Citation for published version:
Hill, M, Scott, S, McGee, D & Cumming, S 2020, 'Coaches' Evaluations of Match Performance in Academy Soccer Players in relation to the Adolescent Growth Spurt', *Journal of Science in Sport and Exercise*, vol. 2, pp. 359-366. https://doi.org/10.1007/s42978-020-00072-3

DOI:
10.1007/s42978-020-00072-3

Publication date:
2020

Document Version
Peer reviewed version

Link to publication

This is a post-peer-review, pre-copyedit version of an article published in Journal of Science in Sport and Exercise. The final authenticated version is available online at: https://doi.org/10.1007/s42978-020-00072-3

University of Bath

Alternative formats
If you require this document in an alternative format, please contact:
openaccess@bath.ac.uk

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Download date: 17. Aug. 2021

Journal of Science in Sport and Exercise

Coaches' Evaluations of Match Performance in Academy Soccer Players in relation to the Adolescent Growth Spurt

--Manuscript Draft--

Manuscript Number:	SSEJ-D-20-00061R1
Full Title:	Coaches' Evaluations of Match Performance in Academy Soccer Players in relation to the Adolescent Growth Spurt
Article Type:	Original Research Articles
Funding Information:	
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.
Corresponding Author:	Megan Hill University of Bath UNITED KINGDOM
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	University of Bath
Corresponding Author's Secondary Institution:	
First Author:	Megan Hill
First Author Secondary Information:	
Order of Authors:	Megan Hill
	Sam Scott
	Darragh McGee
	Sean Pringle Cumming
Order of Authors Secondary Information:	
Author Comments:	7th July, 2020 Dr. Rhodri Lloyd, Journal of Science in Sport and Exercise Dear Dr. Lloyd This letter accompanies our manuscript entitled, "Coaches' Evaluations of Match Performance in Academy Soccer Players in relation to the Adolescent Growth Spurt" that my colleagues and I would like to re-submit for consideration in the Journal of

Powered by Editorial Manager® and ProduXion Manager® from Aries Systems Corporation

	Science in Sport and Exercise. Changes to the original manuscript in line with the reviewers comments have been highlighted in the text. I am the corresponding author for this manuscript. If you have any questions or queries regarding the manuscript, then please do not hesitate to contact me. Thank you in advance for your consideration. Sincerely, Megan Hill Department for Health, University of Bath.
Response to Reviewers:	Comments to the author (if any): Reviewer #2: The authors present an interesting paper regarding coaches subjective decisions regarding playing performance and how those might be influenced by maturity in young male soccer players. The paper provides some novel insight but I also wonder whether there is the possibility to offer a little more insight from the data collected. Introduction: This is very informative and very well written. There is a bit of a tendency when introducing growth and maturity to switch between presenting information for boys and girls to just presenting information on a single sex, which is assumed to be boys but isn't always made clear. I think it would be better to consistently refer to either both sexes or just boys - and given the study focuses on boys, probably the latter. Thank you for this comment- we have re-read the introduction and focused on just boys within the introduction. Are there estimates regarding the prevalence of adolescent awkwardness? Hirtz and Starosta (2002, J Hum Kinetics) offer some data regarding awkwardness. Good point- we have added this reference and a short statement regarding the prevalence of adolescent awkwardness in boys. Methods and Results: It seems like it would be relevant to include growth rate. Was growth rate in stature used in combination with %predicted adult height to verify when players were classed as being in a growth spurt? As a minimum it seems relevant to report the growth rate of each group. Unfortunately, at the point in time of this study being conducted, the football club were only collecting height and weight data for the use of updated percentage of predicted adult height. Although we could go back and collate these measurements and measurement dates, with five years of data and multiple measurements per player it would be extremely difficult to collect and analyse. We have added this as a limitation in the discussion section. In the stats analysis section it is not clear that the analysis is being conducted for each age group, rather it appears that all data will be combined (and it might be worth analysing the total sampling). Thank you- we have amended the method section to make it clearer that ANCOVA's were conducted for each age group separately. In line with your comment we have also added an ANCOVA result looking at the total sample. How are effect sizes being interpreted? They are reported in the table but are not referred to elsewhere in the paper. We have added that the partial eta squared effects sizes were interpreted using Cohen's guidelines and references have been added. Effect sizes were very small in this study and potential reasons behind this are discussed in the limitations paragraph. It would be interesting to know more about the frequency of the classifications. How frequently are players at each stage of maturity given a 1 score, 2/3 score or a 4 score. A chi squared test would identify if a circa group more frequently achieve the lowest rating. This is an interesting point, thank you. We have added a Chi-Squared test to the method and analysis to show the frequency of distributions. A crosstabs table has also been added to the results section. Can the growth rate be used to compare ratings of those with the highest levels of growth to those with lower levels of growth (perhaps based on z score groupings)? Unfortunately, due to not having access to the growth rate data this cannot be done for

