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Maturity-Status ‘Bio-Banding as a Tool for Ongoing Talent (De) Selection of Academy Soccer Players Using a Multi-Disciplinary Approach

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ABSTRACT

This repeated measures design study aimed to provide a greater understanding of the physical, psychological, technical and tactical responses of youth soccer players to maturity status bio-banding within small sided games, as a potential tool for talent identification. Ninety-two youth soccer players aged 11 to 15-years-old (age: 13.6 ± 1.1 years, height: 163.0 ± 9.7cm, weight: 49.5 ± 9.1 kg, % of estimated adult stature attained (EASA): 89.6 ± 4.2 %, years from peak height velocity (YPHV): -0.3 ± 1.1 years) were recruited for the study from three professional soccer club's youth academies. The players were arranged into three maturity status groups; pre-PHV, circa-PHV and post-PHV. This arrangement was completed by the use of predictive maturation equations (Khamis & Roche, 1994; Fransen, et al., 2018). Cut off values for each of the methods were used to distinguish between the groupings (Khamis & Roche, 1994: pre <-1.0 YPHV, circa -1.0-0.0 YPHV and post >0.0 YPHV; Fransen et al., 2018: pre <87.0% EASA, circa 87.0-91.9% EASA and post ≥92.0% EASA). Using their predicted maturity status, players were assigned to one of six teams per testing club, comprised of players with the same maturity status, with the exception of the final testing week where random selection to teams was used. Teams competed against the other five squads once per testing night creating maturity matched and maturity unmatched fixtures during the first two testing weeks and mixed maturity fixtures during the final testing week. Players were monitored using micro-electromechanical systems with an integrated global positioning system, a heart rate monitor and subjectively by a technical and psychological scoring chart, completed by coaching staff. Through linear mixed modelling of the collected data, it was revealed how pre-PHV players experience significantly (Khamis and Roche (1994): $P \leq 0.001$; Fransen et al. (2018) $P < 0.05$) greater physical loading, as determined by the summation of accelerations across three planes of motion using the PlayerLoad™ calculation. They also perceive the small sided match play to be significantly (Khamis and Roche (1994): $P < 0.05$; Fransen et al. (2018): $P < 0.05$) harder, compared to the ‘circa’ and post-PHV maturity bandings, assessed by collection of rating of perceived exertion (RPE) values. ‘Between biological maturity banding’ small sided match play produced very little difference in psychological, technical and tactical values. However, when players competed within maturity ‘matched’ bio-banded games, they produced their best overall performances. Pre-PHV players covered significantly ($P < 0.05$) more distance, with seven of the ten technical variables being scored higher and players also perceived these matches to be less demanding. Post-PHV players perceived a greater challenge, as assessed by RPE, against matched maturity squads and in addition, recorded higher physical and technical marks, with six of their ten technical values scoring higher. PlayerLoad™ was also greater, conveying a greater physical demand, with a significant difference being present between ‘pre’ and ‘post’ squads ($P < 0.05$) (Khamis and Roche (1994); matched: 56.6 AU, post v circa: 54.2 AU, post v pre: 55.0 AU, Fransen et al. (2018); matched: 56.8 AU, post v circa: 55.3, post v pre: 53.3 AU). Tactical differences as assessed by maturity status and fixture setup i.e. maturity status bio-banding were not present within the results, however tactical differences were possibly constrained by pitch dimensions. These findings highlight the possible use of maturity status bio-banded small sided match play within youth soccer for (de)selection purposes by eliciting changes in the physical, technical and psychological responses of the players, facilitating the talent identification process.

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1. INTRODUCTION

Soccer clubs around the globe are continually striving for success, whether that be winning a trophy or simply staving off relegation, to a lower division, for another season. For these clubs to be successful, they must equip themselves with the highest quality pool of players they can attract. However, for many clubs, this means an expenditure far beyond their financial means. For these clubs just to remain competitive, vast transfer sums and the associated costs of employing an elite level player are involved (Williams & Reilly, 2000; Poli, Ravanel, & Besson, 2018). According to the CIES Football Observatory (Centre International d'Etude du Sport), the estimated transfer values for the top-rated players in world soccer was a staggering €200 million per player. The current world record stands at €222 million, paid in 2017 (CIES Football Observatory, 2017). This culminates in an increased risk of clubs being issued financial punishments and penalty points and in extreme cases, facing administration. In recent history, Italian club Parma, past winners of the UEFA Cup and the Coppa Italia, were declared bankrupt with debts amounting to over €170million. As a consequence, the club were forced to reform and begin life anew, in the fourth tier of Italian soccer (Teclab, 2018).

A 2017 Union of European Football Association (UEFA) conducted financial report, into the finances of the clubs involved in the top 20 European leagues, uncovered a combined net debt of €6.8 billion. To put this into greater perspective, the average debt for a team in the top professional league of English soccer, was a reported €66.2 million (UEFA, 2017). For some clubs, their dominance on the global stage and wealthy financiers operating behind the scenes, may act in staving off these debts for the immediate term and maintain the club's operation. However, this is not the scenario the majority of clubs find themselves in. Despite the inherent riches associated with professional competitions (such as the English Premier

League, Italian Serie A and German Bundesliga), many professional soccer clubs operate under tighter financial constraints, are not impervious to serious money woes and can eventually succumb to the pressure. Since the 1992 inception of the Premier League, over half of clubs involved in the English soccer league system have entered into administration and some clubs are repeat offenders (Culture, Media and Sport Committee, 2012). This is primarily due to the money available in the top division. TV revenue for the English Premier League (EPL) is estimated at over £3.5billion, whereas the English Championship attracts around twenty-five times less. Clubs relegated from the EPL are well compensated, however, if they do not achieve near immediate promotion back to the top division, they may have a shortfall of an estimated £100million (Deloitte, 2018).

Due to these obvious monetary issues in soccer, UEFA acted through the introduction of the Financial Fair Play (FFP) regulations in 2012 (UEFA, 2018). From the outlined objectives, it is evident the rules and regulations were implemented to promote the development of 'home-grown' players, that is a player who has been registered with a league club for at least 26 months before turning 21 years old, aiding to reduce the spending on transfers and also to restrict clubs spending to within their operational and financial means, thus reducing the likelihood of teams developing unsurmountable debts (Premier League, 2011). As an intended consequence, clubs are realising the importance of their youth setups, in producing fresh talent for the professional game, at both club and international level and whilst still investing money into this area, it is hoped by placing less reliance on transfers and more dependence on home grown players, it will create a more sustainable future for soccer.

Within these youth systems however, a global selection imbalance exists. Physical discrepancies between youth soccer players brought upon by differing maturational rates related to the individual, is one proposed method influencing the current selection imbalance within youth soccer academies and talent development programmes across the globe (Gil, et al., 2014; Carling, le Gall, Reilly, & Williams, 2009). The majority of the players selected to ‘professional soccer academy programmes’ possess an early birth date within the selection year and as such, there is a prevalence of early born players in club youth setups. The number of players born in the first half of the selection year in youth soccer academies has been recorded at 62.6% (Pena-Gonzalez, Fernandez-Fernandez, Moya-Ramon, & Cervello, 2018) in Spanish clubs and 73.2% (Lovell, et al., 2015) in English “lower league development programmes”. This manifestation and concomitant selection imbalance, is titled the ‘relative age effect’ (Lovell, et al., 2015; Baxter-Jones, Kolen-Thompson, & Malina, 2002). These youth soccer players normally possess a more developed physical profile. Recently, several studies have suggested that the date of birth of an individual is less important to determining success in the selection to talent development pathways, compared to the maturational status and biological developmental timing (Lovell, et al., 2015; Müller, Gehmaier, Gonaus, Raschner, & Müller, 2018; Hill, Scott, Malina, McGee, & Cumming, 2019) . It is this physical advantage attributed to being more biologically developed than peers that is likely to have led to the early success for these players in talent identification processes. However, this advantage is not permanent and as such, many players are deselected from elite development pathways at a later stage, when their slower developing peers have caught up physically and possibly technically and their once held dominance, because of their physical traits, has dissipated (Deaner, Lowen, & Cobley, 2013; Figueiredo, Coelho-e-Silva, Cumming, & Malina, 2019).

Recently, research articles and interventions have been proposed and conducted in an effort to address this imbalance and create a more level playing field for players who are later developing. At the forefront, is the concept of bio-banding, where players are assembled into their squads based upon their physical development stage, as opposed to their chronological age (Cumming, Lloyd, Oliver, Eisenmann, & Malina, Premier League academy soccer players' experiences of competing in a tournament bio-banded for biological maturation, 2017). It is hoped this method will allow less developed players a greater chance to express their skill levels which could be masked when competing against physically dominant and potentially more mature players, even if they shared the same birth year. Conversely, it is hoped to provide a greater challenge to the players who are reliant on their physical supremacy and as a consequence do not develop other areas of their game, such as technical and tactical proficiencies. This in turn may prolong the retention of players within academies and lead to the production of more players, capable of performing within the professional game.

This change of approach is imperative in the shifting face of modern soccer, with many clubs experiencing greater financial woes and placing a greater reliance on their own youth development systems.

2. LITERATURE REVIEW

2.1 PLAYER AND TALENT DEVELOPMENT

With the attempt of Europe’s soccer governing body to prise clubs away from big money spending and focus on developing their own talent, there have been changes to the talent development models in soccer, across the continent. These changes have been influenced by the continued research and progress made in youth athlete development models. These researched pathways have examined the long-term approach to developing talent in children and as such, the transferable application to youth soccer, has been used from national soccer federations, to domestic clubs, in an attempt to improve their youth academy output quality.

Talent development models have been the subject of much research for many years. In 1985, an attempt to understand the process that formed the development pathway of world-class individuals was made (Bloom, 1985). Bloom found the development of these athletes to be closely related, in that they made similar transitions through distinct learning phases. These ‘early-years’, ‘middle-years’ and ‘late-years’ presented unique areas of emphasis of development that resulted in the individual progressing within their skill or event. Advancing through the phases, specificity to the skill/event increased, progressing from basic skill and enjoyment, to competing and being challenged. It was also noted that each phase length was unique, demonstrating an early understanding of differing development rates. This concept of a development model has been extended in recent years to provide a structure and recommendations for youth athletes. One such development model by Balyi and Hamilton (2004) identified that training children in a uniform manner, similar to adults, is not the most beneficial method for development. Instead, by understanding the biological variance within the group and allowing for separate stages of development, children can learn basic skills progressing all the way to training to compete, as they mature, in a ‘late-specialisation model’. The model makes use of PHV (peak height velocity), a marker of maturation, as the determining factor for the design and implementation of an individual’s development programme. This allows key training stimuli to be applied at the relevant time, in relation to PHV. It also notes key periods called “windows of opportunity” where “accelerated adaption” can occur if training is appropriately managed (Balyi & Hamilton, 2004). However, this model has been criticised for lacking supportive evidence for its methodologies (Ford, et al., 2011). The review made several comments, such as highlighting strength development recommendations in the long term athletic development (LTAD) was supported by very little literature and deemed “speculative”. It made comment that improvements in strength training magnitudes were not significantly different dependent on maturity group and as such, a “window of opportunity” may not exist for this characteristic. Lloyd and Oliver (2012) have since reviewed and adapted the model to provide their youth physical development (YDP) models for males and females. Again, it uses PHV as the marker of training characteristic adaption. This adapted model makes use of the recommendations and points offered in the aforementioned review (Ford, et al., 2011). Within it, physical qualities to be developed are highlighted in relation to the growth rate and maturational development of the youth athlete. It also outlines the general structure of sessions to provide age and stage appropriate constructs. Several studies have tested these recommendations to evaluate their actual impact on development. Work by Moran et al., (2017) highlighted the relation of stage of maturation to the response of sprint training, with subjects who were classified as post-pubertal developing their ability in a more positive manner to these who were pre-pubertal. In addition, research has also demonstrated the more effective results of strength and plyometric training to groups of athletes who are post-pubertal as opposed to pre-pubertal (Lloyd R. S., Oliver, Hughes, & Williams, 2011; Asadi, Ramirez-Campillo, Arazi, & Saez de Villareal, 2018). From this work, it can be inferred that youth development features key stages of training and development related to the individual’s biological development.

As such, the models’ underpinning concepts have been pertinent in influencing the changing face of youth soccer (Deutscher Fussball-Bund, 2009; Premier League, 2011). One of the first major revamps of youth talent development witnessed in soccer, was in Germany. A disappointing showing on the European stage in 2000 was the catalyst for their major reform (Grossman & Lames, 2015; Deutsche Fussball-Bund, 2015). Over 360 regional talent development centres were set up for the best local talent to be trained on a more regular basis, by the best Deutscher Fussball-Bund (DFB) coaches. Every senior professional German club was required to develop their own youth setups. Furthermore, to ensure a high standard was maintained within these programmes, rolling evaluations were carried out (Deutsche Fussball-Bund, 2015). Youth development training levels were introduced, detailing that children from three to ten years old enter ‘basic training’ at school, kindergarten and club teams, teaching them social, motor and cognitive skills along with exposing them to a greater social platform. From this stage, they then progress to a ‘talent development’ level for ages ten to eighteen years old, entering centres of excellence, elite soccer schools and regional associations to further progress, under more quality tutorage. After this phase is ‘elite promotion’ and ‘top-level’ for the players most likely to become a professional, exposing this cohort to the senior game in the top clubs’ own setups (Deutscher Fussball-Bund; Grossman, Lames, & Stefani, From Talent to Professional Football – Youthism in German Football, 2015). Since its inception, the German programme has recorded several remarkable achievements on the world soccer stage. In 2009, German youth squads won the European Championships at U17, U19 and U21 age groups along with the senior men’s side winning the World Cup in 2014. This achievement was made more resounding with twenty-one of the twenty-three-man World Cup roster, graduating from a German youth academy and affirming success of the programme.

More recently, in England, there has been the introduction of the Elite Player Performance Plan (EPPP) in 2012, coinciding with the inception of the Financial Fair Play Regulations. The model set out to produce a better standard of player coming through professional youth academies, by improving the level of competition the players face, the standard of coaching available to these players and the quality of environment the players develop in (Premier League, 2011). The new setup involves the induction of players to the pathway at the foundation phase, from as young as four-year-old (Under 5's) up to U9's. From this stage, successful players progress to, or join, the 'youth development phase,' lasting until U16. The final stage is the 'professional development phase,' encompassing players from U17 up to U21 soccer, the final youth stage prior to senior professional soccer. The FA (Football Association) have cited literature concerning youth talent development in their 'long-term player development' model (e.g. Bloom, 1985). The cited literature stated that as children develop, there are key and distinctive stages within the development pathway. From six to thirteen years of age, children are within the 'sampling' stage of development, where they partake in several activities for enjoyment, but a 'gift' or particular 'talent' may be identified by a parent. Whilst 'giftedness' is a difficult construct to fully explain, it is understood to be the exceptional acquisition or ability of knowledge or skills (Davidson, 2009). The authors further stated that this can in turn lead to more directional development towards a particular sport. In soccer, any scout tasked with identifying youth talent for the club or coach, who also recognises this potential, may induct a young player into a development system. The next stage, the specialising years, from thirteen to fifteen years old is far shorter, yet imperative to talent development, where children will commit to fewer activities, but with increased engagement in those elected. The final stage, the ‘investment years,’ is where children become engrossed within one activity, striving for elite performance. This is marked with an increase in hours spent training and learning the skill to a higher level (Côté, 1999).

These development phases are very closely mirrored within the EPPP. The foundation phase, which closely reflects the sampling stage, is designed to let players with potential talent become involved in soccer, learning the game, but with short contact time at the clubs and coaching aimed at learning the basic skills. The youth development segment sees an increase in coaching time and coaching aimed towards teaching the player’s how to compete. This is associated with the specialising years. The final step is learning how to win and being supplied with elite level coaching (Premier League, 2011). Reflected by ‘the investment years’, the professional development phase is where young players should be close to becoming a fully-fledged professional soccer and in turn, are exposed to a similar, challenging environment. Their training pattern will closely follow that of a senior player. Together, this creates a seamless pathway for players to develop and progress towards senior soccer.

Another country, with a different financial soccer landscape to England, but with an equally strong ambition to develop home-grown talent, Scotland, have also recently made changes to the youth soccer scene. Following a national review into the state of Scottish soccer, commissioned by the national governing body for soccer, the Scottish Football Association (SFA), it was identified that for the country to become more competitive at club and international level, they would be required to improve their youth setups in the ambition of producing more self-developed talent, capable of performing on a world stage (McLeish, 2010). The 2010 ‘Performance Development Strategy’ was the beginning of the evolving face of Scottish youth soccer, culminating in performance schools for gifted young players, merging education with on-site school coaching, delivered by qualified SFA coaches, in addition to the categorisation of the club academies (Scottish Football Association , 2019). Club Academy Scotland classify the academies in Scotland based on “measurable performance outcomes”, such as players developed within the club who have achieved senior appearances or international honours, under the title of ‘Project Brave’ via an auditing process. The three tier levels have specific entry standards and requirements of the clubs to ensure the players at the top teams are experiencing the best coaching and development environment available to them. The highest ranked clubs, in the ‘elite’ banding are expected to provide their young players with full time physical, educational and psychological support, in addition to the highest level of technical coaching possible (Scottish Football Association , 2019). There has also been a reduction in the number of club’s receiving funding, meaning more money can be invested in a concentrated pool of teams, in an effort to create a smaller pool of elite talent, as opposed to a larger pool of lesser talented players. The overriding theme set forward by the SFA was to create a ‘best v best’ milieu for players (Scottish Football Association , 2018).

The ultimate aim of the alterations to youth development pathways is to create a clearer route for exceptionally talented young players, on their journey to senior soccer, resulting in a production of a higher quality player, equipped with the physical, technical, tactical and psychological skillset to be a professional soccer player. These changes in the youth development process show the commitment of the soccer bodies to benefit young players in their development. The clubs themselves will also benefit by producing their own assets that in the long run, could save them millions and also fuel potential success.

However, these programmes will only benefit the players within, and there is no guarantee of entry into these systems for budding young players. The decision on whether an adolescent soccer player is selected or deselected from an academy setup is still largely a decision based upon subjective assessment of players and the ability of club staff to identify potential talent. The advent of performance analysis, youth scouting departments, video analysis and the other sectors responsible for recruitment, conducted by adept performance coaches has indeed provided additional support to what the naked eye perceives and what the brain processes (Mackenzie & Cushion, 2013). This greater analysis can be used in the evaluation of "technical, tactical and behavioural activities of individuals" (Drust, 2010). Yet, the verdict is still drawn from the judgement of the coaching jury. Is this a fair trial or are the coaches charged with making these decisions guilty of a selection bias? With this question in mind, the primary aims of the study were to assess the use of technical, tactical, psychological and physical variables in maturity matches small sided games to support and inform the decision-making process of selecting or deselecting players for talent development programmes.

2.2 CURRENT ISSUES SURROUNDING TALENT IDENTIFICATION

As soccer is a multifactorial sport, early supremacy in certain skills or traits, such as technical actions or physical abilities do not always result in a talented senior player (Bennett, Vaeyens, & Fransen, 2018). There is no guarantee that a player will maintain a linear progression in terms of their skills and physical traits. Some players may be reliant on their physicality at a young age and as such, negate their technical and tactical development. To add to the difficultly of successful talent identification, it has been documented that a player's full talent and abilities may not fully manifest at such an early stage. Some talent markers may be present, facilitating with the identification of a gifted presence, however, the true ability of a player is still an unknown, due to the development that can take place in the intervening years (Güllich, 2014). It is possible to overlook some young players who have future potential that is currently not exhibited. It is accepted however, that the earlier a player can be admitted to a development programme, the more exposure and training time they will experience, thus potentially benefiting their overall development. However, this process however does introduce the risk of potential burnout and potentially elevates the risk of injury from overuse (DiFiori, et al., 2014; Read, Oliver, De Ste Croix, Myer, & Lloyd, 2016). Exposure to consistent loading of intensive actions, especially at a young age have been found to contribute towards this increased injury incidence in youths (Hogan & Gross, 2003).

Indicators such as technical ability, psychological and physical qualities are used in the talent selection process in the hope that they will lead to a fully developed, gifted athlete (Howe, Davidson, & Sloboda, 1998; Williams & Reilly, 2000; Reilly, Williams, Nevill, & Franks, 2000). Yet, talent identification in youths still features a large element of guess work. Which player has true talent that will remain throughout their development, allowing successful promotion from the academy ranks is relatively unknown. In Germany, elite youth academy teams have an average turnover in players from U10 to U19 squads of 24.5% (Güllich, 2014). There are few instances of players successfully navigating their full youth career within the same academy setup and even less found a pathway to professional soccer. Güllich (2014) commented that most players recruited at a young age were replaced quickly by players from out with the academy, whose development had been greater. For a player to be successful, they are more likely to have emanated from a ‘collectivistic approach,’ via a selection and de-selection cycle as opposed to an ‘individualistic’ pathway, through a long-term development route within one club, the model that the English and Scottish FA’s, amongst others, have based their youth talent programmes around. From this, a reasonable question would be why the talent development systems are failing so many young players? Many players are deemed unsuitable at one club, but their career can flourish at another club. Have they lost their talent within the academy, or was their giftedness overestimated prior to their selection or, are mistakes simply being made when it comes to the decision of selection and de-selection?

One common issue that could potentially be attributed to the identification, development and success rates in youth sport, involves how the participants are organised into their appropriate age-groupings (Cobley, Baker, Wattie, & McKenna, 2009). Many players who will be selected to an academy are from the first half of the selection year, meaning they will have a greater chronological age compared to those from the second half of the selection year. This finding was evident in a paper by Hill et al. (2019). Players born in just the first quarter of the selection year accounted for 54.8 % in one English youth academy. This bias of early born players being selected, the relative age effect, also coincided with more biologically developed youth players. Of the U15 and U16 players monitored, none were classified as being 'late-developing' in their biological maturation process. This means slower or less developed players and to some extent, those born later into the selection year, are possibly being overlooked and their potential abilities never fully developed within a talent development program.

2.3 THE RELATIVE AGE EFFECT IN SPORT

European soccer academies are structured in the same format as schooling, where children are apportioned into year groups, based on their birth year. This means within a given year band, there is potential for a twelve-month gap between the youngest and oldest individuals (Musch & Grondin, 2001; Helsen W. F., et al., 2012). It is here that some of the major issues still engrained within youth soccer are found. Many studies have confirmed that a selection bias exists within soccer towards players born earlier into the selection year, with one concluding a bias in five European leagues of 30.3% of players from the first quarter of the selection year compared to just 19.9% in the last quarter (Salinero, Perez, Burillo, & Lesma, 2013). This phenomenon of the ‘relative age effect’ is a very well-versed matter across the globe and in different sports (González-Víllora, Pastor-Vicedo, & Cordente, 2015; Barnsley, Thompson, & Legault, 1992). These early-born players are over-represented within youth academies and talent development programmes, normally expressing increased height and weight compared to their younger counterparts (Hirose & Hirano, 2012; Carling, le Gall, Reilly, & Williams, 2009). A prominent display of this bias was identified, where 75% of players signed by an English Premier League club’s youth academy were born in the first half of the selection year (Lovell, et al., 2015). Broken down into the EPPP’s development phases, players born in just the first quarter of the selection year accounted for an average of 46.8% in the foundation phase from U9 to U11, 47.7% in the development phase and 43.3% in the professional phase. Within the youngest age brackets (U9 and U10), players selected from the first quarter of the selection year did not possess substantially greater physical qualities for their chronological age, compared to the national average. However, those few selected to the talent development setups from the final quarter of the selection year were found to have more advanced anthropometric traits, in comparison to the national average. This suggests that reaching biological development quicker than others, being more biologically mature, is almost imperative for late born players to be selected to talent development programmes. This trend is seen throughout the older age groups of the academies, where there is little difference between maturation of early and late born players. The early born players however do appear to possess slight physical advantages as the age groups advance, until the U16 stage, when all players are most likely fully biologically developed.

The chronological banding system currently in use is simple to implement, yet does not account for the differences experienced between the youngest and oldest subjects within the grouping, including a likely greater exposure to training and experiences for the older players (Musch & Grondin, 2001). Away from soccer, several research articles have shown this disposition within younger children on their poorer cognitive development in a schooling setting (Morrison, Smith, & Dow-Ehrensberger, 1995) and their increased vulnerability to psychiatric disorders (Goodman , Gledhill, & Ford, 2003). These younger children also have a lesser chance of being selected to a talent development programme, with players born in the first three months post cut-off being around five times more likely to be participating, compared to those born in the final three months (Carling, le Gall, Reilly, & Williams, 2009). The reasoning for the relative age effects existence has been the source of many research publications, resulting in several very rational inferences. Relative age is not confined to one country, moreover it appears independent of social, cultural and climatic factors. The relative age effect has been found to exist in countries across Europe, Asia, South America and Australia (Musch & Hay, 1999; Massa, et al., 2014).

For a fully developed adult, a one-year difference in age may yield little physical or developmental disparity (Tanner J. M., Growth and Maturation during Adolescence, 1981). However, at a young age, the variances are discernible and can be an influencing factor in talent selection. It has been publicised (Helsen, Van Winckel, & Williams, The relative age effect in youth soccer across Europe, 2005) that one 10-year-old can be 0.2m smaller and around half the weight of a child within the same age banding, representing a physical disadvantage, irrespective of soccer talent. The stature difference could be present at this age due to the earlier born child having more time to progress through their growth development. As they are older, they may also be at a stage closer to puberty, where their rate of growth will accelerate, thus increasing this stature gap to their younger peers (Helsen, Van Winckel, & Williams, 2005; Tanner & Whitehouse, 1976; Baxter-Jones, Kolen-Thompson, & Malina, 2002). Attempts have been made to detail the timing of these changes in athletic ability, that are driven by biological development, in relation to the development of youth soccer players (Towlson, Cobley, Parkin, & Lovell, 2018). Annual stature growth rates from -3.2 years from peak height velocity (YPHV), a marker of maturation, to +0.8 YPHV, were 8.6cm·year^{-1}. Around eight months after peak height velocity (PHV), the growth rate had slowed to an estimated 1.8-3.8cm·year^{-1}. Mass increase followed a similar pattern with an increased tempo breakpoint, leading to an average gain of 7.1kg·year^{-1}, identified at -1.6 YPHV, continuing until +4.0 YPHV. Players who are biologically quicker in developing therefore will undergo these developmental changes before slower developing peers, thus having a physical advantage earlier. Physical capacity traits are also influenced by development and an earlier entry to this stage of development will allow for these abilities to be used in potentially outcompeting opponents. Sprint speed is one such trait that increases in improvement tempo by 31% to 41% from -1.8 YPHV until +1.2-1.3 YPHV.

These physical differences may be one of the reasons for the inefficiency of the talent selection and subsequent development programmes in youth soccer, with recruitment favouring the bigger players. However, when soccer coaches were prompted to rank their desirable traits of young players, technical traits such as first touch and ability under pressure prevailed as imperative for an U13's performance. Physiological and anthropometrical traits were regarded as almost extraneous to a youth soccer player's arsenal (Larkin & O'Connor, 2017). The study found coaches to rank 'decision-making' and 'positive attitude' as most important, along with technical traits such as first touch and striking the ball. 'Moderately' important attributes included 'confidence', 'competitiveness' and 'x-factor'. A study by Towlson et al., (2019) concluded most staff members within youth setups ranked psychological skills significantly ($P < 0.01$) higher than technical/tactical and physical assets. They did however note a positional influence on physical and technical/tactical values with goalkeepers with greater stature having a small to large advantage when being identified. However, these studies somewhat contradict the findings at youth academies where successful players were more likely to be physically bigger than unsuccessful players (Coelho E Silva, et al., 2010). A suggestion therefore is that there is a subconscious bias that exists within youth soccer, towards the more physically developed, early born players.

As many of the earliest born players within a youth age category exhibit physical dominance over the later born players, these players are likely to be labelled as 'gifted' or 'talented' as their physical supremacy allows them to outcompete others (Gil, et al., 2014; Carling, le Gall, Reilly, & Williams, 2009). Whilst this may permit early achievements for a team, it is the player's physical advantage that is a 'talent' as opposed to their soccer proficiency (Carling, le Gall, Reilly, & Williams, 2009; Unnithan, Drust, White, Iga, & Georgiou, 2012; Helsen W. F., et al., 2012). This becomes an issue for talent development programmes when these players reach older age groups (e.g. U17) and post-PHV, when the difference between player's physical composition become less pronounced, as all players will be nearing developmental completion (Mujika, et al., 2009). As such, this early identified 'talent' may become less pronounced and if the players have been reliant on their stature for successful performance, they may ultimately be de-selected from an academy setup. These desirable characteristics are not a fixed component within the player's development and may not continue with them until adulthood, rendering the player less valuable (Vaeyens R. , Lenoir, Williams, & Philippaerts, 2008). Deprez et al. (2015) conducted a study in examining the permanence of anthropometric and soccer specific endurance in pubertal players. They determined through a fitness monitoring assessment that poorer performing players may somewhat close the gap with players of a greater aerobic capacity. In conclusion, "individual development and improvements should be considered".

As such, any player who has been slower in attaining full development, may potentially upskill their abilities to compensate for their inferior physicality. These players may then be classified as 'talented' in the sport, at a later date. This future classification of ‘talent’ however, necessitates that these players haven’t already been removed from a talent development programme due to their true talent being masked by others at an early stage (Mujika, et al., 2009; Unnithan, Drust, White, Iga, & Georgiou, 2012). It is this process of deselecting players from an academy prior to them displaying full potential that is potentially reducing the efficiency and efficacy of academy talent development structures. This concept was highlighted by Cobley et al (2009) in their meta-analysis that states the relative age effect is most likely to be present in soccer due to developmental differences related maturation and the players. The oldest players are more likely to present mature characteristics, such as increased stature, earlier than younger peers simply through being older (Wattie, Cobley, & Baker, 2008). However, this is definitely not the case across the board. Returning to Lovell’s (2015) paper examining the relative age effect in English league soccer highlighted that there seemed to be no clear physical performance advantage to being in the first quartile. It appeared that clubs were selecting players based upon their maturational development, independent on their birthdate. Those late born players were most likely very close to the maturational status of those early born players, thus negating any chronologically linked performance difference. This idea was also noted within a study by Cumming et al. (2018). They commented that the oldest child within a group could, “through the virtue of genetics”, possess the least biologically developed profile. In support of this comment, there appears to be more accompanying literature indicating an ineffectual relationship between relative age effect and maturation within youth athletes (Cumming, et al., 2018).

