlines how coaches identify, 'diagnose' and describe growth and how they manage and treat players in the growth spurt. Further, this theme describes their understanding and awareness of how growth affects their players, largely in relation to performance and potential. The four sub-themes and three case studies provide an overview of how coaches recognise, understand, and perceive the adolescent growth spurt in their players.

Growing was portrayed by coaches as a condition affecting players; coaches described a number of indicators of the adolescent growth spurt. Coaches talked of players being "affected by" and "suffering" from growth with symptoms varying from physical, technical, and psychological factors across players. Coaches described players as "having" growth and perceived them to be struggling, explaining their poorer performances: "I don't know if he has growth or it has been pretty steady, but the way he moves is just horrendous" (Coach 5; player-96.3% PAH, performance grade 2.20). Growth in many cases was not described as a process by the coaches; The word 'have' or 'got' was often used by the coaches when talking about growth.

Coaches expressed that going through growth could be a factor behind some players experiences.

> *Missed a lot of pre-season, or maybe he is going through some growth I don't know, but he hasn't looked as quick (Coach 2; player- growth velocity of 6.59cm/year, 85.3% PAH, performance grade 2.67).*

Players that coaches categorised as experiencing growth were often also performing poorly in training, games, and testing. Some coaches explained performances may return to their pre-growth levels.

> *"…his testing scores throughout have been quiet poor, it may be due to growth, because it has been worse this current season, it may be that he is going to dip and come back up" (Coach 1; player- growth velocity 6.33 cm/year, 88.3% PAH, performance grade 2.76).*

Research has shown growth-related decrements in functionality and performance can temporarily handicap players from showing their full potential and ability (Beunen and Malina, 1988; McKay et al., 2019). Players from this same sample experiencing the adolescent growth spurt have been shown to display performance decrements (see Study Two). In line with this, the coaches described players in the growth spurt as inconsistent or performing below the level expected of them (See Case Study One: The Roller-coaster).

Coaches also expressed worry that the symptoms and side effects experienced by some players in their adolescent growth spurt would not lessen or disappear completely after the adolescent period. Questions and worries about whether a player would return to their pre-growth performances were common.

> *"…because he was playing terribly and he looked all over the place, physically he still does, I don't know whether that is the way he will end up moving or whether it is growth related. You still question, you can't help it, I don't know whether it is totally due to growth, you can't help but worry about the way he is moving, erm and I have seen players in the past come out of growth spurts and not be as fluid as the way they were before, so it is a worry" (Coach 5; player- 96.3% PAH, performance grade 2.20)*

Some coaches emphasised that they worried about the recovery of their adolescent athletes who experienced growth-related injuries. Concerns that athletes would not be the same after their injury was a commonality across the age groups. Research has long shown young athletes are particularly vulnerable to injury due to the physical and physiological processes of growth and possible underdeveloped skills, coordination, and perceptions (Micheli, 1983; Adirim & Cheng, 2003; Caine et al., 2014). It is important for athletes to remain injury free through the growth spurt due to the significant time loss from both training and matches and the negative effects on development (Johnson et al., 2009; Price et al., 2004; Johnson et al., 2019). It is therefore understandable for coaches to worry over their injured athletes' development and future.

> *"…been injured for a long time, even pre-growth spurt and whether that has just exaggerated the problems I just don't know, but he is a terrific player, incredible player, I just hope that he comes out of this period ok" (Coach 5; player- growth velocity 11.55cm/year, PAH 97.6%).*

The preceding quotes highlight that coaches perceive growth as problematic. Coaches perceived growth to be responsible for numerous detrimental side effects. Importantly,

all young players within academy football and youth sport in general, will experience their adolescent growth spurt. Research by Tanner showed rapid growth for boys in the adolescent growth spurt takes place over a number of years; on average a boy increases in height by 7cm, 9cm and 7cm again in the three years of the growth spurt, before the rate of growth declines (1989). Therefore, players may experience accelerated growth and the associated side effects over a sustained period of time. This can have great implications for evaluation of talent, potential and selection decisions. Coaches perceiving these growth spurt years as a condition, in which some players 'have' growth and suffer, and others do not, is therefore problematic.

All normal healthy boys will undergo an adolescent growth spurt (Malina et al., 2004a). Adolescent somatic growth has been shown to be non-linear in nature, with periods of saltation and stasis, which is highly variable between individuals (Lampl et al., 1992; Teunissen et al., 2020). Although each child will differ in the timing and the magnitude of their growth, it is important for coaches to understand the process and the effects. Johnson (2015) suggests monitoring immature athletes closely through their growth spurt, with monthly measures of height and weight, to allow coaches to understand their player's development and adapt their training accordingly. If coaches were better educated regarding the adolescent growth process, perhaps they would perceive growth as less problematic, and not as a 'condition' which can be 'diagnosed'. Consequently, young athletes coming through the system may be better developed and managed through the adolescent growth process, rather than just identified, and labelled as suffering.

1.2: Perceived Signs and Symptoms

In describing their experiences of coaching adolescent boys, coaches described key areas which indicated their players were experiencing the adolescent growth spurt. Coaches described the signs they see in their athletes and the symptoms they hear from the athlete themselves, which suggest the individual is experiencing a growth spurt. These signs and symptoms help a coach "diagnose" an athlete with growth. The following sub-theme describes the signs and symptoms which the coaches discussed and presents a 'symptomology checklist'; signs and symptoms are bolded throughout for further emphasis. Table 11 presents the signs and symptoms perceived by the coaches which characterise growth being described as a condition. It is recognised that these perceived signs and symptoms vary across individuals, however coaches presented a clear pattern of growth symptomology.

Visual signs such as players long legs and big feet, broadening and filling out, and becoming lean and "gangly" were common observations by the coaches indicating a **change in size and proportion**. "He catches his feet when he is walking on the floor, like they are that big" (Coach 10- growth velocity of 9.31cm/year, 91% PAH, performance grade 2.33). Coaches quite rightly observed growth first occurring in the feet and legs; growth occurs distal to proximal, with the outer extremities growing first such as the head, hands, and feet, followed by the arms and legs, length and width of the trunk (Anderson & Twist, 2005; Malina et al., 2004a). Due to this order of growth, peak velocity of growth in the legs occurs before peak growth velocity in the trunk; rapid growth of the lower extremities is thus characteristic of the early phase of the adolescent growth spurt (Beunen & Malina, 1988). Coaches noticing longer legs is, therefore, a good indicator of the adolescent growth spurt.

> *You can see his growth, he is getting bigger, he is starting to fill out slightly, not massively but slightly from what he was like, he doesn't look as gangly at the moment as he did before (Coach 9; player- growth velocity of 5.21cm/year, 91.3% PAH, performance grade 2.09).*
>
> *I don't know where he is growth wise, because whether he naturally just has long legs or whether that is growth related, because at the moment his legs seem very long, he is very long and gangly, lanky almost at times, without being harsh (Coach 6; player- growth velocity of 6.04 cm/year, 96.6% PAH, performance grade 2.43).*

Although coaches noticed visual changes in size and proportion they were interested to know objectively if players had grown.

> *I would be interested to see what his growth spurt has been like…I think he has popped up quite a lot, I think the top part of his torso has filled out quite a bit as well in a short period of time (Coach 4; player- growth velocity of 12.34cm/year, 89.2% PAH, performance grade 2.13).*

Coaches discussed visual changes in their players size and weight, both increasing and decreasing, and some attributed these changes to a growth spurt; "Body weight seems to fluctuate quite a bit, sometimes he looks a bit heavy and I think that is linked to his growth" (Coach 1; player- growth velocity of 2.27cm/year, 88.6% PAH).

> *Seems incredibly skinny, there isn't much mass, erm but quite a good frame if that makes any sense, he is quite tall and broad, very very lean, so he might be quite a big boy when he has bulked out a bit. He is probably growing just because of that mass that I was talking about, he is very lean which would probably mean he has*

just finished or is in a growth spurt (Coach 1; player- growth velocity of 5.76cm/year, performance grade 2.73).

Alongside obvious changes in size and body proportions which the "coaches' eye" could pick up on, coaches perceived other symptoms in their players to indicate a possible growth spurt. Coaches wondered if their players were in a growth spurt when they appeared **lethargic, tired, and sluggish.** Fatigue is seen as an accepted part of adolescence, which reflects both the physiological demands of growth and the increase in educational and social pressures (Viner & Christie, 2005). For young athletes, the increase in the level of training and competition further increases the demands on these individuals. Alongside the many physiological changes and societal pressures in adolescence, sleep laboratory studies have shown adolescents require more sleep than younger children; research shows however, adolescents are consistently reporting not getting enough sleep (Wolfson & Carskadon, 1998; Carskadon, 1990; Brown, Veith, Sampson, Whalan & Fullagar, 2020). For many of the players within this sample, the opportunity to sleep is restricted by weekday school schedules and evening training, and weekends spent socialising or commuting and attending matches (Bergeron et al., 2015). Brown and colleagues found academy players to be resilient to changes in training schedules, however reported their players low sleep durations was problematic (2020). Subsequently, adolescents commonly report daytime sleepiness, which has been shown to be an outcome of puberty irrespective of changes in sleep time (Carskadon, 1990). Consequently, many adolescents face performance dips and failures, their ability to learn is impeded, and their mood affected (Carskadon, 1990). Thus, the results of this study where coaches perceived their adolescent players to be fatigued is unsurprising, yet coaches did not describe if this was measured or managed within the academy; further research pertaining to the impact of adolescent sleep on sport performance is warranted.

A **sudden lack of pace, strength and power** were also common indicators coaches described. "He has been growing, he is very long legged isn't he, he is slow, he has been growing" (Coach 1; player- growth velocity of 10.29cm/year, 88.5% PAH, performance grade 2.8). Coaches perceived many athletes to suddenly appear weaker and slower. Associated with the adolescent growth spurt in height, are adolescent spurts in functional capacities such as VO_2 max, static strength, speed and power (Beunen & Malina, 1988; Beunen et al., 1988; Malina et al., 2004a; Philippaerts et al., 2006; Gerber, Pienaar, Kruger & Ellis, 2014). Unlike the preceding quote, longitudinal research generally shows positive velocities in strength and motor tasks throughout the adolescent growth spurt

(Beunen & Malina, 1988). Largely, these studies and conclusions are, however, based upon group means; thus, it is possible for some individuals to encounter temporary problems with speed, strength, and power (Beunen & Malina, 1988). Beunen and colleagues (1988) conducted a longitudinal study and found a number of motor performance tasks were negatively affected by the growth spurt, mainly for the higher performing players (1988). For static strength, running speed, and explosive strength, 1.4%, 33.5% and 7.0% of the players assessed showed declines in performance at the time of PHV (Beunen et al., 1988). The apparent declines in speed, strength and power observed by coaches for some players in this sample may reflect their higher level of performance and the adolescent growth spurt (See Case Study One- The Roller-coaster) (Beunen & Malina, 1988).

A number of signs and symptoms or "markers of growth" suggested a player was "going through something" to their coach (see Case Study One-The Roller-coaster).

> *Yeah probably been in a dip, can still clearly tell that he is a top player erm just seems to be something going on, he has the markers of someone who is going through growth, you know the lack of focus, being moody, or not quite moving as well, he looks tired, his impact on the game is less (Coach 5; player- growth velocity of 6.55cm/year, 94% PAH, performance grade 2.83).*

Players complaining of **pain and soreness** also indicated to coaches that athletes may be growing: "He has got some knee pain at the moment" (Coach 2; player- growth velocity of 6.31cm/year, 88.1% PAH). Coaches described many of their players playing with pain.

> *Has had growth related injuries, I think a combination of his training load and spikes…he gets aches and pains and hips and he's got a hamstring strain at the moment so he has had a tough run, but quiet a resilient kid he has got on with it (Coach 1; player- growth velocity of 10.80cm/year, 86.9% PAH).*

Growth related injuries in this age range were a common trend and a further indicator for coaches of a boy's growth: "Osgood Schlatters with him, might suggest a bit of a growth spurt" (Coach 3; player- 90.1% PAH). Coaches described various players injuries as a direct consequence of them growing: "…injured, injured, injured, you know the more growth they have, and the amount of injuries is interesting" (Coach 1). Injuries for players in the growth spurt was described as expected by coaches: "…one of those things that happen with growth so, again that would suggest he's gone through a bit of a growth spurt" (Coach 3*;* player- 93.9% PAH, performance grade 2.73). Some players

experienced major injuries resulting in a long period of time out of the game, which coaches believed may have arisen from growth.

> *He has been injured for a very long time… his injury might have some correlation with his growth, with his body make up that he doesn't move that well, and obviously he has constraints within the groin area, putting more pressure in and around the groin to compensate certain things, that might be down to growth, and probably lots more variables that would have a major effect on him (Coach 8; player- growth velocity of 2.34cm/year, 99.5% PAH, performance grade 2.00).*

Pain is not always necessarily associated with injuries (Malmborg, Olsson, Bergman & Bremander, 2018). Previous research shows pain in young athletic adolescents is common, with a prevalence of 4 to 40%; research has also shown a dose-response between pain and time spent participating in sports (Malmborg et al., 2018; Kamada et al., 2016). The athletes involved in this study participate in a high level of elite sport, thus reporting of pain is unsurprising. There is a lack of research, knowledge, and guidance on pain conditions in adolescent athletes; This is due to many athletes continuing to participate in sport and the primary method of measuring conditions, is time loss from participation (Malmborg et al., 2018). Malmborg and colleagues studied the frequency of pain in a group of sports students and found 93.8% of youth athletes experienced some level of pain, mainly in the legs, knees, and feet (2018). Further, boys categorised as in constant pain were associated with poorer sports performances (Malmborg et al., 2018). Similarly, coaches in this study explained their players often complained of lower leg pains, which in turn was perceived to be impacting their performances.

Aligned with the adolescent growth spurt, rapid changes in size increase the risk and susceptibility of musculoskeletal injuries (McKay et al., 2019; DiFiori, 2010). Research in youth football show that time loss per injury and injury incidence is highest in the under-14 and under-15 age groups, coinciding with the period around PHV (Le Gall et al., 2006; Read et al., 2018). Adolescents in PHV, a period of high growth velocities, show increased joint stiffness resulting in an increased risk of injury (Kemper et al., 2015). Further, adolescents are particularly vulnerable to overuse injuries due to the cartilaginous structures such as the physes, apophyses and articular surfaces being less resistant to tensile, shear and compressive forces than mature bone (McKay et al., 2019). This results in a high prevalence of overuse injuries such as Osgood Schlatter disease and Sever's disease (Kemper et al., 2015). This risk is exacerbated by the increasing demands of training and competition that arise from increasing age and competitive level (McKay et al., 2019). Coaches in this study discussed some of their players to be struggling with

growth-related overuse injuries. In line with previous research and recommendations, practitioners should account for their players' growth and maturity status when developing training programmes; children are not miniature adults, and they need time to allow their body to develop (Maffulli & Pintore, 1990)

Changes in attitude, mood and focus were also often attributed to the adolescent growth phase. Typical teenager behaviours such as mood swings and emotion were discussed and again, coaches attributed these behaviours to changes in hormones and that their athletes were entering puberty and the growth spurt: "…definitely going through that you know teenage bit I think, maybe that's a hormonal thing" (Coach 3). Coaches perceived changes in players concentration and mood, as well as adolescent awkwardness led to mistakes and poorer performances.

> *He looks like he's gone through a bit of a growth spurt…his coordination was really off, he was miss kicking things like kicking the floor, and just he seems to have got over that a little bit now, but not all the way through it. Socially and emotionally he can be quite unstable, gets upset quite quickly, doesn't seem to be as mature as some of the other boys in terms of dealing with adversity and challenge. Quite hormonal and irritational isn't he. He is not a great mover, he is quite scuttley... He is quite egocentric isn't he, it is all about him (Coach 2; player-growth velocity 12.63cm/year, 89.6% PAH, performance grade 2.88).*
>
> *Looks like he is going through a horrendous one (growth spurt), how it has affected his brain a little bit, pretty sure he has had issues with focus and stuff before but probably not to this extreme. Some say he looks less interested at the moment I don't really see that I think he is just trying to handle his body going through this incredible period (Coach 5; player-growth velocity 5.96cm/year, 95.7% PAH, performance grade 2.67).*

In-keeping with these findings, adolescents are renowned for their stereotypical 'teenager' behaviour, moody and emotional; this behavioural change has been associated with their new "raging hormones" (Hall, 1904). Research shows, aside from the physical changes often associated with puberty, the hormonally driven process also results in the activation, reorganisation, and rewiring of brain structures impacting emotions, motives, and drives (Blakemore et al., 2010). Adolescence is a time of increased emotional reactivity, increased risk-taking behaviours and a period of time where peer influence plays a significant role in an individual's actions, irrespective of potential consequences (Casey, Jones & Hare, 2008; Blakemore, 2018). As discussed previously, sleep deprivation in adolescence can also affect a player's mood and focus (Carskadon, 1990). Moreover, for elite adolescent athletes in this study, maturing and developing in the 'pressure cooker' academy environment (Mills et al., 2012) may further add to the

teenagers' stress and attitude. Therefore, the coach's experiences of some of their players being 'irrational' or 'unstable' reflect the hormonal, cultural and societal changes occurring in an adolescent's life. Although more research needs to be conducted on how puberty impacts the adolescent brain, education around the development of the teenage brain to educators, coaches and practitioners would also aid in the understanding and management of adolescent individuals.

Adolescent awkwardness was framed by coaches as the primary symptom of the growth spurt. All coaches described adolescent awkwardness in some capacity within the interviews. Discussion around **players movement and technical ability deteriorating** was also a signal to coaches that the athlete may be growing. Visual decrements in otherwise simple tasks such as striking of the ball, skill cleanliness and awkward movements were often attributed to a change in size, even when an observable change in size had not been noticed. Players were described as **clumsy and awkward**; a loss of speed, power and agility was also perceived by coaches as a result of growth:

> *Going through some growth, making him very clumsy, movement is not good, lateral movements again are a bit awkward. He has got no power at the moment where he has grown so much, there is a lack of power, that is what I am seeing in games (Coach 3; player- growth velocity of 9.83cm/year, 92.3% PAH, performance grade 2.44).*

Players perceived to be experiencing growth were often described as "poor movers"; movement was described as being less fluid or efficient than the player has been before due to their growth.

> *Experienced some growth, he is out right now with Osgoods… Completely shut down at the moment. Funny mover, not a nice mover, but he does well in games. Just does not look fluid or effective or efficient, it's quite hips, and feet turned out and his bum stuck out bit like a crab isn't he, he is another scutteler. He doesn't look efficient in his movement, he looks like he is having to work a lot harder to make anything happen, for him to do a turn or to do something like (another player), it is taking him so much effort which is probably due to his growth and the growth related things he is going through, just naturally mechanically, he is not an aesthetic mover, he just doesn't look right (Coach 2; player- growth velocity of 11.23cm/yr, 88.7% PAH*).

Coaches recognised this adolescent awkwardness as a contributor to **making mistakes and inconsistent performances** and put this down to players struggling with proprioception and adjusting to their new size and lengthening limbs in space: "…does have awkwardness, will make mistakes…because his legs are probably longer than his

brain thinks they are" (Coach 1- player growth velocity of 9.31cm/year, 92.3% PAH). Many coaches described their athletes as having a "lack of control" over their body.

> *Really strange running style, has been growing erm, has got really long legs, I have seen some coordination issues not with running and change of direction but often the ball will bounce underneath his foot and from a throw in he will struggle to perceive where the ball is going to his foot and misjudge it (Coach 1; player-growth velocity of 6.70cm/year, 87.6% PAH, performance grade 2.69).*
>
> *He has come back quite a little bit bigger and from that his movement is a lot worse, height wise slightly and weight wise bigger, so that is off throwing him off a little bit, in terms of where he was with his speed and movement and his agility, coordination (Coach 9; player- growth velocity of 9.33cm/year, 91.3% PAH).*

Adolescent awkwardness is a widely discussed and debated topic within the scientific and coaching literature (Beunen & Malina, 1988; Davies & Rose, 2000; Quatman-Yates et al., 2012). This study was no different. Although all coaches discussed awkwardness in the interviews, the understanding, awareness, and belief in the concept of adolescent awkwardness varied greatly. For example, for some coaches in this investigation, a decline in performance and technique signifies adolescent awkwardness and a side effect of the changing adolescent body: "…maybe gone through a bit of a growth at the moment because of the awkwardness that comes with it" (Coach 2). For other coaches within this study, adolescent awkwardness was not a justification for any dips in player performance: "… the technique I am not sure we can put it down to a growth thing, I'm not sure you could do that" (Coach 7).

> *…people said to us yeah but it's because he has gone through a growth spurt and I'm like I don't see how it's affecting him that bad, making his technique that bad (Coach 8).*

The complexity of understanding adolescent awkwardness is confounded by quantitative studies showing inconclusive results and a lack of qualitative exploration of the phenomenon (Beunen & Malina, 1988; Davies & Rose, 2000; Quatman-Yates et al., 2012). The difficulty surrounding if and how adolescent awkwardness can be measured, further adds to the complexity (Quatman-Yates et al., 2012). Although this study, makes no attempt to objectively measure adolescent awkwardness, findings suggest that many youth football coaches 'observe' adolescent awkwardness in some of their players. For the majority of coaches in this sample, adolescent awkwardness was an accepted secondary effect of the growth spurt. More exploratory qualitative studies like this one, may further the debate and aid in the understanding around the complex phenomenon of adolescent awkwardness.

Coaches perceived a dip in the technical side of the game alongside the awkward movements and the signs and symptoms discussed previously as an indicator of the growth spurt.

> *"…don't look particularly fluid, they look uncoordinated in their movement, if you see a sudden drop in the technical side of their game, when they look tired I tend to think is that energy going to growing rather than the game, when they start to lack a bit of focus at times, those would be the main bits, lack a little bit of strength and seem weaker than they were" (Coach 5).*

Case Study One- The Roller-coaster, provides an example of coaches' perceptions regarding a player's struggles with adolescent awkwardness and the signs and symptoms of the growth spurt. This case study depicts one players journey through the study period, and their coach's experiences and perceptions across this time. In this case, the player's high growth rate and the coach's perceptions emphasising performance inconsistencies, provide further evidence of players struggling through their growth spurt.

Table 11**:** Table to show perceived signs and symptoms of the growth spurt.

	Physical	**Technical**	**Psychological/Cognitive**

Signs and Symptoms which coaches described:	• Visual changes in size:
	  – Height
	  – Weight
	  – Proportions; filling out, bulking out, broad or becoming lean.
	  – "Gangly, Lanky"
	  – Long legs
	• Lack of power
	• Lack of Pace
	• Lack of Strength
	• Struggle to cover ground
	• Injuries
	  – Osgood Schlatters
	  – Severs
	• Pain
	  – Knee and hip pain
	• Tired, Lethargic, Sluggish, Fatigued
		• Clumsy, untidy
		• Awkward movements
		• Poor coordination
		• Struggling with footwork
		• Struggling with ball control
		• Struggling with ball striking and accuracy
		• Inconsistent performances
			• Emotional
			• Lack of focus
			• Moody
			• Attitude

Case Study 1: The Roller-Coaster: Timeline of one under 14/under 15 player.

This case study illustrates coaches' perceptions and experiences of one academy player across the three phases of the study. This player is perceived to be struggling through their adolescent growth spurt, with coaches describing their journey similar to a rollercoaster.

Time Frame	**Jan-April 2019**	**May-September 2019**	**October-January 2020**
Quantitative Data	92.7% PAH, Growth velocity of 12.29cm/year Performance grade 2.64 Coach 3	93.8% PAH, Growth velocity of 10.15cm/year Performance grade 2.47 Coach 5 and 6	95.2% PAH, Growth Velocity of 3.28cm/year, Performance grade 2.88 Coach 5 and 6
Coaches Comments	Is an exceptional talent…His last 6 to 12 weeks have been a little bit more **inconsistent.** I haven't really noticed a massive growth spurt with him but he is definitely not striking the ball as cleanly, he is a bit of a free-kick and corner specialist so that's a big thing for him, more so in the last 6 weeks I would say, **not striking the ball as cleanly**, in possession he is a little bit **untidy** which is again just not like him, and yeah probably **not as consistent.** Again, his finishing, his striking, just not as clean as it was… His more inconsistent period for a player of his quality, and let me tell you, he is still a high standard, but I guess with him, he has set the bar so high that when he drops a little bit, you do notice it…but I think the biggest thing for him is he has just **lost a little bit of mobility and his touch** and I have not really noticed a big growth spurt with him but I am hoping it is something we can affect as well, but yeah that is where he is at the moment, as I said despite all that still an exceptional player.	Coach 6: Talented footballer, **extremely inconsistent,** however. Another one I think is going through a growth spurt, which again links to his inconsistencies in his performances, on tour he was exceptional and then the next game he was a 1. **Very inconsistent** in his performances. **Struggling with his set piece delivery**, I think that is a **coordination issue**, contact with the ball, even a dead ball isn't quite right, **affecting his confidence** a little bit, because he is usually good at delivering a ball and he kind of, with that not being there for him because he is in growth at the minute I think is a good reason for why he is struggling a little bit, confidence, consistency and being a **bit emotional** at times. Coach 5: Looks like he is going through something massive at the moment, he looks **knackered,** he looks leggy, he is still lovely with the ball at his feet but around that he **looks slow**, I hope something is happening. There was a recovery run I saw him do the other day where his head is almost throwing him off balance, just so slow and laboured to get back in, but because he is such a good player, he is getting through it. Looks like **something is going on**. Looks like he is definitely growing, and it is definitely **affecting his energy**, he doesn't look as quick.	Coach 6: He has had **some exceptional performances** but again another **inconsistent** player…like I said quite inconsistent in his performances but also he can quite easily put in a four in terms of his match grade, and then the next week or even the next day out in a 1. I don't know if he struggles physically, and I'm not sure whether he is growing a lot, he looks tired a lot of the time he looks **fatigued and lethargic** sometimes, opportunities in games where he has to, put simply if he had run quicker, he would have gone through and scored but like I say yeah he looks lethargic. And **slow**, I don't think he is a slow player, I think he is quite athletic so yeah I don't know hopefully you can tell me different or whether there is some going on. Coach 5: **Really struggling**, yeah, he looks like he has gone through growth and coming out the back of it, I say really struggling for him, the bar is so high for him. You always **see flashes of brilliance**. He has such high expectations of himself when he has gone through these periods of growth and his performance isn't quite what it has been in the past, he just cannot understand why and it is a balance between giving him a reason and giving him an excuse. He was close to tears at the weekend, yes looks like there is **something going on**, he will come out of it, just a little bit of a period where he has struggled to move as well as he has done in the past.