	the present study. Discussion and conclusion: It seems difficult to conclude that coach ratings were reduced for the circa-PHV group when this was only the case for two out of six comparisons. The conclusions could perhaps be better supported if the effect size interpretation concurs, or if additional analyses also demonstrate lower ratings in periods of rapid growth. Thank you, this is a good point. We have amended the manuscript to ensure the discussion interprets and explains effect sizes and added in further analyses. Reviewer #3: Thank you for the opportunity to review this manuscript. The study examined coaches' evaluation of match performance in academy soccer players at different stages of maturity. Overall, the manuscript is well written, but I have outlined some minor issues below that need addressing prior to me considering a recommendation of acceptance for the journal. * Abstract: o Very well constructed * Introduction: o Excellent introduction. My only comment here is that the introduction is quite long. If the authors are able to remove any superfluous text to reduce the overall length, I think this would be a good thing. Thank you. As per your recommendation we have cut down the length of the introduction where possible. * Methods: o Was some form of a priori sample size estimation conducted? What was the statistical power for the study? A priori sample size estimation was not conducted due to the fairly large sample size collected. o Biological maturity section: "…and the biological parents mean height" is missing an apostrophe after parents. There are other instances of this punctuation error, so the author(s) should proof read the paper and correct these. Thank you- we have proofread the documented and hopefully have removed these punctuation errors. o Space needed between "2.2" and "cm" Thank you, this has been edited. o Given the volume of information provided for the Khamis-Roche method, it might be beneficial to state how exactly parents' height was adjusted. This is a good point. We have added more detail and references on how parental height was adjusted. o Full stop missing before "Percentages lower than 86% and greater than 95% were recorded as pre- and post-growth spurt respectively. We have added this punctuation. o Given the serial repeat measures of height, the authors may wish to consider including growth rates in the analysis. Unfortunately, at the point in time of this study being conducted, the football club were only collecting height and weight data for the use of updated percentage of predicted adult height. Although we could go back and collate these measurements and measurement dates, with five years of data and multiple measurements per player it would be extremely difficult to collect and analyse. We have added this as a limitation of the study. o I do not think that "ethics" needs to be covered in a sub-heading, but rather this information can be presented at the end of the participants section. Good point- we have moved the ethics section to the end of the participants section and removed the sub-heading. o Which type of effect size was calculated…provide references where relevant also. We have added that the partial eta squared effect sizes were interpreted using Cohens d and added relevant references.

	o Were data checked for normal distribution, homogeneity of variance? Data was checked for normal distribution and this is included at the start of the results section. * Results: o Please remove horizontal lines from figure 1 Thank you, horizontal gridlines have been removed. o The axes on figure 1 do not seem to have been included Thank you for noticing this, axes have been added. * Discussion o There seems to be an over-reliance in the discussion around statistical significance, without any real reference to the effect sizes. I think this is an omission which would help interpretation of the findings for the readership. Thank you, this is a good point. We have amended the manuscript to ensure the discussion interprets and explains effect sizes and added in further analyses. o Comprehensive limitations paragraph; well done. Thank you o In the final paragraph, reference is made to the fact that not all players will experience growth related decrements in performance. Could this be something that is supported with a reference? How prevalent is adolescent awkwardness in youth/young players? This is a good point, and we have amended this last paragraph accordingly. We have added a reference to show 90% of boys face a period of awkwardness in the growth spurt.