Like the physical dominance in young players, the relative age effect appears to dwindle slightly in the senior game, but still exists. This drop could be through the maturational differences becoming obsolete as all players complete maturity (Hancock, Ste-Marie, & Young, 2008; Lefevre, Beunen, Steens, Claessens, & Renson, 1990). A similar trend is observable in an educational setting where age-related differences at school entry level dissipate with time. It is hypothesized that this could be due to increased work performance by younger pupils to avoid being left behind and/or the assistance from specialist support staff to aid these pupils (Langer, Kalk, & Searls, 1984; Hauck & Finch Jr, 1993). This idea of providing a specialist approach to slower or late developing players was not only identified in a soccer setting by the Belgian Football Association, but acted upon, in 2008. The introduction of a parallel national squad, termed future squads, at youth age groupings, allowed for players who were physically less developed, to be given a chance to continue of a professional development pathway (Bate, 2018; Deconche & Maurer, 2016). From this programme, three players were selected for Belgium's 2018 World Cup squad. This change was introduced as part of a larger scale redevelopment to Belgium's soccer scene that has contributed to their international ranking rise from 66th in 2009 to as high as number one in 2015 (The Statistics Portal, 2019).

The rate at which a youth player develops is therefore a factor that must be considered in the talent development programme decision making process for selecting and de-selecting players. This leads into a further examination of maturational development, a possible influence on the relative age effect and a possible source of the problems encountered within talent selection. As such, efforts must be made to aid the development of both early and late maturing players to upskill both groups and provide them with the greatest chance of success. It is therefore importing to understand the impact biological maturation can have on soccer and how to assess it in a youth soccer environment.

2.4 BIOLOGICAL MATURATION

Maturation is the biological process of becoming mature, which in itself is composed of several substantial changes in biological systems (Meylan, Cronin, Oliver, & Hughes, 2010).

It involves a period of growth and development of the human body, advancing towards a mature and more developed state. Maturational development incorporates skeletal, sexual and somatic changes (Malina, Bouchard, & Bar-Or, 2004). Within maturational development occurs puberty, a period incorporating the adolescent growth spurt. It is within this segment of growth, where PHV, the most rapid and immense, with the exception of the foetal period, occurs in a person's life. It is here, during this quantifiable and significant phase, where children begin their transition into a sexually mature state (Chipkevitich, 2001).

2.4.1 MATURATION IN SOCCER

In soccer, the selection of a youth player into an elite talent development programme can be dependent on their maturational status. At young ages, several years prior to puberty, the RAE can lead to a biased selection of earlier born players (Lovell, et al., 2015; Hill, Scott, Malina, McGee, & Cumming, 2019) however, the primary selection bias influence appears to transition to maturational differences around early adolescence. The relative age effect still manifests through youth academies, even at older age groups, however, it has been recognised that chronologically younger players can have just as great a chance of selection to elite talent development programmes in comparison to older players, if, importantly, those younger individuals are more advanced in their maturational development (Müller, Gehmaier, Gonaus, Raschner, & Müller, 2018; Lovell, et al., 2015). This means the age of player seems to have less bearing on selection or deselection, rather, their maturational stage of development in relation to others within their selection year. One paper published in 2004 documented the maturation stage of elite youth players aged between 13 and 15 within an academy setup. It was concluded that over 50% of the players were in the final two of five stages of maturation (Malina, Eisenmann, Cumming, Ribeiro, & Aroso, 2004).

Therefore, an advantage to early maturing or biologically developed players seems evident within youth soccer. In turn, this could be an indication that maturation will impact on selection and talent identification within a youth setting. As commented in a 2010 paper, the selection decision of a coach in a talent pathway programme is based upon a "multifaceted intuitive knowledge comprised of socially constructed "images" of the perfect player" (Meylan, Cronin, Oliver, & Hughes, 2010). These more mature players expressing desirable traits of speed, power and strength therefore may be construed as talented or gifted in the coach's eye, if no consideration and comparison is made with respect to maturational differences within the talent development pool, from where the decision-making process is occurring.

To revise the statement proposed whilst examining the relative age effect, a subconscious bias exists towards players that are more advanced in maturity and may also be born earlier into the selection year band. As stated however, this effect appears to dissipate in later years, meaning there could be a large pool of talent that is lost from the game, due to deselection and possibly dropping out of soccer at a younger age, due to simply being less biologically developed at the point of decision making in academies (Meylan, Cronin, Oliver, & Hughes, 2010).

2.4.2 MATURATION AND PHYSICAL CHARACTERISTICS

The stage of maturational development a player is at can have an impact on their ability to perform within soccer. As a player progresses through the maturational process, they grow in stature and during their adolescent growth spurt, a male's height increases on average, 10 cm.year^{-1} (Tanner J. M., Growth and Maturation during Adolescence, 1981). This growth rate can have a detrimental, but short lived impact. The growth creates an adolescent awkwardness phase impacting upon movement and motor control (Butterfield, 2015; Philippaerts R. M., et al., 2006; Ryan, et al., 2018). During this phase there is a short decline in performance however this typically recovers and then continues along to a peak development. The reasoning behind this phase is unclear, however, efforts have been made to explain possible mechanisms. It has been suggested that as a child matures rapidly around their APHV, sensorimotor pathways do not develop at the same rate and as such, are still in an immature form when the individual displays mature qualities such as increased stature, mass and secondary characteristics (Quatman-Yates, Quatman, Meszaros, Paterno, & Hewett, 2012). This 'maturational lag' has been discussed by Viel et al., (2009), showing adolescents to utilise different stabilisation and postural control mechanisms, compared to young adults, resulting in less efficient corrective movements. The conclusion from the research pointed towards a period of development where individuals reduce their use of proprioceptive sensory information. Another possible concept suggested includes a decline or stagnation in the sensorimotor complexes due to the quick physical development changes. This period of immense growth also brings a heightened injury risk for the young players. Youth soccer players were found to be 31% above the mean injury incidence value, six months after PHV (Bult, Barendrecht, & Tak, 2018). This increased risk of injury has also been found in a later study where it was shown that players circa PHV had a 115% increased injury incidence (Johnson, et al., 2019). Suggestions made in the research highlight the need for preventative measures and further research on the associated risk factors.

Peak height velocity is difficult to predict due to the dynamic nature between individuals, including the timing, tempo and duration of this period (Philippaerts R. M., et al., 2006). The 'average' age at which PHV occurs within young male soccer players has been calculated to be around 13.8-14.2 years (Malina, Bouchard, & Bar-Or, Growth, Maturation and Physical Activity, 2004; Philippaerts R. M., et al., 2006). As Figure 1 highlights, the greatest physical stature developments occur around the period of PHV. From this growth curve, it can also be understood how players who reach biological maturation quicker, begin this developmental period quicker, in respect to chronological age, compared to similarly aged peers.

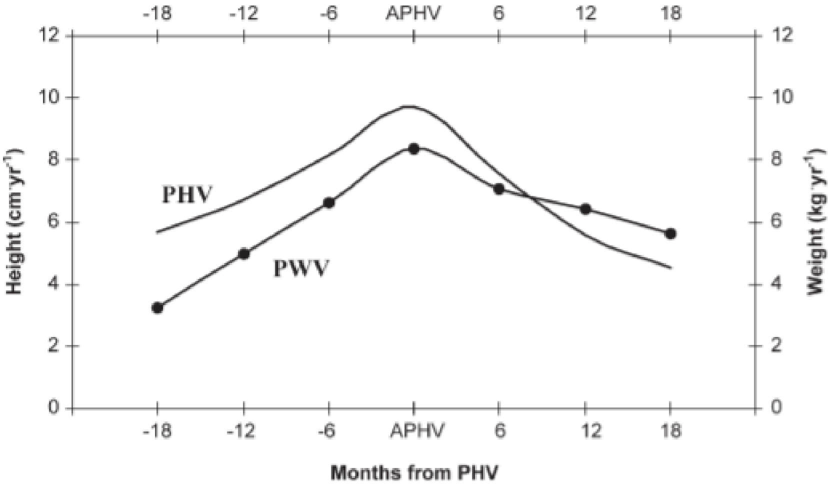


Figure 1: Philippaerts et al (2006) height and weight development velocity curve in relation to PHV for male youth soccer players

Due to the differing in PHV timing and tempo of individuals, there will be a period of time, some adolescents will possess a possibly significant maturational related physical advantage over slower developing or pre-mature players; at least until all players have completed their maturational development. (Tanner & Davies, 1985; Philippaerts R. M., et al., 2006) It has also been documented that the players who enter their adolescent growth spurt at an earlier age, will most likely end their maturational development taller, heavier, faster and stronger than those who are later maturing (Malina, Bouchard, & Bar-Or, Growth, Maturation and Physical Activity, 2004). A 2004 study has highlighted this physical benefit to early maturation, as assessed by stage of pubic hair development, with players at an advanced stage in development being on average, faster over 30m, more powerful, as measured with a counter movement jump and also possessing a greater aerobic capacity (Malina, Eisenmann, Cumming, Ribeiro, & Aroso, 2004). Players classified as stage one, the least biologically developed, recorded an average vertical jump height of 24.9cm and a distance of 1473m in the yo-yo intermittent endurance test (level one). Meanwhile, stage five players, the most biologically developed, scored a mean vertical jump height of 31.9cm ($P < 0.01$) and an aerobic capacity test distance of 2655m ($P < 0.01$), indicating clear physical advantages. Higher levels of fitness can also have a positive influence on match technical actions due to the delay or reduced impact fatigue has upon an individual (Rampinini, et al., 2008).

These physical attributes appear to develop in a linear fashion with age until a breakpoint, +0.6 to + 2.1 YPHV, where tempo of development slows, suggesting players more advanced in maturation should reach their peak values quicker. (Towlson, Cobley, Parkin, & Lovell, 2018).

The ability for a player to rapidly change direction, through deceleration and subsequent rapid acceleration is paramount in team sports (Gabbett, Kelly, & Sheppard, 2008). Previous work has highlighted the importance in soccer, suggesting the ability to change direction quickly could assist with evading an opponent to scoring a goal (Young, Dawson, & Henry, 2015; Trecroci, Milanovic, Frontini, Marcello Iaia, & Alberti, 2018) It has been noted that the ability for one to effectively and quickly decelerate and accelerate is influenced by the physical qualities of that person, including strength, sprint and lower limb power, allowing for the absorption of force and subsequent rapid generation of force (Sheppard & Young, 2006; Asadi, Arazi, Ramirez-Campillo, Moran, & Izquierdo, 2017). Literature suggests that these physical qualities appear to favour more biologically mature individuals (Malina, Eisenmann, Cumming, Ribeiro, & Aroso, 2004) and those competing at a higher level or who are retained within a talent development pathway (Reilly, Williams, Nevill, & Franks, 2000; Vaeyens, et al., 2006; Deprez, Fransen, Lenoir, Philippaerts, & Vaeyens, 2015). It also appears that more biologically mature players will respond with greater development gains through plyometric training in an attempt to improve the physical qualities that influence acceleration and deceleration (Asadi, Arazi, Ramirez-Campillo, Moran, & Izquierdo, 2017). However, work on the impact of maturity status upon in match play acceleration and deceleration quantity and velocity is lacking meaning this area remains relatively unknown within soccer matches.

In 2014, a study into maximal sprinting speed and the relationship to stage of maturational development concluded that as well as being significantly taller and heavier, more mature players and in particular those who had passed their predicted period of PHV, were significantly ($P < 0.05$) faster than those who were at an earlier stage of their maturational development (Meyers R. W., Oliver, Hughes, Cronin, & Lloyd, 2014). Players classified as most developed were measured around 1 $m.sec^{-1}$ quicker than those less biologically developed. Such developed characteristics, such as speed, have been associated with players at the elite professional soccer level. Sprinting speed between professional players, players at a lower level and the general population were compared and it was concluded that the professional players had significantly ($P < 0.05$) quicker times and thus, good acceleration and sprint speed was an “advantageous” trait to be successful in top level soccer (Kollath & Quade). The differences between elite, sub elite and amateur groups of soccer players indicated that over 10m, elite players were significantly ($P < 0.05$) faster than the other factions (Cometti, Maffiuletti, Pousson, Chatard, & Maffulli, 2001). These beneficial traits of can be associated to the increase in hormones such as testosterone and growth hormone, that accompany the adolescent growth spurt (Malina, Bouchard, & Bar-Or, Growth, Maturation and Physical Activity, 2004).

The information is of paramount importance when considering the selection process. One study has demonstrated that players selected to continue at a club, sprinted faster ($P <$

0.05) and also performed better on soccer-specific aerobic endurance testing, in comparison to players deselected from the club (Deprez, Fransen, Lenoir, Philippaerts, & Vaeyens, 2015).

However, this selection of advanced physical characteristics may not always lead to a high quality player from talent development programmes. A 2019 study examined the long-term effect differences in maturity tempo and possibly related physical and technical characteristics had on the career success of under-13 and under-15 players in the Portuguese youth soccer leagues (Figueiredo, Coelho-E-Silva, Sarmento, Moya, & Malina, 2019). Due to the follow up study taking place 10 years after the initial data collection, respondent numbers were lower than baseline measures. As such, the results have considerably more players no longer involved in soccer compared to those who are, which may impact on the significance of the results, however the authors have still completed a strong analysis examining many different factors. From the original U13 age group, the players who have continued playing soccer at a regional or national level were younger and less mature, as assessed by skeletal ageing, albeit not significantly, compared to their youth teammates. Of the U15s still involved in soccer post youth level, most were marginally older, however this was not reflected in skeletal age, although again the difference was trivial. It appears that maturity differences do not manifest and dictate success in later years, as previously mentioned. The main difference between players who have progressed their soccer career, appear to be soccer related skills such as ball control and passing, assessed by their coaches, along with physical proficiency, in particular endurance levels. This may be due to the upskilling of late or less biologically developed players, in comparison to the most developed, who rely on their physicality. The results of this study appear to conform to the results indicated in a 2014 longitudinal follow up investigation. It was documented in an elite Serbian youth soccer division that at 14 years old, 43% of participants were classified as early maturing players, with only 20.8% being late maturing. However, at age 22, of those who had progressed to a career in the elite echelons of soccer, over 60% were classified as late maturing (Ostojic, et al., 2014). This may appear promising to the progress of late maturing players, but it does not document the probable loss of many talented late maturing players prior to this stage, due to deselection at a younger age.

2.4.3 MATURATION AND TECHNICAL AND TACTICAL PROFILES

A developed maturity status does not have clear influence on the technical performance of youth soccer players. A 2017 study identified in a group of 40 young soccer players that maturational development, positively impacted SSG technical perfomances (Moreira, et al., 2017). Players who were classified as having "advanced" biological development had a technical advantage in the SSG. Players with greater biological development had a significantly greater involment with the ball, when maturity status was accounted for. It was suggested that elevated testosterone levels may have been the determing factor, however, these results were presented as a case study with a relatively small sample pool and as such, further research would be required. Many early studies examing technical ability and maturity examined these skills in a 'closed' environment, not representative of the dynamic nature of a soccer match. This positive effect continued by showing there was some contribution of maturity status, to skill ability, albeit statistically insignificant (Unnithan V. , White, Georgiou, Iga, & Drust, Talent Identification in Youth Soccer, 2012). However, other studies have played down this impact, indicating in soccer players aged 13-15, dribbling with a pass skill level had a 21% attribution rate to age and stage of maturity with shooting having only an 8% contribution rate from stage of maturity and height (Malina, et al., 2005). The conclusion of this study stated that for all there may be some biological developmental influence on soccer skill performance, it was likely to make very little difference to the variation seen in performances at youth level. This was reinforced by a later study which found youth soccer players who differ in biological maturation rates and development stage do not vary in functional and skill abilities (Figueiredo, Goncalves, Coelho-e-Silva, & Malina, 2009).

One conclusive finding regarding technical skills and abilities is that they have been shown to correlate with selection and deselection outcomes (Huijgen, Elferink-Gemser, Lemmink, & Visscher, 2012). Players selected for a talent development pathway were shown to complete dribble slaloms quicker, (20.5 sec) compared to deselected players (21.0 sec). Players selected for the talent pathway were also significantly ($P < 0.05$) faster for peak slalom dribble and shuttle dribble. Technical characteristics including positioning and decision and knowledge of ball actions were also higher for selected players.

The tactical profile of players may also be assessed through novel analysis of match play (Folgado, Lemmink, Frencken, & Sampaio, 2012). Findings have highlighted that the age of players influenced the variability of player distribution, decreasing with age. Measured as a ratio of the length to width distribution of the team members on the field, older players had a smaller length to width ratio compared to younger squads, who played exploiting the length of the pitch as opposed to a more possessive width approach (U9 lpwratio = 2.287 au and 2.013 au; U11 lpwratio = 1.130 au and 1.077 au; U13 lpwratio = 0.883 au and 0.541 au).

Further tactical analysis of youth soccer players found younger player cover less distance per minute and as such, appear to setup in a longer playing shape to facilitate the ball moving forward (Silva, et al., 2014). The authors did comment on whether this was a maturity derived physical influence on tactical setup was not conclusive.

These findings highlight the differences in tactical setup based on age and stage. This demonstration of potential developmental differences in tactical strategies within youth soccer has not been extensively researched and further work is required to provide key talent indicators within tactical performance.

2.4.4 MATURATION AND PSYCHOLOGY

Biological maturation and psychology in combination with its impact on soccer performance is one area of research that is lacking. Studies have attempted to quantify and score the importance of psychological traits on talent identification (Williams & Reilly, 2000), however little literature exists on its development along with maturation. One theory that has arisen is that of the “underdog hypothesis”. Early studies found that in the Canadian National Hockey League, the elite players had an inverse relation with the relative age effect and careers of players born later, tended to longer than those with an early birth date in relation to the selection year (Gibbs, Jarvis, & Dufur, 2011). The theory is related to the greater challenges faced by late or less biologically developed players, necessitating that for their selection to or avoidance of deselection from a talent development programme, they must have a greater psychological and technical profile (Cumming, et al., 2018). One psychological trait examined is self-regulation, which involves the psychological aspects of the learning process (Panadero, 2017). One study highlighted elite youth players as having a high self-regulation levels through a questionnaire, compared to a non-elite group (Toering, Elfernink-Gemser, Jordet, & Visscher, 2009). Players scoring high for effort, defined as “I work as hard as possible on all tasks”, were over seven times more likely to be at the elite level ($P \leq 0.01$). There appeared to be a greater awareness of ability in the elite group, in addition to effort. In turn, this may allow a greater and more efficient learning process. Research into self-regulation and maturation found that later maturing players were more likely to participate in self-regulated learning (Cumming, et al., 2018). This may be one of the reasons why relative age effect and maturation bias dissipates towards older age groups and ultimately senior levels, as later maturing players complete a more efficient learning process. However, the authors did note that this hypothesis would only manifest should players be retained within talent development programmes.

2.4.5 METHODS OF MEASURING MATURATIONAL DEVELOPMENT

To account for these maturational differences within youth soccer, it is important to determine, as accurately as possible, the stage of maturational development a young player is at. Three primary methods of biological maturity determination have been produced to best establish this. Due to the dynamic nature and variability between individuals, an accurate assessment of maturation is difficult to ascertain, however work is constantly being undertaken to update and improve the methods. Also, as maturation is not a simple singular event, rather a prolonged process, a solitary measurement does not present a fully reliable result, whereas continual monitoring would be more appropriate (Malina, Bouchard, & Bar-Or, 2004).

2.4.6 SKELETAL ASSESSMENT OF MATURITY

Skeletal maturity is one method in the determination of maturational development. It involves the process of bone analysis. The method involves an x-ray or radiograph of the left hand and wrist of the child, due to the ease of imaging this area and the “predictable” nature of ossification (Creo & Schwenk, 2017). As the markers of skeletal maturation occur in a sequential event, a reasonable indication of the stage of maturation can be pertained (Korde, Daigavane, & Shrivastav, 2017). From the captured image, a visual inspection of the bone can be conducted. This technique then exploits the known transition of the skeleton from cartilage to bone, from conception through to adulthood. This measurable development of the skeleton evolves in the same timeframe as a person grows. It also allows for common markers that are definitive and regular, known as ‘maturity markers’, to determine the maturity status from the calculated skeletal age (Malina, Bouchard, & Bar-Or, 2004). The markers being examined are the degree of ossification, the process of the bone remodelling and appearance change, towards the adult form. Full skeletal maturity is attained when there is complete epiphyseal fusion (Dembetembe & Morris, 2012). There are three methods of visual assessment to determine the stage of maturity a person has reached.

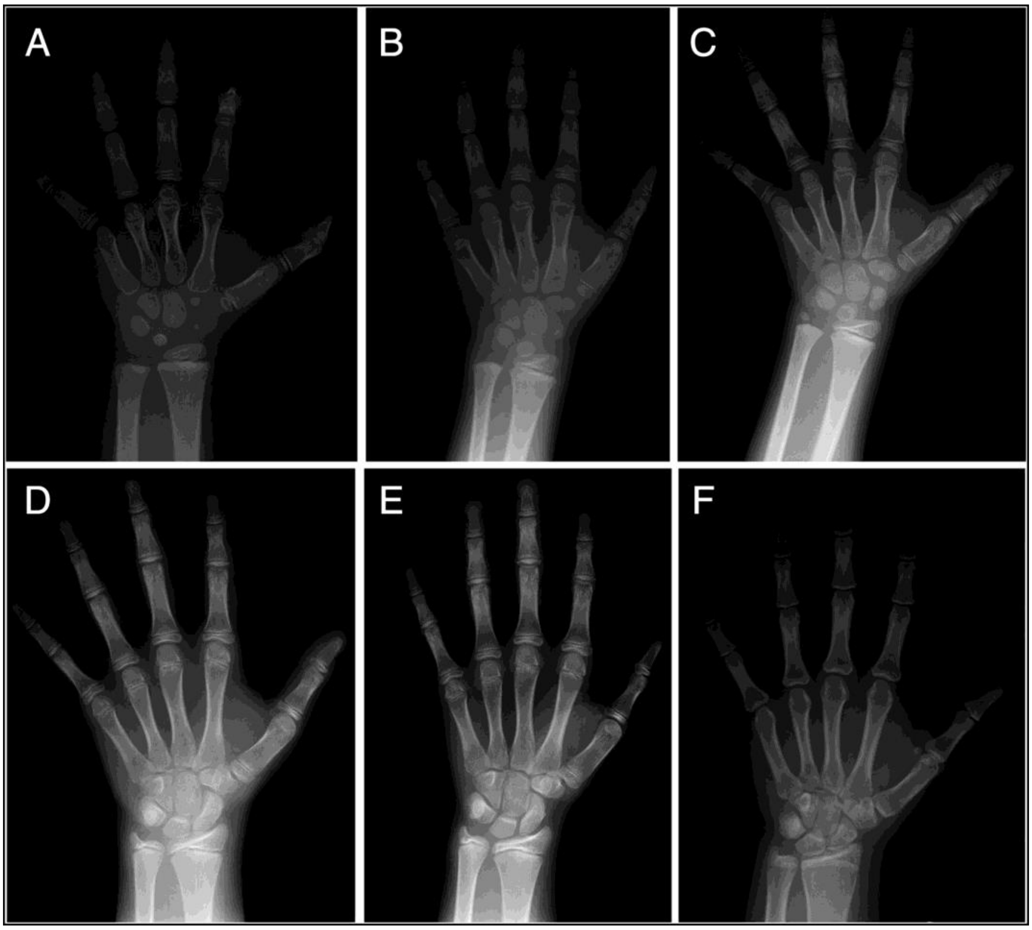


Figure 2: (Creo & Schwenk, 2017) An example of skeletal maturation during childhood at various ages. A, 5 years of age. B, 7 years of age. C, 9 years of age. D, 11 years of age. E, 13 years of age. F, 15 years of age. [Online] Accessed 26th October 2019. Available from: https://pediatrics.aappublications.org/content/140/6/e20171486

The first method is commonly used around the world in determining the skeletal age of a person, due to its simple assessment (Tsehay, Afework, & Mesifin, 2017). The Greulich-Pyle Method originates from a study in 1959, using data from longitudinal analysis conducted in the late 1930's by Professor Wingate Todd, on upper class Caucasian North American children (Mughal, Hassan, & Ahmed, 2014; Greulich & Pyle, 1959; Dembetembe & Morris, 2012). The method comprises of comparison of the left hand and left wrist x-rays, to an atlas of standard reference plates of children aged from birth to nineteen years old in males and up to eighteen years old for females (Todd, 1937). The process relies on the ossification of the bones in the hand and wrist occurring in a sequential order. From this, bones that are visible from the current radiograph/x-ray are matched individually with the plate which is closest in appearance. The median skeletal age of all the plates is then calculated and this provides the final output (Malina, Bouchard, & Bar-Or, 2004). If a child's calculated skeletal age is younger than their chronological age, they would be regarded as premature and the converse would be true for mature individuals. For all a simple to conduct process, the Greulich-Pyle method features several drawbacks which could impact on its reliability in assessing the skeletal age and thus maturational stage of a person. The cohort in the original longitudinal study were selected from the population almost 80-years-ago with the children in the study being of only European ancestry. It has been noted in current literature that differences in maturation rate can occur between children of different ethnic backgrounds, meaning the method is most reliable when conducted on the same ethnic group (Alshamrani, Messina, & Offiah, 2019). Another factor impacting the reliability of the Greulich-Pyle method is the socio-economic status of the original group. All subjects were from an extremely high socio-economic standing. In a 2006 research article, it was highlighted that those exposed to "medical and economic development" and "modernisation" have expedited ossification rates, compared to those who are more impoverished (Schmeling, Schulz, Danner, & Rösing, 2006). These possible sources of error in the method, imply that a one-size fits all approach to determining maturational status, would most likely lead to an incorrect result being attained.

A second method of determining maturational status via skeletal analysis is the Tanner-Whitehouse method. The x-ray or radiograph of a child's left hand and wrist is matched to a series of written criteria (Malina, Bouchard, & Bar-Or, 2004). For each bone, a specific score is assigned based on written criteria and the total scoring is calculated to determine the maturational status. However, the cohort sampled was similar to the Greulich-Pyle method, in that the majority was of white, well-off, Americans (Tanner, Oshman, Bahhage, & Healy, 1997; Malina, Coelho-e-Silva, Figueiredo, Philippaerts, & Hirose, 2018). This means differences between social and economic status, as well as ethnic differences should still be accounted for when calculating skeletal age and maturational stage with groups varying from the original sample. As such, the method has undergone several revisions from the original process to the most revised Tanner-Whitehouse 3 (TW3) method, due to the ever changing face of the population (Ahmed & Warner, 2007). Only short-bones and carpal bones are assessed in the TW3 method compared to 20 bones in the original procedure. The sample of children is now based on populations from across the globe, possibly accounting for the aforementioned ethnic differences. The method does rely on the competency of the assessor in bone assessment and it is here, some error may occur.

The third skeletal assessment of maturational development considered is the Fels method. The sample data used in this method stems from the Fels longitudinal study (Roche A. F., 1992). The cohort at the time of development comprised of 677 children, from Ohio, with over 13,000 measures collected. The children were primarily middle-class and all Caucasian (Nahhas, Sherwood, Chumlea, & Duren, 2013). The method depends on the grading of bones within the hand-wrist complex from a radiograph to described criteria. The criteria for the grading of the bones is determined by the shape of the bones, epiphyses and diaphyses (Malina, Bouchard, & Bar-Or, 2004). Of 98 measures recorded, only between 20 and 66 will be used. The indicators selected depends on the chronological age of the measured subject and acts to remove redundant grades being involved in the final assessment. A computer calculation then outputs the skeletal age and also a value of standard error attributed to the computation. Similarly, to the Greulich-Pyle method, the participants used in the creation of the method is the primary limiting factor to the method.

Although skeletal maturity is considered the ‘gold-standard’ for determining skeletal age as an indicator of maturational stage of development, there are inherent drawbacks in the common methods (Knapik, Duong, & Liu, 2019). All methods, due to the use of radiographs and x-rays require specialist practitioners to conduct the procedure. Following the retrieval of a radiograph there is then the time-consuming process of matching plates in the Greulich-Pyle method or assessing and grading 20 and 22 bones in the Tanner-Whitehouse and Fels methods respectively. As the radiograph only provides a snapshot in time, there may be the requirement for several repeated procedures over time to continually update the maturational stage outcome. This brings possible ethical issues associated with exposure to radiation due to the machinery used. It has been documented however, that this dose is very low, possibly less than everyday background radiation levels (Ward, et al., 2017). In conclusion, assessing skeletal maturity is a highly sophisticated process, however not a viable option in a sporting setting where constant monitoring, large numbers and time-restrictions are present and required.

