Revisiting Youth Player Development in Australian Rules Football: is there a Place for Bio-banding?

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Abstract

Within a group of adolescent Australian Rules Football (ARF) players, individuals of the same chronological age can differ greatly in biological maturation, with some players maturing vastly earlier or later than their peers. Such large differences in maturity can cause a disparity between physical performance, influence the perceptions of talent, and affect training practice. In attempts to address such issues, this overview proposes the concept of bio-banding in ARF, which may be used periodically within the national talent pathway to optimise player development. Bio-banding is the process of grouping adolescent athletes into specific categories or 'bands' based on biological maturation, rather than chronological age. This review describes how bio-banding may be used to enhance player development in ARF, giving context to its background and implementation in other sports.

Keywords: Adolescence, biological maturation, Australian Rules Football, talent identification team sport

Introduction

Australian Rules Football (ARF) is a widely participated game at both youth and adult levels within Australia [1]. The junior participation pathway begins at the local club level, from the age of around six, while talented players may be selected in regional development squads from under-14 to under-19 [2]. Talented junior players may also receive additional development via the National AFL Academy [3, 4], with the talent pathway culminating in an invitation to the AFL (Australian Football League) Draft Combine and selection in the National AFL Draft at a minimum age of 18 years (Figure 1). Academy development aligns to the demands of elite level ARF, where a requirement for both physical and technical abilities are imperative [3, 5]. During youth competition, early maturing players inherently display superior physical qualities, including size, speed, and power [6-9]. This may provide them with distinct advantages over less mature counterparts, such as during contested situations, where technically skilled players who win more contested possessions are more likely to be selected as earlier draft picks into the AFL [10, 11]. Additionally, early maturing players may also be afforded significant selection advantages due to a coaches' greater perception of skill and match performance, indicating that a maturity selection bias may exist within ARF [5, 8, 12]. Therefore, it is important to understand the rate at which different junior players mature and implement strategies to optimise talent identification and development in ARF.

---- INSERT FIGURE 1 NEAR HERE ----

Figure 1. AFL participation and talent pathway, adapted from [2, 4]

Bio-banding is the process of grouping adolescent athletes into specific categories or 'bands' based on biological maturation, rather than chronological age, for a potentially more optimal athlete development [13]. Chronicle age is based on the calendar date on which an individual was born, whereas biological maturation refers to the progress of bodily systems towards an adult state and is determined by a combination of genetic and environmental factors [14]. Typically, junior ARF players are organised into chronological age-based groups to train and compete based on the annual year (e.g., under-14). This system is easily implemented and often allows for players to remain within their usual social groups. Age groups are also ideal in terms of grouping players relative to attributes that follow age (i.e., experience, cognitive, motor, social development). However, age groups do not account for the inter-individual variation in biological maturity among adolescents, where the extent, timing and tempo of growth can differ greatly between two individuals of the same chronological age [13, 15, 16]. Within a group of under-16 ARF players, it has been shown that biological maturity varied by as much as 3.5 years, despite the least mature boy being only 0.4 years chronologically younger than the most mature boy [8]. Similar findings have been observed across multiple studies [6, 7], further confirming the high potential of biological variation within a given ARF team. Despite this, the AFL implements no clear structures or policies in regards to maturation, with other sports, including soccer, rugby and tennis, integrating bio-banding within their development framework [17-21]. This is highlighted by the Fédération Internationale de Football Association (FIFA) approach to talent development, which emphasises the importance of maturity assessment, maturity appropriate training and recommends the application of bio-banding [17].