Powered by Editorial Manager® and ProduXion Manager® from Aries Systems Corporation

"Coaches' Evaluations of Match Performance in Academy Soccer Players in relation to the Adolescent Growth Spurt"

Megan Hill, University of Bath, Department for Health, Bath, UK, m.hill2@bath.ac.uk

Sam Scott, Southampton Football Club, Sports Science and Medicine Department, Southampton, UK

Darragh McGee, University of Bath, Department for Health, Bath, UK.

Sean Cumming, University of Bath, Department for Health, Bath, UK.

Acknowledgements:

The authors would like to thank the participating academy coaches and players for their collaboration.

Declarations:

Funding:

N.A

Conflicts of interest/ Competing Interests:

Megan Hill is a PhD student, part-funded by Southampton Football Club

Sam Scott is an employee of Southampton Football Club

Sean Cumming has worked in research and consultancy roles for the Football Association and the Premier League

Availability of data:

N.A

Code Availability:

IBM SPSS (Version 23), code use available on request.

Click here to view linked References

"Coaches' Evaluations of Match Performance in Academy Soccer Players in relation to the Adolescent Growth Spurt"

Acknowledgements:

The authors would like to thank the participating academy coaches and players for their collaboration.

Declarations:

Funding:

N.A

Conflicts of interest/ Competing Interests:

Availability of data:

N.A

Code Availability:

IBM SPSS (Version 23), code use available on request.

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 challenge 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. Means 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 in, 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 10-12 kg 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 (Pearson et al. 2006; Philippaerts et al. 2006). 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 players test scores according to chronological age if 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 peak height velocity 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 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 1: Table to show descriptive statistics across age groups

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 1). 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 2). 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 3). 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 2: Table to show frequency of match grade classifications by biological maturity status.

Figure 1: 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 3: ANCOVA for mean match grade by maturity status for U9-U16 age groups showing adjusted mean match grades

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 1). 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 and 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 2). Equally, expectations of athletes 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 about 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/realising 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 14s 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 2). 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 impact of the growth spurt upon player performance development 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 peers 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 the puberty is a developmental stage in which potential growth-related decrements in performance are more likely to observed.

Conflicts of Interest:

One author is a PhD student part-funded by the Football Academy.

One author is an employee of the Football Academy

References:

Anderson G, Twist P (2005) Trainability of Children. Idea Fitness J.

Baxter-Jones ADG (2013) Growth, maturation, and training. In: Handbook of Sports, Medicine and Science: Gymnastics. Caine DJ, Russell KW, and Lim L, eds. Chichester, United Kingdom: John Wiley & Sons, p.p.17-27.

Beunen G, Malina RM (1988). Growth and physical performance relative to the timing of the adolescent spurt. Exerc Sport Sci Rev 16:503-540.

Beunen G, Malina RM, Van't Hof MA, Simons J, Ostyn M, Renson R, Van Gerven D (1988) Human Kinetics Publishers sport science monograph series. Adolescent growth and motor performance: A longitudinal study of Belgian boys. Human Kinetics Publishers.

Buchheit M, Mendez-Villanueva A (2014) Effects of age, maturity and body dimensions on match running performance in highly trained under-15 soccer players. Journal of Sports Sciences, 32(13):1271-1278.

Caine D, Purcell L, Maffulli N (2014) The child and adolescent athlete: a review of three potentially serious injuries. BMC Sports Sci Med Rehabil 6(22):1-10

Calvin M (2017) No Hunger in Paradise. London: Penguin.

Cameron N, Bogin, B (2012) Human Growth and Development. 2nd ed. London: Elsevier.

Cohen J (1988). Statistical Power Analysis for the Behavioural Sciences. 2nd ed. New York: Routledge.

Cumming SP, Lloyd RS, Oliver JL, Eisennnann JC, Malina RM (2017) Bio-banding in Sport: Applications to Competition, Talent Identification, and Strength and Conditioning of Youth Athletes. Strength Cond J 39(2): 34-47.

Davies PL, Rose JD (2000) Motor Skills of Typically Developing Adolescents: Awkwardness or Improvement? Phys Occup Ther Pedi 20(1):19-42.

