THE UNIVERSITY OF HULL

The Influence of Pitch Size on the Efficacy of Maturity Status 'Bio-banding' When Using a Multidisciplinary Approach to Identify Talented Adolescent Soccer Players.

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ABSTRACT

The present study aimed to evaluate the effect of relative pitch size on the tactical, technical, physical and psychological performance of youth academy soccer players, during maturity status ‘bio-banded’ small-sided game (SSG) match play, to evidence the consideration of player maturity status, during talent identification and (de)selection. Forty-four youth academy soccer players (age: 12.9 ± 0.9 years, weight: 46.4 ± 8.5 kg and stature: 158.2 ± 14.9 cm) were recruited from, two professional youth soccer academies. Players were allocated into one of four ‘bio-banded’ teams; two each of ‘*post*-PHV’ and ‘*pre*-PHV’ banded players, categorised based on percentage of adult stature attainment (EASA% > 90.0 and < 89.9, respectively) and competed against each other, within a ‘round-robin’ SSG’s format, across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes. Physical, Technical, Tactical and Psychological competence was measured throughout. Data were analysed using a linear mixed marginal-modelling with Sidak adjusted *p* values and effect sizes. Mismatched match play demonstrated an insignificant difference in movement demands between ‘*post*-PHV ‘ and ‘*pre-PHV*’ banded players (p = 0.06 to 0.94), however ‘*pre-PHV*’ banded players demonstrate a significant increase in physical loading and perception of physical experience ($p = \leq 0.001$ to 0.03). Maturity matched SSG match play, demonstrated insignificant differences and equitable physical, technical/tactical, and psychological measures within maturity bandings (p = 0.07 to 0.98), whilst demonstrating a subsequent increase in apparent competence, in comparison to a maturity mismatched game constraint. Relative pitch size was found to be independent of maturity status. Such findings highlight the possible use of maturity status ‘bio-banded’ SSG match play within youth soccer academies for talent identification and (de)selection purposes by eliciting changes in physical, technical/tactical, and psychological response.

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1.0 INTRODUCTION

1.0 Background and Theoretical Framework

In the 2012 – 2013 season, it was reported that the net debt of professional soccer clubs competing in the English Premier League and (EPL) and English Football League (EFL) was £2.4 and £1.0 billion respectively (Conn, 2014a, 2014b). In curt, EPL and EFL clubs made an overall loss of £291 million and £349 million during the 2012 – 2013 season respectively, which evidences the notion that clubs are operating beyond their financial capacity, with detrimental financial deficits. In attempt to amend the financial fragility and instability of European soccer, the Union of European Soccer Associations (UEFA) introduced the notion of Financial Fair Play (FFP), with the collective am of improving the overall financial health of European club soccer, improving transparency in order to protect long term viability and sustainability (UEFA, 2012). To achieve this UEFA forewarn financial and competition-related sanctions if clubs fail to operate within their financial capabilities (UEFA, 2012).

In conjunction with the introduction of the FPP, EPL club's also agreed to a notion in the Elite Player Performance Plan (EPPP), introduced to regulate youth development (Premier League, 2011). The notion regulated a homegrown player quota, in which a minimum of eight of twenty-five registered squad players, must have been registered to an affiliated Football Association club for a minimum period of 36 months (Premier League, 2011). The implementation of such legislation has seen an improvement in the financial health of EPL clubs, with a reported £465 million profit made in the 2018 – 2019 season. This dramatic improvement in financial affairs proves the value of adequate youth development pathways and facilities the drive of homegrown talent and inadvertently reduce financial deficits. The introduction of the EPPP has been fundamental in the transformation and modernisation of academy football structure and philosophy.

Traditionally, participants within a sporting environment are allocated into chronological age groupings, derived from specific cut off dates, applied to ensure a developmentally appropriate environment, inclusive of equitable levels of competition and opportunity (Barnsley, Thompson, & Legault, 1992). The Premier League's EPPP defines a performance pathway, broken down into three distinct phases; foundation phase, youth development phase and the professional development, inclusive of U5 to U21, distinct chronological age groupings (Premier League, 2011), Within such chronological age groupings, there are large, inter-individual variations in player stature, body-mass and ability which have been (Malina, Bouchard, & Bar-Or, 2004) associated with temporary growth and maturation related differences in body size, muscular strength, speed and power, and endurance, all of which influence the functional capacity of adolescent football players (Geithner et al., 2004).

Players who are deemed to be in advance of their natural rate of maturation are classified as *early* maturing and have both a temporary anthropometrical (Hirose, 2009) and physical advantage (Buchheit & Mendez-Villanueva, 2014) compared to players in delay of their predicted maturational growth rate (Lovell et al., 2015), concluding a superior athletic advantage (Cumming, Lloyd, Oliver, Eisenmann, & Malina, 2017). It was reported by Carling, le Gall, Reilly, and Williams (2009) that *early* maturing players, consistently out-perform their peers across a battery of anthropometrical and physiological performance tests. As such an advantage, the *late* maturing players are systematically excluded from football academy systems, with a favourable preference of biologically *early* maturing players (Malina, 2003). Lovell et al. (2015) suggested that talent identification and development practitioners are bias towards the selection of players advanced in biological maturation and physical capacities, restricting the opportunity afforded to less biologically mature players of equitable technical competence, which could evidence the overrepresentation of players born in the first quartile of the selection year (Barnsley et al., 1992; Helsen, van Winckel, & Williams, 2005).

Previously disseminated literature, precluded a systematically skewed birth distribution within a group of players, with a disproportionate increase in the number of players born shortly proceeding the cut-off date for selection, commonly selected due to developmental, anthropometrical and physiological advantages (Votteler & Höner, 2014), however recent evidence suggests that maturity status heavily impacted upon such relative age effects (Müller, Gehmaier, Gonaus, Raschner, & Müller, 2018). Despite demonstrating the overrepresentation of youth academy soccer players born within the first birth quartile, Hill, Scott, Malina, McGee, and Cumming (2019) also demonstrated a selection bias towards players advanced in biological maturation, recognising relative age and maturation and independent constructs, in which soccer players advanced in biological maturation, are more likely to be identified and retained within youth soccer academy structures. Such identification and retention of, affords the opportunity and exposure to an increasingly challenging environment, with access to increased contact time and exposure to higher-level coaching, competition, and training facilities, thereby generating an experience advantage over players in delay of biological maturation, previously excluded from development pathways (Cumming et al., 2017).

A solution to this problem is to categorise players in accordance to their maturity status (rather than chronological age), which is commonly referred to as ‘bio-banding’ (Cumming et al., 2017), in which maturity status refers to the process of growth towards a state of complete maturity or the adult, in which complete biological development is achieved (Malina, Bouchard, et al., 2004; Malina, Rogol, Cumming, Silva, & Figueiredo, 2015).‘Bio-banding’ is applied under the provision of creating competitive equity and reduce the risk of injury, in attempt to address the inter-individual differences in maturity status during adolescence, which will optimize talent identification and athlete development (Cumming et al., 2017). A battery of maturity status assessment are available that consider factors inclusive of chronological age, stature, weight, and mid parental height, in order to express maturity status as either; a percentage of their predicted adult stature attainment (EASA%) or years from age at peak height velocity (APHV), termed a 'maturity offset' (Fransen et al., 2018; Khamis & Roche, 1994; Mirwald, Baxter-Jones, Bailey, & Beunen, 2002; Moore et al., 2015; Sherar, Mirwald, Baxter-Jones, & Thomis, 2005). Salter, Croix, Hughes, Weston, and Towlson (2020) reported a discrepancy between the methods of maturity estimation utilised by youth soccer academies, with category one clubs demonstrating the favourable application of the prediction of adult stature, whilst category two clubs, had a preference for maturity offset. Injury prevention, athlete development, and load management were identified as highest reasoning for the estimation of maturity status, with the legislation from clubs and governing bodies, regarded of least importance, however such assessment was perceived to be dependent upon time constraints, staff resources and competency (Salter et al., 2020).

Early reports from Cumming et al. (2017) suggest that 'bio-banding' is well received by both *early* and *late* maturing players, in which *early* maturing players are exposed and perceived a greater physical and technical challenge, whilst *late* maturing players perceived an increase opportunity to demonstrate technical/tactical abilities, factors which may facilitate athlete identification and development, through the manipulation of athlete response. Reeves, Enright, Dowling, and Roberts (2018) further investigated the reception of 'bio-banding' from the perspective of key stakeholders, reporting a perceived advantage of 'bio-banded' training on technical/tactical, sociological, and psychological performance. However, this was coupled with a perceived disadvantage in the retention of players, during a periodic ‘bio-banded’ phase, due to the misconception that players had been moved down a chronological age grouping, accountable to an inept understanding and interpretation of ‘bio-banding’ principles (Reeves et al., 2018).

Such notion, is supported by the introduction of the EPL’s ‘bio-banding’ program (Premier League, 2011), which was introduced to support the application of research and evidence practice, in order to reduce the over and de-selection of *early* and *late* maturing players respectively (Lovell et al., 2015). The publication of ‘Bigger Shouldn’t Mean Better’ by the International Centre for Sport Studies (Deconche & Maurer, 2016) is a clear indication of the intentions of soccer’s international and national leagues to develop, implement and sustain evidenced supported initiatives to reduce such over selection of *early* maturing (and deselection of *late* maturing) soccer players for long term athletic development programs.

There is a paucity of evidence on the application and long term effectiveness of ‘bio-banding’, as such a greater understanding is required on the effectiveness of ‘bio-banding’ on quantifiable measures of technical, tactical, psychological and physical performance of athletic and player development, deemed necessary for ongoing talent identification and (de)selection (Cumming et al., 2017). Despite the aforementioned characteristic’s demonstrating a holistic approach to talent identification, Towlson, Cope, Perry, Court, and Levett (2019) reported talent identification practitioners to deem a player's psychological characteristics, as a superior construct. Romann, Lüdin, and Born (2020) conducted a pilot study on the acute effects of ‘bio-banded’ interventions in comparison to chronological age groupings and reported a reduction in physical demand, whilst promoting a more technically and tactically challenging match play, which demonstrates an alteration in player response that might support athlete development, talent identification and (de)selection.

The quantifiable measure of technical, tactical, psychological and physical performance are pivotal elements that contribute to the whole person player development as outline by the ‘Four Corner Model’ (The Football Association, 2010), giving such direction for a holistic evidence-based approach for ongoing identification and (de)selection. Generating this understanding is vital to developing scientific observations that will complement intuitive knowledge, to strengthen to talent identification, selection, and de-selection process (Reilly, Williams, Nevill, & Franks, 2000).

It is evident that ‘bio-banded’ interventions can manipulate individual player responses (Romann et al., 2020), however, it can be argued that a greater response in the aforementioned measures, maybe apparent through the manipulation of relative pitch size (Towlson et al., 2020). To date, no studies have examined the interaction between player maturity status and relative pitch size (area per player) during ‘bio-banded’ SSG match play on the technical, tactical, psychological, and physiological responses, factors which preclude overall soccer performance. The current paradigm is to adopt SSG’s within an academy structure, as it allows for the evaluation of inter-individual and intra-individual, soccer-specific performance (Unnithan, White, Georgiou, Iga, & Drust, 2012). Disseminated research is available, which reports the physiological (Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011), psychological and technical, and tactical profiling of adolescent soccer players during SGG’s, independent of maturity status (Unnithan et al., 2012).

It was reported by Castellano, Puente, Echeazarra, and Casamichana (2015) and Casamichana, Bradley, and Castellano (2018) that a change in pitch dimension and subsequent relative pitch size, has a direct influence on the physiological performance of youth soccer players during match play and SSG’s respectively. Changes in relative pitch size have also been shown to influence the team tactical performance of youth academy soccer players (Olthof, Frencken, & Lemmink, 2018). Despite this disseminated research, no research is available which examines the interaction between player maturity status, maturational grouping, and relative pitch size.

It can be suggested that *early* maturing players, who display a dominance in anthropometrical and physiological characteristics, will exhibit enhanced performance across the greatest relative pitch sizes, due to the increased requirements of physiological loading and such extenuating the difference in performance between maturational bandings (Towlson et al., 2017). However, across a 291 m^2 relative pitch size, Lovell et al. (2019) reported total distance, high and very high speed running distance to increase 0.6, 5.4 and 6.9% respectively, per year of estimated age at peak height velocity, suggesting that the external and internal loading of later maturing players can be underestimated when maturity status is not considered. Abbott, Williams, Brickley, and Smeeton (2019) evidenced an increase in the rating of perceived exertion (RPE) of *early* maturing players during 'bio-banded' competition, which precludes a superior physical challenge, in comparison to chronological competition. *Late* maturing players demonstrated no significant difference in the physical and movement demands identified between competition formats, supporting the notion that 'bio-banded' competition manipulates the technical demands, without affording a reduction in the physical demands (Abbott et al., 2019).

It can be suggested that *late* maturing players may be advantage across the smallest relative pitch sizes, due to the increased rate of acceleration, which positively influences the creation of space (Towlson et al., 2017). Qualitative research produced by (Cumming, Brown, et al., 2018) reported *late* maturing players to perceive a technical and tactical benefit from playing under 'bio-banded' conditions, however, this area of research is limited by the absence of objective and quantitative data that examines the interlinking effects of 'bio-banding', relative pitch size and sport-specific performance.

Recognising the needs for change and the modernisation of the academy systems within English football clubs, the Premier League produced the EPPP, a criteria-based procedure, which aims to create world-leading academy systems which serve to increase the number and quality of home grown players and increase the efficiency of youth development investment (Premier League, 2011). However, despite been an appealing initiative there is a paucity of soccer-specific objective and quantifiable evidence, in reference to the efficacy of ‘bio-banding’ and its application as a talent identification and (de)selection tool. As such, for ‘bio-banding’ to become a fully endorsed initiative within talent identification and (de)selection and development, its efficacy must be demonstrated from a multi-disciplinary perspective, inclusive of quantifiable physical, technical and psychological measures (Till & Baker, 2020; Unnithan et al., 2012), across a number of different pitch sizes typically applied by academy practitioners for talent identification and condition.

1.1 Research Rationale

As the application of SSG’s is widespread across academy structures (Unnithan et al., 2012), it is important to understand how the implementation of ‘bio-banded’ interventions, will modify the efficacy of SSG’s for talent identification and develop an understanding of the interaction between players maturity status and respective game constraints (relative pitch size) from a multi-disciplinary perspective. This will help generate the knowledge and information required to strengthen the talent identification process, serving to support the principles of the EPPP (Premier League, 2011). The present research will provide guidance for practitioners on the most appropriate relative pitch size for use when assessing specific facets of player performance and encourage practitioners to consider player maturity during the identification and (de)selection process of players in an attempt to reduce the over-selection of *early* maturing players, whom are beneficiaries of transient maturity related enhancements in anthropometrical and physical characteristics.

1.2 Aims and Objectives

The aim of the present study is to determine and discuss:

1. The effect and interaction between relative pitch size and game format on the magnitude of difference in tactical, technical, psychological, and physical measures between young academy soccer players during SSG match play.
2. The effect of mismatched ‘bio-banded’ interventions on the magnitude of difference in tactical, technical, psychological, and physical measures between young academy soccer players, during SSG match play.
3. The effect of matched ‘bio-banded’ interventions on the magnitude of difference in tactical, technical, psychological, and physical measures between young academy soccer players.

2.0 LITERATURE REVIEW

2.1 Elite Player Performance Plan

Considering the aforementioned financial fragility and current operation of clubs beyond their financial capacity, there is a requirement to implement adequate and improve youth identification and development pathways, in attempt to mitigate such financial burdens and deficits. As such, the Elite Player Performance Plan (EPPP) is a long term strategy plan, devised by the Premier League to advance youth development, with the collective aim of developing an increased number of and quality of home grown players (Premier League, 2011). Following extensive consultation with Premier League Academy Mangers, the EPPP was produced to support the notion of creating world leading academy structures, that increase the efficiency of youth development investment, through the modernisation of academy systems and procedures (Premier League, 2011). The EPPP aims to deliver an environment that promotes excellence and nurtures talented players, capable of playing first team football at the developing club (Premier League, 2011).

The umbrella terms of producing more and better home grown players, is inclusive of three areas of improvement; the staff, the players and the environment (Premier League, 2011). The vision of the EPPP, is to develop a world leading coaching fraternity, capable of providing a world class support service, which will enhance the development of technically excellent and tactically astute players who are fully equipped for a successful career in professional football (Premier League, 2011).

Six fundamental principles were outlined by the EPPP, used as factors to determine and monitor critical success; increased number of quality of home grown players gaining contracts and playing first team football, increased provision for coaching and playing time, improved coach provision; an implemented system of effective measurement and quality assurance, increases strategic investment into the academy system and implement significant gains in all aspects of player development (Premier League, 2011). It is hoped that the adherence to the criteria above will enable English league clubs to consistently outperform international competition in the production of home grown talent (Premier League, 2011).

Implemented within the EPPP, was the Long Term Athletic Development (LTAD) model which adopts a ‘Four Corner Model’ and considers the interaction between technical, tactical, psychological, social, and physical elements of a player's environment (Premier League, 2011). The rational of the EPPP is supported by the Performance Pathway, a multidisciplinary approach which transitions athletes through, foundation (U5 to U11), youth (U12 to U16) and professional (U17 to U21) development phases, by the way of associated chronological age groupings (Premier League, 2011).

Under the EPPP, special consideration was made for the modernisation of sports science and medicine services, allowing for a fully cognitive understanding of how to progress players through the performance pathway (Premier League, 2011). The aim is to ensure the adoption of a fully supportive interdisciplinary approach between support specialists, inclusive of sports scientists, physiotherapists, and strength and conditioning coaches (Premier League, 2011). Alongside this, the EPPP will generate a national database of athletic development, which will allow benchmarking against a national profile, giving information on the effectiveness of sport science interventions, allowing clubs to refine and optimise practice (Premier League, 2011).

The EPPP recognises the growing body of research available to support talent identification and deems it essential that modernised academy systems draw upon this research, to strengthen and assist the talent identification process (Premier League, 2011). Proposed areas of research are inclusive of biological maturation rates and subsequent impact upon recruitment, retention, and the psychological profiling of players (Premier League, 2011), all of which are areas of research interest within the present study.

To summarise, the EPPP aims to deliver a world class development system across four key functions; increase playing time through the implementation of an effective games program, development of educationally rounded individuals in both a formal and footballing context, development of a world leading coaching fraternity and enhance elite performance through innovative ways to promote player identification, recruitment, retention, development, and transition through developmental phases (Premier League, 2011). Therefore, research is required to further develop an understanding of the effect of relative pitch size during 'bio-banded' match play, on the technical, tactical, psychological and physical response, of players with a disparate maturity status, in order to better inform the talent identification, developmental and (de)selection process, satisfying the production of technically excellent and tactically astute players (Premier League, 2011).

2.2 Monitoring Athletic Development in Elite Youth Soccer

The directive of the EPPP to promote talent identification and player development, cultivating in an environment that produces an increased number of and improved quality of 'home grown' players, is reliant on the effective practice of aSport Science and Medicine Programme (Premier League, 2011). Not only does the EPPP aim to generate a club specific multi-disciplinary approach, but it also aims to create a holistic and nationalised approach to athletic development, in which relative player progress can be measured against a national profile, monitoring the relative success of programs and interventions (Premier League, 2011). Defined in the Sports Science and Medicine Programme, the EPPP illustrates the periodic, systematic, and regulated monitoring of anthropometrical, physiological, physical, and biological maturation status, by adopting a standardised battery of field based tests (Premier League, 2011). A recent review of the literature led to the dissemination of the Youth Physical Development (YPD) model, which aims to provide a logical and evidence based approach to the systematic development of physical performance in youth athletes (Lloyd & Oliver, 2012). Such research frameworks the development of physical functionalities in relation to growth rate and maturational development, outlining session structure to provide age and stage appropriate constructs (Lloyd & Oliver, 2012). The dissemination of such research and the publication of the EPPP (Premier League, 2011) are all collated to create a route for talented youth soccer players to progress through the developmental continuum, equipped with the physical, technical, tactical and psychological assets to perform at a professional level, on which is beneficial to both the individual and respective organisation. However, in order to support and implement such athlete development programs, there is an initial requirement to recognises those individuals with such potential to transition into elite performers, capable of at a professional and international level (Premier League, 2011; Till & Baker, 2020).

2.3 Talent Identification

Following on from the introduction of the EPPP (Premier League, 2011), the identification and validation of talented young athletes has become a primary objective of professional sporting clubs and bodies, creating and sustaining an environment that promotes excellence and nurtures talented players, capable of playing first team soccer at the developing club (Cumming et al., 2017). Aligned with the principles of the EPPP, there is an increased endeavour of professional clubs, in the financial investment of talented player identification and the nurture of potentially elite players, due to a limitation in financial resource and the perceived financial and competitive gains (Till & Baker, 2020; Towlson et al., 2019; Williams & Reilly, 2000).

Talent identification can be defined as the process of recognising current participants with the potential of future attainment (Williams & Reilly, 2000) and can be extended to the identification and presence of a desirable characteristic, that correlates to future elite performance (Cobley, Schorer, & Baker, 2013). Talent is typically judged on an individual's rate of success and/or athletic aptitude, with the expectation that desired characteristics will be extrapolated into adolescence and translate into successful athletic performance (Vaeyens, Lenoir, Williams, & Philippaerts, 2008). The talent identification process and an individual's athletic aptitude is impacted by the immediate and direct effects of an individual's physical attributes and functional capacity, in which the athletes deemed to be appropriate for a specific sporting environment and consequential sporting excellence, are channelled into an environment that rewards participation, provides opportunity and exposure to specialised coaching and resources (Cumming et al., 2017). However, it is important to understand that talent identification alone does not translate into elite performance, in which sporting excellence is achieved through a pyramidal structure of talent detection, identification, development, and selection (Reilly et al., 2000; Till & Baker, 2020). As such, Malina (2009) stated that the identification, development and early specialisation of elite youth athletes, is inconducive to maximising potential and that elite youth athletes should be exposed to an environment that permits them to 'be young', which presents the associated health, fitness and social benefits of sport. From a statistical perspective, Güllich and Emrich (2006) reported that from a population of 4,972 German athletes, identified and selected at the youngest possible age in each sport, collated across seven Olympic disciplines, display that only 0.3% (n = 15) went onto ranked within the top ten international senior athletes, within their respective discipline, highlighting the limitation of talent identification pathway to predict success within adulthood.

The talent identification and development process is inclusive of the recognition of current individuals with the perceived potential to become elite players and the provision of a suitable learning environment, in order for such individual to realise their potential (Sarmento, Anguera, Pereira, & Araújo, 2018). The primary aim of such pathways were to develop players for the first team at the respective club, with secondary aims been to develop players for financial gain and to positively impact the personal development of players (Relvas, Littlewood, Nesti, Gilbourne, & Richardson, 2010). Historically, identification and selection is underpinned by the subjective, preconceived perception of an ideal (Larkin & O'Connor, 2017a; Williams & Reilly, 2000), however recent developments have seen the implementation of science based support systems, creating a more holistic approach, aimed to eradicated the repetitive misjudgements in talent identification (Unnithan et al., 2012; Williams & Reilly, 2000). As such, the evaluation of physiological, anthropometrical, technical, tactical, and psychological outcomes measures may provide a greater degree of quantifiable objectivity to such processes (Vaeyens et al., 2008).

Such the requirement to evaluate an array of constructs, it is important to consider the physical, technical, and tactical and makeup of adolescent performance and how that translates into superior performance at an elite level. A systematic review disseminated by Sarmento et al. (2018), revealed elite youth players to score better in physical tests measuring speed, aerobic endurance, anaerobic capacity, and agility and were found to be anthropometrically taller and leaner. It was also summated, there to be a clear association between high achievement levels and superior technical skill, inclusive of passing ability, ball retention, dribbling, and shooting (Sarmento et al., 2018). Putting this into a practical perspective was the Ghent Youth Soccer Project, an assessment of physical, functional, and soccer skill performance, between elite, sub-elite and non-elite youth squads longitudinally, over a five year period (Vaeyens et al., 2006).

Results demonstrated U15 elite players to have significantly lower skinfold values (mm) but were insignificantly different in measures of height (cm) and weight (kg) in comparison to non-elite youth soccer players (Vaeyens et al., 2006). To compliment this

U15 elite players were found to be; more powerful (standing broad jump: elite = 193.4 ± 13.4 & non-elite = 179.8 ± 20.7 cm) , have greater upper body strength (bent arm hang: elite = 40.4 ± 19.2 & non-elite = 21.0 ± 13.7 sec), faster (30 m sprint: elite = 4.4 ± 0.2 & non-elite = 4.7 ± 0.2 sec) and have an increased aerobic (endurance shuttle run: elite = 10.8 ± 1.3 & non elite = 8.7 ± 1.7 min) and anaerobic (shuttle tempo: elite = 69.6 ± 3.5 & non-elite = 75.2 ± 6.2 sec) capacity in comparison to non-elite players (Vaeyens et al., 2006). Technically, U15 elite player demonstrated superior performance across soccer-specific skills when compare with non-elite players, inclusive of dribbling (17.1 ± 1.1 V 19.3 ± 2.2 sec), shooting (23.8 ± 2.5 & 22.4 ± 2.6 points) and juggling (117.4 ± 52.0 & 59.5 ± 57.2 n) respectively. Sæterbakken et al. (2019) aimed to compare match running performance between competitive standards of performance, in which a higher-level competitive standard demonstrated an increase in high intensity performance, inclusive of an increase sprinting distance and number of accelerations.

Due to such variance within performance metrics, it has been suggested for talent identification and development models to move towards a directive that offers an appropriate developmental environment to an increased number of youth soccer players, with the notion that individuals will realise their full potential at differing time points and that selection or deselection should be attributable to performance across and time and maturational time continuum.

As such, developmental environments require a holistic approach to talent identification within soccer, which requires the consideration of technical, tactical, psychological and physical constructs that influence performance, aligned with The Football Association (2010) Four Corner Model of player assessment and development (Unnithan et al., 2012), Deprez, Fransen, Lenoir, Philippaerts, and Vaeyens (2015) reported that motor coordination, speed, endurance, strength, and soccer-specific skills, were characteristics of the greatest importance in the differentiation of between drop out and contract status and such identification of gifted, high-level youth (8 to 18 years) soccer players. Larkin and O’Connor (2017a) demonstrated a hierarchy of attributes perceived as important in the talent identification process, from a multidisciplinary perspective upon which components of; technical (e.g. first touch), tactical (e.g. decision making) and psychological (e.g. positive attitude) were all regarded as important constructs for talent identification. A greater perceived technical competence was justified on the player's first touch, regarded of the highest importance, providing the foundation of all other ball actions, inclusive of passing and assist (Larkin & O’Connor, 2017a).

It is also important to consider that such hierarchy established anthropometrical variables of least importance in the identification of talented youth soccer players (Larkin & O’Connor, 2017a), despite the current tendency to favour anthropometrical characteristics over technical and tactical capabilities (Carling et al., 2009). It is suggested that the selection of players with respect to an anthropometrical superiority satisfies short term success and competitive advantages at youth level, however when such characteristics and physical superiority plateau, a reduced ability to expert an influence upon a match situation is apparent, thus explaining the perception of inept talent and subsequent release from development structures (Unnithan et al., 2012). The attenuation of such anthropometrical and physical superiorities advocates that talent identification be a dynamic and continual development model, in which identification can occur at any stage along a continuum, with the direction to consider biological maturity status (Lovell et al., 2015; Sarmento et al., 2018; Unnithan et al., 2012), upon which the talent identification process is susceptible to the independent constructs and interactions between the factors of physical growth, biological maturation and behavioural development (Cumming et al., 2017). Further research examining the maturity associated variance in adolescent physical activity, demonstrated how individual differences within biological maturation can have a direct and indirect impact upon the talent identification process (Cumming et al., 2017; Cumming et al., 2012).

As such the application of cross-sectional designs are limited, due to the assumption that performance characters of elite players can be extrapolated to identify talented individuals and that pre-adolescent characteristic may not remain prominent through maturation and translate into exceptional performance in adulthood, highlighting the requirement to distinguish between adolescent performance and potential, due to the dynamic changes in physiological and anthropometrical characteristics (Vaeyens et al., 2008). The talent identification process can be indirectly affected by both the individual’s and a practitioner's psycho-social interpretation and management of growth and maturation, in which youth athletes that are perceived to be in delay of biological maturation, are ill afforded of any developmental opportunity and consequentially ignored and excluded from talent identification procedures and long term athletic development plans respectively (Cobley, 2016; Cumming et al., 2017).

Consequently, the informed decision making of talent identification and development on physical attributes would serve to identify the physically adept, leading to the exclusion of *late* maturing players, whom despite being physically and anthropometrically immature, maybe technically and tactically superior, arguably of greater importance in the development of more talented performers at senior level (Carling et al., 2009; Reilly et al., 2000; Vaeyens et al., 2008). Disseminated literature pertains a systematic selection bias in talent identification, towards the selection of players born within the first quartiles of the respective selection period, however recent literature has extended such selection bias towards players in advance of biological maturation (e.g. *early* maturing) (Lovell et al., 2015; Meylan, Cronin, Oliver, & Hughes, 2010). Sherar, Baxter-Jones, Faulkner, and Russell (2007) found biological maturation to influence talent identification selection, in which the selection was representative of a more mature population of athletes. It is suggested that players advance in biological maturation demonstrate a physical dominance, attributable to an increase in stature, strength speed, power, and endurance, however, such characteristics may be transient at youth level soccer (Meylan et al., 2010).

It is apparent that less mature players may be underrepresented within a youth soccer population, due to maturity associated limitations in physical and functional characteristics, despite possessing a superior level of technical competence (Meylan et al., 2010). The favouring of the more physically adept players, represents a respective overinvestment in those players at the expense of those players, with an increasing technical/tactical ability and possess a greater potential to perform throughout adulthood, when physical performance advantages are attenuated (Cumming et al., 2017; Lefevre, Beunen, Steens, Claessens, & Renson, 1990). Despite the regarded transient maturity related enhancements in performance, suggested attenuation of performance advantages and consideration for biological maturity status (Cumming et al., 2017; Lefevre et al., 1990), it was reported by Deprez, Buchheit, et al. (2015) that despite the influence of growth and maturation on the attenuation of the magnitude of difference in soccer specific endurance characteristics, originally poor performers, may only partially catch up, originally high performance, between the ages of 12 to 16 years. For talent identification, this can suggest that such physical performance advantages, persist throughout adolescent growth, and maturation.

When considering the identification of talent youth soccer players, recent evidence suggests that the evaluation of desirable characteristics should reflect an individual’s stage of biological maturation, in order to determine the difference between players who persisted within or dropped out of high level soccer (Deprez, Fransen, Lenoir, et al., 2015). For example, the evaluation of soccer specific skills, soccer specific aerobic endurance and strength should occur pre-PHV, circa-PHV and post-PHV respectively (Deprez, Fransen, Lenoir, et al., 2015).

It is important to consider that such biological maturation and the subsequent transient maturity related enhancements in anthropometrical and physical characteristics, distinguish between the positional specific identification and recruitment of players (Deprez, Fransen, Boone, et al., 2015; Towlson et al., 2017). Players in advance of biological maturation are more likely to characterise key defensive position, due to associate anthropometrical characteristics, however, such transient enhancements will dissipate upon APHV and full biological development (Lovell et al., 2015). As APHV occurs between the 12 and 16 years of age within a male population, it is important for practitioners to understand the influence of biological maturity upon anthropometrical characteristics and subsequent talent identification (Malina, Bouchard, et al., 2004; Till & Baker, 2020). As such, talent identification is a dynamic process, upon which assessment and evaluation, should be representative and consider individual biological maturation, inclusive of a dynamic process that provides long term development opportunities (Vaeyens et al., 2006). In order to better understand such maturity variability, further enhance and better inform the talent identification process, it has been suggested that practitioners periodically measure the maturity status of youth athletes, evidencing any potential performance (Till & Baker, 2020). To further supplement the informed decision making of the talent identification process, it can be suggested that ‘bio-banded’ interventions are implemented (Cumming et al., 2017).

In conjunction, both the Premier League and British Lawn Tennis Association have combined performance, fitness and maturation data into a league wide database system, that allows for age and maturity specific references, which permits the banding and/or consideration of athletes by both chronological age and maturity status when assessing fitness and performance (Cumming et al., 2017). The application of ‘bio-banding' to the talent identification process within a wider sporting context, enables practitioners to better account for individual differences in maturation, supplementing the informed decision making on athletic ability and potential (Cumming et al., 2017).

Towlson et al. (2020) aimed to provide a greater understanding of the physical, physiological, technical and tactical response of youth soccer players to maturational 'bio-banding' within SSG's as a potential tool for talent identification. It was disseminated there to be very little difference in psychological, technical, and tactical values between biological maturity status bandings (Towlson et al., 2020). Despite demonstrating an insignificant difference in movement demands and total distance covered, there was a significant difference and an increase in the physical loading ($p \leq 0.001$; ES = 0.74, *moderate*) and perception of physical experience ($p \leq 0.001$; ES = 1.74, *large*) reported for players pre-PHV, in comparison to post-PHV, in which the maturity dependent difference was attributed to a reduction in movement efficiency and subsequent adolescent awkwardness (Towlson et al., 2020). However, when adolescent soccer players competed within a matched 'bio-banded' SSG constraint, pre-PHV players were shown to produce greater movement and physical demands ($p < 0.05$; ES = 0.55 to 0.68, *small* to *moderate*) , greater technical and tactical competency, whilst reporting a reduced perception of physical experience (Towlson et al., 2020). Such change is consistent with an increase in the perception of physical experience, physical demand, and technical competency for post-PHV players within a matched 'bio-banded' SSG constraint (Towlson et al., 2020). In short, it was reported that such findings highlight the possible use of maturity status 'bio-banded' SSG's within an adolescent youth soccer population, for the purpose of talent identification and (de)selection, by eliciting the desired change in player physical, technical/tactical and psychological response (Towlson et al., 2020).

Similar to the influence of maturity status, the selection of soccer players for academy soccer development programs is generally dominated by those who demonstrate superior anthropometrical dimensions (e.g. stature and weight) and performance capabilities (e.g. power, speed, strength, and endurance) (Carling, Le Gall, & Malina, 2012; Carling et al., 2009). This can be accountable to the selection of players born in the first and second quartiles of the selection years and who are beneficiaries of acceleration's in stature development, consistent during the adolescent growth spurt, leading to the consequential exhibition of advanced anthropometrical characteristics and physiological capacities (Carling et al., 2009; Malina, Eisenmann, Cumming, Ribeiro, & Aroso, 2004). Such transient enhancements in anthropometrical and physical phenotypes result in the selection of adolescent soccer players based on such characteristics, commonly labelled the maturation selection hypothesis, deemed a principal contributor in the over selection of '*early*' maturing academy soccer players for development programs and such systematic exclusion of players born within the latter quartiles of the selection year (Carling et al., 2009; Cobley, Baker, Wattie, & McKenna, 2009; Helsen, van Winckel, & Williams, 2005; Lovell et al., 2015). As such, the consideration and examination of relative age effects are deemed pivotal, to prevent the discrimination of equally talented but younger soccer players from selection for talent development programs, aligned with the underlying principles of the EPPP (Hirose, 2009; Premier League, 2011).

The identification of talented adolescent soccer players is deemed complex, due to the dynamic interaction between technical, tactical, phycological, and physical attributes and such influences (Güllich, 2014; Larkin & O'Connor, 2017a; Reilly & Gilbourne, 2003). The current perception and research paradigm of talent identification, suggests a reductionist approach, in which the characteristics required for successful performance, are subjectively evaluated in isolation, as individual and discrete characteristics (Unnithan et al., 2012). As such, there is the suggestion for the application of SSG’s as an evaluation tool, to allow for the simultaneous evaluation of multiple interacting systems and such inter/intraindividual contributions to successful soccer performance (Unnithan et al., 2012). A breadth of disseminated literature exists, that advocates the application of SSG’s, in order to evaluate soccer specific skill proficiency, as an appropriate tool for talent identification, due to the accurate replication of match play characteristic and movement demands (Bennett et al., 2018; Fenner, Iga, & Unnithan, 2016; Jones & Drust, 2007). Pertinent to the present study was the suggestion that the attenuation of any potential differences in technical, tactical, psychological and physical response between maturational bandings, was suppressed by the SSG pitch constraints, with the suggestion that an increase in relative pitch size may elicit a greater physical response, promoting the demonstration of a greater movement proficiency, appropriate for the purpose of talent identification (Towlson et al., 2020). As such, there is a requirement for research to understand the manipulation of SSG’s (relative pitch size and player numbers) and how such alterations could be applied to elicit potential changes in the physical and technical demand, allowing for a more representative approach to talent identification and (de)selection.

In summary, it can be demonstrated that alongside the directive of the EPPP, current research aims to eradicate the current limitations in the talent identification process, with a consideration of biological maturation, in order to curtail the overrepresentation of *early* maturing soccer players, reduce the unnecessary release of adolescent soccer players when physical characteristics attenuate and better inform decision making by evaluating an array of performance constructs (Cumming et al., 2017; Larkin & O’Connor, 2017a). Pertinent to the present study is the application of ‘bio-banded’ SSG’s to allow for the simultaneous evaluation of multiple interacting systems as a potential tool for talent identification (Towlson et al., 2020; Unnithan et al., 2012).

2.4 Small Sided Games

With the introduction of the EPPP (Premier League, 2011), there has become an increasing demand for the identification and nurture of talent from an *early* age (Reilly & Gilbourne, 2003), emphasising the importance of *early* recruitment into long term athletic development (Unnithan et al., 2012), equating to a justifiable financial investment that promotes the development of technically adept, home grown players (Premier League, 2011). However, traditional subjective cross-sectional models of talent identification have been criticised for the exclusion of *late* maturing players, accountable to a unidimensional and invariable talent identification process, which assumes the natural extrapolation of important characteristics throughout maturation (Vaeyens et al., 2008). As such, the implementation of SSG's, may allow for the simultaneous evaluation of a multitude of technical skills and physical attributes, essential to successful soccer performance (Unnithan et al., 2012). The application of SSG's would be deemed appropriate, due to the replication of movement demands, physiological intensities, and technical requirements of competitive match play (Hill-Haas et al., 2011).