While physically dominant and early maturing youth players excel during underage competition, they may not necessarily maintain this advantage into adulthood [22, 23]. This can result in misidentification of players, as early maturing players may fall short of the standards expected of them. Conversely, late maturing players, overlooked in favour of their more physically mature peers, are devoid of selection and development opportunities [24]. In addition, how young players respond and recover to training stimuli differs in accordance with maturity status [16]. Therefore, the understanding of maturation for the implementation of appropriate training practice, competition and selection are important for long-term player development. Furthermore, bio-banding may have greater importance within ARF compared to other, more technically orientated sports, considering its high physical demands [5], as well as large differences in player size and maturation [6, 8, 9], which can be accentuated during chronological age-matched competition. The purpose of this narrative review is to provide an overview of how bio-banding may be used to optimise talent identification and development in ARF, giving context to its background and implementation in other sports.

Performance and Maturation in Australian Rules Football

ARF is a physically demanding game, where taller, stronger players can possess a clear advantage during contested situations, and speed, power and endurance are all important physical qualities [5]. In a study by Gastin et al. [6], 87 male under-15 players were assessed for biological maturity and categorised into early, average and late developers. Chronological age in this group spanned 1.3 yrs while biological maturity, measured as years to and from peak height velocity (PHV) (period of time when an adolescent grows fastest), spanned 2.7 yrs, highlighting a clear difference in maturity amongst the players [6]. Time motion analysis of match running performance showed that early maturing players covered significantly more total distance, high-intensity running distance and number of high-intensity efforts. Early maturing players were also heavier and taller than their counterparts, and were significantly faster during the 20m sprint test [6]. Considering that taller and heavier players usually play key positions and cover less distance in ARF, the fact that these players still had higher running outputs compared to their smaller peers, further emphasises the impact of biological maturity [6]. Similar findings were also reported by Gastin et al. [7], with greater running performance in both training and competitions observed as a function of increasing biological maturity in a group of under-11 to under-19 male ARF players. Furthermore, Edwards et al. [25], found that early maturing junior ARF players displayed superior sprint acceleration characteristics and split times compared to their later maturing counterparts. While maturation and the relative age effect (the difference in age among individuals born in the same selection period [26]) are two different constructs, the combination of both may magnify physical performance differences between players [7]. Late maturing players who are also born later within their chronological age band, might be at the greatest disadvantage. On the contrary, early maturing players born within the first two-quarters of their chronological age band may be at the greatest advantage[7].

Variance in biological maturity has also been associated with the evaluation of talent in ARF [9]. Fifty under-16 Western Australian Football League players were categorised as either talented (state representative) or non-talent identified (non-state representative). Talented players were biologically older and had greater anthropometric and physical qualities. Interestingly, performance in Australian football skill tests was not influenced by biological maturity [9]. A similar investigation by Cripps et al [8], suggested that early maturing under-16 players were perceived to have superior technical skills, despite no evident advantage during skills testing. In accordance with the aforementioned findings by Gastin et al. [6, 7], these players were also taller and heavier, and outperformed their later maturing counterparts in sprint and jumping tasks [8]. These results have important implications for talent identification, considering that sprinting ability and vertical jump performance are key predictors of selection in the AFL draft, as well as elite junior teams and career success in the AFL [27-30].

The impact of advanced biological maturity on success during junior ARF and subsequent selection in the AFL draft seems clear. However, with adult age, these advantages may be reduced as later maturing players catch up, and even surpass players who mature comparatively earlier [23, 31, 32]. Coutts et al. [31] has suggested that later maturation in a group of older AFL draftees (i.e., >20 years), may have contributed to these players missing out on selection in junior representative teams, and subsequent drafts at the normal age of 18 years. Nevertheless, these players may have developed enhanced skills and tactical abilities while learning to compete at a physical disadvantage against more mature peers during adolescence [31, 33]. This highlights a potential benefit of chronological age-matched competition. Recently, there have been calls to raise the minimum AFL draft age to increase adolescent players' technical, physical and social development, which could additionally benefit later maturing adolescents [34, 35]. While the merits of this suggestion are outside the scope of this review, with a selection bias often shown towards more mature adolescent ARF players [12], late developers could be missing out on selection in elite junior teams and the AFL draft. Consequently, these players may not receive the same exposure to high-level coaching that early access into talent development pathways provides. Therefore, the implementation of bio-banding strategies seems logical for the long-term development of junior ARF players.