1.3: Management and Treatment

As illustrated above, coaches describe growth as a condition with multiple signs and symptoms which can affect players. Some coaches went on to describe how they managed this 'condition' of growth and the signs and symptoms presented. Case Study Two (The Growth Patient) provides a detailed coach account of how one player's training programme was adapted because of suffering in the growth spurt.

Coaches explained monitoring players in the growth spurt was important because of the detrimental effects discussed previously. Education around the subject matter, and an educated sports science/strength and conditioning team made monitoring the growth spurt easier for coaches. Coaches explained that the sports science department were primarily responsible for monitoring the players in their growth spurts.

> *It's not particularly difficult, because we have got S and C guys who are monitoring it every week, yeah it's not that difficult, I think the coaches are far more educated now than they were, we cannot batter them through the growth spurt, there has been enough evidence out there to show the damage and effects we are having on them long term (Coach 5).*

Growth related injuries were described in all interviews with the coaches. Monitoring players' aches and pains was described as one of the strategies of managing the growth spurt.

> *We have to monitor him a little bit because of both of his knees, both his knees, he does have a bit of pain in both his knees, which we have put down to some growth and maybe an onset of Osgood's but just really more growth related so we have to monitor him (Coach 3).*

Reducing training load and modifying training was descried as a technique to reduce growth related injuries (See Case Study Two: The Growth Patient).

> *Hasn't shown any growth related injuries but we have modified his training, just the logic between me and S and C was whilst he is in this kind of peak growth can we do anything to give him more rest because he has played so many games and we still want him to play games because he is doing well (Coach 1).*

Importantly however, in line with Coach 1, coaches need to recognise and identify players at an increased risk of injury due to growth and maturation (Johnson, 2015; Rommers et al., 2019b). The strategy of reducing and monitoring training load during the growth spurt to reduce injuries is accepted in the literature, and amongst the coaches in this sample

(See Case Study Two: The Growth Patient) (DiFiori, 2010; Malmborg et al., 2018; McKay et al., 2019; Teunissen et al., 2020; Horobeanu et al., 2017). Common growth-related injuries including Osgood Schlatters, Sever's and Sliding-Larsen syndrome can be managed by controlling load, rest, and pain palliation (McKay et al., 2019). Although coaches did discuss attempts to manage and reduce injuries, coaches also expressed that more could be done.

Coaches explained that for some adolescent players, they could have better managed their load and game time; "…yeah some players continue to play a couple of games a week, we haven't been too bad with it but I think we could have been better" (Coach 5).

Coaches explained playing the boys in their own age group, rather than challenging them in the age group above was another strategy in protecting the boys in the growth spurt:

> *If you are going through a big growth spurt, whilst going through the physical load of playing up, I can see why you would take that away from them (Coach 7).*
>
> *Whenever you are in a huge growth spurt there is going to be a risk of injury, so yeah maybe bring him back to his age group…. going through that growth spurt, because we think he is going to be the best player, does he need to be pushed at that challenge (Coach 8).*

One coach described using the growth spurt period as a chance to challenge and develop other skills (See Case Study Two: The Growth Patient).

> *Whilst you are going through growth, it's a period of time off the grass where you can hit at something and improve it so you're increasing the base level so when you are back on the pitch again you should still see those improvements (Coach 9).*

Some players perceived to be suffering from adolescent awkwardness were also offered individual practices to practice and work on fundamental movements and skills:

> *Definitely going through some growth, definitely having some issues with his movement, lateral movement, crossing his legs a lot rather than shuffling in small areas, when he receives the ball he is a little bit clumsy sometimes with his first touch, so what we are doing is every week we are giving him some individual practices, 1 to 1, he does 45 minutes every Thursday, also because of his growth, and also the way he runs, we have also got individual work with Strength and Conditioning, so we are working on that with some specific individual practices (Coach 3; player- growth velocity of 11.23cm/year, 91.4% PAH, performance grade 2.88).*

Research suggests variation in training significantly reduces the risk of overloading and repetitive strain injuries (DiFiori, 2010). Variation can be provided naturally by the changes associated with the adolescent growth spurt (Wormhoudt et al., 2017). The ASM suggests children in the pubertal growth stage should continue to participate in activity but rather retrain and refine all basic movement skills in their new, constantly changing body; basic movement skills such as crawling, hopping and walking on all fours enables coordination to be continually developed through this growth phase (Wormhoudt et al., 2017). Lloyd and Oliver suggest training of fundamental movement skills should be present within any programme for an athlete of any age (2012). In keeping with the findings of this study, the adolescent growth spurt phase can present an opportunity to refine fundamental movement skills to maintain and improve physical literacy (See Case Study Two- The Growth Patient) (Lloyd, Oliver, Faigenbaum, Myer & De Ste Croix, 2014).

Finally, coaches described educating adolescent players who were perceived to be struggling in the growth spurt. Coaches expressed understanding and educated players who were described to be suffering from adolescent awkwardness and inconsistent performances.

> *His coordination is all over the place, cannot throw a ball, cannot kick a ball at times, and that leads to him making mistakes in games, I think we always try and frame it in the right way and tell him that we understand it (Coach 1; player- growth velocity of 9.31cm/year, 89.6% PAH, performance grade 2.33).*

Coaches expressed support, patience and empathy for players affected by growth. Educating players on the detrimental effects of the growth spurt also allowed coaches to change a player's focus away from their struggles towards something productive.

> *Has been given a lot of support and seems to have adapted really well. He struggled initially and still struggles to a certain extent with ball striking and coordination, things like that, but I think a few conversations I have had with him have been about taking the pressure off of his performance and ball striking and essentially say that we couldn't care less if you shoot and it goes out for a throw in etc. Its more his response and that type of thing, you know and change his focus from what he can't do at the moment or not that he can't do but he's not consistently able to do, to shift into what can I do, what am I am able to do in spite of growth or being a late maturer or whatever (Coach 6; player- growth velocity of 7.96cm/year, 95.3% PAH, performance grade 2.67).*

There is limited knowledge and research on the education of teenagers on the normal processes of puberty and adolescence. Blakemore suggested educating teenagers on the normal changes, turbulence and difficult times experienced in adolescence, being a natural biological process, would help teenagers understand (Kellaway, 2018). Blakemore goes on to state that teenagers have a right to know and understand the biology behind their changes in body and feelings and suggests educating teenagers on puberty can empower and enlighten teenagers (Kellaway, 2018). In this study, some coaches implied they educated some players on why they may be struggling in the growth spurt, however, this appeared to be an exception rather than the norm. Educating players on the nature and implications of adolescence may help some players through this process and further research in this area is warranted.

Case Study 2: The Growth Patient

One coach described in detail their management and treatment of an adolescent player who was perceived to suffer throughout his growth spurt. This player, now succeeding in the under 18's age group, was brought into the interview by the coach to explain how his training programme was adapted by coaches. The following quotes from the athlete and Coach 9 describe this player's adolescent years from both the player and coach perspectives.

Coach: So he came through (smaller development centre), so he was out on the astro, so we would do all of our training out there under the floodlight and because you had Severs, and SLJ, your hips, Osgoods, everything

Player: I had everything, so we just did shorter sessions didn't we, we just managed it, avoided the astro didn't we, avoided that as soon as I got my Osgood Schlatters and at that time the physio was good with it, explain what it was and like… literally since the 10's season to the 13's season, I had at least one sort of growing pain every training session, my Achilles or my knees, so we just done loads of gym work because I couldn't walk properly, my feet would go in when I walk, so we did loads of erm gym stuff, he would put like insoles in my feet and padding round my Achilles so that helped me out a bit, because at like ten years old when your training, plus day release its quite hard especially in that facility, so you just got to avoid the astro.

Coach: Can you remember in terms of sessions what we would do, was it easier when you were growing compared to when you were fit, or did we work just as hard?

Player: It was like shorter but, we got more rest in, but we had done the hard work, we would get everything out of it so yeah, sort of one of those things we just managed, he would ask me how I felt before and after the session and we would just manage it from there really.

Coach: When you were growing at that time, in terms of ball striking and you had to clear the ball it didn't always happen, how did you feel from the coaches at that time when you wanted to try and hit the fullback but you couldn't do it?

Player: Yeah I couldn't kick a ball properly until I was like 12, but I told myself and he would tell me it's because you are growing and your body cant process this so when I got to the 13's season I started hitting the fullbacks and before that literally the coaches would be like oh man he isn't kicking them, because I used to play up quite a lot as well, so when you play up you have got to be doing that sort of thing and honestly I was scared, I am still not broad but I was really skinny then as well so I didn't have any muscle on me or anything like I couldn't kick a ball properly, but it just came with time and being patient with it, like I used to tell myself and my dad used to say like oh you're growing so you just got to keep on going with it and eventually it will click.

Coach: But it never stopped you did it?

Player: No I always got something out of it, like when you told me to use my right foot for the first time I started crying because I didn't want to do that, but it is about the right mind set.

Coach: It was your mind-set, so like you said you couldn't walk properly so we had to make you, you know the lines on the pitch, walk straight on the lines, seriously yeah, and skipping on the lines to help that and now he walks fine, it's about making those adjustments and it was those extra little bits…like you said work hard, shorter, more rest, like all out and then more rest, it's frustrating coming to day release and everyone else is out training in the afternoon and you aren't doing that and this is why and the rewards will come and like you said you have got to be patient…do you remember in the dome we started doing fundamental movements with you, just loads of it, and then what that lead to was when he turned 14 we could load him, so you get the fundamentals right early…fundamentals, get the basics right, yeah you are growing and your squat might be all over the place, all right no problems, widen your stance, then when you grow again readjust again, like you couldn't train so we did loads of hand eye, which is why you're so good now because we kept it ticking over…it's just giving the time to that physical development to allow them to push on, you know be patient and then the rewards will come.

1.4: Implications for Selection, Retention and Release

Aligned with the detrimental effects of the growth spurt (growth as a condition and signs and symptoms described previously) timing of the growth spurt had further perceived implications for players and coaches.

Firstly, coaches discussed concern regarding the scouts and successive age group coach's perception of players being negatively impacted because of growth (See Case Study Three: The Enigma).

> *Periods where he has really been struggling with coordination and struggling to turn, dealt with it incredibly well, but it has definitely impacted the opinions of the 16's coaches. I think he is going through a growth spurt. But yeah, they went from scholar to not sure about this lad, quite quickly and that coincided perfectly with that time. So, it has had impact (Coach 5; player- growth velocity of 8.57cm/year,* 95.6% *PAH, performance grade 2.46).*

Similarly, coaches recognised their expectations of players had not been met at the start of the season and put this down to a growth spurt.

> *Do you know what though, May to August he had a jump, and that's when we had him and we were not quite sure about him, he isn't what I thought he was going to be, I thought technically he looked really off, and now all of a sudden he has improved (Coach 7; player- growth velocity of 7.63cm/year, 93.5% PAH).*

Equally, coaches expressed they had limited time to get to know and understand where a player was in their development before players transitioned age-groups.

> *A lot of them time as staff we work with them for not even 12 months so you meet the player and he could be in the middle of something or he could be in a good moment and you form an opinion on them and then stuff happens and then you hand them over to someone else (Coach 1).*
>
> *I think that's been one of the benefits of us having them for two years is that we have got to know them a little bit better …you get to know the boy, they get to know you… I think you start to understand not just spot their physical changes because you see them grow, you start to spot that as you're a little bit more aware of it. Sometimes so, like next year…I am going to have to be really mindful of you know who is going through a growth spurt right okay, let's keep an eye on him…but going through that pre to post you know that maturation (Coach 3).*

As well as impacting upon the perceptions of coaches of successive age-groups, the growth spurt also had implications for scholarship decisions. Some coaches believed players experiencing the growth spurt at the time of selection could hinder their chances

of being selected in certain age-groups: “Maybe decisions at 12 and 14’s is a challenge if they are experiencing something that is going to hinder their performance” (Coach 5). The timing of a player’s growth spurt was described as important in terms of selection periods, as growth was described as significantly impacting coaches’ perceptions of player ability and selection:

> *Like I have literally said… who is going to go through a growth spurt next season and again you don’t know for exact but when we know they are pre-growth you’re like oh bloody hell that is going to kill us, just you know… just hold off on your big growth spurt for 6 months and we will be fine, because everyone will go oh he is late it is ok there is more to come, but if you are in it, people go oh he is done with growth, and he is not performing well enough and that massively affects their perceptions of the lads so yeah it is important we have this (Coach 5).*

Coaches worried about their players who did appear to ‘suffer’ from ‘growth’. The symptoms of growth were problematic for coaches; deterioration in movement patterns, performance and attitude changes and injuries attributed to the growth spurt. Coaches described their techniques to reduce players suffering in the growth spurt but also explained the further implications of growth including the change in perception from other coaches and scouts. Case Study Three: The Enigma represents growth as a ‘condition’, perceived signs and symptoms and implications for selection, retention, and release.

Similar to the findings of study two, the adolescent growth spurt can influence coaches’ perceptions of performance and thus ability or potential. Players experiencing their adolescent growth spurt were perceived to perform more poorly than their pre-growth spurt peers; these performance decrements associated with the growth spurt have great implications for evaluation, selection and retention (Study two).

The observations of awkwardness and growth-related declines in performance within this sample coincide with the acceptance of adolescent awkwardness in the coaching community (Lloyd et al., 2013; Ryan et al., 2018). The extent to which this is accepted and discussed within player selection/retention meetings is, however, unclear. Practitioners and academy coaches should continually consider a player’s growth and maturity status in their coaching, evaluations, and selection decisions. Further, as well as the respective age-group practitioners, successive age-group coaches and decision makers ought to be educated and understand the negative implications the growth spurt can have for some boys. Coaches and decision makers should be aware of players suffering through the adolescent growth spurt in the lead up to a selection decision (See Case Study Three-

The Enigma); additionally, perhaps players and parents could be educated as to the adolescent changes and 'side-effects' to relieve the pressure in the run up to selection decisions.

Case Study 3: The 'Enigma'

Many coaches described players who were experiencing problems they associated with the growth spurt. One coach described a player as an "enigma"; the coach described the players' struggles in the growth spurt, how this affected opinions on his potential, but also how he has managed to carry on performing. The following quotes and data relate to this boys' experiences from January to May 2019 as perceived by Coach 5.

"Absolute enigma. Every time I see him at the moment he just looks like he is going through the worst growth spurt in history. I will be honest, he is a really talented footballer, dribbler, goes by people with ease, he is strong, he is going to be a big lad, he is going to be quite physical. I have had to go back and watch 13's fixtures on video, so I have some clips sent to me to remind myself, and just check what he moved like before, it is so bad now that it is really influencing people. We have had scouts going how could you have someone that moves like that, not scouts of our own, this is other clubs, like I remember a couple of years ago he was a beautiful mover what's happened to him? I have just convinced myself as an optimist that once he comes out of it, all of those things will come back, and we will have an incredibly exciting player on our hands. I just can't help but worry when a lad is moving so poorly, even through this growth spurt.

Honestly if you see this lad move at the moment, oh he just can't even move backwards without looking like he is going to fall over… this is a patience, let's see what happens when he comes out of it… you can talk about how bad he looks in his growth spurt, the flip of it is, I cannot believe how he has managed to still perform in this type of growth spurt, he has still had games this season, where he has done really well and been effective. He has to change his game to adjust to the fact that his body is not as coordinated as it once was. I have not seen many lads deal with moving that badly this well. Normally they just play shit and it's obvious for everyone that he is going through a growth spurt and we have to be patient, but he has still played pretty well

…but he looks like he is going through a horrendous one, like how it has affected his brain a little bit. I am pretty sure he has issues with focus and stuff before, but probably not to this extreme… when they are going through this growth spurt there seems to be a lot more complaints about their attitude, and he would be one of them. Lacking focus, so I think people are going to have to be aware of that, that there is a lot of energy going into growing which is taking their energy away from being able to focus, so yeah he is one for me that looks like he is less interested at the moment, I don't really see that, I think he has trying to handle his body going through this period".

Game time in this period: 4 games- 265 minutes

Played all games in Bio-half 2 (least mature) with an average match grade of 2.67

Growth velocity in this period= 6.19cm/year

Percentage of Predicted adult height in January= 94.27%

Percentage of Predicted adult height in May= 95.70%

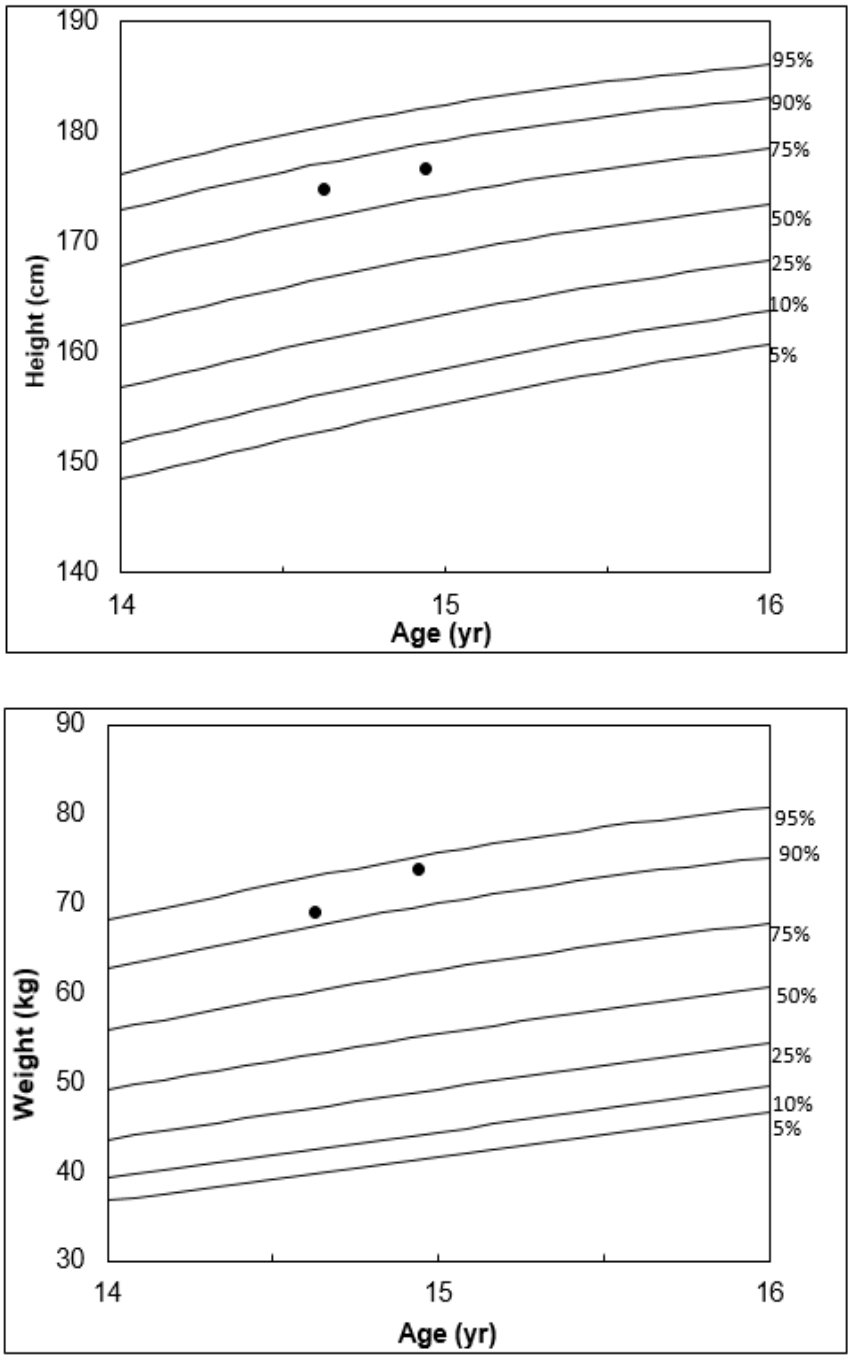

Figure 10: UK growth chart depicting players' height and weight relative to their age for player in Case Study 3

Theme 2: Advantages, Disadvantages and Performance Expectations of Maturity Status and Timing of the Growth Spurt:

Across the age groups, coaches visually identified and categorised the players on either end of the maturity spectrum: "super early" (Coach 1) and "very late maturer" (Coach 3). Coaches also identified and described less extreme early and late maturing boys; coaches described on-time players in very minimal detail. Players who mature on-time were overlooked by coaches as they described the more extreme ends of the maturity spectrum. Further, coaches described many players as late maturing, when in reality some of these players are not delayed in maturation; these players within a normal population would be considered on-time, however in an elite football academy where a maturity selection bias is present (Meylan et al., 2010; Johnson et al., 2017; Hill et al., 2019), coaches consider these players as late maturing. Previous research in this academy showed the majority of the players at the time of the study to be considered 'on-time' in terms of maturity status (Hill et al., 2019). It is important to note when discussing the late maturing players within the academy, some may not truly be late maturing, but are maturing later than their peers. This theme discusses the advantages and disadvantages of early and late maturation, the expectations coaches have of these players, and the implications of maturity status and timing on selection decisions (see Figure 11 for a hierarchy of theme 2).

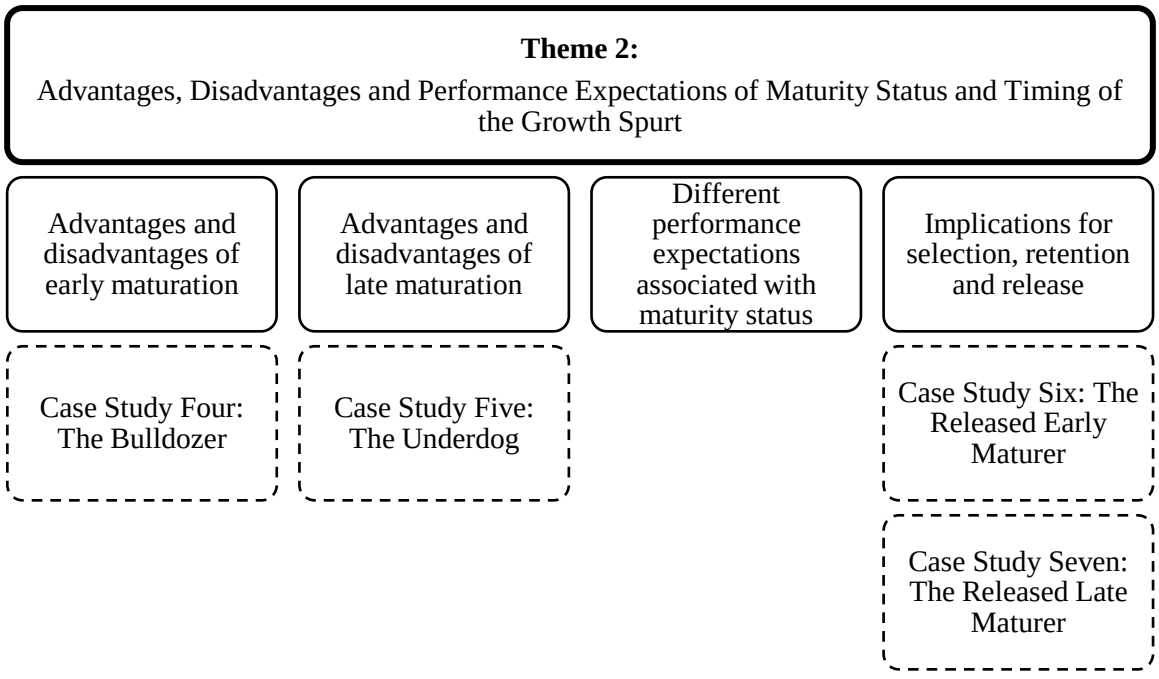

Figure 11: Hierarchy of theme characterising advantages, disadvantages and performance expectations of maturity status and timing of the growth spurt.

2.1: Early Maturation

Coaches perceived a number of advantages associated with their players maturing in advance of their peers and experiencing the adolescent growth spurt earlier than their peers.

Early maturing players were identified by coaches primarily due to their greater size and physical attributes. In addition to objective data, coaches used facial features, muscle development, comparisons to other players and physical testing results to distinguish maturity status. For many early maturing players, there was no worry over their future height and physicality: "I think he is going to be like 6ft1 and he has been this size since he was like 11 or 12 so it has been easy for him" (Coach 1). Early maturing players reach their adult height earlier (Sherar, Mirwald, Baxter-Jones & Thomis, 2005) thus, perhaps there is less anxiety among coaches regarding their future size.

> *Physically he has done quite well, I think he is one of the earlier maturing in the group and you can see that you can see physically he is further ahead than some of the other players. How he has filled out and his physique and also like some of his facial features, you can kind of tell, another good indicator is his range of pass, that fact that he is physically capable to play the ball over a variety of different distances in comparison to others who maybe are later in the group (Coach 6; player- growth velocity of 4.39 cm/year, 97% PAH, performance grade 2.63).*

Coaches noted advanced size and physicality was a benefit of early maturity, as players could use their physical attributes to compete: "He manages to compete quite easily because he can use his body, he can protect the ball, he can move people" (Coach 1; player- growth velocity of 5.96cm/year, 92.9% PAH) (See Case Study Four: The Bulldozer).