The primary benefit of SSG's is the concurrent replication of movement demands, physiological intensities and technical requirements of competitive match play, achieved within a time efficient manner (Gabbett & Mulvey, 2008; Hill-Haas, Coutts, Dawson, & Rowsell, 2010; Hill-Haas et al., 2011). Elite soccer players were reported to cover a significantly greater total distance at sprinting and high intensity running ($p < 0.01$) during SSG's when compared to match play, which represents a percentage increase of 14.7% and 18.6% respectively (Dellal et al., 2012). Hoff, Wisløff, Engen, Kemi, and Helgerud (2002) reported SSG's to elicit a heart rate response of 90 – 95% of maximal heart rate (HR_{max}), which is consistent which the physiological demands of match play, eliciting an average and maximal heart rate response of 85% and 98% of HR_{max} respectively (Bangsbo, 2014). Technical analysis demonstrated that SSG's induce an increased number of ball contacts per individual when compared to larger sided games (Owen, Wong, McKenna, & Dellal, 2011). Through the manipulation of player numbers, pitch size, and game design, we can adjust the desired physiological, technical, and performance outcomes, pertaining to the application of SSG's as a training modality (Fenner et al., 2016). However, recent research has moved away from SSG's as a training modality and focused on its application within the identification of talented post-pubertal soccer players (Unnithan et al., 2012).

Fenner et al. (2016) reported a very large, significant ($p < 0.001$) relationship between game technical scoring chart and total points accumulated ($r = 0.758$), suggesting the predictive ability to identify talented soccer players from performance outcomes within a multiple SSG's model. Of a similar nature, Unnithan et al. (2012) and reported a weak positive correlation ($r = 0.39$, $p = 0.07$) between SSG match outcome and coach's perception of technical ability. Metrics of high speed running distance ($r = 0.547$, $p < 0.05$) and total distance ($r = 0.545$, $p < 0.05$)) was shown to significantly distinguish between standards of performance in identifying talented soccer players (Fenner et al., 2016). The use of total distance (m) as a predictive measure within talent identification (Fenner et al., 2016) can be confirmed as Goto, Morris, and Nevill (2015) reported retained U11 academy players to cover significantly ($p < 0.05$) greater total distance, than a group of released academy players, during a 11-a-side competitive match play (78.7 x 54.1 m). No difference between retained and released academy players were reported for high intensity running distance, but a difference in time spent in speed zone (0.0 – 1.5 $m{\cdot}s^{-1}$) was apparent, suggesting the retained players could attain the demands of high intensity running, with reduced recovery (Fenner et al., 2016; Goto et al., 2015).

The application of SSG's was deemed appropriate in the assessment of talent identification and skill proficiency in youth soccer players (Bennett et al., 2018). Higher level players (guided by professional club structures) demonstrated a greater rate of pass completion, increased number of touches and total skill involvement, which concluded a greater skill proficiency and the application of SSG's methodology to assess soccer specific skill in a practical setting (Bennett et al., 2018). The use of SSG's has demonstrated an increased exposure to technical loading when compared with an increase in relative pitch size, which increases the provision for players and coaches to demonstrate and evaluate technical ability and such reinforced the informed decision on talent identification and player (de)selection (Owen et al., 2011).

The above research highlights the needs to move away from the current paradigm, that adopts a reductionist approach in the evaluation of soccer performance, evaluating discrete components of performance in isolation, when successful soccer performance is the product of interacting tactical, technical, physiological and psychological contributions (Reilly & Gilbourne, 2003; Unnithan et al., 2012).

2.4.1 Effect of Relative Pitch Size

A number of prescriptive variables, inclusive of player numbers, work to rest ratio durations, game regulations, availability of balls and relative pitch shape and size can influence upon the exercise intensity of SSG's, exhibited through movement demands and physiological responses (Balsom, Lindholm, Nilsson, & Ekblom, 1999; Hill-Haas et al., 2011). Of specific interest, is the manipulation of pitch size and the consequential impact upon physiological and movement demands and technical requirements of SSG's (Kelly & Drust, 2009; Owen, Twist, & Ford, 2004; Rampinini, Impellizzeri, et al., 2007). Pitch size can either be expressed in absolute or relative terms, which is the sum of the surface area and the sum of the surface area divided by the number of players, respectively (Hill-Haas et al., 2011). Commonly, pitch sized is expressed in relative terms as it improves the comparability between differentiating SSG's (Castellano et al., 2015).

Absolute pitch size was shown to have a main effect ($p < 0.017$) on heart rate response ($n^2 = 0.321$), blood lactate concentration ($n^2 = 0.331$) and RPE ($n^2 = 0.640$), with *Post-hoc* analysis demonstrating an increase in heart rate and blood lactate concentration which increasing pitch size (Rampinini, Impellizzeri, et al., 2007). This, however, is inconsistent with (Kelly & Drust, 2009), in which absolute pitch size did not significantly alter the heart rate responses observed within SSG's, attributed to the methodological differences between research. In a population of regional level, youth soccer players, significant differences were reported for an increase in $\%HR_{max}$, $\%HR_{mean,}$ and time $@>90\%HR_{max}$ between small (75 m^2) and large (275 m^2) relative pitch sizes (Casamichana & Castellano, 2010). Due to the reported inconsistencies referencing the effect of relative pitch size on physiological responses, a greater understanding is needed regarding the effects upon time motion analysis, movement demands, and physical performance (Casamichana et al., 2018).

An increase in relative pitch size (60 m^2 v 80 m^2) was synonymous with an increase in the total distance covered during running speeds at >13 $km{\cdot}h^{-1}$ ($p < 0.01$), > 16 $km{\cdot}h^{-1}$ ($p < 0.01$) and sprinting speed > 20 $km{\cdot}h^{-1}$ ($p = < 0.05$), however, no differences were reported for distance covered in speed zones between 0 -2 $km{\cdot}h^{-1}$ and 13 – 16 $km{\cdot}h^{-1}$ (Pantelić et al., 2019). A statistically significant difference ($p < 0.05$) was reported between variables of total distance (m), high speed distance (> 5.8 $m{\cdot}s^{-1}$) and distance covered during moderate (2 – 3 $m{\cdot}s^{-2}$) accelerations and decelerations between SSG's conducted on small (30 x 20 m) and larger (50 x 40 m) pitch sizes (Hodgson, Akenhead, & Thomas, 2014). Furthermore, there was an increase in the frequency of technical actions performed within a smaller relative pitch size, with statistically significant ($p < 0.01$) differences between the total number of passes (mean difference [95% CT's] = 3 [0-7]) and shots attempted (mean difference [95% ci's] = 2 [0-5]), which precludes an increasing technical demand on reduced relative pitch sizes, conducive to heightened decision making and frequency of skill execution (Hodgson et al., 2014).

The effects of alterations to individual playing area on the time-motion analysis outcomes of youth soccer players were researched by Casamichana and Castellano (2010), in which a large playing area was synonymous with an increase in total distance (m), distance per minute (m·p·m^{-1}), maximum speed (km·h^{-1}) and distance covered at high (> 18 kh·m^{-1}) and low (7.0 – 12.9 km·h^{-1}) intensity running (m) respectively. The above research, in line with Owen et al. (2004) and Rampinini, Impellizzeri, et al. (2007), concludes an increase in relative pitch size is concomitant with an increase in physical and physiological workloads (Casamichana & Castellano, 2010), which is consistent across sporting disciplines (Malone, Solan, & Collins, 2016).

Research conducted within an elite youth soccer population, demonstrated a significant interaction effect of pitch area upon total distance covered (m), distance per minute (m·p·m$^{\cdot -1}$), $\%HR_{max}$ and rate of perceived exertion ($p < 0.01$), with the requirement of a greater physiological and time motion requirement, with increase relative pitch size, consistent across youth age groupings (Gilogley, 2015a). Such the increased physiological demand, a change in relative pitch size has been shown to influence the technical and tactical actions of youth soccer players (Silva et al., 2014). A greater relative pitch size affords the opportunity for players to express creative behaviours, such as dribbling, however this at the expense of a detrimental effect upon such as shooting, due to an increased distance from the goal (Silva et al., 2014). It can be suggested that an increase in relative pitch size, will be synonymous with an increase in time on the ball and a reduction in ‘off the ball’ movement, due to a reduction in the requirement to create space (Silva et al., 2014).

In short, the manipulation of relative pitch size within a SSG format, allows for the intentional exposure and potentiation of technical and tactical behaviours, coinciding with the experience of physical and physiological demands of competition in a contextualised format (Ometto et al., 2018). It is therefore paramount of academia, to research and develop an understanding of how such manipulations may affect the talent identification process if SSG’s are to be implemented within a multi-faceted talent identification procedure.

2.5 Growth, Maturation and Maturity Status

Biological maturation is a process of growth towards a state of maturity or the adult, in which complete biological development is achieved in all bodily tissues, organs, and systems (Malina, Bouchard, et al., 2004; Malina, Rogol, Cumming, Silva, et al., 2015). Maturation is assessed through status and timing, which refer to the state of maturation at the chronological age at observation and the chronological age at which specified maturational events occur, respectively (Cumming et al., 2017; Malina, Rogol, Cumming, Silva, et al., 2015). When working with adolescent populations in environments of long term athletic development, maturation is expressed as the stage of development attainment in relation to final adulthood status (Malina, Bouchard, et al., 2004). The rate at which maturation progresses is referenced tempo, which is individualised within an adolescent population and independent of decimal aged grouping and calendar years (Malina, Bouchard, et al., 2004). The differential in the tempo of maturation leads to increased variance in biological maturity status across athletic populations, categorised by decimal age, which has a direct impact on anthropometrical, physical and psychosocial development (Cumming et al., 2017; Malina, Bouchard, et al., 2004). It is generally accepted that during adolescence (14 ± 4 years), individuals advanced in biological maturation, displayed improved performance across a range of sports as summarised by Fransen et al. (2018). More specifically, research has shown large variances in the biological maturation of adolescent athletes categorised within the same decimal age groupings in soccer (Helsen et al., 2005), rugby (Till et al., 2010), hockey (Sherar et al., 2007) and swimming (Costa, Marques, Louro, Ferreira, & Marinho, 2013). Across a youth soccer population (9.0 to 14.5 years), Malina, Cumming, Morano, Barron, and Miller (2005) reported percentage of estimate adult stature attainment to range from 75.5 ± 1.2% to 94.1 ± 1.8%.

As disseminated by Hill et al. (2019), it was recognised for the need of professional soccer academies to identify and assess biological maturation and relative age as independently operating constructs, which will better inform the talent identification process and address any respective selection bias. This is supported by legislation from the EPL and the EPPP (Premier League, 2011), who deem the collection, monitoring, and benchmarking of player maturity data compulsory, for the provision of bettering the long term athletic development pathway. In order to supplement this process, a battery of assessment methods have been established in order to assess biological maturation (Malina, Bouchard, et al., 2004), of which these methods will be introduced and discussed in the following section of this thesis.

2.5.1 Skeletal Maturity

The stages of skeletal maturation can be assessed using X-rays and radiographs, to assess the stages of bone development in the hand and wrist, from initial bone ossification through to adult bone formation and adult morphology (Malina, Bouchard, et al., 2004). The use of a hand and wrist radiograph for determining skeletal age is due to the skeletal formation of the respective regions, made up of an array of bone formation (carpals, scaphoid, ulna, and radius) (Bowden, 1976). Throughout these phases of development, they are three identifiable stages of bone development which act as maturity indicators; initial formation of bone centres that illustrates the replacement of cartilage by bone tissue; definition and bone characterization, reflective of the bone's adult nature and to conclude the fusion of the epiphyses with its respective diaphysis (the fusion of the bones end portion with its respective mid-portion) to achieve the attainment of adult bone contours (Malina, Bouchard, et al., 2004). Radiographs that reflect such bone development can be compared to a predetermined atlas of standardised x-ray plates, which correspond to the attained level of skeletal maturity (Malina, Bouchard, et al., 2004). The three most commonly implemented direct methods of skeletal maturity are the Greulich and Pyle (1959), Tanner and Whitehouse (1962) and Fels methods (Malina, Bouchard, et al., 2004). In order to standardise the measurement of biological maturity, skeletal age is presented relative to the individual's decimal age, creating a maturity offset (skeletal age – chronological age), which represents a delay or premature status of maturity (Malina, Bouchard, et al., 2004).

2.5.2 Greulich-Pyle Assessment of Skeletal Maturity

The Greulich-Pyle method of skeletal maturity assessment utilizes the radiographs of a specific individual’s hand and wrist, which are compared to a predetermined atlas of standardised X-ray plates, corresponding to the attained level of skeletal maturity achieved at a specific chronological age (Greulich & Pyle, 1959; Malina, Bouchard, et al., 2004). Each bone in the hand and wrist is assigned a skeletal age, of which a median value is accredited to represent the individual's overall skeletal age (Greulich & Pyle, 1959; Malina, Bouchard, et al., 2004). Putting this information into context, if a radiograph of an eight-year-old individual, is synonymous with the atlas of standardised plates that represent a nine-year-old individual, this corresponds to a skeletal age of nine years, meaning they’re advance in biological maturity (Malina, Bouchard, et al., 2004). Due to the time efficient procedure, coupled with good intra- and inter-observer reproducibility, the Greulich-Pyle methods, is the most commonly used method of skeletal age assessment in clinical populations (Alshamrani & Offiah, 2020; King et al., 1994). This is consistent with Paxton, Lamont, and Stillwell (2013) who reported skeletal age to be 2.2 months less than decimal age and no statistically different in the intra-observer and inter-observer interpretations, when performed across 406 radiographs. The atlas of standardised X-rays was constructed from a white American population for the purpose of clinical practice, which has raised questions around its applicability for divergent populations outside of the United States (Govender & Goodier, 2018; Mughal, Hassan, & Ahmed, 2014) or within diverse academy populations. Therefore, it can be considered that the Greulich-Pyle assessment of skeletal maturity, is neither applicable nor representative of modern populations with such diverse demographics, presentational of modern society (Tisè et al., 2011), offering justification for alternative methods to be utilised.

2.5.3 Tanner-Whitehouse Assessment of Skeletal Maturity

Originally established in 1962 (Tanner & Whitehouse, 1962), the Tanner-Whitehouse method of assessment was first modified in 1975 with the TW2 (Tanner, Whitehouse, Cameron, et al., 1975) and further revised in 2001, with the implementation of the TW3 (Tanner, Healy, Goldstein, & Cameron, 2001). The original cross-sectional sample was of a 3,000 British population, however, as the Greulich-Pyle method of assessment, this was not representative of diverse demographics, which promoted the modification formed in TW3, which references samples from Japan, American, Argentina and Europe (Malina, Bouchard, et al., 2004). The Tanner-Whitehouse methods of assessment use radiographs to assess the ossification (the natural process of bone formation) features of the radius, ulna, short-bones, and carpals, which are matched against a continuum of specifically written criteria of bone development, from the initial bone appearance at birth to a complete mature state (Malina, Bouchard, et al., 2004). Each bone is to be scored against the written criteria, with scores of each bone summated to produce a skeletal score ranging from 0 to 1,000 which represents immaturity and complete maturity respectively, prior to a conversion into a skeletal age (Malina, Bouchard, et al., 2004). When compared to the Greulich-Pyle skeletal maturity assessment, it was suggested that the Tanner-Whitehouse method of assessment should take precedent, due to a reduction in intra-observer variation and superior reproducibility (Bull, Edwards, Kemp, Fry, & Hughes, 1999). On the contrary, it has been reported that substandard methodological execution, can lead to the altered appearance of the epiphysis, promoting difficulty in interpretation and consequently leading to inconsistencies (Cox, 1996). Despite recent efforts to systematically improve the methodology, through technological advancements, the application of the Tanner-Whitehouse method to wider populations is still been questioned. In a recent study produced by Malina et al. (2018), it was reported that the TW3 protocol reported systematically lower skeletal ages when compared the TW2 method, which was reported to have considerable connotations on the maturational classification of players, which is deemed paramount to long term athletic development.

2.5.4 Fels Assessment of Skeletal Maturity

Consistent with the Greulich-Pyle and Tanner Whitehouse methods of assessment of skeletal maturity, the Fels assessment uses radiographs of the hand and wrist to assess skeletal maturity (Malina, Bouchard, et al., 2004). The size and shape of carpal bones, its epiphyses and corresponding diaphyses of the ulna, radius, metacarpals, and carpals of the first, third and fifth digits respectively, are compared to a descriptive criterium and graded accordingly (Chumela, Roche, & Thissen, 1989; Malina, Bouchard, et al., 2004). To supplement the grading, ratios between linear measurements of epiphysis and metaphysis widths are calculated and converted into measures of skeletal age (Chumela et al., 1989; Malina, Bouchard, et al., 2004). A statistical method of maximum likelihood is applied to select the most appropriate indicators of skeletal age for the respective child's decimal age, used to calculate skeletal age and associated standard error of skeletal age estimation (Malina, Bouchard, et al., 2004). A recent study produced by Nahhas, Sherwood, Chumlea, and Duren (2013), applied a statistical Bayesian Paradigm to the Fels method, which prompted improvement is statistical bias, reduce sampling variability and influence a natural interpretation of skeletal age. Van Lenthe, Kemper, and Van Mechelen (1998) reported the Fels method to produce significantly younger skeletal ages in comparison to the TW2 method (Tanner, Whitehouse, Cameron, et al., 1975). This is consistent with Malina, Chamorro, Serratosa, and Morate (2007) in which skeletal age was significantly younger in a population of elite youth soccer players, when measured by the Fels method, made comparable against the TW3 method (Tanner et al., 2001).

2.5.5 Application of Skeletal Maturity within Elite Soccer

The application of skeletal age and maturity assessment is well known in clinical and paediatric populations (Tanner, Whitehouse, Cameron, et al., 1975), with recent applications for age verification in elite youth sports environments (Malina, 2011), to prohibit the deliberate selection and participation of ‘over-aged’ players in younger age categories, representing beneficiaries of unfair physical and performance advantages associated with chronologically older players (Malina, Eisenmann, et al., 2004). The phenomenon of age falsification has become increasingly common across a variance of sporting environments and countries (Hogg, 2009; Malina et al., 2010). One of the highest profiles cases of age falsification was reported in 2013 when 18 players were excluded from representing their respective nations at the African U17 Championships, seven players from Nigeria were excluded from the FIFA U17 World Club and Somalia were expelled from qualifying for the participating in the African U17 championships, all for fielding over aged players (Cryer, 2014). Recent efforts have applied skeletal maturity assessments methods and magnetic resonance imaging (MRI) in attempt to verify stated chronological age groupings and promote fair play (Tritrakarn & Tansuphasiri, 1991), due to the large variance of skeletal age, within a specific chronological age grouping (Malina et al., 2010). As such, Malina et al. (2010) reported the standard deviation and this the individual differences in skeletal ages in the same chronological age grouping, to range from 1.01 to 1.37 years. Despite the logical application of skeletal assessment to validate decimal age, the Fels method (Chumela et al., 1989) has been shown to overrepresent skeletal age and unfairly classify 16% (n =36) of a U17 cohort, as too old for their respective decimal age grouping. The inconsistencies with assessments of skeletal age were cofounded by Malina, Chamorro, et al. (2007), in which a difference was reported in skeletal age by the TW3 (Tanner et al., 2001) and Fels (Chumela et al., 1989) method of assessment, in the same cohort of elite youth soccer players.

In addition to decimal age verification, skeletal age has been applied to assess the development of anthropometrical, functional, physiological, and technical characteristics of elite youth soccer populations (Valente-dos-Santos, Coelho-e-Silva, Simões, et al., 2012). It is generally accepted that youth soccer players who are delayed in skeletal maturation and systematically discriminated against their inclusion in long term athletic development pathways (Malina et al., 2000), due to inferior anthropometrical and physical characteristics, when compared to their skeletally mature counterparts (Malina, Eisenmann, et al., 2004). The relative distribution of '*early*' and '*late*' skeletally maturing elite youth soccer players, was found to be equivalent (21%: n = 13) in U11 to U13 populations (Malina et al., 2000). An increase in decimal age was consistent with the systematic exclusion of boys delayed in skeletal maturation, representing 7% (n= 2) and 2% (n= 1) of the U13 to U14 and U15 to U16 cohorts respectively (Malina et al., 2000).

Skeletal maturity assessments have a number of connotations and limitations that influence its application to an elite youth sport population. The requirement of X-ray or radiographing equipment possesses a protentional health risk, with the use of radiation

(Romann & Fuchslocher, 2016). This is complemented with the financial implications, that deems in not financially viable to assess player maturity through skeletal assessments, demonstrating the need to evaluate alternative methods of maturity assessment.

2.5.6 Sexual Maturity

During the transitional period of puberty from childhood to adulthood, an individual undergoes a continuous process of sexual differentiation, which is inclusive of the development of secondary sex characteristics, upon which the assessment of sexual maturity is based (Malina, Bouchard, et al., 2004). The secondary sex characteristic of concern are the physiological development of breasts and menarche in girls, the formation of genitalia in boys and the pubic hair in both sexes (Malina, Bouchard, et al., 2004; Malina, Coelho-e-Silva, Figueiredo, Carling, & Beunen, 2012; Malina, Rogol, Cumming, Silva, et al., 2015; Vaeyens, Philippaerts, & Malina, 2005), which are assessed along a continuum, ranging from stage one to stage five, which represent the earliest and latest stages of sexual differentiation respectively (Silva et al., 2010). Stage one indicates a prepubertal state, with an absence of development, stage two indicating the initial overt development, stage three and four indicates the continual physiological maturation, through to stage five, which indicates a mature adult state and complement sexual development and differentiation (Malina, Bouchard, et al., 2004). The protocols of sexual maturity assessment have been deemed to be an invasion of personal privacy, due to the direct examination of gentianella or breasts, which has led to an introduction in methods of self-assessment (Leone & Comtois, 2007; Malina et al., 2012). Self-assessment of sexual maturity was found to be reliable and valid against methods of clinical physician assessment (r^2 = 0.86 to 0.97) in elite adolescent athletes (Leone & Comtois, 2007). Despite the interrelationships between clinical and self-assessment methods, there is evidence to suggest large variability between clinical results, due to stage four pubic hair individuals, also been classified as having achieved stage five breast of gentianella development, suggesting a mature adult state, which does not comply with the pubic hair results (Matsudo & Matsudo, 1994). Such findings, coupled with the limitation that sexual maturity can only be assessed through the pubertal stages of growth and maturation (Malina, Bouchard, et al., 2004), have questioned the application of sexual maturity assessments within elite youth soccer (Towlson, 2016).

2.5.7 Application of Sexual Maturity within Elite Youth Soccer

Sexual maturity has shown insufficient evidence as a predictor of technical ability in elite youth soccer players (Malina, Eisenmann, et al., 2004). Vaeyens et al. (2005) researched the variation on sport specific skills in youth soccer players, upon in was reported that clinical examination of pubic hair development was not a significant predictor for tests of shooting accuracy; ball control with body/head and dribbling with a pass (8%, 13%, 14%, and 21% respectively). However, this is inconsistent with recent research disseminated by (Moreira et al., 2017), that found moderate to large relationships between technical performance sets (inclusive of the total number of successful passes and total tackle count) with pubic hair development and genitalia development. The inconsistency could be attributed to a difference in testing conditions, as Vaeyens et al. (2005) adopted an isolated testing environment to assess technical skill, in comparison to the small sided games environment adopted by Moreira et al. (2017).

Alongside technical ability, sexual maturity has also been applied to assess physiological performance (Forbes et al., 2009). Malina, Eisenmann, et al. (2004) reported players categorised in stage five of pubic hair development to demonstrate significant ($p < 0.01$) superior performance in the Yo-Yo Intermittent Recovery Test (Bangsbo, Iaia, & Krustrup, 2008) (+1182m), countermovement jump (+ 7cm) and sprint performance capacity (- 0.6s), when compared to players within stage one of pubic hair development. Due to procedural and qualification difficulties, accompanied by the limitation of use through the pubertal phase, it can be suggested to adopt non-invasive methods of maturity assessment that are more inclusive across a broad population of elite youth soccer players (Towlson, 2016).

2.5.8 Somatic Maturity

The longitudinal data collection for measurements of height can be used to determine the point of inflection on a growth curve that reflects an adolescent growth spurt, which derives the indicator of age at peak height velocity (APHV), is the age when the maximum rate of growth onsets during the adolescent growth spurt (Malina, Bouchard, et al., 2004; Mirwald et al., 2002). Such exposure to radiation, time and financial constraints of skeletal maturity assessments to determine APHV, addressed the need to develop alternative non-invasive measures of somatic maturity, calculated using anthropometrical measures (Fransen et al., 2018; Khamis & Roche, 1994; Mirwald et al., 2002; Sherar et al., 2005). Anthropometrical measures inclusive of stature, body mass, leg length, sitting height, and chronological age, are applied to predict years from peak height velocity (YPHV), which is termed as a maturity offset (Fransen et al., 2018; Mirwald et al., 2002). The present study will now introduce the pertinent measures for the somatic assessment of maturity status (Fransen et al., 2018; Khamis & Roche, 1994; Mirwald et al., 2002; Moore et al., 2015).

2.5.9 Mirwald Somatic Maturity

Mirwald et al. (2002) aimed to establish a non-invasive and practical application to the assessment of maturity status throughout adolescence, with the use of anthropometrical variables, inclusive of height, sitting height and body mass, in order to determine the differential timings of growth and subsequent APHV, which would then be subtracted from chronological age, in order to calculate a maturity offset and determine subsequent years from PHV. The estimation of years from PHV has been implemented by soccer practitioners to assist in the identification of talented adolescent soccer players (Unnithan et al., 2012; Vaeyens et al., 2006). Such a method incorporates the adolescent growth spurt and is commonly employed in the longitudinal study of maturity status (Malina, Bouchard, et al., 2004; Mirwald et al., 2002). However, such a method of assessment has demonstrated that 95% of maturity estimations, collated from a population of 200 children (Saskatchewan Paediatric Bone Mineral Accrual Study) could present a margin of error of one year in maturity status calculations (Mirwald et al., 2002). Further validation demonstrated the accurate measurement of maturity status and such predicted APHV, if the measure was conducted within two years of actual APHV, however, predicted APHV was shown to underestimated and overestimate actual APHV, if calculated three years prior and post PHV, respectively, which questions the application to a youth academy soccer population, due to the overrepresentation of *early* maturing players, with subsequent accelerated maturational development (Deprez, Buchheit, et al., 2015; Malina & Kozieł, 2014). As such, it was deemed necessary for a modification in the regression equations, in order to better validate the application of somatic maturity assessment equations (Moore et al., 2015).

2.5.10 Moore Somatic Maturity

As such the widespread application of the Mirwald et al. (2002) maturity prediction equation, Moore et al. (2015) aimed to modify such regression equations, in order to better improve the accuracy of maturity prediction models. In order to minimalize such identified limitations, Moore et al. (2015) evaluated potential overfitting (inclusion of artificially large coefficients) using the original Paediatric Bone Mineral Accrual Study, assessed changes in R^2 and standard error of estimate with the addition of biological and statistical predictor variables, determine the effect of within-subject correlations with a forward-stepwise regression, applied dominant predictors to assess predictive abilities and calibrated such equations using participants from the Healthy Bone Study (42 boys & 39 girls; 8.9 – 18.9 years) and Harpenden Growth Study (38 boys & 32 girls; 6.5 – 19.1 years). Revaluation of the Mirwald et al. (2002) prediction equation, revealed that maturity offset was predicted accurately within ± 1 year, within 80 – 85% of cases, in comparison to the previously disseminated 95%, for the reason of within-subject correlation and overfitting. Moore et al. (2015) reported the redeveloped equations to predicted maturity offset within ± 1 year, within 90% of cases, despite large variance in APHV and maturity offset. It was also reported for such predictive maturity equations to provide an alternative for anthropometrical use of sitting height in the calculation of predictive maturity status (Moore et al., 2015). Despite such improvements, it was disseminated that the prediction error in predicted APHV, is likely to increase to a greater degree, the further a child is away from their actual APHV, suggesting such modifications do not produce a more valid estimation for those further removed from their APHV, attributable to the assumption of a linear estimation of an inherently nonlinear biological process of somatic growth, during the adolescent growth spurt (Fransen et al., 2018; Moore et al., 2015). As such, it was suggested that a nonlinear relationships between anthropometrical predictors and a maturity ratio (chronological age / AHPV) be applied to the original somatic predictive maturity equation (Fransen et al., 2018; Mirwald et al., 2002).

2.5.11 Fransen Somatic Maturity

As aforementioned, previously disseminated somatic maturity estimation equations were limited by the linear assumption of somatic growth, during the adolescent growth spurt and subsequentially linear growth of anthropometrical characteristics (Fransen et al., 2018). As such, Fransen et al. (2018) aimed to improve the prediction accuracy of APHV from anthropometrical assessment, with the application of a nonlinear model and maturity ratio. Fransen et al. (2018) applied the original dataset of the Saskatchewan Paediatric Bone Mineral Accrual Study (115 boys & 136 girls; 8 to 15 years of age) as per the Mirwald et al. (2002) study, for the development of a new prediction equation and such equation was validated on 1330 high level male youth soccer players, aged 8 to 17 years of age. The new equation was shown to estimate APHV more accurately than the originally developed maturity prediction equation (R^2 = 90.8 Vs. 88.9 %, respectively) within a general population of boys, however, such application was extended to the use within a youth athletic population (Fransen et al., 2018). However, Nevill and Burton (2018) reported such an equation to be misleading and fundamentally flawed, with the suggested that inclusion of the subjects chronological age, in both sides of the predictive equations, will subsequently result in high values of R^2. Another identified limitation of the Fransen et al. (2018) predictive maturity equation is the analysis of repeated measures data, inclusive of between- and within-subject error, in which multilevel modelling would be a more appropriate application, alongside a simplified formula for the disseminations to practitioners (Nevill & Burton, 2018). Due to such identified limitations, there is a requirement to identify an alternative measure and assessment of predicted maturity status.

2.5.12 Khamis & Roche Somatic Maturity

An alternative to the prediction and assessment of maturity status can be achieved through the calculation of the estimated percentage of adult stature, a child has attained at the time of measurement (Khamis & Roche, 1994). Derived from the anthropometrical measures of age, stature and weight of the subject and the mid parental height (average height) of the biological parents, predicted maturity status is interpreted through the estimated percentage of adult stature attainment (%EASA), in which an increase in values, demonstrates an increased level of biological development (Khamis & Roche, 1994). The primary source of development was a population of white males (n = 223) and female (n = 210) participants, originating from the Fels Longitudinal Study (Khamis & Roche, 1994). Between the ages of 4 to 18 years, the reported median error band between predicted and actual mature height is 2.2cm in males (Khamis & Roche, 1994). As such, the requirement to obtain mid parental height can present time consuming and methodological constraints, especially if the biological parents perceived their child to be disadvantaged, as a consequence of such disclosure. The Khamis and Roche (1994) method has previously applied in youth soccer populations (Cumming, Battista, Standage, Ewing, & Malina, 2006) and more recently applied to 'bio-banded' players for biological maturation during competitive match play (Cumming, Brown, et al., 2018), which could suggest it to me to most approach equation, to apply within a high level youth academy structure, for the prediction of maturity status.

2.5.13 Application of Somatic Maturity within Elite Youth Soccer

Estimations of YPHV (Mirwald et al., 2002) and predicted adult stature (Khamis & Roche, 1994; Sherar et al., 2005) are commonly applied in elite youth soccer environments, to assist in the process of generating a holistic approach talent identification and athlete development (Cumming, Brown, et al., 2018; Philippaerts et al., 2006; Unnithan et al., 2012; Vaeyens et al., 2006), providing the ability to distinguish between adolescent performance and future potential (Vaeyens et al., 2008). Somatic maturity has been applied to guide the talent identification process across multiple disciplines; performance analysis (Buchheit & Mendez-Villanueva, 2014; Buchheit, Mendez-Villanueva, Simpson, & Bourdon, 2010; Goto, Morris, & Nevill, 2019), strength, (Emmonds et al., 2017), physical performance (Mendez-Villanueva et al., 2011; Mendez-Villanueva et al., 2010; Philippaerts et al., 2006), aerobic/anaerobic capacity (Buchheit et al., 2010; Lovell & Parkin, 2012; Valente-dos-Santos, Coelho-e-Silva, Duarte, et al., 2012), allowing for the comparison of player development relative to somatic maturity (Towlson, 2016). As such, it is important to consider athletic performance and development as a conditional construct to maturity, due to associated maturational advantages in performance (Buchheit & Mendez-Villanueva, 2014), consequentially impacting upon the talent identification process (Lovell et al., 2015; Meylan et al., 2010).

The estimation and audit of player maturity throughout the youth development phases (under 12 to under 16) of the EPPP (Premier League, 2011) was deemed necessary by Towlson, Cobley, Parkin, and Lovell (2018) given that academy soccer players will likely achieve PHV between 10.7 & 15.2 years of age. Consistent with PHV, advanced normative growth (Carling et al., 2009) and such maturity related advantages, are considered synonymous and influential upon the '*early*' (de)selection of players for continue development programs (Deprez, Fransen, Lenoir, et al., 2015; Sanders et al., 2017).

Lovell and Parkin (2012) reported a significant increase in repeated sprint ability between *late* (< -2.5-years pre-APHV) and *early* (> +2.5-years APHV) maturing youth soccer players (37.3 ± 2.1 s & 31.0 ± 1.2 s respectively). This is consistent with Lloyd et al. (2015), who reported more mature players to outperform younger counterparts, in all tests of physical performance and functional movement screenings ($p < 0.05$). These results highlight the pertinence of an inclusive measure of somatic maturity, in an effort to reduce the systematic over selection of '*early*' maturing soccer players that exhibit, transient maturity related anthropometrical and physiological characteristic, in favour of technically adept, youth soccer players, potentially born in the latter quartiles of the year (Carling et al., 2009; Towlson, 2016).

It has been well documented that there is an evident bias towards the selection of *early* maturing or biological developed soccer players within talent development pathways and soccer academy structures, with the indication that maturation has an influence on talent identification and selection within a youth setting (Malina, Eisenmann, et al., 2004). As reported by Meylan et al. (2010), talent identification and selection is dependent upon the "multifaceted intuitive knowledge comprised of socially constructed images of the perfect player", which suggested the biologically advanced players, who express such desirable traits, may be perceived as 'talented', due to such momentary and transient physical and anthropometrical advantages. Taking this into account, such effects of biological maturation upon physical performance must be considered, allowing comparison to be made with respect to maturational differences.

2. 6 Physical Match-Play Characteristics of High-Level Adolescent Soccer Players

To date, an abundance of literature is available that reports the match play characteristics, movement demands, and patterns of elite soccer, by applying an assortment of tracking technologies (Abbott, Brickley, & Smeeton, 2018; Bangsbo, Nørregaard, & Thorsoe, 1991; Bradley et al., 2009), despite this there is limited disseminated research available that consider the match play characterises of high level youth soccer. The monitoring of match running performance is considered a fundamental part of the contemporary youth development process and an important construct of the talent identification process, helping aid long term athletic development and supplementing the scientific knowledge of player identification, progress, and development over a time continuum (Goto, 2012; Vieira et al., 2019). Due to the unstandardized differences in match conditions, pitch size and game duration of elite youth soccer, normative match running performance data may not be relevant across all age populations but could be applied to determine an age at which players demonstrate the match running outputs that reflects the demands of professional standards (Harley et al., 2010; Vieira et al., 2019), however decisions on player retention cannot be based solely on match running performance data (Paul, Bradley, & Nassis, 2015). From a practical context, time motion analysis can be applied to enable the tailoring of age-specific training programs and stimulate the improvement in long term athletic development interventions, influencing upon the physical training content and prescription (Vieira et al., 2019). As such, this thesis will now introduce the disseminated research regarding the match activity demands of elite youth soccer players.

The reported total distance (m) covered by U15, U17, and U20 elite youth Brazilian soccer players was reported as 7077.4 m, 8638.7 m, and 9809.7 m respectively, with distance dependent upon match duration (Da Silva, Kirkendall, & Neto, 2007). Goto (2012) presented the total distance covered during competitive match play to range from 4056 m to 7697m at U10 and U16 ages respectively, consistent with (Castagna, Impellizzeri, Cecchini, Rampinini, & Alvarez, 2009) in which U14 elite youth Italian soccer players covered a total distance of 6173 m. The results of the respective studies supported the notion that the total distance covered (m) of youth soccer players, is similar to that of professional adult soccer players (9221 m) (Barros, Valquer, Santanna, & Barbosa, 1998; Da Silva et al., 2007). When analysing the data relative to duration, U9 players covered a total distance of 4675 $m{\cdot}h^{-1}$, in comparison to the 6727 $m{\cdot}h^{-1}$and 6564 $m{\cdot}h^{-1}$, covered by the U15 and U16 player respectively, with professional players covering between 6667 $m{\cdot}h^{-1}$ and 9396 $m{\cdot}h^{-1}$, which suggests elite youth soccer players are able to attain the standards of professional soccer players, for the metric of total match distance covered, when they reach the age of 15 (Goto, 2012). However, in consideration, the mean playing time of U15 and U16 players was 63.7 and 70.4 minutes respectively, suggesting a duration of a 90 minute match, may induce fatigue and a consequential decline in work rate, negatively impacting upon such performance outcomes (Goto, 2012).