Assessing Biological Maturity

Skeletal age is often considered the most objective assessment of biological maturity [36]. Radiographic imaging is used to track the transitions of cartilaginous structures during early childhood, most commonly the left wrist, against predetermined reference criteria [16, 36]. The observation of secondary sex characteristics has also been traditionally used in the assessment of maturity [37]. Most notably, the pubertal stages described by Tanner [38] provide reference points to which secondary sex characteristics, like pubic hair growth, can be compared. However, both of these clinical-based methods are highly invasive and carry numerous limitations [39]. Therefore, they are neither feasible, efficient, nor appropriate for broad application in junior ARF [13, 37].

The maturity offset and percentage of predicted adult height (at time of observation) have been developed as two non-invasive methods to determine biological maturity [13]. Both methods have been widely used and are both practical and easily applied in-field. The maturity offset, also referred to as the Mirwald equation [40], provides an indicator of gender-specific maturity timing, reflecting a time before or after PHV and predicted age at PHV. For example, it may be predicted that a 13-year-old boy is 1.5 years away from PHV, which suggests that he'll be reaching his fastest period of growth at 14.5 years. To predict said indicators, an equation is used based on anthropometric measures of height, trunk length and leg length, as well as body mass and chronological age [40]. This method is based on the idea that adolescents who are advanced or delayed in maturation will experience PHV at an earlier or later than expected age, which on average is 13.8 years in boys and 11.9 years in girls [13, 41]. However, the reliability and validity of the maturity offset have been questioned, highlighting systematic errors that are associated with age and maturity timing [42-44]. More specifically, the method tends to over-estimate age at PHV in older adolescents, while also over and under-estimating years from PHV for early and late maturing adolescents, respectively [37]. While it does provide more accurate measures of average maturing adolescents, this somewhat challenges the practicality of the measure. Furthermore, maturity offset is highly dependent upon the precision of anthropometric measurement, specifically within the seated height, which has a direct relationship with several independent variables, thus substantially magnifying the prediction-calculation error if taken incorrectly [40]. The reliability of the method to identify when adolescents actually enter the growth spurt has also been questioned [45]. A recent study comparing estimated and actual age at PHV within 13-year-old academy soccer players found that the Mirwald methods were only able to correctly identify when a player was within +-1 year of PHV in 61% of cases [45].

As an alternative to the maturity offset, and arguably a more accurate method of prediction [45], is the percentage of predicted adult stature [13, 46]. This approach has traditionally been used in the Khamis-Roche method to determine predicted adult height and provides the status of growth as a percentage of predicted final height. The percentage of adult stature can then be compared to age and sex-specific reference values to determine the degree to which a child is advanced, on-time, or delayed in maturation, or used as a proxy of biological (somatic) age. This method is also non-invasive, requiring only anthropometric measurements from both the parents and athlete [46]. Following measurement, this method allows athletes to be grouped into specific bands based on the percentage of ‘predicted’ adult height; <85%, 85–89.9%, 90–94.9% and ≥95% [37]. These bands correspond with pre-pubertal, early pubertal, mid-pubertal and late pubertal, respectively [13, 47]. PHV generally occurs between 88 and 96% of adult height, peaking at approximately 92% [13]. The same longitudinal study of growth in academy soccer players found that this method was able to correctly identify when players entered the 88-96% band in 91% of all cases [45]. The percentage of predicted adult stature method is, however, limited to athletes with access to both parents.