> *Very early maturer, has got some good strong physical attributes because of that in terms of his size, physicality, his range of passes is quite varied because he has the strength to make those much longer passes (Coach 3; player- 94.2% PAH, performance grade 2.75*).

It is known, on average, early maturing boys are taller and heavier from late childhood. Boys who mature in advance of their peers tend to experience a more intense adolescent growth spurt, reaching greater PHV, causing greater pubertal gains in height, weight and lean mass (Malina et al., 2004a; Malina et al., 2015; Cumming et al., 2017a). Further, early maturing boys have an athletic advantage because of their greater size, speed,

strength, and power compared to their peers. Early maturing players also perform better in certain skills, such as dribbling speed, although to a lesser extent (Figueiredo et al., 2009a; Malina et al., 2005; Meylan et al., 2010). Buccheit & Mendez-Villanueva also found that in games, early maturing boys cover greater distances at high speed, reach higher peak speeds and participate in more high-intensity and repeated high-intensity actions (2014). Early maturing players generally therefore are more 'physical' than their on-time or late maturing teammates. Previous research has shown early maturing boys tend to use their physicality to dominate games in their age groups (Cumming et al., 2017b). This investigation shows coaches subjectively perceive and observe, early maturing players dominating and using their physicality in training and games. Similar to the results of study one, coaches perceive early maturing players to perform better than their later maturing teammates.

Players advanced in maturity were described as strong, physical, powerful players who added physicality and protection to the team.

> *He has played up a couple of times and done very well, so he is able to deal with the physicality, he is quite a big strong lad at the moment, and erm he deals with that physical side very well. And he adds that little bit of physicality to us as a group in that middle and central area (Coach 3; player-growth velocity of 8.19cm/year, 95.6% PAH, performance grade 2.75).*

A unique finding from this study is that coaches perceive early maturing players offer protection to other players within the team. This may also explain the finding shown in other studies, where early maturing players tend to dominate the spine positions within a team (Meylan et al., 2010; Malina et al., 2004b; Towlson et al., 2017). Early maturing players not only have the desired size and physical characteristics for the spine positions, but they also provide security for the other players around them.

Early maturing players were also perceived by their coaches to be more consistent in their performances. Coaches believed early maturing players gave the team the best chance of winning games because of the impact they have on matches: "…the lads that are early tend to have a greater effect on games" (Coach 5).

> *"…Tend to be more consistent performers ..everything a range of things from like ball retention, tied in with ball striking, coordination, to the athleticism to cover ground and compete, you know those types of things so yeah they obviously, the early's give you the best shot" (Coach 6).*

Many of the coaches in this study described their early maturing players as not only more physical, but more consistent; however, inconsistency, alongside adolescent awkwardness were described as a side-effect of the growth spurt. For most early maturing players, who have already come through their adolescent growth spurt and have reaped the associated maturity benefits, are thus, not struggling through growth (See Theme 1- Growth as a Condition). Similar to Mitchell and colleagues work in elite adolescent ballet dancers, one of the perceived advantages of early maturity is that the detrimental side-effects of the growth spurt are 'out of the way' (2016). Importantly for early maturing athletes, the problematic growth period is completed in the older age-groups, where the load, competition level and pressure to perform are greater (Mitchell et al., 2016).

Coaches described a notion, where early maturing players increased the chances of the team's success. Due to the early maturing players greater size, physicality and performance consistency, coaches perceived early maturing boys to provide the best opportunity to win games. It therefore makes sense that players advanced in maturity are perceived by coaches, scouts, and selection decision makers as more talented (Cumming et al., 2017b) and why early maturing boys are overrepresented in many sports (Sherar et al., 2007; Malina et al., 2015), including football (Meylan et al., 2010; Figueiredo et al., 2009a; Johnson et al., 2017; Hill et al., 2019).

Equally, coaches discussed some disadvantages to players being early maturing. Coaches discussed some players who they believed to be fully grown, however coaches hoped for a greater end height:

> *Early maturer, his muscle development…very strong and powerful, hasn't particularly grown and I am hoping he isn't done, I am hoping there a few more inches in him (Coach 3- 94.6% PAH).*

Some coaches believed their early maturing athletes were not only fixed in their height, but perceived little or no improvements in physical testing: " I think he is 24, he probably reached his peak probably last year, and you can see now there is nothing else to come" (Coach 7), and "I will hear people talk about him as an early maturer and so what else is there to come" (Coach 5).

> *I think I am right in saying he is an early one, he is powerful, he is quick, we haven't seen anything on the eye, not much change in the last year from him, as in speed, fitness, endurance, I think he has been that size for a while now…we haven't seen him getting more powerful, quicker, getting through games better…if anything he is struggling, I think he reached his peak back end of last season,*

> *hence why we haven't seen a shift in anything from him (Coach 8; player- growth velocity of 0cm/year, 99.7% PAH, performance grade 2.09*).

Young adolescent athletes show their greatest rate of development in many performance and functional capacity tests around the same time as PHV (Beunen & Malina, 1988; Malina et al., 2004a; Philippaerts et al., 2006). After PHV, the rate of improvement in many functional capacity testing slows down (Brown, Patel, Darmawan, 2017). Thus, early maturing players who experience PHV earlier will achieve their peak improvement in strength, speed, and power before their peers; equally, their rate of improvement will also slow while their later maturing peers are continuing to increase. Coaches may therefore perceive that their post-PHV early maturing athletes are not improving. It is important for coaches to understand improvements do continue into adulthood, albeit at a smaller rate, and so early maturing athletes are not 'done' (Brown et al., 2017).

Coaches also perceived their early maturing athletes to depend upon their physicality in training and in games, neglecting improvements in their technical and tactical skills.

> *I would say he gets away with a few things because of his size, I would like to see a neater first touch and more playing off two to improve his tempo, I think he takes extra touches because he can you know. We were doing 1v1, receiving to play forwards and he was just stepping on the ball and doing foot taps and holding the player away and I had to stop him and remind him what the objective of the task was (Coach 4; player- 94.2% PAH, performance grade 2.75*).

Many early maturing players were perceived by their coaches to be physically effective but technically and tactically behind. Commonly, across the age groups coaches discussed a need for early maturing players to continue to develop their technical and tactical ability and not solely rely on their physicality: "The early's see have to then work on their technical attributes, and body positioning, awareness, to combat being an early developer" (Coach 7).

> *Very early, physically really powerful, he is like a bull in a china shop… erm and that is how he identified himself as a player and how he is recognised, coaches have recognised that's what's good about him, he is a destroyer and like a wrecking ball. Technically he is behind, erm his understanding he is behind (Coach 1; player- growth velocity of 2.47cm/year, 88.6% PAH).*

Coaches described early maturing players as "predictable"; early developing players used their strength and size to dominate play through the academy system, at the expense of learning and refining their technical and tactical skills. Coaches illustrated early maturing

players experienced an easier journey through the academy than later maturing players (See Case Study Four: The Bulldozer).

> *He is someone who has got their way through the system by being a bit of a big kid, and not had to think about his game, or how long he spends on the ball, or whether he has to track runners properly because he can just deal with it and catch up (Coach 1; player-growth velocity of 6.70cm/year, 92.5% PAH, performance grade 2.63).*
>
> *Early mentality, which is you stop developing a lot of your game because you don't need to, your touch doesn't need to be perfect because you can bundle your way through, your movement doesn't need to be on-time because you are going to get there anyway, whereas (Late Maturing player) has to be spot on with everything or he knows he isn't going to survive (Coach 5).*

The above quotes highlight a challenge for coaches, whereby early maturing players fail to develop the technical and tactical elements necessary to succeed at the highest levels. Previous research has shown some precocious players can display technical and tactical deficiencies due to over reliance on their physicality (Malina et al., 2015; Cumming et al., 2017b; Bradley et al., 2019). When early maturing players play against less mature boys, they experience less challenge, and consequently limit the development and learning of psychological, technical, and tactical skills which are required to progress to the professional level (Cumming et al., 2017b; Bradley et al., 2019). Failing to develop the psychological, technical, and tactical aspect of their game can be detrimental to an early maturing player's development and ultimately their success (Johnson, Blum & Giedd, 2010) (See Case Study Four: The Bulldozer). Importantly however, not all early maturing players are technically behind, and for those that are technically deficient, many still have good opportunities to progress to the next level (Zuber et al., 2016).

Coaches also described some early maturing players who, despite being early maturing, did not use their physicality to their advantage: "Although he has a physical presence in terms of his size, he doesn't use that at all" (Coach 3). Some coaches perceived their early maturing players not needing to exert their physical strengths, because of their advantageous size, they would still be able to "get there":

> *He can't really jump which is a problem for a goalkeeper, he just reaches which maybe he gets away with at the moment because he is one of the taller ones" (Coach 4).*

This was a common finding across the age-group coaches; many early maturing players were so advanced compared to some of their peers that minimal physical effort was required for them to successfully compete. Again, not only does this hinder the athletes

learning and development, but illustrates the competitive inequity often found in chronological age groups (Cumming et al., 2017a). Bio-banding, a strategy whereby players are grouped based on their maturity status, reduces these extreme differences in maturity and size, creating a more level playing field (Cumming et al., 2017a).

> *He is very early isn't he, I believe he is early, again physically he is very powerful, very quick, very strong, don't think he uses his body well enough at times which is quite interesting, in terms of how he uses it to protect the ball, to win the ball, in those types of situations, even though he is an early he seems to struggle with the ball being played in behind him, he can get caught out sometimes, little bit naïve maybe because of where he has come from, and his background, best player in grass roots football, and got away with a lot of things, now he is being exposed for things like that... Could use his physical attributes to his advantages at times (Coach 6; player- growth velocity of 1.92cm/year, 95.4% PAH, performance grade 2.14).*

Some coaches described a need to play their early maturing players in higher age groups in order to continue their learning and development: "Look where they are physically and if they are early you are going to have to bump people up aren't you, to challenge them" (Coach 7). Playing early maturing players in a higher age group was recognised as a talent identification tool; "…future proofing him" (Coach 1) and as a player development tool "We don't want him to end up as another early who overused his physical attributes and lost other attributes if we are not careful" (Coach 5) (See Case Study Four: The Bulldozer).

Coaches also perceived early maturing athletes would be caught physically but also overtaken in terms of technical and tactical understanding by their later maturing peers.

> *You can only rely on it for a certain amount of time, before ultimately the weaknesses start to open up and show because you haven't worked on them, or not had access to that point to build that gap because they get bigger and bigger as the older you get and the age groups you go in (Coach 8).*

> *He is another one who I think has used his physicality, yeah I think he has done, and I think it has made him look quite good as well, when he comes up against someone now who is a little bit nippy and sharp and speedy yeah he really struggles, he really struggles (Coach 7; player- 98.4% PAH, performance grade 2.11).*

Coaches described some early maturing players who struggled when their later maturing peers caught up to them: "…looks like an early who has got away with a lot in his early years, or early in his journey and then now there are people catching him and he is finding it more difficult" (Coach 6).

The lack of challenge throughout the age groups for early maturing athletes is problematic when the maturity-associated advantages in size and function are diminished in late adolescence and adulthood (Lefevre et al., 1990; Malina et al., 2015). In line with the quotes above, early maturing players are often 'found out' in the older age groups, when their technical and tactical deficiencies show. Researchers suggest this may explain why the players identified as the most talented in the youth game fail to meet expectations in young adulthood (Lefevre et al., 1990; Malina et al., 2015). One of the purposes of bio-banding is to ensure early maturing players continue to develop the technical and tactical element of their game by increasing the physical challenge by playing in maturity-matched groups rather than age-groups (Cumming et al., 2017b). Qualitative research has shown early maturing athletes found bio-banded games promoted a more technical and tactical style of game (Cumming et al., 2017b). Research is warranted to explore whether using strategies such as bio-banding reduce the number of early maturing players who are technically deficient.

2.2: Late Maturation

Coaches perceived a number of advantages associated with their players maturing in delay of their peers and experiencing the adolescent growth spurt later.

Late maturing players were perceived to be the smaller, slighter players on the pitch: "…he is a later maturer within the group, just physically in general, smaller than everyone else" (Coach 6). Coaches recognised late maturing players would make gains in size and physicality. Further, coaches understood late maturing athletes' physical testing results should be evaluated with their maturity status in mind.

> *Late maturing, erm testing for his age group is just average, but biologically is good. Another really exciting prospect because when he physically develops, dad is a giant, dad is 6 foot 4, erm so he is going to be a good size, and he is going to be quite a complete package (Coach 1; player-88.5% PAH, performance grade 2.87).*

The coach's suggestion above to compare athletes against maturity standards is good practice in talent identification and development. Cumming et al suggest using a combination of maturity and fitness data to generate age and maturity specific references for evaluation of fitness (2017a). When comparing a late maturing player to their chronological age group, their physical scores may appear to be poor; however when

compared to players of the same biological age, late maturing athletes' physical testing scores may appear more favourable (Cumming et al., 2017). In line with the quote above, understanding a player's maturity status is therefore paramount when evaluating physical fitness for selection.

Coaches perceived later maturing players to be "exciting prospects" once they caught up physically, because of their advanced technical and tactical understanding.

> *He has learned the tactics and the bigger picture, so he is just waiting for his body to catch up and when it does I think he has got a massive amount of potential (Coach 2).*

Late maturing players were highly developed in their technical and tactical skills to compensate for their lack of physicality. Coaches believed later maturing boys "…are forced to make better decisions" to remain within the system (Coach 5) (See Case Study Five: The Underdog).

> *Awareness, simple as that, awareness, can he work something out, does he not get into that physical battle because if you have got all that you have got understanding and game intelligence so as you get older and you start to grow, you have already got the basics, the fundamentals, the knowledge to get away from that, and as when you become physical if you want to deal with it you can, but you have also got the other bits….I don't care about the physical stuff, I want to see a football brightness or a football intelligence (Coach 8).*

Coaches described some attributes and qualities which late maturing players developed and adapted into their game to compensate for their lack of physicality. Anticipating and intercepting was one example of a late maturing player adapting.

> *"…he is quite a slight lad… he struggles with 1v1 and I think that's where he has adapted his game to you know, anticipate and read the game and intercept it rather than trying to going in for the physical battle" (Coach 3; player- growth velocity of 5.96cm/year, 91.5% PAH, 2nd latest maturer in team, performance grade 2.91).*
>
> *"…but I don't know whether it is by luck or he is quite bright but he is kind of adapted and adapted and adapted and found a way to compete, moving the ball quicker, taking less touches, picking out good spots, but in a 1v1 duel he will struggle" (Coach 1; player- growth velocity of 11.81cm/year, 89.5% PAH, performance grade 2.73).*

The findings of this study are in line with other studies showing that late maturing players are often technically and tactically superior to their peers (Schorer, Baker, Büsch,

Willhelm & Pabst, 2009; Zuber et al., 2016; Cumming et al., 2018). Schorer and colleagues found late maturing players often show superior technical skills (2009). Equally, Zuber and colleagues conducted a longitudinal study of elite youth football players and found late maturing players to possess superior adaptive and technical skills (2016). Research has shown that late maturing players must find ways to cope with their different physical limitations in order to cope against the on-time and early maturing players (Schorer et al., 2009; Vandndriessche et al., 2012). For some late maturing boys, their resilience and mentality to continually fight and adapt, means they overcome the challenges of the environment they are in, and consequently go on to develop into professional athletes; Robert Eenhorn, a former National baseball coach states late maturing athletes are 'diamonds in the rough' (Wormhoudt et al., 2017).

Importantly, while it is argued that late maturing players will eventually rise to the top because of the greater challenge presented to them, a plethora of research has shown late maturing boys are underrepresented in academy football (Meylan et al., 2010; Malina et al., 2015; Johnson et al., 2017; Hill et al., 2019). Thus, the argument only stands for the small number of late maturing athletes who are retained in academies (Johnson et al., 2017; Hill et al., 2019). Whether the small number of late maturing players in the system are selected because of their superior technical ability, which was necessary for them to be initially selected, or if they develop a superior ability due to the challenging environment, warrants further investigation (Cumming et al., 2018). Zuber et al found that despite later maturing players possessing advanced technical and tactical skills, they still failed to progress to the next competitive level (2016). Thus, more research and strategies need to be conducted and trialled to reduce the under-representation of late maturing athletes in youth football.

Finally, coaches believed that due to the level of challenge late maturing boys faced compared to their early maturing peers, in terms of lack of size and physicality, late maturing boys were described as being particularly resilient. Some coaches described their late maturing players as underdogs who had to work harder: "He has definitely got the underdog theory, he is at people tackling them and running around, he is a real terrier (Coach 2).

> *The reason our percentages suddenly start to drift in favour of the lates is because they have had an incredible level of challenge and they have had to keep surviving, natural selection, they have managed to get through that stage because they have something else (Coach 5).*

Like a lot of the kids in here are quite tough and resilient…but this is quite a late maturing group for an academy group…they have been beaten up a lot so when they get beaten up its like oh here we go again, whereas if you've always been striving and always been thriving and then when it gets tough you're like oh what's this (Coach 1).

I think considering how late he is, I think his energy levels and his mobility to keep running and willingness to keep running forward and back, erm doesn't faze him that he is up against someone bigger, he will try and use what physicality he has got, and he is quick, I bet he has so much to come, I think there is a lot there (Coach 7; player -growth velocity of 1.4cm/year, 94.9% PAH, performance grade 2.8).

The above quotes align with the 'underdog' hypothesis discussed within the scientific and coaching literature, whereby relatively younger and/or later maturing players hold the best chance for success at the professional level (Krogman, 1950; Gibbs, Jarvis & Dufur, 2012; Malina et al., 2015; Cumming et al., 2018). Research began in Little League Baseball (Krogman, 1950) and has been advanced in ice hockey (Gibbs et al., 2012) and football (Cumming et al., 2018). Studies suggest that for late maturing and relatively younger athletes to remain within competitive sports programmes and academies, they must possess or develop superior technical, tactical, and psychological skills (Cumming et al., 2018). As described previously, late maturing athletes experience a greater level of challenge within the sport environment which promotes and necessitates the development of many attributes (Cumming et al., 2018). Again however, for late maturing players to benefit from the 'underdog' hypothesis they must be retained within the system (Cumming et al., 2018). Youth sports programmes and academies need to ensure they are not releasing and excluding late maturing players from the system and make certain these boys have the opportunity to go on to the next competitive level.

Coaches also described disadvantages associated with their players being late maturing and experiencing the growth spurt after their peers. Late maturing players were described as having physical issues. Descriptors such as slight, small, and dot, were used to illustrate their lack of physicality: "Obviously there is a physical issue and we have spoken to him about being patient, slight lad" (Coach 3; player- growth velocity of 5.96cm/year, 91.5% PAH, performance grade 2.91). Coaches understood for some late maturing players, their growth spurt was still to come, and in line with Theme 1 (Growth as a 'condition') the issues associated were also still to be experienced: "At the moment he is doing well, his movement is good because he hasn't gone through a growth spurt yet, I think that helps" (Coach 3-87.4% PAH).

> *"…he has been growing less or is later maturing. His coordination compared to the other keepers, so direct comparison, probably the best with his hands and feet in terms of distribution, coordination looks easy for him, he can kick from the floor and he can kick from his hands, best kind of mover, most agility, most kind of spring, but I think that's probably because he hasn't done that much growing yet and he is going to be having these issues maybe later" (Coach 1; player- growth velocity of 5.21cm/year, 86.2% PAH, performance grade 2.83).*

Although coaches of late maturing players understand the athlete's growth spurt and the possible detriments associated are still to occur for late maturing boys, this could be regarded positively. One advantage of developing late is the enormous coordinative strength which can be developed before the onset of the growth spurt (Lloyd & Oliver, 2012). Balyi et al., suggest late maturing athletes could have an advantage over early maturing athletes due to the greater length of time spent in the 'learn to train' stage of the Long Term Athlete Development (LTAD) Model (2013). On the other hand, late maturing athletes are likely to experience their PHV and possible growth 'side-effects' in the older age groups where the intensity of training, matches and overall pressure are also greater (Mitchell et al., 2016).

Further, coaches questioned later maturing athletes' adult height; whether they will be big enough to succeed in their position: "…he is small and there are concerns about his predicted height" (Coach 3; player- growth velocity of 5.21cm/year, 86.2% PAH, performance grade 2.83).

> *Doesn't have attributes to do what we are asking him to do… I am not sure if he should have got through the audit at 12 based on characteristics of where we want him to play, either that or we should be playing him in a different position (Coach 1; player- growth velocity of 13.78 cm/year, 88.3% PAH, performance grade 2.08).*

Findings from this study, illustrated by the quote above, show coaches displaying doubt and uncertainty surrounding predictive height equations. Research has shown predicted end height equations are accurate; The median error bound between actual and precited adult height using the Khamis-Roche method is 2.2cm in males from 4 to 17.5 years of age (Khamis & Roche, 1994). The use of self-reported parental heights in these equations, however, potentially decreases the accuracy of the estimation (Malina et al, 2015). To further increase the accuracy and reliability of the method, boy's parents could also be measured where logistically possible.

Coaches appeared to have greater doubt over later maturing athletes reaching their predicted adult height than early maturing players. Academy practitioners need to understand that late maturing athletes will reach their final adult height often much later than their early maturing peers, thus patience and understanding are required in terms of reaching their final height. Johnson advocates for using this end height prediction to better develop athletes in many sports (2015). The adult height of a young football player can be used to ensure players are in the best position for success, rather than waiting until they are 17 to find out they are too small for the position, ultimately leading to deselection or dropout (Johnson, 2015). Going forward, academies could better use these estimates of final adult size to provide the best opportunity and development for each player's success.

Due to their smaller physique, coaches believed that later maturing players struggled with the physical aspect of the game. Late maturing players were described as having a smaller range of pass, not being able to cover the ground and struggling in physical battles in comparison to their early maturing peers. Coaches added that competing against early maturing teams exacerbated the issue: "…he finds training and games really tough, physically, he just can't get around the pitch, he can't cope" (Coach 7) and "…biologically he is behind and if you play London teams they tend to play their biggest and strongest up front and then he is at the back and struggling" (Coach 1) (See Case Study Five and Seven). Coaches perceived later maturing players struggled to impact games.

> *Our lates and the teams we play against the difference is huge there, we play against some teams who have got five or six players who are fully done, so that's huge, and it makes it harder (Coach 5).*

As previously discussed, there are numerous reasons for coaches perceiving less positive contribution to games from later maturing players compared to their early maturing teammates; late maturing players are smaller and less physical (Malina et al., 2004a), cover less distance and at lower intensities (Buccheit & Mendez-Villanueva, 2014; Gastin & Bennett, 2014; Parr et al., 2020), and are less likely to play in dominant positions (Cumming et al., 2017a). It is, thus, not surprising that coaches perceive later maturing players to have less impact upon games.

Bio-banding is a strategy which could be used by academies to increase the impact late maturing players have on games. Bio-banding allows late maturing players to impact and

showcase their talent due to the physical nature of the game being reduced and allowing them to play in more dominant positions (Cumming et al., 2017a,b; Bradley et al., 2019; Reeves et al., 2018). Research by Abbott and colleagues found that late maturing boys participate in significantly more tackles and significantly less long passes in bio-banded games than in chronological age group games; perhaps late maturing players are more willing to engage in tackling when competitors are of a similar size, and the advantages behind long ball passes to more mature teammates are removed within a bio-banded format (Abbott et al., 2019). Thus, youth sport programmes, academies, and practitioners should utilise bio-banding as a strategy to allow late maturing players to influence games; this would not only develop the later maturer as an athlete, but would allow coaches to better evaluate late maturing players before selection and scholarship decisions by being able to observe certain attributes within a more appropriate group (Cumming et al., 2017a).

Player intentions were also noted by their coaches; although coaches noted some of their late maturing players had good intentions when playing, they lacked the strength, ability or confidence to complete the play (See Case Study Five: The Underdog). Coaches sensed many of their players had game intelligence, in that they understood the correct move or pass to make, however they lacked the physical capacity to follow these actions through. Game intelligence and maturity should be a future line of investigation. Potentially, late maturing players understand they lack the physical capacity or strength to construct certain passes or plays in a game, and thus choose to play a different tactic rather than make a mistake for example. Coaches of current senior international players who were late maturing in their youth, such as Kevin De Bruyne and Thibaut Courtois, recall their excellent understanding and decision making despite not having the physicality to compete (Bate, 2016).

> *He has shown some good intentions in terms of his passing, sometimes he hesitates, takes additional touches, because I think he lacks confidence in his ability to strike the ball, and because of his lack of range (Coach 6).*
>
> *His biggest problem is wanting to go long, because he can't kick a ball properly, so he doesn't want to try it, he just hasn't got the capacity to do it, I don't know whether he doesn't want to do it, or he is scared because he knows he can't do it so he just won't try to do it (Coach 9).*

Case Study 4: The Bulldozer

This case study depicts multiple coaches' evaluations of one early maturing 13-year-old player over two time points, who is perceived to rely on his advanced size and physicality. Some text is bolded for further emphasis.