When distance is considered in categories of linear velocities, Castagna et al. (2009) reported distances of 508 m, 2981 m, 1694 m, 741 m and 234 m for walking (0.4 – 3.0 km·h^{-1}), jogging (3.0 – 8.0 km·h^{-1}), medium intensity running (8.0 – 13.0 km·h^{-1}), high intensity running (13.0 – 18.0 km·h^{-1}) and sprinting (> 18.0 km·h^{-1}) respectively, for U14 elite youth soccer players. Goto (2012) reported distance covered during velocities of walking (0.0 – 1.2 m·s^{-1}), jogging (1.1 – 2.4 m·s^{-1}), low speed running (2.1 – 3.7 m·s^{-1}), moderate speed running (3.2 – 4.9 m·s^{-1}) and high-speed running (> 4.1 - > 4.9 m·s^{-1}), to range between 946 m·h^{-1} to 1121 m·h^{-1}, 1653 m·h^{-1} to 2139 m·h^{-1}, 1098 m·h^{-1} to 1978 m·h^{-1} , 496 m·h^{-1} to 1042 m·h^{-1} and 178 m·h^{-1} to 553 m·h^{-1} for U9 to U16 elite youth soccer players. When analysing these values relative to match duration, the U9 and U16 player spent 46.4% and 39.4% walking, 33.2% and 33.8% jogging, 15.0% and 17.5% low speed running, 4.1% and 6.6% moderate speed running and 1.1% and 2.6% high-speed running respectively (Goto, 2012). The reported measures of percentage time at moderate speed running and high-speed running inclusive of sprinting for English Premier Academy soccer players is comparable to the results published of English Premier League professional players (6.2 – 7.0% vs. 6.4% & 2.6 – 3.0% vs. 2.6% respectively), indicating a similarity between high-intensity activity patterns (Goto, 2012). In short, the above results demonstrate the relative progress and development of match activity profiles through the stages of long-term athletic development, to a stage at which they become comparable with those of elite level soccer players, indicating a physiological readiness for a transition into the professional game.

2.6.1 Methods for Assessing Physical Match Play Activity

The Global Positioning System (GPS) is a satellite based navigation system, originally developed for military application, that enables the tracking and quantitative measurement of three-dimensional player movement (Cummins, Orr, O'Connor, & West, 2013; Malone, Lovell, Varley, & Coutts, 2017). The foundations of the system are built around twenty-seven operational satellites that orbit the Earth, transmitting information from an atomic clock to the GPS receiver, in which the measurable distance between the GPS receiver and four corresponding satellites, allows for the accurate triangulation of the receiver’s location (Cummins et al., 2013; Larsson, 2003). Prior to the introduction of GPS, match activity profiles and movement demands were assessed using video time-motion analysis (Gabbett & Mulvey, 2008), despite been deemed unreliable due to the subjective determinants of locomotive activity (Gabbett, 2010). Preceding the first utilisation of GPS for athletic tracking by Schutz and Chambaz (1997), GPS technology has become commercialised and increasingly applied with team sports environments (Cummins et al., 2013; Malone et al., 2017).

Initially, GPS allowed the measurement of basic movement patterns, inclusive of speed, total distance covered and the number of accelerations and deceleration, however recent technological advancements within microtechnology has led to the integration of micro electrical mechanical systems (MEMS), inclusive of triaxial accelerometers (Neville, Rowlands, Wixted, & James, 2011) and gyroscopes. Triaxial accelerometers enable the quantification of physical loading by measuring a vector magnitude in the X (medial-lateral), Y (anterior-posterior) and Z (vertical) planes of motion and expressing a value as a gravitation force (Cummins et al., 2013). Such technology provides practitioners with quantitative data to assess athletes activity profiles and physical loading, contributing to the comprehensive analysis of on-field player performance during training and competition, allowing for the informed decision making of tailored training and recovery programs, inducing optimal performance and reduced rates in injury (Cummins et al., 2013; MacLeod, Morris, Nevill, & Sunderland, 2009).

GPS systems are currently manufactured with a sampling rate of between 1 and 15 Hz, with the literature suggesting that a higher frequency rate provides greater validity within the data, however, to allow for greater scientific interpretation and add meaning to the data, it is deemed essential that practitioners develop an understanding of validity and reliability, upon which the system may be limited (Cummins et al., 2013; Scott, Scott, & Kelly, 2016).

2.6.2 Validity

Validity is the degree to which a quantitative variable is accurately measured and the ability of a research instrument to consistently produce invariable results when used to assess identical conditions across repeated measures (Heal & Twycross, 2015). The measures of validity are presented in the form of standard estimate of error (SEE), standard error of measurement (SEM), coefficient of variance (CV), or the calculated difference between mean and criterion measures (Scott et al., 2016). Validity within the GPS system can be affected by an abundance of factors, inclusive of the sampling rate (Hz), chipset processor, filtering methods, data processing algorithms, and device positioning, all of which can be dependent upon the manufacturer (Malone et al., 2017). Of practical consideration, it is deemed pivotal that researchers refer to validation studies with products and reported metrics of the same nature (Malone et al., 2017). The present study will now evaluate the respective validity of GPS systems, across varying sampling rates.

Across low velocity (< 3.58 $m{\cdot}s^{-1}$), moderate linear distances, 1 Hz GPS units provide accurate distances between criterion measures (Petersen, Pyne, Portus, & Dawson, 2009; Portas, Harley, Barnes, & Rush, 2010). However, across shorter linear distances (10 – 40m) performed at equitable velocities, an unacceptable level of validity was reported, with a gross underestimation of criterion sprinting distanced covered (Jennings, Cormack, Coutts, Boyd, & Aughey, 2010a), suggesting that 1 Hz GPS units are limited in the application of team sports, due to the nature of repeated high speed and intensity efforts performed over short distances (Gabbett, 2010; Jennings et al., 2010a; Scott et al., 2016). An attributing factor in the measurement of high intensity movements demands is the device's ability to accurately measure instantaneous velocities. Barbero-Álvarez, Coutts, Granda, Barbero-Álvarez, and Castagna (2010) reported positive results in the measure of validity when analysing running velocities, however, questioned the ability of 1 Hz GPS units, to accurately report instantaneous running velocity during team sport activity.

Through technological advancements and the introduction of 5 Hz GPS units, it has seen a remarked increase in the reported validity (Scott et al., 2016). Five Hz GPS units have demonstrated good validity (SEE = 2.9 – 3.1%) for the measures of linear moderate distances (50 – 60 m) performed at low speed running velocities (Petersen et al., 2009; Portas et al., 2010). A good level of validity was reported for the measure of multidirectional distance across walking and running velocities (SEE = 2.2% - 4.4%), however, a suggested increase in course complexity, performed at running speeds, was seen to increase the margin of error (Portas et al., 2010). Across short distances (< 20 m) 5 Hz GPS units were reported to produce an inadequate level of validity for running and sprinting velocities, which questions the efficacy of using 5 Hz GPS systems to quantify high speed movements and accelerations over short distances in team sports (Jennings et al., 2010a; Johnston et al., 2012).

To combat the limitation of 5 Hz GPS units to measure high speed intensities across short distances, recent research has focused upon the validity of GPS units with a sampling frequency of 10 Hz (Castellano, Casamichana, Calleja-González, San Román,

& Ostojic, 2011; Johnston, Watsford, Kelly, Pine, & Spurrs, 2014). Ten Hz GPS units presented an acceptable measure of validity when comparing maximal sprint speed efforts, performed across 15 and 30m distances (SEM = 5.1 - 10.9 %) (Castellano et al., 2011). The results of the respective study as reciprocated in Johnston et al. (2014), in which 10 Hz GPS units produced no significant differences between measures of total distance and criterion distance, performed across a team sport simulation circuit, inclusive of high-speed (14 – 19.9 km·h^{-1}) and very high-speed running (> 20.0 km·h^{-1}). Johnston et al. (2014) demonstrated the improved ability of 10 Hz GPS units to accurately measure the movement demands of team sports, in comparison with 1 Hz and 5 Hz units, despite identifying the limitation of 10 Hz units to accurately measure movement demands performed at speeds > 20 km·h^{-1}. Good to moderate levels of validity were demonstrated for the measurement of instantaneous velocities across linear distances, during constant velocity running and the acceleration phase of running (Varley, Fairweather, & Aughey, 2012). A limitation occurs throughout the measurement of instantaneous velocity during periods of deceleration across linear distances and periods of acceleration during simulated team sports circuits (Varley et al., 2012). Despite concerns regarding the inability to accurately measure high speed movement demands, it can be summated that 10 Hz GPS units produce sufficient accuracy to quantify the movement demands of team sports (Castellano et al., 2011; Johnston et al., 2014; Varley et al., 2012).

Recent increases in sampling rates, through the supplementation of 10 Hz GPS units with accelerometer data, has seen the introduction of GPS units with a sampling rate of 15 Hz, however, the recent technological introduction has highlighted the need for further research on such validation (Johnston et al., 2014). Johnston et al. (2014) reported no significant difference between criterion distance and total distance covered during a team sport stimulated circuit, suggesting that in general, 10 Hz GPS units measure movement demands with a great level of validity, with no requirement to determine the differential effects of validity between 10 Hz and 15 Hz GPS units (Johnston et al., 2014). The application of 10 Hz GPS units for the measurement of team sport movement demands was confirmed when Scott et al. (2016) suggested there to be no additional benefit to the increased sampling rate that a 15 Hz GPS unit offers.

2.6.3 Reliability

Measures of reliability can form two constructs, intra-unit and inter-unit reliability, which refers to the consistency of measurement with-in a singular device across multiple incidences and the consistency of measurement between two individual GPS units, gauging the same performance metric respectively (Coutts & Duffield, 2010). Measurements of reliability are presented in two formats, coefficient of variance (CV) and typical error of measurement (TEM), in which levels of reliability are measured against a continuum of good (< 5%), moderate (5 – 10%) and inadequate (> 10%) (Scott et al., 2016).

One Hz GPS units were reported to have a good level of intra unit reliability (CV < 5%) for the measurement of linear, curvilinear and non-linear distances (50 – 8800 m) during walking, jogging and running velocities inclusive of multidirectional changes (Gray, Jenkins, Andrews, Taaffe, & Glover, 2010; Petersen et al., 2009; Portas et al., 2010). An increase in the speed of movement and reduction in distance, demonstrated a decrease in reliability, identifying the limitation of 1 Hz GPS units to measure high intensity and short distance running, inclusive of team sport environments and such inappropriate application (Jennings et al., 2010a). In reference to inter-unit reliability, Gray et al. (2010) reported good to moderate level of reliability for walking, running, and sprinting across linear and curvilinear distances (CV = 1.46 – 6.04%).

The measure of inter-unit reliability is negatively affected for distances covered at a high (> 14.4 km$\cdot$h^{-1}) and very high-intensity running distance (> 20 km$\cdot$h^{-1}) (Coutts & Duffield, 2010). In short, Scott et al. (2016) summated the competence of 1 Hz GPS unit to consistently reproduce measures of distance within team sport environments using a singular unit or between unit, however, highlighted the need for careful consideration when comparing reported distances that occurred at a high velocity over short distances.

An increase in sampling rate has shown a remarked increase in the measure of reliability, with 5 Hz GPS units demonstrating good levels (CV = < 5%) of intra-unit reliability during linear and curvilinear distances, in addition to good to moderate measures of distance for walking and running (CV = 3.71 – 6.72%) throughout multidirectional movements (Petersen et al., 2009; Portas et al., 2010). Of greater relevance, is the improved intra-unit reliability for the measure of high velocity movement, performed across courses inclusive of gradual changes of direction (CV = 7.9 – 10.0%), acute changes in direction (CV = 8.6 – 9.7%) and simulated team sport environments (CV < 5%) (Jennings et al., 2010a; Portas et al., 2010).

When considering the inter-unit reliability of 5 Hz GPS units, Jennings, Cormack, Coutts, Boyd, and Aughey (2010b) reported differences (± 90% CI) between individual units for linear running movements (11.9 ± 19.5%) and team sports circuits (11.1 ± 4.2%), along with total distance (10.3 ± 6.2%) and high-intensity running distance (10.3 ± 15.6%) measured during match play. It can be suggested that comparison between individual deceives of very high speed running would be inappropriate, with the recommendation to apply a player specific device across all sessions, in order to achieve best practice (Jennings et al., 2010b; Scott et al., 2016).

This is consistent with Varley et al. (2012), in which 5 Hz GPS units were reported to demonstrate poor levels of inter-unit reliability (CV > 10%) for measures of instantaneous velocity, during an initial low constant velocity, or through the duration of acceleration and deceleration phases of running. Moderate levels of inter-unit reliability were produced for measures of instantaneous velocity with an initial moderate or high velocity (CV = 6.7% & 6.3%) respectively (Varley et al., 2012). Research suggests good levels of intra-unit reliability (CV = 0.78 – 2.06%) when measuring maximum velocity and velocity over distances between 10 to 20 m (Waldron, Worsfold, Twist, & Lamb, 2011). However, Johnston et al. (2012) reported the above measure of reliability, are not consistent and do not translate into team sport movements and as such, multiple 5 GHz GPS units can be used for comparison with a. team sport environment.

An increase in sampling rate and the application of 10 Hz HPS units for the measurement of distance, demonstrated an improved level of reliability, addressing the limitation of 1 Hz and 5 Hz GPS units in the reliable measure of distance performed at high velocities. Castellano et al. (2011) reported 10 Hz GPS units to produce good measures of intra-unit reliability (CV < 5%) and inter-unit reliability (CV = 1.3% & 0.7%) for the measurement of 15m and 30m sprinting distance, respectively. Across a team, sport stimulated circuit, 10 Hz units demonstrated good levels on inter-unit reliability for total distance, low speed and high speed running distance (TEM = 1.3 - 4.8%), however the reporting of very high speed (> 20 km$\cdot$h^{-1}) distance covered, presented a decrease in the inter-unit reliability (TEM = 11.5%) (Johnston et al., 2014). These findings still advocated the reliable application of 10 Hz GPS units for the analysis of distance covered during team sport movement demands, but drew caution to any distance covered at velocities exceeding 20 km$\cdot$h^{-1} (Johnston et al., 2014).

Measures of instantaneous velocity during periods of acceleration, deceleration, and constant velocity running, regardless of initial velocity, have demonstrated good to moderate (CV = 1.9 - 6.0%) levels of inter-unit reliability (Varley et al., 2012). In support of this, Johnston et al. (2014) demonstrated the reliable capacity of 10 Hz GPS unit in the measurement of maximum velocity across team sport simulated circuits (TEM = 1.6%).

Of importance, it was found that 10 Hz GPS units were able to quantify the smallest worthwhile change in measures of speed, reporting reduced values of noise, in comparison to smaller sampling rates (Scott et al., 2016). As such, practitioners can confidently report and compare measures of velocity and speed from separate athletes during a singular session or individual athletes across separate sessions.

2.6.4 Influence of Maturity of Physical Match Activity

Recent research has shown that soccer academy players advanced in maturation (maturity offset: + 0.9 ± 0.4) demonstrated greater maximum velocities and covered a great distance at high speed (> 16 $km\cdot h^{-1}$) but demonstrated no significant difference between total distance covered, during 11 a-side, competitive match play (Buchheit & Mendez-Villanueva, 2014). Age at peak height velocity (APHV) contributed significantly to total distance, high speed running (13.1 – 16.0 $km\cdot h^{-1}$) and very high-speed running (16.1 – 20.0 $km\cdot h^{-1}$) distances in a population of adolescent soccer players (n = 278) (Lovell et al., 2019). An increase in APHV by one year was associated with 0.6%, 5.4% and 6.9% increase in total distance high-speed running distance and very high-speed running distance, independent of playing position, in which later maturing players, displayed enhanced match play characteristics (Lovell et al., 2019). It is suggested that this difference is accountable to an increase in ‘off the ball movement’, in order to create space, in which to receive possession and avoid any physical contest with more mature and physically adept players (Lovell et al., 2019). Another point of consideration is that enhanced match player characteristics, bear increase external and internal loads, making symptoms of match induced fatigue more prevalent and impacting upon talent selection and development opportunities (Lovell et al., 2019).

When evaluating the efficacy of biological maturation upon performance characteristics, it is important to analyse the effects across a continuum of chronological age grouping with a large variance, due to the respective subsequent effects upon performance outcomes (Goto et al., 2019; Patel, Nevill, Cloak, Smith, & Wyon, 2019). A recent study published by Goto et al. (2019), analysed the influence of biological maturity on the match play performance of 8 – 16-year-old, elite Premier League Academy, male soccer players. In the U9/10 chronological age grouping, earlier matures had an increase match play duration (~ 6 minutes, $p < 0.01$) resulting in a greater total distance covered (~ 13%, $p = < 0.01$), providing an increased opportunity to demonstrate and develop match performance characteristics (Goto et al., 2019). When evaluating the U13/14 chronological age group, the variance in match duration was discounted for, however *early* maturing players covered a greater distance for relative high-speed running (~44%) and spent a greater proportion of time performing high-speed running when compared to later maturing players (3.5% & 2.5%) respectively (Goto et al., 2019). The results of the respective study demonstrate the dynamic effects of biological maturation and chronological age upon performance and highlights the need to address maturity status throughout differing chronological age groupings.

Although not pertinent to the present study, it is of importance to consider such anthropometrical and physical characteristics, independent of match play characteristics, of a high level youth soccer population, due to the suggested relationships between the aforementioned factors (Aquino et al., 2020; Bradley et al., 2011; Castagna, Manzi, Impellizzeri, Weston, & Alvarez, 2010; Rampinini, Bishop, et al., 2007). Research precludes that within chronological age groupings, adolescent males who are in advance of biological maturation, perform better across tasks of physical performance when compared to those in a delay of maturational growth, most prominent between thirteen and sixteen years of age (Malina, Eisenmann, et al., 2004; Philippaerts et al., 2006). Recent research has been focused upon the independent effects of biological maturation on maximal oxygen uptake (VO_{2max}), physical performance, functional capacity and soccer specific skill performance (Cunha, Célia, Ribeiro, & Oliveira, 2008; Cunha et al., 2011; e Silva et al., 2010; Malina, Eisenmann, et al., 2004; Malina, Ribeiro, Aroso, & Cumming, 2007; Philippaerts et al., 2006; Vaeyens et al., 2006). As such, this thesis will now introduce and detail, the recent dissemination, in reference to the effects of biological maturation on performance.

The tendency for an adolescent male soccer player to be advanced in biological maturation is consistent across the disseminated research, in which maturation status has a consequential impact upon an array of characteristics and attributes (Malina, 2003). Without analysing the independent effects of biological maturation upon selected performance metrics, we can still hypothesise the perceived effects of advanced biological maturation on such performance (e Silva et al., 2010; Goto et al., 2019; Malina, Eisenmann, et al., 2004). Despite all five stages of pubic hair development been evident with a sample of 13 – 15-year-old, adolescent soccer players, there is an increase representation of players in stage four and stage five of pubic hair development, 30%, and 28% respectively (Malina, Eisenmann, et al., 2004). When applying chronological age at PHV to assess biological maturation, Goto et al. (2015) found the portion of *early* and average maturing players to be 19% and 81% respectively, in which no players of an *early* maturing nature were present, within a population (n = 80) Premier League Academy soccer players.

As expected, those players advanced in maturation, were significantly heavier and taller, and performed better across tests of functional capacity and soccer specific skill performance (e Silva et al., 2010). As a player progresses through the maturational process, growth in stature during their adolescent growth spurt, growth in male stature (cm) can increase 10 $\text{cm} \cdot \text{year}^{-1}$, on average (Tanner, 1981). The most biologically advanced, stage five players, were shown to demonstrate a clear physical advantage, in the performance of vertical jump height (31.9 cm) and yo-yo intermittent endurance test distance (2655 m), in comparison to stage one players (24.9 cm & 1473 m) respectively (Malina, Eisenmann, et al., 2004).

It can be suggested that the impact of biological maturation upon player selection and retention is a consequence of the respective effect upon performance measures, inclusive of physiological and functional capacities (Cunha et al., 2008; Cunha et al., 2011). As such, when VO_{2max}, is expressed in absolute terms, a significant difference ($p < 0.05$) was observed between the classification of prepubescent, pubescent and postpubescent individuals (Cunha et al., 2008; Cunha et al., 2011). Similar findings were reported by Meyers, Oliver, Hughes, Cronin, and Lloyd (2015) in which players who had experienced their PHV, were significantly faster than those who were in delay of maturational development, displaying a difference of 1 $m \cdot s^{-1}$. However, Cunha et al. (2011) reported that when evaluating the physiological performance of adolescent soccer players, it is pivotal to adopt allometric scaling, which allows for the consideration of an individual's body mass (kg), an anthropometrical characteristic, that is strongly correlated with increased VO_{2max}.

A study published by Malina, Ribeiro, et al. (2007) reported the stage of pubic hair development and height to significantly predict soccer skill performance, accounting for 21% of the total explained variance. Players in the highest quintiles of composite soccer skill performance, on average, tended to be taller and heavier and displayed an improve functional capacity than their counterparts, which indicates the inter-relationship between growth, maturation and functional capacity upon soccer skill specific performance (Malina, Ribeiro, et al., 2007). It was reported that, 82% of the players within the highest and high composite skill quintiles, were in stage 4 (PH 4) and 5 (PH 5) of pubic hair development, reflecting upon the positive influence of maturity status on a holistic component of performance in adolescent male soccer players (Malina, Ribeiro, et al., 2007). As such, we can deduce the need for extended research, in reference to the potential effects of biological maturation upon performance, in an array of contexts.

Philippaerts et al. (2006) monitored the longitudinal changes in height, weight, and physical performance across a five-year period, in order to determine the incidence of peak height velocity and its subsequent impact upon a battery of physical performance measures. Balance, explosive strength, running speed and agility, cardiorespiratory endurance, and anaerobic capacity and muscular endurance were among a number of performance metrics, in which peak development was synonymous with peak height velocity (Philippaerts et al., 2006). As the incidence of peak height velocity and the rate of biological maturation, is dependent upon timing and tempo, it is important to account for individual growth velocities within an adolescent population of youth soccer players, as the physiological effects are often transient and can significantly impair the talent identification process (Malina, 2003; Philippaerts et al., 2006).

Coinciding with a beneficial impact upon individual differences within physical performance, an individual’s maturational process and adolescent growth spurt can cause detrimental and transitory consequences, in the form of adolescent awkwardness (Butterfield, 2015; Philippaerts et al., 2006). This phase is synonymous with a decline in performance, in which suggestions attribute a reduction in sensory motor pathway formation and a decline or stagnation in sensory motor complexes, due to the rapid developmental changes in physical attributes, however, such causes remain unclear (Quatman-Yates, Quatman, Meszaros, Paterno, & Hewett, 2012). It can be suggested that adolescent awkwardness is accountable for a 31% increase in the injury incidence of (*n* =170) talented youth soccer players, within six months post PHV, most prominent with a U15 population, 49% respectively (Bult, Barendrecht, & Tak, 2018). Despite biological maturation having a pertinent effect on such physical attributes, there is limited evidence which supports the notion that transient physical advantages, afforded by individuals advanced in maturation, translate into improve locomotion and match running performance (Buchheit et al., 2010; R. Lovell et al., 2019).

2.7 Technical and Tactical Match-Play Characteristics of High-Level Adolescent Soccer Players

As with the introduction of the EPPP, soccer clubs are placing a greater emphasis on the identification of talent, as it is deemed to be a more efficient and effective financial investment (Fenner et al., 2016; Reilly et al., 2000; Unnithan et al., 2012). Traditionally the identification and recruitment of talented players are dependent upon coaches subjective opinion of player performance, however, when this recruitment technique is used in isolation, it can results in the repeated misjudgement of player performance and an associated low predictive value, upon which its application has been criticised (Vaeyens et al., 2008).

2.7.1 Methods for Assessing Technical and Tactical Match Activity

In order to supplement the talent identification process, cross-sectional models that measure anthropometrical, physiological and soccer specific skill performance has been adopted in order to predict the future success of adult performance in adolescence, based upon the assumption that important characteristics of successful adult performance can be extrapolated from the identification of talented adolescent players (Vaeyens et al., 2008). However, such long term predictive models are deemed unreliable with the individual differences in maturation, growth, development, and training, all of which make talent development an unstable and non-linear factor (Vaeyens et al., 2008). As such, the requirement to develop an approach the simultaneously evaluates a combination of technical and physical attributes that contribute to successful soccer performance is deem essential (Unnithan et al., 2012).

Addressing the respective situation, Fenner et al. (2016) introduce a model that evaluated prepubertal soccer players talent potential through the platform of small sided games, with the application of a game technical scoring chart (GTSC), enabled to mimic the perception of a coach during the talent identification and retention process. The principle of the GTSC follows a comprehensive evaluation of 10 footballing elements inclusive of passing, first-touch, control, assist and shooting, scored against a criterion between poor (1) and excellent (5) execution (Fenner et al., 2016). The inter-tester reliability of the GTSC has been established, demonstrating no significant difference between two coach's (F.A. Level 1) perception of the same individual across three game scenarios (Fenner et al., 2016). In addition, a measure of construct validity demonstrated a significant inter-observer difference of technical skill in only one of the three-game situations, for a difference between GTSC via video feedback and live on-field player assessment (Fenner et al., 2016).

The results of the respective study demonstrated a significant ($p < 0.001$) and very large relationships ($r = 0.76$) between accumulated GTSC points and the total points accumulated for the fixtures results, suggesting the ability to identify the most talented players based upon the greatest number of accumulated wins, players can then be differentiated between the measure of physiological fitness and time-motion analysis characteristics (Fenner et al., 2016). Of interest, high-speed running distance was shown to have a large ($r = 0.55$) and significant ($p < 0.05$) correlation with GTSC, in which players who exhibit greater high speed movements, also demonstrate advance technical skill (Fenner et al., 2016). Of a similar nature, talented players were shown to cover a greater total distance than their less talented peers, as total distance was moderately ($r =$ 0.55 & 0.44) and significantly ($p < 0.05$) correlated with GTSC and total points accumulated respectively (Fenner et al., 2016). In curt, Fenner et al. (2016) produce a model that addresses previous limitations of the talented identification process, with the ability to evaluate performance objectively, across a number of technical, tactical, physiological and time-motion analysis constructs.

From a time motion analysis perspective, recently disseminated research has analysed the influence of pitch area restrictions on the tactical behaviours of elite level, male professional soccer players, with specific reference to spatial analysis and player dispersion in relation to teammates and opposition (Gonçalves, Marcelino, Torres-Ronda, Torrents, & Sampaio, 2016). Considering the evaluation of tactical competence, higher level players demonstrated an increased regularity in displacement, in which an increase in distance to the nearest opposition was seen to increase with the level of cooperation, demonstrating a dynamic ability to adapt behavioural response, with a better understanding of positional demands (Gonçalves et al., 2016).

2.7.1 Inertial Measurement Units

Gyroscopes, accelerometers, and magnetic sensors are able to quantify angular velocities, summate gravitational and linear inertial accelerations and quantify the local magnetic field components, respectively (Camomilla, Bergamini, Fantozzi, & Vannozzi, 2018). However, when the three sensors are applied independently to acquire information on the physical quantities related to the motion of a body, levels of accuracy are reported to be inadequate for such specific applications (Sabatini, 2011). As such, the advent of Micro-Electro-Mechanical Systems (MEMS) and dual axial sensors, has allowed for an improvement in the accuracy of two dimensional orientation estimation, with the combined integration of gyroscopes and accelerometers, within an Inertial Measurement Unit, in which the respective sensors exploit the principle of inertia to provide angular velocities and accelerations (Camomilla et al., 2018). The IMU's orientation and such reflection of body position are derived from an estimation combining data measured from the respective sensors, through means of a sensor fusion algorithm, in order to produce estimations on temporal, kinematic and dynamic parameters (Camomilla et al., 2018; Sabatini, 2011). Recent technological advancements and the advent of MEMS, has led to the cost effective production of miniaturised IMU's, having a consequential impact upon their applicant within sporting contexts (Camomilla et al., 2018; Wagner, 2018). Sampling frequency, full-range scale, power consumption, and portability are all factors to consider when determining an IMU's specific application to a sporting context (Camomilla et al., 2018).

A large proportion of disseminated research, presents the application of IMU's within a clinical setting, measuring the biomechanical movement patterns during activities of daily living (Luinge & Veltink, 2005). However, such technology has presented an opportunity to move away from testing within the environment of a laboratory, allowing for the monitoring of performance during sport specific situations, training, and match play performance (Wagner, 2018). Such applications have been revised within; swimming (Mooney, Corley, Godfrey, Quinlan, & ÓLaighin, 2016), running (Norris, Anderson, & Kenny, 2014) and team sports with the integration of GPS technology (Cummins et al., 2013; Dellaserra, Gao, & Ransdell, 2014; Waegli & Skaloud, 2009). Camomilla et al. (2018) summate that multidisciplinary teams and athletes alike are increasingly benefiting from inertial sensor technology, reviewing a number high number of publications that conclude the technology is suitable for assessing player capacity, technique, and match workloads for both individual and team sport athletes.

2.7.2 Influence of Maturity on Technical and Tactical Match Activity

Relevant to the current study, is the influence of biological maturation on youth soccer performance during a small sided game (SSG constraint), reflective of training structures, within a youth academy environment, and an indicator of math play performance (Moreira et al., 2017). It was disseminated that biological maturation had a moderate to large relationship on a technical performance set, inclusive of the total number of passes, effectiveness, goal attempts, and total tackles, whilst refuting an influence of anthropometrical measures on SSG match play (Moreira et al., 2017). However, it should be noted that Figueiredo, Gonçalves, Coelho e Silva, and Malina (2009) reported there to be no difference in functional and skill abilities, performed in isolation, in individuals who differ in biological maturation.

From the respective research, it is evident that biological maturation has a direct influence on match play and locomotion characteristics, derived through changes in physical and functional capacity (Buchheit et al., 2010; Goto et al., 2019; Lovell et al., 2019). However, when adopting a holistic approach to long term athletic development, it is important to consider the consequential effects of biological maturation upon technical performance (Saward, Morris, Nevill, & Sunderland, 2019). In a population of 126 elite male adolescent soccer players, maturity status had a significant effect upon the number of tackles, blocks, and interceptions performed, in comparison to on-time maturing players (Saward et al., 2019). The respective study also demonstrated no significant difference between *early* and on-time maturity players for frequencies of successful passes, shots on target, dribbles or crosses, in which it was suggested that technical performance was only influenced by advantages in functional and physiological characteristics, associated with advanced maturity (Saward et al., 2019).

The stigma of increased biological maturation and improved technical skill performance as reported by Saward et al. (2019), is inconsistent with research produced by Cripps, Hopper, and Joyce (2016), in which *small* to t*rivial* effect size comparisons, were reported for technical skill performance between *late*, average and *early* maturing, semi-elite adolescent Australian Football players. This comparison is limited due to the difference in the respective sporting disciplines, however, it is interesting to note, that despite demonstrating no congruent advantage in technical skill performance, the *early* maturing players were perceived by coaches, to have superior technical abilities and afforded significant selection and competition advantages (Cripps et al., 2016).

2.8 Psychological Match Play Characteristics of Adolescent Soccer Players

As such the requirement for the application of a multidisciplinary approach to talent identification, there is a growing body of literature, regarding the psychological characteristics in high level youth soccer, however, such research is still in its infancy (Larkin & O'Connor, 2017a; Murr, Feichtinger, Larkin, O 'Connor, & Höner, 2018; Toering, Elferink-Gemser, Jordet, Pepping, & Visscher, 2012). Therefore, it is pertinent to consider such psychological evaluation and such influence on biological maturation on psychological characteristics.

2.8.1 Methods for Assessing Psychological Match Activity

Larkin and O'Connor (2017a) aimed to develop an understanding of the attributes and characteristics deemed important by youth soccer practitioners, in the identification of skilled and talented youth soccer players. As such, a hierarchy of attributes associated with high level youth soccer was disseminated, upon which three of the seven characteristics, regarded of most importance, were of a psychological nature (Larkin & O'Connor, 2017a). Such attributes were; coachability (ability to be coached and respective responsiveness); positive attitude (resilience and ability to overcome adversity) and decision making (identification of options and respective appropriate choice) (Larkin & O'Connor, 2017a). The respective literature advocates the application of a holistic multidisciplinary approach to talent identification, inclusive of psychological parameters, however, it should be considered that the definitions of psychological characteristics, as per Larkin and O'Connor (2017a), have not been validated for the purpose of talent identification in a high level, youth soccer population.

2.8.2 Influence of Maturity on Psychological Match Activity

Of all the disseminated research, the effect of biological maturation on psychology and the consequential impact upon sports performance is arguably the most limited. One pertinent study was published by Gibbs, Jarvis, and Dufur (2012), which reported an inverse relationship between career duration and relative age effect, in which the players born in the later quartiles, played the game longer. Labelled ‘the underdog hypothesis’, it is precluded that *late* maturing players must either possess and/or develop superior technical, tactical and psychological skill, in order to be competitive and be retained in youth sport development programs, necessitated through a comparatively greater physical challenge (Cumming, Searle, et al., 2018; Gibbs et al., 2012). Kelly et al. (2020) suggested the careful consideration of socio-environmental dynamics when promoting new initiatives to eliminate the relative age effect within talent identification and athlete development. It was suggested that a hostile environment may promote such holistic characteristics (technical, tactical, physical and psychological) that can be associated with greater development outcomes and the successful transition from academy to professional soccer (Kelly et al., 2020; Sarmento et al., 2018). Such characteristics are deemed to be masked through adolescence, however become more salient in *late* adolescence and *early* adulthood when physical maturity is attenuated (Cumming, Searle, et al., 2018; Gibbs et al., 2012). In support of the requirement to possess adaptive and behavioural skills to develop excellence in sport, it was reported that youth soccer players in delay of maturation, to possess a superior adaptive response and technical skill (Zuber, Zibung, & Conzelmann, 2016).

Recent evidence has suggested that for later maturing players to be selected and retained within a long term athlete development program, then it would be beneficial to possess and develop an adaptive psychological response, with a specific consideration made towards self-regulation (Zimmerman, 2006). Self-regulation enables individuals to control their thoughts, feelings, and actions, inclusive of self-initiated processes to convert mental abilities into physical skills, such individuals are able to approach tasks with greater levels of effort and possess increase levels of self-efficacy, shown to assists effective learning, develop potential and differentiate between levels of performance/success (Toering et al., 2012; Zimmerman, 2006). Engagement in self-regulation permits the evaluation of training outcomes, improvement through planning and reflection, in which there are a greater requirement and emphasis on later maturing players to develop more adaptive self-regulatory skills, in order to remain competitive within chronological age groupings (Cumming, Searle, et al., 2018; Toering et al., 2012).

2.9 'Bio Banding' in Sport

Adolescent athletes are traditionally categorised into chronological age groupings for the application of training and competition, with the collective aim of creating an environment inclusive of training and competitive equality, through the restriction of maturity associated variance in size, strength and technical skill (Cumming, Brown, et al., 2018; Cumming et al., 2017). However, within chronological age groupings, large inter-individual discrepancies are apparent between chronological age and an individual's biological age, due to the fluctuation in rates of biological maturation (Cumming et al., 2017; Fransen et al., 2018). Tanner, Whitehouse, Marshall, and Carter (1975) reported a maximum differentiation of four years in biological age, in girls and boys, at the time of the adolescent growth spurt. With such biological variations, the notion of 'bio-banding', has been implemented to curtail and seek to eschew the difference in physical attributes across applied groupings (Cumming et al., 2017).

'Bio-banding' is a recent effort, which serves as an adjunct to chronological age groupings, which attempts to address the inter-individual differences in biological maturation, by grouping players on the basis of attributes associated with growth and maturation. (Cumming et al., 2017; Malina et al., 2019). Such bandings are derived from maturity estimate equations that model either the normal growth curves of adolescents, applying somatic characteristics, inclusive of stature, leg length, body mass, and decimal age, or equations which encompass mid parental height (average height of biological parents) (Fransen et al., 2018; Khamis & Roche, 1994; Mirwald et al., 2002; Moore et al., 2015).

‘Bio-banding’ precludes, that through the restriction in maturity associated variance of size and strength, an environment in which competitors are matched on physical attributes will be created, influencing greater levels of competitive equity, reduced injury risk and enhanced talent identification and (de)selection for development programs, with consequential improvements in player perception (Baxter-Jones, 1995; Cumming, Brown, et al., 2018; Gallagher, 1969). The aim of the notion is to prevent the over selection of young soccer players who possess transient superior anthropometric dimensions (stature and body mass) and performance capabilities (power, speed, strength, and endurance), characteristics that influence player (de)selection for academy soccer development programs (Carling et al., 2012; Carling et al., 2009; Vaeyens et al., 2006).

‘Bio-banding’ has a large scope for application, which has relevance to numerous multi-disciplinary aspects, inclusive of talent identification, long term athletic development, strength and conditioning, and competition (Cumming, Brown, et al., 2018). Despite its positive reception within the literature, there is a paucity of evidence for the efficacy of ‘bio-banding’ in uncovering multi-disciplinary components of soccer talent, with the limited dissemination of objective and quantifiable evidence that ‘bio-banding’ can enhance the detection of desired characteristic for player retention and development (Cumming et al., 2017). As such, this thesis will now introduce the historical concept and current application of Bio-bandings used to address biological variation within a sporting context.

2.9.1 Historical Background

Early disseminations reported the influence of weight, height, and maturity status in adolescent boys upon work, social affairs, and athletic aspects of life as reported by Foster (1910). The first notion that followed the principles of grouping adolescents on physical attributes was introduced by Crampton (1944), in which the stages of the development of pubic hair was deemed a suitably appropriate indicator of an individual’s readiness to work during the industrial revolution and child labour movement, a requirement to determine an age above which a child was deemed safe to work (Cumming et al., 2017; Malina et al., 2019). Proceeding the technological advancements in radiographic imaging, Rotch (1909) proposes the use of anatomical age, derived from the radiographic assessment of the carpals and epiphyses of the wrist, to group and therefore account for individual differences with school, sport/athletic and child labour populations (Cumming et al., 2017; Malina et al., 2019).

