Bio-banding in soccer: Past, present, and future

Authors:
Chris Towlson & Sean P. Cumming

Affiliations:
University of Hull, Hull, UK
University of Bath, Bath, UK

For publication in:
Annals of Human Biology

Number of tables: 0
Number of figures: 1

This is an Accepted Manuscript of an article published by Taylor & Francis in Annals of Human Biology on 27th September 2022, available online: https://doi.org/10.1080/03014460.2022.2129091

Abstract

Maturity-related selection biases are engrained within professional academy soccer programmes. The process of grouping of children by biological maturity ("bio-banding"), rather than age is not new. However, practice of bio-banding is becoming increasingly popular with youth soccer development programmes where maturity-related differences in size and athleticism have been cited as key mechanisms behind the over-selection of early over late maturing players. However, the objectives of bio-banding require further clarity to avoid a disconnect between contemporary academic evidence and present and future practitioner practice. Therefore, the purpose of this commentary is to 1) provide a concise overview of the literature (to date), 2) identify possible applications of bio-banding to permit more informed decisions relating to the evaluation and management of young soccer players and (3) propose future directions for both research and applied practice.

Keywords: Maturation; Maturity, talent identification; Long-term athletic development

The Past

The process of grouping of children by biological maturity, rather than age, was first considered in relation child labour laws in the early 1800's (Malina et al., 2019). The concept of a 'physiological age' was later proposed by Baldwin (Malina et al., 2019) as a criterion for determining readiness for physical training and directed play among high school students. Following the development of radiographs in 1895, Rotch (Rotch, 1908, Rotch, 1909) also suggested that anatomic age, based upon indices of skeletal maturation in the hand/-wrist, be used as a method for grouping of boys and girls in athletics. It was not until the end of the 20th century, however, that scholars (Beunen and Malina) revisited this concept; arguing that the process of maturity matching, currently labelled as bio-banding, had relevance to the grouping of young athletes in competition, talent identification, and the design, prescription, and implementation of training. Although variations of bio-banding, where young athletes are grouped based on age and mass, exist in combat and some collision sports where player safety and competitive equity are paramount, it is only recently that national governing bodies and professional sports team have started to investigate the potential benefits of grouping players by maturation.

The Present

Bio-banding is currently used to recategorize adolescent (~10 to ~16 years) athletes according to thresholds of biological maturation (Cumming et al., 2017, Malina et al., 2019) anchored to the timing of the adolescent growth spurt. This is often identified using measures of skeletal maturation (Tanner et al., 2001) or estimated (Fransen et al., 2021) using somatic or secondary sex based methods (Moore et al., 2015, Fransen et al., 2018, Mirwald et al., 2002, Kozieł and Malina, 2018, Khamis and Roche, 1994) (see Towlson et al. (2020b) for a review of methods).

The practice of bio-banding has received greatest interest in boys' soccer where maturity-related differences in size and athleticism have been cited as key mechanisms behind the over-selection of early, over late maturing (i.e., often taller, faster, and stronger) players in academy soccer (Lovell et al., 2015, Towlson et al., 2017, Deprez et al., 2015), eliciting significant investment in the provision of sports science and medical support(Malina et al., 2015, Salter et al., 2020) to assist talent identification(Unnithan et al., 2012, Salter et al., 2021) and training load management(Johnson et al., 2022b). The practice of bio-banding is less common in girls' soccer, though has been piloted by US Soccer in their Developmental and Major League Soccer academies. Endorsed by the English Premier League(Cumming, 2018) and, more recently, the International Federation of Association Football (FIFA)(Association, 2021), bio-banding has become increasingly popular in youth soccer academies to exclusively (see Towlson et al. (2021c)) remove maturity selection bias. A recent survey of leading European soccer academies indicated that 66 percent engaged in bio-banding as part of routine practices(Yaghoubinia et al., 2022).