2.4.7 SEXUAL ASSESSMENT OF MATURITY

Sexual maturity assessment is another possible method in the evaluation of an individual’s maturational stage. It is alike to skeletal assessment, in that it too is a continuous progression, from conception through to complete sexual maturity. Sexual maturity is the end phase of development where the organism is capable of reproduction (Sizonenko, 1987). The transition of childhood to adulthood is marked by puberty, where a number of indicators are present, conveying the stage of sexual maturation an individual is presently at, on the pathway to becoming sexually mature. The markers used in the evaluation of male and female’s sexual maturity stage are secondary sex characteristics. They include the stage of pubic hair growth in both sexes, along with genital development in males and in females, the menarche and breast development (Malina, Bouchard, & Bar-Or, 2004). As the current study examines exclusively males, female development will not be discussed. The most commonly employed scale examines pubic hair and genital development (Tanner J. M., 1962). There are five stages of growth featuring certain criteria to appropriately assign an individual to. Stage one is classified as pre-pubertal where secondary sex characteristics are absent. Stage two refers to the preliminary development of the characteristics, where there is an early appearance, this stage is termed early-puberty. Stages three and four are a continuation in the development of the genitals and pubic hair. The individual is now expected to be in a ‘mid-puberty’ period (Malina, Bouchard, & Bar-Or, 2004). By stage four, the testes and penis have become enlarged compared to the earliest stage and there has been development on glans (Marshall & Tanner, 1970). Pubic hair is now of adult type, however with considerably less area coverage, in particular, no hair on inside of the thigh region. Stage five defines the individuals as having the characteristics of the mature state (Chipkevitch, 2001).

Sexual maturity assessments may be straight forward in the criteria required to assign a person to the stage they are at, it has several weaknesses. It is not sensitive enough to discriminate between individuals within each stage and as such, the rate of development is unable to be calculated successfully. Also, as the grading system only allows differentiation after pubertal onset, it is impossible to calculate the maturational stage of development someone out with this period, is at. There are also major ethical implications associated due to the manner of assessment. The invasive process would require specialist personal to conduct the examinations along with the need for privacy. As such, a clinical setting would be the most appropriate location, which would be unsuitable for a large group of adolescents.

2.4.8 SOMATIC ASSESSMENT OF MATURITY

The final considered method of evaluating maturation is the assessment of somatic maturity. The use of one-off anthropometric measurements alone is not sufficient in determining a maturity status, however, when combined with longitudinal data that encompasses the whole maturational development process, indicators of maturity status attributed to growth, can be attained. These markers may include the age of PHV, the period of greatest stature growth, with the exception of the first year of life. Peak height velocity, or the adolescent growth spurt, also corresponds with the onset of puberty. These developmental changes are a consequence of an increase in level of hormones such as growth hormone and testosterone caused by pubertal onset (Rogol, Clark, & Roemmich, 2000). The growth of the axial and appendicular skeleton during this transitional period towards and beyond puberty is not uniform. During pre-pubertal growth, the greatest increase in growth is seen in the long bones of the appendicular skeleton, such as the femur. The trunk or axial skeleton then develops during mid to later adolescence (Malina, Bouchard, & Bar-Or, 2004). With this knowledge, through the measurements of standing and seated heights, to determine leg and trunk length, estimations may be made upon the maturational development status of an individual. Several research publications have used longitudinal data in an attempt to calculate maturational stage of development with predictive equations, through the assembled known timings of these maturational related growth events relating to an individual’s standing height, sitting height and leg length. (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002; Khamis & Roche, 1994).

The first method discussed was produced by Mirwald et al. (2002). It incorporates the adolescent growth spurt, the most commonly employed strategy for determining maturity in longitudinal studies according to Malina & Bouchard (1991). They examined the “differential timings” of growth related to whole body, sitting height and leg length and through analysis of how these measures present themselves within a person at a particular period in time, it becomes possible to estimate the current stage of maturation through time from growth spurt, or the age of expected peak height velocity (APHV) (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). Data was collected on over 200 Caucasian children in the 1990’s derived from the Saskatchewan Paediatric Bone Mineral Accrual Study. This method is relatively non-invasive and can be completed by the relevant staff within a youth soccer setup, making it a favourable method for this population. However, it has been documented that an error margin of around one year could be present in 95% of the calculations (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). A validation study conducted by Malina and Koziel (2014) identified that APHV was accurate if the measure was within two years of the actual peak height velocity event. A time period of greater than three years led to a considerable over/underestimation. It was also noted that the method is “applicable” in average maturing boys aged 12-15 years old. However, as mentioned, soccer normally favours early maturing players, meaning they have an accelerated maturational development, calling the accuracy of this method into question for this population (Malina & Koziel, Validation of Maturity offset in a longitudinal sample of polish boys, 2014). In addition, due to testing the sample’s ethnic uniformity, the limitations of this equation are also extended to cover measurements made on participants from differing ethnic backgrounds. Differences have previously been found in the pattern of skeletal development between black and white South Africans, leading to doubts regarding the suitability of this methods within a diverse subject pool (Schoenbuchner, et al., 2017).

A review of the method noted the limitations of the Mirwald et al. (2002) equation, however, did appreciate the benefits of being able to use the simple equation and anthropometric data collection on large populations, at one time (Lovell, et al., 2015).

Efforts have been made to improve the reliability of the equation and test the updated method within the sporting setting, due to the favourable and practical nature of the process. These studies, primarily steered by Fransen et al. (2018), led to an updated maturity offset equation being proposed. In the study, a new data set from Belgian soccer players was used to validate the equation, leading to a greater level of accuracy of prediction in using the equation in youth soccer. The authors commended updated iterations of the Mirwald equation, including Moore et al. (2015), however, commented on the failure of a more accurate or reliable prediction of APHV, in those measured that are “further removed” from PHV. Fransen et al. (2018) noted a linear equation was being used in the “non-linear” process of the growth spurt period. Thus, the Mirwald et al. (2002) predictive equation was altered to apply this concept.

$$Maturity\ ratio = 6.986547255416 + 0.115802846632 * Chronological\ Age) + 0.001450825199 * Chronological\ Age2 + 0.004518400406 * Body\ Mass - 0.000034086447 * Body\ Mass2 - 0.151951447289 * Stature + 0.000932836659 * Stature2 - 0.000001656585 * Stature3 + 0.032198263733 * Leg\ Length - 0.000269025264 * Leg\ Length2 - 0.000760897942 * (Stature * Chronological\ Age)$$

FIGURE 3: FRANSEN ET AL (2018) UPDATED POLYNOMIAL MATURITY RATIO EQUATION

The results from the study were positive, with a greater coefficient of deviation (R^2) value (Original $R^2 = 89.72\%$, Fransen et al. (2018) modification = 90.82%). This improvement in accuracy is welcomed for a non-invasive, efficient method of maturity prediction, however, the method still contains errors linking back to the Mirwald et al. (2002) equation. Those furthest from APHV are still not predicted as accurately as those closest to their PHV period and also those not maturing at an ‘average’ rate are still likely to have a less accurate APHV prediction (Malina & Koziel, Validation of Maturity offset in a longitudinal sample of polish boys, 2014). However, due to its simplistic method and ease of application to a high volume of participants, there is a counterbalance to the use of the APHV method.

A second predictive method of assessing maturity status involves calculating the percentage of adult height a child has reached at the time of assessment (Khamis & Roche, 1994). The Khamis and Roche (1994) method stems from an update of the Roche-Wainer-Thissen predictive method. The previous calculation required both somatic and skeletal assessments to calculate maturity status, making it impractical to the assessment of large numbers. The Khamis and Roche (1994) calculation requires heights of both biological parents along with the height and weight of the measured subject. This data is input into the predictive calculation and returns a value that is interpreted as the percentage of adult stature attained (EASA). The greater the value to 100%, the closer to full development. As with many of the previously mentioned methods of assessment, the primary data source originates from a test group consisting of only white participants, from the Fels longitudinal study (Roche A. F., Growth, Maturation and Body Composition: The Fels Longitudinal Study 1929-1991, 1992). The calculation contains an error of less than 4.5cm in 90% of measured individuals. This is still a considerable error value, larger than that of the previous equation that incorporates skeletal aging. The method also features the difficult process of obtaining the heights of the biological parents. Not only would it be a time-consuming process, it may not even be possible in all situations, including sensitive issues relating to the biological parents (e.g. deceased, divorced). Parents may also over report height in the hope that a greater predicted adult height for their child is looked on favourably. However, it is understood there is increased accessibility to this method, making it more favourable.

To conclude the methods of maturity status assessment, no method is without a weakness. The gold standard of skeletal aging requires trained staff to operate the equipment, in a process also demanding a possibly time-consuming analysis period.

Secondary sexual characteristic assessment is more invasive than desired in studies involving large numbers of young children. Finally, somatic methods of prediction for both PHV offset (Fransen, et al., 2018), and EASA (Khamis & Roche, 1994) have error ingrained in the calculations, due to the sample groups used to collect the predictive data from and natural variability in maturation that a set calculation cannot account for (Malina, Bouchard, & Bar-Or, 2004). In one study (Mills, Baker, Pacey, Wollin, & Drew, 2017) comparing anthropometric and skeletal radiography assessments, radiography was considered the best, however, it was noted that anthropometric methods did accurately predict PHV. However, the anthropometric methods overestimated the timing of PHV in the year immediately prior to PHV. The methods accuracy can be improved through early implementation and multiple measurements recorded longitudinally. The final comments recommended an updating of the data used to inform PHV studies. These anthropometric based methods also include the possibility for human error within the measurement phase of the calculation, which could result in an individual being termed the wrong maturity status (Shearer, Mirwald, Baxter-Jones, & Thomis, 2005). Errors pertaining to anthropometric measurements have previously been shown to be of acceptable levels between testers (McKenna, Straker, & Smith, 2013) and between repeated measures (Carsley, et al., 2019). Recommendations have been set forward to ensure the most reliable and robust methodology is used to diminish any possible human error (Mony, Swaninathan, Gajendran, & Vaz, 2016). These include the use of a certified lead anthropometrist, calibrated and robust equipment and standard operating procedures. Despite these inherent issues, somatic methods of assessment appear most appropriate and accessible to the youth soccer setup as they allow for the processing of many players, with little equipment and cost associated.

Studies have attempted to identify the level of agreement between the differing methods. Correlation values in Portuguese youth soccer players ranged between 0.16 to 0.50

for assessment via pubic hair growth (Tanner J. M., 1962), non-invasive predictive equations (Khamis & Roche, 1994; Mirwald, Baxter-Jones, Bailey, & Beunen, 2002) and skeletal radiographs (Roche A. F., 1992). Overall, the poor concordance between values suggest the methods used are not interchangeable and continued work is needed in this area.

Once the player's maturational stage has been processed, this allows a greater understanding of how developed they are in comparison to their peers. This information can then be applied within the talent selection and deselection process to inform practitioners and allow the biological differences to be taken into account in the decision-making process. This practice, if used correctly, could greatly benefit the current talent identification process.

2.5 TALENT IDENTIFICATION PROCESSES

For a youth academy pathway to be wholly successful, it must identify and progress the players with the greatest chance of earning a professional contract to the next level and release the players who are not expected to reach the level required. This is a simple concept, until the process of talent identification in children is examined in detail. Talent identification at youth level is fundamentally identifying players who possess the qualities to potentially become elite (Williams & Reilly, 2000). The early induction of these identified individuals is hoped to expose them to a greater duration of "high-level" coaching and training, complementing the participant's early 'talent', resulting in an overall more developed player (Deprez, Fransen, Lenoir, Philippaerts, & Vaeyens, 2015). This process becomes is very difficult though due to the non-linear development nature of talent and as such clubs will employ large networks of scouts to travel the country in their continued search of this future talent at all ages and stages of development (Vaeyens R. , Lenoir, Williams, & Philippaerts, 2008). New talent is always required due to the high level of dropout rates from these programmes, citing reasons such as injury, other life priorities and loss of desire for their sport (Enoksen, 2011; Deprez, Fransen, Lenoir, Philippaerts, & Vaeyens, 2015).

There are several methods employed by clubs and organisations in their talent identification and selection process in an attempt to ensure the individuals recruited are suitable. A study in 2000 used a ‘testing battery’ to assess physiological, psychological and soccer-specific skills (Reilly, Williams, Nevill, & Franks, 2000). The investigation was to distinguish the characteristics between elite and sub-elite youth players. The results highlighted a number of traits including greater speed, agility, dribbling, anticipation, ego characteristics and aerobic power to be closer related to the elite level players. A significant difference ($P < 0.01$) was present for technical assessment of dribbling and shooting. Thirty metre sprint times were also significantly ($P < 0.05$) different between the elite and sub-elite players with elite players running around 0.2 seconds quicker. (Elite: 4.3 ± 0.1 s, sub-elite: 4.5 ± 0.2 s). Psychologically, elite players scored significantly ($P < 0.01$) lower somatic anxiety intensity scores, highlighting more control of physical responses to stressful situations (Elite: 11.9 ± 1.6 au, sub-elite: 17.6 ± 5.0 au).

The examination of an individual’s soccer related skills could potentially provide a means of assessing ‘talent’. This model of structured testing was examined in the Ghent Youth Soccer Project by Vaeyens et al. (2006). Players across elite, sub-elite and non-elite youth squads were assessed physically, functionally and soccer-skill specifically over a five-year period. It was found elite players had lower skinfold values, were significantly more powerful and faster, (under-15 30m sprint: elite = 4.1 ± 0.2 sec, sub-elite = 4.2 ± 0.2 sec, non-elite = 4.4 ± 0.3 sec) had a greater aerobic capacity and had greater soccer skill levels for dribbling, shooting and juggling (under-15 elite = 80.2 ± 59.3 count, sub-elite = 58.4 ±

46.5 count, non-elite = 34.2 ± 35.4 count) than the non-elite and to a lesser extent, sub-elite players.

Assessment of technical and psychological traits by a standardised process may allow an evaluation of the player’s skillset to determine their suited development level. This process was noted to be potentially helpful in calculating a minimal entry standard for recruitment into a talent development program by Reilly et al. (2000), thus assisting the talent identification process. However, the testing battery approach is sterile and does not account for the variance and demands of a soccer match. Technical traits are not performed in an isolated incident and as such, a skills test may not reflect actual match performance. Also lacking is the psychological aspect of both the testing and soccer performance. During a match, psychological factors not seen in skills testing may impact performance. This was noted in a 2018 paper, where comment was made on the revision of scouting assessment forms to now include psychological characteristics, in addition to technical skills such as shooting and dribbling (Musculus & Lobinger, 2018).

Further research by Deprez et al., (2015) attempted to identify the influence of physical attributes and abilities upon the ultimate success or failure of a player within a high-level soccer talent development pathway. The results suggested that regardless of age or stage in the development pathway, motor coordination and speed were imperative to success. The groups results also agrees with previous literature (Vaeyens, et al., 2006) that physical qualities such as endurance can be used as a predictor of a higher level player. A second study by Deprez et al., (2015) found that the greatest predictor of future contract status for youth graduates was explosivity, as measured by the standing broad jump. As such, power or markers of, should seriously be considered in the talent selection process. The study did note no difference was present between the anthropometric and maturity status of individuals continuing or dropping out. An argument proposed for this is that the group has been comprised of an already biased selection of advanced maturity and bigger players from an early stage (Deprez, Fransen, Lenoir, Philippaerts, & Vaeyens, 2015; Figueiredo, Coelho-e-Silva, Cumming, & Malina, 2019).

Another study examining the physical qualities of graduates from an elite youth academy assessed the players' dependant on their resulting level of soccer participation; International, professional and amateur, across three age groups (le Gall, Carling, Williams, & Reilly, 2010). Little significance was found, however a trend of improved physical performance for tests such as vertical jump and speed markers, favoured the higher level of player. The authors recognised these markers alone are not sufficient in the talent identification process, but may indicate whether a player has the physical abilities to progress to a high level of soccer. Further research regarding the talent identification process and maturation has suggested the use of soccer-specific and non-specific motor coordination tests that appear not to be influenced by maturational status and tempo of biological development (Vandendriessche, et al., 2012). The results suggested that the specific and non-specific motor tests are a better indicator of 'future potential' rather than physical tests which highlight the physical capacity of an individual, which are an indication of their current physical abilities, which can be influenced by their current maturity status or developmental tempo (Meyers R. W., Oliver, Hughes, Cronin, & Lloyd, 2014; Deprez, et al., 2015). This strategy in addition to the later or less developed players also attempting to compensate for their physical disadvantages by upskilling technical and tactical skills (Gibbs, Jarvis, & Dufur, 2011; Vandendriessche, et al., 2012; Cumming, et al., 2018) may prevent the deselection of some later developing players.

2.6 PHYSICAL ACTIVITY PROFILING OF MATCH-PLAY CHARACTERISTICS

One method of athlete monitoring that is becoming more prevalent in soccer is the use of micro-electromechanical systems (MEMS) with global positioning system (GPS) functionality. This ‘wearable’ technology captures information using inbuilt sensors including accelerometers to measure the change in velocity, magnetometers to measure the direction and gyroscopes for orientation. This information can provide the movement of a player, the speed they work at and in which direction they move (Camomilla, Berganini, Fantozzi, & Vannozzi, 2018). In addition, GPS technology can track this movement using triangulation with satellites and the unit worn by individual players, to record distances and movement. These devices also have the capacity to measure acceleration across three individual planes (up/down, forwards/backwards and sideways) and quantify work done and capture the total load experienced by a player (Barrett, et al., 2016). Early versions of these devices have been shown to be limited in their capacity to accurately measure distance across high speed thresholds and high intensity actions, such as accelerations (Scott, Scott, & Kelly, 2016). These devices, with a sampling rate of one to five hertz have since been replaced by smaller units, with greater sampling power. Ten hertz units, which have become standard equipment for many professional sports clubs, have demonstrated greater validity and reliability in sports (Scott, Scott, & Kelly, 2016). Total distance measures have been shown to have under one percent error values and peak speed was also within error limits (<2%) (Johnston, Watsford, Pine, Spurrs, & Sporri, 2013). The study concluded that the updated GPS units have “further improved validity and reliability”.

By capturing this player data through GPS and MEMS devices, analysis of physical measures such as speed and acceleration could segregate the ‘elite’ and ‘sub-elite’ players within a group. This method may also allow for evaluation of physical traits within in a soccer match, as opposed to a testing battery which could be beneficial as it will provide a more valid assessment of a player’s physical qualities. Studies have attempted to discriminate between high and lower level soccer players game physical activity profile (Sæterbakken , et al., 2019). High level players completed around 24% and 20% greater distance in comparison to the two standards below. High speed running values were greater although statistically insignificant ($P > 0.05$). Sprinting distance was significantly ($P < 0.05$) greater for the top tier players, compared to both level two and four, by around 80 metres. In youth talent selection processes, it is important to account for maturational differences if examining physical activity profiles as a predictor of talent or ability. Early maturing or more developed players will most likely possess greater muscle mass, assisting strength and power, influencing speed in a positive manner (Meyers R. W., Oliver, Hughes, Lloyd, & Cronin, 2016). The ability to maintain a high intensity of work-rate throughout a soccer match could be attributed to maximal oxygen uptake values, which themselves are positively impacted by biological development through increases in fat free mass, and general growth (Carvalho, Coelho-e-Silva, Eisenmann, & Malina, 2013). This means later or less developed players may struggle to reach and maintain these high intensity action values, seen in the higher level of player. This idea has been supported from research by Buchheit and Mendez-Villanueva (2014). It was shown that more mature players covered greater distances at a higher velocity speed compared to less developed peers. Maturation was also *almost certainly* an influence on the greater number of high intensity actions for the more developed players. The authors concluded the importance of cogitating the impact maturation may have upon physical activity profile players, during soccer. During this study, a low sampling GPS unit was used, possibly leading to some error in the results, however, the units do still provide a reliable and valid method of monitoring the collected metrics. This study’s findings have also been supported by the results of an investigation into the influence of biological maturity on running performance in Australian football (Gastin, Bennett, & Cook, 2013), which reported that high speed running (>14.4 $km.h^{-1}$) was significantly and positively related to an increasing maturity status. It should be noted that the method of maturity assessment within the study has previously been shown to contain some level of error (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002).

However, recent research has questioned these findings (Lovell, et al., 2019) , suggesting that later maturing players may actually be able to cover more high speed running (>13 $km.h^{-1}$) distance in soccer matches. The study did reference one limitation in that the majority of the sampled population were post-PHV at the time of testing. This allows suggests that later maturing players who are post-PHV may have the ability to perform more high speed running, however doesn't provide evidence to support the differences possibly seen between post-PHV and pre-PHV players.

Running performance within matches has been suggested to play a role in the talent selection process. Improved running performance has been suggested to provide an advantage that could ultimately result in improved match performance and ultimately talent selection chances (Lovell, et al., 2019; Gastin, Bennett, & Cook, 2013). This could be a result of more involvement within the match.

For a talent selection or deselection purpose, normative values by playing position could potentially be used as an indicator as to a player's potential to fulfil the physical requirements of the role. Players retained within club soccer have been shown to outperform players deselected, with regards to soccer-specific endurance (Deprez, Fransen, Lenoir, Philippaerts, & Vaeyens, 2015). Players with poor levels of these fitness markers, or inability to perform to set physical levels are therefore at a greater risk of deselection. Multiple papers have been produced documenting the requirements by position, in relation to typical total distance, sprint distance and repeated high intensity efforts (Buchheit M. , Mendez-Villanueva, Simpson, & Bourdon, 2010; Harley J. A., et al., 2010). It was noted that older players recorded significantly ($P < 0.05$) higher total distance, high speed running and sprint distance (Harley J. A., et al., 2010). An important methodological consideration arising from this study involves the use of relative age-related speed thresholds for players and their GPS device. This comprises of calculating the mean peak velocity of the individual age groupings and set the movement bands velocity threshold, such as walking and high-speed running, from percentages of this figure, as opposed to assigning all players to the same banding thresholds. Abt and Lovell (2009) have also researched this area, highlighting the individual differences in the transition between running velocities and the possibility of the underestimation of high speed running distance. However, value was still seen in the use of an absolute threshold when players are being compared, due to differences in aerobic fitness levels, which is a possibility within young players. Players who are less aerobically fit may be seen to be completing more high-speed running, if the method of calculating their speed thresholds involved a maximal oxygen uptake testing procedure. Maturation has been shown to be a contributing factor in maximal oxygen uptake level within youth basketball (Carvalho, Coelho-e-Silva, Eisenmann, & Malina, Aerobic Fitness, Maturation and Training Experience in Youth Basketball, 2012). Recommendations for a high-speed running threshold to be used were made, but the decision within clubs to use individualised or generic bands may be made by availability of equipment, time and staff.

Assessment of player’s physical, technical, tactical and psychological profile within full match play conditions is not always possible due to numbers, pitch restrictions and time. Also, the drawbacks associated with battery testing limit the talent identification process methods. One solution to this is to incorporate the assessment method into a regular soccer training component, allowing continual assessment in a repeatable format that replicates soccer match play.

2.7 SMALL-SIDED GAMES

In an effort to improve the talent identification process, small sided games (SSG) have been increasingly studied as a potential showcasing event for players to demonstrate potential talent in a game like scenario (Fenner, Iga, & Unnithan, 2016). SSG are a commonplace in soccer training due to the likeness of a regulation soccer match, but with the advantage of requiring less numbers and area space. Due to its familiar concept to players, this makes it advantageous method of assessing talent, as players with regular soccer exposure will be accustomed to the setup.

The technical skill of a player has previously been shown to be a determining factor of talent and playing level (Meylan, Cronin, Oliver, & Hughes, 2010). Technical skill assessment has been validated in SSG using retrospective video analysis (Bennett, et al., 2017). High level players scored significantly ($P < 0.01$) higher skill proficiency value for dribbling, passing, touch and shooting than lower level players. Through the video evaluation of skill completion, it was possible to determine playing level from the SSG match play.

In addition, SSG studies have exhibited that players are exposed to an increased level of technical loading, in comparison to larger sided match play games (Owen, Wong, McKenna, & Dellal, 2011). This could allow for greater opportunities for recruitment staff, to make an informed decision. Therefore, the use of a competitive SSG format, which should induce a high amount of technical actions, could potentially discriminate between the skill and talent level of individuals, whilst maintaining a game-like setting, as opposed to a technical testing battery.

One study found in post-PHV youth soccer players, there was a strong nearing statistically significant ($P = 0.07$) relationship with a *moderate* level of agreement ($r = 0.39$)

between success in SSG and coach perceived technical ability (Unnithan V. , White, Georgiou, Iga, & Drust, 2012). A paper published by Fenner et al. (2016) stated how a higher technical score, consisting of a combination of ten soccer components such as passing and control, marked from one to five, as perceived by a coach, had a significant ($P < 0.05$) positive relationship with overall success in the SSG (Fenner, Iga, & Unnithan, 2016). Technical actions and success rate also provide a strong correlation between high- and low-level skilled youth soccer players, as determined by their playing level (Bennett, et al., 2017). In addition, Jones and Drust (2007) also highlighted the similarity in "work-rate" profiles, namely the proportion of different movement intensities such as walking and jogging, between 11-a-side match play and four against four SSGs, strengthening the reasoning for this method to be used in talent identification.

Furthermore, within SSG's, a novel assessment of spatial analysis has been implemented in recent studies (Goncalves, Marcelino, Torres-Ronda, Torrents, & Sampaio, 2016) which have examined the dispersion of players in relation to teammates and opponents using the GPS coordinates and is hoped to provide a picture of how players of different levels and development stages move on the soccer field. The study, examining amateur and professional players, found the higher level of player had a greater level of cooperation compared to their lower standard counterparts. This was reflected in a lower distance to the nearest opponent, indicating a more organised structure (Distance to nearest opponent: Professional v 3 opponents = 5.9 ± 0.7m, amateur v 3 opponents = 7.2 ± 2.0 m; professional v 5 opponents = 4.6 ± 0.5 m, amateur v 5 opponents = 5.5 ± 1.0 m; professional; v 7 opponents = 4.0 ± 0.5 m, amateur v 7 opponents = 4.6 ± 0.5 m). Studies have also focused on the tactical style of players against differing levels of opposition, which may be applicable to the physical and technical challenges faced by players of differing biological maturation stages (Folgado, Duarte, Fernandes, & Sampaio, 2014). It was shown a greater level of synchronisation, classified as sharing same area and intention, movement and action, when competing against higher level of opposition. This highlighted a higher demand for "collaborative work".

Silva et al. (2014) found in a study of tactical performances in youth soccer within SSGs that the pitch dimensions influenced the tactical and technical actions of the players involved. Larger SSG pitch dimensions afforded more opportunity for creative play such as dribbling, however with being further from goal, technical traits such as shooting may decrease. The larger dimension SSG pitches led to greater distances to the nearest opponent, allowing more time on the ball, however, small dimension pitch sizes may demand a greater level of 'off-the-ball' movement to create space, a potentially valuable trait in soccer. As this type of tactical analysis is still in its infancy, further research is required to provide conclusive trends for spatial movement between playing levels and development stages. However, if implemented correctly, it could provide a valuable tool for evaluating the tactical skill levels of players. In combination, these talent identification methods demonstrate strong reasoning to implement SSG as a potential talent identification tool. These talent identification procedures in addition to the understanding of biological differences in physical, technical and psychological performance can be used in the decision-making process. To introduce the biological difference comparison into the talent selection or deselection biological maturation derived method, biological banding may be the most appropriate means.

2.8 BIO-BANDING IN SPORT

Bio-banding assembles children into grouped bands based upon their physical measures (Cumming, Lloyd, Oliver, Eisenmann, & Malina, Premier League academy soccer players' experiences of competing in a tournament bio-banded for biological maturation, 2017). This is not a new concept; several historical proposals have been made to use an “anatomical age” and later a “physiological age” to define when a child was physically ready to work (Cumming, Lloyd, Oliver, Eisenmann, & Malina, Premier League academy soccer players’ experiences of competing in a tournament bio-banded for biological maturation, 2017; Crampton, 1908). This details that there is knowledge of the physical development disparity in children, however, there still exits a lack of evidence for or against bio-banding in youth sport. Some weight-based sports have introduced methods of banding similar to ‘bio-banding’ where players compete in weight designated categories. One prominent circumstance is in New Zealand where children of a certain lineage are more likely to mature at a quicker rate, providing them a physical benefit in a contact sport where a large disproportion of stature could lead to serious injury (World Rugby, n.d.). However, as weight is not the only determining factor in soccer performance, recent studies have begun to assess the possibility of bio-banding through maturational development status to create appropriate categories that players will fall under, dependant on their biological development status.

A 2017 study examined the response of young elite level soccer players in England to a bio-banding 11-a-side tournament (Cumming, Brown, Mitchell, & Dennison, 2017). Players were segregated into bandings, as determined by percentage of adult height attained. Players were selected upon falling into a percentage bracket, which included players who could be “playing up”, early maturing, or “playing down”, late maturing. Late maturing players conveyed the benefit of this tournament’s setup, allowing them more “freedom” as they were playing against players of a similar stature and not being physically outcompeted. Late maturing players adopted a greater level of leadership to assist their chronologically younger peers, not seen when competing with more developed players. The early maturing players also noted a greater physical demand and an increased emphasis on their technical performance.

These findings are not stand alone, with another study documenting the response of both ‘late’ and ‘early’ maturing players to a bio-banded soccer tournament (Bradley, et al., Bio-banding in Academy Football: Player’s Perceptions of a Maturity Matched Tournament, 2019). They found that the most developed, ‘early’ maturing players when competing against their own band, found a greater challenge, both physically and technically. ‘Later’ maturing players found the matches to be less challenging but allowing them a greater chance to exhibit their skillset.

This current literature highlights the possible technical, physical and psychological benefits to bio-banding that could induce players soccer related characteristics that are hidden by the physical advantage or disadvantage they endure in chronological banded matches. These bio-banded matches could provide the opportunity for talented soccer player to express their abilities independent of their biological development status or that of the opposition. It could also provide a greater challenge for those players currently deemed as talented, allowing more chance for progress and prevent possible development stagnation.