Day D (2011) Craft Coaching and the 'Discerning Eye' of the Coach. International Journal of Sports Science & Coaching 6(1):179-195.

Epstein LH, Valoski AM, Kalarchian MA, et al (1995) Do Children Lose and Maintain Weight Easier Than Adults - A Comparison Of Child And Parent Weight Changes From 6 Months To 10 Years. Obes Res 3(5):411-417.

Faigenbaum AD, Lloyd RS, Oliver JL (2019) Essentials of Youth Fitness. Champaign IL: Human Kinetics.

Froholdt A, Olsen OE, Bahr R (2009) Low Risk of Injuries Among Children Playing Organized Soccer: A Prospective Cohort Study. Am. J. Sports Med 37(6):1155–1160

Hirtz P, Starosta W (2002) Sensitive and Critical Periods of Motor Co-ordination Development and its Relation to Motor Learning. J. Hum. Kinet. 7:19-28.

James S (2014) Meet the Man who discovered Gareth Bale- in a six-a-side aged nine [online]. The Guardian. Available from: https://www.theguardian.com/football/2014/may/17/man-who-discovered-gareth-bale-champions-league-real-madrid [accessed 24/04/2020].

John C, Rahlf AL, Hamacher D, Zech A (2018) Influence of biological maturity on static and dynamic postural control among male youth soccer players. Gait and Posture, 68:18-22

Johnson A, Doherty PJ, Freemont A (2009) Investigation of growth, development, and factors associated with injury in elite schoolboy footballers: prospective study. BMJ 338:b490.

Khamis HJ, Roche AF (1994) Predicting Adult Stature Without Using Skeletal Age - The Khamis-Roche Method. Pediatrics 94(4):504-507.

Lakes K (2013) Restricted Sample Variance Reduces Generalizability. Psychol Assess, 25(2):643-650.

Lloyd RS, Oliver JL, Faigenbaum AD, Myer GD, De Ste Croix, MB (2014) Chronological age vs bioloigcal maturation: implications for exercise programming in youth. J Strength Cond Res, 28:1454-1464.

Lloyd RS, Read P, Oliver J, Meyers RW, Nimpius S, Jeffreys I (2013) Considerations for the development of Agility During Childhood and Adolescence. Strength Cond J 35(3):2-11

Lund S, Soderstrom T (2017) To See or Not to See: Talent Identification in the Swedish Football Association. Sociol. Sport J 34(3):248-258.

Malina RM, Bouchard C, Bar-Or O (2004) Growth, Maturation, and Physical Activity. 2nd ed. Human Kinetics, Champaign, IL.

Malina RM, Cumming SP, Morano PJ, Barron M and Miller SJ (2005) Maturity status of youth football players: A noninvasive estimate. Med. Sci. Sports Exerc 37(6):1044-1052.

Malina RM, Rogol AD, Cumming SP, et al (2015) Biological maturation of youth athletes: assessment and implications. Br. J. Sports Med 49(13):852-859.

Malina RM, Cumming SP, Rogol AD, Coelho-e-Silva MJ, Figueiredo AJ, Konarski JM, Koziel SM (2019) Bio-Banding in Youth Sports: Background, Concept, and Application. Sports Medicine 49(11):1671-1685.

Marshall WA (1971) Evaluation of Growth Rate in Height over Periods of Less than One Year. Arch. Dis. Child 46:414-420.

Marshall WA, Tanner JM (1970) Variations in the Pattern of Pubertal Changes in Boys. Arch. Dis. Child 45(239):13-23.

McKay C, Cumming SP, and Blake T (2019) "Youth Sport: Friend or Foe?" Best Pract. Res.: Clin. Rheumatol 33(1):141-157.

Meylan C, Cronin J, Oliver J, Hughes M (2010) Talent identification in soccer: The role of maturity status on physical, physiological and technical characteristics. International Journal of Sports Science & Coaching 5(4):571–592.

Mitchell SB, Haase AM, Malina RM, et al. (2016) The role of puberty in the making and breaking of young ballet dancers: Perspectives of dance teachers. J. Adolesc 47:81-89.