The first high profile research and review of maturity associated variation within a sporting context was conducted by Krogman (1959), in which 45% (n = 25) of Baseball Little League World Series players, had a skeletal age advanced by more than + 1.0 years, which is an overrepresentation compared to the 10% (n = 5) of whom were delayed by more than – 1.0 years when compared to their respective chronological age. It was argued that success was synonymous with advanced biological maturation, characterised by been more structurally and functionally advanced and developed, highlighting the consideration of maturity assessments to determine player eligibility and evaluate athletic potential (Cumming et al., 2017; Malina et al., 2019).

In a population of youth soccer players, there is a general acceptance for the overrepresentation and underrepresentation of *early* and *late* maturing players aged 13 – 15 years of age, independent of the method of assessment (Malina, 2011). An increase in the overrepresentation of *early* maturing players displays a consistent linear relationship with increasing chronological age and is consistent across varying sporting environments, inclusive of team (American football, baseball and ice hockey) and individual (swimming and athletics) disciplines (Malina, Rogol, Cumming, Silva, et al., 2015).

The underlying principle of bio-banding and the consequential grouping of athletes on the basis of age, height and weight criteria, has been commonly applied in both combat (boxing, wrestling, and judo) and contact/collision (rugby and American football), in which extreme deviations in size and strength are considered to have implications on competitive equity and the associated risk to injury (Albuquerque, Fukuda, Da Costa, Lopes, & Franchini, 2016; World Rugby, 2020). The extent of application has been extended to positional specific, weight-based criteria in American football, distinguishing between running backs, quarterbacks, and wide receivers (Cumming, Brown, et al., 2018). Of a similar principle, the New York State Public High School Agency increase the inclusivity of participation within high school sports to athletes with a deemed level of readiness, subject to the stratification of a holistic combination of physical, psychological and technical attributes, inclusive of physical size, fitness and maturity status (The New York State Education Department Office of Elementary Middle Secondary and Continuing Education 2005).

Cumming et al. (2017) highlighted the recent efforts to practically implement bio-banding principles within a sporting context, however, indicated the absence of scientific inquiry and accentuated the need explore and quantify the effectiveness of such applications in a wider sporting context, with a specific focus on how biological maturation can influence talent identification and long-term athletic development.

2.9.2 Competition and Performance

The large variation of biological maturity within an adolescent population breeds an environment of competitive inequity, in which the mismatching of a player's physical attributes (e.g. size, strength, and maturation status) can impede athletic development and promote a competitive advantage and disadvantage for *early* and *late* maturing players respectively (Abbott et al., 2019; Cumming et al., 2017; Malina, Rogol, Cumming, e Silva, & Figueiredo, 2015). Within competition, it is suggested that the physical dominance of *early* maturing players, prevents the illustration of technical skill within the physically less mature players (Reeves et al., 2018). In curt, it was suggested that athletes who are more mature in advance to their peers experience a competitive advantage, accountable to superior size, strength, and athleticism (Malina, Bouchard, et al., 2004). Research pertaining the potential benefits and limitations of restricted bio-banded competition is limited and restricted due to variation within the methodology, however recent scientific inquiry, is developing a scientific backbone for its application with competition (Cumming, Brown, et al., 2018; Cumming et al., 2017).

The diversification of the competitive environment with youth sport can be beneficial to both *early* and *late* maturing players (Cumming, Brown, et al., 2018). *Early* maturing players would be exposed to competition against players of a comparable physical state, of similar nature to open age competition, restricting their reliance upon physical attributes and imposing a requirement to utilise and develop their technical and tactical attributes (Cumming, Brown, et al., 2018). A competitive environment, inclusive of equitable physical attributes, would afford *late* maturing players the opportunity to utilise and demonstrate technical attributes, which has the consequential impact on the developmental context, in which players are reviewed and critiqued (Cumming, Brown, et al., 2018).

Cumming, Brown, et al. (2018) conducted a study with Premier League, youth academy soccer players (*n* = 66), aged between 11 and 14 years and a predicted adult stature of between 85 – 90%, investigating player experience when participating in a tournament ‘bio-banded’ for biological maturity. Comparison were made between ‘bio-banded’ and age group competition across three 11 v 11 sided games, performed on a full-size pitch (Cumming, Brown, et al., 2018). The general consensus of the ‘bio-banded’ format was positive, with the recommendation for the Premier League to implement the structure into the existing game program (Cumming, Brown, et al., 2018). As previously hypothesised, *early* maturing players were required to adapt their playing style, placing a greater emphasis to technical and tactical skill, due to increased physical demands, with *late* maturing players perceiving the games as less physically challenging, promoting the opportunity to demonstrate their technical, tactical, physical and psychological competencies (Cumming, Brown, et al., 2018). The closing statement advocated ‘bio-banding’ strategies in positively contributing to the holistic development of young soccer players but identifies the limitation of disseminating qualitative data, with a recommendation to analyses the effect of ‘bio-banding’ on quantitative measures of performance (Abbott et al., 2019; Cumming, Brown, et al., 2018).

Abbott et al. (2019) conducted the first study which objectively assesses physical and technical performance between bio-banded and chronological competition. Across chronological age formats, *late* maturing athletes displayed a significantly higher RPE, as a result of a habitual exertion response to competing against those of a higher relative physical development, however during bio-banded competition, *early* maturing athletes produced significantly higher RPE, accountable to the increased perception in physical demands (Abbott et al., 2019). Technically, *early* developers demonstrated an increase in the number of short passes (< 20 m in distance) and subsequent decreased in the number of dribbles performed, due to the reduced ability to dribble around less physically maturing players, developing a reliance on short passing to advance the ball towards the opponent's goal (Abbott et al., 2019). In *late* developing players, the prevalence of frequency of long passes (> 20 m in distance) was reduced, as within bio-banded competition, *late* maturing players cannot rely on the presence of a more physically mature teammate (*early* maturing) to ‘hold up the ball’, in which the game format requires an alteration in tactical performance (Abbott et al., 2019). When monitoring physical performance, no significant differences were reported between chronological and ‘bio-banded’ game formats for metrics of the total, high-speed running, and explosive running distances (Abbott et al., 2019).

Recent disseminated literature by Romann et al. (2020) deduced ‘bio-banding’ to attenuate the dominance and physical advantage afforded by *early* maturing players, stimulating an emphasis on technical and tactical development, in order to compete with an individual of physical equality. The main findings of the respective study demonstrated a reduction in distance covered at jogging, running and high speed intensities during a ‘bio-banded’ game constraint, in comparison to a chronological age grouping, synonymous with a reduction in mean ball possession per action and a trend of a reduce manganite of difference between teams for ball possession (Romann et al., 2020). The total number of passes remained unaffected but the rate of successful and unsuccessful passes was reduced and increased respectively (Romann et al., 2020). In curt, the study provided evidence to advocate the application of ‘bio-banded’ game constraints to reduce the magnitude of difference in physical demands, for the benefit of a greater technical and tactical demand, promoting a quicker style of play, inclusive of increased involvement for later maturing players (Romann et al., 2020).

Abbott et al. (2019) and Romann et al. (2020) highlighted the importance of ‘bio-banded’ competition, in placing a unique technical constraint on academy soccer competition, without alteration to the physiological demands and its adjunct application in encouraging a holistic development through continued exposure to varied stimuli. Alongside Towlson et al. (2020), there is enough evidence to suggest to that maturity status ‘bio-banded’ SGG’s can be an appropriate application for the identification of talent youth academy soccer players. For the purpose of the present study, competition formats will be referenced as maturity matched or mismatched ‘bio-banded’ interventions, for when ‘bio-banded’ teams compete against a team of equitable or inharmonious maturity status respectively, a method derived from Towlson et al. (2020), in order to categories teams based upon maturity status.

2.10 Aims

The primary research question aims to provide data relating to:

1. The effect and interaction between relative pitch size and game format on the magnitude of difference in tactical, technical, psychological, and physical measures between young academy soccer players during SSG match play.
2. The effect of mismatched ‘bio-banded’ interventions on the magnitude of difference in tactical, technical, psychological, and physical measures between young academy soccer players, during SSG match play.
3. The effect of matched ‘bio-banded’ interventions on the magnitude of difference in tactical, technical, psychological, and physical measures between young academy soccer players.

2.11 Hypotheses

1. An increase in relative pitch size will accentuate the difference in tactical, technical, psychological, and physical measures between ‘*post*-PHV’ and ‘*pre*-PHV’’ maturing academy soccer players during SSG match play.
2. A maturity mismatched (‘*post*-PHV’ Vs. ‘*pre*-PHV’) ‘bio-banded’ SSG game constraint will extenuate the magnitude of difference in tactical, technical, psychological, and physical measures between young academy soccer players, during SSG match play.
3. Maturity matched (‘*post*-PHV’ Vs. ‘*post*-PHV’ & ‘*pre*-PHV’Vs. ‘*pre*-PHV’) ‘bio-banded’ match play between matched maturational groups (i.e. ‘*post*-PHV’ Vs. ‘*post*-PHV’; ‘*pre*-PHV’Vs. ‘*pre*-PHV’) will reduce the magnitude of difference in technical, tactical, psychological and physical measures between players during SSG match play.

3 METHODS

3.1 Participants

This study received appropriate ethical approval (FHS189) from the University of Hull, Department of Sport, Health and Exercise Science Ethics Committee, in which written informed consent was obtained from all participants prior to the commencement of the study. The primary investigator was Disclosure and Barring Service checked, prior to the commencement of any data collection. Data were collected from forty-four (*n* = 44) high level youth male soccer players (mean ± SD: age 12.9 ± 0.9, body mass 46.4 ± 8.5 kg and stature 158.2 ± 14.9 cm) from the Youth Development Phases of the EPPP (U12: n = 10; U13: n = 15; U14: n = 19), split between a Premier League Category One (*n* = 24) and Category Two (*n* = 20) clubs. For the purpose of this study a high level youth soccer, development center was defined as talent development program that was governed by the English Premier League and the EPPP initiative (Premier League, 2011), located within the UK professional soccer clubs competing in the Championship level of football, at the time of data collection. In addition to this, a high level youth soccer player was defined as a young male soccer player, enrolled within a talent development program regulated by the EPPP at the time of data collection. All participating players were receiving six to twelve hours of coaching each week, inclusive of competitive matches at the respective centres due to their categorisation under the Youth Development phases (U12 – U16) of the EPPP (Premier League, 2011). All participants were declared free from injury and medically fit to participate in the present study, by their respective parent club.

Table 1: Anthropometric variables and estimated maturity status of (*n* = 44 high level youth soccer players, biologically banded using the Khamis and Roche (1994) predictive equation.

Anthropometric's	**'*post*-PHV'** **(*n = 20)***	**'*pre*-PHV'** **(*n = 24)***
Age *(years*)	13.6 ± 0.4	12.29 ± 0.7
	ES = 2.17, $p \leq 0.001$	
Stature (*cm*)	168.4 ± 6.9	149.78 ± 14.7
	ES = 1.57, $p \leq 0.001$	
Mass (*kg*)	52.8 ± 6.1	40.99 ± 6.1
	ES = 1.93, $p \leq 0.001$	
EASA (*%*)	92.5 ± 1.8	85.05 ± 2.6
	ES = 3.32, $p \leq 0.001$	

Mean (± SD) values of anthropometrical variables for '*post*-PHV' (EASA% > 90) and '*pre*-PHV' (EASA% < 89.9) maturing youth soccer players biologically banded using the Khamis and Roche (1994) predictive equation. Effect Size (ES): Trivial (< 0.2), Small (0.2 to 0.6), Moderate (0.6 to 1.2), Large (1.2 to 2.0) and Very Large (> 2.0) (Hopkins et al., 2009).

3.2 Experimental Design

The study used a repeated measures design approach, in which a two-step experimental protocol was followed. The selected players participated within four sessions at their respective clubs, conducted once a week, across a four-week period, accounting for recovery between session and minimising any learning effect. Eighty high level male youth soccer players aged 11 to 14 years of age, from two English professional soccer academies were invited to participate in the study. Of the initial sample, an estimation of adult stature attainment was calculated (Khamis & Roche, 1994). The Khamis and Roche (1994) method has been previously applied to ‘bio-band’ adolescent soccer players and adopts self-reported mid parental height (Cumming, Brown, et al., 2018) in conjunction with chronological age, player stature and body mass to categorise each player based upon their percentage of estimated adult stature attainment (EASA%), '*post*-PHV' (> 90.0 EASA%) and '*pre*-PHV' (< 89.9 EASA5). Players anthropometric data was collated within a month period, prior to the testing period, extenuating the influence of biological growth and such accurate maturational banding. Such maturity bandings are not consistent with suggestions made within the literature (Cumming et al., 2017), however, we applied due to the player pool available, which the consideration that bandings between 89 to 95% EASA, are representative of peak height velocity (PHV). Such bandings aim to reflect and encapsulate individual differences within physical and potentially technical/tactical traits, due to the assumption that an improvement or decline in performance is not synonymous with the onset of PHV (Towlson et al., 2018)

Using the aforementioned Khamis and Roche (1994) method, 'bio-banded' players were randomly assigned into one of four 'bio-banded' teams, two teams of '*post*-PHV' (n = 4) maturing players and two teams of '*pre*-PHV' (n = 4) maturing players. If players were unavailable due to injury or illness, such players were replaced with an individual of the most appropriate and equitable biological maturity status. In order to generate a control condition, representative of chronological age groupings and current academy structures, two players from each of the '*post*-PHV maturing teams, were randomly assigned by the principal investigator, to play with two players from each of the '*pre*-PHV' maturing teams, to create four 'mixed' teams. A 20-minute active recovery period was allocated between 'bio-banded' and 'mixed' conditions, in order to remove the influence of induced fatigue. Teams will then compete against each other within a 'round robin' small sided games format for both the 'bio-banded' and 'mixed' teams game format (Table 2). Each week of small-sided games represents a different relative pitch size: Week 1, Small: 17 m x 17 m (288 m^2; 36 m^{2}per player), Week 2, Medium: 24 m x 24 m (576 m^2; 72 m^{2}per player), Week 3, Large: 29.5 m x 29.5 m (870 m^2; 108 m^{2}per player), and Week 4, Expansive: 34 m x 34 m (1152 m^2; 144 m^2 per player), with the relative pitch size been consistent through the duration of the specific testing week. The sequence of small-sided games (Table 2) was consistent across Week 2, Week 3, and Week 4.

Table 2: Schedule of fixtures for the small-sided game's 'round-robin' mini league format.

Team Category		**Team Category**
'late' matruing (2)	*Versus*	'early' maturing (2)
'late' maturing (1)	*Versus*	'early' maturing (1)
'late' maturing (1)	*Versus*	late' maturing (2)
'early' maturing (2)	*Versus*	'early' maturing (1)
'early' maturing (1)	*Versus*	'late' maturing (2)
'early' maturing (2)	*Versus*	'late' maturing (1)
'mixed' (4)	*Versus*	'mixed' (2)
'mixed' (3)	*Versus*	'mixed' (1)
'mixed' (3)	*Versus*	'mixed' (4)
'mixed' (2)	*Versus*	'mixed' (1)
'mixed' (1)	*Versus*	'mixed' (4)
'mixed' (2)	*Versus*	'mixed' (3)

Note: The order of fixtures was consistent for the conditions in week 1, week 2, week 3 and week 4.

After conducting a club specific, 15 minute standardised warmup, each player was categorised according to the previously mentioned, aforementioned Khamis and Roche (1994) method and contested three, four versus four, SSG's with a duration of five minutes each (15 minutes total playing time) on an outdoor 3G surface, within a 'bio-banded' games format. Each SSG will be interspersed with a three-minute interlude of passive recovery (Fenner et al., 2016), in order to limit such influence of induced fatigue. Following a technical washout period of ten minutes, players were assigned into the control conditioned teams (mixed) and the aforementioned protocol was replicated, with the exclusion of a standardised warm-up. As validated by Fenner et al. (2016) two (2 m x 1 m) goals with no identified goalkeepers were applied. Inclusive of promoting players to demonstrate tactical, technical, and creative match play behaviours, goals were only permitted to be scored from a position in the attacking half of the pitch. Ensuring match fluency, a multi ball system was adopted, in which balls were placed around the pitch perimeter, in order to maintain a continuous nature.

Club staff were reframed from providing any verbal feedback or encouragement throughout the duration of the session, in order to prevent (sub)conscious coaching and selection bias. Players were informed of the score and referee decision during each SSG. As per Fenner et al. (2016), players scored *four* points for a win, *two* points for a draw and *zero* points for a loss respectively for each SSG, accompanied by an additional *one* point if their team scored. Each team would receive a minimum of five and a maximum of fifteen minutes of low intensity, active recovery between SSG's, in which players performed club specific, standardised technical drills to maintain match readiness and reduce tedium. Throughout the duration of the SSG's, player's tactical, technical, psychological, and physical attributes will be monitored and assessed. All SSG's will be filmed to allow for retrospective tactical and technical measures of analysis.

3.2.1 Anthropometric Measures

All procedures of anthropometrical measurement followed the recommendations as outlined by the International Society of Kinanthropometry (ISAK) (Marfell-Jones, Stewart, & De Ridder, 2012). A portable stadiometer (Seca 217, Chino, U.S.A) was used to measured player stature, players were required to put their shoeless feet together with heels touching the scale, their heads were positioned into the Frankfort plane in order to perform the stretch stature method, whereby players were required to take a deep breath in and hold the position of their head (Marfell-Jones et al., 2012). Multiple measures of stature were recorded to an accuracy degree of 0.1 cm (Marfell-Jones et al., 2012). Seated height was also measured using a portable stadiometer (Seca 217, Chino, U.S.A), whilst players were in a seated position on a plinth of a standardised height, with hands resting on their thighs (Marfell-Jones et al., 2012). Similarly, players were positioned into the Frankfort plane and performed the stretch stature method for the measurement of their seated height. Estimated leg length was recorded as stature minus seated height (Marfell-Jones et al., 2012). Body mass was recorded using high capacity digital scales (Seca Robusta 813, Chino, U.S.A), in which players wore their normal training attire with shoeless feet, following the outlines recommended procedures (Marfell-Jones et al., 2012). In order to maintain validity and reliability, if measurements deviated ≥ 0.4 cm or 0.4 kg, a third measure was taken and the median value was recorded (Marfell-Jones et al., 2012).

3.2.2 Maturity Status

Anthropometric measures and the Khamis and Roche (1994) method was used to predict mature adult height based upon an adolescent's current age, height, and weight, whilst factoring in mid parental height (average height of the biological parents). The present study collated self-reported stature of both biological parents and adjusted for over-estimation using sex specific equations based on measured and self-reported stature of US adults (Cumming, Brown, et al., 2018; Epstein, Valoski, Kalarchian, & McCurley, 1995). It is acknowledged that PHV typically onsets at approximately 86% of estimated adult stature attainment (EASA%) (Cumming, Brown, et al., 2018), to permit common terms to be used and for the purpose of the present study, with the consideration of current professional soccer academy structures, bandings were defined as '*post*-PHV' (> 90.0 EASA%) and '*pre*-PHV' (< 89.9 EASA%).

These bandings were selected as it is deemed representational of the youth development phase, inclusive of *late* childhood and the initiation of the pubertal growth spurt (Cumming, Brown, et al., 2018). Such bandings are representative of PHV, reported to occur with 85 to 96% of adult height, with the adolescent growth spurt standardised at 90% of final height, reflecting a window of PHV (Sanders et al., 2017). Parr et al. (2020) disseminated PHV to be attained with 88.9 ± 3.1% (81.1 to 93.9%) of predicted adult height, consistent with Sanders et al. (2017), in which PHV was attained within 90.0 ± 2.1% and 90.2 ± 4.0% of predicted adult height, reported across two longitudinal studies. The bandings in the present study were adjusted to permit adequate statistical sample power and to allow the evaluation of worst case scenario measures between '*post*-PHV' and '*pre*-PHV' maturing players, developing on previous research that included player in 'circa' of biological maturation (85.0 – 90.0% EASA) (Cumming, Brown, et al., 2018; Parr et al., 2020; Sanders et al., 2017). In order to categorise 'mixed' maturity teams, two players of each '*pre*-PHV' and '*post-PHV*' maturity bandings, were randomly assigned by the principal investigator, into one of four 'mixed' maturity teams.

3.2.3 Tactical and Technical Measures

To assess technical and tactical player performance, this thesis adopted the Game Technical Scoring Chart (GTSC), a tool applied to measure coach and scout perception of player performance, purposed for the identification of talented soccer players, supplementing the decision making process of player retention or release (Fenner et al., 2016). The GTSC is deemed a reliable and valid measure of technical and tactical player performance (Fenner et al., 2016). A pilot study demonstrated no significant differences ($p < 0.05$) for inter-tester reliability, consistent with disseminated reliability values of 0.83 and 0.78, reported by Unnithan et al. (2012). Player performance is evaluated on ten footballing criteria; cover/support, communication, decision-making, passing, first touch, control, one versus one, shooting, assists, and marking, on a subsequent score between 0 and 5. Each point describes player performance against the following criterium: 1 – poor, 2 – below average, 3 – average, 4 – very good and 5 – excellent, in which the points will be accumulated across individual games, ‘bio-banded’ games and ‘mixed’ games. Players will be assessed in accordance with the GTSC by a coach with a minimum standard of F.A. Level 2 in Coaching Football, in which coaches will be assigned a maximum of two players per small sided game.

In order to assess technical performance indicators, inclusive of total time on the ball (sec), average ball possession (AU) and average ball regain time (sec), players were equipped with a foot mounted inertial measurement unit (IMU) (PlayerMaker, Florida, USA). The IMU (PlayerMaker, Florida, USA) is comprised of two components from within the MPU-9150 multichip motion tracking module (InvenSense, California, USA). These MEMS components are a 16g tri-axial accelerometer and a 2000°/sec tri-axial gyroscope, each containing three 16-bit analogue to digital converters for digitising their respective outputs. The tri-axial accelerometers measure a composite vector magnitude, expressed as gravitational force, by quantifying the sum of accelerations in the sagittal, frontal, and transverse plane of motion (Waldron et al., 2011). The tri-axial gyroscope is responsible for measuring the angular velocity of the shank during locomotion (Luinge & Veltink, 2005). The foot-mounted IMU (PlayerMaker, Florida, USA), samples at a rate of 1000 Hz, in which data is filtered using system specific machine learning algorithms within the manufactures cloud-based software, sampling at a rate of 250 Hz. Each high level youth soccer player was equipped with two foot-mounted IMUs (PlayerMaker, Florida, USA) devices, (one device per foot), encased within silicone straps supplied by the manufacturer, which was encased and fitted by the research team. The devices affixed bilaterally to the lateral malleoli of the foot. Devices were activated ten minutes prior to the commencement of the experimental protocol as per the manufacturer guidelines.

Marris, Barret, Abt, and Towlson (2020) reported the concurrent validity and subsequent portion of agreement between PlayerMaker^{TM} and performance analysis software for the variables of; ball touches (P_A% = 96.1, [P_A% 95% CI = 95.0 to 95.3]) and ball release (P_A% = 97.6, [P_A% 95% CI = 97.5 to 97.7]).

3.2.4 Psychological Measures

In order to monitor psychological attributes, coaches will be provided a modified version of an English Academy template of player evaluation, in which coaches will be asked to evaluate players on the five psychological attributes of confidence, competitiveness, coachability, positive attitude and x-factor. The respective attributes were selected based upon their regarded importance when identifying players for talent development programmes (Larkin & O'Connor, 2017b). Coaches will be provided with the operational definitions for each of the respective attributes defined within (Table 3), as disseminated by Larkin and O'Connor (2017b). Attributes will be given a score between 0 and 5, in which each point reflects the player performance during small sided game match play, adopting the following criteria: 1 – poor, 2 – below average, 3- average, 4 – very good and 5 – excellent, with points accumulated over individual, 'bio-banded' and 'mixed' game formats.

Table 3: Psychological characteristics and associated operational definition used by coaches to score players during small sided game match play.

Attribute	Operational Definition
Confidence	Wants to receive the ball under pressure and has the desire to try and fail and do something different.
Coachability	Willingness and ability to learn and be coached with responsive behaviour.
Positive attitude	Demonstrating a resilience and positive reaction to mistake and the manner in which they handle disappointment.
Competitiveness	Winning mentality, resolve and desire.
X-Factor	Unredictable, creative and thinks outside the box.

3.2.5 Physical Measures

Players were equipped with a MEMS device (Optimeye S4, Catapult Innovations, Melbourne, Australia) containing a global positioning satellite (GPS) chip with a sampling rate of 10 Hz with an integrated tri-axial accelerometer (100 Hz), gyroscope (200 – 2000 Hz) and magnetometer (100 Hz), deemed to produce sufficient accuracy to quantify the activity profiles of team sports movement demands (Varley et al., 2012). To minimalize the effects of inter-unit error, players were assigned a specific unit for the entirety of the testing duration. The MEMS device was applied to record time-motion data for the apparent parameters with applied absolute running speed thresholds (Buchheit et al., 2010). As recommended by McLean, Cummins, Conlan, Duthie, and Coutts (2018), microtechnology units were fitted and worn, with manufacturer provided vests, to best provide valid and reliable information and prevent any incidental movement and consequential skewed data.

Across the duration of the study, activity range and speed velocities remained constant to allow for the direct comparison between chronological age grouping and maturity bands (Buchheit et al., 2010). The activity ranges were applied as followed; low intensity running distance (LIR; running speed < 13.0 $km{\cdot}h^{-1}$), high intensity running distance (HIR; running speed > 13.1 $km{\cdot}h^{-1}$) and sprinting distance (Sprinting; running speed >19.1 $km{\cdot}h^{-1}$), selected to reflect the match running performance of high level youth soccer players (Buchheit et al., 2010). Speed thresholds were also applied for the movement demands of; Accelerations (> 2.0 $m{\cdot}s^{-2}$) and Decelerations (< 2.0 $m{\cdot}s^{-2}$). Such application of absolute arbitrary speed threshold is supported by the notion that individualised speed thresholds does not provide addition value in the determination of dose-response activity (Scott & Lovell, 2018) The MEMS devices were also applied for measures of: Total Distance (m), Meterage per Minute ($m{\cdot}min^{-1}$), Total PlayerLoad (AU), Maximum Velocity ($m{\cdot}s^{-1}$) and PlayerLoad 1D (Forward, Up and Side) (AU).

Average Horizontal Dilution of Precision (HDOP) was reported to be 0.84 AU and 0.77 AU at the Premier League Category One and Category Two youth soccer academy, respectively. The number of satellites was reported to be 11.54 and 10.95 at the Premier League Category One and Category Two youth soccer academy, respectively.

In addition to the measures of physical activity profiles, following each experimental condition, players will be asked to provide a rating of perceived exertion (RPE), as such reflecting the measure of internal training load, through players perception of effort and exertion of match demands (Coutts, Reaburn, Murphy, Pine, & Impellizzeri, 2003). RPE was collected using Borg's CR-10 scale (Borg, 1998) and multiplied by session duration to give session RPE (sRPE). Players responded individually to avoid social pressure and such influence on their perceived rating. Based upon typical error values (Fenner et al., 2016), the threshold for meaningful change will be set at 9% of the player's physical measure established during the non 'bio-banded' small sided game formats.

3.2.6 Data Analysis

Data were analysed using the SPSS statistical software (IBM SPSS Statistics 25, Version 25). Data analyses adopted a general linear mixed modelling to compute estimated marginal means with Sidak adjusted *P* values, with condition (i.e. tactical, technical, psychological & physical) and 'bio-banding' (including control) as fixed factors and individual as a random factor, in order to determine the difference in estimated marginal means for physical, technical, tactical and psychological player characteristics, according to maturity status and relative pitch size (Kelly & Drust, 2009; Khamis & Roche, 1994). For the purpose of statistical analysis, the results from teams: '*mixed 1*' and '*mixed 4*'and teams: '*mixed 2*' and '*mixed 3*' were collated and will be referred to as '*mixed 1*' and ‘*mixed 2*’ respectively. Statistical significance for all null hypothesis tests was set at $P \leq 0.05$. All data was found to be of normal distribution.

The mean difference (95% confidence interval) between the match-play measures, tactical/technical and physical conditions composite score and Cohen’s *d* effect size will be reported, with *d* evaluated according to the following scale of magnitudes: < 0.2 trivial, 0.2 – 0.59 small, 0.6 – 1.19 moderate, 1.2 – 1.99 large and ≥ 2.0 very large (Hopkins, Marshall, Batterham, & Hanin, 2009). Cohen’s *d* effect size was determined by the calculation of the mean difference between the two teams of respective maturity bandings and then dividing the results by the average standard deviation, of the two groups. All statistical assumptions were examined using standard graphical methods (Grafen & Hails, 2002). The points accumulated by each player for each small sided game outcome (i.e. win, lose or draw) were correlated using linear regression analysis, expressed as a correlation coefficient (R^2) with their technical, psychological and physical composite scores (Fenner et al., 2016).

4 RESULTS

4.1 Maturity Mismatched (‘*pre*-PHV’ Vs. ‘*post*-PHV’) ‘Bio-Banded’ Conditions

4.1.1 Anthropometric Measures

Adopting the Khamis and Roche (1994) ‘bio-banding’ method, ‘post-PHV’ banded players had a mean age of 13.6 (13.5 to 13.7) years and were shown to be significantly ($p \leq 0.001$) older while displaying a large effect size (ES) (ES = 1.97) in comparison to ‘*pre*-PHV’ banded players (12.3 [12.2 to 12.4] years). This trend continued for estimated maturity status (Khamis & Roche, 1994), demonstrating a significant difference ($p \leq 0.001$) and very large effect size (ES = 3.64) between ‘*post*-PHV’ (92.6 [92.3 to 92.9] %) and ‘*pre*-PHV’ banded players (84.8 [84.5 to 85.1 %]). A statistically significant difference ($p \leq 0.001$) and large ES (ES = 1.97 & 1.74) were demonstrated for body mass (‘*post*-PHV’: 51.7 [50.9 to 52.6]; ‘pre-PHV’: 0.8 [39.9 to 41.5] kg) and stature (‘*post*-PHV’: 167.2 [165.8 to 168.6] 150.4 [149.0 to 151.8] cm) between ‘*post*-PHV’ and ‘*pre*-PHV’ banded players respectively.

4.1.2 Physical Measures

No significant difference ($p = 0.09$ to 0.94, ES = 0.02 to 0.47, small) was reported for the measure of total distance covered (TD) between ‘*post*-PHV’ and ‘*pre*-PHV’ banded players during maturity mis-matched ‘bio-banded’ SSG format, consistent across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes (Figure 1). Total PlayerLoad^{TM} (PL^{TM}) demonstrated no significant difference ($p > 0.05$) between ‘*post*-PHV’ and ‘*pre*-PHV’ maturing players, of equitable game constraints, consistent across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes ($p = 0.17$ to 1.00; ES = 0.00 to 0.35, trivial to small). The results demonstrated are consistent for high speed (HSRD [> 13.0 km·h^{-1}]) and low speed (LSRD [< 13.0 km·h^{-1}]) running distance across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes (p = 0.06 to 0.94; ES = 0.02 to 0.50, small).

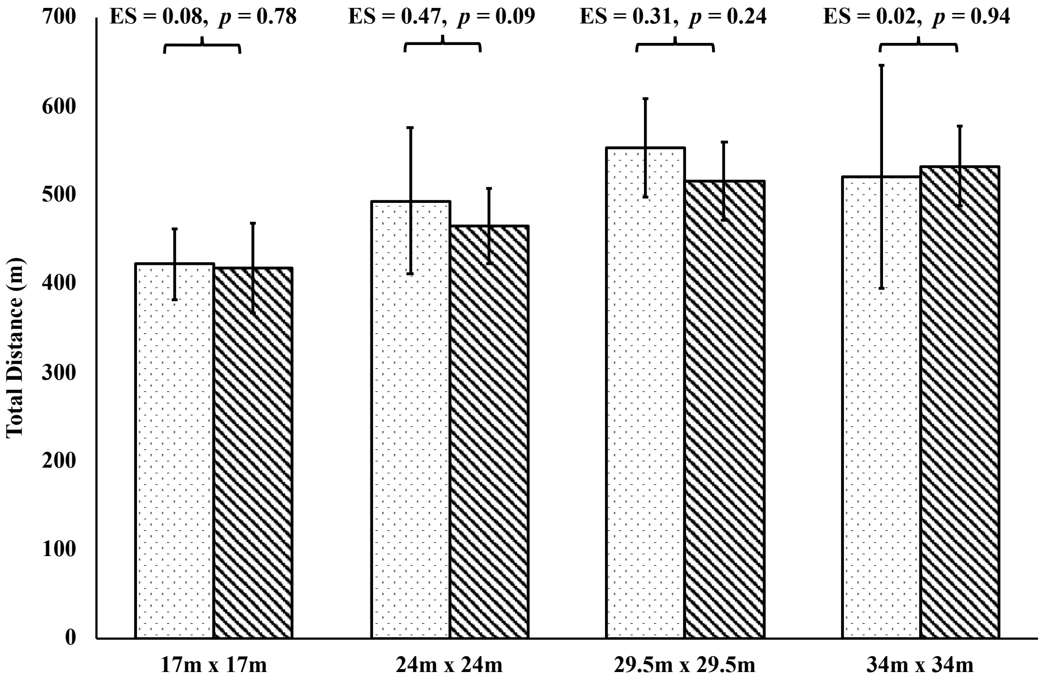

Figure 1: Estimated marginal mean difference (±SD) in total distance covered (m) between '*post*-PHV' (EASA% > 90) and '*pre*-PHV' (EASA% < 89.9) maturing players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

The physical key performance indicators between '*post*-PHV' and '*pre*-PHV' maturing players, during a mismatched 'bio-banded' SSG game format are presented with (Table 4 (p = 0.01 to 0.99; ES = 0.00 to 0.89, trivial to moderate). '*Post*-PHV' maturing players demonstrated a significant difference for the measure of sRPE – Training Load (sRPE – TL), in comparison to '*pre*-PHV' maturing players (Figure 2) across small (36 m²), medium (72 m²), large (109 m²) and expansive (145 m²) relative pitch sizes (p = 0.00 to 0.03; ES = 0.58 to 1.46, small to large).

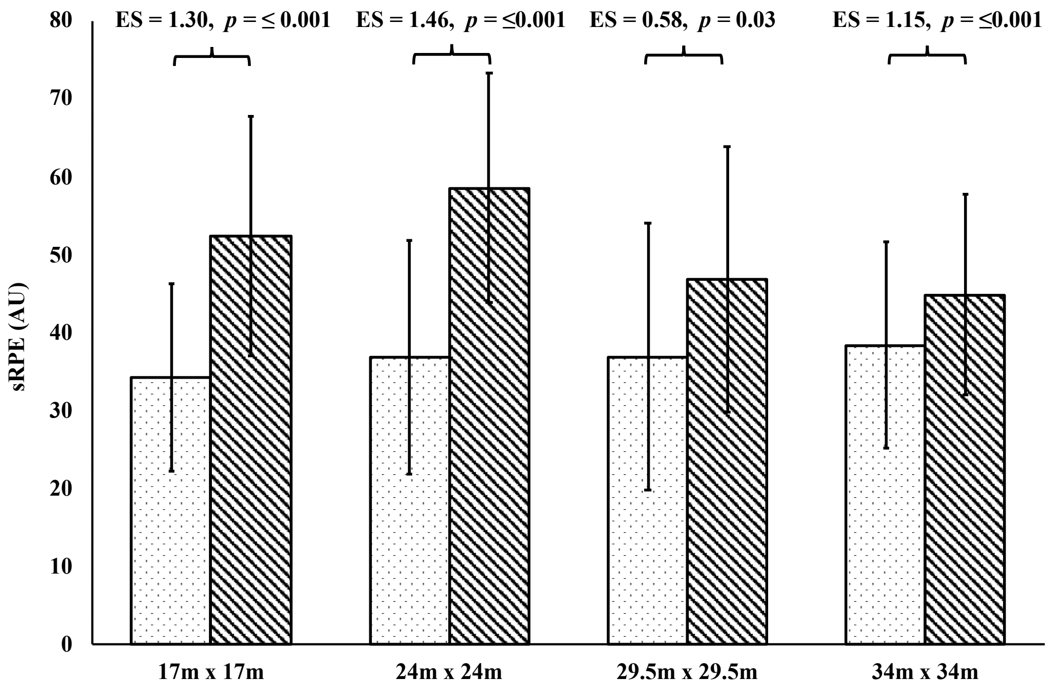

Figure 2: Estimated marginal mean difference (±SD) in sRPE – Training Load (AU) between '*post*-PHV' (EASA% > 90) and '*pre*-PHV' (EASA% < 89.9) maturing players across small (36 m²), medium (72 m²), large (109 m²) and expansive (145 m²) relative pitch sizes.

Table 4: Estimated marginal means (± SD) micro-electromechanical systems (MEMS) device, associated effect sizes and values of significance ($p < 0.05$) of *post*-PHV (EASA% > 90) and *pre*-PHV (EASA% < 89.9) academy soccer players, during maturity status 'bio-banded' (*post*-PHV v *pre*-PHV) small-sided games, across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch size.