Time Frame:	**May-September 2019**	**October- January 2020**
Quantitative Data	91.9% PAH Growth Velocity of 9.33cm/year Performance Grade 2.89 Coach 1 and 2	94.2% PAH Growth Velocity of 11.23cm/year Performance Grade 2.46 Coach 1,2, 3 and 4
Coaches Comments	Is early, could be **super early**. Good thing about him is he scores goals, and consistently scores different types of goals. He **relies a lot on power and holding up the ball and overpowering his opponent** and last year he could do that when he played up. So, when he is put in his bio-banded group he doesn't, **he struggles to adapt** his game to know what to do. **It is whether what he is doing now, he will be able to do in the end**. Not very quick, but a bright player, he wants to get better and wants the challenge, but he has had lots of success throughout the age groups, I just wonder when he gets to 16, I think he is going to be average size, maybe quite stocky, but [another late maturer] will be a better athlete than him so they are nicely matched up, when they get to 16 I think [another late maturer] will win those battles. **Extremely confident,** he is quite a **good all-round player**, but I have some concerns because his natural way, he can just do it, if he played up would he become a different kind of striker. He **should probably play up all the time**, but it is a jigsaw.... But if it was all about him that is what you would do, you would play him up the whole season. If you judge him on potential, I think he is lower, I think the audit is interesting because he was given an A, but I don't think his potential is that. I think at 16 or 17 he will be an ok player.	Coach 1 and 2: **Super early**, he hasn't been with us recently, we requested him to play in the 14's because you know in our age group it is a bit of a false reading of his potential, because he is so early, so we pushed quite hard for him to go up and fortunately he is now... If we sit down with him and talk about performance, we can say yes you are **scoring goals, and impacting games but he is playing in the wrong age group**. He was getting tastes of playing up in the 14's playing out of position or playing limited time, so we just needed to do it for a period where were actually sure what we are looking at… He always trains well, he just needs to do that an age group up, because the way he plays in the 13's is a **big strong powerful target player** but actually when you put him in the 14's he is not that big, he can handle himself but he is not going to be a problem for a 14 year old defender. So, it is just **future proofing him** of whether he is going to be that type of player, or whether he is going to play further back… so it's just protecting what he is going to look like in the future. Coach 3 and 4: he is playing up with us you see, another one that has **relied so heavily on his size** that he has picked up a **few little bad habits** particularly with his movement you know, he always wants the ball to feet because **he knows he can turn the player**, and now that he is having trouble doing that we are saying there's no point having it to feet all the time because they are bigger and stronger than you so what are you going to do. This is going to benefit him but I think he should go back go to his own group now though because he has been with us a little while and I think he is starting to suffer a little bit with a lack of confidence because he is not having the success and he is a striker, so we need to keep his self-belief up.

Case Study 5: The Underdog

This case study depicts the coach's perceptions over three phases of one 14/15-year-old later maturing player. This player was described as being physically behind his teammates, however, was technically and tactically ahead of his peers.

Time Frame	Jan-April 2019	May-September 2019	October- January 2020
Quantitative Data	91% PAH, Growth Velocity of 9.31cm/year Performance Grade 2.33 Coach 3 and 4	93.2% PAH, Growth Velocity of 10.70cm/year Performance Grade 2.13 Coach 5 and 6	94% PAH, Growth Velocity of 7.49cm/year Performance Grade 2.46 Coach 5 and 6
Coaches Comments	**Steady** player, he is probably a 6 out of 10 in games and in training. Really good feet in terms of ball manipulation, but probably over does it, probably takes too many touches, impact of that is he then tends to get caught on the ball… We certainly can see some qualities there which is why he has been retained but without being too harsh probably **needs to be more consistent**…he has got the ability to make decent passes. Generally shorter ones he is quiet a pass and move type of player, so we do need to increase his range… Tough year for him, last year on a smaller pitch, he was more effective, like **he can't get close to people**, the **big pitch** really, I mean **people just knock him out of the way** he **can't really affect the game as much**, his first touch has been a little bit off. He has got bit very big feet for a young boy and for his size. Late maturer, catches his feet when he is walking on the floor, like they are that big and bless him it has been quiet a tough one for him, but we see he has **got potential still**. The physical side is a good point, later maturer going on a big pitch, size 5 football. You know in that central role as well, can be quite demanding physically so stamina wise he is very good, he **can run forever, but when it gets to the contact part he struggles a little bit.** He gets over there and then suddenly in one movement all that hard work of getting over there is just gone, but luckily we really are quite educated here so at least we can see it. He is **beating himself up about it**.	Quite obviously that he is a **later maturer** within the group, just physically in general, **smaller** than everyone else, you can also see in terms of opposite of [EM]…he **sees things and tries to execute it but doesn't have the range of pass in him**, quite important for us to understand this is where maturation plays a huge part in understanding that it is the intention that is the right thing, but actually expecting them to complete it can come later. He has done really well, he has **shown some good intentions** in terms of his passing, sometimes **he hesitates, takes additional touches, because I think he lacks confidence** in his ability to strike the ball, and because of his **lack of range**, but his understanding of the position he plays in is above anybody in the age group… **Movement to receive is exceptional, even the little things, awareness of the ball, body shape, all those things he needs for his position are exceptional**. It is just connecting the range of passes…Sometimes **struggles to cover the ground** I think. He has struggled a lot in previous seasons, but I quite like him, **good mover, clever player, gets into good positions**, probably in terms of the 4, **his understanding is probably ahead of [EM] even though EM performs better or is more effective in games**... He gives it a really good go, gets into great positions, help us play, when we lose the ball you know that he is **not going to be able to cover the ground**, so **ultimately the team does suffer from that**. In terms of **potential** I do think there is something there.	Performances have probably been relatively consistent which is unusual, because of his age, and the fact he is later maturing… you would expect him being inconsistent in his performances but I would say apart from last week it's been the opposite of that. He has gone **down with the 14s and not stood out,** and the Opta stats in the last game he played, he gave the ball away double the amount of any other player, lost possession of the ball, you could look at like he has gone down and probably used it as an opportunity to try things which could be a reflection of how confident he is you know, performing well in the 15's, been given an opportunity to drop down and play with players of similar physical age and seen it as an opportunity to be experimental and take risks… Will turn down some passes if they don't think they are able to do it or don't have the range so you can see that they can see the pass but they choose not to play the pass which they do find themselves in trouble in losing the ball. **Not confident** in their contact with the ball... still probably some issues around how much he can cover the ground, I mean he is **clearly late** but I also think he is not going to be a fantastic mover anyway. He seems to be more aggressive; he is positioning himself better, you **can see the tactical element of his game**, he seems to be more confident…you just **hope when we get to 16's that people can see he is late because I know that is a question that keeps coming up from a lot of people about how much he impacts the game**.

2.3: Differential Performance Expectations by Maturity Status

Coaches portrayed different expectations of their players depending on maturity status. Across the age groups, coaches had superior expectations of the players more advanced in maturity: "The early's are critiqued harsher, yeah maybe it goes back to expectations, they are higher" (Coach 6) and "Some of the early maturing boys at times I can expect too much" (Coach 5) (See Case Study Six: The Falling Star). Players advanced in maturity who excel in their own age group and can compete or thrive in the age group above are portrayed as "exceptional".

> *Physically, early maturer, has played up in both the age group above and the one above that this year, which is a fantastic achievement. Played well yeah, consistent you know (Coach 3; player- 94.2% PAH, performance grade 2.67).*

Early maturing players were expected to impact games and perform well in their own age category. Those not considered capable of playing up were perceived to be struggling by their age-group coaches: "…really struggled, consistently been one of the weaker performers, tended to only play well really when he plays in the 14/15's game, which considering he is early maturer is a worry" (Coach 5).

> *Early maturer that is probably struggling so yeah a double negative…he is a concern because he is probably bottom third of the group and he should be able to play up and it wouldn't even be considered, but for an early maturing player, poor testing scores, average performances, should be looking to strive to play up and probably doesn't (Coach 1; player- growth velocity 9.68cm/year, 90.1% PAH, performance grade 2.47).*

Further, players advanced in maturity who were played in higher age group games were expected to perform:

> *I am worried about him, he has been top boy in younger age groups, and he's played up for me probably about four or five times and looked very average (Coach 1; player- growth velocity 8.94cm/year, 91.3% PAH, performance grade 2.69).*

Previous research has shown early maturing players to be perceived as more talented, explaining their over-representation in youth football academies (Meylan et al., 2010; Johnson et al., 2017; Cumming et al., 2017a). Coaches expectations for players that are perceived to be more talented are bound to be higher, thus it is understandable that expectations for early maturing boys are greater.

When early maturing players participate in bio-banded games, the level of challenge both physically and technically is greater in comparison to chronological age groups (Cumming et al., 2017b; Bradley et al., 2019). Findings from this study show that coach expectations however appear to remain the same. Early maturing players are expected to perform well in both chronological and bio-banded groups. Although bio-banding can be used as an evaluation tool to ensure some early maturing youth are not being identified and invested in because of their advanced physicality (Cumming et al., 2017a), there appears to be a greater pressure on early maturing players to consistently perform. It is important to remember however, advanced maturity status is only one aspect of talent evaluation; for example, early maturing players may be experiencing growth (see Theme 1: Growth as a Condition), or even problems off the field (school/home). The quotes above, for instance, describe players experiencing high growth velocities and percentages of predicted adult which would be considered around PHV (Baxter-Jones, 2013; Cumming et al., 2017a). Early maturing boys playing with chronologically older players in bio-banded games are being exposed to new developmental opportunities and challenges; early maturing players when bio-banded can learn to cope with vulnerability, adversity, and anxiety (Hill et al., 2020).

On the other hand, late maturing players who were managing in their own age group were perceived to be excellent: "…he is an alien, erm he is late maturing but physically one of the best in the group" (Coach 1; player- growth velocity 13.04cm/year, 87.6% PAH, performance grade 2.93). Players who were delayed in maturity who managed to succeed in their own age group and compete in the age group above, where the gap in maturity was even greater were described by a coach as "freaks" as they surpass the expectations placed upon them. These players were perceived to be able to compete with boys they "shouldn't be able to".

> *A player that is later within the group he doesn't really look it, I think he manages it well, a positive when you are dealing with late maturers that are coping in a category one academy in their own age group, it is impressive (Coach 5).*

Coaches described an expectation that late maturing athletes playing down an age group should perform well: "Again playing down this weekend should be a breeze for him. He should be top two in the group" (Coach 2). Late maturing players who played down were expected to excel, and coaches worried about players who had played down and not succeeded.

Yeah he has, but that hasn't had any effect on him, his performances haven't, it's not like (age-group below) coaches have come back and said his performance was very good, he ran the game (Coach 8).

Coaches often described bio-banding as an evaluation tool, where players were assessed against biologically similar players, and expected to perform well. Bio-banding, because it creates competitive equity, is useful as a talent identification and evaluation strategy; however, this is not the only use for bio-banding (Cumming et al., 2017a; Bradley et al., 2019). Bio-banding also creates unique learning and development opportunities for players on either end of the maturity spectrum (Abbott et al., 2019; Cumming et al., 2017; Hill et al., 2020).

The bio-banding strategy should not preclude the consideration of psychological and or technical skills (Cumming et al., 2017a). Thus, for late maturing players who are described to be thriving in their own age-group, playing down an age group with boys of similar maturity may not be beneficial (Cumming et al., 2017a). For the late maturing players who are moved to play with chronologically younger but biologically similar boys, coaches should not always expect them to be 'the best in the group'. As already discussed, late maturing players may be experiencing challenges associated with the adolescent growth spurt (See Theme 1: Growth as a Condition). Moreover, bio-banding presents an opportunity for late maturing players to take on positions of leadership and show self-efficacy on the pitch (Hill et al., 2020). Importantly, late maturing players playing down an age group may not have outperformed all the chronologically younger athletes, but they may have advanced other attributes such as leadership. Academies and youth sport coaches should acknowledge bio-banding has benefits other than talent evaluation, and perhaps reduce the pressure placed upon both early and late maturing players to succeed in bio-banded matches. Education around the merits of bio-banding could change the measure of success for coaches from 'outplaying' their peers to the development of other attributes.

Coaches described biases stemming from these differing expectations: "I have got to be careful of a bias…. I expect more of [Early] than I do of [Late], I expect him to play better (Coach 5; player-Early=99.5% PAH, Late=93.1% PAH) and "I've got bias, and my bias is always for the underdog, so I want the underdog to do well someone like [late maturer]" (Coach 2).

This bias was discussed in terms of coaching, performance grades and selection decisions. Coaches expressed they "…could have been better" with their coaching of some early maturing boys and the system needs to support all athletes irrespective of their stage of development.

> *I think I could have actually been better with him, he is a massively early maturer, and I think there is an element of me that has got, yeah there is a bias maybe slightly, I have become so conscious of growth and maturation, maybe even too much, a little bit, that I sometimes start to think that these players that are closer to 100% (precited adult height) are done, yet cognitively I know that's not the case, they are still a particular age, low training age, so I have probably been quite hard on him (Coach 5; player- 99.5% PAH).*

> *Again no problem with the club if they want to sign the early's but then the early's need to have their bespoke programme, with what are we doing to work and aid the early's, it's not their fault they are early, and we signed them, so Southampton is currently very geared up for the late ones, and we have got this in place for them and we have got the data for them to show they're only 93.8% and that's great and we are aware of that but what are we doing for the ones who are 99.8%, a plan needs to be put in place for them because ultimately they are the ones who get caught up and ultimately discarded at some point because there is no effective learning taking place. Everything is geared up to the lower percentages, the lates, the Q4's, you know we have to cater for everyone (Coach 8).*

In terms of performance grades, one coach discussed a late maturer and an early maturer delivering the same performance but the late maturer receiving a higher performance grade as the expectations upon that player are lower:

> *If [early] has a slight off game he goes down to a 2, and that is going to affect his performance grade and his audit score. If [late] had exactly the same performance that [early] just had I would give him a 4, because my bias is clearly going on and I am thinking I cannot believe he has just managed to do all that as a late maturer, but an early I just expect it, so there is a bias (Coach 5; player- Early=98.5% PAH, Late=93.3% PAH).*

An increasing number of recent articles discuss an over-representation of early maturing athletes in many youth sports (Malina et al., 1982; Baxter-Jones et al., 1995; Sherar et al., 2007; Hill et al., 2019; Johnson et al.,2017; Meylan et al., 2010). Consistently research has shown early maturing footballers tend to outperform their later maturing peers (Study One; Meylan et al., 2010; Figuerideo et al., 2009a; Coelho E Silva et al., 2010; Vandendriessche et al., 2012; Buchheit & Mendez-Villanueva., 2014; Gastin & Bennett, 2014; Cripps et al., 2016). Thus, a great deal of the headlines, conclusions and strategies have been focused upon decreasing the selection bias against late maturing players (Study

One; Figueiredo et al., 2009a; Malina et al., 2015; Doward, 2015; Johnson et al., 2017; Hill et al., 2019). Coaches in this study recognised their improvements in managing and developing late maturing players. Equally, coaches acknowledged the development and education around late maturing athletes was at the expense of the development of their early maturing players. Youth sporting systems and programmes need to ensure athletes from both sides of the maturity spectrum are on the best programme for their maturity status and development.

2.4: Implications for Selection, Retention and Release

Aligned with the advantages and disadvantages associated with early and late maturation described by coaches, maturity status and timing had implications for the selection, retention, and release of players. Early maturing players were often described as the best players in the team and were often selected over their late maturing teammates, because of their advanced physicality, game impact and performance consistency:

> *" …he is a relatively early maturing player and probably done the majority of his growing, so hence probably ties in with the element of consistency in his performances and things" (Coach 6).*

An overrepresentation of early maturing athletes in football academies is not a new finding (Meylan et al., 2010; Johnson et al., 2017; Hill et al., 2019). This is the first study to the author's knowledge, to qualitatively investigate why this bias exists from the perception of coaches.

> *Probably the best keeper, but physically he is bigger than all of the others as well, so I think whether he is the best, it is more of his physical presence, his maturity, you know you compare him to [Late Maturer] who is the same age, I would say [Late Maturer] is half the size, you know a lot smaller [Coach 3] (Selected early maturing player= 92.9% PAH, height and weight= 178cm/80.7kg, growth velocity of 5.21cm/year, performance grade ??, compared to released later maturing player=89.7% PAH, height and weight=162.3cm/46.6kg, growth velocity of 6.55cm/year, performance grade= 2.42).*

On the other hand, some early maturing players were released, or their scholarship was deliberated because of their technical/tactical deficiencies (See Case Study Six: The Falling Star) "…let go due to technical ability they didn't see that he had pushed on enough, obviously liked him physically but didn't feel like his technical ability was good enough for next level" (Coach 5).

Has played up and done quite well when he has gone up, you're starting to see quite a few deficiencies in his game which have naturally happened because he has been early and athletic, so we were trying to work on that and his footwork and his defending is off, his balance, he can just bundle people out of the way so we are really careful at the moment that when he comes back he will need to be in with the 16's quite quickly, I think if he stays in with this group those deficiencies won't go away. A lot of people suggesting early scholar, I am probably not as convinced at the moment if I am honest, I think he has got more to do, I think he is now slightly getting caught physically and I'm seeing some deficiencies in his game (Coach 5; player- growth velocity of 1.92cm/year, 95.4% PAH, performance grade 2.14).

Zuber and colleagues found precociously developed players, even with technical and psychological deficiencies, showed the most promise to be retained (2016). Importantly, in both this study and Zuber and colleague's investigation, not all technically deficient early maturing players were retained, highlighting advanced maturation alone is not enough to be retained. Coaches recognised however, that early maturing players had an easier journey through the academy because of their advanced size and physicality.

In contrast, late maturing players were often scholared for their excellent technical ability and their unexpected physical ability. For most late maturing players, coaches described them as physically behind; Late maturing players who were also physically developed were identified as likely to be signed and scholared: "He is a bit of an anomaly, because he is late but physically one of the best in the group" (Coach 2) and *"*Alien. Late maturing but physically of the best in the group. He is the best in the academy in my opinion...Offered an early scholarship" (Coach 1 and Coach 3).

As described previously, coaches generally felt later maturing athletes impacted games less because of their lack of physicality. Coaches talked about a need for patience with late maturing boys, waiting for them to physically catch up. The deadline for making scholarship and selection decisions confounded coaches' patience with later maturing players.

"…at the moment because of the lack of physicality he is really finding it quite difficult. We have got to overlook that, we can't make decisions based on physicality at the moment" (Coach 3- player was released).

I think we still need to hang on to him and be patient and just wait and see what we see, he moves well, he looks agile, he gets around the goal, his feet are good, and he is still quite little, and when he plays [in age group below] he still looks, he even looks like [age group below], we would see bigger goalkeepers in our age group so think he is playing with [own- age group] is unusual. He has done alright when playing with us [age group below]. I think he has the most potential and it

would be a shame to make an early judgement on him because I think he needs more time (Coach 1-Player was released).

For many late maturing players, their lack of physicality was a factor in their release, however.

He has played about a quarter of his games in the [age group below] because he is a low bio-banded because he is a late maturer. He has got some ability, physically however since he has been here, it has been a struggle physically. Lack of pace, lack of turn, lack of agility, you can still see that in the 13's as well, absolutely… I just think this is the wrong environment for him (Coach 3- Player was released).

Coaches perceived it was harder to get late maturing players "over the line" with scholarships: "…without question it is harder to get a later maturer over the line for a scholar, especially when you get people coming in that make decisions that haven't seen much of them" (Coach 5). One coach explained why it was harder for late maturing players to be signed at under 16.

It must be so tough for those boys like so tough, experiencing growth in those age groups at that time, bigger football, bigger pitches, all those things that demand you to be bigger, you're then playing against teams who are generally early and then we critique and grade them, sometimes yeah the expectations are too high (Coach 6).

This finding is in line with Mitchell and colleague's suggestion, that a disadvantage of late maturity is that athletes experience the growth spurt when the load, intensity, and pressure upon them is greatest (2016).

Late maturing players who were impacting games and managing to compete in their own age group, coaches described as probable scholars and exciting prospects. Coaches described some late maturing players as synonymous with potential; Players further away from being mature had more still to come, and so were retained or scholared based on their potential:

I think considering how late he is, I think his energy levels and his mobility to keep running and willingness to keep running forward and back, erm doesn't faze him that he is up against someone bigger, he will try and use what physicality he has got, and he is quick, I bet he has so much to come, I think there is a lot there (Coach 7).

He for me is an absolute shoo in for scholar, but there has been a little bit of uncertainty at times, and interesting, I was talking to (age-group above coach)

about the chances of (Cup game) and the first thing he said was it's a real shame we haven't got [Late maturing player] and I said how come and he said because he'd have helped us go through, and I thought, because they are a bit unsure, and I thought if you believe that about a late maturer then he should be a shoo in scholarship…everyone is seeing him have an impact on games still, even though he is late, which for me if you have those types of players, they need to be scholars as they don't come around very often. Late and impacting still you know (Coach 5) (Late maturer who was retained and scholared-Growth velocity of 1.4cm/year, 94.9% PAH, performance grade 2.8).

The findings of this study show coaches perceive late maturing players to be less capable of achieving success at the next level and thus are less likely to be retained and offered scholarships. Research has shown delayed maturity can be compensated for through a high level of technical, tactical, and psychological ability in the younger age-groups (Zuber et al., 2016). At the older age groups however, even highly skilled achievement-orientated late maturing players fail to progress to the next level (Zuber et al., 2016). Thus, for late maturing athletes to be successful in selection and retainment decisions, they must not only display superior technical, psychological and tactical skills, but also be physically capable despite their delayed maturity; the quote above, where a late maturing player is described as an 'alien' shows the retainment and scholarship of a late maturing player as rare. This study shows that for late maturing players to be offered scholarship and selection they must be exceptional.

Many late maturing athletes, who do not reach the exceptional level required to be offered a scholarship, are released from academies. The quotes above illustrate the notion that coaches often see potential in their later maturing athletes, but the timing pressure of scholarship decisions means there is a greater risk in offering one of the limited scholarship places to a late maturing athlete (See Case Study Seven: Released Late Maturer). Coaches struggle to differentiate between a lack of ability or a lack of physical development in their late maturing players; in selection decision meetings, there are more unknowns for coaches regarding later maturing players than there are for early maturing players. However, there are some exceptional famous cases, where talented late maturing athletes have been retained and scholared but played down an age-group until they developed (Premier League, 2013). Although logistically challenging, signing late maturing athletes and allowing them time to develop in a chronologically younger age group could be a way of successfully signing late maturing players.

Case Study 6: The Falling Star

This case study represents coaches' perceptions of two early maturing players over the first and last study period (Jan- Aril and Oct-Dec). Quantitative data and figures provided present context of the player within the team and their growth velocity, game time and maturity status. This case study illustrates early maturing players who were released at the end of the season.

Phase 1: Jan-April:

Coach 5: Erm again, this is an early maturer that I have questioned whether there is a bias there because I know his physical attributes that he has now, are not going to be that much further clear of other players as he gets older, so he has really struggled as technically he is quite a way off as well. Probably the lowest in the group at the moment…really struggled, he really struggled, consistently been one of the weaker performers, tended to only play well really when he plays down one or two age groups, which considering he is an early maturer is a worry…I was worried he would get caught physically. And then the other things that he maybe he hasn't built up over the years, hasn't been challenged, I think we are now probably seeing that if I am honest

Game time in this period: 8 games, 550 minutes
Played all games in Bio-half 1 (most mature) with an average match grade of 2.13
Growth velocity in this period= 1.49cm/year
Percentage of Predicted adult height in January= 99%
Percentage of Predicted adult height in May= 99.2%

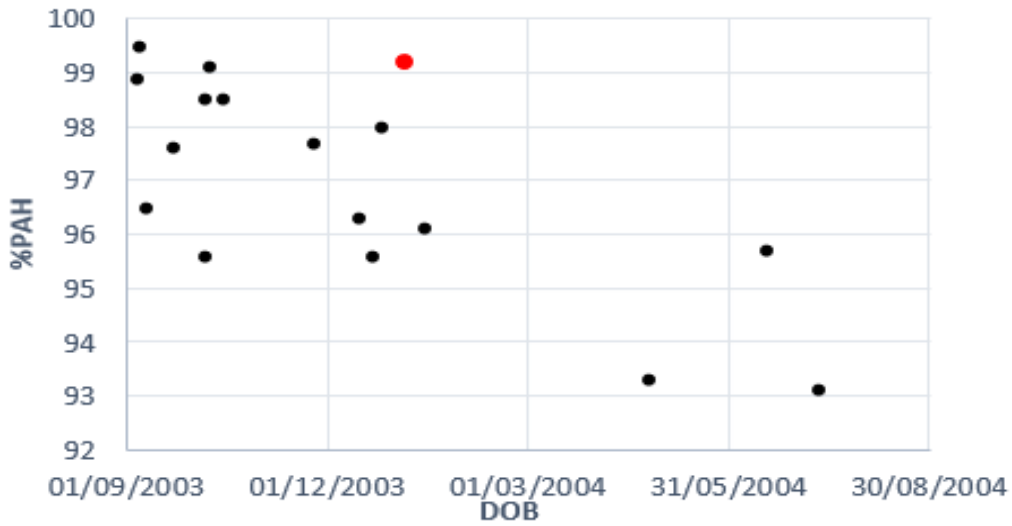

Figure 12: Graph depicting players' percentage of predicted adult relative to their chronological age with player from case study six highlighted in red

Case Study Six continued: The Falling Star

Phase 3: Oct-Jan:

Coach 7: He is another one, just an early developer, his attributes probably as an under 15 have got him through to a certain point, again now, players are becoming quicker, not just physically but brain wise as well, players have gone past him, he tries to still rely on the attributes that got him here like his size, but ultimately he is not big is he now, he is done, he was probably that size at 13 or 14, and he has plateaued, there is no more growth in him, his shoulders are done, his cheekbones are done.

Coach 8: I might be wrong but I think, I have a feeling, at 13 when he signed and he would have impressed because of all the things you just said, he would have been an early back then I would imagine, whereas now I think he sits in the middle of the group, but he relies on what he had when he was 13, and it just doesn't happen, there is no cleverness to his footwork or to his game, I think he will get wider, but there is no more height. I think he just hasn't had to use it before, he has relied on physicality and so he has never had to use a technical quality or have a good understanding of when and where to move, which is why he doesn't have it now, the game is too quick for him now

Coach 7: you can only rely on it for a certain amount of time, before ultimately the weaknesses start to open up and show because you haven't worked on them, or not had access to that point to build that gap because they get bigger and bigger as the older you get and the age groups you go in.