Nicholls JG (1984) Achievement motivation: Conceptions of Ability, Subjective Experience, Task Choice and Performance. Psych Rev 91(3):328-346

Pearson DT, Naughton GA, Torode M (2006) Predictability of physiological testing and the role of maturation in talent identification for adolescent team sports. Journal of Science and Medicine in Sport 9(4):277-287.

Philippaerts RM, Vaeyens R, Janssens M, Van Renterghem B, Matthys D, Craen R, Bourgois J, Vrijens J, Beunen G, Malina RM (2006) The relationship between peak height velocity and physical performance in youth soccer players. J Sports Sci 24(3):221-230.

Price RJ, Hawkins RD, Hulse MA, Hodson A (2004) The Football Association medical research programme: an audit of injuries in academy youth football. Br. J. Sports Med 38(4):466-471.

Quatman-Yates CC, Quatman CE, Meszaros AJ, Paterno MV, Hewett TE (2012) A systematic review of sensorimotor function during adolescence: a developmental stage of increased motor awkwardness? Br. J. Sports Med 46(9):649-655

Roche A, Tyleshevski F, Rogers E (1983) Non-invasive measurements of physical maturity in children. Res Q Exercise Sport 54:364-371.

Rogol AD, Clark PA, Roemmich JN (2000) Growth and pubertal development in children and adolescents: effects of diet and physical activity. Am. J. Clin Nutr 72(2):521S-528S

Ryan D, McCall A, Fitzpatrick G, Hennessy L, Meyer T, McCunn R (2018) The influence of maturity status on movement quality among English Premier League academy soccer players. Sport Performance and Science Reports, 32(1).

Sanders JO, Qiu X, Lu X, Duren DL, Liu RW, Dang D, Menendez ME, Hans SD, Weber DR, Cooperman DR (2017) The Uniform Pattern of Growth and Skeletal Maturation during the Human Adolescent Growth Spurt. Scientific Reports, 7.

Stolen T, Chamari K, Castagna C, Wisloff U (2005) 'Physiology of soccer', Sports Medicine, 35 (6):501–536

Stratton G, Oliver JL (2014) The impact of Growth and Maturation on Physical Performance. In: Strength and Conditioning for Young Athletes: Science and Application. Lloyd RS and Oliver JL, eds. London, United Kingdom: Routledge. P.p:3-18

Tanner JM (1989) Fetus into man: physical growth from conception to maturity. Cambridge, MA: Harvard University Press.

van der Sluis A, Elferink-Gemser MT, Coelho-e-Silva MJ, Nijboer JA, Brink MS, Visscher C (2014) Sport Injuries Aligned to Peak Height Velocity in Talented Pubertal Soccer Players. International Journal of Sports Medicine 35(4): 351-355.

Viel S, Vaugoyeau M, Assaiante C (2009) Adolescence: a transient period of proprioceptive neglect in sensory integration of postural control. Motor Control 13(1):25-42.

Viru A, Loko J, Harro M, Volver A, Laaneots L, Viru M (1999) Critical Periods in the Development of Performance Capacity During Childhood and Adolescence. European Journal of Physical Education, 4(1):75-119

Williams A, and Reilly T (2000) Talent identification and development in soccer. J. Sports Sci 18(9):657-667.

Wik EH, Martínez-Silván D, Farooq A, Cardinale M, Johnson A, Bahr R (2020) Skeletal maturation and growth rates are related to bone and growth plate injuries in adolescent athletics. Scand J Med Sci Sports 30(5):894-903.

Table 1 Click here to access/download;Table;Table 1.docx

		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

Table 2 Click here to access/download;Table;Table 2.docx

Maturity Status	**Match Grade (Expected Frequency)**			
	1	***2***	***3***	***4***
	(10.29%)	***(45.45%)***	***(42.67%)***	***(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%