Considerations for Strength and Conditioning

Accommodating for the growth and maturation of young athletes when implementing strength and conditioning is important to maximise sensitive periods for accelerated development [48]. This may have further significance in ARF, considering the large inter-individual variation in biological maturity that often exists, as well as substantial anthropometric differences between players (e.g., height, limb lengths) [6-8]. Biological maturation is associated with changes in athletic movement competency in junior ARF players [49], and as such, a key focus of training programs should be the practice of athletic motor skill competencies relevant to ARF (Figure 1). Due to the chronic repetitive, high impact forces experienced when running, jumping and kicking during ARF, combined with rapid skeletal growth and a temporary reduction in motor skills, adolescent players are at risk of traction apophysitis (e.g., Osgood-Schlatter or Sever disease) [13, 50]. These injuries are particularly common in the year before, and during the period of PHV [13, 51]. Thus, closely monitoring growth, adapting training to accommodate individual circumstances and promoting the practice of efficient movement will help to alleviate such issues. For these reasons, models of programming accounting for maturation are strongly advocated to ensure optimal developments through the adolescent process. The youth physical development (YPD) model provides a thorough, evidence-based approach to physical development in young athletes [52]. This model recognizes that athletes should be exposed to all fitness attributes throughout childhood and adolescence, but training stimuli should complement their stage of maturation [13, 52]. Specifically, technical movement competencies may be developed during the pre-pubertal period to enhance neural coordination. Training that requires high levels of neural activation will benefit this group most, including sprinting and plyometrics, as well as developing general strength through the practice of athletic motor skills [13, 52]. As players progress through the mid-stages of puberty, programs should be modified to gradually increase loading for further development of muscular strength and power [13, 52]. Finally, as players advance past puberty, more substantial gains in muscle fibre hypertrophy can be achieved due to increased levels of circulating hormones (e.g., testosterone), which will ultimately result in more rapid increases in strength, power and speed [13, 52]. Greater training volumes and intensities may be used to capitalise on such biological changes, while helping to prepare players for the rigors of adult competition. However, without the systematic progression of strength and conditioning through the previous stages of puberty, where technical competencies are learned and gradual loading is implemented, optimal player development may not occur.

---- INSERT FIGURE 2 NEAR HERE ----

Figure 2. Athletic motor skill competencies of youth Australian Rules Football players

Similar models of programming exist with a focus on critical maturation timings. Jan Willem Teunnisen, one of the authors of the Athletic Skills Model [53], advanced a protocol for adapting training load and content during the growth spurt. More specifically, training load was reduced as players entered the growth spurt with a greater emphasis on activities that involved the development and refinement of core strength, balance, coordination, and fundamental and sport-specific movement skills [53]. A recent application of this protocol across a competitive season at an English soccer academy resulted in a 72% reduction in time-loss injury incidence among players mid-growth spurt [54]. Likewise, in junior ARF players experiencing maturation, Edwards et al. [25] recommend the use of heavy sled pushes and pulls to improve lower limb force-generating capacity, sprint technique and coordination, which will provide a foundation for enhancing sprinting ability and maximal power. Additionally, including exercises that challenge neuromuscular control and proprioceptive ability may help to alleviate “adolescent awkwardness”, which is commonly observed during mid-adolescence [13].

Application of Bio-banding in Soccer and Other Sports

The English Premier League (EPL) academy system has led the way in terms of recognising and implementing bio-banding as part of their Elite Player Performance Plan (EPPP)[20]. All players within this system undergo regular physical performance testing, including assessment of growth and maturation [21]. In implementing bio-banding, the EPL firstly educated academy coaches and staff on the processes of growth and maturation, creating a system that enables clubs to better assess, monitor and interpret differences in player development [20]. Further, several EPL clubs have partaken in bio-banded tournaments where academy players compete based on biological maturity, rather than chronological age. In one instance, a group of EPL academy players aged between 11-15, corresponding to 85-90% of predicted adult stature, competed in a bio-banded and chronological fixture to compare physical and technical performance between the two formats [55]. These players were divided into early, on-time and late developers. It was found that the bio-banded games placed a greater emphasis on certain technical skills (e.g., passes and tackles) compared to the chronological format, without reducing the physical demands [55]. Increased emphasis on technical and tactical parameters was also observed in a study by Romann et al [56], which analysed the performance of adolescent soccer players from the Swiss talent development program during bio-banded and chronological age-matched games.