Key Performance Indicator	17m x 17m		24m x 24m		29.5m x 29.5m		34m x 34m	
	'*pre*-PHV'	'*post*-PHV'	'*pre*-PHV'	'*post*-PHV'	'*pre*-PHV'	'*post*-PHV'	'*pre*-PHV'	'*post*-PHV'
Total PlayerLoad (AU)	59.4 ± 8.1	61.6 ± 12.4	60.8 ± 11.9	60.8 ± 9.8	65.4 ± 7.8	68.5 ± 10.0	57.7 ± 14.6	67.2 ± 9.4
	ES = 0.20, *p* = 0.51		ES = 0.00, *p* = 0.99		ES = 0.35, *p* = 0.17		ES = 0.78, *p* = 0.01	
Meterage per Minute ($m \cdot min^{-1}$)	83.9 ± 7.9	83.3 ± 10.1	98.8 ± 16.5	93.3 ± 8.9	110.0 ± 11.2	102.7 ± 8.9	103.7 ± 24.9	105.9 ± 8.9
	ES = 0.08, *p* = 0.80		ES = 0.43, *p* = 0.12		ES = 0.74, *p* = 0.01		ES = 0.13, *p* = 0.63	
Mean Heart Rate. ($b \cdot min^{-1}$)	154.8 ± 20.7	147.9 ± 32.9	160.8 ± 25.9	154.7 ± 29.5	165.4 ± 21.3	151.8 ± 28.0	156.8 ± 25.9	151.9 ± 29.9
	ES = 0.25, *p* = 0.42		ES = 0.22, *p* = 0.41		ES = 0.54, *p* = 0.04		ES = 0.18, *p* = 0.51	
Low Speed Running Distance (m)	400.6 ± 31.9	398.4 ± 46.2	431.0 ± 56.7	421.1 ± 35.9	461.8 ± 33.3	444.8 ± 34.1	425.9 ± 94.4	446.0 ± 31.8
	ES = 0.05, *p* = 0.86		ES = 0.22, *p* = 0.43		ES = 0.5, *p* = 0.06		ES = 0.3, *p* = 0.26	
High Speed Running Distance (m)	14.9 ± 11.1	15.8 ± 10.3	40.7 ± 21.4	32.3 ± 14.4	52.3 ± 20.3	46.6 ± 16.6	57.1 ± 25.1	56.7 ± 22.2
	ES = 0.08, *p* = 0.78		ES = 0.47, *p* = 0.09		ES = 0.31, *p* = 0.24		ES = 0.02, *p* = 0.94	
Acceleration Efforts (*f*)	80.1 ± 7.7	81.9 ± 5.7	75.3 ± 9.4	76.4 ± 4.9	74.1 ± 5.1	75.9 ± 5.4	68.7 ± 10.0	73.8 ± 5.0
	ES = 0.29, *p* = 0.35		ES = 0.15, *p* = 0.58		ES = 0.34, *p* = 0.19		ES = 0.66, *p* = 0.02	
Deceleration Efforts (*f*)	78.4 ± 7.5	79.1 ± 5.2	70.8 ± 8.6	71.2 ± 6.2	68.9 ± 4.1	70.9 ± 5.4	65.0 ± 8.2	67.5 ± 4.5
	ES = 0.11, *p* = 0.72		ES = 0.06, *p* = 0.81		ES = 0.41, *p* = 0.16		ES = 0.38, *p* = 0.16	

Mean (± SD) values of key performance indicators for '*post*-PHV' (EASA% > 90) and '*pre*-PHV' (EASA% < 89.9) maturing players across small (17 x 17 m^2), medium (24 x 24 m^2), large (29.5 x 29.5 m^2) and expansive (34 x 34 m^2) relative pitch sizes. Low Speed Running Distance (< 13.0 $km \cdot h^{-1}$), High Speed Running Distance (> 13.1 - 16.0 $km \cdot h^{-1}$), Acceleration Efforts Frequency (0 - 2 $m \cdot s^{-1}$) and Deceleration Efforts Frequency (-2 - 0 $m \cdot s^{-1}$).

4.1.3 Technical / Tactical Measures

Total GTSC results were shown to be significantly different ($p \leq 0.001$) between '*post*-PHV' and '*pre*-PHV' maturing soccer players, across a 72 m^2 relative pitch size (Figure 3). During a maturity mismatch 'bio-banded' SSG format, coaches perceived and evidenced no significant difference ($p > 0.05$) for all construct metrics of the GTSC, inclusive of ball control, decision making, communication, 1 v 1, passing, cover/support, receiving, assist, shooting and marking ($p = 0.06$ to 0.97; ES = 0.01 to 0.59, trivial to small), consistent across small (36 m^2) and expansive (145 m^2) relative pitch sizes.

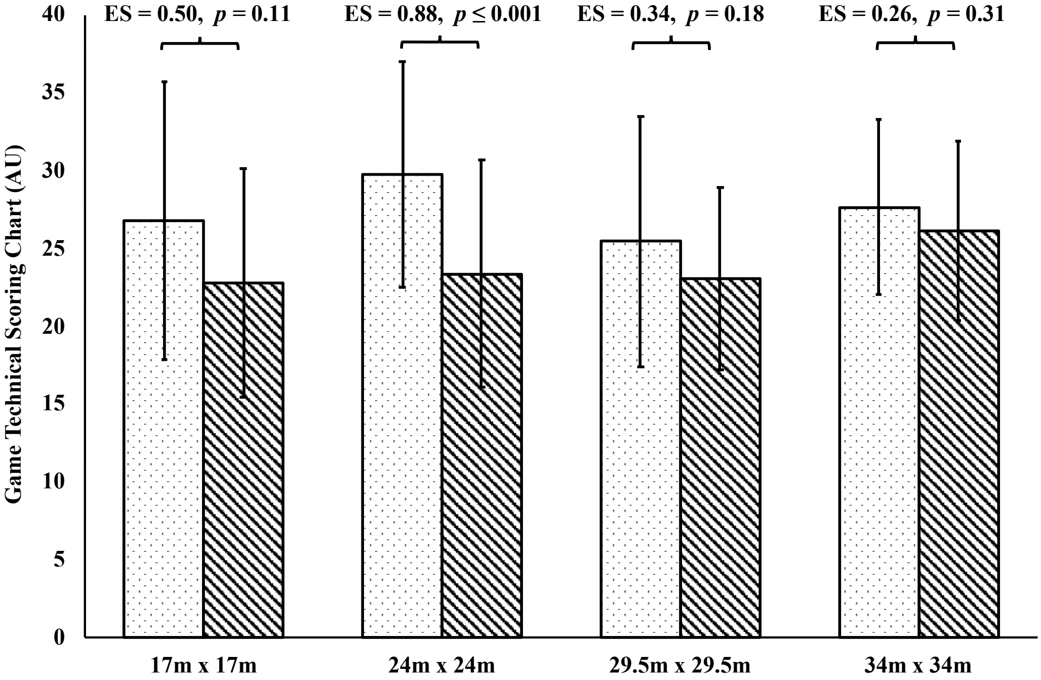

Figure 3: Estimated marginal mean difference (±SD) in Game Technical Scoring Chart (AU) result between '*post*-PHV' (EASA% > 90) and '*pre*-PHV' (EASA% < 89.9) maturing players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

All respective metrics, exclusive of communication and marking ($p = 0.20$ to 0.39; ES = 0.22 to 0.33, small) were shown to evidence a significant difference between '*post*-PHV' and '*pre*-PHV' maturing academy soccer players (p = 0.001 to 0.04; ES = 0.52 to 0.92, small to moderate) consistent across a medium (72 m^2) relative pitch size.

Significant differences ($p \leq 0.001$) were also reported for TTOTB between '*post*-PHV' and '*pre*-PHV' maturing soccer players, consistent across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes (Figure 4). '*Post*-PHV' maturing players were shown to demonstrate an increased amount of ball possession (*Post*-PHV: 63.6 [59.6 to 66.4]; *Pre*-PHV: 36.4 [33.6 to 40.4] %) and demonstrated a decrease in average ball regain time (*Post*-PHV: 6.8 [5.9 to 7.8]; *Pre*-PHV: 12.1 [8.6 to 15.1] sec) when compared with '*pre*-PHV' maturing soccer players across a mismatched 'bio-banded' game format. The relationship between GTSC (AU), TD (m), total points (TP) accumulated (AU) and HSRD (m), are presented within (Figure 5) (R^2 = 0.30 to 0.88, weak to strong).

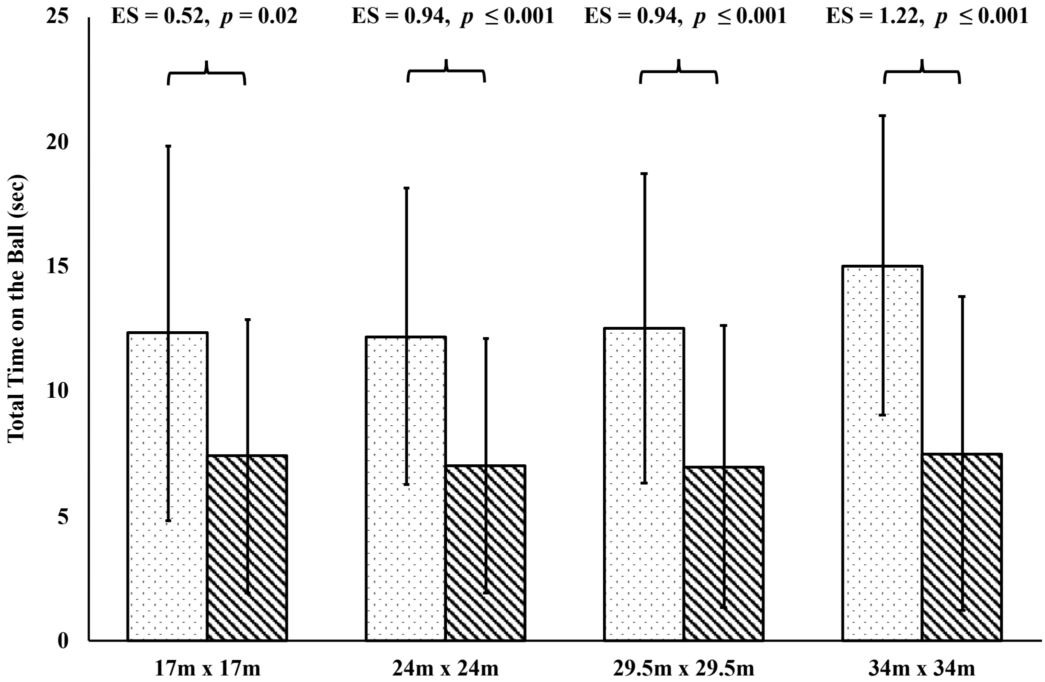

Figure 4: Estimated marginal mean difference (±SD) in Total Time on the Ball between post-PHV '*post*-PHV' (EASA% > 90) and '*pre*-PHV' (EASA% < 89.9) maturing players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

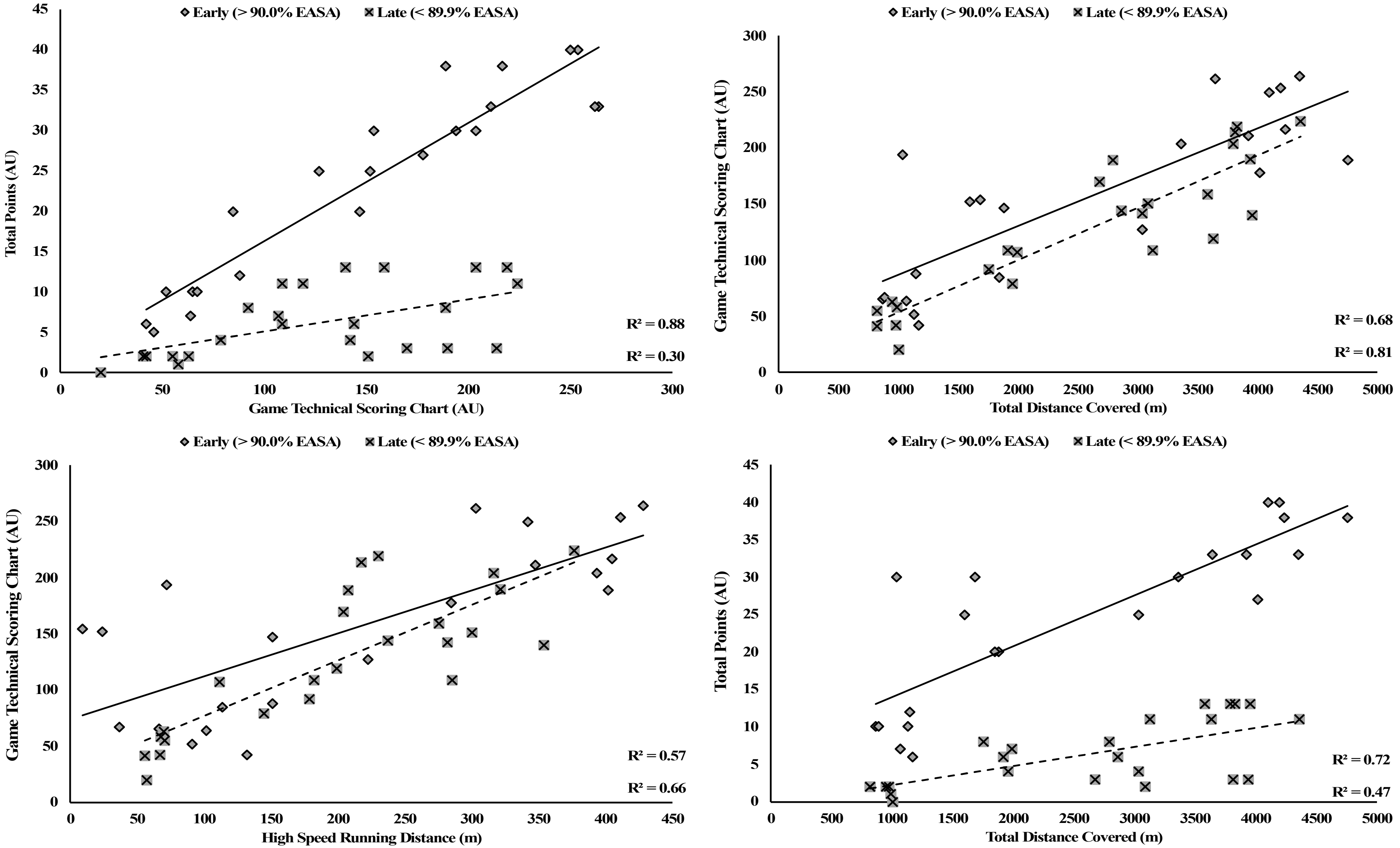

Figure 5: Relationships of *post*-PHV (EASA% > 90) and *pre*-PHV (EASA% < 89.9) maturing soccer players between Total Points (AU) accumulated and Game Technical Scoring Chart (AU), Game Technical Scoring Chart (AU) and Total Distance Covered (m), Game Technical Scoring Chart (AU) and High Speed Running Distance (m) and Total Points (AU) and Total Distance Covered (m) collated from estimated marginal means across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes, during ‘bio-banded’ small-sided games format.

4.1.4 Psychological Measures

During a maturity mis-matched 'bio-banded' SSG format, coaches scored '*post*-PHV' maturing players significantly higher for evidence of 'confidence' (p = 0.001 to 0.06; ES = 0.75 to 1.02, moderate) and 'positive attitude' (p = 0.01; ES = 0.65 to 0.77, moderate), across small (36 m^2), medium (72 m^2) and large (109 m^2) relative pitch sizes. Levels of 'competitiveness' were shown to be significantly greater (p = 0.00 to 0.01; ES = 0.65 to 0.96, moderate) for '*post*-PHV' maturing players across small (36 m^2) and medium (72 m^2) relative pitch sizes. Maturity mis-matched 'bio-banded' SGG formats on an expansive (145 m^2) relative pitch size, demonstrated no significant difference between '*post*-PHV' and '*pre*-PHV' maturing players for measures of coachability, positive attitude, confidence, competitiveness and x-factor (p = 0.06 to 1.00; ES = 0.00 to 0.50, trivial to small). The above are composite metrics of the game psycho-social score, presented within (Figure 6).

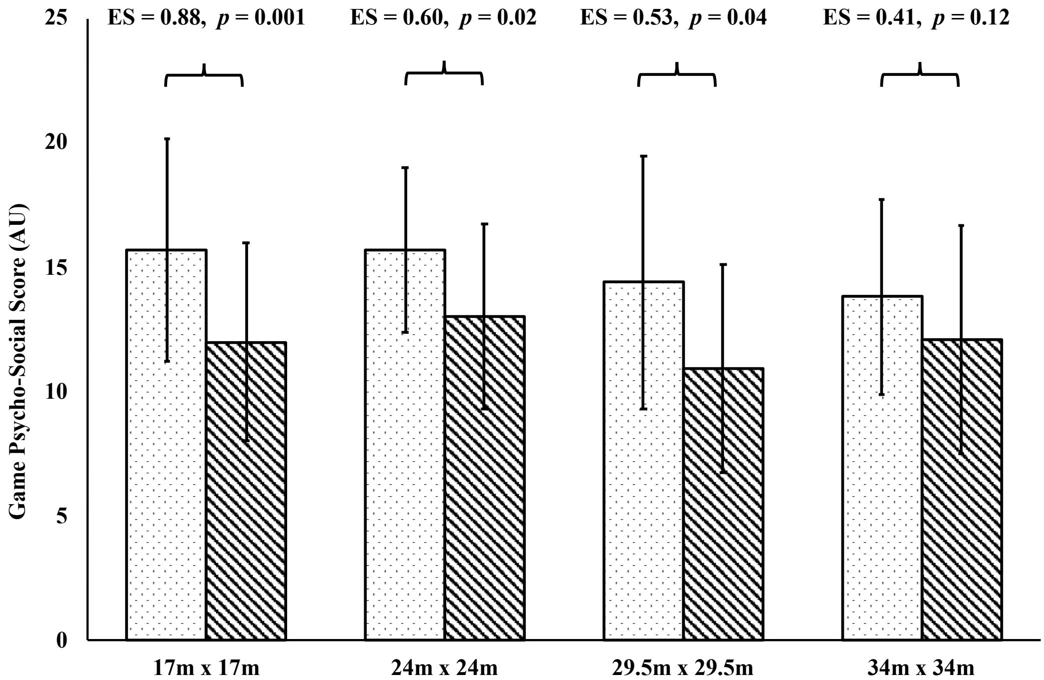

Figure 6: Estimated marginal mean difference (±SD) in Game Psycho-Social Score (AU) between '*post*-PHV' (EASA% > 90) and '*pre*-PHV' (EASA% < 89.9) maturing players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch size.

4.2 Matched ‘Bio-Banded’ Conditions (‘*Post*-PHV’ Vs. ‘*Post*-PHV’)

4.2.1 Anthropometrical Measures

Adopting the Khamis and Roche (1994) ‘bio-banding’ method players were categorised in accordance to EASA% into one of two ‘*post*-PHV’ maturing teams, *Post*-PHV 1 and *Post*-PHV 2 , respectively. ‘*post*-PHV 1’ banded players had a mean age of 13.7 (13.5 to 13.8) years and demonstrated no significant difference for age ($p = 0.57$; ES = 0.15, trivial) in comparison to ‘*post*-PHV 2’ banded players (13.6 [13.4 to 13.7] years). Measures of EASA% demonstrated a significant difference ($p \leq 0.001$; ES = 0.95, moderate) between ‘*post*-PHV 1’ banded players (93.4 [92.8 to 94.0] %) and ‘*post*-PHV 2’ banded players (91.7 [91.0 to 92.4] %). This trend is consistent for measures of stature (cm) and body mass (kg) in which ‘*post*-PHV 1’ banded players (169.2 [166.9 to 171.5] cm and 53.9 [52.1 to 55.8] kg) reported significant differences ($p = 0.02$ & ≤ 0.001 respectively) in comparison to ‘*post*-PHV 2’ (165.0 [162.6 to 167.5] cm and 49.5 [47.4 to 51.3] kg) banded players (ES = 0.55 to 0.91, small to moderate).

4.2.2 Physical Measures

The results demonstrated no significant difference for TD (m) between ‘*post*-PHV 1’ and ‘*post*-PHV 2’ banded players during a matched ‘bio-banded’ SGG format, consistent across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes (Figure 7). Total PlayerLoad^{TM} demonstrated no significant difference between ‘*post*-PHV 1’ and ‘*post*-PHV 2’ banded players of equitable game constraints across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes ($p = 0.64$ to 0.93; ES = 0.05 to 0.26, trivial to small). No reported significant difference is consistent for HSRD (> 13.0 $km{\cdot}h^{-1}$) and LSRD (< 13.0 $km{\cdot}h^{-1}$) across small

($36\ m^2$), medium ($72\ m^2$), large ($109\ m^2$) and expansive ($145\ m^2$) relative pitch sizes ($p = 0.07$ to 0.98; ES = 0.01 to 1.19, trivial to small).

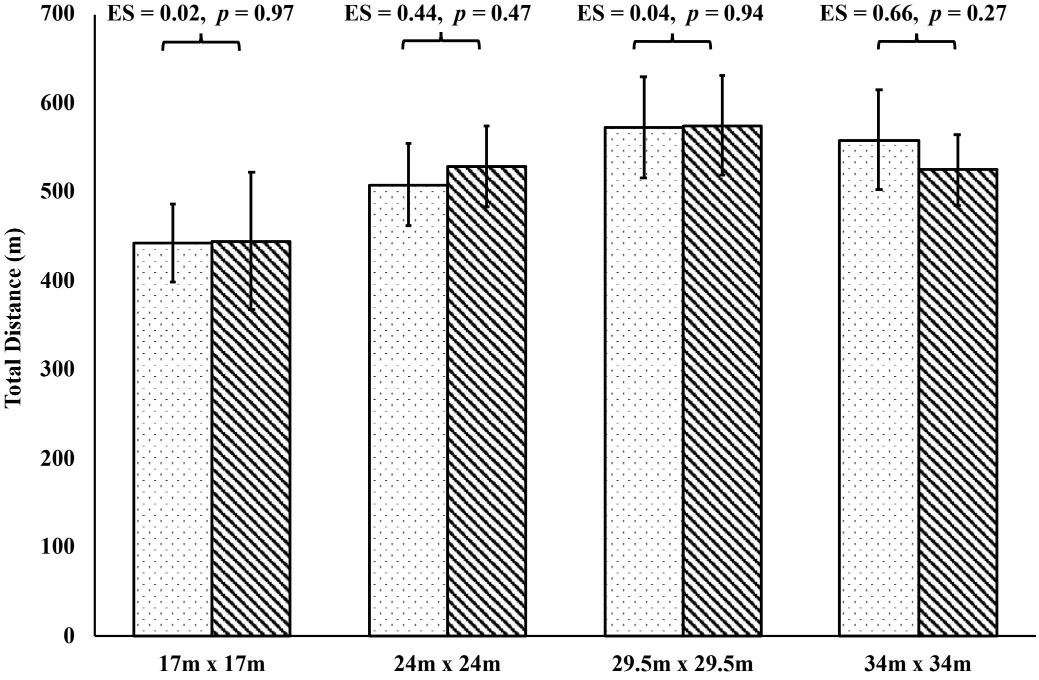

Figure 7: Estimated marginal mean difference (±SD) in total distance covered (m) between '*post*-PHV 1' and '*post*-PHV 2' (EASA% > 90) maturing players across small ($36\ m^2$), medium ($72\ m^2$), large ($109\ m^2$) and expansive ($145\ m^2$) relative pitch sizes.

The physical key performance indicators between '*post*-PHV 1' and '*post*-PHV 2' 'bio-banded' players, during a matched 'bio-banded' SSG game format are presented with (Table 5) ($p = 0.09$ to 0.98; ES = 0.01 to 1.00, trivial to moderate). '*post*-PHV 1' banded players demonstrated a significant difference ($p = 0.03$) for the measure of sRPE - TL (AU) in comparison to "*post*-PHV 2' banded players across a medium ($72\ m^2$) relative pitch sizes, however no significant difference was demonstrated across small ($36\ m^2$), large ($108\ m^2$) and expansive ($145\ m^2$) relative pitch sizes ($p = 0.34$ to 0.65; ES = 0.24 to 1.25, small to moderate) (Figure 8).

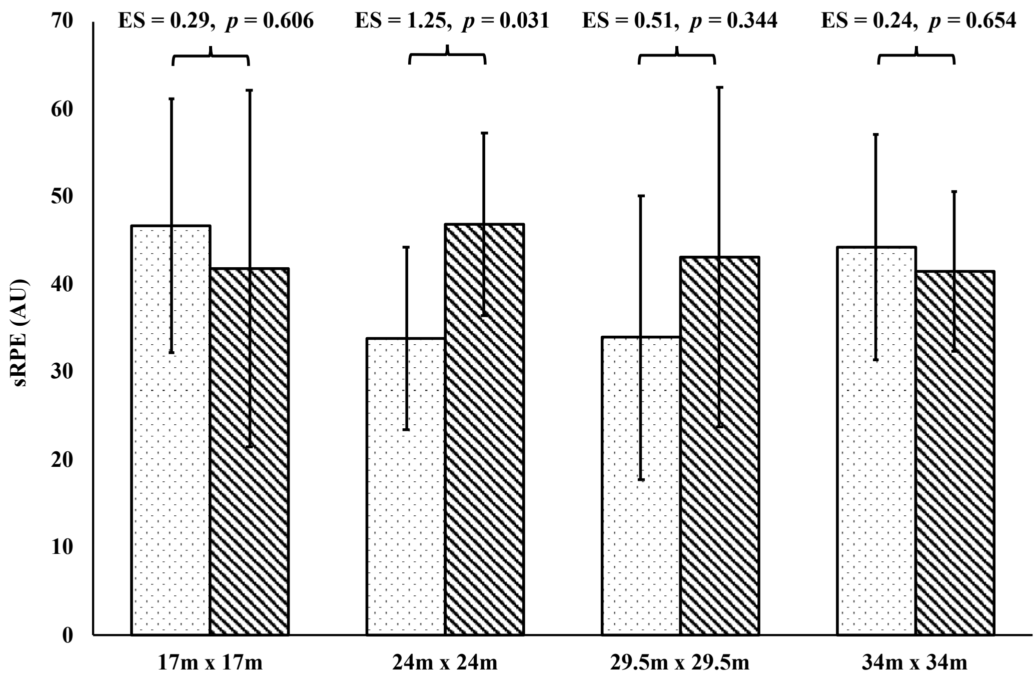

Figure 8: Estimated marginal mean difference (±SD) in sRPE – Training Load (AU) between '*post*-PHV 1' and '*post*-PHV 2' (EASA% > 90) maturing players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

Table 5: Estimated marginal means (± SD) micro-electromechanical systems (MEMS) device, associated effect sizes and values of significance ($p < 0.05$) of '*post*-PHV 1' and '*post*-PHV 2' (EASA% > 90) academy soccer players, during a matched maturity status 'bio-banded' (*post*-PHV v *post*-PHV) small-sided games, across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

Key Performance Indicator	**17m x 17m**		**24m x 24m**		**29.5m x 29.5m**		**34m x 34m**	
	'*post*-PHV 1'	**'*post*-PHV 2'**	**'*post*-PHV 1'**	**'*post*-PHV 2'**	**'*post*-PHV 1'**	**'*post*-PHV 2'**	**'*post*-PHV 1'**	**'*post*-PHV 2'**
Total PlayerLoad (AU)	61.2 ± 8.50	63.6 ± 10.5	62.4 ± 10.9	62.9 ± 10.1	69.1 ± 6.0	70.3 ± 8.6	62.9 ± 9.6	61.2 ± 6.9
	ES = 0.26, *p* = 0.64		**ES = 0.05, *p* = 0.93**		**ES = 0.15, *p* = 0.78**		**ES = 0.20, *p* = 0.70**	
Meterage per Minute (m·min^{-1})	88.5 ± 8.8	88.8 ± 15.4	101.5 ± 9.1	105.5 ± 9.1	113.4 ± 11.6	113.9 ± 11.5	111.1 ± 10.7	104.6 ± 8.3
	ES = 0.02, *p* = 0.97		**ES = 0.45, *p* = 0.46**		**ES = 0.04, *p* = 0.94**		**ES = 0.65, *p* = 0.28**	
Mean Heart Rate. (b·min^{-1})	165.2 ± 19.9	142.2 ± 26.8	162.8 ± 25.9	158.9 ± 29.8	163.9 ± 21.8	174.9 ± 11.9	167.6 ± 22.3	166.8 ± 24.7
	ES = 1.00, *p* = 0.09		**ES = 0.10, *p* = 0.85**		**ES = 0.66, *p* = 0.25**		**ES = 0.03, *p* = 0.95**	
Low Speed Running Distance (m)	417.1 ± 42.0	417.7 ± 63.0	455.0 ± 25.4	447.7 ± 28.1	475.4 ± 39.9	461.9 ± 27.7	439.4 ± 37.9	438.2 ± 17.2
	ES = 0.01, *p* = 0.98		**ES = 0.28, *p* = 0.65**		**ES = 0.40, *p* = 0.47**		**ES = 0.04, *p* = 0.95**	
High Speed Running Distance (m)	19.8 ± 13.9	21.7 ± 12.2	32.1 ± 12.1	51.2 ± 20.4	58.3 ± 21.1	60.6 ± 20.2	63.5 ± 24.1	46.9 ± 19.9
	ES = 0.15, *p* = 0.79		**ES = 1.19, *p* = 0.07**		**ES = 0.11, *p* = 0.84**		**ES = 0.73, *p* = 0.23**	
Acceleration Efforts (*f*)	80.5 ± 2.9	84.2 ± 4.9	78.1 ± 5.1	80.2 ± 4.8	74.9 ± 6.9	73.1 ± 5.1	70.5 ± 4.1	72.0 ± 4.6
	ES = 0.94, *p* = 0.11		**ES = 0.41, *p* = 0.49**		**ES = 0.28, *p* = 0.61**		**ES = 0.35, *p* = 0.56**	
Deceleration Efforts (*f*)	76.3 ± 3.9	76.7 ± 6.7	73.1 ± 4.6	71.6 ± 5.9	69.1 ± 5.2	69.00 ± 5.53	71.1 ± 3.9	72.0 ± 4.4
	ES = 0.08, *p* = 0.89		**ES = 0.30, *p* = 0.62**		**ES = 0.03, *p* = 0.96**		**ES = 0.21, *p* = 0.72**	

Mean (± SD) vlaues of key performance indicators for '*post*-PHV 1' and '*post*-PHV 2' (EASA% > 90) 'bio-banded' players across small (17m x 17m), medium (24m x 24m), large (29.5m x 29.5m) and expansive (34m x 34m) realtive pitch sizes. Low speed running distance (< 13.0 km·h^{-1}), high speed running distance (>13.1 - 16.0 km·h^{-1}), Acceleration Efforts (0 - 2 m·s^{-1}) and Deceleration Efforts (-2 - 0 m·s^{-1}).

4.2.2 Technical and Tactical Measures

Game Technical Scoring Chart (Figure 9) demonstrated no significant difference between '*post*-PHV 1' and '*post*-PHV 2' banded soccer players (p = 0.41 to 0.78; ES = 0.18 to 0.47, trivial to small), consistent across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes. During a matched 'bio-banded' SSG format, coaches perceived and evidence the only statistically significant difference between '*post*-PHV 1' and '*post*-PHV 2' banded players to be for the metric of 'marking' ($p \leq 0.001$; ES = 1.57, large) across an expansive (145 m^2) relative pitch size.

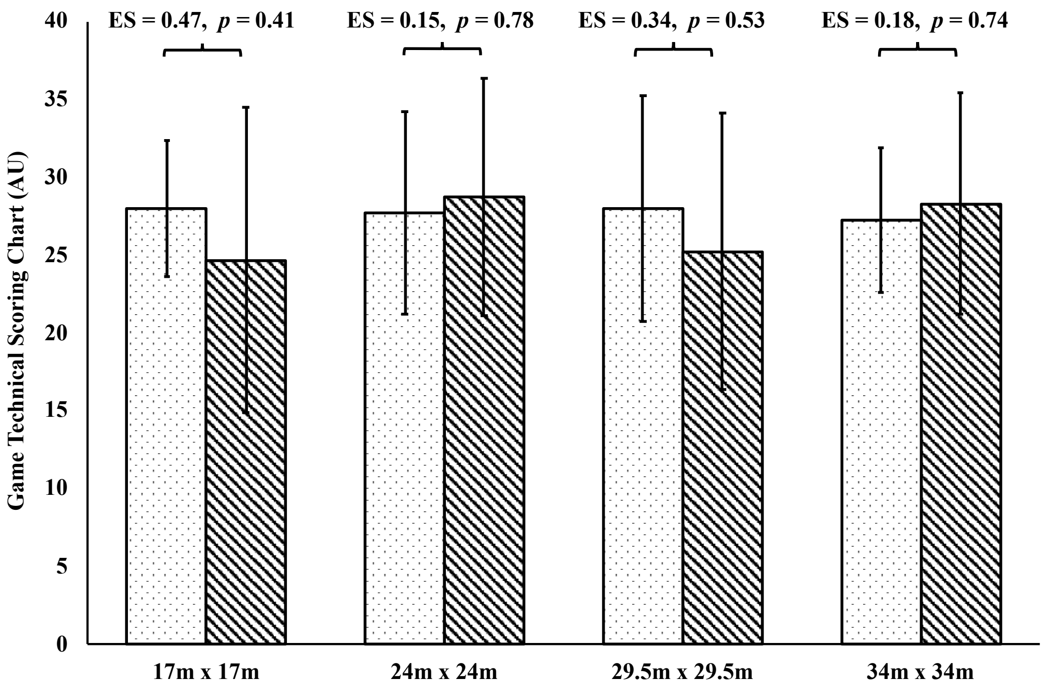

Figure 9: Estimated marginal mean difference (±SD) in Game Technical Scoring Chart (AU) result between '*post*-PHV 1'and '*post*-PHV 2' (EASA% > 90) maturing players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

All remaining construct metrics of the GTSC (AU), inclusive of ball control, decision making, communication, 1 v 1, passing, cover/support, receiving, assist, shooting and marking, demonstrated no significant difference for '*post*-PHV 1' banded, in comparison to '*post*-PHV 2' banded players (p = 0.07 to 0.98; ES = 0.02 to 0.97, trivial to moderate), consistent across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes. No significant difference was reported for TTOTB between '*post*-PHV 1'and '*post*-PHV 2' banded players, consistent across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes (p = 0.18 to 0.68; ES = 0.24 to 74, small to moderate) (Figure 10).

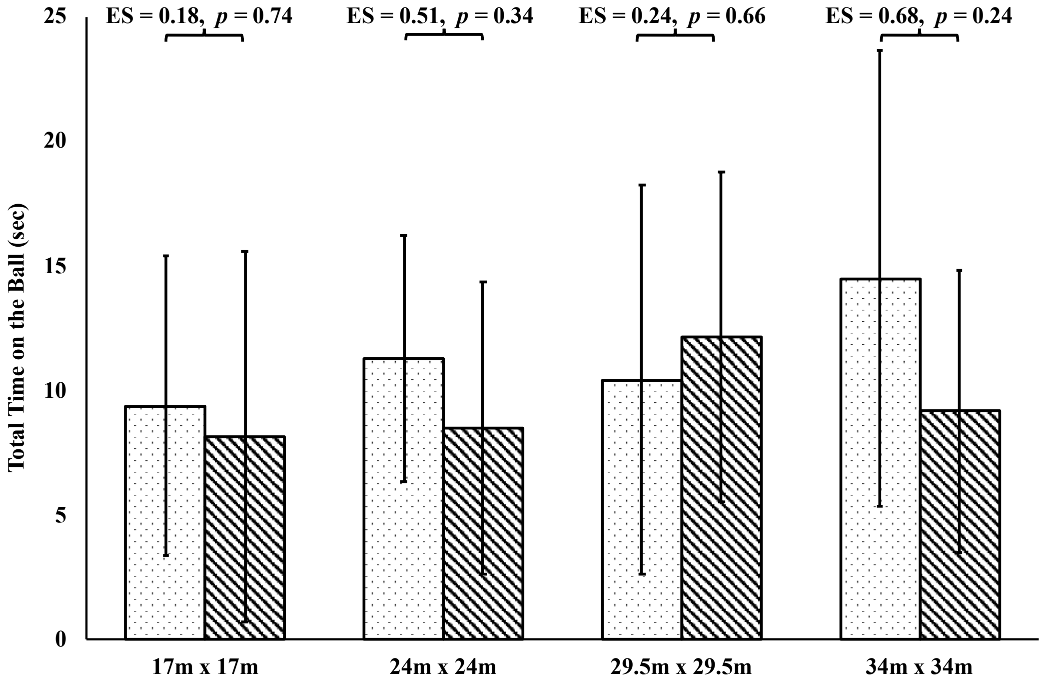

Figure 10: Estimated marginal mean difference (±SD) in Total Time on the Ball between '*post*-PHV 1' and '*post*-PHV 2' (EASA% > 90) maturing players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

Trivial differences were reported between '*post*-PHV 1' and '*post*-PHV 2' banded players for the constructs of ball possession (*post*-PHV 1: 51.1 [40.5 to 61.0]; *post*-PHV 2: 48.9 [39.0 to 59.5] %) and average ball regain time (*post*-PHV 1: 8.8 [5.7 to 11.6]; *post*-PHV 2: 9.0 [5.9 to 13.3] sec). during a maturity matched 'bio-banded' game format. The relationships between GTSC (AU), TD (m), TP's accumulated (AU), and HSRD (m) for ‘*post*-PHV 1’ and ‘*post*-PHV 2’ banded players are presented within (Figure 11) (r = 0.40 to 0.97, moderate to strong).