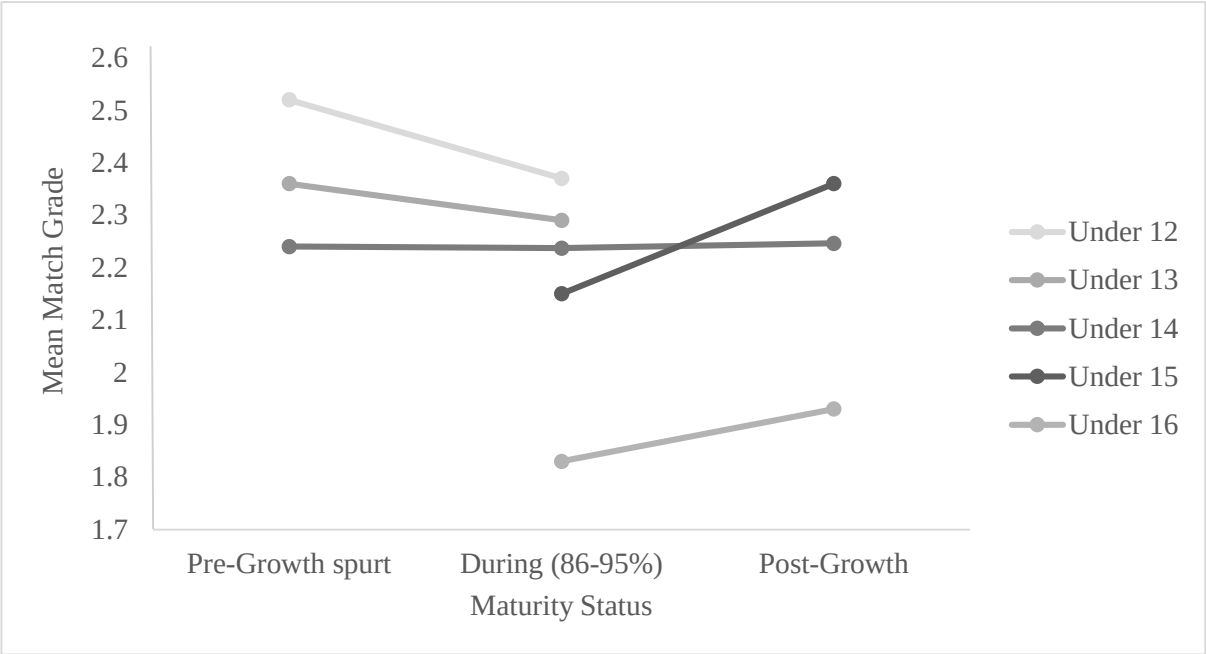
Click here to access/download;Table;Table 3.docx

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.

Figure 1

Click here to access/download;Figure;Figure 1.docx



Comments to the author (if any):
Reviewer #2: The authors present an interesting paper regarding coaches subjective decisions regarding playing performance and how those might be influenced by maturity in young male soccer players. The paper provides some novel insight but I also wonder whether there is the possibility to offer a little more insight from the data collected.

Introduction:
This is very informative and very well written. There is a bit of a tendency when introducing growth and maturity to switch between presenting information for boys and girls to just presenting information on a single sex, which is assumed to be boys but isn't always made clear. I think it would be better to consistently refer to either both sexes or just boys - and given the study focuses on boys, probably the latter.

Thank you for this comment- we have re-read the introduction and focused on just boys within the introduction.

Are there estimates regarding the prevalence of adolescent awkwardness? Hirtz and Starosta (2002, J Hum Kinetics) offer some data regarding awkwardness.

Good point- we have added this reference and a short statement regarding the prevalence of adolescent awkwardness in boys.

Methods and Results:
It seems like it would be relevant to include growth rate. Was growth rate in stature used in combination with %predicted adult height to verify when players were classed as being in a growth spurt? As a minimum it seems relevant to report the growth rate of each group.

Unfortunately, at the point in time of this study being conducted, the football club were only collecting height and weight data for the use of updated percentage of predicted adult height. Although we could go back and collate these measurements and measurement dates, with five years of data and multiple measurements per player it would be extremely difficult to collect and analyse. We have added this as a limitation in the discussion section.

In the stats analysis section it is not clear that the analysis is being conducted for each age group, rather it appears that all data will be combined (and it might be worth analysing the total sampling).

Thank you- we have amended the method section to make it clearer that ANCOVA's were conducted for each age group separately. In line with your comment we have also added an ANCOVA result looking at the total sample.

How are effect sizes being interpreted? They are reported in the table but are not referred to elsewhere in the paper.