A recent publication also conveyed the idea of manipulating the playing variables, by bio-banding the players in 11v11 match play (Abbott, Williams, Brickley, & Smeaton, 2019). They found an increase in the perceived physical and technical demands for further developed (early maturing) players in bio-banded competition, as opposed to chronological competition (Rating of Perceived Exertion (RPE) Chronological = 6.6 ± 0.5 au, bio-banded = 7.5 ± 0.9 au). RPE in sport, is the summation of an individual’s perceived effort, relating to the physiological output, required in a match or physical action. The rating is not standard across individuals due to the influence of recall, if the RPE is scored after the event, understanding of the scale and effort completed and previous exposure to similar events and scoring (Eston, 2012). There are a number of methods of obtaining this player perception value. The original scale, proposed by Borg (Borg G. A., 1980) and titled the Borg CR10 is a zero to ten scale with a "non-linear" increase between descriptive values associated with the numerical numbers (Hareendran, et al., 2012). Borg has also produced a scale from six to twenty, with a strong correlation to heart rate (HR) when multiplied by ten (Williams N. , 2017). More recently, a modified CR-100 scale, with a scale of zero to one hundred, with similar descriptive values associated to numerical values (Fanchini, Modena, Schena, & Coutts, 2015). A lack of evidence exists to support the use of these scales within an adolescent population. One study examining the children's OMNI (omnibus) scale of perceived exertion, designed by Robertson et al. (2002) was more valid and reliable in a younger population than the CR100 (Pivarnick, Womack, Reeves, & Malina, 2002), with reliability across two days of studying for the OMNI scale being calculated as 0.95, compared to 0.78 for the CR100. More recently, the CR100 has shown interchangeability with the Borg CR10, however, the CR100 was viewed as more precise. the newer CR-100 RPE scale due to its more "finely graded" scaling, compared to the CR-10, which presents closely related scoring with "verbal anchors" (Fanchini, et al., 2016). However, the CR-10 scale has still been shown to be valid and with good reliability across different ages, sexes and experience levels (Haddas, Stylianides, Djaoui, Dellal, & Chamari, 2017)

The study also presented significant differences in technical performances. One finding that highlighted this difference and technical approach required by players when maturity bio-banding was introduced, related to the number of dribbles players attempted. The early developers attempted 7.7 ± 2.1 in chronological matches but only 6.0 ± 2.2 in bio-banded matches, indicating less creative freedom in biologically matched games. Conversely, late developers appeared to play with more expression, attempting an additional mean number of 1.9 dribbles in bio-banded matches, up from 3.0 ± 1.6 in chronological gameplay. This highlights the possibility of altering performance for potential identification of talent, within maturity status bio-banding. This in turn may allow for the possibility to extract hidden qualities of players, or alter the challenge, consequently assisting in the production of a greater level of high-quality player, progressing to the professional game. As such, the idea of bio-banding challenging the more developed players technically and also allowing the less developed players more opportunity to express their talent appears very attractive.

Currently, no set protocols exist for the process of identifying the maturity status of an individual. Most recent studies adapt one of two different methods of estimation making comparison difficult due to the differing procedures, the maturity offset (Fransen, et al., 2018) and estimated adult stature (Khamis & Roche, 1994) equations. One study examining the concordance of these methods in addition to comparison with a “clinically established” process, in skeletal aging using the Fels method (Roche, Chumlea, & Thissen, 1989). The study found the predictive equations to be poor in relation to skeletal aging, but with the estimated adult stature equation (Khamis & Roche, 1994) showing slightly better correlation. This suggests these methods are not fully interchangeable. Further evidence is required to present how these possible differences can manifest within a practical setting.

The research of this study, therefore, is being conducted in an effort to further the knowledge on the concept and effects of bio-banding and SSG’s in a youth soccer population.

2.9 AIMS

The primary research questions aim to provide data relating to:

1) To establish if physical, technical, psychological and tactical differences exist between players of different biological maturity bands in biologically matched, unmatched and mixed match SSG match play within youth soccer.
2) In addition, to identify if the method of somatic predictive maturity assessment method used, influences the results and data collected.

2.10 HYPOTHESES

The following hypotheses have been put forward for the research article:

1) Matched ‘bio-banding’ will reduce the magnitude of difference in technical behaviours between players during SSG match-play. However, these measures for biologically developed players will be greater when matched against their less biologically developed counterparts.
2) Matched ‘bio-banding’ will reduce the magnitude of difference for tactical behaviours between players during SSG match-play. However, these measures for biologically developed players will be greater when matched against their less biologically developed counterparts.
3) Matched ‘bio-banding’ will reduce the magnitude of difference for physical measures between players during SSG match-play. However, these measures for less biologically developed players will be greater when matched against their biologically developed counterparts.
4) Matched ‘bio-banding’ will reduce the magnitude of difference for psychological behaviours between players during SSG match-play. However, these measures for less biologically developed players will be greater when matched against their biologically developed counterparts.
5) Matched ‘bio-banding’ will reduce the magnitude of difference of internal (heart rate and sRPE) and external (GPS metrics i.e. PlayerLoad™ etc.) measures during SSG match-play. However, these measures for less developed players will be greater when matched against their biologically developed counterparts.

3 METHODS

3.1 PARTICIPANTS

Having written consent from the player's parent/guardian, which was obtained alongside University of Hull ethical approval (reference: 1819011), 92 youth soccer players aged 11 to 15-years-old (age: 13.6 ± 1.1 years, height: 163.0 ± 9.7cm, weight: 49.5 ± 9.1 kg, EASA: 89.6 ± 4.2 %, YPHV: -0.3 ± 1.1 years), were selected from three professional soccer academies across England and Scotland. The players designated for the trials were selected dependent on their estimated maturational status, using two separate anthropometric-based equations from the academy's pool of players, from the under 12 to under 16 age groups (Fransen et al., 2018; Khamis & Roche, 1994).

The two predictive anthropometric measurements were used to classify individuals as being pre-, circa- or post-PHV. This prefix for the maturity banding was selected due to its use in previous research papers and publications (Read, Oliver, Myer, De Sre Croix, & Lloyd, 2018; Towlson, Cobley, Parkin, & Lovell, 2018). The least biologically developed players, termed pre-PHV, were individuals equal to or more than one year away [<-1.0 years] from their APHV during Fransen et al. (2018) and below [<87.0% EASA] for the Khamis and Roche (1994) predictive equation. The circa-PHV banding, those players around PHV, included players within one year [-1.0-0.0 years] of their APHV for the Fransen et al. (2018) equation and between [87.0 – 91.9% EASA] for Khamis and Roche (1994). Finally, the most biologically developed group, post-PHV, consisted of those who had been calculated to have past their APHV [>0.0 years] for the Fransen et al. (2018) predicative equation and [≥ 92.0% EASA] for the Khamis and Roche (1994) equation.

For comparison purposes and terminology continuity, the ‘post’, ‘circa’ and ‘pre’ prefixes were maintained for both Fransen et al. (2018) and Khamis and Roche (1994) equations. The maturity banding values used are not consistent with suggestions made in previous literature (Cumming, Lloyd, Oliver, Eisenmann, & Malina, 2017), however, were selected due to the player pool available. Had the bandings of pre-PHV [<-1.0 years APHV], circa-PHV [±1.0 years APHV] and post-PHV [>1.0 years APHV] for the Fransen et al. (2018) method been used, an imbalance of players would have made maturity status bio-banded teams impossible. Similarly for the Khamis and Roche (1994) method, it is understood that the Khamis and Roche (1994) method is a percentage of adult stature attained and not a percentage relation to PHV, so players should ideally be sorted dependant on their developmental percentage value. It has been shown however, that players around 89-95% of EASA are most likely circa-PHV, with a higher value being post-PHV (Cumming S. P., Practical Case Study of Assessing Growth and Maturity in the Premier League, N.D). Again, due to the pool of players available for testing, modified breakpoints of 87% and 92% EASA were introduced to create three balanced banding groups. These bands, referred to as maturity bands, are representative of three categorised sections of the continual biological development towards and beyond maturation.

Through the information available on maturity influence on physical development timing and tempo, it has been shown that improvements or decline in performance and anthropometric characteristics, such as sprint speed and stature, do not occur exactly in relation to onset of PHV (Towlson, Cobley, Parkin, & Lovell, 2018). As such, the adapted maturity bandings will still encapsulate individual differences in the physical and potentially technical and tactical manifestation of traits, within the maturity bandings selected.

Table 1: **Anthropometric variables of the 72 youth soccer players biologically banded using the Khamis and Roche (1994) predictive equation.**

Khamis Roche			***Banding***	
Variable	*N (per band)*	*Pre-PHV*	*Circa-PHV*	*Post-PHV*
Age (years)	24	12.9 (± 0.6) **Circa**^{L}**, Post**^{VL}	13.6 (± 0.9) **Pre**^{L}**, Post**^{L}	14.4 (± 1.0) **Pre**^{VL}**, Circa**^{L}
Stature (cm)	24	155.8 (± 4.8) **Circa**^{L}**, Post**^{VL}	161.2 (± 6.3) **Pre**^{L}**, Post**^{VL}	173.1 (± 8.4) **Pre**^{VL}**, Circa**^{VL}
Mass (kg)	24	43.5 (± 5.7) **Circa**^{L}**, Post**^{VL}	48.1 (± 6.4) **Pre**^{L}**, Post**^{VL}	58.3 (± 8.0) **Pre**^{VL}**, Circa**^{VL}
EASA (%)	24	85.8 (± 1.6) **Circa**^{VL}**, Post**^{VL}	89.7 (± 2.2) **Pre**^{VL}**, Post**^{VL}	94.1 (± 2.6) **Pre**^{VL}**, Circa**^{VL}

MEAN VALUE (±S.D): ***BOLD TEXT*** *= SIGNFICANCE (P<0.05). EFFECT SIZE (ES):* ^{T}*TRIVIAL,* ^{S}*SMALL,* ^{M}*MODERATE,* ^{L}*LARGE &* ^{VL}*VERY LARGE. TRIVIAL <0.2, SMALL 0.2-0.6, MODERATE 0.6-1.2, LARGE 1.2-2.0, VERY LARGE >2.0.* ***(HOPKINS, MARSHALL, BATTERHAM, & HANIN, 2009)***

Table 2: Anthropometric variables of the 72 youth soccer players biologically banded using the Fransen et al (2018) predictive equation.

Fransen			***Banding***	
Variable	*N (per Band)*	*Pre-PHV*	*Circa-PHV*	*Post-PHV*
Age (years)	24	12.8 (± 0.7) **Circa**^{VL}**, Post**^{VL}	13.6 (± 0.8) **Pre**^{VL}**, Post**^{VL}	14.6 (± 0.9) **Late**^{VL}**, Circa**^{VL}
Stature (cm)	24	154.7 (± 5.4) **Circa**^{VL}**, Post**^{VL}	161.6 (± 7.1) **Pre**^{VL}**, Post**^{VL}	171.8 (± 6.2) **Pre**^{VL}**, Circa**^{VL}
Mass (kg)	24	42.0 (± 4.77) **Circa**^{VL}**, Post**^{VL}	49.5 (± 6.9) **Pre**^{VL}**, Post**^{VL}	57.9 (± 6.9) **Pre**^{VL}**, Circa**^{VL}
YPHV (years)	24	-1.4 (± 0.4) **Circa**^{VL}**, Post**^{VL}	-0.3 (± 0.7) **Pre**^{VL}**, Post**^{VL}	0.8 (± 0.6) **Pre**^{L}**, Circa**^{VL}

MEAN VALUE (±S.D): ***BOLD TEXT*** *= SIGNFICANCE (P<0.05). EFFECT SIZE (ES):* ^{T}*TRIVIAL,* ^{S}*SMALL,* ^{M}*MODERATE,* ^{L}*LARGE &* ^{VL}*VERY LARGE. TRIVIAL <0.2, SMALL 0.2-0.6, MODERATE 0.6-1.2, LARGE 1.2-2.0, VERY LARGE >2.0.* ***(HOPKINS, MARSHALL, BATTERHAM, & HANIN, 2009)***

Table 3: Anthropometric variables of the 72 youth soccer players within the 'mix' week testing period.

Mix		***Grouping***		
Variable	*N (per group)*	*Group 1*	*Group 2*	*Group 3*
Age (years)	24	13.6 (± 1.1) Group 2^{T,} Group 3T	13.6 (± 1.1) Group 1^{S}, Group 3^{T}	13.6 (± 1.1) Group 1^{T}, Group 2^{T}
Stature (cm)	24	13.2 (± 1.2) Group 2^{T}, Group 3^{T}	13.5 (± 1.2) Group 1^{T}, Group 3^{S}	13.2 (±1.2) Group 1^{T}, Group 2^{S}
Mass (kg)	24	46.4 (±10.8) Group 2^{S}, Group 3^{T}	49.3 (± 9.4) Group 1^{S}, Group 3^{S}	47.1 (± 8.9) Group 1^{T}, Group 2^{S}
YPHV (years)	24	-0.8 (± 1.3) Group 2^{S}, Group 3^{T}	-0.5 (± 1.3) Group 1^{S}, Group 3^{T}	-0.7 (± 1.2 Group 1^{T}, Group 2^{T}
EASA (%)	24	87.9 (± 5.0) Group 2^{T}, Group 3^{T}	87.9 (± 5.3) Group 1^{T}, Group 3^{T}	88.6 (± 4.7) Group 1^{T}, Group 2^{T}

MEAN VALUE (±S.D): ***BOLD TEXT*** *= SIGNFICANCE (P<0.05). EFFECT SIZE (ES): ^{T}TRIVIAL, ^{S}SMALL, ^{M}MODERATE, ^{L}LARGE & ^{VL}VERY LARGE. TRIVIAL <0.2, SMALL 0.2-0.6, MODERATE 0.6-1.2, LARGE 1.2-2.0, VERY LARGE >2.0.* ***(HOPKINS, MARSHALL, BATTERHAM, & HANIN, 2009)***

3.2 EXPERIMENTAL DESIGN

The selected players attended four sessions in total at their respective clubs. The study was conducted one day per week, across a four-week period per academy club, to allow for recovery between sessions and minimise any learning effect. The testing trials ran within the normal training slots for the club and players to minimise possible disruption.

Player's anthropometric data and parental heights were collected for the anthropometric calculations, no later than one month prior to the beginning of each clubs assigned testing period, to ensure up-to-date data, as any significant growth may have led to a player being assigned to a different maturational group. The output of which, was used to assign the players to one of six teams at each club, dependant on their maturational stage. Of the six teams, two were comprised of 'pre-PHV' players, two of players around their maturational transition stage, ‘circa-PHV’ and two teams with players who were estimated to have surpassed their peak maturational development period, ‘post-PHV’.

Testing days comprised of assigning each player a MEMS device with GPS functionality, a HR monitor and a numbered sports vest to aid with player identification. Four members of coaching staff from each club academy, possessing at minimum, an FA Level two coaching certificate, formed the talent identification staff who assessed each player’s technical and psychological traits and abilities. The coaches were assigned at random, one player for opposing squads. Each squad played the other five teams once per testing week, in a five-minute SSG. The teams not involved in the match being assessed were kept active by completing low-intensity technical drills and challenges, led by club academy coaches. The final result of every match was recorded in addition to the RPE, technical and psychological scoring. This process was repeated for each testing week, within each club academy.

Week one was an introductory session for players and coaching staff alike. During this, coaching staff were exposed to the marking methods and criteria and players were informed of the testing procedures and rules involved. This protocol allowed for a familiarisation process so as to ensure fluidity and greater understanding of the monitoring process that would be conducted over the following weeks. It was determined that due to the multitude of factors implicated in match play and the players previous training history and exposure to small sided games, any learning effects that took place would not impact the players overall scoring.

Week two was the first week of monitored testing, using a maturity bio-banding method. The first banding process was the Khamis and Roche (1994) method. This method predicts adult height using the current age, height and weight of the player and the mean stature of the player's biological parents (mid-parent stature). This equation has a mean error value of 2.2 cm in males, between their predicted and their final mature stature (Khamis & Roche, 1994). Maturity status was categorised in one of three bands, using the same prefix as the Fransen et al. (2018) equation, with the most developed players titled post-PHV, those in the transitional stage around PHV titled circa-PHV and the least developed in the pre-PHV banding. The English clubs involved in the study had the self-reported parental heights attuned for potential overestimation, using an adjustment calculation through access to the EPPP's performance management application (PMA) (Epstein, Valoski, Kalarchian, & McCurley, 1995). The output is the player's present height as a percentage of their EASA, used to categorise the players into the three groups. Players within the band closest to 100% of EASA were considered most biologically developed, with those in the band furthest from 100%, classified as the least biologically developed. The Khamis and Roche (1994) method has been validated in youths as a method of non-invasive maturity estimation (Malina, Dompier, Powell, Barron, & Moore, 2007). Players were arranged into two teams per maturity band and competed in the SSG play against each other and the other banded squads, with each team playing five matches.

Week three used the Fransen et al. (2018) method as a predictive equation to calculate the player's APHV. The APHV is attained through use of somatic measurements (stature, seated stature and leg length) and decimal age in a predictive equation. This value can then subtracted from their current decimal age to give YPHV. This method was selected due to the increased accuracy in reporting of estimated stage of maturational development as YPHV (Fransen, et al., 2018) compared to previous versions (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). The Mirwald et al. (2002) equation calculated APHV to ± 0.24 years (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). Players beyond their estimated APHV (positive value) were considered biologically developed, with those furthest from

APHV (negative value), considered least biologically developed. The bandings used were to allow for sufficient players per maturity band, however, similarly to the Khamis and Roche (1994) banding method, the physical changes that occur within the bandings used, allow for differences to be present (Towlson, Cobley, Parkin, & Lovell, 2018). Again, a total of six teams were formed, two at each banding.

Week four was the final testing session. Players were randomly assorted into their teams, creating a mix of maturational levels within squads, similar to a normal soccer match. This match data was then used as the control sample.

3.3 ANTHROPOMETRIC PROFILE PROTOCOL

As per standard and previously published protocol (Towlson, Cobley, Parkin, & Lovell, 2018) with use of one ISAK (International Society for the Advancement of Kinanthropometry) accredited practitioners per testing club (n = 3), a stadiometer (Seca 213, Germany) was used to measure player's height. For stature, shoes were removed prior to measurement, with heels pressed to the platform, whilst the head was positioned into the Frankfort plane (Pearson & Grace, 2012). Players were instructed to take a large inhalation whilst the horizontal headpiece was lowered to the top of the head. This process was repeated until an agreement of results within 0.2 cm, to aid a reliable and accurate measure of stature. Seated stature was recorded in a similar manner, where participants were sat upright on a box of known height, with their back pressed flat against the stadiometer (Seca 213, Germany). Whilst their hands were rested upon their lap, they were once more requested to inhale deeply, whilst their seated stature was recorded in relation to the horizontal headpiece. The process was repeated until a consistent measure, to within 0.2 cm of agreement, was obtained. This method has been shown to be reliable in comparison to a 'sitting height stadiometer' and more appropriate than the 'long-sitting position' when the data collected is being used for maturity calculations (Massard, Fransen, Duffield, Wignell, & Lovell, 2019). Leg length was deduced as standing stature minus the seated stature. Mass was measured by portable scales (Seca 875 electronic class III, Germany), whilst participants were shoeless and in their normal training wear. Mass was recorded at least twice per participant, or until the result were within 0.1kg of agreement and recorded to the nearest 0.1kg. For the Khamis and Roche (1994) equation, parental height information was obtained for the study through self-reported surveys. The Fransen et al. (1994) equation made use of anthropometric and age data only.

3.4 SMALL SIDED GAMES (SSG)

The five minute small sided games were played on AstroTurf (3rd Generation) pitches at the participating club's academy training centre. The games were an absolute five minute duration using a multi-ball system to increase ball in play duration. The SSG pitch dimension was set at 23m x 18.3m, giving a pitch area of 420m^2, or 52.6m^2 per player, the same spatial dimensions to the four versus four SSG in previous SSG studies (Fenner, Iga, & Unnithan, 2016). This SSG match play setup had previously been used in a very similar format, which has been validated as a possible method of talent identification in a 2012 study (Unnithan V. , White, Georgiou, Iga, & Drust, Talent Identification in Youth Soccer, 2012). Two small goals (2m x 1m) were placed at opposite ends of the pitch with the border of the pitch being clearly defined by markers and a halfway line lined using flat panel markers. As no goalkeepers were used in the SSG, the condition of players only being able to score whilst in the opposition half of the field, was implemented. The SSG's used a point scoring system for each team, with four points awarded for a win, two points for a draw in addition to one point per match, if the team scored a goal. The match order was random, but the sequence of matches remained the same for all testing weeks and clubs. Games were played back to back with teams having an average break between matches of ten minutes. To lessen the effect of fatigue on SSG performance, no team played consecutive matches. There was a total of 15 fixtures per testing night, per club, with each individual team competing in five matches.

3.5 PHYSICAL MEASURES PROTOCOL

Players wore MEMS devices (MEMS; Catapult OptimEye X4, Catapult Innovations, Melbourne, Australia) containing a 10 hertz (Hz) global positioning satellite (GPS) chip and 100 Hz accelerometer that recorded time-motion data (total distance covered (m), high-speed running distance (m), max velocity (m.sec^{-1}), accelerations and decelerations (count in a sports vest, fitted in their upper-back, between their shoulder blades, as per common procedure. The vests provided to the players ranged in size to provide the most appropriate fitting. Literature has previously suggested the influence poor or loose fitting garments to house the MEMS devices can have upon the accumulated accelerometer load in rugby players (McLean, Cummins, Conlan, Duthie, & Coutts, 2018). As such, all players wore a vest that held the unit tight against their body, without being restrictive or discomforting.

Four absolute velocity bandings were set to distinguish between the different speeds of movement, to quantify and categorise the running profile of the players. A velocity of below 13 km.h^{-1} was classified as low intensity running, 13.1 to 16 km.h^{-1} was considered high speed running, 16.1 to 19 km.h^{-1} was very high intensity running and above 19.1 km.h^{-1} was sprinting. These velocities were selected due to use in other investigations into match performance in young athletes, allowing the collection of validated and comparable results (Buchheit, Mendez-Vilanueva, Simpson, & Bourdon, 2010; Harley J. A., et al., 2010).

At the end of every SSG, players were asked to provide an RPE score to gauge the player’s individual perception of effort and exertion of match demands (Coutts, Murphy, Pine, & Impellizzeri, 2003). Players had been familiarised with the use of the scale either through common practice within their habitual academy setting or within the pre-testing introductory week. The RPE was collected using Borg’s CR-10 scale (Borg, Hassmén, & Lagerstrom, 1987). The method of RPE collection was designed in conjunction with the recommendations in Borg’s 1998 publication (Borg G. , 1998). A clear verbal instruction of “can you point to the description that best matches the effort level required for your last match” was used and repeated to every participant. Players were also instructed that where their desired response lay between two verbal descriptors, an appropriate whole number could be applied. Subjects performed the rating individually to avoid social pressure or influence on their scoring. Literature has suggested that an RPE value collected under 30 minutes after activity has stopped may be influenced by the intensity of work immediately before the end of exercise (Foster, et al., 2001). However, more recent research (Uchida, et al., 2014) has suggested that no significant different is present between sessional RPE (sRPE)(RPE multiplied by exercise duration), across differing exercise intensities, recorded at 10 and 30 minutes post exercise. The impracticality of waiting at least 10-minutes between games due to the quick turnaround times for teams led to RPE being scored round five minutes post individual matches.

Players were also fitted with HR monitors, (Polar T31-Coded, Polar Electro Oy, Finland) worn around their chest, at a level close to their sternum on an elasticated belt, to monitor and record their HR response to the exercise. Prior to attaching the belt, the plastic electrode area was moistened as per recommended operating protocol. Data on maximal HR (beats/minute^{-1}), mean HR and time in HR training zones (min) was collected using this procedure.

3.6 PLAYER ANALYSIS PROTOCOL

During these SSG matches, four soccer coaches from the participating club, possessing at least FA Level two coaching qualifications, were assigned two players each, one from either team, to score on their technical and psycho/social ability and performance. These coaches were blinded as to what team represented each maturity banding category. The coach's two assigned players per SSG were also allocated randomly, to reduce the likelihood of any marker bias. Coaches scored the technical attributes (e.g. passing, shooting, dribbling) of the players using the game technical scoring chart (GTSC)(Fenner, Iga, & Unnithan, 2016). The scoring attributes validity was established in Fenner et al's. (2016) study, with use of highly qualified (FA A Licence) soccer coaches. Inter-test reliability had previously been carried out on this method of technical assessment with positive results. Inter-rater reliability was calculated as 0.83 au with no significant ($P > 0.05$) differences (Unnithan V. , White, Georgiou, Iga, & Drust, Talent Identification in Youth Soccer, 2012). During a pilot study to Fenner's 2016 paper, there was one instance of significant ($P < 0.05$) difference in one of three marked matches, so caution was taken when comparing coaches' assessments of players. Inter-tester reliability was analysed within this study two weeks on from completion of the games programme at each club, with coaches invited to reassess the players scoring, using the video footage. No significant ($P > 0.05$) difference was found between the live scoring of the SSG and the following video scoring marks. The reliability results for this are available in the appendix (see Appendix 1).

The GTSC (see Appendix 2A: definitions Appendix 2B) was used in combination with a similar novel structured scoring template for four psychological attributes, entitled the game psycho-social scoring chart (GPSC), complete with operational definitions (see Appendix 3). These psychological traits were selected based upon the results of a previous study (Larkin & O'Connor, 2017) examining what psychological abilities were most associated with elite performance in youth soccer. A scoring system of one to five (1-Poor, 2-Below Average, 3-Average, 4-Very Good, 5- Excellent) was used for both charts. Accompanying each scoring criteria, was a definition, to reduce the likelihood of misunderstanding the specified attribute by marking panel. Both the GTSC and the GPSC was used as a method to numerically record the perception of a players technical and psychological skills, as assessed by a coach, in a manner not to different to the current state of talent identification (Fenner, Iga, & Unnithan, 2016). The inclusion of the coach derived assessment of these traits arises from the work of Larkin and O'Connor (2017), who commented on the talent ID practitioner's perceived importance of these characteristics.

The games were video recorded using the Endzone video system. The camera (Sony Handycam FDR-AX33 4K Ultra HD Camcorder) was mounted upon an elevated tripod, at a mean height of 7.3 (± 2.9) metres and at a distance from the pitch of 13m. The camera was placed at the halfway line to capture the whole pitch.

3.7 TACTICAL AND CREATIVE BEHAVIOUR PROTOCOL

The players' latitude and longitude coordinates were exported from the GPS systems post testing. They were then processed using appropriate routines in Matlab (MathWorks, Inc., Massachusetts, USA) to compute the spatial exploration index (SEI) (Gonçalves et al., 2017). Spatial exploration index is a novel metric designed to quantify an individual's pitch exploration in a match. Pitch mapping was completed by collecting the perimeter coordinates of the pitch using 60 second intervals at the corners and either side of the half way line. Spatial exploration index is computed by calculating the players mean pitch position and the mean distance from this point at every position sampled by the GPS unit (Goncalves, et al., 2016). Data on the distance to the nearest teammate (m) and nearest opponent (m) was also calculated and a mean value was returned. By determining the mean position of a full team, the distance for each player to their team's and opponent's centroid was computable. These values provide details on the structure and setup of a team and also how they respond to their opponent's match play. This analysis was made possible by collecting the perimeter coordinates of the SSG pitch, using a GPS unit (MEMS; Catapult OptimEye X4, Catapult Innovations, Melbourne, Australia). The unit was moved and positioned around the pitch, with a pause of one minute at each corner and at both ends of the halfway line.

3.8 STATISTICAL ANALYSIS

Data were analysed used the SPSS statistics software (IBM SPSS Statistics 25, Version 25). Data pertaining to unmatched bandings were processed by general linear mixed modelling to compute estimated marginal means, with the means compared using Sidak confidence interval adjustments. Prior to the execution of the statistical analysis process, data was examined for normal distribution using visual inspection of histograms. Random variance was also assessed using a covariance of random effects analysis, between clubs to account for any tactical or coaching differences, with no significant differences found (Significance set at $P < 0.05$). The difference of the estimated means was compared for significance. Significance was set at $P < 0.05$ with confidence intervals being set at 95%. Magnitude based inferences were calculated using a custom created spreadsheet, using sample size, mean group value and standard deviation values. Magnitude based inference (effect sizes) thresholds were set at: *Trivial < 0.2, Small 0.2-0.6, Moderate 0.6-1.2, Large 1.2-2.0, Very Large >2.0* (Hopkins, Marshall, Batterham, & Hanin, 2009). Comparison of the matched bandings was computed by independent samples t-test, after confirming equal variance through 'Levene's test for equality of variance'. Significance was set at $P < 0.05$.

4 RESULTS

Analysis was conducted on the individual banding methods, to provide results on the differing match protocols and methods. Firstly, ‘between maturity banding’ analysis examined the response on players within their maturity band in the SSGs, against the other maturity banded squads. Within this analyses, the ‘mixed maturity’ matches were also analysed, whereby players of all maturity bandings competed within the same squads. To allow for the ‘between squad’ analysis to be conducted in a similar manner to the ‘between maturity banding’ analysis, teams were grouped together. Teams one and two became ‘group 1’, teams three and four became ‘group 2’ and finally, teams five and six were represented by ‘group 3’. The second method of analysis examined the response of the players representing the different maturity bands, within the mixed match play SSG. This hoped to provide a representation of the current status of youth soccer, where players at different stages of maturation compete with one another. The final analysis examined players response to biologically matched SSG and compared these results to the metrics and values collected for the between banding match play, to allow for a better understanding as to the impact maturity bio-banding can have upon players.