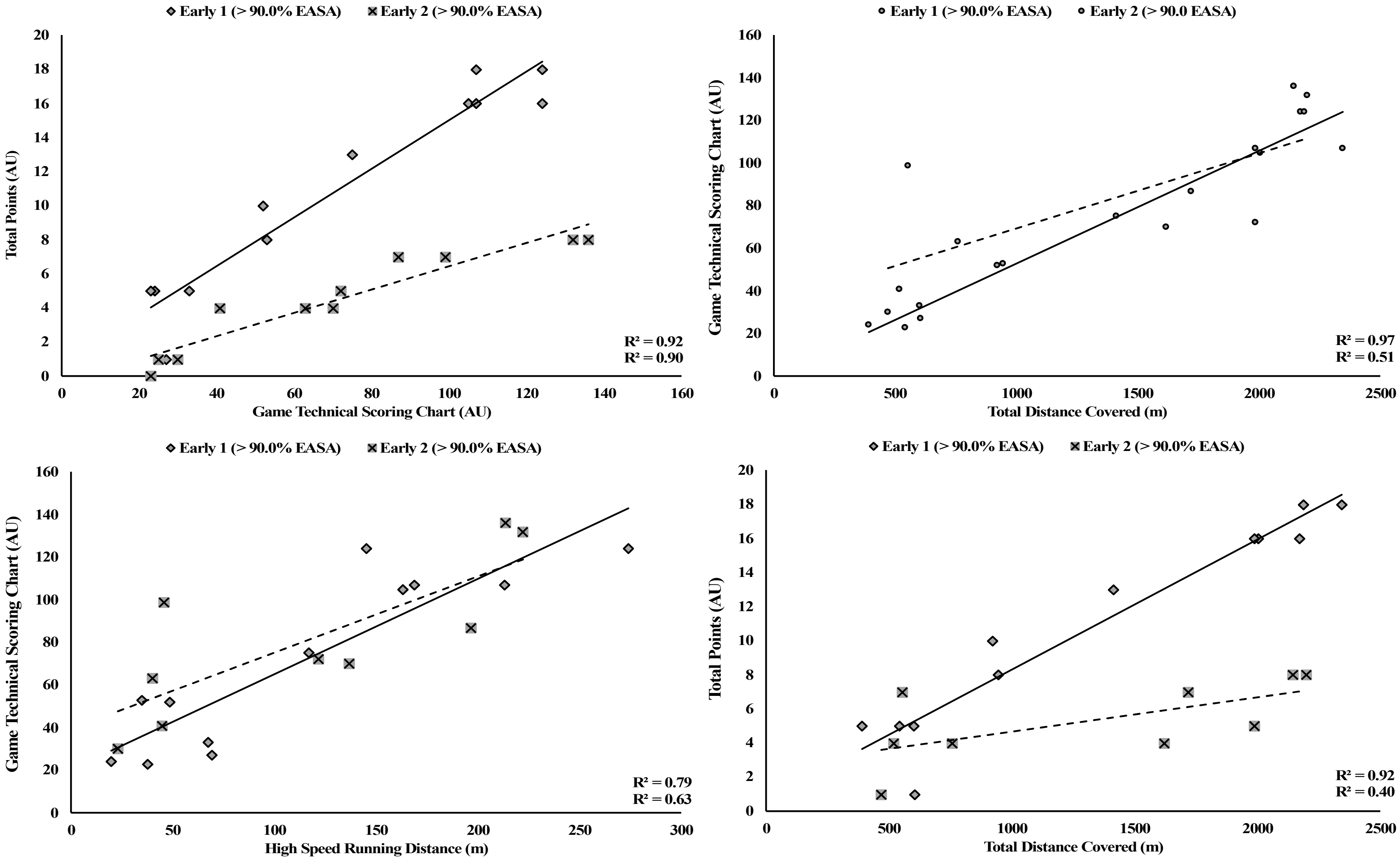

Figure 11: Relationships of '*post*-PHV 1' and '*post*-PHV 2' (EASA% > 90) banded soccer players between Total Points (AU) and Game Technical Scoring Chart (AU), Game Technical Scoring Chart (AU) and Total Distance Covered (m), Game Technical Scoring Chart (AU) and High Speed Running Distance (m) and Total Points (AU) and Total Distance Covered (m) collated from estimated marginal means across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes, during a matched 'bio-banded' small-sided games format.

4.2.3 Psychological Measures

During a maturity matched ‘bio-banded’ SSG format, coaches perceived and evidence a statistically significant difference in the measures of positive attitude (p = 0.04; ES = 1.15, large) and coachability (p = 0.03, ES = 1.30, large), across a medium (72 m^2) and large (145 m^2) relative pitch size respectively, however such performance metrics, were deemed not to be significantly different across the remaining relative pitch sizes (p = 0.24 to 0.68; ES = 0.23 to 0.66, moderate). A maturity matched ‘bio-banded’ SSG format, demonstrated no significant differences between ‘*post*-PHV 1’ and ‘*post*-PHV 2’ banded players, for measures of confidence, competitiveness and x-factor (p = 0.08 to 0.83; ES = 0.24 to 0.99, small to moderate). The above metrics are constructs of the game psycho-social score, presented within (Figure 12).

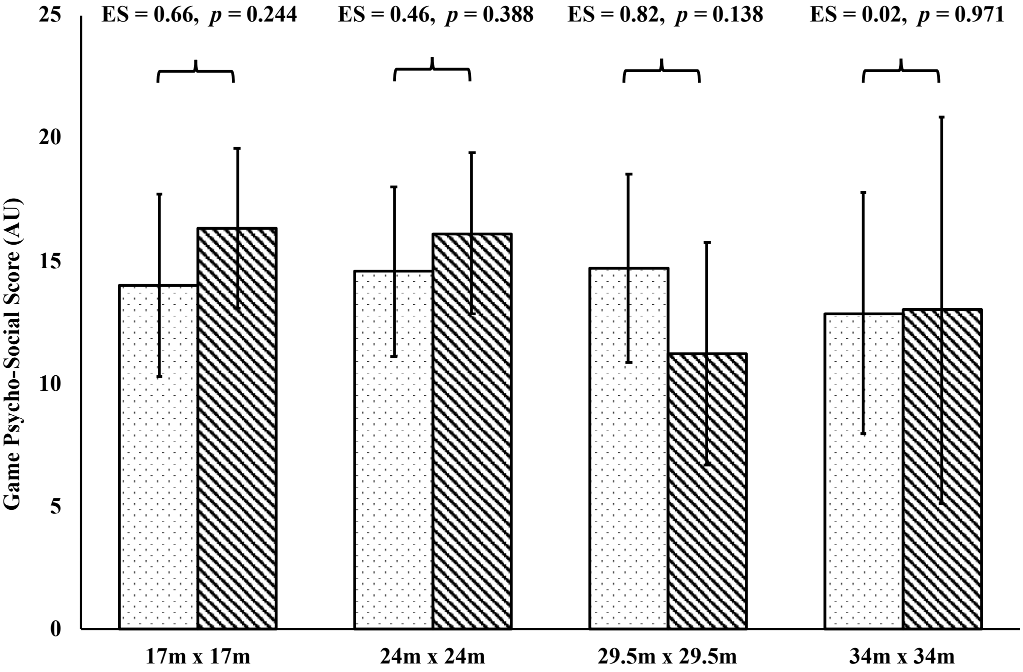

Figure 12: Estimated marginal mean difference (±SD) in Game Psycho-Social Score (AU) between ‘*post*-PHV 1’ and ‘*post*-PHV 2’ (EASA% > 90%) maturing players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch size.

4.3 Maturity Matched ‘Bio-Banded’ Conditions (‘*pre*-PHV’ Vs. ‘*pre*-PHV’)

4.3.1 Anthropometrical Measures

Applying the Khamis and Roche (1994) method of maturity assessment, players were categorised into accordance of EASA% into one of two ‘*pre*-PHV’ maturing team, *pre*-PHV 1 (*pre*-PHV 1) and *pre*-PHV 2 (*pre*-PHV 2) respectively. ‘*pre*-PHV 1’ banded players had a mean age of 12.3 [12.0 to 12.6] years and demonstrated no significant difference (p = 0.81; ES = 0.10, trivial), in comparison to ‘*pre*-PHV 2’ banded players (12.3 [12.1 to 12.6] years). Measures of EASA% demonstrated no significant difference (p = 0.60; ES = 0.13, trivial) between ‘*pre*-PHV 1’ banded players (84.6 [83.8 to 85.4] %) and ‘*pre*-PHV 2’ banded players (84.9 [84.1 to 95.8] %). This trend is consistent for the measure of body mass (kg), for ‘*pre*-PHV 1’ banded players (39.4 [37.5 to 41.4] kg), in comparison to ‘*pre*-PHV 2’ banded players (42.1 [40.1 to 44.0] kg) (p = 0.07, ES = 0.47, small). However, a significant difference was demonstrated for the measure of stature (cm), between ‘*pre*-PHV 1’ banded (146.0 [142.1 to 149.9] cm) and ‘*pre*-PHV 2’ banded (154.8 [150.8 to 158.7] cm) academy soccer players (p = 0.003, ES = 0.79, moderate).

4.3.2 Physical Measures

The results demonstrated no significant difference for the measure of TD (m) between ‘*pre*-PHV 1’ and ‘*pre*-PHV 2’ banded players (Figure 13) during a maturity matched ‘bio-banded’ SSG format, consistent across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes (p = 0.07 to 0.81; ES = 0.12 to 0.97, trivial to moderate). Total PlayerLoad^{TM} demonstrated no significant difference between ‘*pre*-PHV 1’ and ‘*pre*-PHV 2’banded players of equitable game constraints across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes (p = 0.37

to 0.96; ES = 0.05 to 0.46), trivial to small). No difference was present for HSRD (> 13.0 km·h^{-1}) and LSRD (< 13.0 km·h^{-1}) across small (36 m^2), medium (72 m^2) and large (109 m^2) relative pitch sizes (p = 0.12 to 0.91; ES = 0.06 to 0.82, trivial to moderate). However, '*pre*-PHV 2' banded players were reported to cover a great distance at low speed (< 13.0 km·h^{-1}) across an expansive (145 m^2) relative pitch size (p = 0.04; ES = 1.15, moderate), nonetheless, HSRD (> 13.0 km·h^{-1}) demonstrated no significant difference across such respective pitch size (p = 0.90; ES = 0.06, trivial).

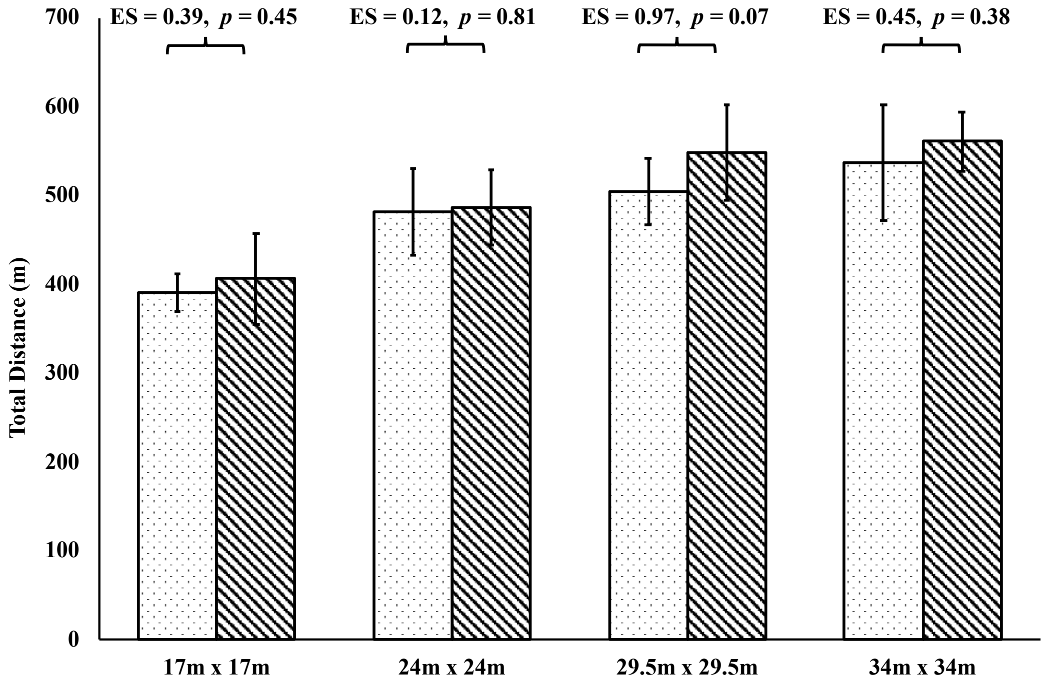

Figure 13: Estimated marginal mean difference (±SD) in total distance covered (m) between '*pre*-PHV 1' and '*pre*-PHV 2' (EASA% < 89.9) banded players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

No significant difference was reported for the measure of sRPE - TL (AU) (Figure 14) for '*pre*-PHV 1' banded players, in comparison to '*pre*-PHV 2' banded players, across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes (p = 0.23 to 0.90; ES = 0.06 to 0.63, trivial to small). The difference in physical key performance indicators and such comparison between ‘*pre*-PHV 1’ and ‘*pre*-PHV 2’ banded players, during a maturity matched (‘*pre*-PHV’ v ‘*pre*-PHV’) ‘bio-banded’ SSG format, are presented within (Table 6) (p = 0.04 to 1.00; ES = .0 to 1.15, trivial to moderate).

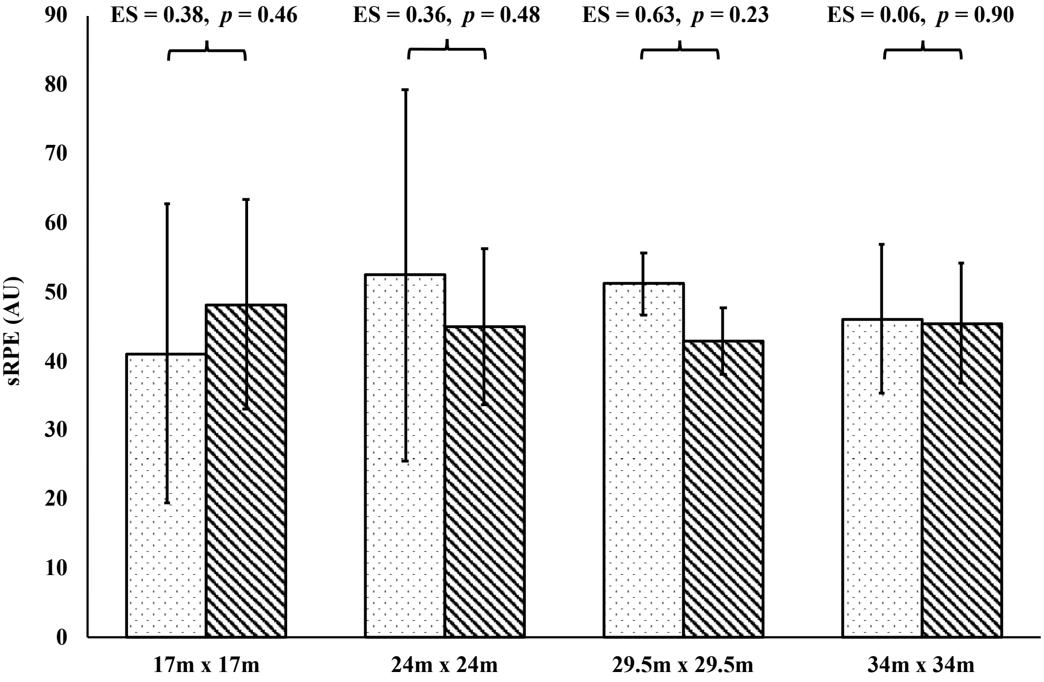

Figure 14: Estimated marginal mean difference (±SD) in sRPE – Training Load (AU) between ‘*pre*-PHV 1’ and ‘*pre*-PHV 2’ (EASA% < 89.9) maturing players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

Table 6: Estimated marginal means (± SD) micro-electromechanical systems (MEMS) device, associated effect sizes and values of significance ($p < 0.05$) of ‘*pre*-PHV 1’ and ‘*pre*-PHV 2’ (EASA% < 89.9) academy soccer players, during a matched maturity status ‘bio-banded’ (*pre*-PHV v *pre*-PHV) small-sided games, across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

Key Performance Indicator	**17m x 17m**		**24m x 24m**		**29.5m x 29.5m**		**34m x 34m**	
	'*pre*-PHV 1'	**'*pre*-PHV 2'**	**'*pre*-PHV 1'**	**'*pre*-PHV 2'**	**'*pre*-PHV 1'**	**'*pre*-PHV 2'**	**'*pre*-PHV 1'**	**'*pre*-PHV 2'**
Total PlayerLoad (AU)	57.3 ± 7.2	60.4 ± 13.6	64.7 ± 9.9	62.7 ± 9.7	64.9 ± 9.8	69.9 ± 11.6	69.8 ± 9.8	69.6 ± 9.1
	ES = 0.28, *p* = 0.58		**ES = 0.21, *p* = 0.69**		**ES = 0.46, *p* = 0.37**		**ES = 0.05, *p* = 0.96**	
Meterage per Minute (m$\cdot$min^{-1})	75.9 ± 4.2	78.9 ± 9.6	95.7 ± 9.5	96.8 ± 8.1	100.3 ± 7.5	109.2 ± 10.5	106.9 ± 12.9	111.6 ± 6.4
	ES = 0.40, *p* = 0.44		**ES = 0.12, *p* = 0.81**		**ES = 0.98, *p* = 0.01**		**ES = 0.45, *p* = 0.38**	
Mean Heart Rate. (b$\cdot$min^{-1})	155.6 ± 20.9	155.1 ± 27.3	166.7 ± 25.1	156.1 ± 29.1	169.1 ± 16.2	159.9 ± 20.7	155.5 ± 24.2	151.8 ± 42.5
	ES = 0.02, *p* = 0.97		**ES = 0.39, *p* = 0.45**		**ES = 0.46, *p* = 0.37**		**ES = 0.10, *p* = 0.86**	
Low Speed Running Distance (m)	372.9 ± 23.7	390.6 ± 46.6	411.5 ± 36.5	437.9 ± 27.8	434.1 ± 19.5	455.9 ± 31.9	435.2 ± 34.8	467.9 ± 19.9
	ES = 0.48, *p* = 0.36		**ES = 0.82, *p* = 0.13**		**ES = 0.82, *p* = 0.12**		**ES = 1.15, *p* = 0.04**	
High Speed Running Distance (m)	13.5 ± 4.1	12.9 ± 12.1	47.7 ± 11.8	37.8 ± 14.6	46.9 ± 15.2	53.7 ± 18.1	60.4 ± 31.5	58.8 ± 18.2
	ES = 0.06, *p* = 0.91		**ES = 0.74, *p* = 0.16**		**ES = 0.40, *p* = 0.43**		**ES = 0.06, *p* = 0.90**	
Acceleration Efforts (*f*)	77.4 ± 4.6	80.0 ± 7.0	73.9 ± 5.5	73.9 ± 4.6	69.6 ± 7.9	70.6 ± 3.6	69.5 ± 5.6	70.3 ± 8.6
	ES = 0.44, *p* = 0.39		**ES = 0.00, *p* = 1.00**		**ES = 0.16, *p* = 0.75**		**ES = 0.10, *p* = 0.84**	
Deceleration Efforts (*f*)	81.0 ± 5.5	80.4 ± 7.5	77.0 ± 4.6	78.5 ± 5.6	72.1 ± 4.3	74.8 ± 4.5	73.4 ± 5.4	72.9 ± 7.3
	ES = 0.10, *p* = 0.85		**ES = 0.29, *p* = 0.57**		**ES = 0.60, *p* = 0.25**		**ES = 0.08, *p* = 0.88**	

Mean (± SD) values of key performance indicators for '*pre*-PHV 1' and '*pre*-phv 2' (EASA% < 89.9) maturing players across small (17 x 17 m^2), medium (24 x 24 m^2), large (29.5 x 29.5 m^2) and expansive (34 x 34 m^2) relative pitch sizes. Low Speed Running Distance (< 13.0 km$\cdot$h^{-1}), High Speed Running Distance (> 13.1 - 16.0 km$\cdot$h^{-1}), Acceleration Efforts Frequency (0 - 2 m$\cdot$s^{-1}) and Deceleration Efforts Frequency (-2 - 0 m$\cdot$s^{-1}).

4.3.3 Technical / Tactical Measures

Game Technical Scoring Chart (Figure 15) reported no significant difference between ‘*pre*-PHV 1’ banded players in comparison to ‘*pre*-PHV 2’ banded soccer players (p = 0.12 to 0.38; ES = 0.45 to 0.82, small to moderate), consistent across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes. During a maturity matched (‘*pre*-PHV’ v ‘*pre*-PHV’) ‘bio-banded’ SSG format coaches perceived and evidenced ‘*pre*-PHV 2’ banded players to score greater than ‘*pre*-PHV 1’ banded players for the measures of decision making and receiving (p = 0.01 to 0.04; ES = 1.12 to 1.50, moderate to large) across a medium (72 m^2) relative pitch size.

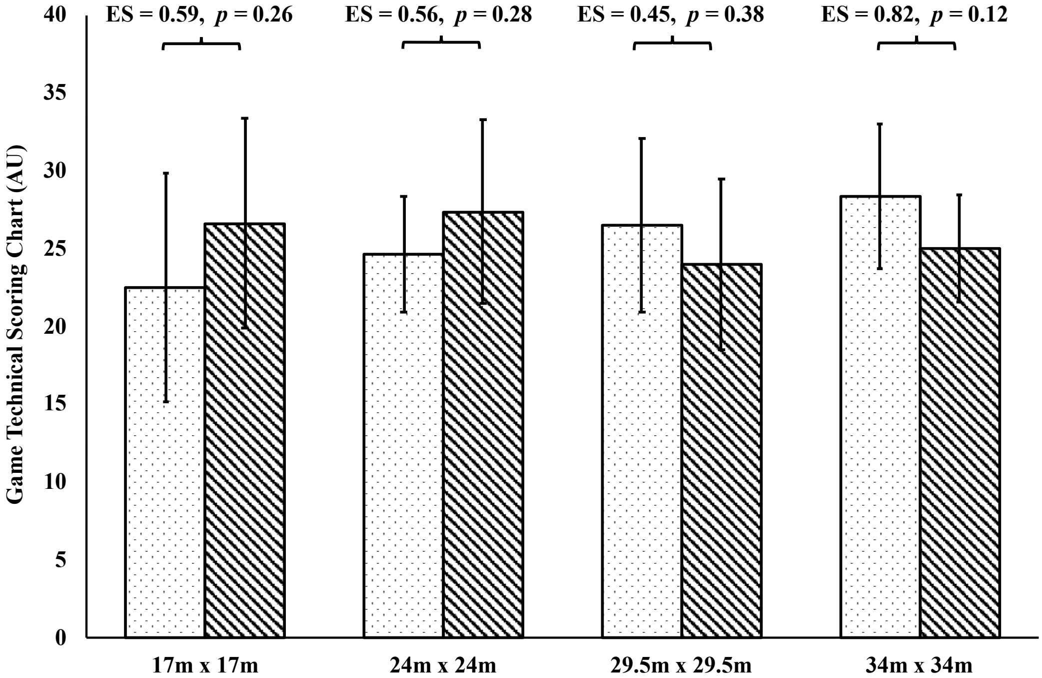

Figure 15: Estimated marginal mean difference (±SD) in Game Technical Scoring Chart (AU) result between ‘*pre*-PHV 1’and ‘*pre*-PHV 2’ (EASA% < 89.9) maturing players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

This significant difference is consistent for the measure of ‘passing’, in which ‘*pre*-PHV 1’ players evidenced greater scores, in comparison to ‘*pre*-PHV 2’ banded players (p = 0.02; ES = 1.27, large), across an expansive (145 m^2) relative pitch size.

The remaining composite metrics of the GTSC, inclusive of cover/support, communication, ball control, 1 v 1, shooting, assist and marking, were shown to be not significantly different for ‘*pre*-PHV 1’ banded, in comparison to ‘*pre*-PHV 2’ banded players (p = 0.17 to 1.00; ES = 0.00 to 0.73, trivial to moderate), consistent across small (36 m^2), medium (72 m^2), large (108 m^2) and expansive (145 m^2) relative pitch sizes. No significant difference was reported for TTOTB between ‘*pre*-PHV 1’ and ‘*pre*-PHV 2’ banded players (Figure 16), consistent across consistent across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes (p = 0.09 to 0.58; ES = 0.29 to 0.91, small to moderate).

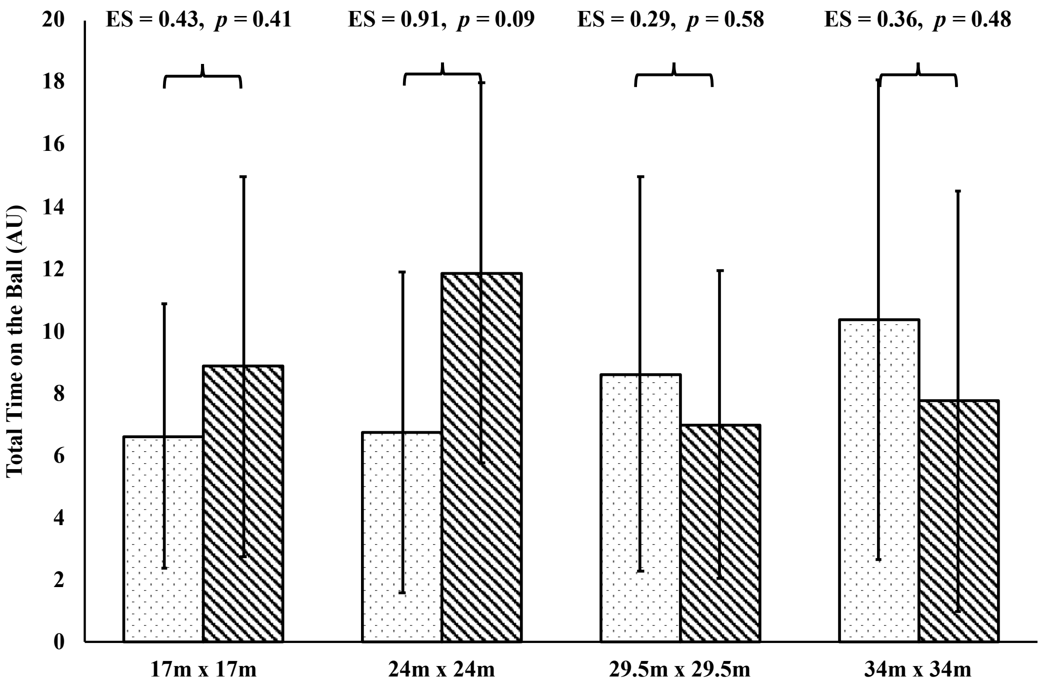

Figure 16: Estimated marginal mean difference (±SD) in total time on the ball between ‘*pre*-PHV 1’ and ‘*pre*-PHV 2’ (EASA% < 89.9) maturing players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

Trivial differences were demonstrated for the amount of ball possession (*pre*-PHV 1: 52.9 [45.5 to 64.0]; *pre*-PHV 2: 47.1 [36.0 to 54.5] %) and average ball regain time (*pre*-PHV 1: 7.7 [5.5 to 11.7]; *pre*-PHV 2: 8.4 [6.5 to 10.5] sec) demonstrated between '*pre*-PHV 1' and '*pre*-PHV 2' banded players, across a maturity matched ('*pre*-PHV' Vs. '*pre*-PHV') 'bio-banded' game format. The relationships between GTSC (AU), TD (m), TP's accumulated (AU), and HSRD (m) for '*pre*-PHV 1' and '*pre*-PHV 2' banded players are presented within (Figure 17) (r = 0.50 to 0.85, strong).

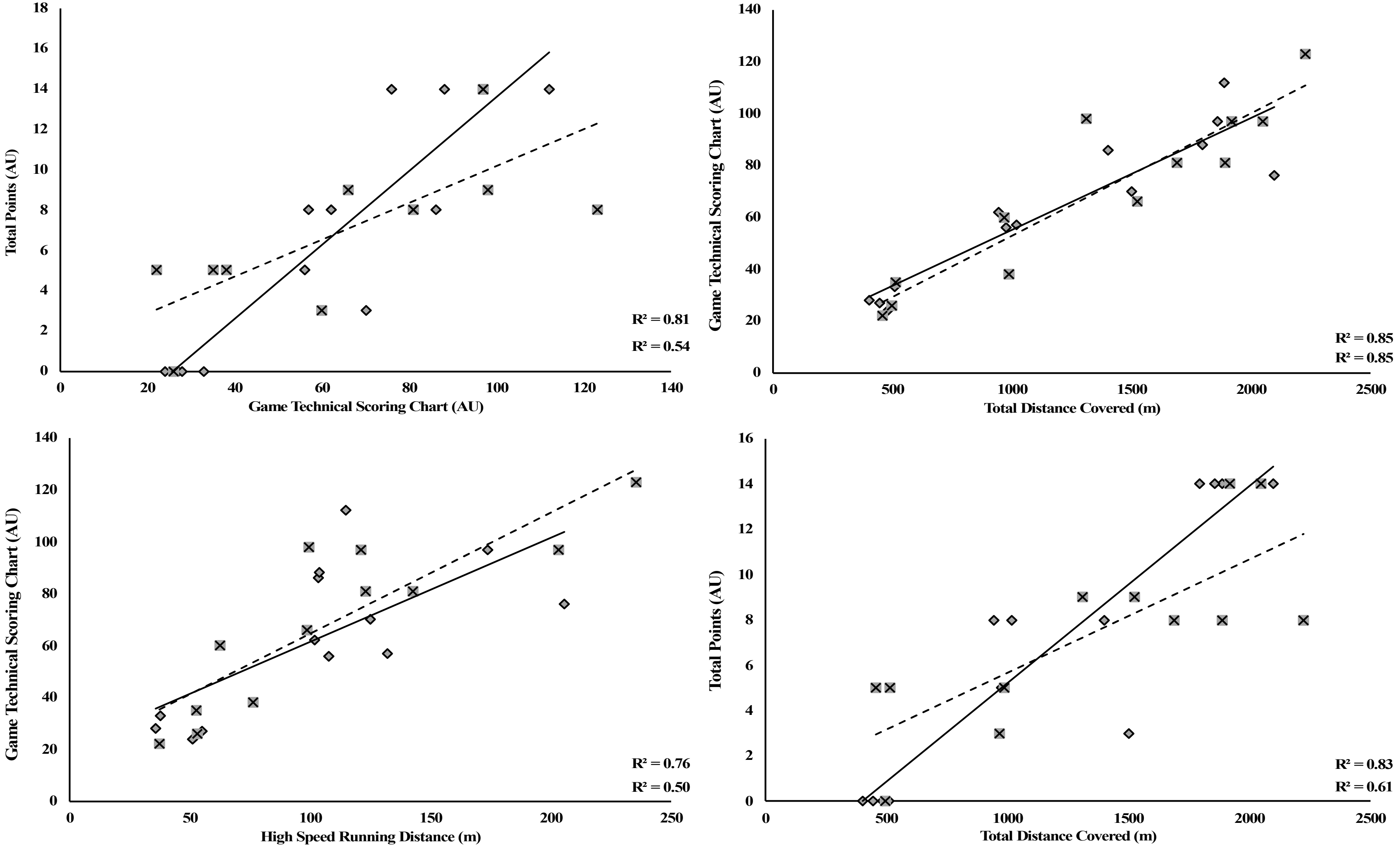

Figure 17: Relationships of ‘*pre*-PHV 1’ and ‘*pre*-PHV 2’ (EASA% < 89.9) banded soccer players between Total Points (AU) and Game Technical Scoring Chart (AU), Game Technical Scoring Chart (AU) and Total Distance Covered (m), Game Technical Scoring Chart (AU) and High Speed Running Distance (m) and Total Points (AU) and Total Distance Covered (m) collated from estimated marginal means across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes, during a matched ‘bio-banded’ small-sided games format.

4.3.4 Psychological Measures

During a matched ('*pre*-PHV' v '*pre*-PHV') 'bio-banded' SSG format, coaches perceived and evidenced no statistically significant difference, in the measures of coachability, positive attitude, confidence, competitiveness, and x-factor (p = 0.14 to 1.00; ES = 0.00 to 1.04, trivial to moderate), consistent across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes. The above are composite metrics of the game psycho-social score, presented within (Figure 18).

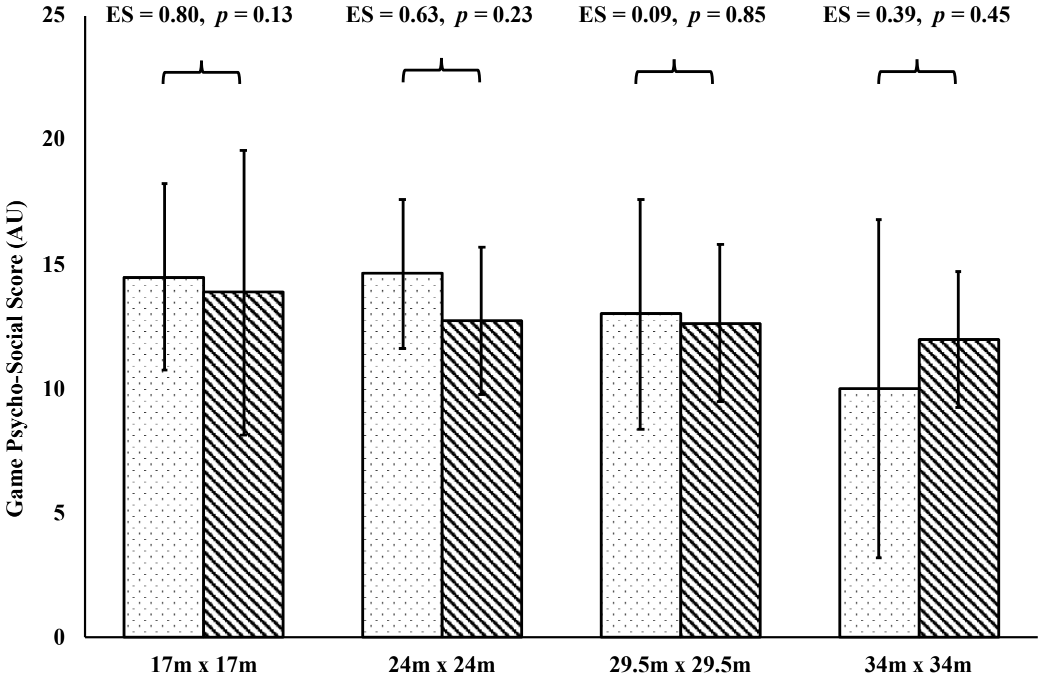

Figure 18: Estimated marginal mean difference (±SD) in Game Psycho-Social Score (AU) between '*pre*-PHV 1' and '*pre*-PHV 2' (EASA% > 90) maturing players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch size.

4.4 ‘Mixed’ Conditions

4.4.1 Anthropometrical Measures

Adopting the Khamis and Roche (1994) method of maturity status assessment, two ‘*post*-PHV’ maturing (EASA% > 90) and two ‘pre-PHV’ maturing (EASA% < 89.9) academy soccer players, were randomly assigned into one of four *mixed* ‘bio-banded’ teams ‘*Mixed* 1’ banded players had a mean age of 13.0 (12.9 to 13.2) years and demonstrated no significant difference in age (p = 0.61; ES = 0.20, small), in comparison to ‘Mixed 2’ banded players (12.9 [12.7 to 13.0] years). Measures of EASA% attainment demonstrated no significant difference (p = 0.62; ES = 0.05, trivial) between ‘*Mixed* 1’ banded (88.0 [87.4 to 88.7] %) and ‘*Mixed* 2’ banded (88.3 [87.6 to 88.9] %) soccer players. This is consistent for measure of body mass (kg) and stature (cm) for ‘*mixed* 1’ banded players (46.7 [45.5 to 47.8] kg and 157.9 [156.1 to 159.8] cm) in comparison to ‘*Mixed* 2’ banded players (45.3 [44.1 to 46.4] kg and 158.8 [156.9 to 160.7] cm) respectively (p = 0.09 to 0.53; ES = 0.07 to 0.18, trivial).

4.4.2 Physical Measures

The results demonstrate a significant difference for the measure of TD (m) between ‘*mixed* 1’ and ‘*mixed* 2’ banded players (Figure 19) during a *mixed* ‘bio-banded’ SSG format across a small (36 m^2) relative pitch size. This is inconsistent with no significant difference reported for total distance covered (m) between ‘*mixed* 1’ and ‘*mixed* 2’ banded players across medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes (p = 0.17 to 0.92; ES = 0.02 to 0.30, trivial to small). Total PlayerLoad^{TM} demonstrated no significant difference between ‘*mixed* 1’ and ‘*mixed* 2’ banded players of equitable game constraints, across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes (p = 0.11 to 0.87; ES = 0.03 to 0.39, trivial to small). ‘*Mixed*

1’ banded players were reported to cover a greater LSRD (< 13.0 km·h^{-1}) in comparison to ‘*mixed* 2’ banded players across a small (36 m^2) and expansive (145 m^2) relative pitch sizes (p = 0.03 to 0.05; ES = 0.44 to 0.47, small). This trend was found to be inconsistent across a medium (72 m^2) and large (109 m^2) relative pitch sizes, with results demonstrating no significant difference between ‘*mixed* 1’ and ‘*mixed* 2’ banded players for LSRD (< 13.0 km·h^{-1}), (p = 0.31 to 0.79; ES = 0.06 to 0.22, trivial to small). A significant difference was reported for the measures of HSRD (> 13.0 km·h^{-1}) between ‘*mixed* 1’ and ‘*mixed* 2’ banded teams across a small (36 m^2) relative pitch size (Table 7), however, this trend was not consistent across medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes (p = 0.21 to 0.85; ES = 0.04 to 0.27, trivial to small).