We have added that the partial eta squared effects sizes were interpreted using Cohen's guidelines and references have been added. Effect sizes were very small in this study and potential reasons behind this are discussed in the limitations paragraph.

It would be interesting to know more about the frequency of the classifications. How frequently are players at each stage of maturity given a 1 score, 2/3 score or a 4 score. A chi squared test would identify if a circa group more frequently achieve the lowest rating.

This is an interesting point, thank you. We have added a Chi-Squared test to the method and analysis to show the frequency of distributions. A crosstabs table has also been added to the results section.

Can the growth rate be used to compare ratings of those with the highest levels of growth to those with lower levels of growth (perhaps based on z score groupings)?

Unfortunately, due to not having access to the growth rate data this cannot be done for the present study.

Discussion and conclusion:
It seems difficult to conclude that coach ratings were reduced for the circa-PHV group when this was only the case for two out of six comparisons. The conclusions could perhaps be better supported if the

effect size interpretation concurs, or if additional analyses also demonstrate lower ratings in periods of rapid growth.

Thank you, this is a good point. We have amended the manuscript to ensure the discussion interprets and explains effect sizes and added in further analyses.

Reviewer #3: Thank you for the opportunity to review this manuscript. The study examined coaches' evaluation of match performance in academy soccer players at different stages of maturity. Overall, the manuscript is well written, but I have outlined some minor issues below that need addressing prior to me considering a recommendation of acceptance for the journal.

* Abstract:
o Very well constructed

* Introduction:
o Excellent introduction. My only comment here is that the introduction is quite long. If the authors are able to remove any superfluous text to reduce the overall length, I think this would be a good thing.

Thank you. As per your recommendation we have cut down the length of the introduction where possible.

* Methods:
o Was some form of a priori sample size estimation conducted? What was the statistical power for the study?

A priori sample size estimation was not conducted due to the fairly large sample size collected.

o Biological maturity section: "…and the biological parents mean height" is missing an apostrophe after parents. There are other instances of this punctuation error, so the author(s) should proof read the paper and correct these.

Thank you- we have proofread the documented and hopefully have removed these punctuation errors.

o Space needed between "2.2" and "cm"

Thank you, this has been edited.

o Given the volume of information provided for the Khamis-Roche method, it might be beneficial to state how exactly parents' height was adjusted.

This is a good point. We have added more detail and references on how parental height was adjusted.

o Full stop missing before "Percentages lower than 86% and greater than 95% were recorded as pre- and post-growth spurt respectively.

We have added this punctuation.

o Given the serial repeat measures of height, the authors may wish to consider including growth rates in the analysis.

Unfortunately, at the point in time of this study being conducted, the football club were only collecting height and weight data for the use of updated percentage of predicted adult height. Although we could go back and collate these measurements and measurement dates, with five years of data and multiple measurements per player it would be extremely difficult to collect and analyse. We have added this as a limitation of the study.

o I do not think that "ethics" needs to be covered in a sub-heading, but rather this information can be presented at the end of the participants section.

Good point- we have moved the ethics section to the end of the participants section and removed the sub-heading.

o Which type of effect size was calculated…provide references where relevant also.

We have added that the partial eta squared effect sizes were interpreted using Cohens d and added relevant references.

o Were data checked for normal distribution, homogeneity of variance?

Data was checked for normal distribution and this is included at the start of the results section.

* Results:
o Please remove horizontal lines from figure 1

Thank you, horizontal gridlines have been removed.

o The axes on figure 1 do not seem to have been included

Thank you for noticing this, axes have been added.

* Discussion
o There seems to be an over-reliance in the discussion around statistical significance, without any real reference to the effect sizes. I think this is an omission which would help interpretation of the findings for the readership.

Thank you, this is a good point. We have amended the manuscript to ensure the discussion interprets and explains effect sizes and added in further analyses.

o Comprehensive limitations paragraph; well done.

Thank you

o In the final paragraph, reference is made to the fact that not all players will experience growth related decrements in performance. Could this be something that is supported with a reference? How prevalent is adolescent awkwardness in youth/young players?

This is a good point, and we have amended this last paragraph accordingly. We have added a reference to show 90% of boys face a period of awkwardness in the growth spurt.