Coach 8: and the technique I am not sure we can put it down to a growth thing, I'm not sure you could do that, I have seen some people like go a bit wobbly, because he's shot up quickly and he is kicking the floor more often than not, but I saw a technique before, whereas I am not seeing any sort of improvement or technique from him.

Growth Velocity=3.65cm/year

Performance Grade=2.00

Case Study 7: Released Late Maturer

This Case study is an example of a late maturing player who was released. Three coaches over two time periods (Jan-April and May-Oct) share their perceptions of this late maturing player. Quantitative data shows where within the team this player was positioned in terms of maturity, growth velocity and performance grade. This Case Study shows the different opinions surrounding the same player in the run up to a selection decision.

Growth Velocity in this Period: 8.19cm/year

%PAH in January= 92%; %PAH in April=93.3%

Played all games in Bio-half 2 (least mature) with an average match grade of 2.29

Coach 5:

Really interesting one, now this is purely on the eye, because I have not seen his, but it just seems like everyone else is going through theirs or have gone through theirs, but he just still looks like a 13-year-old. He has lovely balance, lovely player technically but I would look at where most people are at the start of the season and for him the physical changes don't seem to have been that big, like others, and people are starting to pull away, he just seems to have been quite steadily really late, and it clearly has impacted his performances and his impact on the game.

My view, ok I gave him a B in the audit, I think he will get a scholar, but in order for that to happen, and all the talk is going that way, is that we will need to be very patient.

So I think with, he should be fine, and I think it will be one that we call here, one wild card, I am not sure it needs to be called that yeah I think he will get that but it does worry me because a beautiful footballer, balance, technique, you know he's going to be physical… he has got the traits, but it's just mad if he had gone through his growth spurt early you would probably again be talking about an early scholar, yet he goes through it late and he is going to have to go right up to the wire.

He is good, he is good physically, but he is not at that level so the gap between him and an early is so much greater. Throw into that the position he has largely been played in this season, he is in the 10 for most of this season, which is notoriously going to have big 4's and centre backs around you… Goalkeepers are massively early, centre backs massive early, 9's massive early, at least one of the midfielders if not 2 are massive and early. So that is who you are up against, we don't do it that way, we try and put you in a position we think you're going to end up in so for him its likely it could be a 10, so he has been in there and that's just what he is up against.

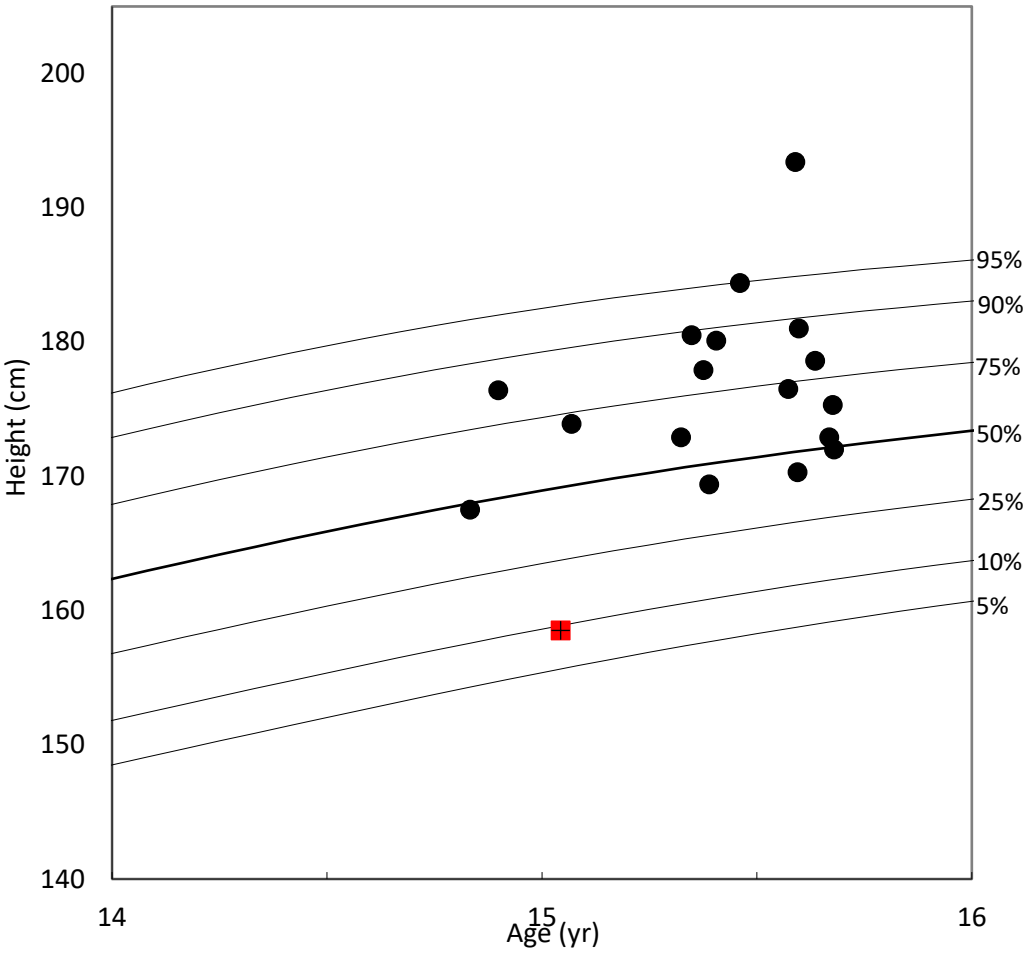

Figure 13: UK Growth Charts depicting the distribution of the players' heights relative to age, with the case example from case study seven highlighted in red.

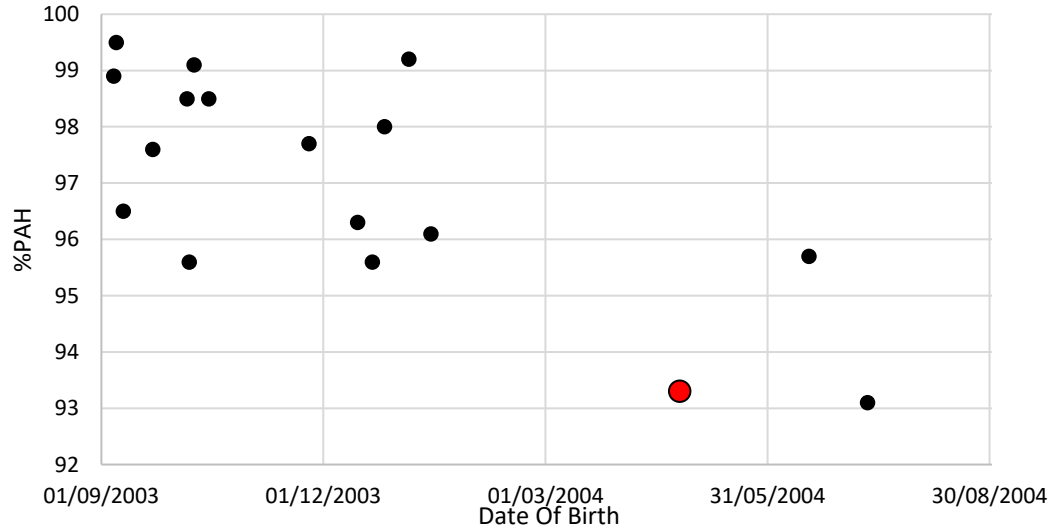

Figure 14: Graph depicting players' percentage of predicted adult height relative to their chronological age with case example from case study seven highlighted in red.

Case Study Seven continued: Released Late Maturer:

New Season: May-Released in November.

Growth Velocity in this Period: 4.81cm/year

%PAH in November= 95.1%

Played all games in Bio-half 2 (least mature) with an average match grade of 1.82.

Coach 5: It was obvious he was late, that was discussed, we probably felt he could go further than other people felt…Just so late, in the year we have seen him, I don't think we have seen much growth.

Coach 8: I think you have to be careful, I think he is late, but I think, I don't think much more will come from his dynamics, I can't see him having an extra kick, he is a plodder, everything is just below three quarters he hasn't got a change in speed or a turn or acceleration, and that's just him, I don't think that will come, regardless of where he is in his growth and maturity, I think that's him done.

Coach 7: he finds training and games really tough, physically, he just can't get around the pitch, he can't cope, erm, but on the very flip of it when you look into the minute details of it, he doesn't do himself any favours with how he controls the ball or where he puts it, he creates fights because of bug heavy touches and things, where I would like to see him be like [another late maturing player] and work it out more, and adapt he doesn't.

Coach 8: go and fight the battles you can win by being not marked, he doesn't. sounds simple doesn't it.

Interviewer: do you play him down an age-group?

Coach 8: he has yeah he has, but that hasn't had any effect on him, his performances haven't, it's not like 15's coaches have come back and said his performance was very good, he ran the game, whereas [another late maturer] can play up for us, and physically can't recover and get forward as much, but stands in good areas and does well.

Theme 3: Player development within institutional constraints

The third and final theme describes and interprets the coaches' perceptions pertaining to the difficulties of developing adolescent players within a competitive restrained environment. Coaches explained the value of wining, difficulties in judging potential and the conflict of developing players in an elite competitive environment.

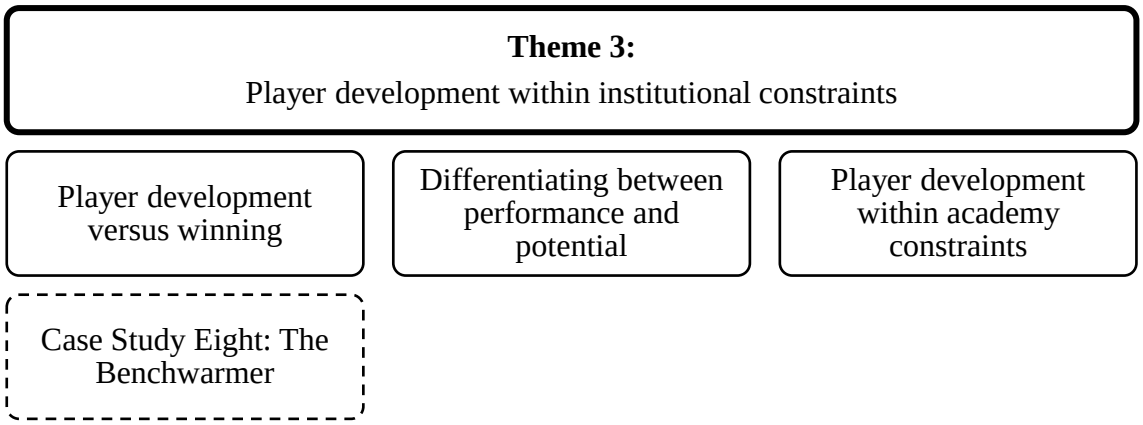

Figure 15: Hierarchy of theme characterising player development within institutional constraints

3.1: Player Development versus Winning

Coaches described their experiences and beliefs regarding managing players in a competitive environment, where often, winning games is an important outcome. Although the primary aim of academy football is developing players for the future, the competitive nature and importance of winning remains throughout the academy. The importance of winning games was described by several coaches as being to the detriment of player development. This speaks to an underlying conflict in the academy model, between, on the one hand, the success of the team and the coach's reputation, and the ultimate long-term development of all young athletes.

Coaches described the importance behind the competitive nature of the game. The value of winning was also identified as important across all the academy age groups. Winning was described as important for players' self-belief, team cohesion and as something that both the players and coaches strived for and enjoyed: "…tough to keep them confident and together…just not winning. Not winning is literally that simple" (Coach 5) and "Because I want to win, and I know the kids want to win" (Coach 1).

> *This team winning as a group in games this season has been one of the biggest factors in them all coming together, feeling confident and pushing on. I couldn't have created that out of nothing, that's them doing it (Coach 5).*

The importance of winning games for both coaches and players requires further consideration. Coaches explained both the players and the coaches had a desire to win games. In a highly competitive, selective, environment, it is no surprise that both coaches and players wanted to win games (McCallister, Blinde & Weiss, 2000). Competitiveness has been described as a key factor perceived by academy coaches to influence youth footballer's success (Mills et al., 2012). For players to succeed to the professional level, coaches describe a need for a winning mentality (Mills et al., 2012). Winning is also an integral part of competition and youth sport, and it would be unrealistic to state that winning is unimportant in youth sport; However, player development should be the primary goal of youth sport programmes and winning should come as a consequence of such development (Cumming et al., 2007). Coaches' perceptions of the importance of winning may be problematic if winning is not positioned in a healthy perspective for their adolescent players (Cumming et al., 2007). Research, albeit at a less competitive level has demonstrated that coaching behaviour and climate is more important than winning in terms of predicting player enjoyment (Smith, Smoll & Curtis, 1978; Cumming et al., 2007).

The importance of winning games can have consequences for adolescent players. For many athletes, winning or losing has been equated to success or failure respectively (Sagar, Lavallee & Spray, 2007). If losing football games is perceived by coaches and players to be a failure, experiencing failure may be a common occurrence for many (Sagar et al., 2007) and research has shown outcomes considered a loss can influence perceived competence and emotional states (Horn & Hasbrook, 1986; Wilson & Kerr, 1999; Sagar et al., 2010). Sagar and colleagues suggest adolescent football players within elite academies are likely to fear failure, due to the highly competitive environment where the pressure to succeed is great (2010). Elite adolescent footballers within academies are subjected to continuous performance evaluations, whereby failure could lead to adverse consequences such as deselection (Sagar et al., 2010). Research shows fearing failure adversely impacts the performance of adolescent athletes (Sagar et al., 2010). It has thus been recommended for football academies to focus upon development rather than the win-loss result of games (Sagar et al., 2010). Coaches should focus on creating a mastery-involving motivational climate, focusing on player development and 'being competitive'

within games, rather than the absolute outcome of win or loss (Cumming et al., 2007; McArdle & Duda, 2002; Mills et al., 2012).

Maturation was described as a contributing factor in the result of games. More specifically, teams were more likely to lose when competing against opposing teams who were more advanced in maturation. Losses, in turn, impacted the confidence and morale of both the team and the individual players.

> *"…most teams it has been physically impossible, impossible, no matter what you have done, the lads have struggled to experience winning a lot, to experience the right level of challenge and support, it's just hard, because the games you're sending them out into you're sending them out into an absolute war (because they are later maturing)… they are good technically and that is why it ends up being alright...they know all the other teams they are playing, they lose consistently, you can support them as much as you want, they are going to suffer big time in confidence, belief and ultimately the job as a coach is to build belief, you're trying to build something that is getting chopped away from under them" (Coach 5).*

Many of the coaches in this study perceived their team and players to be less mature than opponents. It is well established that in academy football, advanced maturity status positively predicts identification, selection and retention and so early maturing players are overrepresented in academy football (Meylan et al., 2010; Carling et al., 2012; Malina et al., 2015; Johnson et al., 2017). Previous research from the same academy as in this study (Hill et al., 2019), shows the majority of players to be considered 'on-time' and the odds ratios associated with a maturation selection bias to be smaller than the equivalent values reported from another Premier League Category One academy (Johnson et al., 2017). Thus, coaches' observations of their team being later maturing than their opposition may be correct, however further research on maturity biases in other academies should be conducted.

Aligned with the value of winning games coaches discussed fielding their strongest team, involving a bias towards early maturing boys. Coaches perceived early maturing boys, because of their athletic advantages (described in Theme 2: Advantages, Disadvantages and Performance Expectations of Maturity Status and Timing, sub-theme 1: Early Maturation) to provide the best opportunity to win games. Coaches explained they had to consciously acknowledge their maturity bias when selecting squads, even though this may be detrimental to the result of the game.

> *I would say the strongest team generally has the biggest, earliest, strongest kids in because it's easy for them to compete so you find a way to get [lists early*

> *maturing players] on the pitch together, and you would probably leave [late maturing player] somewhere else, and so I consciously go, we have to do this and we have to do that, and there is moments where you are, you know setting yourself up to fail, in a performance outcome way, and like from a competitive sports point of view, it's really tough (Coach 1)*

As described in Theme 2, coaches indicated that fielding their strongest team would involve leaving later maturing players out of the squad and/or playing them for less minutes, because of their lack of physicality.

> *His challenge is lack of power and lack of strength at the moment and the impact that has on him is he has very little impact on a game, in as much as, he goes into the midfield, the opponents are often bigger and stronger, so struggling to really deal with that, not because of attitude, or effort, simply because they are bigger and stronger, so that has led to him coming off a few times and trying to manage his load through games (Coach 3; player- 90.7% PAH, performance grade 2.47).*

Coaches primarily described the importance of winning in cup games and tournaments. A player's growth and maturity impacted team selection for cup games, where winning was perceived to be of greater importance (See Case Study Eight: The Benched Late Maturer). Early maturing players who usually play in the age group above, are returned to their chronological age group to assist the team in winning the game due to their athletic advantages. This finding supports the finding by Gilbert and Trudel, where coaches often make decisions in critical matches with the primary focus on winning (2004).

> *Focus is too much upon winning the game… I will move a player up and a coach becomes very defensive saying can I have him back, he fits into the team well, he is good for the group, but the reality is that he wants him in so that it gives him a better chance of winning (Coach 5).*

> *Interestingly he plays more for us, more in our cup games, so the games he has played for us have been our cup games, because we have a different mentality when in a cup game, it's the one environment when we want to try and give them a learning to win environment and mentality, so it is still a leaning tool you know not win at all costs, but in those environments and games we try to create a slightly different environment you know maybe playing for your place kind of thing and a little more emphasis on what changes we do or don't make, we might not necessarily do the 50 50 game time, that we guarantee them 50% of the game normally, sometimes in cup games we might not, so it is more of an experience of what they would experience in the older age groups. Probably the best keeper, but physically he is bigger than all of the others as well, so I think whether he is the best, it is more of his physical presence, his maturity, you know (Coach 3; player- growth velocity= 5.21cm/year, 92.9% PAH).*

Late maturing players, who were described to impact games less than their early maturing peers, were less likely to play in important games (See Case Study Eight: The Benched Late Maturer).

> *My feeling would be we have been consistent in providing equal game time, however the Cup games could skew that a little bit because you play them to win, therefore probably at times the best performing players in those moments have been early maturing players, and so the lads that haven't impacted games like [late maturer] and that have missed out. Having said that they did all start last week as an example they played half and they played half at the weekend. We have tried to even out as much as we can, I would suggest the early's have probably had more game time (Coach 6).*

Under the Premier Leagues EPPP, a number of different competitions and cups are available for all academy age groups (Premier League, n.d.). It is these games where coaches describe an added importance on game outcome, compared to normal academy fixtures. Although coaches described the result of the cup games to be of upmost importance, within the interviews some coaches used the result of all games, including normal fixtures, as a rationale for their coaching decisions and for if their team were performing. Perhaps the coaches' desire and interest in winning games arises from the coaching context (Lyle, 2002; Côté & Gilbert, 2009); academy football comprises of performance coaching, where there is an "intensive commitment to a preparation programme for competition and a planned attempt to influence performance variables" (Lyle 2002; Côté & Gilbert, 2009). Within this context, coaches may feel their effectiveness or expertise are defined by their team's success (win-loss percentage) (Côté & Gilbert, 2009). The reasons behind the academy coach's desire to win requires further investigation.

> *We played [Category 1 Academy] at the weekend and we drew, should have won really but we had [Late Maturer] playing left wing back just to get game time and things like that, and we scored two own goals and he was one of them…its funny it just shows if we had stuck with our strongest team and players in the best position we would have won that game quite comfortably but it was a good test for the boys (Coach 6).*

The above quote highlights that coaches do not play all games to win, and player development is central to the academy philosophy, however coaches were aware focusing on development contributes to the outcome of the game. The continued use of the win, draw, loss outcome on games reduces the broader element of player development and learning. The importance of the game outcome and winning for coaches probably reflects

the professional level of the sport, where winning is the primary goal (McCallister et al., 2000). Often in competitive environments, especially at the high school and collegiate level in the United States of America, the stability of a youth coaches' employment is based upon their athlete and team's success (Baker et al., 2018).

A conflict between the aim of player development and the ambition of winning games was central to the coach's experiences of the academy games programme in this adolescent period. Coaches described the biases in game time between their early and late maturing players to stem from their competitive nature.

> *Yeah the early maturers play more minutes and there is a subconscious big one around winning with the coaches definitely. I know I have that as well, so that isn't me saying it is other people. There are excuses that are true but they are still excuses, and those are, early boys probably can manage the minutes better and the distances they are having to cover on the pitch…but clearly if you play them more minutes you have a chance of doing well so that is a bias (Coach 5).*

> *I have really tried to spread the minutes and spread the starts and we have done a good job with that between the early's and the lates and good players and rubbish players in this moment, but like it is difficult to explain how much that goes against your values as a competitive person (Coach 1).*

Equally, coaches discussed another bias in playing time for the exceptional 'A grade' players. Coaches described needing these players within their squad in order to win games, even if the player was not currently performing well. Coaches desired talented players experiencing the negative 'signs and symptoms' of the growth spurt to still play in games, despite demands to reduce their load, in order to win the game.

> *If the lad going through a growth spurt is a top player, they are less likely to want him to rest, because they want him because he is going to impact the game, so an example, if [A grade player] is going through a growth spurt which he looks like he is, erm and you turn around and speak to his coaches about rest, they would struggle to understand why, if you speak about [C grade player] for example, a lower grade player needing rest or limited minutes, the coaches are very quick to say yeah ok that's fine…no one would like to admit that but I have seen it happen quite a bit and I know that I still get that feeling if they turn around and say [A grade player] right now needs 20 minutes, I am exaggerating but 20 minutes ok, just to get him through this period, I would struggle more than if they went yeah [C grade player] needs 20 minutes, I would still go with it but I know in my head I would go is that right for [A grade player], really what would be going through my head is I don't want to lose him for 60 minutes, so yeah there is a bias there, your ego takes over the kids best interest (Coach 5)*

Coaches reiterated the importance of player development despite the importance of the result of the game. Coaches discussed the notion of reframing winning away from the

result of games, towards the development of players. “I always say the winning bit is important, but it shouldn’t take the place of development” (Coach 5). Coaches proposed reframing “winning” away from the result of the game:

> *“…maybe winning is player development rather than winning the game…or ticking these individual challenges or finding a way to compete against a bigger boy, but it’s, it’s like a thirty second conversation but when you are living it it’s so tough, like you can be winning a game and make the right changes from a player development point of view and then lose the result, and then go I knew that was going to happen, but that is fine, but does everyone know why it is fine” (Coach 1).*

The quote above highlights that although coaches value winning and success, player development is the primary goal. Within a development model of sport, which academy football should employ, the measure of success should involve delivering maximum effort, developing of skills, and enjoying and learning from the competitive element of winning and losing (Cumming et al., 2007). Youth sport programmes should be structured to ensure continued participation, high levels of performance, and importantly, personal development (Côté & Hancock, 2016). The Developmental Model of Sport suggests that within childhood and adolescence, coaches should not overemphasise performance; however, often within youth sport programmes, performance is overstated at the expense of participation and personal development (Côté., 1999; Côté & Vierimaa, 2014). In line with the quotes above, coaches can reframe winning away from the win-loss result towards more developmental outcomes, however many coaches described this as difficult. Despite the quote above showing coaches prioritise development over winning, the preceding quotes in this sub-theme highlights inconsistencies between coaching philosophy and coach actions.

Coaches emphasised the greater importance of player development within the interviews, however, several examples of actions contrary to this also arose in the interviews; Biased game time towards early maturing and high potential players, leaving late maturing lower impact players on the bench, and requiring ‘A grade’ players to remain within the team are just a few examples of coaches inconsistencies in terms of development versus winning (See Case Study Eight: The Benched Late Maturer). Often, despite the coach’s best intentions, the findings of this study show an ego-involving climate appears within the academy where the coaches’ favour more talented players to achieve success (Cumming et al., 2007). This is not the first study to show youth coaches inconsistences in winning and development (McCallister et al., 2000; Gilbert & Trudel., 2004). Similar

to the findings of this study, McCallister and colleagues found youth baseball and softball coaches had the best intentions to create a healthy playing environment for their players and deemphasise winning, however unequal game time, and a win-win approach would materialise when in games (2000). Wilcox and Trudel showed similar findings in ice hockey, where coaches claimed a belief in equal playing time for players but were swayed by the score and time left in the game (1998). Research suggests that teachers often have little awareness of their own behaviour and how it contributes to student experience (Smith, Smoll, & Hunt, 1977). It is important to know if coaches are aware of the discrepancy between their supposed values and their actions. Further research, education, and strategies should be applied to understand and reduce the inconsistencies between academy philosophy and coach behaviour.

Case Study 8: The Bench Warmer:

This case study demonstrates coaches bias against later maturing athletes in terms of player development and playing time, due to their impact on the game. This quarter four late maturing player in the under 13/14 age group was described by Coach 1 and Coach 5 as very talented over two time points. Perceptions of his impact on games meant he was not selected for prestigious games in the first and final phase of the study. Quantitative data shows where this player was positioned within the team in terms of maturity, growth velocity and performance grade, while the qualitative data highlights the coach's experiences and perceptions behind not playing this talented late maturing player.