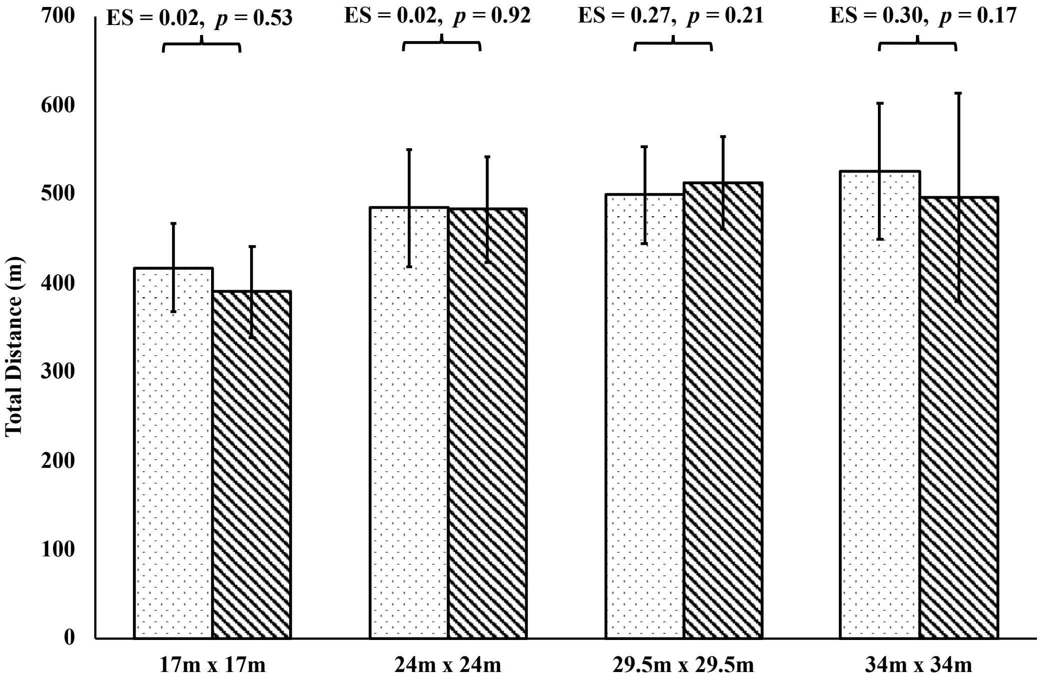

Figure 19: Estimated marginal mean difference (±SD) in total distance covered (m) between ‘*mixed* 1’ (88.0 ± 4.1 EASA%) and ‘*mixed* 2’ (88.3 ± 4.1 EASA%) banded players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

‘*Mixed* 2’ players were reported to significantly evidence decrease levels of sRPE - TL in comparison to ‘*mixed* 1’ banded players across small (36 m^2) and medium (72 m^2) relative pitch sizes, however, this trend was inconsistent across large (109 m^2) and expansive (145 m^2) relative pitch sizes (p = 0.00 to 0.82; ES = 0.05 to 0.85, trivial to moderate) (Figure 20). The difference in key physical performance indicators and such comparison between ‘*mixed* 1’ and ‘*mixed* 2’ banded players, during a *mixed* ‘bio-banded’ SSG format are presented with (Table 7) (p = 0.02 to 0.87; ES = 0.03 to 0.52, trivial to small).

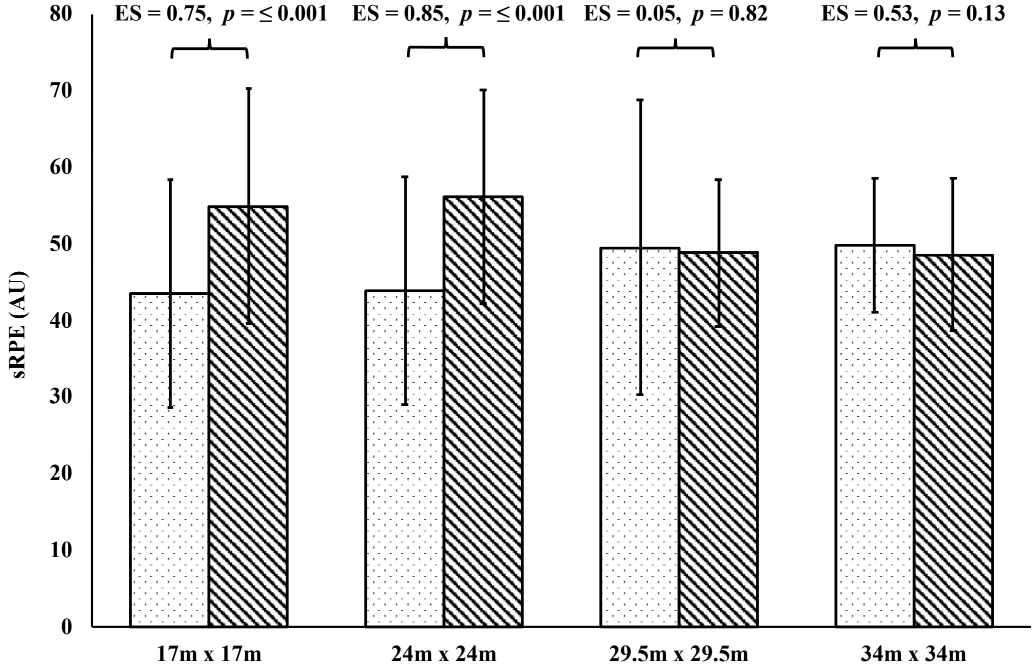

Figure 20: Estimated marginal mean difference (±SD) in sRPE – TL (AU) between ‘*mixed* 1’ (88.0 ± 4.1 EASA%) and ‘*mixed* 2’ (88.3 ± 4.1 EASA%) banded players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

Table 7: Estimated marginal means (± SD) micro-electromechanical systems (MEMS) device, associated effect sizes and values of significance of '*mixed* 1' (88.0 ± 4.1 EASA%) and '*mixed* 2' (88.3 ± 4.1 EASA%) academy soccer players, during a *mixed* 'bio banded' small-sided game format, across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

Key Performance Indicator	**17m x 17m**		**24m x 24m**		**29.5m x 29.5m**		**34m x 34m**	
	'Mixed 1'	***'Mixed 2'***	***'Mixed 1'***	***'Mixed 2'***	***'Mixed 1'***	***'Mixed 2'***	***'Mixed 1'***	***'Mixed 2'***
Total PlayerLoad (AU)	60.1 ± 9.56	56.5 ± 10.9	61.9 ± 12.5	61.4 ± 9.6	63.0 ± 9.3	62.7 ± 9.8	63.4 ± 12.6	58.4 ± 13.2
	ES = 0.35, *p* = 0.11		**ES = 0.05, *p* = 0.80**		**ES = 0.03, *p* = 0.87**		**ES = 0.39, *p* = 0.66**	
Meterage per Minute (m·min^{-1})	82.9 ± 9.8	77.7 ± 10.2	96.6 ± 13.14	96.1 ± 11.9	99.5 ± 11.0	101.9 ± 10.2	104.6 ± 14.9	98.8 ± 23.4
	ES = 0.52, *p* = 0.02		**ES = 0.04, *p* = 0.86**		**ES = 0.23, *p* = 0.27**		**ES = 0.30, *p* = 0.18**	
Mean Heart Rate. (b·min^{-1})	145.6 ± 26.3	157.4 ± 27.2	151.8 ± 31.4	161.2 ± 22.7	163.5 ± 22.3	161.2 ± 21.6	158.8 ± 19.9	160.6 ± 23.6
	ES = 0.44, *p* = 0.05		**ES = 0.34, *p* = 0.12**		**ES = 0.11, *p* = 0.63**		**ES = 0.08, *p* = 0.72**	
Low Speed Running Distance (m)	394.6 ± 42.4	374.7 ± 42.1	427.5 ± 51.6	424.8 ± 39.4	434.4 ± 39.3	442.4 ± 34.9	438.7 ± 41.0	409.4 ± 87.1
	ES = 0.47, *p* = 0.03		**ES = 0.06, *p* = 0.79**		**ES = 0.22, *p* = 0.31**		**ES = 0.44, *p* = 0.05**	
High Speed Running Distance (m)	17.8 ± 11.0	12.9 ± 11.1	39.9 ± 16.3	39.1 ± 18.3	40.3 ± 18.4	45.3 ± 18.5	50.6 ± 23.2	52.3 ± 24.6
	ES = 0.44, *p* = 0.04		**ES = 0.04, *p* = 0.85**		**ES = 0.27, *p* = 0.21**		**ES = 0.07, *p* = 0.75**	
Acceleration Efforts (*f*)	76.4 ± 5.9	77.7 ± 4.9	72.4 ± 5.2	74.4 ± 4.8	71.5 ± 4.6	70.7 ± 4.9	68.3 ± 5.9	66.9 ± 8.8
	ES = 0.24, *p* = 0.26		**ES = 0.39, *p* = 0.08**		**ES = 0.14, *p* = 0.48**		**ES = 0.19, *p* = 0.39**	
Deceleration Efforts (*f*)	81.2 ± 5.3	79.9 ± 5.3	78.2 ± 5.6	77.5 ± 4.5	74.2 ± 5.9	76.7 ± 4.9	74.8 ± 5.5	70.5 ± 10.9
	ES = 0.23, *p* = 0.29		**ES = 0.13, *p* = 0.55**		**ES = 0.44, *p* = 0.03**		**ES = 0.51, *p* = 0.02**	

Mean (± SD) values of key performance indicators for '*mixed* 1' (Mean ± SD = 88.04 ± 4.14 EASA%) and '*mixed* 2' (Mean ± SD = 88.27 ± 4.10 EASA%) maturing players across small (17 x 17 m^2), medium (24 x 24 m^2), large (29.5 x 29.5 m^2) and expansive (34 x 34 m^2) relative pitch sizes. Low Speed Running Distance (< 13.0 km·h^{-1}), High Speed Running Distance (> 13.1 - 16.0 km·h^{-1}), Acceleration Efforts Frequency (0 - 2 m·s^{-1}) and Deceleration Efforts Frequency (-2 - 0 m·s^{-1}).

4.4.3 Technical / Tactical Measures

Game Technical Scoring Chart (Figure 21) was reported to be significantly different for '*mixed* 1' banded players in comparison to '*mixed* 2' banded soccer players, across a medium (72 m^2) relative pitch size ($p \leq 0.05$; ES = 0.41, small), of which the coaches perceived and evidenced '*mixed* 2' banded players, to score greater than '*mixed* 1' banded players for the measures of passing, shooting and assist ($p = 0.02$ to 0.04; ES = 0.42 to 0.47, small).

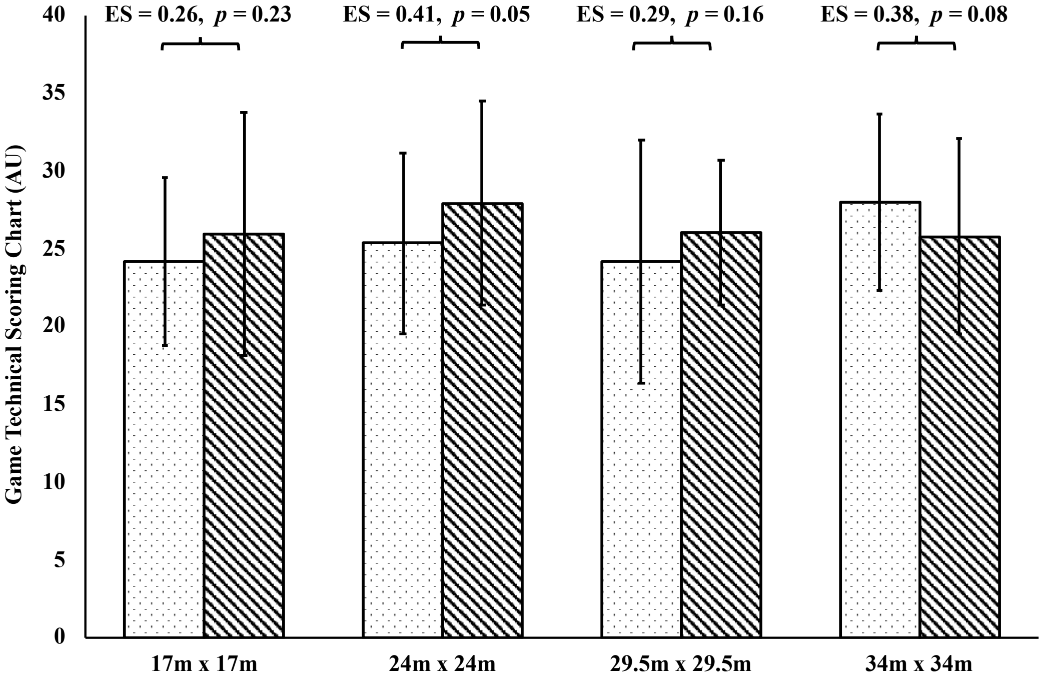

Figure 21: Estimated marginal mean difference (±SD) in Game Technical Scoring Chart (AU) result between '*mixed* 1' (88.0 ± 4.1 EASA%) and '*mixed* 2' (88.3 ± 4.1 EASA%) banded players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

A significant difference was reported for TTOTB '*mixed* 1' and '*mixed* 2' banded players across a large (109 m^2) relative pitch size ($p = 0.01$; ES = 0.59, moderate), however this is inconsistent with no significant difference reported over small (36 m^2), medium (72 m^2) and expansive (145 m^2) relative pitch sizes ($p = 0.11$ to 0.63; ES = 0.10

to 0.34, trivial to small). The relationships between GTSC (AU), TD (m), total points accumulated (AU) and HSD (m) for '*mixed* 1' and '*mixed* 2' banded players are presented within (Figure 22) (r = 0.50 to 0.85, strong).

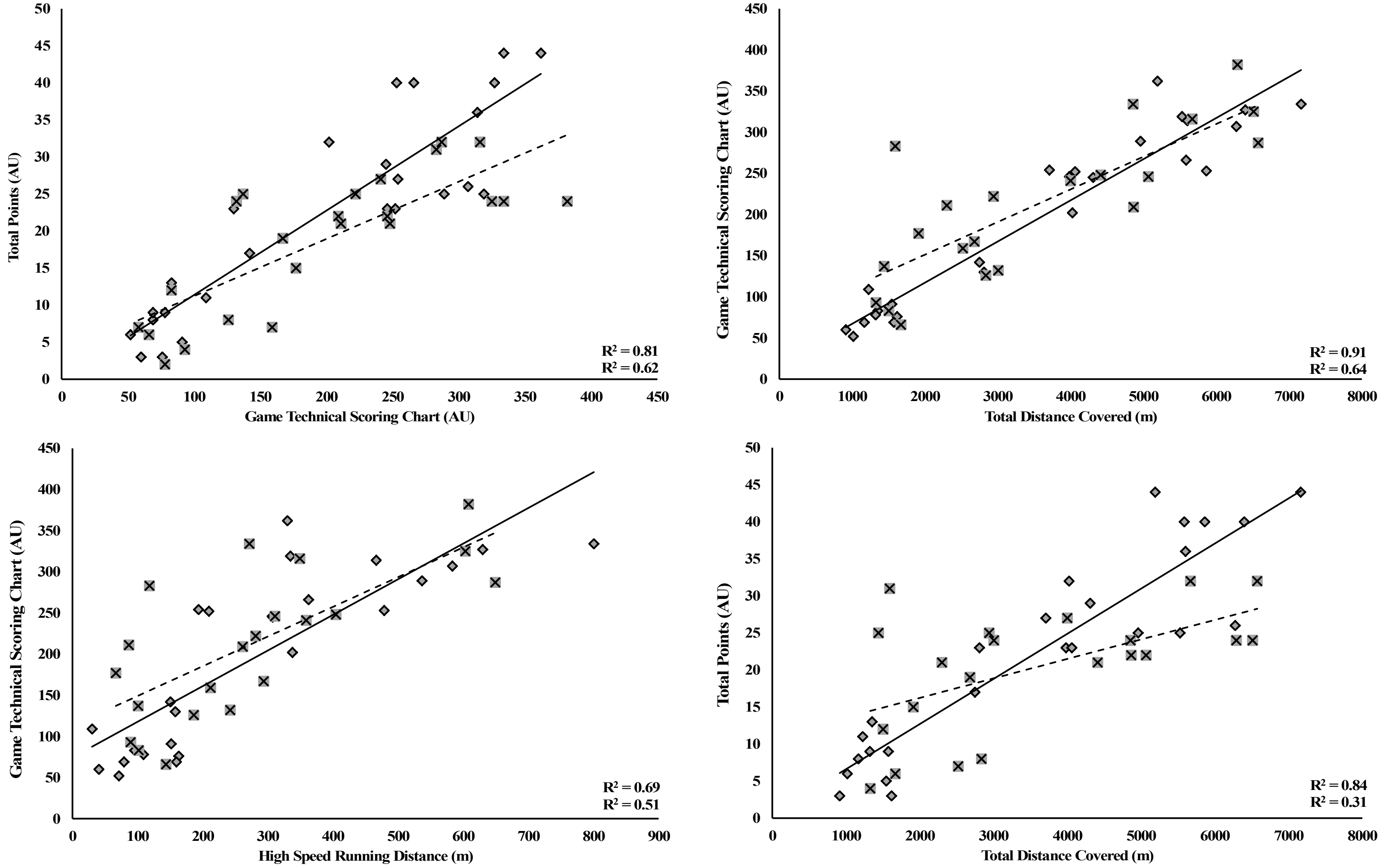

Figure 22: Relationships of ‘*mixed* 1’ (88.0 ± 4.1 EASA%) and ‘*mixed* 2’ (88.3 ± 4.1 EASA%) banded soccer players between Total Points (AU) and Game Technical Scoring Chart (AU), Game Technical Scoring Chart and Total Distance Covered (m), Game Technical Scoring Chart (AU) and High Speed Running Distance (m) and Total Points (AU) and Total Distance Covered (m) collated from estimated marginal means, across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes, during a *mixed* ‘bio banded’ small sided games format.

4.4.4 Psychological Measures

During a maturity mix matched ‘bio-banded’ SSG format, coaches perceived and evidenced a statistically significant difference in the game psycho-social scoring chart (Figure 23) across a medium (72 m^2) relative pitch size (p = 0.03, ES 0.48, small), demonstrating significant differences in behaviours of confidence and x-factor (p = 0.02, ES = 048 to 0.49, small), however such findings were inconsistent across medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes, demonstrating no significant difference (p = 0.24 to 0.46, ES 0.15 to 0.23, small).

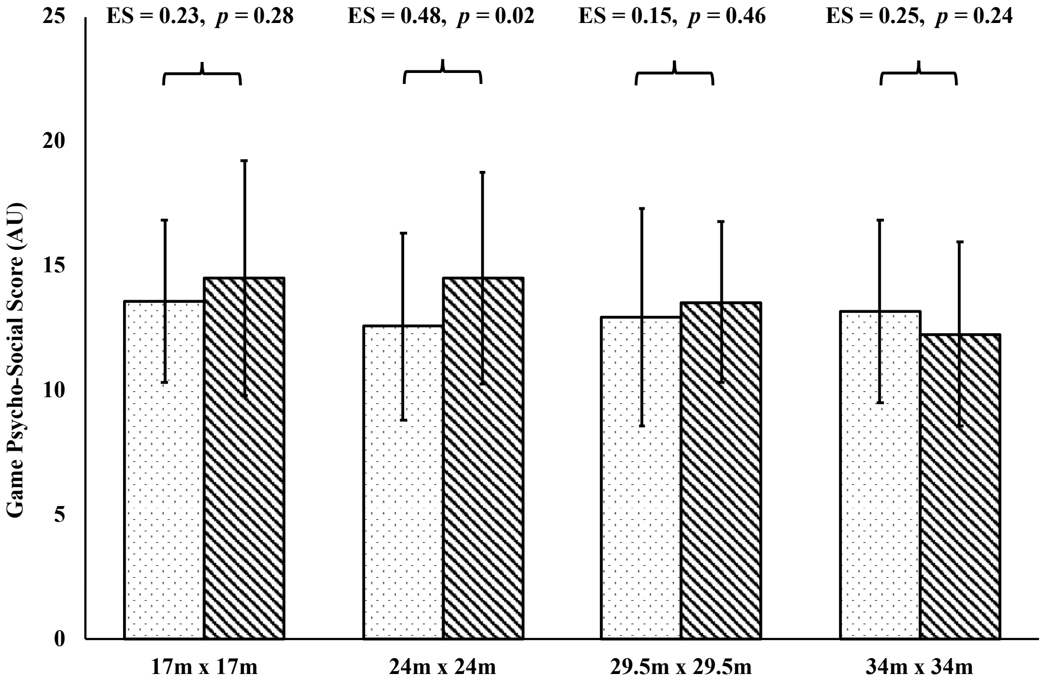

Figure 23: Estimated marginal mean difference (±SD) in Game Psycho-Social Score (AU) between ‘*mixed* 1’ (88.0 ± 4.1 EASA%) and ‘*mixed* 2’ (88.3 ± 4.1 EASA%) banded players across small (36 m^2), medium (72 m^2), large (109 m^2) and expansive (145 m^2) relative pitch sizes.

5.0 DISCUSSION

Previously disseminated research informs the influence of biological maturation and consequential maturity status on technical, tactical, physical and psychological characteristics and such indirect influence on the talent identification process of academy soccer players (Meylan et al., 2010; Unnithan et al., 2012). As such, the aim of the present study was to determine the effect of relative pitch size (a game constraint) during 'bio-banded' match play on the match play characteristics of young academy soccer players and such determine the efficacy of maturity status 'bio-banding' when applying a multidisciplinary approach to talent identification, disseminating evidence to support or refute such application. This was achieved by assessing, from a multidisciplinary perspective, the effect of relative pitch size on tactical, technical, psychological and physical performance variables associated with talent (de)selection of young soccer players during small-sided game (SSG) match play format, under mismatched, matched and mix-matched 'bio-banded' conditions. Analysis was conducted on a population of 11 to 14-year-old male academy players and attempted to identify differences between players who were banded of an '*post-PHV*' or '*pre-PHV*' maturity status. The results of the present study present the following key findings:

1. During a mismatched 'bio-banded' SSG match play, there was no apparent difference in the external loading between players of apposing maturational bandings, however, the results evidence a difference in the perception of internal and such physical experience between contrasting maturational bandings, across equitable match play conditions.
2. During a mismatched 'bio-banded' SSG match play format, there is a significant difference in the coach perception of technical, tactical characteristics and psycho-social performance, with players demonstrating a significant difference in total

time on the ball (TTOTB) and levels of confidence between contrasting maturational bandings, across equitable match play conditions.

3. Matched 'bio-banded' game constraints, reduces and attenuates the magnitude of difference in technical, tactical, psychological and physical performance variables of talent identification and (de)selection between teams of an equitable maturation status, affording the opportunity to demonstrate greater performance variables for respective maturational bandings, in comparison to a mismatched 'bio-banded' game constraints and currently adopted chronological age groupings.
4. An increase in relative pitch size is associated with greater physical performance characteristic, however, is deemed to have very little influence upon technical, tactical, and psychological characteristic. In addition, relative pitch size seems to be an independent construct of maturity status, in which the magnitude of difference between maturational bandings is not attenuated or extenuated through alternations in the playing area.

5.1 Maturity Mis-matched (i.e. '*pre-PHV*' vs '*post-PHV*') 'Bio-Banded' Conditions

The application of the Khamis and Roche (1994) anthropometric based maturity prediction equation, allowed to distinguish between biological maturity status and such anthropometric and physical characteristics, allowing to examine the influence of biological development on physical, technical, tactical and psychological attributes and such impact on the talent identification and (de)selection process. Such comparative difference in performance metrics between maturational bandings can be used as evidence to support or refute the application of maturity status 'bio-banding' in the identification of talented adolescent soccer players, in which some differences dissipate and performance in enhanced during maturity matched 'bio-banding'.

Physical characteristics

Results of the present study evidence a *trivial* to *small* increase in total distance covered (m) between '*post-PHV*' and '*pre-PHV*' banded players, however, such difference remains insignificant ($p > 0.05$), consistent with Buchheit and Mendez-Villanueva (2014), in which total distance (m) was indistinguishable between less (APHV: -0.3 ± 0.3 years) and more (APHV: 0.9 ± 0.4 years) mature players. In support no significant difference ($P > 0.05$) in total distance covered was reported between 'pre' (< 87.0% EASA), 'circa' (87.0 – 91.9% EASA) and 'post' (≥ 92.0% EASA) (Towlson et al., 2020). Of consideration, Abbott et al. (2019) reported '*pre-PHV*' developers produce significantly greater total distance when compared to '*post-PHV*' developers across overall formats ('bio-banded' and chronological age groupings), performed on standard full-sized pitch (100 x 64 m), reflecting a 290 m^2 relative pitch size, during an 11 Vs. 11 format. Such findings are inconsistent with the results of the present study; however it can be suggested that a substantial difference in match derived relative pitch size (290 m^2 Vs. 36 m^2, 72 m^2, 109 m^2 &145 m^2) and match play format, can account to an alternation in physical match play characteristics (Beenham et al., 2017; Olthof et al., 2018). From a constraints-based framework, it could be derived that for '*pre-PHV*' developers to maintain their competitiveness, there would be a requirement to produce a greater total distance. However, it can be suggested that '*post-PHV*' banded players, who are beneficiaries of transient, maturity related enhancements in anthropometrical and physical attributes, are likely to cover a greater distance at higher intensities (Buchheit et al., 2010). A point of consideration is that the tactical makeup of teams was not considered in the present study, with the understanding that '*post-PHV*' banded players characterise key defensive positions, due to affording enhanced anthropometrical and physical qualities and '*pre-PHV*' banded players characterising key attacking positions and therefore could have indirectly effected such polarisation of maturity bandings and reflected match activity profiles (Towlson et al., 2017).

No reported significant differences in the external load measure of the total distance between '*post-PHV*' and '*pre-PHV*' maturity bandings is consistent with no reported significant difference in the internal load measure of Total PlayerLoad^{TM}, across small, medium and large relative pitch sizes, which could be attributable to the *strong* association between total distance covered (m) and internal PlayerLoad^{TM} (Casamichana, Castellano, Calleja-Gonzalez, San Román, & Castagna, 2013; Towlson et al., 2020). Due to the ability of micromechanical electricals systems (MEMS) to accumulate external load across horizontal (X), vertical (Y) and anterior/posterior (Z) planes of motion, it is possible to derive and quantify the mechanical stress imposed on an athlete, with tri-axial accelerometry having the sensitivity to detect changes within an individual's movement mechanics. As such the present study demonstrated a significant difference ($p \leq 0.001$) in PlayerLoad^{TM} across an expansive relative pitch size, demonstrating a greater measure of PlayerLoad^{TM} 1D (Side) for '*pre-PHV*' banded players, precluding an influence of neuromuscular fatigue, accountable to the requirement of increased movement demands. It might be postulated that the greater measure of PlayerLoad^{TM} 1D (side) may a result of adolescent awkwardness (Malina, Eisenmann, et al., 2004; Philippaerts et al., 2006; Quatman-Yates et al., 2012). Such a phenomenon precludes that the extremities of the skeletal system undergo periods of accelerated growth, in advance of the associated musculature development, leading to a transient decline in movement mechanics and performance, attributable to the temporary disturbance in sensorimotor capacity (Ryan et al., 2018). A remarked reduction on functional movement quality of "*pre-PHV*" maturing players could contribute to an increase in the accumulated levels of lateral loading (PlayerLoad^{TM} 1D side) and subsequently present an enhanced risk to sustaining a non-contact or growth-related injury during SSG's (Barrett et al., 2016). Such information can be used to better inform the design of training stimuli, with consideration to maturational differences and subsequent athlete response to such training loads, in an attempt to reduce injury risk and allow for greater athlete development (Towlson et al., 2020).

Despite demonstrating no significant difference in the external measure of PlayerLoad^{TM}, '*pre-PHV*' banded players demonstrated significantly greater sRPE-TL, in comparison to '*post-PHV*' banded players, suggesting a disparate perception of the internal load and physical experience during a mismatched game constraint. Such findings are consistent with Towlson et al. (2020) in which player experience of physical loading was dependent upon their stage of maturational development, with '*pre'* PHV demonstrating an increased perception of physical loading, in comparison to '*post*' PHV players, which such differences independent of physical work completed. '*Later*' maturing players were evidenced to accumulate greater perceived sRPE-TL during maturity mismatched 'bio-banded' SSG's, despite demonstrating no reasonable difference in physiological exertion (e.g. heart rate) (Towlson et al., 2020).

Although *small* differences were apparent for mean heart rate between '*post-PHV*' and '*pre-PHV*' banded players, it can be suggested that '*pre-PHV*' banded players were unable to distinguish between the perception of physical, technical and psychological effort, in which it is suggested that the *small* to *large* increase in sRPE-TL, cannot be accountable to the central measure of breathlessness or lower extremity leg muscle exertion. Such suggestion can be made, that the difference in sRPE-TL is due to an increase in technical and cognitive demand, in which '*pre-PHV*' banded players have to adapt to a more extensive match play format, afforded by the transient enhancement in anthropometrical and physical qualities of '*post-PHV*' banded players. Despite biological maturation having a pertinent effect on such physical attributes, there is limited evidence to support the notion that, transient physical advantages, afforded by individual advanced in maturation, translate into improved locomotion and match activity profiles (Buchheit et al., 2010; Lovell et al., 2019), which provides ramification to suggest that the psychological makeup on an individual may have a more enduring effect.

As the present study aims to evaluate the influence of such factors on the efficacy of maturity status ‘bio-banding’, it is of importance to review the effect of relative pitch size on mismatched ‘bio-banded’ SSG match play, with comparison made to a maturity matched ‘bio-banded’ structure. The results of the present study demonstrate greater time motion analysis outcomes, aligned with an increase of relative pitch size in a youth soccer population, inclusive of greater measures for total distance, low speed and high-speed running distance, meterage per minute and total PlayerLoad^{TM} consistent with previously demonstrated research (Casamichana & Castellano, 2010; Owen et al., 2004; Rampinini, Impellizzeri, et al., 2007). However, it should be considered that the magnitude and significance of difference in physical performance indicators, remains largely unaffected by an increase in relative pitch size. As such, it can be postulated that a maturity mismatch ‘bio-banded’ intervention, is not advocated for the purpose of talent identification, due to the apparent magnitude of difference in physical characteristics. Such differences observed during maturity mismatched ‘bio-banding’, refute the underlying fundamentals of ‘bio-banding’ principles, in which performance characteristics are attenuated, creating a match play situation, representative of equitable performance characteristics, leading to the suggestion that maturity matched ‘bio-banding’ SSG’s to be a more appropriate application.

It was be expected that the magnitude of difference in key performance indicators between maturational bandings, would be accentuated with an increase in relative pitch size, with the transient maturity related enhancements in anthropometrical and physical characteristics becoming more pronounced. Such statement is in line with da Silva et al. (2011), in which biological maturation had no reported correlation with exercise intensity, technical or tactical performance, despite advocating the appropriate application of

SSG’S as an adequate tool for talent identification in a population of youth soccer players with heterogenous maturation levels. As such, we can refute the hypothesis of the present study, which suggested that an increase in relative pitch size, would promote an alteration in physical and technical demands, reflecting a greater level of competency and as such supplementing the talent identification process. In addition, we can suggest that the manipulation of player numbers, maybe a more appropriate alteration, in order to pronounce superior movement demands and proficiency, technical and tactical qualities, thus evidencing the talent identification process.

Technical and Tactical characteristics

Published literature in reference to the effect of biological maturation on technical and tactical performance, suggests technical performance is predominantly influenced by advantages in functional and physiological characteristics, associated with advanced maturity, despite inconsistent reports of technical skills between disparate maturational banding (Cripps et al., 2016; Saward et al., 2019). However, it is suggested that despite the minimal difference in technical and tactical performance between maturity bandings, there are sizable discrepancies in coach perception favourable to the biologically advance (Cripps et al., 2016). The present study reports *small* to *moderate* differences in game technical scoring chart between maturity bandings, significant across a medium relative pitch size, in favour of ‘*post-PHV*’ banded players during maturity mismatched ‘bio-banded’ SSG match play. Such reported difference does not promote the efficacy of maturity mis-matched ‘bio-banding’ for the purpose of talent identification, due to apparent difference in technical competence, which could afford the exclusion of '‘*later*’ banded players. The results of the present study demonstrate an improved competence for technical behaviours of ball control, passing and receiving, apparent over a medium relative pitch size, however such difference could be influenced by the respective relative pitch size and the increase in ball involvement and technical demand, afforded by the nature of play associated with a reduction in space and time on the ball, in comparison to a more expansive relative pitch size (Ometto et al., 2018).

It could be suggested that an increase in relative pitch size affords an increased opportunity for players to express creative behaviours, afforded by an increase in space, time on the ball and opportunity to 'attack' the opposition in 1 Vs. 1 and dribbling scenarios (Silva et al., 2014). As such, it would be expected than an increase in relative pitch size, would reflect an increase in coach perception of technical ability, due to the afforded increase in player dispersion and subsequent increase in TTOTB to demonstrate technical competence (Olthof et al., 2018). However, the results of the present study, demonstrate negligible changes in GTSC as relative pitch size increases, which could be associated to the negligible differences in TTOTB between relative pitch sizes, in the present study.

Despite such considerations, the results of the present study demonstrate GTSC to be superior for '*post-PHV*' banded players, consistent across small, medium, large, and expansive relative pitch sizes, demonstrating *small* to *moderate* effect sizes. Such difference may be accountable to significantly ($p \leq 0.001$ to 0.016) greater total time on the ball for '*post-PHV*' banded players, in comparison to '*pre-PHV*' banded players. Such evidence is supported by greater levels of ball possession (63.6 ± 7.9 Vs. 36.4 ± 7.9 %) for '*post-PHV*' banded soccer players, across a mismatched 'bio-banded' match play format. Such differences can suggest that '*post-PHV*' banded players have a greater platform in which to demonstrate such technical and tactical ability, influencing the GTSC, providing an accurate representation of respective skill and ability. However, it could also suggest that '*late*r' banded players are not afforded the opportunity and consequential time on the ball, in which to demonstrate such technical and tactical skill, suggesting the GTSC underrepresents such abilities. From a talent identification perspective, a maturity mismatch 'bio-banded' SSG, ill affords '*pre-PHV*' maturing players the opportunity to demonstrate their technical and tactical competence, thus increasing the likelihood that such players are overlooked and/or deselected from academy structures (Cumming et al., 2017).

In an attempt to further supplement the talent identification process during maturity status 'bio-banded' SSG's when using a multidisciplinary approach to talent identification and (de)selection, the present study adopted the protocol of Fenner et al. (2016), in which aggregated points accrued over the SSG format were correlated with key physical performance indicators. The results demonstrate a greater correlation between GTSC (AU) and total points accumulated for '*post-PHV*' banded (r^2 = 0.88) in comparison to '*pre-PHV*' banded (r^2 = 0.30) soccer players suggesting coach perception of talent is influenced by match outcome during a mismatched 'bio-banded' SGG format. Such results also suggested that SGG's, indicative of a high number of technical involvements, are able to discriminate between talent and less talented players, a constant determination between elite and non-elite players (Fenner et al., 2016; Meylan et al., 2010). Associated with an elevated perception of technical and tactical competence, such a trend between GTSC and total points accumulated, suggests that '*post-PHV*' banded players have developed the ability to win, regardless of team combination, eluding to the influence of cognitive and social factors. It can be suggested that from a talent identification perspective, the most talented players, can be identified from the dependent constructs of total points accumulated. Such notion is supported by the results of the present study, in which '*post-PHV'* banded players demonstrated a significant increase in GTSC, in comparison to '*pre-PHV'* banded players. However, evaluation of match outcome as an independent factor for the purpose of talent identification, doesn't allow to differentiate between what made the '*earlier*' banded players more successful, in comparison to the '*pre-PHV*' banded players, when success is deemed to be the result of a multitude of interacting factors (Unnithan et al., 2012), thus the requirement to examine a multitude of physiological, time motion analysis and technical characteristics (Fenner et al., 2016).

Results of the present study demonstrate *moderate* ($r^2 = 0.68$) and *strong* ($r^2 = 0.81$) relationships between GTSC and total distance covered for '*post-PHV*' and '*pre-PHV*' banded players respectively, using a mismatched 'bio-banded' SSG match constraint, across small, medium, large and expansive relative pitch sizes. Such results illustrate that the more technically and tactically adept players cover a greater distance, a metric in which coaches, consciously or unconsciously consider when identifying the potential of players to progress through an academy structure (Fenner et al., 2016). Despite being aligned with previous literature, in which total distance covered is a possible determinant of talent identification and (de)selection (Fenner et al., 2016; Goto et al., 2015; Mohr, Krustrup, & Bangsbo, 2003), the results of the present study presume total distance covered, not to be a differentiating factor between maturational bandings and such performance measures. A similar trend was reported for the relationships between GTSC and high-speed running distance cover in which '*post-PHV* ($r^2 = 0.57$) and '*pre-PHV*' ($r^2 = 0.66$) banded players both demonstrated a *moderate* relationship, suggesting that holistically, players who demonstrate greater high-speed movement demands, exhibiting increase technical skill. Again, such relationships fail to distinguish any differentiating factor between maturational bandings and consequential effect upon talent identification and (de)selection. However, any such difference may be accountable to the time spent within the speed zone of 0.0 to 1.5 $m{\cdot}s^{-1}$, with more technically adept players having the ability to recover quickly from bouts of high intensity activity (Goto et al., 2015).

Previous literature has suggested that players in advance of maturation may be advantaged in talent identification (Cumming et al., 2017), however, such results suggested that technical skill level and not physical attributes may be the determining factor for distinguishing between maturational bandings during talent identification and (de)selection (Fenner et al., 2016). In addition to the technical competence to talent identification, it is also of importance to evaluate the psychological contribution and such influence of difference between maturational bandings, during the talent identification process, in which recent evidence suggests psychological factors are perceived to be of higher importance than sociological, technical/tactical and physical factors (Larkin & O'Connor, 2017a; Toering et al., 2012).

Psychological characteristics

Previous disseminated literature contents that '*later*' maturing players must demonstrate and developed superior technical, tactical and psychological skill, in order to be competitive and retain within a long term youth athletic development program, in which an increase physiological demand is thought to necessitate such development, through increased engagement in self-regulation (Cumming, Searle, et al., 2018). Inconsistent with the results of the present study, '*post-PHV*' banded players demonstrated a reduction in game psycho-social score, evidencing greater levels of confidence, positive attitude, and competitiveness across respective relative pitch sizes, in comparison to '*pre-PHV*' banded players during a mismatched 'bio-banded' SSG format. It can be argued of the inability of the game psycho-social scoring chart, to evaluate and postulate levels of adaptive self-regulation, in which the football specific self-regulated learning questionnaire (FSSRLQ) could have been a more appropriate measure, as validated by Toering et al. (2012).