4.1 BETWEEN MATURITY BANDING ANALYSIS

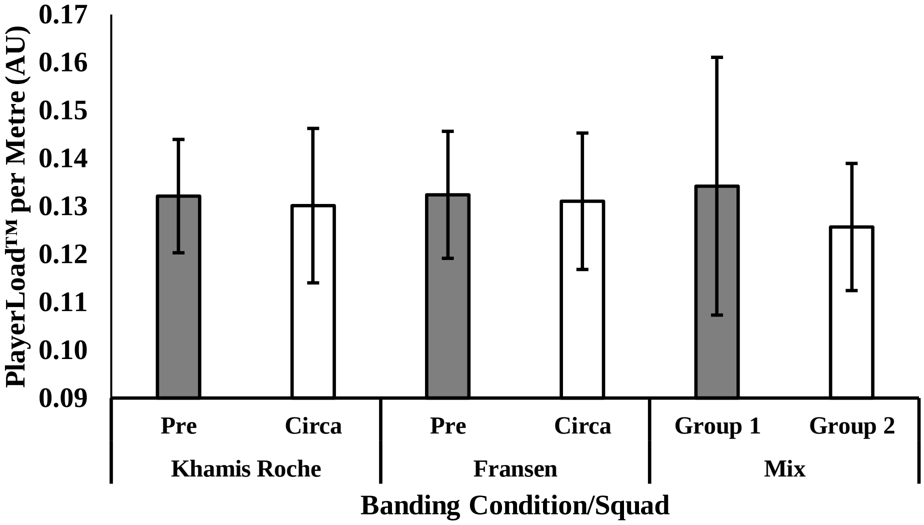
4.1.1 AGE AND ANTHROPOMETRICS

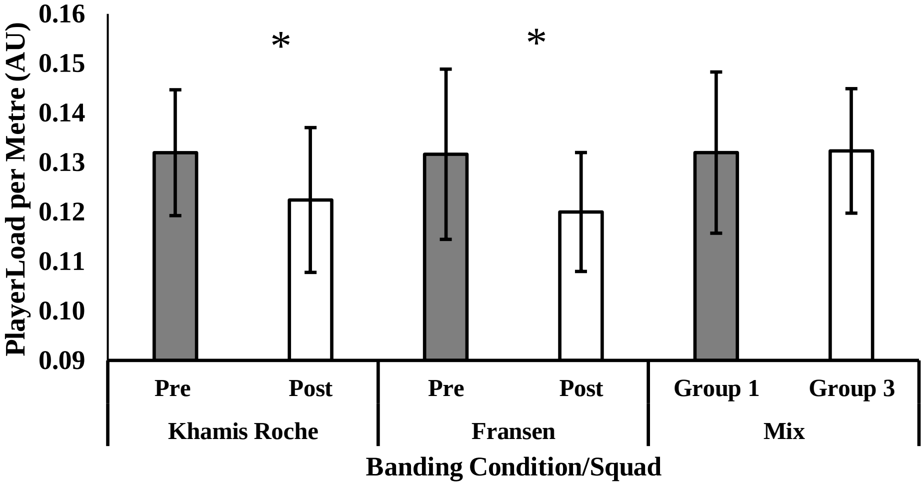
During the Khamis and Roche (1994) testing conditions (Table 1) the pre-PHV (‘pre’) players were the youngest (12.9 ± 0.6 years) compared to the circa-PHV (‘circa’) (13.6 ± 0.9 years, ES = 1.05) and the post-PHV (‘post’) (14.4 ± 1.0 years, ES = 2.66) players. The difference between these three banded groups was considered statistically significant ($P \leq 0.001$). For stature measures, the ‘pre’ players were significantly smaller (155.8 ± 4.8 cm; $P \leq 0.001$) than the other two banded groups (‘pre’ v ‘circa’ mean difference (MD) = 5.4 cm, ES = 0.94; ‘pre; v ‘post’ MD = 17.3 cm, ES = 3.64), with the tallest group being the ‘post’ players (173.09 ± 8.41 cm). There was a statistically different ($P \leq 0.001$) between the groups in terms of mass (‘pre’ v ‘circa’ MD = 4.7 kg, ES = 0.93; ‘pre; v ‘post’ MD = 14.9 kg, ES = 3.48). The ‘post’ groups possessed the greatest value (58.3 ± 8.0 kg) compared to the other bands. These trends continue during the Fransen et al. (2018) testing conditions (Table 2), with the ‘pre’ player again, being the youngest banding by a significant value (12.8 ± 0.7 years, $P \leq 0.001$). This significant difference ($P \leq 0.001$) continued for stature and mass values. The ‘pre’ group had the smallest mean average value for stature (154.7 ± 5.4 cm) and mass (42.0 ± 4.9 kg), with both the ‘circa’ and ‘post’ groups having significantly ($P \leq 0.001$) greater values (stature: ‘pre’ v ‘circa’ MD = 6.9 cm, ES = 1.08; ‘pre; v ‘post’ MD = 17.1 cm, ES = 2.91; mass: ‘pre’ v ‘circa’ MD = 7.6 kg, ES = 1.26; ‘pre; v ‘post’ MD = 16.0 kg, ES = 2.66). Finally, during the mix week testing conditions, there was no significant difference calculated between any of the 3 groups. ($P > 0.05$) As can be seen in Table 3, effect sizes were *trivial* for age and *trivial* to *small* for difference of maturity estimations by both Khamis and Roche (1994) and Fransen et al. (2018). Mass values provided the greatest difference, however the effect size (*moderate)* was considered statistically insignificant. (*P* > 0.05)

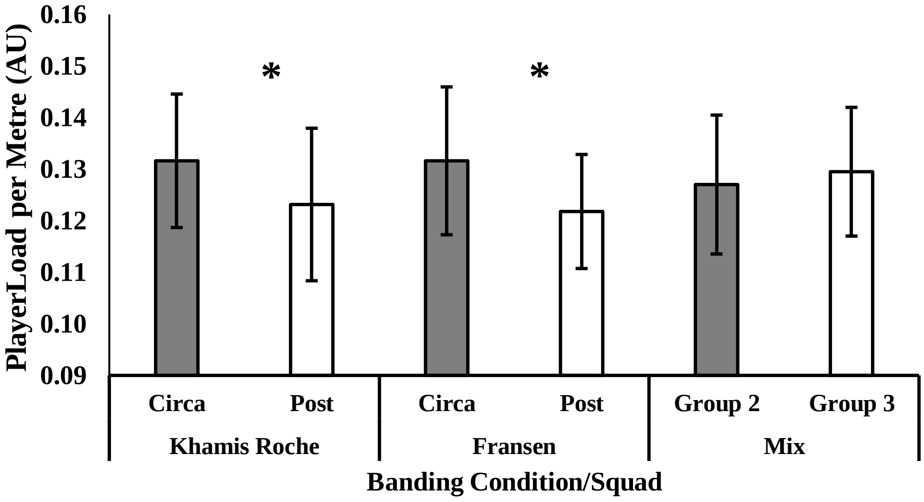
4.1.2 EXTERNAL AND INTERNAL LOADING

There was no significant difference between ‘pre’, ‘circa’, and ‘post’ squads across all three testing conditions (*P* = 0.10 to 0.764) for total distance covered, with effect sizes ranging from *trivial* to *small* (‘pre’ v ‘circa’ ES: 0.13 to 0.41, ‘pre’ v ‘post ES: 0.08 to 0.16, ‘post’ v ‘circa’ ES: 0.11 to 0.37).

Significant differences and *moderate* effect sizes were found for PlayerLoad™ per metre. During the ‘pre’ v ‘circa’ conditions for Khamis and Roche (1994) and Fransen et al. (2018) weeks, there was no significant differences (*P* = 0.51 to 0.65) between the banded squads with effect sizes ranging from *trivial to small.* (ES: 0.08 to 0.4) However, as can be seen in Figure 4, a significantly greater PlayerLoad™ per metre value was recorded for the ‘pre’ and ‘circa’ squads when compared to the ‘post’ banded teams during the Khamis and Roche (1994) and Fransen (2018) testing weeks (‘pre’ v ‘post’: Khamis and Roche (1994) *P* = 0.001; ES = 0.74 *moderate*, Fransen et al. (2018) *P* = 0.01, ES = 0.91 *moderate,* ‘mix’ *P*=0.128*;* ES = 0.01 *trivial*; ‘circa’ v ‘post’: Khamis Roche *P* = 0.005; ES = 0.67 *moderate;* Fransen et al. (2018) *P* ≤ 0.001, ES = 0.96 *moderate,* ‘mix’ *P* = 0.366; ES = 0.15 *trivial).* No significant difference was present between the squads during the ‘mix’ week. (*P* = 0.10 to 0.37)





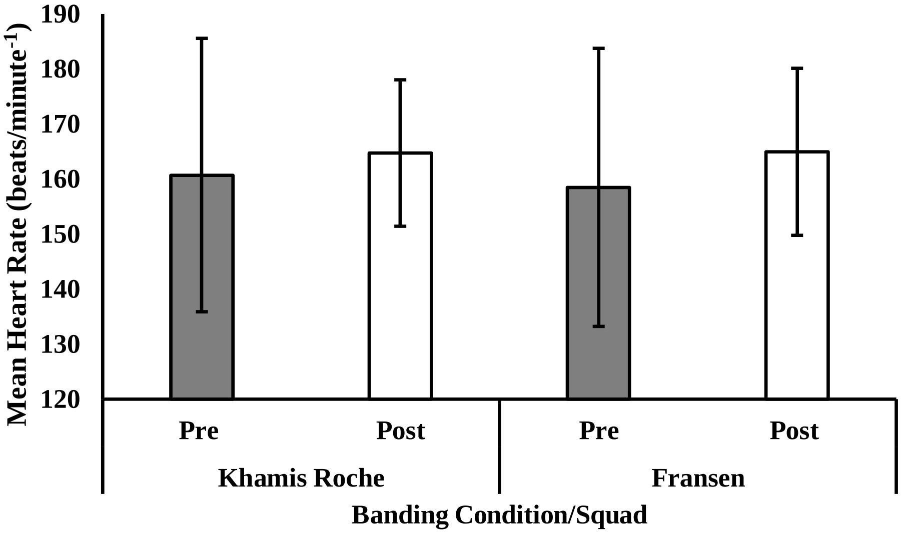


MEAN VALUE (±S.D); * INDICATES A SIGNIFICANT (P < 0.05) DIFFERENCE BETWEEN BANDING/SQUADS.

Figure 4: PlayerLoad™ per metre values from between banding match play across all testing conditions.

There was no significant difference (*P* = 0.08 to 0.44) for meterage per minute between all maturity banded teams across all testing conditions. Effect sizes for this variable ranged from *trivial* to *small (*ES = 0.08 to 0.23*)*. The greatest estimated mean difference registered equated to approximately 20 m during the individual SSG, recorded during the 'mix' week matches between 'group 2' and 'group 3', however again, there was no significant difference between the squads during the 'mix' week (*P* = 0.08).

There was no significant difference (*P* = 0.08 to 0.91) for maximum HR and mean heart rate between all banded squads across all three testing conditions. Effect sizes for these variables ranged from *trivial* to *small* (ES = 0.04 to 0.23). The 'pre' mature players did however have a lower mean HR value compared to 'post' maturity group, as seen in Figure 5.



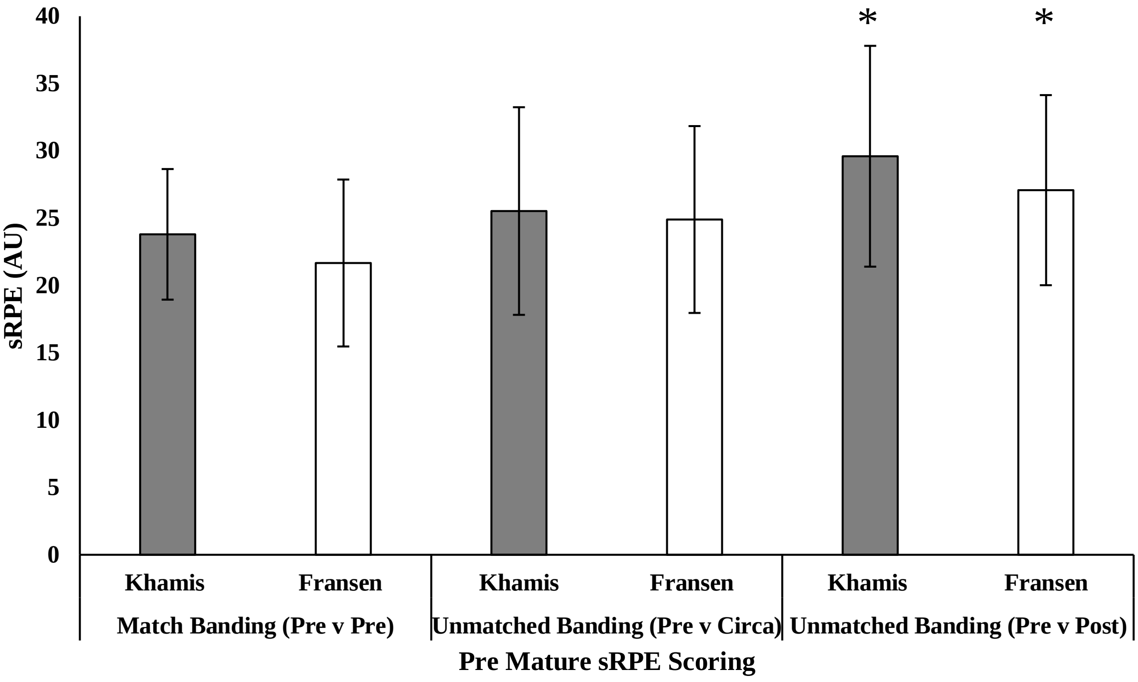
MEAN VALUE (±S. D); * INDICATES A SIGNIFICANT (P<0.05) DIFFERENCE BETWEEN BANDING/SQUADS.

FIGURE 5: Mean heart rate (beats/minute^{-1}) of the pre-phv and post-phv players during both Khamis and Roche (1994) and Fransen et al. (2018) testing weeks

A significant difference was present for maximum velocity values between the ‘pre’ (4.8 m.sec^{-1} ± 0.5) and ‘circa’ (5.0 m.sec^{-1} ± 0.6) groups in the Khamis and Roche (1994) banding conditions. (*P* = 0.05; ES = 0.43 *small)* There was no significant difference between the Fransen et al. (2018) or mix testing conditions between these two groups. For ‘pre’ against ‘post’ matches, there was again no significant difference (P = 0.11) for maximum velocity with effect sizes equalling *small.* (ES = 0.33 to 0.37 *small*) During ‘post’ and ‘circa’ matches, significant differences were found during the Khamis and Roche (1994) method, (‘post’: 5.1 m.sec^{-1} ± 0.5; ‘circa’: 4.8 m.sec^{-1} ± 0.6; *P* = 0.03, ES = 0.48 *small*) but not during the Fransen et al. (2018) method testing week.

High speed running (>13 km.h^{-1}) measures presented no significant difference between any testing group across all testing conditions. Effect sizes ranged from *trivial* to *small* (ES = 0.01 to 0.26). No significant differences were found during the ‘mix’ week also (*P* = 0.25 to 0.77). Other high intensity measures including acceleration and decelerations (>2m.sec^{-1}) presented only two instances of significant difference. The first presentation was for decelerations in the Khamis and Roche (1994) testing conditions between ‘pre’ maturing (0.2 counts ± 0.5) and ‘circa’ (0.5 counts ± 0.8) (*P* = 0.04, ES = 0.45 *small*). The second significant difference was for accelerations between ‘pre’ (0.5 counts ± 0.7) and ‘post’ (1.1 counts ± 0.7) players (*P* = 0.04, ES = 0.61 *moderate*). The remaining fixtures and banding methods were considered insignificantly different (P = 0.13 to 0.74) with effect sizes ranged from *trivial* to *small.*

The session rating of perceived exertion values, as seen in Figure 6, returned some significant differences between banded groups. For ‘pre’ against ‘circa’ matches, a significant difference was present for both the Khamis and Roche (1994) (Pre = 25.5 ± 7.2 au; Circa = 19.9 ± 6.7 au; $P \leq 0.001$, ES = 0.81 *moderate*) and Fransen et al. (2018) (Circa = 24.9 ± 6.6 au; Post = 21.3 ± 9.0 au; *P* = 0.03, ES = 0.46 *moderate*) conditions, with the ‘pre’ squad recording a higher sRPE value. ‘Pre’ and ‘post’ maturing teams had an even greater difference in estimated mean value differences and also presented significant differences (Khamis and Roche (1994): pre = 29.6 ± 8.2 au; Post = 16.6 ±6.5 au; $P \leq 0.001$, ES = 1.74 *large;* Fransen et al. (2018): pre = 27.1 ± 7.1 au; Post = 19.5 ± 4.3 au; $P \leq 0.001$, ES = 1.30 *large)*. Again, the ‘pre’ group recorded the highest sRPE value. The ‘circa’ v ‘post’ conditions also identified significant differences (Khamis and Roche (1994): Circa = 25.2 ± 7.9 au; Post = 18.9 ± 5.2au; $P \leq 0.001$, ES = 0.95 *moderate;* Fransen et al. (2018): Circa = 26.0 ± 8.1 au; Post = 21.6 ± 5.9 au; $P = 0.003$, ES = 0.63 *moderate)*. The ‘circa’ squads scored an on average higher sRPE value compared to the ‘post’ squads. There was no significant difference between any of the ‘mix’ week matches with effect sizes ranging from *trivial* to *small.*



* Indicates significance ($P < 0.05$) compared to Maturity matched banding fixtures.

FIGURE 6: Session rating of perceived effort (au) value from 48 measures in biologically matched fixtures between pre-PHV players and matches against circa-PHV and post-PHV squads.

In total, the control condition involving the 'mix' testing conditions provided only one instance of significant difference between the group's match play variables. This occurred for maximum speed values between 'group 2' and 'group 3' ('group 2': 4.9 $m.sec^{-1}$ ± 0.5; 'group 3': 5.2 $m.sec^{-1}$ ± 0.5; $P = 0.03$, ES = 0.46 *small*). The remaining variables demonstrated no statistical difference ($P = 0.06$ to 0.97) with effect sizes ranging from *trivial* to *small* (ES = 0.01 to 0.48).

4.1.3 GAME TECHNICAL SCORING CHART

The technical skill of the players across all bandings and testing weeks provided very little statistical differences or considerable effect sizes. There were only three instances of a significant difference and only two instances of effect sizes being greater than *small.* During the 'pre' v 'circa' Fransen et al. (2018) banded week, as seen in Table 4, there was a significant difference between the 'shooting' scores ($P = 0.02$; ES = 0.75 *moderate*). Table 5 displays shooting also provided a significant difference between the 'post' and 'pre' teams during the Khamis and Roche (1994) testing week ($P = 0.05$; ES = 0.58 *small).* A significant difference was also present for the 'assist' technical variable during the 'circa' against 'post' match during the Fransen et al. (2018) testing weeks, as highlighted in Table 6 ($P = 0.05$; ES = 0.89 *moderate*). No trends in the data were detectable and the majority of results were far from significance. There was no significance or effect sizes greater than *small* during the mix weeks for 'group 1 v 'group 2', 'group 1' v 'group 3' or the 'group 2' v 'group 3' conditions.

Table 4: Pre-PHV v circa fixture game technical scoring chart values for the 24 players per grouping, across all testing conditions

	Khamis & Roche (1994)		**Fransen et al. (2018) et al (2018)**		**Mix**	
Variable	**Pre**	**Circa**	**Pre**	**Circa**	**Pre (Group 1)**	**Circa (Group 2)**
Control (AU) (n = 45)	2.7 (±0.9)	2.9 (±0.8)	2.6 (±0.7)	2.6 (±0.9)	2.8 (±0.4)	2.6 (±0.9)
	P = 0.281; ES = 0.230 *small*		*P* = 0.698; ES = 0.08 *trivial*		*P* = 0.230; ES = 0.25 *small*	
Communication (AU) (n = 48)	2.5 (±0.9)	2.7 (±0.9)	2.4 (±0.9)	2.5 (±0.9)	2.5 (±0.7)	2.5 (±0.9)
	P = 0.409; ES = 0.17 *trivial*		*P* = 0.363; ES = 0.19 *trivial*		*P* = 0.897; ES = 0.25 *small*	
Decision Making (AU) (n = 47)	2.8 (±0.8)	2.9 (±0.9)	2.6 (±0.8)	2.8 (±0.9)	2.7 (±0.8)	2.8 (±0.8)
	P = 0.513; ES = 0.14 *trivial*		*P* = 0.561; ES = 0.12 *trivial*		*P* = 0.904; ES = 0.03 *trivial*	
Passing (AU) (n = 48)	3.0 (±0.8)	3.00 (±0.8)	2.9 (±0.9)	2.8 (±1.0)	3.0 (±0.9)	2.8 (±0.8)
	P = 0.802; ES = 0.05 *trivial*		*P* = 0.616; ES = 0.10 *trivial*		*P* = 0.347; ES = 0.19 *trivial*	
1st Touch (AU) (n = 47)	3.0 (±0.8)	3.0 (±0.8)	3.1 (±0.8)	3.0 (±0.9)	3.1 (±0.8)	2.9 (±1.0)
	P = 0.805; ES = 0.05 *trivial*		*P* = 0.486; ES = 0.14 *trivial*		*P* = 0.184; ES = 0.27 *small*	
Control (AU) (n = 42)	3.0 (±0.9)	2.9 (±0.9)	3.2 (±0.9)	2.9 (±0.9)	3.2 (±1.0)	2.8 (±1.0)
	P = 0.911; ES = 0.03 *trivial*		*P* = 0.056; ES = 0.43 *small*		*P* = 0.680; ES = 0.43 *small*	
1v1 (AU) (n = 43)	2.8 (±1.0)	3.0 (±0.8)	2.8 (±0.8)	2.8 (±0.9)	3.0 (±0.8)	2.7 (±1.0)
	P = 0.243; ES = 0.26 *small*		*P* = 0.914; ES = 0.02 *trivial*		*P* = 0.180; ES = 0.34 *small*	
Shooting (AU) (n = 25)	2.8 (±0.8)	2.9 (±0.9)	**2.8 (±0.8)**	**3.4 (±0.9)**	3.0 (±0.9)	3.1 (±0.9)
	P = 0.659; ES = 0.13 *trivial*		***P* = 0.015*; ES = 0.75 *moderate***		*P* = 0.746; ES = 0.09 *trivial*	
Assist (AU) (n = 14)	2.5 (±0.7)	2.9 (±0.9)	2.9 (±0.5)	3.0 (±0.7)	3.5 (±0.7)	3.4 (±0.6)
	P = 0.161; ES = 0.59 *small*		*P* = 0.538; ES = 0.23 *small*		*P* = 0.561; ES = 0.22 *small*	
Marking (AU) (n = 44)	2.6 (±0.8)	2.7 (±0.7)	2.6 (±0.7)	2.5 (±0.9)	2.6 (±0.7)	2.7 (±0.9)
	P =0.603; ES = 0.12 *trivial*		*P* = 0.496; ES = 0.14 *trivial*		*P* = 0.614; ES = 0.11 *trivial*	

MEAN VALUES (± S.D) ****BOLD TEXT*** *INDICATES A SIGNIFICANT (P<0.05) DIFFERENCE BETWEEN BANDINGS/SQUADS. ES = EFFECT SIZE. Trivial <0.2, Small 0.2-0.6, Moderate 0.6-1.2, Large 1.2-2.0, Very Large >2.0. (Hopkins, Marshall, Batterham, & Hanin, 2009)*

Table 5: Pre-PHV v post fixture game technical scoring chart values for the 24 players per grouping, across all testing conditions

	Khamis & Roche (1994)		Fransen et al (2018)		Mix	
Variable	**Pre**	**Post**	**Pre**	**Post**	**Pre (Group 1)**	**Post (Group 3)**
Control (AU) ***(n = 48)***	2.7 (±0.8)	2.8 (±0.7)	2.7 (±0.9)	2.8 (±1.0)	2.9 (±0.9)	2.6 (±0.8)
	P = 0.815; ES = 0.05 *trivial*		*P* = 0.643; ES = 0.10 *trivial*		*P* = 0.129; ES = 0.31 *small*	
Communication (AU) ***(n = 48)***	2.3 (±0.8)	2.6 (±0.9)	2.3 (±0.9)	2.6 (±1.0)	2.7 (±0.9)	2.6 (±1.0)
	P = 0.062; ES = 0.39 *small*		*P* = 0.172; ES = 0.28 *small*		*P* = 0.172; ES = 0.28 *small*	
Decision Making (AU) ***(n = 48)***	2.6 (±0.9)	2.7 (±0.9)	2.7 (±0.8)	2.8 (±0.9)	2.8 (±0.8)	2.7 (±0.9)
	P = 0.778; ES = 0.06 *trivial*		*P* = 0.793; ES = 0.05 *trivial*		*P* = 0.562; ES = 0.12 *trivial*	
Passing (AU) ***(n = 48)***	2.7 (±0.8)	2.8 (±0.8)	3.0 (±0.9)	2.7 (±1.0)	2.8 (±0.8)	2.7 (±0.9)
	P = 0.686; ES = 0.08 *trivial*		*P* = 0.274; ES = 0.23 *small*		*P* = 0.495; ES = 0.14 *trivial*	
1st Touch (AU) ***(n = 48)***	2.9 (±0.8)	2.9 (±0.8)	3.2 (±0.9)	2.9 (±1.0)	3.0 (±1.1)	2.9 (±0.9)
	P = 0.769; ES = 0.06 *trivial*		*P* = 0.157; ES = 0.30 *small*		*P* = 0.612; ES = 0.10 *trivial*	
Control (AU) ***(n = 42)***	2.6 (±0.8)	2.8 (±0.8)	2.9 (±0.9)	2.8 (±1.1)	3.2 (±0.9)	2.9 (±1.0)
	P = 0.349; ES = 0.21 *small*		*P* = 0.650; ES = 0.10 *trivial*		*P* = 0.214; ES = 0.27 *small*	
1v1 (AU) ***(n = 44)***	2.5 (±0.8)	2.8 (±0.8)	2.6 (±0.9)	3.0 (±1.0)	2.9 (±0.9)	2.7 (±1.0)
	P = 0.130; ES = 0.33 *small*		*P* = 0.155; ES = 0.31 *small*		*P* = 0.212; ES = 0.26 *small*	
Shooting (AU) ***(n = 25)***	**2.8 (±0.8)**	**3.3 (±0.9)**	2.8 (±0.7)	2.9 (±1.1)	3.1 (±0.9)	2.8 (±0.9)
	***P* = 0.05*; ES = 0.58 small**		*P* = 0.728; ES = 0.10 *trivial*		*P* = 0.190; ES = 0.36 *small*	
Assist (AU) ***(n = 14)***	2.5 (±0.8)	2.7 (±1.1)	3.1 (±0.5)	3.3 (±0.8)	3.2 (±0.4)	3.1 (±0.6)
	P = 0.709; ES = 0.17 *trivial*		*P* = 0.676; ES = 0.17 *trivial*		*P* = 0.599; ES = 0.19 *trivial*	
Marking (AU) ***(n = 44)***	2.6 (±0.9)	2.9 (±0.8)	2.5 (±0.8)	2.7 (±0.9)	2.7 (±0.8)	2.5 (±1.0)
	P = 0.116; ES = 0.36 *small*		*P* = 0.249; ES = 0.25 *small*		*P* = 0.351; ES = 0.20 *trivial*	

MEAN VALUES (± S.D) ****BOLD TEXT*** *INDICATES A SIGNIFICANT (P<0.05) DIFFERENCE BETWEEN BANDINGS/SQUADS. ES =* ***EFFECT SIZE.*** *Trivial <0.2, Small 0.2-0.6, Moderate 0.6-1.2, Large 1.2-2.0, Very Large >2.0. (Hopkins, Marshall, Batterham, & Hanin, 2009)*

Table 6: Circa v post fixture game technical scoring chart values for the 24 players per grouping, across all testing conditions

	Khamis & Roche (1994)		**Fransen et al (2018)**		**Mix**	
Variable	**Circa**	**Post**	**Circa**	**Post**	**Circa (Group 2)**	**Post (Group 3)**
Control (AU) ***(n = 47)***	2.8 (±0.8)	2.9 (±0.9)	2.4 (±1.0)	2.7 (±0.9)	2.7 (±0.9)	2.5 (±1.0)
	P = 0.642; ES = 0.10 *trivial*		*P* = 0.670; ES = 0.38 *small*		*P* = 0.437; ES = 0.16 *trivial*	
Communication (AU) ***(n = 47)***	2.6 (±0.8)	2.7 (±0.8)	2.3 (±0.9)	2.6 (±1.1)	2.5 (±1.0)	2.4 (±0.8)
	P = 0.832; ES = 0.04 *trivial*		*P* = 0.133; ES = 0.31 *small*		*P* = 0.513; ES = 0.13 *trivial*	
Decision Making (AU) ***(n = 48)***	2.8 (±0.7)	2.7 (±0.8)	2.4 (±0.9)	2.7 (±0.9)	2.7 (±0.8)	2.7 (±0.8)
	P = 0.578; ES = 0.11 *trivial*		*P* = 0.249; ES = 0.24 *small*		*P* = 1.00; ES = 0.00 *trivial*	
Passing (AU) ***(n = 47)***	2.9 (±0.7)	2.9 (±0.8)	2.9 (±1.0)	2.8 (±1.0)	2.8 (±0.9)	2.7 (±0.8)
	P = 1.00; ES = 0.00 *trivial*		*P* = 0.914; ES = 0.02 *trivial*		*P* = 0.726; ES = 0.07 *trivial*	
1st Touch (AU) ***(n = 48)***	3.0 (±0.8)	2.9 (±0.8)	2.7 (±0.9)	2.9 (±1.0)	2.7 (±1.1)	2.7 (±0.8)
	P = 0.590; ES = 0.11 *trivial*		*P* = 0.537; ES = 0.13 *trivial*		*P* = 0.914; ES = 0.07 *trivial*	
Control (AU) ***(n = 41)***	2.9 (±0.9)	2.9 (±0.8)	2.6 (±0.9)	2.9 (±1.0)	2.9 (±1.0)	2.9 (±0.8)
	P = 0.861; ES = 0.04 *trivial*		*P* = 0.181; ES = 0.30 *small*		*P* = 0.810; ES = 0.05 *trivial*	
1v1 (AU) ***(n = 44)***	2.7 (±0.7)	2.8 (±0.8)	2.6 (±0.9)	2.8 (±1.0)	2.7 (±1.0)	2.9 (±0.9)
	P = 0.723; ES = 0.08 *trivial*		*P* = 0.233; ES = 0.26 *small*		*P* = 0.377; ES = 0.18 *trivial*	
Shooting (AU) ***(n = 25)***	2.8 (±1.0)	3.0 (±0.8)	2.9 (±1.0)	3.0 (±1.0)	3.1 (±1.0)	3.0 (±0.8)
	P = 0.594; ES = 0.15 *trivial*		*P* = 0.569; ES = 0.17 *trivial*		*P* = 0.752; ES = 0.08 *trivial*	
Assist (AU) ***(n = 16)***	2.8 (±0.8)	2.9 (±0.9)	**2.6 (±0.8)**	**3.3 (±0.7)**	3.2 (±0.8)	3.1 (±0.7)
	P = 0.573; ES = 0.22 *small*		***P* = 0.044*; ES = 0.89 *moderate***		*P* = 0.625; ES = 0.16 *trivial*	
Marking (AU) ***(n = 44)***	2.6 (±0.8)	2.9 (±0.8)	2.3 (±0.9)	2.5 (±0.9)	2.7 (±1.0)	2.6 (±1.0)
	P = 0.166; ES = 0.30 *small*		*P* = 0.376; ES = 0.19 *trivial*		*P* = 0.747; ES = 0.07 *trivial*	