Jan-April 2019:

Coach 1: At times we have to explain it to the kids as well, because they want to win, so you're like no no keep the strongest team on and you're like, well we have to, and the strongest team is also like a dynamic thing, like, the 11 at the beginning is not the 11 now, and so there is like gold standard games or you know, what's the word, high value games, where kids that probably don't deserve to start have started, not didn't deserve to start that's not the right language, wouldn't give you the best opportunity to win have started, because that is the right thing to do, but it is really challenging to do it…

Anecdotal story is we were playing [big team], and my strongest team wouldn't have included [late maturing player]. So, he was going to be in the squad… and it was a prestigious game and good for him. So I was going to give him half of the game, then we got 2 or 3 pull out sick, 2 or 3 play up and all of a sudden he had to play 80 minutes from the start and he was amongst the top three on the pitch. Pointed out by our scouts, and you're like I wouldn't have done that, and I was quite comfortable to go that was a complete fluke and he has proved me wrong there (Coach 1; player- growth velocity 10.861cm/year, 86.9% PAH, 6 games, 386minutes, performance grade of 2.5).

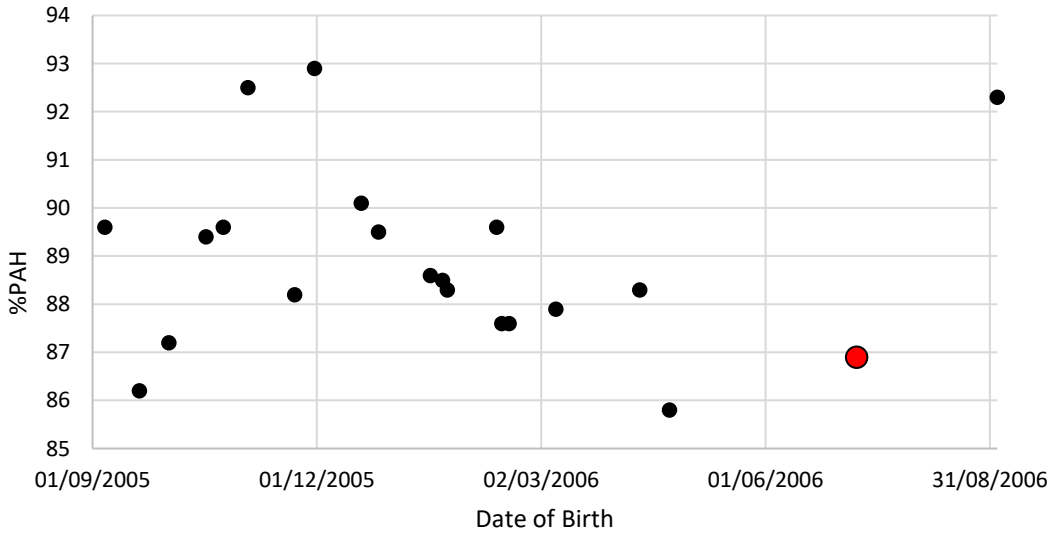

Figure 16: Graph depicting players' percentage of predicted adult height relative to their chronological age group with player from case study 8 highlighted in red.

Case Study 8 continued: The Bench Warmer:

Oct 2019- Jan 2020:

Coach 5: When you have a late or someone who is struggling, people will say they need less game time, because they can't cover the distance, it is harder for them, I don't believe that is the real reason, I think often it is because they have an impact on the game and it affects your ego…
Here is an example he scored very high in the audit, he is very late, but he has not been highlighted as someone who needs limited minutes or anything, yet because he is late he has less experiences of the cups, less minutes, and if we are saying games and experiencing pressure is important, then why is he not involved in it. Instead you are giving a C grade player the opportunity even though you say he has less potential because right now he has been performing better.

(Coach 5- 89.1% PAH, performance grade of 2.24).

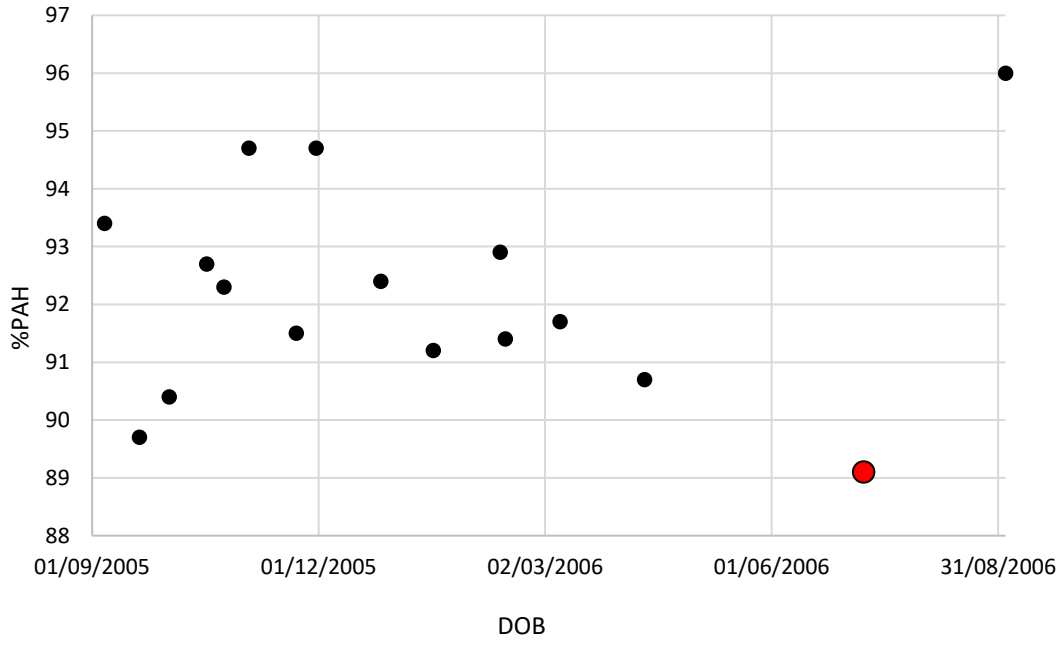

Figure 17:Graph depicting players' percentage of predicted adult height relative to their chronological age group with player from case study 8 highlighted in red.

3.2: Differentiating between Performance and Potential

When describing their team and players, coaches discussed judging potential. The primary role of football academies is to identify, develop and nurture young potential into future professional athletes. The definition of potential being, 'having or showing the capacity to develop into something in the future' (Silzer & Church, 2009). Identifying and developing the players with the most potential was thus central to the coach's experiences. Coaches described the process and problems with judging the potential of their athletes.

Coaches perceptions of potential often differed dependent upon a player's maturity status. Similar to the advantages, disadvantages and different expectations of maturity status (See Theme 2), coaches judgement of players potential was influenced by maturity status: "Typically audit scores, the lates tend to get a slightly lower potential grade than the early's" (Coach 5). When unpicking why early maturing players were generally deemed to have more potential, coaches explained their current performance tended to better than their later maturing peers.

> *Yeah and he [growth velocity of 5.21cm/year, 89.6% PAH, performance grade of 2.64] isn't that good, but he looks better than him [growth velocity of 10.80cm/year, 86.9% PAH, performance grade of 2.5] because of all this (Coach 1).*

In this study, early maturing players in the younger age groups were generally deemed to impact games more than their later maturing peers and were therefore graded as more talented by their coaches. The perception of age-group coaches within academies is critical, as coaches play a central role in talent identification and selection (Williams & Reilly, 2000). Coaches influence selection and deselection decisions based upon their perception of an athlete's long-term potential (Cripps et al., 2016). Maturity status has been shown to bias a coach's perception of potential; coaches perceived later maturing players to have a significantly lower long term potential, where 72% of late maturing players were predicted to go no further than the adolescent level of competition compared to 50% of early maturing players (Cripps et al., 2016). Consistent with the results from Cripps and colleagues, academies should be aware that variation in performances associated with delayed maturity (See Theme 2) can influence coaches' opinions of potential (2016). As evidenced in the quotes above, coaches acknowledged their

perceptions were swayed by maturity status. Potentially, the increased knowledge and awareness within this academy surrounding adolescent growth and maturation influences coach understanding the impact of their perceptions, however further research and education needs to be done to mitigate the bias on selection decisions.

Coaches questioned the high potential of early maturing athletes deemed talented in the younger age groups. Coaches speculated it was their advanced maturation making them talented footballers in the younger ages: "We debated signing him because he was so early" (Coach 1) and "Why are they A grade players, because that is not an A grade player though is it, that's just early, the attributes in that moment of time" (Coach 8). Coaches in this academy appear to be well educated on the advantages of early maturation (See Theme 2). Further, it appears from the quotes above, some coaches understand these advantages are transient, and by late adolescence or adulthood maturity-associated advantages will be diminished or even reversed (Lefevre et al., 1990; Cumming et al., 2017a). This increased understanding and awareness among these age-group coaches has led them to question the selection of some early maturing athletes.

Some late maturing players on the other hand were described in the interviews as synonymous with potential (See Theme 2), despite generally their potential grade being lower than their early maturing peers.

> *I don't think he has developed the capacity to be able to get around the pitch and perform. I think he has loads of potential. The pitch looks big for him, I think he is one that could be a very good player because he is intelligent, and he understands the game well. I just don't think he has the resources to be able to do what he can just yet. So I think in a couple of years' time when he has gone through his growth spurt, I think then we might see him, and his understanding will fall into place because he has got the resources to do it…he is probably that whispering talent, not obvious, not every club would take him, but at 17 18 I think he will be pretty good if he carries on at this standard (Coach 2; player- 84.3% PAH- Latest maturer in team, performance grade 2.75)*

For late maturing athletes, coaches described a need for patience and understanding of their delayed development in order for them to be retained and signed (See Theme 2).

> *I would be putting him around the C bracket in an audit, you know someone who has got a chance, you just hope when we get to 16's that people can see he is late because I know that is a question that keeps coming up from a lot of people about how much he impacts the game. I see a fair bit of potential in him (Coach 5; player- growth velocity of 7.49cm/year, 94% PAH, performance grade =2.46).*

Coaches often perceived late maturing players to have more to 'give', therefore considered these players to have potential (See Theme 2). The findings suggest coaches understood late maturing players required more time to mature and develop as athletes before their full potential would be appreciated. It appears however, the highly competitive and selective environment that exists within elite youth football academies, pressures coaches into making selection decisions on players; for many late maturing players, this means they are still experiencing growth (See Theme 1) and competing against early maturing players (See Theme 2) when the competition and pressure to succeed are higher. As already mentioned, despite coaches perceiving enormous potential in some late maturing players, it appears the risk in offering one of the few scholarships available to a late maturing player is too great (Baker et al., 2018); very few late maturing players can be observed in the older age groups in football academies (Johnson et al., 2017; Hill et al., 2019). Importantly however research shows after adolescence, when maturity status becomes irrelevant, late maturing players outperform their peers and have a greater chance of being successful (Krogman, 1959; Lefevre et al,, 1990; Ostojic et al., 2014). Lefevre and colleagues showed that late maturing adolescent players are often better performers in most motor performance tests in adulthood (1990) and Ostojic and colleagues found late maturing boys were proportionally at a greater chance of achieving the highest level of professional football (2014). Excluding or deselecting late maturing players in adolescence is thus a flawed system, as it reduces the pool in which players can be selected from because of maturity-associated factors only relevant in youth age-groups (Johnson et al., 2017).

Potential grades were often described as fixed, whereby coaches felt once a player had been perceived as an 'A grade player' this evaluation could not be changed. Early maturing boys were often described as fixed high potential 'A grade' athletes in younger ages, despite successive age group coaches disagreeing. Coaches described a conflict between grading future potential and the athlete's current performance. Grading and changing a player's potential was sometimes seen as a point of tension with other coaches and parents.

> *If somebody comes into your group and they are an A, it's like yeah cool, or not, are you going to challenge that, it's just not what we think it is. The grade isn't something that is attached to you, it's similar to like an Olympic medal, so at one point Tiger Woods was an A, but he is no longer the best, he is not an A golfer anymore. But that is what we are doing, we are going this kid is Tiger woods, which he might have been at 12 but at 13 he is not now (Coach 1).*

He has got a tattoo on him somewhere saying A, but he is not a player that has performed at an A grade and that is two very different things. And that leaks out whether intentionally or not that starts to permeate into the players understanding of themselves and the parents understanding of where he is in everything. So then you get a review meeting with two coaches that have taken them for the first time and are commentating on what they have seen and they'll say well he's probably performing at a B at the moment and then they go oh he's not a B, definitely not a B and you've got this whole issue around this mindset that has been created by us, we are judging potential, he shouldn't be an A and stay an A the whole way through the pathway, because then you get an A performing at a lower level and then you get a lot of panic around the staff (Coach 2).

Finally, coaches explained their struggles with evaluating and grading potential of players: "…do we know what we are looking at" (Coach 1). Coaches highlighted several difficulties in judging potential including growth, maturity/physicality, relative age, and training age. Although, generally potential grades were deemed to be fixed, for a few players big changes in potential grades were perceived: "Yeah progress in performance the highest, looks really confident, has gone from a C grade potential to A in the most recent audit" (Coach 6), causing further questions on the ability to identify talent.

An A grade is an elite player, so we have to think about what an elite 12 year old looks like, I don't know what that means because there are many definitions of elite…you're already elite if you're with Southampton because you're in the highest percentile, but I suppose elite in our mind would be playing for England that would put you in the top 0.0001% or whatever so calling 9, 10 year olds elite, why, you might have a higher training age or bigger physicality that isn't elite that's just circumstance (Coach 2).

With the primary purpose of football academies to select and develop young athletes into future professional players, talent identification and evaluation is crucial (Vaeyans et al., 2006; Williams & Reilly, 2000). The process however, of identifying and developing talent, is challenging; talent identification programmes are shown to have limited success (Bergeron et al., 2015). The challenge facing football academies and youth sport programmes, is only a limited number of athletes can receive resources and coaching. In agreement with the quote above, research shows talent identification at the youth level is often confounded by chronological age and maturational factors, whereby chronologically older and more mature players are identified and labelled as the most talented (Malina et al., 2015; Meylan et al., 2010; Bergeron et al., 2015) and are thus offered more of the opportunities, coaching and resources to further develop (Bloom &

Sosniak, 1985; Cumming at al., 2017a). Players graded an 'A', or elite, may therefore remain an 'A' due to the continued investment in their progress (Siekanska, Blecharz & Wojtowicz, 2013), even if the player does not improve. Coaches in this study questioned the process of labelling players as talented or elite at the youth level due to the uncertainty of evaluating talent, but also the danger of the talent label.

The labelling of talent is an interesting phenomenon. Across multiple different disciplines, children from young ages are evaluated for their ability and talent, and often labelled as gifted or talented (Malina, 2010; Baker et al., 2018). However, research has shown early predictors of talent are weak (Barreiros & Fonesca, 2012; Barreiros et al., 2014) and more importantly, talent is not fixed because it can change over time (Baker et al., 2018). As the findings from this study and other research shows, early maturation, height, and weight indicate youth success, but do not determine adult success (Baker et al., 2018; Cumming et al., 2017a). Labelling young athletes as talented is therefore challenging, because at young ages talent is based upon innate fixed characteristics (maturity status, date of birth etc) (Baker et al., 2018). Malina suggests the impact of labelling children as talented requires further investigation (2010). These findings point to the need for further research on the impact of a talent label on successive age group coaches.

Injuries, especially growth-related injuries, were also deemed to confound a coach's evaluation of potential: "We haven't seen his full potential because of the injury" (Coach 3). Coaches expressed difficulty in judging potential of athletes that haven't been able to play, especially around selection/scholarship decision periods:

> *Out with his knee so we haven't seen him at all, looks like he has shot up, looks like he has grown loads, but we haven't seen him play once since he came in (Coach 7).*
>
> *Flying up until Christmas, A grade in the audit, we voted him an A for potential, but then has just been ill and injured and probably shouldn't do but it has raised questions about his resilience (Coach 5; player- growth velocity of 2.81cm/year, 97% PAH).*

As already mentioned, remaining injury free in adolescence is important to continue playing and developing (Johnson et al., 2009; Price et al., 2004). However, the coach's perspectives above also suggest injuries in adolescence complicate talent selection decisions for coaches. Players with injuries are not participating in training or games and thus coaches cannot evaluate their development or potential. It is therefore vitally

important for academies to try to reduce injuries within adolescence and the growth spurt; monitoring the growth spurt, estimating maturity status and individualising training programmes are all strategies which academies should employ and research (Johnson et al., 2019).

3.3: Player Development vs Institutional Constraints

Coaches outlined several institutional constraints in terms of being able to manage their adolescent team and the added complexities of growth and maturation. Problems and constraints were discussed by the coaches, as well as some possible solutions for better player management, development, and selection.

Coaches described the timing of selection decisions were a limiting factor for some players. Some coaches explained they needed more time with players to make a decision due to injuries, change of position and uncertainty over potential: "…unfortunately, he is one of those in the 50 50 area, I have asked for more time on, I just feel like I need to see him playing more" (Coach 3). Equally, coaches described the need to expose their players to different challenges before any selection decision is made.

> *Tough one to manage and to balance out but you have got to do what is right for them and you've got to put them in and take them out, you've got to give them the experiences and they have to succeed and fail, that's the only way (Coach 9).*

One strategy to expose their players to new challenges was playing the athlete in a group more closely aligned to their biological age and maturity status rather than their chronological age. Bio-banding, a strategy of grouping players in terms of their maturity status rather than age, was discussed by coaches as an approach used to better develop players and aid talent identification.

> *I mean before we pull the trigger, again the wrong language, you know we should have a mechanism in place where we can go, he needs to play 12 games down and let's see whether he is any better in there (Coach 1).*

Playing boys in the age group below or above for late and early maturing players respectively, was used for players at the extreme ends of the maturity spectrum. Coaches described playing boys up an age group as mainly positive, but playing boys down an age group had a stigma attached to it for the parents and the player:

Play [him] up and then play [him] up, and play the 16's in the 18's because you're then exposing them to the need to be quicker, make quicker decisions, touches of the ball, brain processing it, because maybe then they won't end up technically behind (Coach 7).

Joined the 13's around Christmas and we made the decision to completely move his schedule. We saw his testing and he was like so early we converted him completely which I think is the way to go, he is a 13 in every extent, in all of my sessions, plays all of the games, and it's you know, he is one of the team (Coach 1; player-growth velocity of 9.311cm/year, 92.3% PAH).

He is a late maturer, spent a lot of time last year with the younger group because of his physicality. We will have to consider that for him again this year, he is completely anti-it, parents are completely against it, really don't understand the rationale behind it (Coach 3; player-88% PAH, performance grade 2.08).

Coaches described moving late maturing players down an age group was an approach to retaining later maturing and relatively younger players. The stigma around athletes playing down an age-group was challenging for coaches.

Identifying Q4's saying there is something about this boy, can we hide him down for a year… We could do a better idea, a better job of this is why we are doing it and commit to it even more, so if we like for [late maturing player], why don't we say you're going to be here until 16 to kind of, I think there is a lot of anxiety and worry, and parents think as soon as you play them down, well you're on the chopping block and it's only a matter of time. If we back ourselves which we do back ourselves and say yeah you're going to be here till scholarship decision some of that will involve playing down a year until you do some stuff (Coach 1).

Most coaches in this study perceived bio-banding to be a positive strategy for the development and evaluation of players. The level of understanding throughout this academy related to bio-banding appears to be higher than has been observed in other research (Reeves et al., 2018). One of the perceived disadvantages of bio-banding is the interpretation by players, staff, and parents that late maturing players are being moved 'down' (Reeves et al., 2018). The language often used by coaches within this investigation was moving players 'up and down'; Coaches expressed players and parents were often against being played down. Although bio-banding aids player development, most coaches in this study described it as an evaluation tool, perhaps explaining the stigma and anxiety attached to playing in a younger age group. To reduce the stigma associated with being played 'down' an age group, academies need to provide education for all stakeholders and ensure transparency with the strategy (Reeves et al., 2018). Further, the language used by coaches is imperative in how parents and players perceive

the strategy, therefore changing the dialect from playing down may help reduce the stigma.

One coach described a few ways in which players can move age-group; numerous problems with moving players up and down the age groups were discussed including group size, logistics and level of challenge.

> *Three ways they can move, one is a full six weeks review…can move individuals down for six weeks if we feel it's going to benefit them… the challenge we have got at the minute with this particular group, the group below is so big in its numbers, lads could lose out if they go down, if I move a [Late maturing player] down who say is thriving still even though he is late, he might end up getting 40 minutes instead of 80. So, although we gain a new insight into him and he gains a new challenge he could lose too much, but yeah we have the review process where we can move individuals down for six weeks if we feel it's going to benefit them, we can move them mid-review and the way we are doing it at the moment is probably the last minute one, where someone requires a player (Coach 5).*

The logistics of moving players up and down age-groups within the academy was also problematic for coaches (See Case Study Four: The Bulldozer):

> *"…so he should play up all the time, but it is a jigsaw because (player in age-group above) is a 9, and he is 10, [player in age-group above] is a good player but probably maturity behind him, but what do you do, [player in age-group above] shouldn't play down that would be a tough sell, but he should play up but then you are pushing him to the bench or out wide or it's difficult. But if it was all about him that is what you would do you would play him up the whole season" (Coach 1-player who should play up= 91.9% PAH, growth velocity=9.33cm/year, performance grade 2.89 compared to player in age group above= 89.7% PAH, growth velocity=12.35cm/year, performance grade 2.45).*

Coaches generally described the benefits of moving players up and down the age groups, including exposure to new challenges, however coaches described some detrimental outcomes. In line with sub theme 1 (player development versus winning) coaches explained the movement of players into different age-groups may impact the result of the game; players moved into different age groups were perceived to play less minutes and be graded lower by their original age group coach.

> *I have noticed the lads that moved up didn't get as many minutes, so clearly they will play them up, yeah I am happy with that to challenge the early's, but actually they come into the team, and they only play for forty minutes because they don't want them to impact the result …it is their ego and they want a better chance of winning the game that's the truth…The interesting bit is the lads I notice down*

the bottom performance wise, are the lads that play up more, and (coach) rightly or wrongly doesn't really matter, just grades lower than me… they have a bias towards the lads they coach, I bet the data would back this up, 15's going in would have a lower match grade than the 16's and you know sometimes you cannot get away from that. I think I did It even last week with some 14's that came up, they got a lower grade than the ones I normally coach (Coach 5).

Coaches found the logistics of moving players up and down squads according to their maturity status challenging. Again, the importance of winning influenced coaches' perceptions on playing bio-banded squads; teams losing the strong, powerful early maturing players and receiving chronologically older but later maturing players, were perceived to be less likely to succeed. Equally, coaches described a bias in playing time for the players who had moved age group in order to maintain competitive. Players remaining in their age group despite their maturity status being better suited for another age-group, or playing those athletes reduced minutes defeats the object of bio-banding. Coaches described the academy philosophy of a player-centred approach, however the quotes above highlight inconsistencies.

Athletes' playing time and performance grade were perceived to be affected when playing up and down an age-group with a new coach. Reeves and colleagues suggested a disadvantage of bio-banding was the coach-athlete relationship is less developed in bio-banded formats (2018). Research has shown as the knowledge of each other (coach and athlete) increases the ability of the coach to increase the athlete's development also increases (Reeves et al., 2018; Mageau & Vallerand, 2003). Thus, the limited interaction between coaches and the players moving up and down the age groups, may hinder the coach-athlete relationship and in turn hinder the players development. This may also explain the reduced game time and poorer performance grades for players moved into a new age group for bio-banding. Further research is warranted to understand if these perceived disadvantages outweigh the perceived advantages of the bio-banding strategy.

Some coaches also explained moving players up and down the age group can occasionally have detrimental effects for the player: "…we played him up all last year all season, which when you reflect on something, that was probably a mistake because he is just mentally shot" (Coach 3). This quote reflects the need for youth sport programmes utilising the bio-banding strategy to consider psychological skills and ability (Cumming et al., 2017a; Hill et al., 2020).

> *…obviously a few years ago he was in that older age group permanently because at the time he was doing well and he could handle it, but that has shot him to bits so confidence is gone completely (Coach 9; player-, growth velocity of 6.31cm/year, 89.3% PAH performance grade 2.55).*

Bio-banded games were described as an occasional strategy used rather than the permanent moving of players up and down the age-groups. Coaches explained the desire to compete and play in bio-banded games more often, but logistical problems limited the ability to use this strategy. Playing in a bio-banded format more often may also counteract the limited interaction, knowledge and relationship between coaches and athletes described earlier.

> *In an ideal world I would say I would want at least one of these every review period, in an ideal world it would be two, so they would play almost three games normal and a quarter of their games would be in bio-banding, because I think it would give us enough data and enough subjective opinion… other teams won't do it, we can do it and play against an age group but in bio-banded games we try every year and people won't do it. I think there is a solution, my view is that the premier league should run a bio-banded tournament the season where you play one in every four or five games you have this bio-banded tournament, and I think the Premier League come in three times a season, so it isn't going to be perfect but they can do heights and weights of everyone at the clubs, because the reality is you can't trust the clubs to do it properly so it would need to come from the Premier League. The other reason some struggle is because you end up with all your goalies and centre backs going up and you end up with a team full of wide players and 10's because that is where the bias clearly is where the early's and lates play (Coach 5).*

Aside from bio-banding, coaches described squad sizes as a potential strategy to alleviate some of the problems and biases associated with adolescent players and growth and maturation. Coaches described working with bigger groups as a strategy to reduce injuries and game time, but harder to manage.

> *Whether having a bigger group, so you can spread the minutes, erm…is going to help you through this Youth Development Phase period... I have gone to games with 17 or 18 players and from a coaching point of view hated it because you can't get any flow and quarter to quarter is different and I can't give the kids the games time they perhaps deserve…the flip of that is then kids are regularly playing 40 to 60 minutes, and there might be something there…but if we ran with bigger groups through the 13's, 14 and 15's you would get days where you could say we don't need to take him because he's got growth…you know it's that holistic. (Coach 1).*

Smaller groups were described as easier to manage and better for player development, however on the other hand training load and game time were required to be higher.