In two further studies [57, 58], both investigating subjective experiences of participating in a bio-banded competition, players were drawn from multiple professional English clubs and grouped as per the percentage of predicted adult height. These players reported a positive response to the bio-banded tournament and recommended that these games be consistently scheduled into the academy season as an adjunct to, not a replacement for, age-group competition [13, 57, 58]. Early maturing players, who previously had a greater physical advantage playing within their chronological age group, now found that the bio-banded games were more physically challenging, which required them to utilise their technical and tactical skills on a higher level. In contrast, late-maturing players appreciated the opportunity to demonstrate their technical, physical and psychological abilities, without the same physical challenge as what they would normally contend with against more mature boys in their chronological age-based competition [57]. Additionally, players across both studies also reported enhanced feelings of leadership and social skills [57, 58]. These experiences have been matched in bio-banded tournaments held by US soccer, with both male and female players suggesting that bio-banded competition created a superior learning experience that was beneficial to their development [37].

Several other sports have also implemented bio-banding strategies into their long-term athlete development models. Both the Bath Rugby Academy and the British Lawn Tennis Association considers players' biological maturity to identify talent, assess physical performance and prescribe appropriate strength and conditioning practices [18, 19]. Concerning talent identification, these organisations use the periodical assessment of maturation to standardise assessment of physical performance and match players by maturity status, rather than age [18, 19]. New Zealand Cricket has also introduced bio-banding to help address maturation bias, where they have identified that there is a severe under-representation of late-maturing players in their talent system [33]. Subsequently, a 3-day skill development camp for talented under-13 boys was organised, with players banded into two groups of early and late maturers [33]. Skill-based activities and bio-banded games were then performed, with both players and coaches noting the enjoyment and additional challenge that was experienced, as well as the opportunity to develop a varied range of skills compared to traditional age group competition [33]. While not based on bio-banding per se, since 2017 Australian Rugby Union has become the first major contact sport in Australia to implement size-based grouping strategies [59]. Their policy identifies 'outliers' based on weight and height, which is followed by an independent assessment of the players' experience, skill, fitness and maturity [59, 60]. Players may then potentially be moved up or down an age group to a maximum of two grades [59]. This follows in the footsteps of New Zealand Rugby, which has long implemented weight-based criteria to more evenly match youth players [13].

Potential application of bio-banding in Australian Rules Football

It is firstly important to recognise that bio-banding is not a complete substitute for traditional-age group training or competitions, but can be used in addition to develop and evaluate talent [13]. To optimise player development in ARF, bio-banding may be gradually integrated throughout the national talent pathway in four progressive phases (Figure 3). Beginning at phase one, assessment of growth and maturation takes place during customary physical performance testing and screening at regional development squads and throughout the national talent pathway for players across all age groups, both trialing and selected. While a range of models exists to determine maturational status, the percentage of predicted adult stature is the suggested method for use, due to its enhanced accuracy of prediction and high validity and reliability [45]. This data is stored and may then be used to support talent identification via the evaluation of athletic ability and potential while guiding strength and conditioning provision [13]. Age and maturity specific fitness standards for ARF can then be developed, allowing staff to compare players more evenly and provide a reference for sub-optimal performance, which can occur during the mid-growth spurt [13, 61, 62]. Within phase two, individual players in talent academies may be periodically moved into older or younger age groups to train, based on their stage of maturation, technical competence and psychosocial readiness [13]. As a logical progression, phase three would then involve such individual players being periodically moved to compete. Finally, in phase four, a series of games at the regional and national level, designed for players up to 16 years of age, could be organised each season based on maturity bands, providing a unique opportunity for player development and alternative perspective for talent identification [13, 37]. After 16 years of age, players are outside of the expected PHV period, having achieved, or very close to achieving full adult stature [13]. Thus, variation in maturation is reduced and benefits of bio-banded competition would be limited [63]. Nevertheless, evaluation of maturity status across all youth ages (phase one) is required to detect the occasional player who is highly delayed in maturation, providing reference to their functional performance and removing the potential for misidentification [57]. In this way, all phases within this structure co-exist, with the assessment of maturation in phase one informing player selection strategies in phases 2-4.