MEAN VALUES (± S.D) ****BOLD TEXT** INDICATES A SIGNIFICANT (P<0.05) DIFFERENCE BETWEEN BANDINGS/SQUADS. ES =* ***EFFECT SIZE.*** *Trivial <0.2, Small 0.2-0.6, Moderate 0.6-1.2, Large 1.2-2.0, Very Large >2.0. (Hopkins, Marshall, Batterham, & Hanin, 2009)*

4.1.4 GAME PSYCHOLOGICAL SCORING CHART

Psychological scores did not differ significantly during the ‘pre’ v ‘circa’ matches for any of the testing conditions. For variables ‘positive attitude’, ‘confidence’ and ‘competitiveness’, the effect size was *trivial* across both Khamis and Roche (1994) and Fransen et al. (2018) conditions (ES = 0.00 to 0.15). Only during the Fransen et al. (2018) testing week for the variable ‘x-factor’, was the effect size *small* (P = 0.26; ES = 0.24). During the ‘pre’ v ‘post’ Khamis and Roche (1994) fixtures, there was significant differences between scores for a number of variables; ‘positive attitude’ (‘Pre’ = 3.1 ± 1.0 au, ‘post’ = 2.4 ± 0.8 au; $P \leq 0.001$; ES = 0.75 *moderate),* ‘confidence’ (‘Pre’ = 3.0 ± 1.1 AU, ‘post’ = 2.6 ± 1.2 AU; P = 0.03; ES = 0.47 *small*) and ‘competitiveness’ (‘Pre’ = 3.0 ± 1.0 AU, ‘post’ = 2.4 ± 0.9; P = 0.05; ES = 0.59 *small*). ‘X-factor’ was the only variable during this banding method not registering a significant difference (‘Pre’ = 2.4 ± 1.1 AU, ‘post’ = 2.1 ± 1.0 AU; P = 0.16; ES = 0.30 *small*). The ‘pre’ v ‘post’ Fransen et al. (2018) banding conditions, presented no significant difference, with effect sizes ranging from *trivial* to *small.* There was also no significant difference nor effect sizes greater than *small* during the ‘circa’ v ‘post’ conditions. The matches between the ‘mixed’ squads produced no significant differences in results with effect sizes ranging from *trivial* to *small.*

4.1.5 TACTICAL ANALYSIS

For ‘pre’ against ‘circa’ matches during both the Khamis and Roche (1994) and Fransen et al. (2018) banding weeks, there was no significant difference for the measured variables (P = 0.11 to 0.93; ES = *trivial* to *small*). The ‘pre’ v ‘post’ matches produced some instances of significant variation in the results. Spatial exploration analysis was statistically insignificant (P = 0.63; ES = 0.11 *trivial*) during the Khamis and Roche (1994) method, however, it was considered significantly (*P* = 0.01; ES = 0.65 *moderate*) in the Fransen et al. (2018) testing conditions (Pre = 5.9 ± 1.1 AU; Post = 5.2 ± 1.0 AU). Distance to nearest teammate (m) was significantly different during the Khamis and Roche (1994) testing method (*P* = 0.02; ES = 0.55 *small*) with the 'pre' team registering a mean value of 7.0 ± 1.2 m compared to the 'post' squads 6.4 ± 1.2 m. There was no significant difference between the squads during the Fransen et al. (2018) method. Distance to nearest opponent (m) was statistically insignificant (*P* = 0.24 to 0.66) during both testing conditions. There was also no significant difference (P = 0.09 to 0.63) for distance to centroid (m) and distance to opponent's centroid (m) across both testing conditions. During the 'circa' versus 'post' matches, only two notable differences were recorded. Both of these differences occurred during the Fransen et al. (2018) testing conditions. Distance to teammate produced a significant ('circa' = 6.3 ± 0.9 m, 'post' = 6.9 ± 0.6 m; *P* = 0.02; ES = 0.89 *moderate*) difference, as did distance to centroid (m). ('circa' = 5.6 ± 0.7 m, 'post' = 6.2 ± 0.7 m; *P* = 0.04; ES = 0.78 *moderate*) Distance to opponent and distance to opponent centroid were statistically insignificantly (*P* = 0.08 to 0.95) different. There was no significant (*P* = 0.17 to 0.65) differences identified within the mix week matches, with effect sizes ranging from *trivial* to *small.*

4.2 ‘MIXED' MATCH ANALYSIS (BY MATURITY STATUS)

Analysis was conducted on the individual maturational bands (pre, circa and post) within the ‘mixed’ match play fixtures to highlight any differing responses in the measured variables to players within teams of mixed maturity.

4.2.1 EXTERNAL AND INTERNAL LOADING

Table 7 conveys the physical metrics collected from the different maturational bands within the ‘mixed’ week fixtures. ‘Post’ (mature) players excelled in terms of physical qualities, recording the greatest values for total distance (m), high speed running (m), meterage per minute ($m.min^{-1}$) and maximal velocity. ‘Pre’ mature players scored the opposite, presenting with lower total values. The ‘pre’ players however did experience the greatest PlayerLoad™, even with their lower physical values. They also continued to perceive the matches to be the most challenging, when compared to the other biological banded players.

4.2.2 GAME TECHNICAL SCORING CHART

Table 8 displays the game technical scoring chart values for the different maturational banded players within the ‘mixed’ week fixtures. The ‘post’ players recorded the highest scoring for seven of the ten technical variables, with the ‘pre’ players scoring the lowest overall marks for nine of the ten technical variables. The ‘post’ maturation players are significantly better scored for communication, shooting and marking.

4.2.3 GAME PSYCHOLOGICAL SCORING CHART

The ‘post’ mature players were rated the highest for three of the four psychological attributes within the ‘mixed’ match play. The ‘pre’ mature players scored the lowest values for all four psychological variables in within the ‘mixed’ week matches. Table 9 conveys the respective values and significance in difference.

4.2.4 TACTICAL ANALYSIS

No significance difference (P = 0.19 to 0.94) was found between the maturational bandings, nor were any trends of particular interest. Effect sizes between maturity bands were all scored as *trivial*.

TABLE 7: **External and internal loading values for the players of each maturational stage group within the mix testing matches**

Metric	Pre	Circa	Post
Total Distance (m)	449.0 (± 58.1). Post^{T}, Circa^{T}	450.5 (± 62.5) Post^{T}, Pre^{T}	457.6 (± 55.2) Circa^{T}, Pre^{T}
Total Player Load (AU)	60.8 (± 9.8) **Post*^{S},** Circa^{T}	59.7 (± 9.1) **Post*^{S},** Pre^{T}	55.6 (± 9.2) **Circa*^{S}, Pre*^{S}**
Meterage per Minute (m.min^{-1})	88.3 (± 12.5) Post^{T}, Circa^{T}	89.6 (± 13.1) Post^{T}, Pre^{T}	89.6 (± 11.6) Circa^{T}, Pre^{T}
Mean Heart Rate (beats/minute^{-1})	151.3 (± 23.5) **Post*^{S},** Circa^{S}	156.1 (± 23.3) Post^{S}, Pre^{S}	161.1 (± 15.0) Circa^{S}, **Pre*^{S}**
Maximum Velocity (m.sec^{-1})	4.9 (± 0.5) **Post*^{S},** Circa^{T}	4.8 (± 0.5) **Post*^{M},** Pre^{T}	5.2 (± 0.6) **Circa*^{M}, Pre*^{S}**
High Speed Running (m)	33.0 (± 18.5) **Post*^{S},** Circa^{T}	30.2 (± 17.2) **Post*^{S},** Pre^{T}	40.6 (± 20.2) **Circa*^{S}, Pre*^{S}**
Accelerations (>2m.sec^{-1}) (Count)	0.6 (± 0.8) **Post*^{T},** Circa^{T}	0.6 (± 0.9) **Post*^{T},** Pre^{T}	0.9 (± 1.1) **Circa*^{T}, Pre*^{T}**
Decelerations (>2m.sec^{-1}) (Count)	0.4 (± 0.6) Post^{T}, Circa^{S}	0.2 (± 0.5) **Post*^{S},** Pre^{S}	0.4 (± 0.6) **Circa*^{S},** Pre^{T}
sRPE (AU)	22.8 (± 6.3) Post^{S}, Circa^{T}	22.6 (± 6.8) Post^{T}, Pre^{T}	21.3 (± 6.1) Circa^{T}, Pre^{S}

MEAN VALUES (± S.D) ****BOLD TEXT INDICATES A SIGNIFICANT ($P<0.05$) DIFFERENCE BETWEEN BANDINGS/SQUADS.*** *EFFECT SIZE: ^{T} = TRIVIAL, ^{S} = SMALL, ^{M} = MODERATE, ^{L} = LARGE, ^{VL} = VERY LARGE TRIVIAL <0.2, SMALL 0.2-0.6, MODERATE 0.6-1.2, LARGE 1.2-2.0, VERY LARGE >2.0.* ***(HOPKINS, MARSHALL, BATTERHAM, & HANIN, 2009)***

TABLE 8: **Game technical scoring chart values for the players of each maturational stage within the mix testing matches**

Variable	Pre	Circa	Post
Cover	2.5 (± 0.8) Post^{S}, Circa^{S}	2.7 (± 0.8) Post^{T}, Pre^{S}	2.8 (± 1.0) Circa^{T}, Pre^{S}
Communication	2.3 (± 0.8) **Post*^{S},** Circa^{S}	2.6 (± 0.8) Post^{T}, Pre^{S}	2.7 (± 0.9) Circa^{T}, **Pre*^{S}**
Decision Making	2.6 (± 0.7) Post^{S}, Circa^{S}	2.8 (± 0.8) Post^{T}, Pre^{S}	2.8 (± 0.9) Circa^{T}, Pre^{S}
Passing	2.7 (± 0.8) Post^{S}, Circa^{S}	2.9 (± 0.8) Post^{T}, Pre^{S}	3.0 (± 0.9) Circa^{T}, Pre^{S}
1st Touch	2.8 (± 0.9) Post^{T}, Circa^{T}	3.0 (± 0.9) Post^{T}, Pre^{T}	2.9 (± 1.0) Circa^{T}, Pre^{T}
Control	2.9 (± 0.9) Post^{T}, Circa^{S}	3.1 (± 0.9) Post^{T}, Pre^{S}	3.0 (± 1.0) Circa^{T}, Pre^{T}
1v1	2.7 (± 0.9) Post^{S}, Circa^{T}	2.8 (± 0.9) Post^{T}, Pre^{T}	2.9 (± 1.0) Circa^{T}, Pre^{S}
Shooting	2.8 (± 0.9) **Post*^{S}**, Circa^{S}	3.0 (± 0.8) Post^{S}, Pre^{S}	3.2 (± 0.9) Circa^{S}, **Pre*^{S}**
Assist	3.2 (± 0.6) Post^{T}, Circa^{T}	3.1 (± 0.8) Post^{S}, Pre^{T}	3.4 (± 0.7) Circa^{S}, Pre^{T}
Marking	2.5 (± 0.8) **Post*^{S}**, Circa^{S}	2.7 (± 0.8) Post^{T}, Pre^{S}	2.8 (± 0.9) Circa^{T}, **Pre*^{S}**

MEAN VALUES (± S.D) ****BOLD TEXT INDICATES A SIGNIFICANT (P<0.05) DIFFERENCE BETWEEN BANDINGS/SQUADS.*** *EFFECT SIZE: ^{T} = TRIVIAL, ^{S} = SMALL, ^{M} = MODERATE, ^{L} = LARGE, ^{VL} = VERY LARGE. Trivial <0.2, Small 0.2-0.6, Moderate 0.6-1.2, Large 1.2-2.0, Very Large >2.0. (Hopkins, Marshall, Batterham, & Hanin, 2009)*

TABLE 9: Game psychological scoring chart values for the players of each maturational stage within the mix testing matches

Variable	Pre	Circa	Post
Positive Attitude	2.5 (± 0.9) **Post*^{S}, Circa*^{S}**	3.0 (± 1.0) Post^{T}, **Pre*^{S}**	3.0 (± 1.0) Circa^{T}, **Pre*^{S}**
Confidence	2.5 (± 0.9) **Post*^{S}, Circa*^{S}**	2.8 (± 1.0) Post^{T}, **Pre*^{S}**	2.9 (± 1.0) Circa^{T}, **Pre*^{S}**
Competitive	2.6 (± 1.0) **Post*^{S},** Circa^{T}	2.8 (± 1.0) Post^{T}, Pre^{T}	2.9 (± 1.1) Circa^{T}, **Pre*^{S}**
X-Factor	2.1 (± 1.0) Post^{S}, **Circa*^{S}**	2.5 (± 1.0) **Pre*^{S}**, Post^{T}	2.4 (± 1.1) Circa^{T}, Pre^{S}

MEAN VALUES (± S.D) ****BOLD TEXT INDICATES A SIGNIFICANT (P<0.05) DIFFERENCE BETWEEN BANDINGS/SQUADS.*** *EFFECT SIZE: ^{T} = TRIVIAL, ^{S} = SMALL, ^{M} = MODERATE, ^{L} = LARGE, ^{VL} = VERY LARGE. Trivial <0.2, Small 0.2-0.6, Moderate 0.6-1.2, Large 1.2-2.0, Very Large >2.0. (Hopkins, Marshall, Batterham, & Hanin, 2009)*

4.3 MATCHED MATURITY BANDING ANALYSIS

In addition to the ‘between banding’ findings, further analysis was conducted on the matched banding data. This analysis examines the results in matched fixtures, where squads competed against opposition of the same maturational stage, compared to the results when they competed against the other bandings.

4.3.1 PRE-PHV SQUADS BIOLOGICALLY MATCHED RESULTS

4.3.2 EXTERNAL AND INTERNAL LOADING

An incremental trend was found for session rating of perceived exertion. ‘Pre’ players perceived matched banding matches to be the least demanding. As shown in Figure 6, when ‘pre’ players compete against players of a more advanced maturational development stage, their perception of the effort required increased. This effect was present across both the Khamis and Roche (1994) and Fransen et al. (2018) testing conditions. In the largest biological mismatch, ‘pre’ v ‘post’ squads, this sRPE value difference is statistically significant (*P = 0.04)* with effect sizes classified as *moderate* (ES = 0.82 to 0.88).

‘Pre’ players covered a statistically significant (*P = 0.01 to 0.03*) total distance (m) difference, with effect sizes ranging from *small* to *moderate* during biologically matched fixtures (ES = 0.55 to 0.68). In addition to this, the meterage per minute is also highest in this condition compared to when ‘pre’ players competed against ‘circa’ and ‘post’ squads.

Intensity of work, including high speed running (m) and meterage per minute (m.min^{-1}) was also primarily greater for the ‘pre’ players during the maturity matched testing weeks, in comparison to matches against other biological banded squads .

As shown in Table 10, the maximum velocity was also recorded for the ‘pre’ maturing group within their matched banding week, for both testing conditions. Maximum velocity was significantly (*P = 0.03*) slower when competing against the ‘post’ group, albeit the effect size was classified as *small.* (ES = 0.52) No discernible trend was present for accelerations and decelerations (>2m.sec^{-1}).

4.3.3 GAME TECHNICAL SCORING CHART

For seven of the ten technical variables, matched banding fixtures provided the highest, or joint highest score, when compared to fixtures against the different maturational banded teams. Table 11 highlights the scored values and significance of difference; however, most differences were reported as statistically insignificant (*P = 0.06 to 0.99*) with effect sizes ranging from *trivial* to *small.* Variables ‘first touch’ and ‘assist’ provided mixed results with the highest score across the banded weeks showing no clear trend. The poorest technical values appeared to be most frequent when ‘pre’ players competed against the ‘post’ squads.

4.3.4 GAME PSYCHOLOGICAL SCORING CHART

During matched banding fixtures, as seen in Table 12, ‘pre’ players scored higher values for ‘confidence’ in the Khamis and Roche (1994) week and their joint highest score in the Fransen et al. (2018) week, compared to matches against ‘circa’ and ‘post’ groups. Differences were statistically insignificant (*P* > 0.05) with effect sizes ranging from *trivial* to *small* (ES = 0.08 to 0.48).

‘Competitiveness’ and ‘positive attitude’ were scored highest again, when in matched fixtures, however again, differences were statistically insignificant (*P = 0.22 to 0.76*) with effect sizes ranging from *trivial* to *small* (ES = 0.13 to 0.43).

‘X-factor’ was highest in matched banding play for Khamis and Roche (1994), however, was second highest in the Fransen et al. (2018) week, with the highest score being recorded in the match against ‘post’ maturity opposition.

4.3.5 TACTICAL ANALYSIS

No clear trend was present when the spatial data was analysed. No significant differences were present, with all effect sizes ranging from trivial to small. Table 13 displays the values present for matched week compared to matches against opposition banded groups.

TABLE 10: Pre-PHV internal and external matched banded values compared to values against the other maturity banded squads

		Pre v Pre	**Pre v Circa**			**Pre v Post**		
Banding Method	**Metric**	**Mean Value**	**Mean Value**	**Significance**	**ES**	**Mean Value**	**Significance**	**ES**
Khamis	**Meterage per Minute (m.min^{-1})**	99.0 (± 19.6)	91.2 (± 12.1)	0.081	*0.50 Small*	88.6 (± 12.4)	0.07	*0.66 Mod*
Fransen		94.6 (± 10.3)	89.2 (± 7.3)	**0.013***	*0.61 Moderate*	88.8 (± 11.1)	***0.03****	*0.54 Small*
Khamis	**Total Distance (m)**	499.7 (± 92.6)	457.3 (± 60.0)	**0.025***	*0.55 Small*	448.7 (± 56.)	**0.006***	*0.68 Mod*
Fransen		477.4 (± 54.7)	449.7 (± 36.4)	**0.013***	*0.61 Moderate*	445.4 (± 55.9)	**0.025***	*0.58 Small*
Khamis	**Total Player Load (AU)**	61.1 (± 9.0)	59.4 (± 10.0)	*0.510*	*0.17 Trivial*	60.4 (± 9.5)	0.782	*0.07 Trivial*
Fransen		61.3 (± 8.2)	59.1 (± 11.5)	*0.420*	*0.22 Small*	59.6 (± 8.3)	0.415	*0.21 Small*
Khamis	**Maximum Velocity (m.sec^{-1})**	5.2 (± 1.1)	4.8 (± 0.5)	0.097	*0.52 Small*	4.8 (± 0.5)	**0.033***	*0.52 Small*
Fransen		5.0 (± 0.5)	4.8 (± 0.5)	0.227	*0.30 Small*	4.9 (± 0.7)	0.529	*0.16 Trivial*
Khamis	**Mean Heart Rate (beats/minute^{-1})**	159.2 (± 23.1)	160.8 (± 23.9)	0.802	*0.07 Trivial*	159.9 (± 25.1)	0.919	*0.03 Trivial*
Fransen		158.7 (± 28.8)	161.8 (± 22.1)	0.634	*0.12 Trivial*	158.5 (± 25.3)	0.978	*0.01 Trivial*
Khamis	**High Speed Running (m)**	38.5 (± 22.1)	35.5 (± 24.2)	0.613	*0.13 Trivial*	28.6 (± 14.2)	**0.026***	*0.55 Small*
Fransen		31.6 (± 17.1)	29.8 (± 16.4)	0.665	*0.11 Trivial*	36.6 (± 21.8)	0.332	*0.26 Small*
Khamis	**Decelerations (>2m.sec^{-1}) (Count)**	0.3 (± 0.5)	0.2 (± 0.5)	0.714	*0.10 Trivial*	0.3 (± 0.5)	0.945	*0.02 Trivial*
Fransen		0.3 (± 0.6)	0.2 (± 0.4)	0.359	*0.22 Small*	0.4 (± 0.6)	0.657	*0.11 Trivial*
Khamis	**Accelerations (>2m.sec^{-1}) (Count)**	0.6 (± 0.7)	0.8 (± 1.0)	0.392	*0.21 Small*	0.5 (± 0.6)	0.359	*0.23 Small*
Fransen		0.3 (± 0.7)	0.4 (± 0.6)	0.767	*0.07 Trivial*	0.9 (± 0.8)	**0.006***	*0.73 Moderate*

MEAN VALUES (± S.D) ***BOLD TEXT** *INDICATES A SIGNIFICANT (P<0.05) DIFFERENCE BETWEEN BANDINGS/SQUADS. ES = EFFECT SIZE.*
Trivial <0.2, Small 0.2-0.6, Moderate 0.6-1.2, Large 1.2-2.0, Very Large >2.0. (Hopkins, Marshall, Batterham, & Hanin, 2009)

TABLE 11: Pre-PHV game technical scoring chart matched banded values compared to values against the other maturational banded squads

		Pre v Pre		**Pre v Circa**			**Pre v Post**	
Banding Method	**Metric**	**Mean Value**	**Mean Value**	**Significance**	**ES**	**Mean Value**	**Significance**	**ES**
Khamis	**Decision Making (AU)**	2.9 (± 0.9)	2.8 (± 0.8)	0.665	*0.11 Trivial*	2.6 (± 0.9)	0.316	*0.25 Small*
Fransen		2.9 (± 0.8)	2.6 (± 0.8)	0.28	*0.28 Small*	2.7 (± 0.8)	0.478	*0.18 Trivial*
Khamis	**Cover (AU)**	2.8 (± 0.8)	2.7 (± 0.9)	0.784	*0.07 Trivial*	2.8 (± 0.8)	0.957	*0.01 Trivial*
Fransen		3.0 (± 0.8)	2.6 (± 0.7)	0.032	*0.54 Small*	2.7 (± 0.9)	0.175	*0.35 Small*
Khamis	**Communication (AU)**	2.6 (± 0.9)	2.5 (± 0.9)	0.504	*0.17 Trivial*	2.4 (± 0.8)	0.166	*0.34 Small*
Fransen		2.5 (± 0.8)	2.4 (± 0.9)	0.684	*0.10 Trivial*	2.3 (± 0.9)	0.463	*0.19 Trivial*
Khamis	**Passing (AU)**	3.0 (± 0.8)	3.0 (± 0.8)	0.99	*0.00 Trivial*	2.8 (± 0.8)	0.394	*0.21 Small*
Fransen		3.0 (± 0.9)	2.9 (± 0.9)	0.571	*0.15 Trivial*	3.0 (± 0.9)	0.708	*0.10 Trivial*
Khamis	**1st Touch (AU)**	2.9 (± 0.9)	3.0 (± 0.8)	0.563	*0.14 Trivial*	3.0 (± 0.8)	0.618	*0.12 Trivial*
Fransen		3.1 (± 0.9)	3.1 (± 0.8)	0.842	*0.05 Trivial*	3.2 (± 0.9)	0.903	*0.03 Trivial*
Khamis	**Control (AU)**	3.1 (± 0.8)	3.0 (± 0.9)	0.692	*0.11 Trivial*	2.7 (± 0.8)	0.072	*0.48 Small*
Fransen		3.0 (± 0.9)	3.2 (± 0.9)	0.408	*0.23 Small*	2.9 (± 0.9)	0.836	*0.06 Trivial*
Khamis	**1v1 (AU)**	3.0 (± 0.9)	2.8 (± 1.0)	0.415	*0.21 Small*	2.5 (± 0.8)	0.044	*0.53 Small*
Fransen		2.8 (± 0.8)	2.8 (± 0.8)	0.955	*0.02 Trivial*	2.6 (± 0.9)	0.428	*0.23 Small*
Khamis	**Shooting (AU)**	2.9 (± 1.0)	2.8 (± 0.8)	0.634	*0.16 Trivial*	2.8 (± 0.8)	0.556	*0.20 Trivial*
Fransen		2.9 (± 0.9)	2.8 (± 0.8)	0.598	*0.18 Trivial*	2.8 (± 0.7)	0.546	*0.19 Trivial*
Khamis	**Assist (AU)**	3.2 (± 0.5)	2.5 (± 0.7)	0.045	*1.31 Large*	2.5 (± 0.9)	0.09	*1.16 Moderate*
Fransen		3.0 (± 0.6)	2.9 (± 0.5)	0.546	*0.24 Small*	3.1 (± 0.5)	0.546	*0.24 Small*
Khamis	**Marking (AU)**	2.8 (± 2.8)	2.6 (± 0.8)	0.494	*0.18 Trivial*	2.6 (± 0.9)	0.524	*0.17 Trivial*
Fransen		2.9 (± 0.8)	2.6 (± 0.7)	0.192	*0.06 Trivial*	2.5 (± 0.8)	0.062	*0.52 Small*

MEAN VALUES (± S.D) ****BOLD TEXT*** *INDICATES A SIGNIFICANT (P<0.05) DIFFERENCE BETWEEN BANDINGS/SQUADS. ES = EFFECT SIZE.*
Trivial <0.2, Small 0.2-0.6, Moderate 0.6-1.2, Large 1.2-2.0, Very Large >2.0. (Hopkins, Marshall, Batterham, & Hanin, 2009)

TABLE 12: **Pre-PHV game psychological scoring chart matched banded values compared to values against the other maturational banded squads**

		Pre v Pre		**Pre v Circa**			**Pre v Post**	
Banding Method	**Metric**	**Mean Value**	**Mean Value**	**Significance**	**ES**	**Mean Value**	**Significance**	**ES**
Khamis	**Confidence**	3.2 (± 1.1)	2.9 (± 0.9)	0.231	*0.30 Small*	3.0 (± 1.1)	*0.758*	*0.08 Trivial*
Fransen		3.0 (± 1.0)	2.8 (± 1.1)	0.386	*0.22 Small*	3.0 (± 1.1)	*0.583*	*0.14 Trivial*
Khamis	**Competitive**	3.2 (± 1.1)	2.8 (± 1.0)	0.221	*0.31 Small*	3.0 (± 1.0)	*0.523*	*0.16 Trivial*
Fransen		3.0 (± 1.1)	2.7 (± 1.1)	0.275	*0.28 Small*	3.0 (± 1.0)	*0.431*	*0.20 Small*
Khamis	**Positive Attitude**	3.4 (± 0.9)	3.0 (± 0.9)	0.089	*0.43 Small*	3.2 (± 1.0)	0.324	*0.25 Small*
Fransen		3.0 (± 1.0)	2.7 (± 1.1)	0.326	*0.25 Small*	2.9 (± 1.1)	0.601	*0.13 Trivial*
Khamis	**X-Factor**	2.6 (± 1.1)	2.3 (± 1.0)	0.305	*0.27 Small*	2.4 (± 1.1)	0.536	*0.16 Trivial*
Fransen		2.4 (± 1.2)	2.3 (± 1.1)	0.889	*0.04 Trivial*	2.4 (± 1.3)	0.940	*0.02 Trivial*

MEAN VALUES (± S.D) ****BOLD TEXT*** *INDICATES A SIGNIFICANT (P<0.05) DIFFERENCE BETWEEN BANDINGS/SQUADS. ES = EFFECT SIZE.*
Trivial <0.2, Small 0.2-0.6, Moderate 0.6-1.2, Large 1.2-2.0, Very Large >2.0. (Hopkins, Marshall, Batterham, & Hanin, 2009)

TABLE 13: Pre-PHV tactical analysis matched banded values compared to values against the other maturational banded squads

		Pre v Pre		**Pre v Circa**			**Pre v Post**	
Banding Method	**Metric**	**Mean Value**	**Mean Value**	**Significance**	**ES**	**Mean Value**	**Significance**	**ES**
Khamis	**SEI**	5.6 (± 0.9)	6.2 (± 1.4)	0.093	*0.56 Small*	5.4 (± 1.1)	0.558	*0.17 Trivial*
Fransen		5.8 (± 0.8)	6.2 (± 0.7)	0.057	*0.58 Small*	5.9 (± 1.1)	0.541	*0.18 Trivial*
Khamis	**Distance to Nearest Teammate (m)**	6.1 (± 1.0)	6.7 (± 1.2)	0.081	*0.56 Small*	6.6 (± 1.2)	0.45	*0.23 Small*
Fransen		6.8 (± 2.3)	6.5 (± 0.9)	0.523	*0.21 Small*	6.3 (±1.0)	0.286	*0.30 Small*
Khamis	**Distance to Nearest Opponent (m)**	4.5 (± 1.0)	4.7 (± 0.9)	0.343	*0.29 Small*	4.5 (± 0.8)	0.775	*0.08 Trivial*
Fransen		5.0 (± 2.0)	4.6 (± 0.9)	0.335	*0.31 Small*	4.4 (± 1.0)	0.129	*0.42 Small*
Khamis	**Distance to Centroid (m)**	5.7 (± 1.3)	6.1 (± 1.4)	0.288	*0.33 Small*	5.9 (±1.4)	0.540	*0.18 Trivial*
Fransen		6.3 (± 2.6)	6.1 (± 1.1)	0.645	*0.15 Trivial*	5.7 (± 1.0)	0.231	*0.34 Small*
Khamis	**Distance to Opponent Centroid (m)**	7.1 (± 2.1)	7.3 (± 1.9)	0.772	*0.09 Trivial*	7.0 (± 1.9)	0.836	*0.06 Trivial*
Fransen		7.9 (± 3.2)	7.4 (± 1.7)	0.505	*0.21 Small*	6.7 (± 1.9)	0.101	*0.45 Small*

MEAN VALUES (± S.D) ****BOLD TEXT*** *INDICATES A SIGNIFICANT (P<0.05) DIFFERENCE BETWEEN BANDINGS/SQUADS. ES = EFFECT SIZE.*
Trivial <0.2, Small 0.2-0.6, Moderate 0.6-1.2, Large 1.2-2.0, Very Large >2.0. (Hopkins, Marshall, Batterham, & Hanin, 2009)

4.4 POST-PHV SQUADS BIOLOGICALLY MATCHED RESULTS

4.4.1 EXTERNAL AND INTERNAL LOADING

Total distance covered (m) was greatest during the biologically matched fixtures for the ‘post’ squads, compared to fixtures against the other maturity banded groups. The difference was classed as significantly greater against the ‘circa’ group (P = 0.04), but statistically insignificant against ‘pre’ (P = 0.10).