Emerging evidence suggests that bio-banding has the potential to improve competitive equity (Johnson et al., 2022a, MacMaster et al., 2021, Malina et al., 2015) in children, alter task demands (Towlson et al., 2020a, Abbott et al., 2019, Lüdin et al., 2021) game constraints, present new learning opportunities and challenges (Bradley et al., 2019, Cumming et al., 2018a, Reeves et al., 2018). Considering these initial observations, the purpose of this commentary is to 1) provide a concise overview of the literature (to date), 2) identify possible applications of bio-banding to permit more informed decisions relating to the evaluation and management of young soccer players and (3) propose future directions for both research and applied practice.

Bio-bandings effect on anthropometric and fitness characteristics

Bio-banding is designed to limit maturity-associated variance in both size and athleticism. Initial evidence (Malina et al., 2019, MacMaster et al., 2021, Johnson et al., 2022a) supports this contention, with bio-banding leading to marked reductions in within group variance in stature, body-mass, mass-for-stature, and, to a lesser extent, physical fitness when compared to chronological age groups. Of note, the strongest effects of bio-banding are observed for those attributes (e.g., size, strength, power, speed) most directly associated with the maturation process (MacMaster et al., 2021).

Bio-bandings and in-game characteristics

Biological maturity has been shown to influence physical activity profiles of players (Parr et al., 2021, Goto et al., 2019, Lovell et al., 2019). The introduction of bio-banding to control for maturity-related differences in locomotor differences has shown early promise to negate the transient, anthropometric, and physical fitness advantages afforded to early maturing (or post-peak height velocity [PHV]) players' (Towlson et al., 2020a, Abbott et al., 2019). That said, Lüdin et al. (2021) observed early maturing players' perform more high intensity acceleration actions during matched bio-banded matches. Towlson et al. (2020a) observed few between maturity group differences in locomotor variables in maturity mixed small-sided games, and little difference in locomotor variables during the most extreme condition (i.e. pre-PHV Vs post-PHV players') (Towlson et al., 2020a). The impacts of bio-banding upon locomotor performance may, however, vary across full and small-sided games.

Early and late maturing players describe bio-banded games as more and less physically demanding, respectively (Bradley et al., 2019, Cumming et al., 2018a). Abbott et al. (2019), and Towlson et al. (2020a) have shown bio-banding to effect players' perceptions of fatigue, with early maturing players' reporting higher ratings of perceived exertion during matched bio-banded formats when compared to chronologically age-grouped games and pre-PHV players'

accumulated greater session ratings of perceived exertion when competing in miss-matched (e.g. Pre-PHV vs post-PHV) small-sided games. Although the authors showed meaningful differences between-maturity groups for session ratings of perceived exertion during miss-matched match-play, measures of mean heart rate have demonstrated no difference between groups. Culminating in speculation to suggest that pre-PHV players' may have been perceiving a different facet (e.g., technical, tactical, psychological) of match-play as physical exertion.

Bio-bandings relationship(s) with technical and tactical characteristics

Technical and tactical skills are a key consideration for talent selectors (Towlson et al., 2019) and influenced by age and advancing maturity in academy soccer (Moreira et al., 2017). Early and late maturing players describe bio-banding as encouraging technical and tactical over physical styles of play (Bradley et al., 2019, Cumming et al., 2018a). On-time and later maturing players' perform more short passes, complete less long passes and have greater opportunity to run whilst in possession of the ball during match-play when bio-banded (Abbott et al., 2019). Late maturing players' also demonstrate greater use of technical and tactical skills in bio-banded games (Cumming et al., 2018a), a finding corroborated in a subsequent study by Lüdin et al. (2021). Conversely, early maturing players' report greater reliance upon technical and tactical attributes to succeed when bio-banded and a requirement to think and release the ball more quickly. In agreement, Towlson et al. (2021b) found bio-banding mitigated maturity-related technical and tactical differences during match-play. However, the effect remained during maturity mis-matched formats, limiting the conclusions that can be inferred.