As such, the results of the present refute the recommendation to use a mismatched 'bio-banded' SSG match play format, as a method of talent identification and (de)selection, affordable to the diversity of and magnitude of difference between maturity bandings. However, such results do advocate the application of a multi-disciplinary approach to talent identification and (de)selection, as the magnitude of difference in key performance indicators (physical, technical/tactical or psychological) between maturity bandings can range from having a *trivial* to *large* influence on performance.

5.2 Maturity Matched 'Bio-Banded' Conditions ('*Post-PHV*' v '*Post-PHV*')

The results of the present study demonstrate a reduction in the magnitude of difference for physical, tactical, technical, and psychological behaviours between players of a comparable maturation status during matched 'bio-banded' SGG match play. An insignificant difference was reported for the measures of total distance, total PlayerLoad^{TM}, high-speed running distance, and sRPE – Training Load between '*post-PHV* 1' and '*post-PHV* 2' banded players during matched 'bio-banded' match play, consistent across the respective relative pitch sizes. Such reduction in the magnitude of difference for the respective performance metrics demonstrates the efficacy of maturity matched 'bio-banding', promoting equal opportunity, in the identification of talented youth soccer players.

The results of the present study also demonstrate greater total distances covered, high-speed running distance, total PlayerLoad^{TM,} and sRPE – Training Load for '*post-PHV*' banded players during a match 'bio-banded' game constraint, in comparison to a mismatched 'bio-banded' game constraint, consistent across small, medium, large and expensive relative pitch sizes. Greater movement demands for '*post-PHV'* banded players, supports the efficacy of maturity matched 'bio-banding, providing a unique physiological demand and opportunity to evidence such physical competence, for the purpose of talent identification. Such increase in the key performance indicators of physical performance highlights an increased perception of physical activity and movement demands when competing against those on an equitable maturity status

(Abbott et al., 2019). It can be suggested that a matched 'bio-banded' constraint provides a superior physical challenge and learning stimulus, increasing the demand of and emphasis upon technical and tactical competence (Cumming, Brown, et al., 2018). Such demands are deemed essential for athlete development, providing exposure to a diverse learning experience, presenting the challenges traditionally encountered by those in a delay of maturation, which prepares athletes for when the transient maturity associated enhancements in anthropometrical and physiological attributes are attenuated, reflective of elite level, adulthood soccer (Cumming, Brown, et al., 2018). It is of importance to highlight the reduced dominance and physical advantage of '*post-PHV*' maturing players, which promotes technical and tactical development, aligned with the principles of long-term athlete development, creating proficiency across a holistic spectrum of skills and attributes (Romann et al., 2020). From a talent identification perspective, the attenuation in physical dominance promotes the exposure of technical and tactical competence, and such better informs the respective process (Romann et al., 2020).

Results demonstrate a consistency with previously disseminated literature in which an increase in relative pitch size, was associated with an increase in total distance covered, across an SSG match play format (Casamichana & Castellano, 2010; Hodgson et al., 2014; Pantelić et al., 2019). It should be considered that an increase in relative pitch size does not always represent an increase in movement demands, with the suggestion than such increase causes a reduction on 'off the ball' movement, due to a reduction in the requirement to create space (Silva et al., 2014). Total distance covered was shown not to increase across an expansive relative pitch size, which suggests there to be no physiological benefit for the application of such pitch size. It is suggested that a large relative pitch size, induces the greatest physiological demand, without a consequential reduction in the frequency of technical actions and ball involvement, deeming its practical application for both talent identification, (de)selection and long-term athletic development.

Consistent with an insignificant difference in key performance indicators of physical performance, there was no reported difference in GTSC and TTOB between '*post-PHV* 1' and '*post-PHV* 2' banded players, during matched 'bio-banded' SSG match play. In addition, results demonstrated a *small* reduction in GTSC for '*post-PHV*' banded players during matched, in comparison to a mismatched 'bio-banded' game constraint. Such results highlight the discrepancies in technical and tactical performance, which are often overlooked when coaches are evidencing technical performance across a mismatched 'bio-banded' constraint. No reported significant difference in GTSC supports the efficacy of maturity matched 'bio-banded' SSG match play, with the suggestion that such match play, better challenges the technical and tactical competence of competing teams (Romann et al., 2020). It can be suggested that the perception of technical ability for '*post-PHV*' maturing players will be transiently reduced, due to an alteration in playing style, afforded by the attenuation of physical and anthropometrical characteristics, the option to play a more expansive style, in which longer passes and hold up play is removed, along with the inability to dribble around less physically mature opponents, however, such alternation may provide additional opportunities for skill acquisition in the long run (Abbott et al., 2018; Romann et al., 2020). As such, it would be expected that '*post-PHV*' banded players exploit a shorter style of football, synonymous with greater pass frequency, which would be expected to be perceived as technically advanced (Abbott et al., 2019; Cumming, Brown, et al., 2018). Such expectation would be consistent with Romann et al. (2020) in which 'bio-banding' resulted in quicker ball movement and change of match play situations. Such alteration of the frequency of technical alternations demonstrates the manipulation of technical performance, proficient of important technical skill parameters for success at top level professional soccer (E. Rampinini, Impellizzeri, Castagna, Coutts, & Wisløff, 2009). Such manipulation of technical competence advocates the use of a maturity matched 'bio-banded' SSG format, for the purpose of talent identification.

It should be noted, that during a matched 'bio-banded' game constraint, '*post-PHV*' banded players experienced a reduction in TTOB, in comparison to a mismatched 'bio-banded' game constraint, consistent with Romann et al. (2020) in which the mean time in ball possession per action was reduced and a trend towards a lower difference in ball possession between 'bio-banded' teams was apparent. Such results suggest a quicker change in match play situations between 'bio-banded' teams (Romann et al., 2020), it is also plausible to suggest there to be a reduction in the opportunity for players to express technical/tactical abilities, which could influence coach perception and consequential GTSC results. In support of the attenuation of anthropometrical and physiological characteristics, '*post-PHV*' banded players demonstrated a greater average ball regain time, which supports the notions of a superior physical challenge and refutes the notion of physical dominance (Cumming, Searle, et al., 2018). Supported by an increase in the number of duels, it can be suggested that the 'bio-banding' of *post-PHV* maturing players provided a physically equitable level of competition, in which an increase in set pieces situations, represent the inability to use physical dominance over the opposition, supporting the notion of a more technically and tactically demanding match play style (Romann et al., 2020). The attenuation of such anthropometrical and physiological characteristics provided an equitable platform in which to evaluate technical/tactical performance and such advocates the efficacy of a maturity matched 'bio-banded' SSG format, for the purpose of talent identification.

In reference to game constraints, it can be argued that an increase in relative pitch size had a negligible effect upon technical performance during a matched 'bio-banded' SSG game constraint, as referenced by the GTSC. Such statement is consistent with Owen et al. (2004), in which it was concluded that technical demands are more influenced by an alteration in the number of players, with relative pitch size, having a greater influence upon physiological and movement demands. Such manipulations should be considered when trying to determine the requirements of technical and physical outcomes of athlete development and identification.

Results of the present study demonstrate a *strong* correlation (r^2 = 0.9 to 0.92) between GTSC and total points accumulated, for both '*post-PHV*' maturing teams respectively. Such results demonstrate, that when anthropometrical and physiological characteristics are homogeneous between competing teams, a competitive multiple SSG model, inducive of a high number of technical actions, is able to discriminate between the technically adept and inept players on performance outcome alone, providing an appropriate and adequate tool for talent identification and (de)selection (Fenner et al., 2016). High-speed running distance is suggested to be the differentiating factor between the technically adept and inept, with results demonstrating a *strong* (r^2 = 0.63 to 0.79) relationships between high-speed running distance and GTSC (Fenner et al., 2016). Increased demand of high-speed movement, can suggest the technically adept players, endeavour to adopt a shorter style of play, indicative of greater ball involvement and short pass completion, in which there is a greater requirement to create space, through high intensity activity (E. Rampinini et al., 2009).

Despite reporting an insignificant difference in total distance covered between '*post-PHV* 1' and '*early*2' banded players within the present study, evident differences are apparent between such bandings for the relationships between total distance covered and GTSC / total points accumulated, respectively. '*Post-PHV* 1' banded players demonstrated a *strong* (r^2 = 0.97 to 0.92) relationships between the apparent metrics, whilst '*post-PHV* 2' banded players, demonstrated *weak* to *moderate* (r^2 = 0.40 to 0.51) correlations for equitable relationships. Buchheit and Mendez-Villanueva (2014) reported biological maturity status to have a negligible effect on total distance covered, in which the restricted variance in anthropometrical and physiological variance, produced an insignificant difference in total difference covered between maturation bandings. However, Fenner et al. (2016) reported that more talented players covered a greater distance than their peers, having the ability to distinguish between standards of soccer players, but the results of the present study, also demonstrated an insignificant difference in GTSC between matched bandings. Such results suggest of a unknown confounding variable, that is attributable to the difference in relationships between GTSC, total points accumulated, and total distance covered within a specific maturational banding.

Results of the present study demonstrate an insignificant difference in game psycho-social score between '*post-PHV* 1' and '*post-PHV* 2' banded players, with '*post-PHV*' banded players demonstrating a slight reduction in the magnitude of difference between maturity matched 'bio-banded' competition, in comparison to a mismatched 'bio-banded' game constraint, specifically presenting a reduction in levels of confidence and positive attitude, associated with an increase in x-factor. This could be attributable to an increased reliance on technical and tactical characteristics, afforded by the inability to rely on trainset maturity related enhancements in anthropometrical and physiological characteristics, that would be apparent is mismatched 'bio-banding' and chronological age groupings. It can be suggested that such reliance on technical and tactical skill is supported by an increased x-factor, as players endeavour to demonstrate an adept level of technical ability. Such results are consistent in providing '*post-PHV*' banded players with a more diverse learning environment, inclusive of a greater emphasise of technical and tactical ability over physicality, whilst stimulating the psychological challenge of perceiving the game in a different manner, in which players may be forced to adapt decision making (Cumming, Brown, et al., 2018).

In reference to the participation of '*post-PHV*' maturity soccer players in a maturity matched 'bio-banded' SSG match play constraint, it can be concluded, that there is a reduction in the magnitude of difference and dominance of anthropometrical and physical afforded physical advantage, which precludes an increased demand on technical and tactical development (Romann et al., 2020). Such strategies enable coaches to better account for individual differences in maturational and physical characteristics, for the purpose of talent identification and (de)selection, advocating the efficacy of such application (Cumming et al., 2017).

5.3 Maturity Matched 'Bio-Banded' Conditions ('*Pre-PHV*' v '*Pre-PHV*')

As per an '*post-PHV*' maturing matched 'bio-banded' SSG constraint, the results of a '*pre-PHV*' maturing matched 'bio-banded' constraint demonstrate a reduction in the magnitude of difference between players of an equitable maturation status, during SGG match play. As such, the results of the present study demonstrated an insignificant difference for the measures of total distance covered, total PlayerLoad^{TM}, high-speed running distance and sRPE – TL consistent across small, medium, large and expansive relative pitch sizes. Such results again support the efficacy of a maturity matched 'bio-banded' game constraint, for the purpose of talent identification and (de)selection for '*pre-PHV'* banded players.

The results of the present study demonstrate greater total distances covered and high-speed running distance, whilst demonstrating a reduction in sRPE – TL despite minimal change in total PlayerLoad^{TM}, for '*pre-PHV*' banded players during a maturity matched 'bio-banded' game constraints, in comparison to a mismatched 'bio-banded' game constraint. Greater total distances covered and high-speed running distance could be attributable to a learned response, induced by the previous task constraints and demands, imposed on by '*post-PHV*' developing players, during chronological age groupings, in which '*pre-PHV*' maturing players are required to produce a higher workload, in order to remain competitive within the competition structure, suggesting an innate response of physiological requirements (Abbott et al., 2019). Such results of total distance covered are consistent with previously disseminated literature in which an increase in relative pitch size was associated with an increase in total distance covered (Casamichana & Castellano, 2010; Owen et al., 2004; Pantelić et al., 2019). From the perspective of physical competence, the results of the present study demonstrate the efficacy of maturity matched 'bio-banded' match play, for the purpose of talent identification.

Gilogley (2015b) demonstrated a significant interaction between relative pitch size with the requirement of a greater physiological and time motion demand, however, such results are not aligned with a reduction in sRPE in the present study. It can be suggested that a reduction in sRPE – TL is accountable to the perception of a less physically challenging competition environment, due to the attenuation of anthropometrical and physiological characterises (Abbott et al., 2019; Cumming, Brown, et al., 2018). The attenuation of any physical dominance promotes a greater opportunity for '*pre-PHV*' banded players to utilise, demonstrate and develop technical attributes, supported by an increase in match and ball involvement (Romann et al., 2020). The results of the present study are supported by Abbott et al. (2019) in which 'bio-banded' competition saw a reduction in the number of long passes attempt and an increase in the number of tackles, accountable to a reduction in the physical dominance and relative strength of opposing players, supporting the notion to promote technical competence and thus advocating the efficacy of maturity matched 'bio-banded' SSG match play. However, it can be suggested that such interventions should only serve as an adjunct to chronological age groupings or a mismatched 'bio-banded' game constraint, in order to expose '*pre-PHV*' banded playing to a physically challenging environment, reflective of elite level adulthood soccer, with the idea of a holistic long term athlete development plan (Cumming, Brown, et al., 2018; Cumming et al., 2017; Romann et al., 2020). It was summated by Cumming, Brown, et al. (2018) that maturity matched 'bio-banded' games encourage a more technically and tactically oriented game, which is aligned with the EPPP and the development of technically excellent players who are tactically astute, equipped for a career as a professional footballer (Premier League, 2011).

The attenuation of physical dominance and greater opportunity to utilise, demonstrate and develop technical and tactical attributes is supported by greater GTSC and TTOB for '*pre-PHV*' banded players during a maturity matched 'bio-banded' game constraint, in comparison to a maturity mismatched 'bio-banded' game constraint. Game Technical Scoring Chart and TTOB were also reported to be insignificantly different between '*pre-PHV* 1' and '*pre-PHV* 2' banded teams, during a matched 'bio-banded' game constraint. Such evidence can suggest that '*pre-PHV*' maturing players are technically adept, however chronological age groupings, does not afford them the opportunity to demonstrate such abilities, due to the physical dominance of '*post-PHV*' banded players (Abbott et al., 2019; Cumming, Brown, et al., 2018). Silva et al. (2014) suggested an increase in relative pitch size to be associated with an increase in TTOB, consistent for '*pre-PHV*' banded players within the present study. Such greater TTOB supports the notion that a maturity matched 'bio-banded' game constraint, affords '*pre-PHV*' maturing players an increased level of match involvement, deemed beneficial for both long term athletic development, talent identification, and (de)selection (Romann et al., 2020). When an evaluation is made against the two game constraints, it can be suggested that coach perception of technical and tactical ability, is heavily influenced by physical characteristics, as when physical dominance is attenuated during matched 'bio-banded' constraints, '*pre-PHV*' maturing players are perceived as technically advanced, in comparison to their '*post-PHV*' maturing counterparts (Fenner et al., 2016). The results of the present study demonstrate that those teams who demonstrate greater TTOB, demonstrate a higher score for the GTSC, which across an increased relative pitch size affords the opportunity for players to express creative behaviours. In short, it can be suggested that a maturity matched 'bio-banded' game constraints promotes an environment that might aid in the technical and tactical identification and development of '*pre-PHV*' banded players, afforded by greater match play involvement (Romann et al., 2020).

Greater match play involvement was reported to be associated with an increase in the exertion of influence on the game, with '*pre-PHV*' maturing players adopting positions of leadership, which precludes there to be a psychological benefit of maturity matched 'bio-banded' game constraints (Cumming, Brown, et al., 2018). Results of the present study demonstrate insignificant differences between '*pre-PHV* 1' and '*pre-PHV* 2' banded players for measures of game psycho-social score, with '*pre-PHV*' maturing players demonstrating greater psychological performance within a maturity matched 'bio-banded' game constraint, in comparison to a maturity mismatched 'bio-banded' game constraint. The requirement of desired psychological related characteristics have been deemed an important requisite for talent identification and (de)selection, adopting a multidisciplinary approach to talent identification that regards psychological as an equal with physical and technical/tactical components of performance (Christensen, 2009; Reilly et al., 2000). Greater levels of confidence, game psycho-social score and composure on the ball, could be attributed to a reduction in the perception of injury, as a consequence in the attenuation of physical dominance (Bradley et al., 2019).

In refute of maturity matched 'bio-banding' from a psychological perspective, it could be suggested an increase in psycho-social competence, as reported by the present study could lead to a greater expectance and pressure to succeed when competing against those of an equitable maturity status, an expectance than is not present when competing within chronological age groupings, in which such expectations could induce a stress responses detrimental to performance (Cumming, Brown, et al., 2018). Previously disseminated literature reports '*pre-PHV*' maturing players to possess a psychological advantage as evidenced in greater self-regulation, which supports the notion of an 'underdog' hypothesis (Cumming, Searle, et al., 2018), however, the results of the present study are inconsistent with such findings, however, it could be considered that such characterises can only be practically evaluated, during the relevant game constraint.

5.4 '*Mixed*' Conditions

The maturity '*mixed*' match play between randomly assorted biological maturity squads, acted as a control within the present study, to simulate current chronological age groupings within soccer and the current '*mixed*' maturity setup. The results of the present study present limited significant differences in the key performance indicators of physical, technical, and psychological performance between '*mixed* 1' and '*mixed* 2' maturity banded teams, however, such differences are exclusive and do not represent any trends within the data. The results of the present study demonstrate a significant difference in the total distance covered across a small relative pitch size, between '*mixed* 1' and '*mixed* 2' maturity banded teams. As a consequent of spatial constraints, with a reduced relative pitch size, reflecting a 'short' style of play, indicative of an increased frequency of high velocity movements and changes of direction, with the requirement to 'make space', it could be suggested that a reduction in anthropometrical stature (cm) for '*mixed 1*' players, in comparison to '*mixed 2*' players was an attributing factor, in which shorter players may perform better for high velocity movement demands (Vardakis, Mikikis, & Metaxas, 2019). This statement is supported by a reported significant increase in high-speed running distance covered by '*mixed 1*' banded players, across a small relative pitch size. As such, when relative pitch size was increased, such difference in total distance covered was attenuated, suggesting an exposure to equitable movement and physical demands.

However, despite such exposure, ‘*mixed 2*’ banded players demonstrated an increase in the perception of such physical experience, demonstrating an increase in sRPE – TL, consistent across small and medium relative pitch sizes. Due to ‘*mixed 2*’ banded players demonstrating a reduction in movement and physical demands, it can be suggested that an increase in sRPE- TL, is accountable to an increase in psychological and cognitive demand. Despite insignificance, ‘*mixed 2*’ banded players were shown to be lighter (kg) than ‘*mixed 1*’ banded players, which could suggest an inability to compete physically, forcing an increased reliance on technical and tactical characteristics and such increase the cognitive demand of such tasks (Abbott et al., 2019). Such difference in sRPE – TL, is only apparent across small and medium relative pitch sizes, which are associated with an increase in technical and tactical competence, which supports the notion of an increase in cognitive demand (Silva et al., 2014).

‘*Mixed 2’* banded players evidenced a greater technical and tactical competence across a medium relative pitch size, specifically with an increased competence of passing, assist, and shooting characteristics. An increase in passing competence can be related back to an increase in cognitive demand, due to the reliance on technical and tactical competence, due to anthropometrical and physical incompetence. From a psychological perspective, ‘*mixed 2*’ banded players evidenced an increase in game psycho-social score, in comparison to ‘*mixed 1*’ banded players across a medium relative pitch size. ‘*Mixed 2*’ banded players demonstrated an increase in stature over ‘*mixed 1*’ banded players, which could develop a persona of a perceived anthropometrical advantage, which internally develops a sense of confidence, evidenced by the coaches. In short, it can be suggested that on a whole, maturity ‘*mixed*’ match play suppress any difference in key performance indicators, due to the blend of maturity status within each team and the confirmation of such performance values, refuting such efficacy for the purpose of talent identification and (de)selection.

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

1. An increase in relative pitch size will accentuate the difference in tactical, technical, psychological, and physical measures between '*post-PHV*' and '*pre-PHV*' maturing academy soccer players during SSG match play.

Rejected – The magnitude of difference in technical, tactical, psychological, and physical measure remains relatively consistent between 'post-PHV' and 'pre-PHV' banded academy soccer players during SSG match play. Results of the present study demonstrate an increase in physical movement demands and loading as relative pitch size increases, however, there is not so influence upon technical, tactical, and psychological demand.

2. A maturity mismatched ('*post-PHV*' Vs. '*pre-PHV*') 'bio-banded' SSG game constraint will extenuate the magnitude of difference in tactical, technical, psychological, and physical measures between young academy soccer players, during SSG match play.

   Partially accepted – Physical movement demands are not significantly different between mismatched maturity banded groups; however, the perception of the physical experience was deemed to be different, technical and tactical ability is not significantly different, however, there is a persistent difference for total time on the ball between maturity bandings. Significant psychological and sociological variance exists between maturity banded groups.

3. Maturity matched ('*post-PHV*' Vs. '*post-PHV*' & '*pre-PHV*' Vs. '*pre-PHV'*) 'bio-banded' match play between matched maturational groups will reduce the magnitude of difference in technical, tactical, psychological and physical measures between players during SSG match play.

Accepted – A maturity matched 'bio-banded' SSG format reduces the magnitude of difference between the opposition of an equitable maturity status. More biologically developed players demonstrated an increase in physical movement demands but a reduction in technical/tactical and psychological profiling. Less biologically developed players demonstrated an increase in physical movement demands, technical/tactical profiling, and psychological and sociological characteristics. Such evidence supports the efficacy of a maturity matched 'bio-banded' SSG game constraint, for the purpose of talent identification and (de)selection.

5.5 Limitations

Although predictive maturity equations have proven to be practical in the inexpensive, time efficient, and valid application, research has recognised and questioned the longitudinal accuracy of such somatic maturity estimation equations (Deprez, Fransen, Boone, et al., 2015). Derived from decimal age and somatic characteristics, and mid parental height, a measurement error of 2.2 cm was reported between actual and estimated adult stature in male athletes aged between 4 and 18 years, reflective of the current study population (Cumming, Brown, et al., 2018). Parr et al. (2020) reported that despite the improved statistical performance of the Khamis and Roche (1994) predictive maturity equation, there is an increasing demand for information input and as such may provide issues in relation to input data reliability and calculation complexity. It is also important to consider, that such predictive maturity equations, may not be reflective of and applicable to the ethnically diverse makeup of high level soccer academies (Parr et al., 2020). It could be argued that the Khamis and Roche (1994) predictive maturity equation is further limited by demonstrating PHV velocity to occur within a range of 85 to 96% of EASA, which could attribute to the incorrect assignment of maturity bandings, for individuals encompassing banding thresholds (Parr et al., 2020).

A significant contribution to the systematic error of the Khamis and Roche (1994) predictive maturity equation is the requirement of mid parental height (mid height of biological parents) despite the improvement in systematic accuracy, applied through an adjustment calculation (Epstein et al., 1995). Considering parental contribution, it can be precluded that if youth soccer players parents believe of the club's desire to select players with the greatest anthropometrical and physical potential, there may be an over reporting and discrepancies in the heights reported. In accordance, the application of non-invasive indicators maturity status, for the purpose of youth classification during talent identification and development, has been questioned (Malina et al., 2012), with the suggestion to use a radiograph-based methodological approach to identify maturity status in an adolescent population (Mills, Baker, Pacey, Wollin, & Drew, 2017), however, such invasive approaches, are not deemed appropriate to the application of a high level youth soccer population and environment (Parr et al., 2020). Concluding the aforementioned factors, it could be suggested of the inaccurate calculation of player maturity status and such the miscategorisation of players, into maturity status banded teams, effecting upon such performance measures.

It could be suggested that the current study is also limited by the sample size (*n*) as an independent construct and in reference to methodological game constraints, despite the present study not reporting a sample power calculation. As such, the small sample size decreased the statistical power, thus reducing the ability to detect an effect or change, in addition to an increase in the margin of error, ultimately reducing the confidence level of the study and impairing the conclusiveness of such results. In relation to the game constraints, the sample size of each maturity banded team was (*n* = 4), which suggests a reduction in statistical power, specifically when analysing contrasting maturity bandings (e.g. '*post-PHV* Vs. '*pre-PHV*'). Statistical power and sample size were less affected during the analysis of mismatched 'bio-banded' competition, due to an increase in the number of fixtures and thus an increase in data points and sample size. When considering the constructs of each team, it can be argued that one individual represented a large contribution (25%) to overall team performance, in which large variance and subject heterogeneity in player's performance could be extenuated, upon the calculations of team averages.

The present study is further limited by the significant differences present for chronological age between and across maturity bandings, however, due to the apparent differences in biological maturity, independent of chronological age, it can be argued that a subject population with an equitable chronological age, would have been a more appropriate application to the present study (Lloyd, Oliver, Faigenbaum, Myer, & Croix, 2014). It can be argued that the attenuation of the difference in chronological age between maturity banded teams, would have permitted the evaluation of biological maturity as an independent construct, however, such application may be deemed impractical, due to the availability of the required study population.

When considering coach perception of technical and psycho-social performance, the current study is limited by each coaches' subjective opinion on technical characteristics and perception of talent, developed through their individual experiences and current footballing ideology. Despite all coaching staff in the present study, meeting the minimal requirements of coaching qualifications, and been educated on the technical and psycho-social definitions, it could still lead to a difference of opinion from coaches within the same or across a footballing organisation. Such limitation can be evidenced by Dugdale, Sanders, Myers, Williams, and Hunter (2020), which demonstrated *moderate* agreement between subjective ratings of displayed performance between coaching staff. The respective study also indicated skewed levels of agreement between subjective and objective measures of performance, for moderately performing players, identifying the existing concerns when evaluating homogeneous samples using both subjective and objective measures, a limitation apparent in the present study (Dugdale et al., 2020). Such limitation was amplified by the inability to maintain and keep the coaching staff consistent throughout the testing weeks, further increasing the subjectivity and variance within the data. Despite disseminated literature demonstrating GTSC to be insignificantly different for coach's perception for an individual player over three competitive fixtures and demonstrating good levels of reliability of GTSC score between coaches, there is still a concern for the live assessment of technical ability, in which a significant difference was reported between live GTSC and GTSC when using video footage to reassess scoring (Fenner et al., 2016; Unnithan et al., 2012).

Despite the validation of the GTSC to evaluate technical and tactical competence (Fenner et al., 2016), the results of the present study are limited, due to no previous validation of the GPS, to evaluate the psychological competence of high level youth soccer players, during a competitive SSG match play constraint, upon which several disseminated results are required to develop a body of evidence, to support the validity of such testing measures (Impellizzeri & Marcora, 2009).

As with the requirement to alternate coaching staff for the technical and psychological scoring, due to the rigorous commitment of a professional football setup, the present study was limited by the use of 'replacement' players, when players of the original selection pool were unavailable due to injury, illness or representative commitments, negating from the originally selected study population. It could be suggested that such replacement of players could cause week to week variance in the maturity bandings and effect such EASA%, which would either attenuate or extenuate the magnitude of difference in biological maturation between maturity banded teams. The weekly variations in EASA% introduced an additional independent variable, which reduces the efficacy that any reported week to week difference in performance indicators are attributable to changes in relative pitch size alone.

The study is further limited by the inability to distinguish between and conduct positional analysis. Technical characteristics, movement demands, and match activity profiles are likely to depend upon positional demands and requirements, therefore it would be deemed appropriate to analyse the influence of pitch size on the efficacy of 'bio-banding' within positional groupings, rather than between maturity banded teams, inclusive of a differential number of positions (Pettersen & Brenn, 2019; Towlson et al., 2017). In support of this, the study is limited by a paucity of contextual factors inclusive of team and player interaction, footballing ideology and style of play, score line, tactics, and opposition that could attenuate the difference between levels of biological maturation. The current study applied absolute and pre-defined speed thresholds, conducive to constraints of working within a professional academy setting, with the consideration that the systemic methodology to identify individualised speed thresholds, would be time consuming and an inappropriate use of valuable research time. Scott, Thornton, Scott, Dascombe, and Duthie (2018) reported absolute speed thresholds to underestimate physical loading, which the direction to apply relative thresholds, that permit the improved prescription and monitoring of external training loads, reflective of individual physical capacities. As such, the present study is limited with the use of absolute speed thresholds, in which the disseminated literature suggests a significant alternation in the reported quantity of high-speed running performance, which can preclude that the use of individualised speed thresholds, may alter the magnitude of difference between maturational bandings, for high intensities and speed actions, extenuated over an increase in relative pith size.

The application of an inertial measurement unit, attached bilaterally to the lateral malleoli of the foot, allowed for the technical and tactical analysis of player performance, in reference to TTOB in the present study but such systems permit the analysis of a number of performance indicators, inclusive of the total number of touches. However, it is important to consider that such systems are limited with an inability to detect and recorded ball involvement for body parts, exclusive of the feet (e.g. head, chest, and knee). It can be argued that the beneficiaries of transient maturity related enhancements in anthropometrical and physical characteristics, may adopt a more expansive and direct route of football, that would be characterised by a high frequency of touches from other respective body parts.

A final limitation of the present study is that it can be argued that the '*mixed*' banded teams, inclusive of two '*post-PHV*' and two '*pre-PHV*' banded players, may not be representative of the chronological age groupings, of which players normally reside in. As such, an inaccurate representation may disturb the magnitude of difference in key performance indicators and reduce the efficacy of 'bio-banded' game constraints, in comparison to the currently adopted chronological age groupings.

5.6 Future Research

Despite still being in its infancy, the present study aims to further develop an understanding of the efficacy of maturity status 'bio-banding' and such influence of relative pitch size when applying a multidisciplinary approach, as a potential tool for talent identification. The results of the present study demonstrated relative pitch size to bear minimal influence upon the magnitude of difference between maturational bandings throughout SSG match play. As such future research could be directed towards the manipulation of player numbers, effecting upon special distributions and performance behaviours, which could suggest an alteration in the analysis of physical, technical and psychological performance measures between maturational bandings, accountable to the alternation in physical and technical demands (Silva et al., 2015). Aligned with such physical and technical demands, specific manipulations could be applied to illicit desired characteristics from a talent identification perspective.

In order to better inform the talent identification process, future research should work towards the development and installation of objective measures of technical, psychological, and sociological characteristics. Such measures would remove individual coach subjectivity and remove bias both within and across academy structures. In addition, future objective measures of performance should pertain positional analysis and accompanied maturity status, due to the documented difference in physical and technical profiling between positional splits. From a talent identification perspective, this would enable the appropriate (de)selection of players with the characteristics deemed synonymous with the movement, technical and psychological demands of such positional splits. When considering objective measures of performance, it can be suggested that future research is inclusive of an independent consideration of sociological maturation, due to its unknown rate of development and maturation, in relation to biological maturation.

Despite the present study been convergent towards the influence of relative pitch size and biological maturation, upon talent identification and (de)selection, there is still a requirement of future research to consider the acute and chronic implication of ‘bio-banding’ upon both talent identification and long-term athlete development. From a chronic perspective, current disseminated research supports the operation of ‘bio-banding’ principles as part of a multifaceted and holistic program of development, however, such research is still in its infancy. In accordance, research pertaining to the acute effect of ‘bio-banding’ for talent identification, requires additional evidence.

As previously aforementioned, although predictive maturity equations have proven to be practical in application, research has questioned the longitudinal accuracy of such somatic maturity equations to an elite youth soccer populations (Deprez, Fransen, Lenoir, et al., 2015). As such, future research should be directed towards the improvement of systematic, methodological protocols of predictive maturity equations, that aims to reduce the margin of error between actual and predicted PHV. Future research should also aim to reduce the margin of error when applying an adjustment calculation algorithm when accounting for reported mid parental height.

6.0 CONCLUSION

The results of the present study achieved the objectives of the primary research question, in illustrating the influence of relative pitch size of the efficacy of maturity status 'bio-banded' small sided games, for the purpose of talent identification and (de)selection, within an adolescent academy soccer population. Such results describe the physical, technical, tactical, and psychological response between maturational bandings, during mismatched and matched 'bio-banded' SSG match play constraints. The study has initiated research in reference to the manipulation of variables that may have previously suppressed the magnitude of difference between maturity status bandings, whilst generating an avenue to explore the alteration of additional variables that may attenuate or extenuate such difference.

A greater understanding has been developed in reference to the exposure to an increased physical demand for '*post-PHV*' and '*pre-PHV*' banded players when competing against those of an equitable maturity status, which allows for a more representative view of player's physical competence. For '*pre-PHV*' banded players, the study provides additional advocation, to maturity equitable competition, as a platform to express technical and tactical competence, when anthropometrical and physical differences are attenuated. For '*post-PHV*' banded players, the study develops a great understanding on how the attenuation of transient maturity related anthropometrical and physical characteristics, exposes an inept level of technical and tactical competence. Form a psychological perspective, the study advocates the application of a matched 'bio-banded’ constraint to develop psychological competence, as part of the holistic athlete development.

From a talent identification and (de)selection perspective, it can be concluded that biological maturity matched SSG match play constraints, provide the most appropriate platform, upon which to evaluate the technical, tactical, physical and psychological competence of both ‘*post-PHV*’ and ‘*pre-PHV*’ maturing, high-level youth soccer players. When considering the evaluation of physical competence, the results of the present study support the application of an expansive relative pitch size, with an associated increase in physical loading. However, it can be concluded for technical and tactical competence to be independent of relative pitch size and such selection of an appropriate relative pitch size, such be the coach’s discretion.

In short, the study demonstrates the appropriate SSG’s constraints, in which to promote optimal player response for physical, technical, tactical and psychological competence and develop an understanding of how player response is influenced by development and subsequent maturity status, in order to better inform the talent identification and (de)selection process. As such, this research is aligned with the principles of the EPPP, with the notion to deliver an environment that promotes excellence, nurtures talent, and systematically converts talent into professional competent players.

6.1 Practical Applications

The results of the present study may provide a practical bearing for the identification of talented adolescent soccer players within an elite youth soccer academy structure. Considering the results of the present study and for the purpose of talent identification and (de)selection, practitioners should apply a maturity matched ‘bio-banded’ SSG constraint, for ‘*post-PHV*’ maturing, high level youth soccer players, in order to expose the respective players to a more physically challenging match environment, due to competition against players of an equitable biological maturity status, with such notion supported by a perceptual increase in physical experience. Such increase in physical demand is likely to reflect an increase in player engagement and could cause a subsequent improvement in coach perception of physical competence, better informing the talent identification and (de)selection process, further supporting the efficacy of a maturity matched ‘bio-banded’ SSG constraint for ‘*post-PHV*’ maturing players.

Manifested from an increase physical demand and the inability to rely on trainset maturity related enhancements in anthropometrical and physiological characteristics, a maturity matched ‘bio-banded’ constraint, provides an increased opportunity for ‘*post-PHV*’ maturing players, to demonstrate technical and tactical competence, adding value to the informed decision making processes of talent identification and (de)selection, moving away from the traditional deselection of ‘*post-PHV*’ banded players at a later stage, when anthropometrical and physiologically characteristics are attenuated and inept technical competence is exposed, due to the over reliance on a physical dominance throughout developmental pathways. Practitioners should consider, from a chronic perspective, the provision afforded to ‘*post-PHV*’ banded players to develop technical and tactical, contributing to a holistic long term athlete plan, aligned with the principles of the EPPP (Premier League, 2011), however current knowledge pertains that such interventions should only be served as an adjunct to current chronological age groupings.

Practitioners should also be directed to introduce a biological maturity matched SSG match play constraint for the purpose of talent identification and (de)selection, when evaluating the competence of ‘*pre-PHV*’ maturing, high level youth soccer players, for the reason that competition against individuals of an equitable maturity status, stimulates a more physically demanding environment as reflected by an increase in physical movement demands and the associated reduction in the perception of physical experience.

From a talent identification and (de)selection perspective, this notion provides the efficacy to implement a maturity matched 'bio-banded' SSG constraint, when analysing such physical and physiological competence.

To further to support the efficacy of a maturity matched SSG constraint for '*pre-PHV*' maturing players, is the attenuation of the magnitude of difference in anthropometrical and physical characteristics, which affords the opportunity for '*pre-PHV*' banded players to demonstrate a higher level of technical competency and such better informing the talent identification process. Such opportunity allows for a more representative showing of true technical and tactical competence required for the selection into talent identification and long-term athletic development programs, which will prevent the premature release of talented and technically adept players, who possess the potential to succeed at a professional level when anthropometrical and physiological characteristics become attenuated.

As the results of the present study demonstrate, an increase in relative pitch size promotes an increase in the movement and physical demand, independent of biological maturity status, we can infer that from a talent identification and (de)selection perceptive, it would be appropriate to increase the dimensions of a SSG constraint, if to analyses physical competence and differentiate between levels of performance. However, there is no perceived additional benefit, in the alternation of relative pitch size, for the analysis and evaluation of technical/tactical and psychological competence from a talent identification and (de)selection perspective.

Adopting a holistic viewpoint, it is clear to see that maturity status 'bio-banding' can be applied to promote the expression of desirable traits, which provide an indication of the required competencies of talented adolescent soccer players. However, such an application may not be limited to an elite youth soccer population, in which its application should be considered across a wider continuum of sports, both individual and team based.

In addition, such application could be considered form an educational setting, in which cognitive development is matched, promoting a more appropriate learning environment. However, the application of ‘bio-banded’ practices should always be considered as an adjunct to current chronological age groupings, with the aim to develop holistically adept individuals.

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