These ‘post’ players perceived the matched status fixtures to be the most demanding and experienced the greatest physical loading in these games, compared to fixtures against the other maturity banded squads. These differences were however, classified as statistically insignificant (P = 0.23 to 0.76).

The remaining physical variables, including mean HR, high speed running (m) and acceleration/deceleration (count), showed no trend nor significance in differences, between matched and unmatched game play. Table 14 highlights the values of these metrics.

4.4.2 GAME TECHNICAL SCORING CHART

As is shown in Table 15, no significant difference was present between matched and unmatched game play for technical attributes. Khamis and Roche (1994) testing did appear to show a positive trend in performance for matched maturity bio-banding games compared to fixtures against the other banding squads. Cover, communication, decision making, passing, 1st touch and marking were all scored higher than unmatched fixtures, during this testing condition. Fransen et al. (2018) testing scored higher in matched game play for cover, passing, 1st touch and control, compared to unmatched fixtures.

Attacking variables including 1v1's, shooting and assists scored higher when 'post' squads competed against 'pre' teams, with the matched banding fixtures showing a lower mean score for these variables.

4.4.3 GAME PSYCHOLOGICAL SCORING CHART

Matched maturity status games involving the 'post' players presented the highest psychological scoring values for all of the measures during the Khamis and Roche (1994) testing weeks, and for three of the four variables during the Fransen et al. (2018) testing conditions. Only for competitiveness in Khamis and Roche (1994) conditions was this difference significant, however, highlighted in Table 16.

4.4.4 TACTICAL ANALYSIS

During matched fixtures, players recorded a higher spatial exploration index compared to matches against the 'circa' and 'post' opposition. Against 'circa' the effect size was classified as *trivial* and against 'post' the effect was *small*. The Fransen et al. (2018) testing conditions created a significant difference ($P = 0.03$) when compared to the matched fixture. The values are shown in Table 17.

Distance to nearest teammate also registered a significant difference in the Fransen et al. (2018) condition between 'circa' and the matched fixtures. However, this metric showed no trend across the testing conditions. No other trends or significant difference were highlighted within the spatial analysis. The remaining effect sizes range from *trivial* to *small.* These values are available in Figure 18.

TABLE 14: **Post-PHV external and internal loading matched banded values compared to values against the other maturational banded squads**

		Post v Post	**Post v Circa**			**Post v Pre**		
Banding Method	**Metric**	**Mean**	**Mean**	**P Value**	**ES**	**Mean**	**P Value**	**ES**
Khamis	**Total Distance (m)**	478.4 (± 98.7)	437.1 (± 59.6)	0.036	*0.52 Small*	445.8 (± 62.0)	0.098	*0.41 Small*
Fransen		458.1 (± 57.5)	453.1 (± 59.1)	0.762	*0.09 Trivial*	441.3 (± 70.9)	0.363	*0.26 Small*
Khamis	**Total Player Load (AU**	56.6 (± 10.3)	54.2 (± 11.2)	0.389	*0.23 Small*	55.0 (± 11.1)	0.557	*0.15 Trivial*
Fransen		56.8 (± 10.4)	55.3 (± 9.6)	0.606	*0.14 Trivial*	53.3 (± 11.8)	0.274	*0.31 Small*
Khamis	**Meterage per Minute ($m.min^{-1}$)**	95.0 (± 19.6)	87.1 (± 11.8)	**0.042**	*0.51 Small*	87.1 (± 12.4)	**0.043**	*0.50 Small*
Fransen		90.6 (± 11.8)	89.9 (± 11.8)	0.848	*0.05 Trivial*	87.8 (± 14.2)	0.446	*0.22 Small*
Khamis	**Mean Heart Rate (beats/minute^{-1})**	161.6 (± 25.2)	157.7 (± 21.0)	0.507	*0.17 Trivial*	165.3 (± 13.4)	0.432	*0.19 Trivial*
Fransen		171.7 (± 11.9)	165.6 (± 10.4)	0.059	*0.55 Small*	165.0 (± 15.2)	0.095	*0.50 Small*
Khamis	**Maximum Velocity ($m.sec^{-1}$)**	5.1 (± 0.7)	5.1 (± 0.5)	0.881	*0.04 Trivial*	5.1 (± 0.6)	0.940	*0.02 Trivial*
Fransen		5.1 (± 0.6)	5.2 (± 0.6)	0.618	*0.14 Trivial*	5.1 (± 0.7)	0.765	*0.09 Trivial*
Khamis	**sRPE (AU)**	19.0 (± 5.9)	18.9 (± 5.2)	0.939	*0.02 Trivial*	17.3 (± 7.6)	0.349	*0.25 Small*
Fransen		23.3 (± 6.4)	21.6 (± 5.9)	0.248	*0.29 Small*	19.5 (± 4.3)	**0.011**	*0.05 Trivial*
Khamis	**High Speed Running (m)**	33.0 (± 21.7)	37.6 (± 20.8)	0.406	*0.21 Small*	38.1 (± 20.9)	0.353	*0.24 Small*
Fransen		39.8 (± 23.5)	40.8 (± 24.5)	0.874	*0.04 Trivial*	36.8 (± 19.0)	0.595	*0.14 Trivial*
Khamis	**Accelerations (>2m.sec^{-1})(Count)**	0.9 (± 0.8)	0.9 (± 0.9)	0.826	*0.06 Trivial*	1.1 (± 1.1)	0.410	*0.20 Small*
Fransen		1.1 (± 1.0)	1.1 (± 1.2)	0.766	*0.09 Trivial*	1.0 (± 1.1)	0.923	*0.03 Trivial*
Khamis	**Decelerations (>2m.sec^{-1})(Count)**	0.1 (± 0.5)	0.5 (± 0.6)	**0.019**	*0.60 Small*	0.4 (± 0.6)	0.066	*0.46 Small*
Fransen		0.4 (± 0.5)	0.3 (± 0.5)	0.961	*0.01 Trivial*	0.4 (± 0.7)	0.769	*0.09 Trivial*

MEAN VALUES (± S.D) ****BOLD TEXT*** *INDICATES A SIGNIFICANT (P<0.05) DIFFERENCE BETWEEN BANDINGS/SQUADS. ES = EFFECT SIZE. TRIVIAL <0.2, SMALL 0.2-0.6, MODERATE 0.6-1.2, LARGE 1.2-2.0, VERY LARGE >2.0.* ***(HOPKINS, MARSHALL, BATTERHAM, & HANIN, 2009)***

TABLE 15: Post-PHV game technical scoring chart matched banded values compared to values against the other maturational banded squads

		Post v Post	**Post v Circa**			**Post v Pre**		
Banding Method	**Metric**	**Mean**	**Mean**	**P Value**	**ES**	**Mean**	**P Value**	**ES**
Khamis	**Cover (AU)**	3.1 (± 0.6)	2.9 (± 0.9)	0.191	*0.32 Small*	2.7 (± 0.7)	**0.033**	*0.56 Small*
Fransen		3.0 (± 0.8)	2.7 (± 0.9)	0.452	*0.19 Trivial*	2.8 (± 1.0)	0.596	*0.14 Trivial*
Khamis	**Communication (AU)**	2.7 (± 0.8)	2.7 (± 0.8)	0.944	*0.02 Trivial*	2.6 (± 0.9)	0.747	*0.08 Trivial*
Fransen		2.5 (± 1.0)	2.6 (± 1.1)	0.818	*0.06 Trivial*	2.6 (± 1.0)	0.803	*0.06 Trivial*
Khamis	**Decision Making (AU)**	3.0 (± 0.7)	2.7 (± 0.8)	0.293	*0.28 Small*	2.6 (± 0.9)	0.077	*0.44 Small*
Fransen		2.6 (± 0.8)	2.7 (± 0.9)	0.922	*0.03 Trivial*	2.8 (± 0.9)	0.509	*0.17 Trivial*
Khamis	**Passing (AU)**	3.0 (± 0.8)	2.9 (± 0.8)	0.483	*0.18 Trivial*	2.8 (± 0.8)	0.232	*0.31 Small*
Fransen		2.9 (± 0.9)	2.8 (± 1.0)	0.699	*0.10 Trivial*	2.7 (± 1.0)	0.468	*0.19 Trivial*
Khamis	**1st Touch (AU)**	3.0 (± 0.8)	2.9 (± 0.8)	0.582	*0.14 Trivial*	2.8 (± 0.9)	0.360	*0.23 Small*
Fransen		2.9 (± 0.9)	2.9 (±1.0)	0.920	*0.03 Trivial*	2.9 (± 1.0)	0.982	*0.01 Trivial*
Khamis	**Control (AU)**	2.9 (± 0.6)	2.9 (± 0.8)	0.943	*0.02 Trivial*	2.8 (± 0.8)	0.568	*0.16 Trivial*
Fransen		3.2 (± 0.8)	2.9 (±1.0)	0.275	*0.32 Small*	2.8 (± 1.1)	0.152	*0.43 Small*
Khamis	**1v1 (AU)**	2.8 (± 0.6)	2.8 (± 0.8)	0.979	*0.01 Trivial*	2.8 (± 0.8)	1.000	*0 Trivial*
Fransen		2.8 (± 0.9)	2.8 (± 1.0)	0.958	*0.01 Trivial*	3.0 (± 1.0)	0.490	*0.19 Trivial*
Khamis	**Shooting (AU)**	2.7 (± 0.8)	3.0 (± 0.8)	0.406	*0.28 Small*	3.3 (± 0.9)	0.067	*0.61 Moderate*
Fransen		2.9 (± 0.8)	3.0 (± 1.0)	0.716	*0.13 Trivial*	2.9 (± 1.1)	0.883	*0.05 Trivial*
Khamis	**Assist (AU)**	2.5 (± 0.6)	2.9 (± 0.9)	0.281	*0.61 Moderate*	2.7 (± 1.1)	0.728	*0.21 Small*
Fransen		3.1 (± 0.7)	3.3 (± 0.7)	0.546	*0.25 Small*	3.3 (± 0.8)	0.644	*0.20 Small*
Khamis	**Marking (AU)**	3.0 (± 0.8)	2.9 (± 0.8)	0.733	*0.09 Trivial*	2.9 (± 0.8)	0.638	*0.13 Trivial*
Fransen		2.6 (± 0.8)	2.5 (± 0.9)	0.595	*0.14 Trivial*	2.7 (± 0.9)	0.813	*0.06 Trivial*

MEAN VALUES (± S.D) ****BOLD TEXT*** *INDICATES A SIGNIFICANT (P<0.05) DIFFERENCE BETWEEN BANDINGS/SQUADS. ES = EFFECT SIZE. Trivial <0.2, Small 0.2-0.6, Moderate 0.6-1.2, Large 1.2-2.0, Very Large >2.0. (Hopkins, Marshall, Batterham, & Hanin, 2009)*

TABLE 16: Post-PHV game psychological scoring chart matched banded values compared to values against the other maturational banded squads

		Post v Post	**Post v Circa**			**Post v Pre**		
Banding Method	**Metric**	**Mean**	**Mean**	**P Value**	**ES**	**Mean**	**P Value**	**ES**
Khamis	**Positive Attitude**	2.8 (± 0.9)	2.7 (± 0.9)	0.427	*0.20 Small*	2.4 (± 0.8)	0.048	*0.50 Small*
Fransen		2.9 (± 1.0)	2.8 (± 1.1)	0.641	*0.12 Trivial*	2.8 (± 0.9)	0.846	*0.02 Trivial*
Khamis	**Confidence**	2.9 (± 1.0)	2.7 (± 0.9)	0.420	*0.20 Small*	2.5 (± 1.0)	0.161	*0.35 Small*
Fransen		2.9 (± 0.9)	2.9 (± 1.1)	0.938	*0.02 Trivial*	2.9 (± 1.0)	0.939	*0.15 Trivial*
Khamis	**Competitive**	3.0 (± 0.9)	2.6 (± 0.9)	0.063	*0.47 Small*	2.4 (± 0.9)	**0.004**	*0.76 Moderate*
Fransen		2.9 (± 1.1)	2.8 (± 1.1)	0.696	*0.10 Trivial*	2.8 (± 1.0)	0.559	*0.02 Trivial*
Khamis	**X-Factor**	2.5 (± 0.8)	2.1 (± 1.0)	0.067	*0.50 Small*	2.1 (± 1.0)	0.113	*0.43 Small*
Fransen		2.3 (± 0.7)	2.0 (± 1.1)	0.243	*0.34 Small*	2.0 (± 1.0)	0.168	*0.39 Small*

MEAN VALUES (± S.D) ****BOLD TEXT*** *INDICATES A SIGNIFICANT (P<0.05) DIFFERENCE BETWEEN BANDINGS/SQUADS. ES = EFFECT SIZE. Trivial <0.2, Small 0.2-0.6, Moderate 0.6-1.2, Large 1.2-2.0, Very Large >2.0. (Hopkins, Marshall, Batterham, & Hanin, 2009)*

TABLE 17: Post-PHV tactical analysis matched banded values compared to values against the other maturational banded squads

		Post v Post	Post v Circa			Post v Post		
Banding Method	**Metric**	**Mean**	**Mean**	**P Value**	**Banding Method**	**Metric**	**Mean**	**Mean**
Khamis	**SEI (AU)**	5.8 (± 1.5)	5.7 (± 0.9)	0.587	*0.15 Trivial*	5.5 (± 1.0)	0.238	*0.31 Small*
Fransen		6.0 (± 1.1)	5.9 (± 1.0)	0.765	*0.11 Trivial*	5.2 (± 1.0)	**0.030**	*0.72 Small*
Khamis	**Distance to Nearest Teammate (m)**	6.9 (± 1.1)	6.9 (± 1.1)	0.839	*0.06 Trivial*	7.0 (± 1.1)	0.743	*0.09 Trivial*
Fransen		6.6 (± 0.5)	6.9 (± 0.6)	0.070	*0.68 Moderate*	6.4 (± 0.8)	0.638	*0.17 Trivial*
Khamis	**Distance to Nearest Opponent (m)**	5.2 (± 1.8)	4.8 (± 1.3)	0.378	*0.24 Small*	4.8 (± 1.2)	0.387	*0.23 Small*
Fransen		4.5 (± 0.8)	4.8 (± 0.9)	0.351	*0.34 Small*	4.5 (± 1.0)	0.971	*0.01 Trivial*
Khamis	**Distance to Centroid (m)**	6.3 (± 1.4)	6.3 (± 1.3)	0.875	*0.04 Trivial*	6.3 (± 1.2)	0.848	*0.05 Trivial*
Fransen		5.9 (± 0.8)	6.2 (± 0.7)	0.215	*0.44 Small*	5.8 (± 0.9)	0.939	*0.03 Trivial*
Khamis	**Distance to Opponent Centroid (m)**	7.8 (± 2.8)	7.4 (± 2.5)	0.519	*0.18 Trivial*	7.2 (± 2.1)	0.315	*0.27 Small*
Fransen		6.9 (± 1.5)	7.4 (± 1.6)	0.412	*0.29 Small*	7.1 (± 2.3)	0.848	*0.07 Trivial*

*MEAN VALUES (± S.D) ***BOLD TEXT** INDICATES A SIGNIFICANT (P<0.05) DIFFERENCE BETWEEN BANDINGS/SQUADS. ES = EFFECT SIZE.*
Trivial <0.2, Small 0.2-0.6, Moderate 0.6-1.2, Large 1.2-2.0, Very Large >2.0. (Hopkins, Marshall, Batterham, & Hanin, 2009)

5 DISCUSSION

The maturity status of academy soccer players has been shown to influence the talent identification processes (Unnithan, Drust, White, Iga, & Georgiou, 2012; Meylan, Cronin, Oliver, & Hughes, Reviews: Talent Identification in Soccer: The Role of Maturity Status on Physical, Physiological and Technical Characteristics, 2010). Therefore, this study aimed to provide supporting evidence to support or refute the effectiveness of bio-banding, in SSGs, as a tool for talent (de)selection. The aim of the present thesis was to investigate the technical, tactical, psychological and internal and external physical responses to the bio-banding process in academy soccer players across several clubs in England and Scotland, during SSGs. Through the analysis of the data and critique of the results, several key findings can be reported.

1) Findings highlight the difference in perception of effort required in small sided match play between players of different maturational stages. Furthermore, the players in different maturity bandings not only perceive matches in a significantly different manner, their physical experience, particularly relating to physical loading, is substantially different.
2) The psychology of players is very much determined by the level of opposition, with mature players demonstrating lower levels of competitiveness and positivity when compared against the ‘pre’ mature groups, only for these levels of competitiveness to be enhanced when in maturity matched game play. ‘Pre’ players’ present high scoring psychological values against the ‘post’ opposition in between maturity banding games, however, their highest psychological scoring occurs in the matched maturity banding games.

3) Technical and tactical performances can differ, dependant on the match play setup. When in mixed match play, similar to the current chronological setup of youth soccer, biologically developed players are seen by the technical staff as better quality, with more desirable attributes, compared to less developed players. However, in biologically matched banding fixtures, the majority of technical and psychological variables are scored higher for all maturity groups, suggesting evidence for bio-banding as a sensitive tool for talent identification method, by showcasing the true technical ability of players, when not impacted by the psychological and physical constraints of the opposition.
4) Finally, it appeared that the method employed to estimate the maturity status of participants led to some instances of a differing maturity status being attached to players, however these differences did not extend to variation within physical, technical, psychological or tactical differences.

5.1 AGE AND ANTHROPOMETRICS

The use of both the Khamis and Roche (1994) and Fransen et al. (2018) anthropometric based maturity prediction calculations led to the creation of physically different player pools. With this, it allowed the study to compare the effect that the differences in biological development, including, but not limited to these physical differences have on the identification of talent and the opinion of qualified coaches on player's skill levels. The 'mixed' groupings were representative of a 'control' group, made up of a multitude of physical and biological profiles.

Firstly, it is important to address the age difference between the bio-banded groups. This spread from youngest to oldest being relatively large, may be the primary factor influencing the results. However, this can possibly be explained by the variation in mean age, within the clubs involved in the study. A significant ($P \leq 0.01$) difference was present between the mean age values (see Appendix 4) of the three clubs, however, this was not reflective in the results, where random variance analysis concluded the collected data was not influenced by the individual clubs, suggesting the same trends and findings were present in the youth academies, independent of the chronological age of the participants. The oldest player within Hamilton Academicals testing group was around two years older than the oldest participant from Hull City. With this, mean ages of the maturity groups may be skewed.

The differences created during the Khamis and Roche (1994) conditions highlighted the substantial physical and developmental advantage of being amongst the most developed, post-PHV players. The 'pre' players, who were predicted to be at 85.83% of their estimated adult stature, were almost 10% off their EASA, compared to the 'post' players, who had a mean EASA of 94.06% ($P \leq 0.001$). The Fransen et al. (2018) conditions also created physical imbalances, favouring 'post' maturing players. 'Pre' players consistently scored the lowest for age, stature, mass and years from peak height velocity. These findings agree with the literature that shows the physical discrepancies, such as stature and mass, that exists in youth athletes when arranged by maturity status (Helsen, Van Winckel, & Williams, 2005; Gil, et al., 2014). Similar results were shown in a longitudinal study by Malina et al. (2004). Players who were further into their maturational development expressed greater stature (PH (pubic hair stage) 1 stature = 155.8 cm; PH5 stature = 175.9 cm) and mass (PH1 mass = 43.5 kg; PH5 mass = 63.9 kg) despite only being, on average, three months older. As was highlighted in the research findings of Towlson et al. (2018), players are growing in stature by around 8.6 $\text{cm}\cdot\text{year}^{-1}$ from 3.2 years before APHV and 7.5 $\text{kg}\cdot\text{year}^{-1}$ from 1.6 years before APHV. This means players who are post-PHV will have undergone this massive growth period with those pre-PHV, yet to fully develop these physical traits. Importantly, as shown in Figure 1, the tempo and instensity of these physical gains increases towards PHV, then tapers off. This means reaching PHV earlier allows for these physical developments at an earlier stage compared to later maturing players, regardless of chronological age. It is this growth curve and its intensification around PHV that can allow for this aforementioned 10% difference in EASA to occur between the maturity banded groups.

These physical advantages that can bring instant success at youth level, are a primary driver for the selection bias, favouring more developed players. These physically bigger players, who are more likely to be selected to the talent development programmes (Coelho E Silva, et al., 2010) are able to demonstrate their maturity enhanced physical traits such as speed and power better than the pre-PHV, or less developed players, who have not reached the intensified period of their physical development curve. (Malina, Eisenmann, Cumming, Ribeiro, & Aroso, 2004; Meyers R. W., Oliver, Hughes, Cronin, & Lloyd, 2014). It is this lack of desirable traits that allow for the more developed players to be selected at the crucial talent development and (de)selection period (Deprez, Fransen, Lenoir, Philippaerts, & Vaeyens, 2015). As previously stated, these beneficial traits related to the physical profile of developed players can result in these individuals relying on their physical advantages and neglecting technical, tactical or psychological development, rendering them more likely to be deselected in the future, when others have caught up biologically and developed technically and tactically (Figueiredo, Coelho-E-Silva, Sarmento, Moya, & Malina, 2019).

By bio-banding the players therefore, a physically fair platform is created allowing players to demonstrate and develop their technical and tactical abilities. However, it must be accepted that physical disparity will manifest at the senior and professional level of soccer and this challenge being completely eradicated from youth soccer development may not be entirely beneficial to a player's learning process.

5.2 TALENT IDENTIFICATION

5.2.1 BETWEEN MATURITY BANDING ANALYSIS

The primary analysis conducted on the ‘between banding’ fixtures highlighted very few differences between the squads, with only a few instances of significance in performance being evident.

Figure 4 relayed one of the most significant findings, showing players experience physical loading, the summation of external load as computed by PlayerLoad™, differently, dependant on their stage of maturational development. There is a significant increase in loading for players who are ‘pre’ PHV compared to ‘post’ players. This is also true for ‘circa’ individuals who were also identified as experiencing a significantly greater load in comparison to the mature players. This highlighted that the ‘pre’ and ‘circa’ players may be completing the SSG matches with poorer movement efficiency, in comparison to the ‘post’ players. With external loading metrics indicating a lack of significant difference between the biological bandings, it can be understood that this increased loading is not associated with a greater level of work done.

A relationship is also seen between PlayerLoad™ values and player’s perception of exertion, as measured by RPE. An increased RPE scoring is conveyed in Figure 4, with a significant difference ($P < 0.05$) between the ‘pre’ players to both ‘circa’ and most significantly, the ‘post’ group. This could indicate that the ‘pre’ group and ‘circa’ group experienced greater levels of perceived exertion compared to the ‘post’ group and as such, their movement patterns became less efficient, resulting in a higher PlayerLoad™ value. The scale used in RPE collection for the study has been questioned for its reliability and use in younger populations (Pivarnick, Womack, Reeves, & Malina, 2002) with the OMNI scale possibly offering a more favourable method of evaluation (Robertson, Utter, Nieman, &

Kang, 2002). However, with the players involved in the study being pre-exposed to the CR-10 scale it was selected to provide continuity and familiarity

One possible explanation for the maturity-dependant differences could be due to the adolescent awkwardness period, where the rapid growth, especially of the lower limbs, creates gawkiness in movement (Butterfield, 2015). This could lead to players moving in a manner less efficient and controlled, compared to mature players who have surpassed this stage of development and have built up greater competence of their motor control. As players develop, strength improvements and muscle growth, such as increased trunk strength, may allow for better and more efficient postural and movement control (Philippaerts R. M., et al., 2006; Meyers R. W., Oliver, Hughes, Lloyd, & Cronin, 2016). This increase in muscle development may explain why the 'circa' players, who should be the group impacted the most by adolescence awkwardness still performing more physical work and at higher intensities than the 'pre' group.

The idea has support in the literature with research by Ryan et al., (2018) also highlighting physical performance differences between youth soccer players of differing maturity bands. Their results concluded that movement quality as assessed by a functional movement screen™ (FMS™) was similar for 'pre' and 'circa' players, with both groups scoring a lower value than the 'post' group. However, *large* to *very large* differences were present between the three groups for physical traits. The research group suggested that whilst their appears to be movement related issues for 'pre' and 'circa' pubertal athletes, the increase in muscle mass with maturational development may offset the diminishment of physical attributes for 'circa' players, compared to 'pre' players.

This information could have a potentially critical impact on injury reduction in youth sports, where athletes are exposed to the same training stimuli, however, through the maturational differences, the less developed athletes experience a greater overall load. In turn, ‘pre’ and ‘circa’ players may fatigue quicker and with this, comes an increased injury risk (Marshall, Lovell, Jeppson, Anderson, & Siegler, 2014; Barrett, et al., 2016). This knowledge could allow for appropriate training adaptions to be implemented in an attempt reduce this injury risk, reducing days lost to injury and as a consequence, allowing for a greater development period. Through the incorporation of maturity bio-banded events within clubs, players more susceptible to higher loading could be given a needed break from the high demand, possibly reducing injury risk from overloading, with more developed players being provided a stronger training stimulus. Whilst this remains speculative, further investigation into this is seriously required.

Interestingly, this increased perception of effort and load is not matched by an equally greater internal loading value, as measured by HR. Rating of perceived effort has been validated (Vahia, Kelly, Knapman, & Williams, 2019) as a measure of internal response to work, with a *large* strength of association ($r = 0.60$ to 0.73). Figure 4 highlighted this, showing the mean HR for ‘pre’ and ‘post’ players was statistically insignificant ($P > 0.05$) different with a *trivial* effect size between the differences that were present. This increased sRPE may stem from the greater physical load experienced by ‘pre’ players, as calculated by PlayerLoad™, however this is difficult to establish due to the encompassing nature of the Borg CR10 scale, accounting for all effort exertion. A modified RPE scale, the dRPE (Differential Rating of Perceived Exertion) may have allowed for a better understanding of the cause of increased perception of effort. Making use of the CR100 scale, players would score rating of exertion for legs and breathlessness, dissociating between local and central “perceptual exertion” in addition to a match and technical value (Weston, Siegler, Bahnert, McBrien, & Lovell, 2014). By distinguishing the greatest contributor to effort, a more detailed overview of how ‘pre’ and ‘post’ mature players experience load and match play could be produced. Further research into this area may provide differences between how the different biological demands perceive the SSG and if the primary locus of exertion alters with opponent toughness.

With the exception of RPE and PlayerLoad™ values, there was little difference between the bandings for other physical measures. The technical analysis, as viewed in Tables 4 to 6, convey the between banding values of the game technical scoring chart, for all between banding fixtures and between 'mixed' group matches. As is shown, there are no perceptible trends or consistent instances of great effects being recorded. This lack of difference, even between the largest biological maturity mismatch, the 'pre' and 'post' squads, may be due to the SSG pitch constraints. Larger pitch sizes within 4v4 SSG competition have been shown to elicit greater physical responses, that may not be possible to replicate within the dimensions and game duration of this study (Halouani, Chtourou, Dellal, Chaouachi, & Chamari, 2017). The 2004 publication by Owen et al. (2004) has identified that when increasing pitch dimensions and player numbers, physical demands may increase. This could allow a physical talent identification process to occur as players may reach greater velocities and demonstrate greater movement proficiency. However, within the same study, it was shown that the number of technical actions per player were not impacted by pitch size alterations (Owen, Twist, & Ford, Small-Sided Games: The Physiological and technical effect of altering pitch size and player numbers, 2004). This finding of technical actions not being influenced by pitch size was also drawn from another study by Guven et al. (2014). Total passes in a large dimension SSG equated to 76.0 ± 29.6 with 74.6 ± 20.8 in the small dimension SSG. Similarly, the total number of dribble attempts in the large dimension SSG was 12.8 ± 7.1 and 11.3 ± 6.2 for the small dimension game. This suggests that SSG between maturity bands could be adapted to identify physical talent with a change in dimension or player number, however, technical demand and technical ability assessment within SSGs is not made easier by a pitch dimension alteration. This method of small sided game play and bio-banded competition would therefore not be recommended for technical talent identification.