> *This group has got 18 or 19 players, I think, and they can hardly get a bare 11 out there it's just so many injuries consistently in that group. This group has lost three players already so they are down to 10 fit players, so it is easier and your programme can be more individualised, I can probably fly through their development plans quite easily now as it's such a small group so they get more focus, the down side is at the moment late or not they are close to playing 80 minutes every game, they played a 16's team last weekend, they've got a 16/17 team this weekend, so they're getting two massive hits against men almost… we have to be careful we don't end up with loads of injuries. I don't think there is a perfect number for squads but probably around 16 is a decent number to operate off, gives you licence to have a couple of injuries and it means you can have a proper individualised programme, I think with a small squad like this, if s and c turn around and say he should only play 40 minutes this weekend because of his loading or growth, it isn't as easy to make that happen, you're almost having to get through, whereas a bigger squad you can go oh ok he doesn't play this weekend and you can move things around a little bit more (Coach 5).*

Limited resources was the limiting factor in running bigger squads or 'shadow squads': "…squad where you give these lads a chance but again what is there fixtures like, how could you fund that" (Coach 5). Talent development programmes are limited by financial and logistical resources provided by the National Governing Body (NGB) or professional club, such as quality of training facilities, number of staff and number of player spots available (Bennett et al., 2019). In some established football nations, 'futures programmes' have been established to increase the talent pool and mitigate confounding factors such as the relative age effect and maturity biases (Vandendriessche et al., 2012; Bennett et al., 2019). The Belgium Football Association are just one established footballing nation to create a successful futures programme, where late maturing players are retained within the talent pool (Vandendriessche et al., 2012; Bate, 2016; Bennett et al., 2019). Shadow or futures squads require added investment and resources; however, they do allow the talent pool to be maximised and late maturing players time to develop.

Coaches explained the limited resources and coaching was focused on the players who were deemed to have the most potential.

> *Incidentally the ones that we have highlighted as needing a bit of help you know have had it, (A grade player) is on an individual programme as well, (him) and (him) are also A and B players, we put a big more focus on our better players because we tended to neglect the better players and always worked on the others but at 14 with it being a decision year when we get to December, January and we*

> *know more or less what is going to happen, my argument is we then have to focus on the ones we are keeping, still give them all practice time but really the extras should go to those who are staying (Coach 3).*

Aligned with the sub-theme, differentiating between performance and potential, one coach wondered if the wrong players were provided with more opportunities and resources.

> *What about that C grade player, if we give him an equal amount of resources he could prove himself to be an A, and maybe way back that player who was performing well but we never saw the potential (Coach 2).*

As mentioned previously, the labelling and grading of talent in sport warrants further consideration. In line with the quotes above, coaches recognise their greater investment in players they perceive to be more talented and with greater potential (A grade). This finding is consistent with Pygmalion and Matthew effects in sport (Rejeski et al., 1979; Siekanska et al., 2013; Hancock et al., 2013; Wattie et al., 2015). In line with the Pygmalion effect (a self-fulfilling prophecy), the coaches offer more support, time, and investment into the athletes they regard as talented, thus the athlete rises to the coach's high expectations. On the other hand, players regarded as less talented by their coaches, often the chronologically younger and later maturing, receive less support, resources and opportunities and therefore fulfil the low expectations placed upon them (Siekanska et al., 2013; Hancock et al., 2013). Similarly, the Matthew effect proposes "the rich get richer and the poor get poorer", whereby players begin with an initial advantage which persists over time. For example, chronologically older players and/or early maturing players have an advantage, which their peers do not, which begets further advantages (Hancock et al., 2013; Wattie et al., 2015). These theoretical models explain challenges within talent identification systems. In this study there was disagreement among the coaches as to whether more resources and coaching should go to the identified A grade players or the lower potential C grade players.

Finally, coaches highlighted their challenge of grading potential and match performance in their athletes: "I am becoming less and less interested in the match grades we make decisions in the face of them… are they a useful metric?" (Coach 1). Coaches described some pitfalls of the academies grading of potential and performance in terms of the effects of growth (See Theme 1), maturity biases (See Theme 2) and uncertainty of potential.

The scoring system used within the academy of a 1 to 4 scale of performance was described as problematic by one coach:

> *His average grade was a 2.8 so I was going to give him a 3, and then I was advised you can't give him a three because of the message it might say. And I said I don't know if I agree with that, because it makes this all nonsense, why are we giving the kids grades and then going I know I have given you loads of 3's but actually you are a 2. And then it is whether the coach is talking about performance in football or is he talking about the whole thing. Because I argued I should give a three and S&C could give a 1 or 2 and say this is stuff that's going to hold your back, which is what I ended up delivering… I have only given about 4 1's the whole year… a one is you are not at academy standard for me, that's like you're a one legged, you know they can't run around (Coach 1).*

The one to four measure of performance used in this academy has limitations (See Study One and Two). The four-point scale limits the variation in responses coaches can give. Further, the majority of grades given by coaches were twos and threes, with noticeably less ones and fours being awarded (Hill et al., 2020). The coaches' comment above is in concordance with the objective data observed in study one and two of this thesis. Although this scale does have ecological validity, research determining the validity and reliability of the scale is necessary (Hill et al., 2020).

Summary

Limitations

The mixed methods approach employed in this study aimed to develop a greater contextualised understanding of coaches' experiences and perceptions of male adolescent football players than currently exists in the literature. By combining the quantitative measures of growth rate, maturity status and performance rating with the coach's perceptions and experiences over time, a deeper understanding of the complex nature of growth and maturation within talent pathways could be studied. However, the results of this study are specific to one professional football academy in the EPL, and thus may not be generalisable to other football academies around the world with different club philosophies, values, and practices. The study is also limited to the experiences and perceptions of only nine youth football coaches; however, elite youth academy coaches are a hard to reach sample, as access into elite level samples is often restricted. Further research across a larger sample, including more academies and talent pathways is required

to substantiate and develop these findings. Additionally, this body of work is focused upon male adolescent football players and therefore cannot be generalised to female athletes. The differences between male and female changes in puberty are distinct and warrant research separately. Further, the context of elite youth football is very different for females than males, and so their coaches experiences of adolescence will likely be very different and so is worthy of investigation independently; this was not possible within the scope of this PhD, however.

The longitudinal nature of this study is a strength of the research. Adolescent players had their growth, maturity status and performance tracked over a 12-month period, alongside their coach's perceptions and evaluations. Studies with a high frequency of measurement are logistically challenging yet provide more detailed information on the nature of growth and development (Cameron, 2014). The level of measurement within this research allowed for a greater understanding of the growth process within academy football, while remaining logistically feasible within the setting. Although measures were taken to reduce measurement error, the field in which they were taken means error cannot be eliminated. Measurements were taken at the same time each month, in the same clothes (club kit), by two experienced and trained staff, following the stretch stature protocol to minimise potential error (Stewart et al., 2011).

Height and weight measurements were used to estimate maturity status and decipher growth velocities. Many growth velocities recorded in this study were higher than the average rate expected in peak height velocity of around eight to fourteen centimetres (Malina et al., 2004a). This potentially may be down to measurement error, but equally, the high frequency of height measurements may also explain the high velocities; the non-linear, saltatory nature of growth, where periods of rapid growth are interspersed with plateaus, mean significantly higher growth rates are not uncommon (Teunissen et al., 2020; Lampl et al, 1992). Also, it is important to note that, this study used a non-invasive measure of maturity status as this is the most applicable method in this setting. The method used is based upon data and reference standards for North American youth (Khamis and Roche, 1994), which has demonstrated moderate concordance with maturity classifications based upon skeletal age and has shown concurrent and predictive validity in European youth (Malina et al., 2005; Malina et al., 2012).

Conclusions

The findings from this study emphasise the complexities of experiencing and managing adolescent growth and maturation in the context of elite youth football. The three distinct themes and various sub-themes and case studies provide an in-depth understanding of how adolescent coaches experience, perceive, and manage adolescent players through the academy programme. The discourse coaches use around the adolescent growth spurt, being like that of a condition with various signs and symptoms, is a novel finding of this study; no studies to date have explored coaches' perceptions of the adolescent growth spurt. Coaches perceive many of their athletes to struggle through the adolescent growth spurt, which in turn has implications for training and selection decisions. This is an important finding which warrants further exploration.

In terms of maturity, coaches had different perceptions and expectations for players based upon their biological maturity status. Early maturing players were seen to impact games and play more consistently, but often were described to depend too much on their advanced physicality. On the other hand, late maturing players were often described as technically and tactically advanced, but their smaller size and physicality meant their impact upon the game was insignificant. The different perceptions and expectations for early and late maturing players had implications for playing time, performance grades and selection decisions, where it was perceived early maturing players were likely to play more minutes, be evaluated higher and have a greater chance at selection.

The competitive nature of academy football and the coaches desire to often win, further exacerbated selection biases towards early maturing players. Although coaches described the importance of player development, inconsistencies in their coaching actions showed the challenges associated with managing a competitive youth team where players differ in biological maturity status. The social stimulus value of growth and maturation, and how athletes are judged and perceived by others is highly dependent upon the environment and culture, and thus a biocultural approach is necessary (Cumming et al., 2005). The high-performance competitive environment of academy football exacerbates the social stimulus value of an athlete. This research highlights the complexity of growth and maturity within academy football and brings to light the various sociocultural layers that impact player development.

Discussion

Main Findings

The aim of this thesis was to understand the influence of growth and maturation upon coaches' evaluations and perceptions within youth academy football. More specifically, this thesis intended to add the coach's experiences and perceptions of adolescence, growth, and maturation to the literature. Utilising a combination of quantitative and qualitative data, this thesis supports and advances the existing knowledge and literature relating to the importance of growth and maturity in youth sport.

The findings from this series of studies adds to the literature surrounding the impact of biological maturation upon player selection and performance in academy football (Meylan et al., 2010). This research showed a player's biological maturity status within their team can influence the coaches' perceptions of their performance (study one). Previous research has shown early maturing adolescent players tend to outperform their peers in most physical fitness tasks and to a smaller extent, skill tasks (Lefevre et al., 1990; Malina et al., 2004; Buccheit & Mendez-Villanueva, 2014); this research adds that these physical and athletic advantages are reflected in the coaches subjective evaluations of performance. Biological maturation positively predicted coach's performance evaluations in some age groups. A coach's perception of a player's performance is pivotal in selection, retention, and release decisions; thus, it is vital when evaluating players, coaches recognise differences in biological maturity are important.

The third study of this thesis further examined coaches' perceptions and understanding of individual differences in maturity status. Coaches described early maturing players to use their physicality to easily compete and offer protection to the team. Early maturing players were also described to be more consistent, have more impact in games and consequently provided the best chance for success. Further, early maturing players had come through the difficulties associated with the growth spurt which their peers are still experiencing (See Theme 1; Mitchell et al., 2016). These findings perhaps further explain why early maturing players are graded higher in matches by their coaches, but also potentially why they are continually over-represented in many youth sports, including football (Meylan et al., 2010; Malina et al., 2015; Johnson et al., 2017). The nature of growth and maturation within academy football is therefore highly complex and dynamic, whereby a player's maturity status can significantly alter their journey and success.

It is well known that late maturing players are at a disadvantage and under-represented in academy football (Gastin & Bennett, 2014; Cumming et al., 2017; Johnson et al., 2017; Hill et al., 2019). Coaches in this study generally described late maturing players as physically behind, technically advanced, exciting prospects; however, with little impact on games they are evaluated poorly compared to their peers and with their growth spurt still to come, it appears academies may be reluctant to use one of their sought after academy positions on someone less developed. The few late maturing players who are retained within talent pathway systems may benefit from the underdog hypothesis (Gibbs et al., 2011; Cumming et al., 2017a); athletic potential is greater after facing significant challenges and trauma (Collins, MacNamara & McCarthy, 2016). In order to be retained late maturing individuals must possess and or develop superior technical/ tactical and psychological attributes. For this benefit to occur however, these athletes must first be on the talent pathway, and evidence suggests that these individuals are disproportionality underrepresented or excluded (Meylan et al., 2010). The findings from this study challenge the idea that late maturing players eventually come through to succeed.

It is important to highlight however, many of the late maturing players which the coaches described in this study are not truly late maturing, but just depicted this way by their coach because they are later than some of their peers. Previous research in this academy shows the majority of academy players to be categorised as on-time, with very few late maturing players in the system in the older age groups (Hill et al., 2019). Despite most players being categorised as on-time, coaches did not describe or discuss on-time players within the interviews (Theme 2). Perhaps the large quantity of research focusing upon the extreme ends of the maturity spectrum (Gastin & Bennett, 2014; Cumming et al., 2017), has caused on-time athletes to be overlooked within academy contexts.

In addition to maturity status, being early, on-time or late, the adolescent growth spurt also impacted coaches' evaluations of match performance (study two). Irrespective of maturity status, the timing of the adolescent growth spurt appears to negatively influence the coach's performance evaluations. Although results were only significant in two age-groups (under 12 and 15), the general trend showed grades declined from pre- to during-growth spurt, before increasing again post-growth spurt. One proposed reason behind the dip in performance grades in the growth spurt was adolescent awkwardness (Beunen & Malina; 1988; Hirtz & Starosta, 2002; Lloyd & Oliver 2013). The notion of adolescent awkwardness was widely discussed among the youth coaches in study three

of this thesis (Theme 1: Growth as a Condition). Coaches described awkwardness as a common symptom of the adolescent growth spurt for many players; coaches recognised visual decrements in movement, technical ability, and physical capabilities, supporting the debated concept of adolescent awkwardness (Beunen & Malina, 1988; Ryan et al., 2018; John et al., 2018). Coaches clearly portrayed adolescent awkwardness and the associated decrements in athletic performance to be problematic for many players, despite very little empirical evidence of the phenomena (Davies & Rose, 2000; Malina et al., 2005).

In addition to adolescent awkwardness, coaches described many adverse side effects or symptoms of the adolescent growth spurt which impact performance (see Theme 1). In study three of this thesis, coaches described some players to be 'suffering' through their growth spurt. Growth related pains and injuries, tiredness, and changes in mood were all described to affect some players experiencing growth; it is thus not surprising that coaches described some players to be 'suffering' through their growth spurt. These perceived signs and symptoms of the adolescent growth spurt may also contribute to why the performance of players in the growth spurt are poorer than players pre- and post-growth spurt grades. The timing of the growth spurt is therefore highly important in academy football.

Talent identification and selection decisions may be influenced by the timing of the adolescent growth spurt. Coaches, whose subjective opinions are highly influential in talent identification pathways (Day, 2011; Williams & Reilly, 2000), can be negatively influenced by the growth spurt. As shown in study three (Theme 1- Implications for selection, retainment, and release), coaches explained their perceptions and expectations of players changed aligned with the adolescent growth spurt. Therefore, in the run up to selection decisions, players suffering through their growth spurt may be at a disadvantage for selection. Further, late maturing players who are already disadvantaged due to their delayed maturity status, may be even further disadvantaged when they experience their growth spurt during the later years of the academy, when training load and the pressure to succeed is greater (Mitchell et al., 2016). On the other hand, early maturing players who gain maturity-associated advantages earlier and come through the potential disadvantages of the growth spurt younger, are at a potential advantage for selection, further explaining their over-representation (Johnson et al., 2017; Hill et al., 2019). Youth sport practitioners need to recognise and understand the large range of possible detrimental effects of growth for some players when identifying talent. By educating

youth sport coaches and scouts, talented players may not be overlooked or disregarded because of their growth and maturity status. Additionally, this research provides further support for the importance of monitoring athletes through the growth spurt (Johnson, 2015).

The adolescent growth spurt is a normal, necessary process in a child's development (Malina, Bouchard & Bar-Or, 2004), however, an interesting and new finding from this research, shows the coaches in this sample perceive the adolescent growth spurt as problematic. Coaches described the adolescent growth spurt alike a condition, with observable signs and symptoms (see Theme 1). It is important to clarify, the adolescent growth spurt is not a condition; nevertheless, coaches use language such as signs and symptoms, that frame growth as a disorder. Understanding how coaches describe and the language they use in relation to growth and maturation in adolescence is important, in order to change and reduce the growth and maturity-associated biases observed. Coach education on adolescent changes and the growth spurt may help reduce the notion that the growth spurt is problematic; the growth spurt is not something which can be prevented, thus coaches should use this phase as an opportunity to refine and develop basic skills and movements (See Case Study Two: Lloyd et al., 2014; Wormhoudt et al., 2017).

Within one age-group, children will span different stages of maturity and so coaches will be presented with players pre-, during- and post-growth spurt (Buccheit & Mendez-Villanueva, 2014; Cumming et al., 2017a). The individual differences in maturation within the age-group and with some players experiencing their growth spurt, youth coaches are uniquely challenged. Coaches in this study explained for some players, training load was adjusted when experiencing the growth-spurt (See Theme 1: Management and Treatment), however this appeared to be an exception rather than the norm. Understandably for youth coaches, it is simpler to design one training plan for the whole chronological age group; however precocious players may be underloaded compared to players who develop later, who would be overloaded (Lloyd and Oliver, 2012). Further individualised training according to growth and maturity status would benefit the long-term development of young players (Lloyd & Oliver, 2012). The Royal Belgian Football Association have tailored their programmes by categorising players based upon development age (Philippaerts et al., 2004; Vandendriessche et al., 2012) and the English Premier League (EPL) are trialling strategies such as bio-banding to address individual differences in biological maturity (Cumming et al., 2017; Bradley et al., 2019).

These approaches are a step towards further individualising training programmes for all players, rather than a minority.

Bio-banding, or training in groups matched on biological age, may also aid coaches' ability to train and evaluate their players (Cumming et al., 2017). A novel finding of this thesis was coaches' expectations of players differ by maturity status. This research found coaches had greater expectations of their early maturing athletes compared to later maturing players. Further, when bio-banding, players were expected to cope or thrive against biologically matched peers; generally, coaches perceived bio-banding to be a performance evaluative tool (See Theme 2). The bio-banding strategy however should also be perceived as a learning and training tool, where early maturing players learn to cope with vulnerability and late maturing players learn leadership skills for example (Hill et al., 2020). A multi-disciplinary approach to bio-banding, with education and support from coaches and sports psychologists, all players could benefit from a mixed-age, bio-banded format (Hill et al., 2020). Coaches should acknowledge the multiple different benefits of training in mixed age-groups (Hill et al., 2020), which in turn may reduce the different expectations of performance within games.

Performance of youth players was a key variable within this thesis. It is recognised that performance is a key indicator in a player's academy journey, where talent identification often relies upon a coach's subjective evaluation of performance (Williams & Reilly, 2000; Baker et al., 2018). This research has shown, both growth and maturity influence coaches' subjective grades of performance (Study one and two). A consistent finding throughout this thesis however, also focused on the overall performance of the team and the outcome of matches. Study one and two of this thesis found the outcome of the game was a key predictor in a player's performance grade, whereby if the result of the game was positive (i.e. a win), the coaches evaluated match grades were higher. Study three of this investigation further explored the coach's perceptions and experiences of wining in academy football. Coaches deemed winning to be pivotal for players confidence and enjoyment; they described coaching actions and behaviours which exemplified the importance of wining (Theme 3). This study supports current research which suggests winning is highly influential for youth coaches in sport (Mills et al., 2012; McCallister et al., 2000).

The academy institution and competitive environment has further implications on youth adolescent athletes. The contradictions and inconsistences between player development and winning games was apparent in the coach's interviews in study three.

Coaches suggested growth and maturation confounds the team's ability to win, and so unequal game time and biased match grades arise. Perhaps the pressure or desire to win for coaches in youth academies exacerbates the maturity-associated biases and difference in expectations observed throughout this thesis. Further research is required to understand why the outcome of games is so pivotal for coaches in academy football and how this affects player development.

Application

The findings from the studies in this thesis show the complex nature of how adolescence, growth, and maturity impact academy football. Both quantitative and qualitative data shows coaches are influenced by individual differences in maturation and the adolescent growth spurt. The preceding sections have highlighted how maturity timing and experiencing the adolescent growth spurt influence coaches' perceptions, evaluations, and management of players. This section aims to propose suggestions for applied practice and future recommendations for research in the area of growth and maturity in youth football. These suggestions and recommendations rely upon the routine measurement of growth and maturity status of adolescent athletes.

The studies in this thesis explored how growth and maturity influence coaches' perceptions, experiences, and management of adolescent football players. Findings show compelling evidence that growth and maturity status has great implications across several domains such as training, evaluation, and selection (Lloyd and Oliver, 2012; Cumming et al., 2017a; Johnson et al., 2017)

Importance of Monitoring Growth and Maturity Status: Training

The coach's perceptions and experiences of individual differences in biological maturation and the adolescent growth spurt illustrate the difficulties in managing a youth team. The difficulty in navigating players through their growth spurt was evident through the signs and symptoms described. The perceived side effects of the growth spurt, including physical, technical, and psychological affects, were experienced by many players across the age groups. Equally, the timing of the growth spurt had further implications for coaches. Players who matured early, experienced 'growth' in the earlier years of their training; players who matured later experienced growth when pressure to succeed and training load was much higher (Mitchell et al., 2016; Van der Sluis et al., 2015). The perceived side-effects of the growth spurt may therefore be greater for later

maturing adolescents who are navigating their growth spurt at a more challenging point of time. If academies monitor the growth spurt and adjust training accordingly, all players, but especially late maturing players, may 'suffer' less through adolescence.

Youth coaches must monitor and manage one chronological age group which may encompass multiple growth and maturity stages (Johnson et al., 2009; Buccheit & Mendez-Villanueva, 2014; Cumming et al., 2017). The players at different stages of growth and maturity require different environments for optimal learning and safe development (Lloyd & Oliver, 2012; Cumming et al., 2017; Wormhoudt et al., 2017; Malmborg et al., 2018). Although accommodating for different growth and maturity statuses in one age group is complex, it is necessary for coaches to be flexible and adapt training (Lloyd & Oliver, 2012). In relation to the YPD model, the components of the model are required to move earlier or later depending upon a child's maturation status; for example early maturing players require more complex advanced training techniques at an earlier age than their later maturing peers (Lloyd & Oliver, 2012). Training prescriptions should therefore vary according to chronological age, and so one age group coach may have to deliver numerous training programmes.

Individualising training and load is also suggested to reduce pain and injuries within the growth spurt. Children in the growth spurt are at an increased susceptibility for injuries and pain (Johnson et al., 2019; Read et al., 2017; Van der Sluis et al., 2014). While injuries are an accepted consequence of playing sport, coaches perceived injuries in the growth spurt to be expected. Within the literature it is accepted that reducing and monitoring training load for players in the growth spurt is a necessary step to reduce injury and pains (DiFiori, 2010; Horobeanu et al., 2017; Johnson et al., 2019). Monitoring of growth and maturity status is therefore imperative to individualise training and load (Lloyd & Oliver, 2012). Youth sport programmes and academies should prioritise individualising training loads in relation to growth and maturity status to mitigate and safeguard athletes from unnecessary growth-related injuries. Future research should aim to understand how maturity status and timing influence different types of injury and understand how monitoring and reducing the training load affects injury risk.

The measurement and consideration of growth and maturity status within youth football training is improving. Past research has highlighted the importance of monitoring growth and maturity status within academies to improve training (Cumming et al., 2017; Lloyd & Oliver, 2012). Some research has shown academies to assess growth and maturity status for bio-banding, a strategy to reduce maturity associated variation

(Cumming et al., 2017; Bradley et al., 2019; Abbott et al., 2019), and to assess injury risk (Johnson et al., 2019; Van der Sluis et al., 2014; Rommers et al., 2019b). However, the uptake of monitoring growth and maturity status outside of research purposes, to inform training and practice is unknown. Within this academy, maturity was assessed for bio-banding but primarily for an evaluation tool rather than applied to training. Some coaches in this study described monitoring and reducing load when players were growing, however, strategies need to be considered programme wide rather than on an individual basis. Further, coaches expressed growth and maturity measures to be assessed and understood by strength and conditioning coaches but not necessarily by the primary football coach. Without a whole club holistic approach to monitoring growth, maturation and adapting training for adolescent players, inconsistencies across departments are likely to occur.

Importance of Monitoring Growth and Maturity Status: Evaluation and Selection

Talent identification relies upon a holistic approach considering the physical, technical, and psychosocial attributes of an athlete (Vaeyens et al., 2008; Williams & Reilly, 2000). As well as multi-disciplinary testing, selection decisions are also based upon a coach's subjective evaluation of a player (Williams & Reilly, 2000; Day, 2011; Lund & Soderstrom, 2017). This research shows growth and maturity status and timing, influences a coach's evaluation of a player and consequently development and selection.

Late maturing players appear to be adversely affected by their delayed maturation both directly and indirectly (Cumming et al., 2017). The direct effects such as smaller size and physical capability means late maturing players are at a disadvantage against their precocious peers (Cumming et al., 2017; Gastin & Bennett, 2014; Malina et al., 2004b). The indirect effects such as the athlete's perception of themselves and the coach's perception and management also affect late maturing athletes (Cumming et al., 2017). Playing time, position, and appearances in gold-standard games were all examples of late maturing players being indirectly affected by their maturity status. Due to their delayed maturity status, coaches described it more difficult to sign and scholar late maturing athletes.

A significant body of evidence shows late maturing players are underrepresented in academy football (Meylan et al., 2010; Malina et al., 2015; Johnson et al., 2017; Hill et al., 2019). Coaches explained late maturing players were physically behind, impacted games less, and still had to overcome growth related decrements in performance. The

challenge with selecting and retaining late maturing athletes meant one of the very few scholarship positions was taken by a player who was still to develop. Importantly however, the aim of academy programmes is to identify and develop talent for the future (Williams & Reilly, 2000), thus delayed maturation should not hinder a player's chance of success. Strategies are required to educate youth sport practitioners to ensure late maturing athletes are not overlooked in talent identification systems.