---- INSERT FIGURE 3 NEAR HERE ----

Figure 3. Potential application of bio-banding in the national AFL talent pathway.

In following the footsteps of the EPL and for successful application of bio-banding in ARF, thorough education is paramount for all stakeholders involved (e.g., academy staff, AFL club recruiters, players and parents), particularly in regards to its purpose and impact [57, 64]. Educating coaches and staff on the processes of growth and maturation will allow AFL clubs and talent academies to better evaluate and enhance player development [20]. One perceived disadvantage reported by stakeholders during bio-banding interventions in soccer has been related to the confusion that late maturing players may think that they are being moved down an age group [64]. Further, feelings of apprehension have been raised by some players due to being moved away from friends or at least, teammates whom they were familiar with [64]. These perceived negative associations of playing down an age group can be mitigated when education is provided to both the player and parent to highlight the benefits. In this case, playing down may present an opportunity to become a leader of the group, progressing a player's social skills. Therefore, AFL academies must consider the psychosocial development of players when moving players and selecting groups [13].

Technical abilities can be unaffected by maturational status across both ARF and soccer [8, 9, 47]. When bio-banding is being applied, sessions should not hinder the technical development of players. Whilst a player of an advanced maturation may be able to withstand the physical demands of playing up an age group, they may not be of the required technical standard or psychological maturity, and a severe over-stimulation can occur if too frequently implemented. Moreover, technical ability should also be taken into account during selection, as it is unlikely that a late-maturing player will benefit from competing against players of similar maturity status if they are already thriving in their normal age group. To optimise the benefits of bio-banding, certain English soccer clubs align their psychological support service to bio-banded phases ensuring that early and late maturing players are best prepared to meet the next challenges of opportunities that bio-banding formats present [65]. Employing principles derived from the study of mixed-age classrooms, conditions are created to 'scaffold' the experiences of early and late maturing players. Coaches and practitioners help early maturing players develop the necessary skills to adapt to greater challenges and potentially, failure. In contrast, late-maturing older players are encouraged to take on the position of leaders and consolidate their learning through teaching, organising, motivating and communicating with their younger yet physically matched peers [65].

The precise measurement of anthropometric values is vital for accurately estimating adult stature and as such, those responsible for the assessments must be appropriately trained [13]. Further study and validation [13] of field-based maturity assessments are also needed. Median and 90th percentile errors across the 11-15 years age range of the percentage of predicted adult height equation translate to approximately 1.5% and 3.0% of predicted height for the average male [46]. This may mean that some players are in or out of a band due to errors associated with this prediction [37]. Additionally, the height prediction equations used in bio-banding have been developed from higher privileged American children and adolescents of European ancestry. Thus, variation may exist between different ethnicities, countries of origin and possibly sports [37, 66], which is of particular consideration for application within ARF given the diversity of the game [1].

Implementing bio-banding may be challenging at local levels (i.e., AFL player participation pathway), mainly from a resources perspective [13]. Thus, it would be logical to first implement bio-banding in the national talent pathway. Within the current structures at local levels, and as an alternative to bio-banding, periodically moving players up or down in age groups for training and/or competition should be encouraged, based on player skill and ability, as well as size and maturity. Rule modifications in junior ARF, such as reduced ground sizes, positional zones and fewer players on the field, may also enhance skill development and player retention [67]. While the intensity and extent of physical activity may be limited with such modifications, skill development and enjoyment within the junior participation pathway should be the highest priority [67, 68]. This may be further emphasised by varying player positions, rotations and team selection, allowing all players the opportunity to progress [68].