5.3 MIXED MATURITY MATCH ANALYSIS

The 'mixed' match play, between randomly assorted biological-maturity squads, acting as a control to represent soccer in its current mixed-maturity setup, produced no significant difference between the groups for the measured variables. It could be surmised that with the blend of different maturity groups within single squads, technical and scoring values conformed to one another due to the mix of players represented and as such it appeared an even playing field for every player and squad. As can be seen in Figure 3 and Tables 4, 5 and 6, the mixed squads appeared to experience the same physical demands and produce similar technical outputs. However, as has been stated previously, there are maturity dependant differences that can occur within SSG, such as PlayerLoad™ and effort perception. Therefore, analysis of the individual maturity bands within the 'mixed' match play was completed in an attempt to identify trends and significance that may be experienced by individuals within the squad, that have been obscured by the squad mean values.

Within the 'mixed' match play, the main issues faced by 'pre' mature players in the talent selection process and one of the underpinning reasons for this study was highlighted and results presented in Tables 7 to 9. For both technical and psychological scoring, along with physical output, 'pre' mature players presented the lowest scores for almost all variables, as marked by the technical coaching staff. These findings are not surprising, as players on the same soccer field within a similar age group, can be immensely different biologically. As found my Meyers et al. (2014), more mature players were taller (group 1 = 139.1 cm; group 5 = 171.8 cm), heavier (group 1 = 33.8 kg; group 5 = 68.4) and significantly

($P < 0.05$) faster. These maturity differences may be due to the large chronological age differences within the study sample, however, due to the differences in individual's timings and tempo of biological maturation (Towlson, Cobley, Parkin, & Lovell, 2018), these physical imbalances and not inconceivable.

This showing is representative of why a lack of 'late' or 'less' biologically developed players within academies exists (Malina, Bouchard, & Bar-Or, Growth, Maturation and Physical Activity, 2004). The bigger players may be able to exert more influence over the game due to their dominance and as such, make less developed players look poorer. As highlighted by Meylen et al., (2010) the subjective selection process is based upon an image one has of a 'perfect player'. This image is multifaceted, comprising of physical, technical and psychological attributes, amongst others. Previous research has already highlighted the importance placed upon developed physical characteristics and performance to the likelihood of success in youth soccer players (Deprez, Fransen, Lenoir, Philippaerts, & Vaeyens, 2015) in addition to the value placed on psychological traits by coaching and talent identification staff (Larkin & O'Connor, 2017; Towlson C. , Cope, Perry, Court, & Levett, 2019). With these poorer scores, 'pre' players are less likely to be selected by academy staff to engage within the talent development programme.

Psychologically, the 'pre' players appear almost withdrawn from their team, allowing developed players to do the work, with a perceived poor psychological mindset and lack of positive involvement. This appears to be the opposite finding from the "underdog" hypothesis put forward by Gibbs et al, (2011), suggesting later developing players may be more adaptive to learning and challenging scenarios. However, a possible reasoning for this could be explained through the findings by Cumming et al. (2018). They found the association of maturation and self-regulation to be small in magnitude and commented that this more "adaptive self-regulation profile" may not supersede the physical dominance held by mature players (Cumming, et al., 2018). The ‘pre’ players may lose their confidence and positive attitude, if not involved as much as ‘post’ players in SSG play. It has been shown that when bio-banded within a maturity matched game play, technical involvement doubles (Thomas, Oliver, Kelly, & Knapman, 2017; Cumming, et al., 2018). This means exposing the less developed, pre-PHV players to challenging circumstances could promote positive psychological developments that could aid the possible psychological advantages of self-evaluation and adaption, however, only if they are still allowed to compete within the situations.

Conversely, the more developed players appear the most ‘talented’ according to the scoring chart results. In addition to the perceived technical superiority, ‘post’ player’s psychological values present significantly different scores, compared to ‘pre’ mature players. This could have significant bearing on the selection process, due to the value placed upon psychological traits by coaching and recruitment staff (Larkin & O'Connor, 2017; Towlson C. , Cope, Perry, Court, & Levett, 2018). These developed players appear more confident and influential, making them more appealing in a talent selection process. Maturation has previously been shown to exert some influence over technical actions within a SSG setup (Moreira, et al., 2017). The possible maturity related changes may be the primary factor in this, with elevated testosterone levels potentially improving technical skills through potential developments in visuospatial ability and spatial memory and cognition.

The external loading values between the ‘pre’ and ‘post’ players was also greatest when comparing metrics associated with intensity. Differences between maximal velocity, high speed running, and accelerations were significant ($P < 0.05$), however total distance did not differ greatly. This indicates that mature players are more capable of explosive actions and maintaining an intensity throughout SSG. This again relates to the physical capacities of the players due to differences in maturity timing and tempo (Towlson, Cobley, Parkin, & Lovell, 2018) with the ‘post’ players most likely possessing greater muscle mass, strength and power supporting quicker and more powerful actions (Meyers R. W., Oliver, Hughes, Cronin, & Lloyd, 2014). These advantages may be another desirable trait leading to the increased selection of these mature players, due to the significance between the physical capabilities of the players. Deprez et al. (2015) confirmed that players selected were likely to outperform those deselected in terms of physical capacity. When these high-speed actions are transferred into a large sided or full-sized match, they may become more pronounced with the greater space available (Owen, Twist, & Ford, 2004). As such, this may further support developed players for selection. An individual’s physical capacity may also influence the technical actions performed by that player. Previous research (Malina, Eisenmann, Cumming, Ribeiro, & Aroso, 2004; Deprez, et al., 2015) has suggested that early and more developed youth soccer players possess greater aerobic fitness levels than those less biologically developed. These higher fitness levels can act in slowing the onset and impact of fatigue, which has been shown to negatively impact short passing levels in youth soccer players (Rampinini, et al., 2008). The authors highlighted that the performance decrement related to fatigue was associated with the individual’s fitness levels.

These findings highlight the need for a games setup for talent identification, free from influence of maturational development, as a method of drawing out favourable and un-biased physical, technical and psychological displays. With biologically matched SSG, less physically developed players should be provided the platform, free from the unsurmountable physically differences, thus allowing a performance reflective of technical ability. More developed players are also provided with a more challenging opposition, forcing the use of technical, tactical and psychological abilities that may not be required or fully tested in ‘mixed’ or ‘between-banding’ match play. This setup was examined and analysed within the biologically matched banding fixtures.

5.4 MATCHED MATURITY BANDING ANALYSIS

It is shown in Tables 10 through 17 that physical, technical and psychological performance improves on average, when players compete against an opposition team, at a similar stage of biological development. This has been seen with the increased involvement in biological maturity matched youth soccer fixtures (Thomas, Oliver, Kelly, & Knapman, 2017). Work done, the intensity of this work, technical scoring and psychological skills all increase in value, adding to a better standard of performance, as perceived by both data collected on MEMS/GPS devices and technical coaching staff. The reasoning for this is most likely explained by separate justifications, individual to the maturational groups.

Beginning with 'pre' players, their performance against the more biologically developed players, both 'circa' and 'post', are on the whole poorer. They cover less distance, at a slower rate, in addition to scoring lower for most of their technical and tactical variables and also, perceive these matches to be harder. One positive when in competition against the most developed squads, is their psychological scoring, appearing to show the players to be psychologically 'up' for the challenge, scoring higher values than when in competition with 'circa' squads. Unfortunately, this more positive mental mind-set during SSGs against other maturity banded squads does not transpire into an improved performance. This different psychological response compared to the 'mixed' maturity match play results may be due to the less developed players all being grouped within a single squad, competing together and feeling more involved, due to no one player in their team being dominant. Within the 'mixed' match play, the more biologically developed players appear take a greater role within the team. This concept could be confirmed or denied through use of technical analysis on player involvement in maturity 'matched' and 'mixed' SSGs. However, it has been identified that their overall most confident showing is within the biologically matched fixture, when the players can express their abilities without the physical challenge provided by the ‘post’ PHV individuals. This concept of increased confidence has been shown in a 2019 publication examining the player’s opinion of bio-banding tournaments (Bradley, et al., 2019). The results concluded that ‘late maturing’ players found less physical and technical challenge within the maturity matched bio-banded fixtures and were able to express their talents better.

The increased confidence of the players within this study does appear to influence their performance levels, where, in the biologically matched banding competition, the ‘pre’ mature players recorded their best scoring for the majority of their technical skills and also produce their highest external loading outputs. Although not significantly better technical performances in these matched fixtures, the effect of the improvements ranged from *trivial* to *moderate* across both the Fransen et al. (2018) and Khamis and Roche (1994) testing methods. There is also a definitive trend, with seven of the ten variables being scored higher during the matched banding weeks. This greater perception of their performance by the coaches, matched by the physical statistics, may allow this group better success in a small sided game talent identification process. It would therefore be suggested that this method of biological matched fixture for ‘pre’ mature players be used as a method to assess technical and physical traits of players.

An interesting finding relating to this improved performance involves perception of effort. Table 10 shows the matched banding conditions leading to significantly ($P < 0.05$) greater distances being covered, at greater intensities, by a margin of over 11 $m.min^{-1}$ when compared to fixtures against ‘post’ PHV opposition in the Khamis and Roche (1994) testing methods. The player’s perceived effort for these matched games however, as scored by sRPE, is lower than in the matches against other biological bands. This appears to be contradictory, with the players experiencing a greater overall physical load, having completed more work, yet scoring their match as being easier. This finding agrees with the results found in the Bradley et al. (2019) research study, where maturity matched fixtures were found to be physically less demanding. A possible explanation for this could be related to the aforementioned mental challenge and cognitive demand that is experienced in match play, when competing against more developed opposition. With this oppositional challenge removed, there is a corresponding drop in the effort needed in competition. Again, a differentiated method of scoring RPE may have allowed a greater insight to what area of perceived effort is altered with the competition level.

The post-PHV players had a similar response to the matched game play, recording better physical, technical and psychological scoring. Their perception of the SSG demands are increased, a similar finding to research by Abbott et al. (2019). The perceived increased physical challenge was also documented within the Cumming et al. (2017) paper. Due to the greater level of similarly developed opposition, players must rely more on technical and tactical ability. Players also found this setup beneficial in preparation for competition against older and better opponents in the future (Abbott, Williams, Brickley, & Smeaton, 2019). This is important for their development and success within talent development programme, as most pre-PHV or early maturing players are deselected at a later stage, due to reliance on their physical superiority (Carling, le Gall, Reilly, & Williams, 2009; Helsen W. F., et al., 2012). As such, they may not have upskilled their technical and tactical traits, allowing slower developing players to surpass their ability level. However, by exposing the more developed players to a different challenge, this may enforce these changes. Within chronological age soccer matches, this constant challenge is difficult to replicate with the multitude of different levels of biological development.

Post-PHV player’s performance in the ‘between’ maturity banding game play also draws an interesting finding. The results convey the ‘post’ group appear to drop their competitiveness and related psychological skills in matches against the less biologically developed squads. This is also seen with corresponding lower perception of effort (sRPE), as seen in Table 14, less physical loading and a decrease in work rate, compared to the biologically matched game play. It is this drop-in performance levels, that is potentially causing the physical, technical and psychological differences in the between biological banding game play to be insignificant. The ‘post’ group perceive less challenge against the less biologically developed players and in turn lose interest and focus performance in the match, having a detrimental impact on performance. This is also reflected in the psychological scoring of the post-PHV players, with their lowest scoring for the four psychological traits occurring in fixtures against the ‘pre’ squads. This drop in effort is reversed when the oppositional challenge is increased and with this, subjective scoring for the technical variables follows. Connections could be made to the “underdog hypothesis”, however, with an inverse relationship (Cumming, et al., 2018). Due to the perceived reduced physical challenge faced, players may not apply their full ability into the situation. The results do however convey that the attacking skills of mature players are scored higher, when competing against the ‘pre’ and ‘circa’ groups, indicative of the reduced defensive challenge that these teams posed to their more developed counterparts.

The tactical analysis for both banded groups showed very few instances of significant differences, or indeed identifiable trends in the results. Due to the constant close proximity to opposition and team-mates, with the limited pitch space, tactical variables may have been restricted and as such, could explain the lack of novel findings. Had the pitch dimensions been larger, more tactically and technically astute players may stand out with the increased demands on playing style, with longer passes and more area to attack and defend being present. This was confirmed within the publication regarding altering SSG pitch dimensions and playing numbers by Owen et al. (2004). By exposing players to more technical actions, this may allow for more assessment of player’s qualities.

In relation to the hypotheses set out prior to the study:

1) Matched ‘bio-banding’ will reduce the magnitude of difference in technical behaviours between players during SSG match-play. However, these measures for biologically developed players will be greater when matched against their less biologically developed counterparts.

   Partially Accepted – During ‘mixed’ match play, developed players score considerably better that the less developed individuals for technical skills. However, during the ‘between banding’ fixtures, these differences are not as evident. As such, the improvements seen in the ‘matched’ games are only reduced in magnitude compared to the ‘mixed’ testing

2) Matched ‘bio-banding’ will reduce the magnitude of difference for tactical behaviours between players during SSG match-play. However, these measures for biologically developed players will be greater when matched against their less biologically developed counterparts.

   Rejected – Tactical differences were largely unchanged across all testing conditions for all maturity banded squads.

3) Matched ‘bio-banding’ will reduce the magnitude of difference for physical measures between players during SSG match-play. However, these measures for less biologically developed players will be greater when matched against their biologically developed counterparts.

   Rejected – Physical differences are not significantly different between the maturity groups in the ‘unmatched’ and ‘matched’ fixtures. The physical values actually increase for all maturity groups during the maturity ‘matched’ SSGs. Less *biologically developed players produce an increased physical output in 'matched' fixtures.*

4) Matched 'bio-banding' will reduce the magnitude of difference for psychological behaviours between players during SSG match-play. However, these measures for less biologically developed players will be greater when matched against their biologically developed counterparts.

   Unclear – Psychological variance occurs dependant on opposition. Within maturity matched SSGs, psychological scoring increases for maturity groups. However, the magnitude is greatest between developed and less developed players during 'mixed' match play, in favour of the developed players. This is reversed during 'between' maturing game play where the less developed players appear to possess the highest psychological skill scoring. As such, no clear conclusion can be drawn due to the change in scoring within different setups.

5) Matched 'bio-banding' will reduce the magnitude of difference of internal (heart rate and sRPE) and external (GPS metrics i.e. PlayerLoad™ etc.) measures during SSG match-play. However, these measures for less developed players will be greater when matched against their biologically developed counterparts.

   Accepted – This can be clearly seen and supported through the sRPE values and PlayerLoad™ output when less biologically developed players compete against the developed groups. These values are then decreased within the maturity 'matched' game play.

5.5 LIMITATIONS

The study aimed to provide a robust data set, worthy of valid and reliable analysis to successfully answer the proposed research questions. However, as with most research, there were a number of limitations involved in the study.

The predictive maturity equations used in the maturity bio-banding process lack accuracy in their estimation. As such, some players may have been assigned to an incorrect maturity banding group if their predicted maturational stage of development was incorrectly estimated. The Fransen et al. (1994) method, modified and improved from the Mirwald et al. (2002) equation, still has limited accuracy for players, several years away from their APHV (Koziel & Malina, 2018). These equations, making use of age and somatic data in addition to normative growth data, are most accurate for those individuals closest to their APHV (e.g ± 1 year) (Koziel & Malina, 2018). To increase the accuracy, multiple measurements across a time period would be beneficial to track and improve the precision of the measurement as the individuals near their APHV. The Khamis-Roche (1994) method, measuring EASA, has around a 2.2 cm predicted error when compared to their fully developed height. Again, this potential small error may lead to the incorrect maturity banding being assigned to a player if the EASA value is on the threshold of the maturity bandings used in the study. This equation requires the mid-height of the biological parents which may be a potential contributing factor in the error of calculation. If heights are not measured or reported by the parents accurately, the output becomes less reliable. Parents may understand the desire of clubs to select players with the most physical potential and as such, over report their own heights. Epstein et al. (1995) have attempted to correct this by applying an adjustment calculation to account for possible over reporting of parental height. However, as this feature was only available on the data storage for the English clubs, the

Scottish club's parental height values were not adjusted. This method is however a validated predictive equation for biological development.

Secondly, the large overall sample size provided a good level of statsitcial power, however, not all methods of monitoring providing maximal efficiency in the production of results. Devices such as the MEMS units and HR belts did not record full data sets in some matches. In addition, coaches were advised not to score players on technical actions not seen in match play, such as shooting. This in turn led to some variables having a reduced sample size. This had a potential impact on the statistical analysis of the data such as *P*-values (Thiese, Ronna, & Ott, 2016). One such example of this featured in the 'game technical scoring chart' analysis, where there was a large variation in data points (e.g. cover n=50; assist n=12).

Another limitation occurred from the markers of the 'game technical scoring chart' and 'game psychological scoring chart'. All coaches met the qualification criteria; however, each club provided their own marking staff. This could lead to a differing of opinion on technical qualities and perception of talent across the clubs and countries involved in the study. Inter-tester reliability of the GTSC has been shown to be statistically non-significant between coaches scoring one player over three matches (Fenner, Iga, & Unnithan, 2016). Further reliability assessment of the GTSC has shown good (Cronbach's alpha = 0.83 and 0.782) levels of reliability between coaches (Unnithan V. , White, Georgiou, Iga, & Drust, 2012). However, during the same reliability study, significant ($P < 0.05$) differences were present for one assessed match, when using video footage to reassess scoring. A more robust method of this would be to involve the same marking staff at every testing session of every club, however, for this study, this was considered highly unfeasible, but not impossible for future studies.

A fourth limitation involves the common theme of the testing match play setup. The dimensions, player numbers and rules were selected from a previously validated study (Fenner, Iga, & Unnithan, 2016) and provided a sound testing protocol that facilitated the collection of data rich variables. This protocol was also used as it was a familiar setup in youth soccer academies across the United Kingdom. However, as mentioned, the small playing area, short duration and low player numbers may have dampened the response of some of the measured variables. As such, the data collected may not have produced as significant a result had the setup parameters been altered. Owen et al. (2004) have examined the differences in physical outputs and involvement when pitch dimensions and playing numbers are altered. Larger pitch areas allowed for greater physical demands and more opportunity to reach higher velocities, potentially allowing for discrimination between speed characteristics within match play. It has also been shown that larger SSG pitch dimensions create more scenarios for players to perform creative actions, such as dribbling and 1v1's, which may be lost when in constant proximity to teammates and opponents in smaller dimension SSG (Silva, et al., 2014). Nevertheless, the study has still provided the responses seen in 4v4 SSG match play in youth soccer athletes and from it, a number of worthwhile observations have been concluded.

During the post-testing debrief with coaches, to discuss preliminary results of the study, the difficulty in maintaining track of players whilst scoring the technical and psychological levels of the participating players was expressed by the technical staff. It was noted additional marking staff would have alleviated the pressure and led to the scoring being less rushed, possibly resulting in greater quality of marking. However, comparison of the game technical scoring chart and game psychological scoring, to scoring completed via video analysis post-study proved the reliability of the on-field marking results. The results of this comparative analysis are present in Appendix 1.

The study necessitated 72 players with a backup of six players per club. Ideally, these back up players would not have been used, ensuring greater reliability of the results due to the same participants competing in each testing week. However, as with youth soccer, injuries, illness and other absences prevented this. Replacement players were selected from the appropriate maturational banding group, maintaining the study validity, however, these player changes do slightly negate from the ‘gold-standard’ participant group.

5.6 FUTURE RESEARCH

The present study has uncovered novel findings pertaining to the usage of SSG match play in youth soccer, as a potential tool for talent identification. As aforementioned, a limitation to the study related to the dimensions of the playing area and the related space per player. The key variables involved in small sided games include the dimensions of the pitch, the players on the pitch and the duration of time of the matches. If these variables could be altered, it may be possible to see a greater demand placed upon physical qualities (dimensions and duration) and also technical qualities (dimensions and player numbers). This concept has already been proved in previous studies (Owen, Twist, & Ford, 2004; Owen, Wong, McKenna, & Dellal, 2011; Silva, et al., 2014). Greater playing area may allow velocity dependant measures such as high-speed running and maximal velocity to be influenced by maturational differences, due to a greater area and more time and distance to reach higher speeds (Lovell, et al., 2015). This may assist within the decision making process for selection of players to a talent identification process due to the elite/non-elite split between max velocity (Cometti, Maffiuletti, Pousson, Chatard, & Maffulli, 2001). Larger pitch dimensions may also promote greater opportunity for longer passing, dribbling and 1v1’s. Conversely, smaller pitch dimensions increase the shooting chances and need for players to be aware of their surroundings to create space to get on the ball (Silva, et al., 2014). Either of these alterations may change the coach's perception of players in a talent identification process.

Technical analysis throughout this research was subjective to the coaching staff of the clubs involved. Objective assessment of the technical actions such as counts of involvement and actions may allow the analysis of the influence players of differing maturity bands have upon mixed and maturity bio-banded SSGs. Emerging technology may also allow for this process to be simplified and provide further insight into the impact maturity and biological development can have upon the selection process within youth soccer.

Further analysis on the subjective assessment of loading may also be possible through the incorporation of a differentiated RPE scoring system. This could allow a better understanding of how biological development impacts the perception of effort and what the greatest influencing factor is in the scoring of effort. This should breakdown physical and cognitive loading to present a clearer assessment of how the individual elements relating to overall perception of effort contribute to the final scoring.

Finally, a major source of information relating to the maturity bio-banding process has originated from the interviews of players and coaching staff within previous studies (Cumming, Lloyd, Oliver, Eisenmann, & Malina, 2017). A follow up study of the players and coaching staff involved within the present study should allow for the collection of qualitative data relating to the perception of mixed and maturity matched/unmatched SSGs. This could act to inform decision making within the clubs relating to the practices used within training and also setup for selection and deselection processes.

5.7 PRACTICAL APPLICATION

These results may have a practical bearing within youth soccer. ‘Pre’ players can be challenged to work physically harder by competing against matched biologically developed players. From a talent identification perspective, a higher level of technical competency is seen when matched against similarly developed opposition. This setup could allow for a more representative showing of true ability for talent identification programmes, where players technical traits are not masked by the opposition’s maturational status and possible physical advantages. They can, however, be challenged psychologically by competing against more developed players. During this setup, the underdog hypothesis of creating more adaptive ‘late’ or ‘less’ developed players (Cumming, et al., 2018). This setup though does create a problem for the mature players, as they lower their performance levels due to the ‘lesser’ seeming opposition.

‘Post’ players can be challenged physically and technically by ‘matched’ banding competition, in a similar manner to the ‘pre’ mature players. In this situation, it is possibly the ‘harder’ opposition leading to greater engagement and as such, a better reflection of true abilities. The developed players can no longer rely primarily on their physical supremacy and as such, this can lead to increased opportunity for technical and tactical development for these players. This has been a main issue for the selection process, within talent development programmes, due to the deselection of the many ‘early’ developers at later stages, by not upskilling technical abilities, through their reliance on physical dominance during their development pathway (Ostojic, et al., 2014; Figueiredo, Coelho-E-Silva, Sarmento, Moya, & Malina, 2019).

The ‘circa’ players produced results that primarily fell within the ‘pre’ and ‘post’ maturity banding groups scoring. This group of players, due to the increased injury risk associated with the period of PHV (Bult, Barendrecht, & Tak, 2018; Johnson, et al., 2019), should have their development carefully monitored, in addition to the inclusion of preventative measures, such as physical tasks to promote balance, coordination and other vital motor skills. In addition, to prevent overuse injuries during this period of increased vulnerability, adaptions to the physical loading experienced by players could be made through alterations to the pitch dimensions and playing numbers (Owen, Twist, & Ford, 2004).

This concept of maturity bio-banding to draw out desirable traits within individuals may not be restricted to just the soccer field. This process could play a role in an educational setting, with grouped learning periods. Less cognitively developed students may feel more comfortable and more engaged in a ‘matched’ classroom and as such, display full learning skillsets that could be hidden when situated with more developed or advanced learners. Similarly, more developed learners when matched may be placed in a position that pushes them further by elevating the level of learning environment, they are in.

6 CONCLUSION

The study has achieved its aims of describing the response of youth soccer players, of different maturational stages, to small sided match play. Results relating to the perception of effort, physical loading, technical, tactical and psychological responses have been described. The study has created an avenue for further research to explore the alterations of the variables that may have restrained further responses from being produced. A greater understanding of the greater physical demands ‘pre’ players face has been established along with how these players respond in a multitude of manners to competition against players at a similar stage of development, to those at a more advanced stage.
It has been shown that during chronologically organised match play, ‘pre’ players are viewed as being technically and physically poorer, compared to mature counterparts. However, when these players are arranged within a maturity bio-banding setup and allowed to compete against players of a similar stage of maturational development, performance scores improve, and overall physical demands can be altered. When bio-banded, ‘pre’ players work well and when the opposition is identified as being harder, they collectively step up their performance levels, in particular, psychological traits. When in a ‘mixed’ squad, these ‘pre’ players are left behind and they are perceived to struggle.

This information can go some way in providing those involved in the talent identification pathway, an understanding of how players of different stages of development respond when in small sided match play. As such, with further research on the manipulation of the game variables, small sided games could be used as a talent identification method in the use of (de)selection in youth soccer.

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8 APPENDIX

8.1 APPENDIX 1: Reliability of GTSC (FENNER, IGA, & UNNITHAN, 2016) and GPSC values with post testing video reassessment scores as completed by FA Level Two qualified coaching staff. (*P* < 0.05 = significance)

Pairing	Variable	Mean Value	(n)	Standard Deviation	Sig (2-tailed)
Pair 1	Cover	2.42	19	0.838	0.706
	2nd Cover	2.53	19	0.772	
Pair 2	Communication	2.42	19	0.961	0.448
	2nd Communication	2.63	19	0.684	
Pair 3	Decision Making	2.53	19	0.841	0.667
	2nd Decision Making	2.42	19	0.769	
Pair 4	Passing	2.79	19	0.918	0.408
	2nd Passing	3.00	19	0.577	
Pair 5	1st Touch	2.68	19	0.885	0.310
	2nd 1st Touch	2.42	19	0.692	
Pair 6	Control	2.40	10	0.699	1.000
	2nd Control	2.40	10	1.075	
Pair 7	1v1	2.20	10	0.632	0.780
	2nd 1v1	2.10	10	1.370	
Pair 8	Shooting	2.50	4	0.577	0.391
	2nd Shooting	2.25	4	0.957	
Pair 9	Assist	2.00	2	0.000	n/a
	2nd Assist	3.00	2	0.000	
Pair 10	Marking	2.53	15	0.834	0.531
	2nd Marking	2.33	15	0.816	
Pair 11	Positive Attitude	2.53	19	0.841	0.262
	2nd Positive Attitude	2.79	19	0.855	
Pair 12	Confidence	2.42	19	0.902	0.287
	2nd Confidence	2.68	19	0.885	
Pair 13	Competitive	2.42	19	0.692	0.205
	2nd Competitive	2.68	19	0.671	
Pair 14	X-Factor	1.88	16	0.885	0.388
	2nd X-Factor	2.13	16	0.806	

	Game 1 (Coach Initial:)					**Game 2 (Coach Initial:)**					**Game 3 (Coach Initial:)**				
Criteria	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Cover / Support															
Communication-Team work															
Decision making															
Passing															
Receiving-1st touch															
Control-Running with the ball															
1v1															
Shooting															
Assist															
Marking															
Game Score (won, draw or loss and write score)															

Key

5 - Excellent 4 - Very good 3 - Average 2 – Below Average 1 - Poor

8.2 APPENDIX 2A: Game technical scoring chart (FENNER, IGA, & UNNITHAN, 2016) and marking key as provided to technical scoring staff for technical assessment

8.3 APPENDIX 2B: Definitions of the technical criteria from the GTSC (FENNER, IGA, & UNNITHAN, 2016) marking variables

Criteria	Definition
Cover / Support	Providing assistance to teammates in the form of additional protection of area/space to back their efforts
Communication-Team work	Providing constructive information to teammates to assist within the match
Decision making	The ability to make a judgement decision relating to the match
Passing	A strike of the ball to a teammate to retain possession of the ball
Receiving-1st touch	The ability to trap or take the ball under control
Control-Running with the ball	Moving whilst maintaining possession of the ball
1v1	The ability to take on an opponent, whilst in possession of the ball and retain it
Shooting	A deliberate effort at goal in attempt to score
Assist	Transferring the ball to a teammate to allow them a shooting opportunity at goal
Marking	Positioning one’s self in a manner against an opposition player to prevent them receiving the ball, or making it harder for them to be involved within play

	Game 1 (Coach Initial:)					Game 2 (Coach Initial:)					Game 3 (Coach Initial:)				
Criteria	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Positive Attitude Positive reaction after a mistake; how they handle disappointments; resilience; ability to overcome adversities; not wanting to give up															
Confidence Brave; wants to be involved; wants the ball; wants the ball under pressure; wants to get into positions to receive the ball all of the time; have the guts to try and fail and do something different;															
Competitive Resolve; desire; hunger; strong willed; determination; intense; fighting approach towards wanting the ball; winning mentality.															
X-Factor Unpredictable, creative, thinks outside of the box															
Game Score (won, draw or loss and write score)															

8.4 APPENDIX 3: Game psychological scoring chart adapted from the (FENNER, IGA, & UNNITHAN, 2016) GTSC complete with criteria definitions

8.5 APPENDIX 4: Mean age of the 92 youth soccer players aged 11 to 15-years-old players involved in the study separated by parent club

Club	Mean Age (Years ± S.D)
Hamilton Academicals FC	13.8 (± 0.9)
	Hull City, Middlesbrough
Hull City FC	12.9 (± 0.8)
	Hamilton, Middlesbrough
Middlesbrough FC	13.4 (± 1.1)
	Hamilton, Hull

Mean value (± S.D). **Bold text** = significant ($P \leq 0.01$)