The importance of winning may be a potential reason behind why early maturing players are continually overrepresented (Meylan et al., 2010; Johnson et al., 2017; Hill et al., 2019). Quantitative data shows advanced maturation predicts higher performance grades in some age groups. Early maturing players were described to be more physical, consistent and to have a greater effect on games. Coaches acknowledged their advanced maturity provided the team more chance for success. Additionally, coaches in this study described a safeguarding issue when playing late maturing players against other more mature teams within the league. Thus, the desire to win in academy football may be driving the selection process. Augste and Lames suggested the same to be true for the RAE, where academy teams select chronologically older players for immediate success (2011). There appears to be a conflict in academy football, between wanting to win the present game and developing late maturing players for the future. To overcome this, initiatives need to be taken programme wide. National Governing Bodies need to encourage strategies and approaches to tackle the maturity associated selection biases from the top down, in which all clubs and teams would follow.

Bio-banding, a strategy trialled by the Premier League and some academy teams, groups players based upon maturity status rather than chronological age (Cumming et al., 2017). The initiative aims to retain late maturing players and equally challenge early maturing players by playing them with biologically matched peers, creating competitive equity (Cumming et al., 2017; Bradley et al., 2019). Research has shown in bio-banded formats, early maturing players perceived greater physical and technical challenge, while late maturing players perceived less physical and technical challenge than traditional age group formats (Bradley et al., 2019; Hill et al., 2020). Coaches in this study suggested early maturing players had often relied upon their physicality and become technically and tactically deficient (Theme 2). Incorporating bio-banding into an academy programme may therefore facilitate development for players on both ends of the maturity spectrum, by providing various challenges and environments (Bradley et al., 2019; Hill et al., 2020). Academies should integrate bio-banding into their programme for development purposes,

but also to evaluate players against their biologically matched peers to ensure optimal selection decisions (Cumming et al., 2017).

Aside from biological maturity status, players experiencing their adolescent growth spurt may also be at a disadvantage for selection. Coaches evaluated performance grades appear to decline when players undergo PHV, before rising again post-PHV. Moreover, coaches perceive some players to struggle through their growth spurt, suffering from a number of signs and symptoms, leading to poorer performances. Importantly, selection decisions within academy football take place at 12, 14 and 16 years of age, the years in which most boys will experience PHV (Mills et al., 2012; Malina, Bouchard & Bar-Or, 2004). Experiencing PHV in the run up to selection decisions could therefore be problematic; youth sport programmes need to measure, identify, and recognise players undergoing PHV when evaluating and selecting players.

Education

For the assessment and consideration of growth and maturation to have greatest effect within youth sport programmes, is it paramount for coaches and practitioners to fully understand the concepts, and how to measure, interpret and apply this knowledge. The findings of this thesis suggest coaches have good awareness of adolescent growth and maturation, however much of their understanding is driven by theories and anecdotal stories rather than empirical evidence. For example, coaches' descriptions of the adolescent growth spurt show some level of knowledge, yet their language depicting a condition could be problematic. Coaches understanding of individual differences in maturation and the implications this can have on training, selection and evaluation was a key finding of this thesis. However, their application of this knowledge was often limited.

Education around adolescent changes for players and parents may be equally important as educating academy staff and coaches. Some coaches highlighted providing education and support to struggling adolescent players aided their development (See study three- theme 1). As Blakemore explains, teenagers have a right to understand their changing adolescent body (Kellaway, 2018) and the varied implications this can have. The player, parent and coaches are all key stakeholders within academy football, and thorough education on adolescent changes and maturity differences may alleviate selection anxieties, pressure to succeed and may gain buy-in for innovative approaches such as bio-banding (Hill et al., 2020). Research on the impact of educating adolescent players, parents and coaches on normal adolescent changes is warranted.

While we know the adolescent growth spurt is not a medical condition, the coaches perceiving it this way requires further consideration. Although the coaches' perception of growth being a condition is false, the consequences of this perception may be beneficial. Athletes experiencing and suffering through the adolescent growth spurt should be offered more support from youth sport programmes. Coaches spent a large proportion of time describing the many ways in which players can suffer, such as pain and injuries, adolescent awkwardness, mood changes and tiredness (see Theme 1). If coaches and youth sport programmes adopt the assumption that growth is problematic for young athletes, perhaps athletes may be better supported; from early maturing players, who experience growth much earlier than their peers, to late maturing players who experience their growth much later than their peers when the pressure to succeed is greater. Athletes may benefit from being educated and supported through their adolescent changes by their coaches, or even older players who have recently experienced these changes (Hill et al., 2020). Such approaches may assist and encourage growing adolescent players who are 'suffering' through their growth spurt. Falsely perceiving growth as a condition may therefore facilitate more opportunities to help adolescent athletes through this phase.

Youth coaches have a challenging, unique position working with adolescent football players. As described throughout, coaches have to recognise, manage and navigate the many adolescent changes while developing these young players as footballers. Although coaches showed some understanding of how to manage growing adolescent football players, they often expressed the sports science department to be more knowledgeable. The understanding of how growth and maturation affects players and their coach's evaluations and perceptions is important for all academy staff to understand; all departments within an academy should understand the impact of the adolescent growth spurt and individual differences in maturity status, such as scouting and recruitment, psychology and medicine. A holistic, programme wide understanding and approach is needed to better develop, manage, and support adolescent players and mitigate associated biases. The gap in knowledge across departments needs to be bridged in order to better manage and treat adolescent players; Academy programmes could benefit from interdisciplinary education around paediatric changes and development.

Impact

The work within this thesis highlights the need for the application of existing knowledge around growth and maturation to the development of academy footballers. The inconsistencies and lack of application within the coach's experiences and management of players demonstrates the need for more education and innovative strategies within youth academies. Further research and application of knowledge may improve athlete development for players on both ends of the maturity spectrum.

Alongside the studies involved within this thesis, a placement within the academy also took place. This provided an opportunity to apply the knowledge gained from conducting the research within an elite Premier League academy. Working within the sports science department of Southampton Football Club allowed for a unique opportunity to apply the knowledge gained and co-create strategies with the coaches from the sample. Although my primary role within the academy was that of a researcher, the role evolved to develop educational materials and continuing professional development (CPD) sessions for the academy staff on the topic of adolescence, growth, and maturation.

The research findings were disseminated to academic audiences through publications and conferences (Hill et al., study two). Additionally, findings were distributed throughout the academy from management through to the sports science and coaching departments. It was hoped that the circulation of the research would increase awareness of the impact of growth and maturation and educate coaches on how their perceptions are influenced. CPD sessions were designed to circulate the research findings but also create conversation and creation of innovative strategies to approach growth and maturation within the academy, such as biased evaluations, and changing perceptions with the growth spurt.

The first two studies within this thesis highlighted to academy staff the impact of growth and maturation upon player evaluations. These two studies gained buy in from the coaches and management to the importance of this research and permitted the longitudinal tracking investigation seen in study three. The third study within this body of work, created continuous long-term discussions around the impact of growth and maturation within each age group; although the primary aim of this was for research purposes, the secondary outcome of continued conversations was positive. Coaches considering and acknowledging the importance of growth and maturation throughout the age groups may

perhaps be an intervention, whereby their increased knowledge and awareness may reduce growth and maturity associated biases.

Recommendations for future research

The coach's experiences of managing adolescent athletes were primarily related to the detrimental effects of the growth spurt. Quantitative research has shown the adolescent growth spurt is associated with increases in size and physical capabilities (Malina, Bouchard and Bar-Or, 2004) but also injury risk (Caine et al., 2014; Van der Sluis et al., 2014) and adolescent awkwardness (Malina and Beunen, 1988; Hirtz and Starosta, 2002). Coaches in this study explained qualitatively that many adolescents struggle with their growth spurt; a number of signs and symptoms were presented to be associated with the growth spurt (see Theme 1). Future research should further assess the implications of the adolescent growth spurt in academy football, such as fatigue, pain, and attitude changes. The signs and symptoms observed by coaches should be objectively measured and tracked throughout adolescence. Research regarding the players perspective of their experiences of the adolescent growth spurt is also warranted.

Future research should focus on tackling the phenomena of adolescent awkwardness. Adolescent awkwardness is a largely disputed concept because of the lack of empirical evidence supporting the theory (Beunen & Malina, 1988; Davies & Rose, 2000; Quatman-Yates et al., 2012). The coaches in this investigation however perceived many of their athletes to suffer from adolescent awkwardness despite the lack of objective evidence. More exploratory qualitative studies like this one, may further the debate and aid in understanding why awkwardness is an accepted concept in the coaching community (Ryan et al., 2018). Again, investigating the players perspective of adolescent awkwardness would be beneficial.

The indirect effects of maturity status within an academy football context also necessitate further investigation. The direct effects of maturity, the immediate impact of variance in maturity, is well researched (Malina et al., 2004; Meylan et al., 2010; Buchheit and Mendez-Villanueva, 2014; Parr et al., 2020). The indirect effects of maturity however, such as the way maturity status influences perceptions, treatment and management of athletes is under researched (Cumming et al., 2017a). This investigation showed the complexity in managing adolescent athletes within a competitive environment, and delved into the coaches differing perceptions of athletes by maturity

status; however, the results of this investigation demonstrate a small sample of coaches within one academy and thus results cannot be generalised. Understanding how maturity status indirectly effects players within academy football will benefit the development of all players.

Not only does maturity status directly and indirectly affect how coaches perceive and manage their athletes, but it also influences the athlete themselves. It is known boys advanced in maturity status tend to have higher perceptions of themselves and present a more adaptive motivational profile (Cumming et al., 2011, 2012, 2017a). Interestingly coaches in this study presented other effects of maturity status within their players, such as motivation, game intelligence and ability to adapt (see Theme 2). Coaches described early maturing players as complacent, due to their advanced physicality; late maturing players were described as adaptors, whose game intelligence was higher due to their smaller physique. Although this is an interesting finding, objective research is required to understand how these variables, such as game intelligence, vary by maturity status.

Conclusions

This thesis contributes a deeper understanding of the experiences and perceptions of youth coaches surrounding the complex nature of adolescence, growth, and maturity within academy football, by employing an interdisciplinary, mixed methods approach. Embedded within an English Premier League football academy, this series of studies explores how coaches' experiences and perceptions are influenced by the combination of growth and maturity in their players. Previous research within this area has focused upon objectively measuring selection biases, injury risk and differences in physical testing (Johnson et al., 2017; Johnson et al., 2019; Parr et al, 2020). This thesis explored coaches' evaluations, experiences, and perceptions throughout the adolescent phase, and added a qualitative narrative of coaches' experiences to better understand the impact of growth and maturity.

Coaches described both advantages and disadvantages for early and late maturing players, however the competitive nature of academy football complicates the nature of managing adolescent athletes. The implications of growth and maturation differ for early and late maturing players. Although late maturing players appear more technically and tactically advanced, their physicality means their impact on games is less than their peers and thus they play less minutes. On the other hand, early maturing players use their

physicality to dominate and influence the result of games, thus many tend to be selected throughout the age groups, however often their technical and tactical capabilities are lacking. Further, early maturing players come through the difficulties associated with their growth spurt earlier than their late maturing peers, and consequently are more likely to be selected. The pressure to succeed and continuous evaluations of players throughout the age-groups means the academy system is more conducive for early maturing players.

The adolescent growth spurt, irrespective of maturity timing, also confounds the evaluation of talent. Athletes experiencing their adolescent growth are perceived to perform poorer than adolescents pre- or post-growth spurt; when in the growth spurt adolescents are described to struggle with fatigue and injuries, and their physical and technical ability appears to decline. Thus, academies should measure and track adolescents within their growth spurt and implement strategies to reduce the 'struggles' which many athletes face.

Finally, the competitive nature of academy football and the importance of winning exacerbates the implications of growth and maturity within youth football. Result of the games was seen to influence the coach's evaluations of players, but also player selection and opportunities. Within youth sport programmes, including academy football, the primary aim should be player development, and thus the magnitude of winning for youth coaches is a concern. Future investigations and interventions should focus upon trying to mitigate and reduce the prominence of winning within youth sport, which in turn may perhaps reduce the growth and maturity-associated biases within youth sport.

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Appendix A

Interview schedule:

Background:

What age group are you coaching?

How long have you been coaching this level of football?

Can you talk about your current age group players briefly?

Describe their characteristics:

Performances?

Injuries?

Growth and maturation characteristics?

Growth:

Are you aware when a player is experiencing their growth spurt and how? Who in your age group is currently experiencing their growth spurt?

Is the growth spurt period easy to spot? Why? Can you recall any particular changes associated with adolescence and puberty which you identify in your players?

All players will experience an adolescent growth spurt: How do you think this affects them in your age group?

Physically?

Socially?

Psychologically?

Performance?

Are these positive or negative?

How do you manage this?

How does your job as a coach alter or change when players are experiencing growth?

Maturation:

What is the difference in your group between players in terms of maturity status? How do you know?

What are the implications of these differences on a day to day basis? Any stories or experiences to highlight this?

Within your age group, how do you manage the differences in maturity status? Any examples?

How do you as a coach perceive and experience these differences within your age group?

Appendix B:

Theme and Subtheme	Quotes from Coaches Transcripts:
1.1 Having growth	• I believe he is one that is experiencing growth at the moment, so could be linked to his inconsistencies and his performances. Coach 6. • I think he may have had a bit of growth, and now he's at the point where he is like oh hello what's happened to me but copes with it well. Coach 3. • Erm so hasn't really got any growth issues and mentally hasn't been affected by it Coach 1. • You don't even need the data to see it they have had a massive growth spurt. Also interesting will be to see how they come out of it, they could have long term issues there. Coach 5.
1.2 Signs and Symptoms	• Ha yeah you can really see that he is growing in him yeah really, bit gangly and losing a bit of power, and his movement you know needs a little bit help. Coach 3. • I think it depends, whenever you are in a huge growth spurt there is going to be a risk of injury, so yeah maybe bring him back to his age group. Coach 7. • You can see his growth, he is getting bigger, he is starting to fill out slightly, not massively but slightly from what he was like, he doesn't look as gangly at the moment as he did before. Coach 9 • Recently put on a lot of weight, don't know if that is a lifestyle thing or a growing thing, looks a bit round might be puppy fat, it might be something that he will grow out of it, it might be that. Coach 1. • but I think will just be a very nice up within his growth and I don't think it will change much with his dynamics, his feet haven't gone stupidly big yet, his body is in proportion to what you would expect it to be in this moment in time. Coach 8.

	• Yeah still growing, I think he still has a bit left in him, I think he could be an animal, he could be 6foot1 6foot2 dynamic midfielder, yea because he has got no quads on him, no hair no hair. Coach 8 • becoming at bit smoother with his ball striking, before he would struggle to get the ball anywhere off of the floor, now he is starting to get through the ball just a little bit easier, now it is easier for him. Coach 9 • seems to have got taller, with no muscle development, coordination not bad considering he looks quite tall, he has got a bit rangier over the last month or so from my eye. That's why his movement and stuff might be a bit off looking. Coach 4.
1.3 Management and Treatment:	• That leads to him making mistakes in games, I think we always try and frame it in the right way and tell him that we understand it. Coach 1. • so what we are doing is every week we are giving him some individual practices , 1 to 1, he does 45 minutes with him every Thursday, also because of his growth, and also the way he runs, we have also got individual work with SandC, so we are working on that with some specific individual practices on a Thursday so he has individual sandc and induvial practice as well as his own individual work that he does. Coach 3. • I say its interesting but the support that he has had has meant that he is dealt with it better. Coach 6. • he only trains one day release a week, I wonder when doing less in a period of growth can help potentially. Coach 5. • I think it depends, whenever you are in a huge growth spurt there is going to be a risk of injury, so yeah maybe bring him back to his age group…. going through that growth spurt because we think he is going to be the best player, does he need to be pushed at that challenge when he is gong to have less success, less influence, less touches, less of wanting to be there himself, so who sets the challenge, what's the content of him playing up, what's the value in it, are we just playing him up for the sake of it because we think he needs that challenge or is there value in his current age group going through this growth spurt and having lots of success, I don't know. Coach 8.
1.4 Implications for selection, retainment and release.	• Do you know what though, may to august he had a jump, and that's when we had him and we went were not quite sure about him, he isn't what I thought he was going to be, I thought technically he looked really off, and now all of a sudden he has improved but he has plateaued look from August, we would have had him in pre-season look in July and we were like that's not what we were expecting of him, that little period there look that's when I was saying to you I am not sure he is technically as good as I thought he was. Coach 7 • Certainly looks quite low down in the group, he is late but he has always managed it before, difference is when you get to 15's if you are late and the 16's if you are late you are dealing with men being late so just about how he manages himself and offering him support. Coach 5. • The new coach gets a new group and does an audit and makes decisions based upon people he's only known four months, like what, and the 16's they get even less time to go these ones are scholars these ones might be scholars and these ones need to be got rid. Coach 6.

	• growth velocity has never gone below 5cm all year, that is interesting and the thing about him is, I am not sure the coaches above are having him that much, but everyone else at the club would be high believers in MA, 16's coaches just haven't seen it themselves, and I think he can probably sense that a bit. Coach 5.
2.1 Advantages and disadvantages of Early Maturation:	• because a lot of the early's see have to then work on their technical attributes, and body positioning, awareness, to combat being an early developer. Coach 7 • Out of possession because of his physicality he wins balls, I think he could be more aggressive and there are times when you see it but only against smaller players, when he is up against bigger or physically matched players I think he could be braver, stop being a chicken, so maybe playing with the 15's might help him. Coach 3. • We need to keep stretching him, because he is biologically 14 and a half I think. We plan to play him central defence and left back to make sure he has got two positions in his locker. He manages to compete quite easily because he can use his body, he can protect the ball, he can move people. Coach 1. • He should probably be playing up, technically he shouldn't be and game understanding and game impact he shouldn't be, but I argue to expose him to how much technical work he has got to do, he should play up. I think he is super early. Coach 2. • Definitely a very talented footballer, no doubts about it, been with England recently, called up again, probably a lot of that is down to him being an early maturer, his physical stuff, physique and stature. Coach 5. • Physically he has done quite well, I think he is one of the earlier maturing in the group and you can see that you can see physically he is further ahead than some of the other players. How he has filled out and his physique and also like some of his facial features, you can kind of tell, another good indicator is his range of pass, that fact that he is physically capable to play the ball over a variety of different distances in comparison to others who maybe are later in the group. Coach 6. • I think he is 24, he probably reached his peak probably last year, and you can see now there is nothing else to come from him I don't think… Coach 8. • He is another one who I think has used his physicality, yeah I think he has done, and I think it has made him look quite good as well, when he comes up against someone now who is a little bit nippy and sharp and speedy yeah he really struggles, he really struggles. Coach 7.
2.2 Advantages and disadvantages of Late Maturation:	• My bias is going on and I am thinking I cannot believe he has just managed to do all that as a late maturer. Coach 5. • His challenge is that he is a bit of a dot compared. We need to monitor his growth and be sure that he is going to be that kind of 6.2 kind of 6.3 figure. Coach 3. • Wouldn't be right putting him up there because of how slight he is physically, and it would just be wrong to put him in there because it would just completely kill him off, so he is better off playing down in the 13's to be able to handle that. Coach 9. • He has played down and strived, scored more goals in the games he's played down, absolutely chilled out about playing down, no kind of

	ego or status attached to it. He likes it because he can show oh hang on this is actually easier for me, gone in accepted it, enjoyed it and embraced it. Coach 1. • Physically nice, he moves well, late maturer and like competes, could probably compete up as well. Left footed, so he has a good physical profile, and he is a defender, predicted height is 6 foot plus, he should make scholarship just because of the position and the raw ingredients he has got. He loves to defend, he ticks a lot of boxes. Coach 2. • I think considering how late he is, I think his energy levels and his mobility to keep running and willingness to keep running forward and back, erm doesn't faze him that he is up against someone bigger, he will try and use what physicality he has got, and he is quick, I bet he has so much to come, I think there is a lot there. Coach 7.
2.3 Different performance expectations associated with maturity status	• I think he is probably earlier than we think he is, which is a bit of a concern because physically, in games physically he looks pretty poor. Coach 1. • When he goes up to the older age group because of where his maturity is, he hasn't got it, he looks slow, his technique is all over the place. Coach 5 • He will be playing down in the bio-banding so I would expect him to do really well, I expect him to score some goals or at least be one of the top three boys in that game. Coach 2. • he has yeah he has, but that hasn't had any affect on him, his performances haven't, its not like 15's coaches have come back and said his performance was very good, he ran the game, whereas can play up for us, and physically cant recover and get forward ad much, but stands in good areas and does well. Coach 8.
2.4 Implications for Selection, retention and release.	• He has found this season, very very difficult. Although he has a physical presence in terms of his size, he doesn't use that at all, he is the second or third highest maturer and so he is an early maturer that demonstrates fear. Although he is big, he is not quick, he is not powerful…poor in 1v1's, doesn't use what he has got in any way shape or form, his movement is poor, his agility and coordination is very average. I could say more things, but he is just in the wrong environment, at this stage I don't think we can see or get him to what is needed at a premier league cat 1 club. Coach 3. • when he got to 16's he couldn't, when we see it, so when we see [early player] when we see it at a young age, you have got to tell them that's not real, that's not going to work, I think the coach has to be aware that it is not real. Coach 7 • but they have to have the little bit different make up than an earlier so they have to have the technical attributes to manipulate balls, you cant just say they're a late, they have to show some sort of you know… I think that is what has happened to [player], everyone's gone he is a late, so sign him and he will come through, but I don't see any technical qualities, I don't see any influence on the game. Coach 8 • I have to admit a bias that I probably had was I wonder if everyone is raving about this kid because he is so early, actually he isn't as early as I thought, he has done really well when he has gone in with the 16's. Coach 5.

3.1 Player Development vs winning.	• They're all getting decent minutes because of the size of the squad, but I would say the early's are playing in positions at the moment where we are short on players, so they are naturally playing more. Coach 5 • I know all coaches do this, they have a good excuse, when you have a late or someone who is struggling, people will say they need less game time, because they cant cover the distance it is harder for them, I don't believe that is the real reason, I think often it is because they have an impact on the game and it affects your ego, but it is how we approach that because there probably is an element of truth, lads going through growth, pulling their minutes down is probably a useful tool, but I am not convinced that we are doing it for the right reasons. Coach 5 • my feeling would be we have been consistent in providing equal game time however the Cup games Could skew that little bit because you play them to win, Therefore probably at times the best performing players in those moments have been early machining players, and so the lads that haven't impacted games like DB and that have missed out. Having said that they did all start last week as an example they played half and they played half at the weekend. We have tried to even out as much as we can I would suggest the early's have probably had more game time. Coach 6.
3.2 Differentiating between performance and potential	• I have seen this happen a number of times, two C grade players, so a C in our opinion is we don't think they are going to get close to having a scholar, we don't think they are going to get one, in with a slight chance, but they will probably get something elsewhere… if we say they are a D they are released. So, you're debating these two lads, one is early, and one is incredibly late. Now you're probably about right that the potential of both of them is probably around a C. The early, is one of the top performers as a C, so he is offering a shed load to the group, he is making the players around him better, the midfielders have got a chance to pass in behind more because he can get there , the players around him have some physical protection, they are able to experience success. The C that is a late, it feels like he is bringing nothing to the programme, it is the harshest way you can look at it…but this lad is probably potential wise not going to be at that level… he is bringing very little to the team, so actually he is making everyone else have to work much harder and feel much worse about themselves, and he isn't meaning to, but that's what happens when you're not bringing anything" (Coach 1). • He came out of the audit with an A, because of a lot of situational stuff, he is left footed, his dad is an absolute monster, his brother is 6ft6 and his dad 6ft5, and I know that's not everything, but from all the data he is going to be a big boy, monster, plus he can move, and he is quick, and he is a defender, you don't find many of those people, he wants to defend, you don't find that profile. COACH 1 • I think we see like not just good potential but like post 16 potential with him, we just need to be patient with him. I think he has got one of the highest potentials in the group because relative to his size, he is a good athlete he is strong and agile and psychologically he is very good, he is tough, he is sort of resilient, technically he is very good, and tactically you can see his intentions so although he might not be able to achieve you know because he might get brushed off the ball or whatever but his

	intentions are always really good and you can see what he is trying to do, so when he does go through his growth spurt, and starts to catch up with the likes of BW, he will be able to get away with it. He has learned the tactics and the bigger picture so he is just waiting for his body to catch up and when it does I think he has got a massive amount of potential. COACH 2. • Yeah progress in performance the highest, looks really confident, has gone from a C grade potential to A in the most recent audit. COACH 6.
3.3 Player Development within academy constraints:	• unfortunately, he is one of those in the 50 50 area, him I have asked for more time on, I just feel like I need to see him playing more. COACH 3. • So this group has got 18 or 19 players, I think, and they can hardly get a bare 11 out there its just so many injuries consistently in that group. This group has lost three players already so they are down to 10 fit players, so it is easier and your programme can be more individualized, I can probably fly through their development plans quite easily now as its such a small group so they get more focus, the down side is at the moment late or not they are close to playing 80 minutes every game, they played a 16's team last weekend, they've got a 16/17 team this weekend, so theyre getting two massive hits against men almost… we have to be careful we don't end up with loads of injuries. Coach 5 • The issue I see is unless you are an exceptional player you are almost not going to get into an academy if you are below the national average which means we could potentially be missing out on a whole pool of players, well 50% of players you just hardly looking at them. Coach 5. • Tough one to manage and to balance out but you have got to do what is right for them and you've got to put them in and take them out, you've got to give them the experiences and they have to succeed and fail, that's the only way. Coach 9. • Every age group has coaching pairs, so one should stay with them and one should be somebody new, and that should happen every year, so everyone works 2 years and one of you should move with the players, so you should get some new eyes and consistent eyes because if both of us stay with the same age group, we almost solidify and we understand personalities, and I think you need this change and challenge where a new person can come in and change things up and you can gain further insight into the players. Coach 2.