Conclusion

Bio-banding is the process of grouping adolescent athletes for optimal development based on biological maturity, rather than chronological age. This practice can accommodate for substantial inter-individual variation in maturity, as has been found in adolescent ARF players [6, 8], and create a more diverse and developmentally appropriate learning environment [13]. The EPL implements bio-banding as part of their long-term development strategy, with coaches noting that it allows them to evaluate players' skills and attributes in a more evenly matched environment [13]. A similar approach can be taken to integrate bio-banding within the national AFL talent pathway, with four progressive phases used to evaluate maturation, guide training practice, inform talent identification and create a unique competitive environment. Grouping players by maturity status will attenuate, but not eliminate natural differences in size and function [58]. Players who are early maturing, yet genetically short in stature, must still learn to play with their taller peers [58]. This is important considering that ARF requires players of different heights and sizes that are more suited to certain positions. Nevertheless, bio-banding has the potential to reduce the degree to which early maturing junior ARF players can rely solely on size and athleticism to dominate less mature counterparts.

A thorough understanding of the impact of growth and maturation is important for coaches to optimise training programs for young ARF players [49, 57]. However, since bio-banding is a relatively new concept, questions regarding its efficacy still require answering and more research is needed to replicate initial findings. In particular, further research is required to validate field-based methods used to estimate the maturation of ARF players. Original research studies are also needed to understand the effectiveness of implemented bio-banding strategies in ARF training, competition and talent identification.

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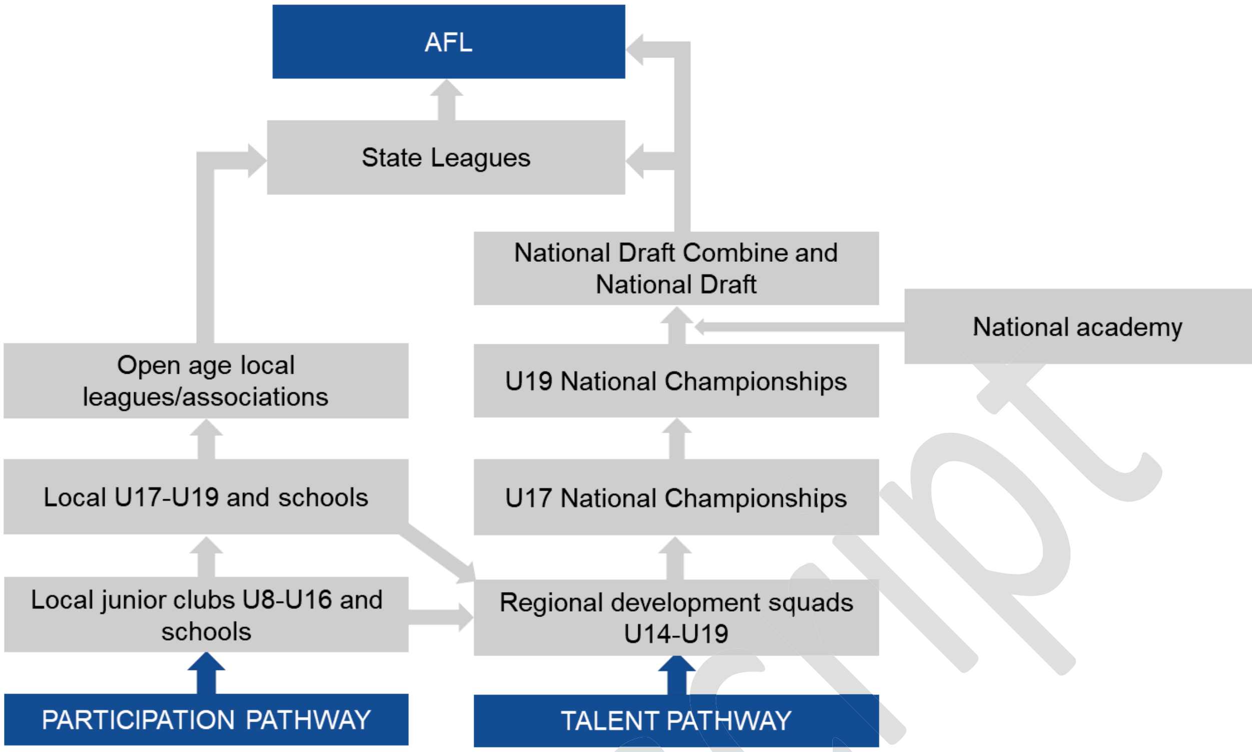

Figure 1.

Figure 2.

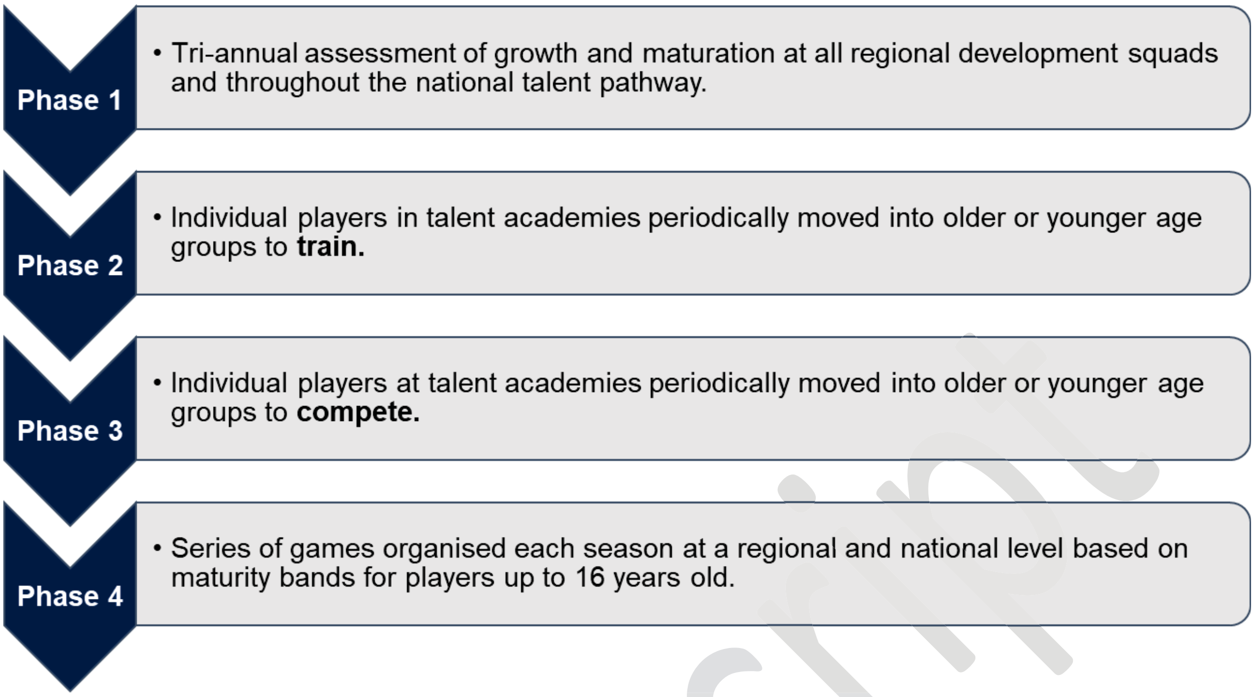
Phase 1
• Tri-annual assessment of growth and maturation at all regional development squads and throughout the national talent pathway.
Phase 2
• Individual players in talent academies periodically moved into older or younger age groups to **train.**
Phase 3
• Individual players at talent academies periodically moved into older or younger age groups to **compete.**
Phase 4
• Series of games organised each season at a regional and national level based on maturity bands for players up to 16 years old.

Figure 3.