Bio-bandings relationship(s) with psychosocial characteristics

Evidence suggests because of factors related to selection and/or challenge, later maturing players possess more adaptive psychological profiles than their early maturing peers (Cumming

et al., 2018b, Gibbs et al., 2012). Competing in bio-banded competition, later maturing players' report greater engagement in leadership and mentoring behaviours, less risk for injury, more composure on the ball; yet greater pressure to perform (Bradley et al., 2019, Cumming et al., 2018a). This suggests that bio-banding affords later maturing players an environment in which they can better use and develop psychological skills important for selection (Towlson et al., 2019). Early maturing players' report greater confidence and pride in their performance, describing bio-banded games as a superior learning experience (Bradley et al., 2019, Cumming et al., 2018a). Conversely, maturity mis-matched small-sided games (Pre vs Post-PHV) have been shown to result in more positive evaluations for attitude, confidence, competitiveness, and total psychological scores for later maturating players; perhaps offering support for the 'underdog hypothesis'(Gibbs et al., 2012, Cumming et al., 2018b) whereby less mature players' are more likely to require/demonstrate superior psychological skills to succeed in such contests(Gibbs et al., 2012). The application of bio-banding to support the identification of such characteristics is of particular importance to practitioners given that self-regulatory skills have been found to distinguish elite athletes from their less-skilled counterparts(Toering et al., 2012). Therefore, systematically affording early maturing players the opportunity to regularly compete against equally, or more mature players may enhance psychological skills which they wouldn't otherwise develop during their chronologically age-ordered groupings due to them depending on their maturity-related enhancements in anthropometric and physical characteristics. Rather than them having to utilise problem solving skills, independent thinking and resilience to overcome challenging scenarios (e.g., like playing against an equally big/bigger opposition).

The Future

The application of bio-banding in soccer is increasingly popular (Abbott et al., 2019, Bradley et al., 2019, Cumming et al., 2018a, Hill et al., 2020, Lüdin et al., 2021, MacMaster et al., 2021, Moran et al., 2021, Reeves et al., 2018, Romann et al., 2020, Towlson et al., 2021a, Towlson et al., 2020a, Towlson et al., 2021b) and there is growing evidence to supports its use in competition, talent evaluation, and for the design and implementation of training programmes. Further research is, however, required to evaluate the long-term effectiveness of bio-banding, identify, and understand the potential mechanisms behind any benefits, and establish best practice and of course barriers to its use. Particular attention should be paid to the impact of bio-banding upon coaches and scouts' evaluations of talent, technical and tactical aspects of performance such as attacking and defensive actions and scanning behaviour. The impact of bio-banding upon performance and challenge in specific phases of play where athletic ability may be more important (e.g., one on one and transitions plays) should also be considered. In terms of injury prevention, further research is also required to determine when and how best to adjust training programmes to mitigate the risk of specific injuries and how this varies relative to the distal-to-proximal growth gradient.

From an applied perspective, researchers and practitioners should explore how to best support players and coaches before and during bio-banded phases of competition. Educating players and coaches on the purpose of bio-banding and providing early and late maturing players with the requisite psychological skills necessary to adapt to their new challenges and responsibilities will be key in optimising the potential benefits of this practice. A more systematic approach to bio-banding whereby training sessions and coaching practice are adapted towards individualised goals and players progress is re-evaluated post competition, can also ensure that bio-banding achieves it intended outcomes. This is likely due to evidence suggesting that bio-banding creates a more equitable playing environment, characterised by homogeneous groups of adolescent soccer players' who possess similar maturity-related

anthropometric characteristics (MacMaster et al., 2021). Evidence reported within this commentary suggests that bio-banding has the potential to be used as a method to alleviate some of the maturity-related differences in match-play running performance and technical-tactical capabilities of players' (Abbott et al., 2019, Lüdin et al., 2021, Towlson et al., 2020a, Towlson et al., 2021a, Towlson et al., 2021b). Which are both likely influenced by the highly individualised timing and development of key anthropometrical and physical fitness characteristics (Towlson et al., 2018). There is emerging evidence to suggest that using bio-banding to miss-match players' for maturity status may enhance the identification of key psycho-social characteristics of players' (Towlson et al., 2020a). That said, caution when using bio-banding is warranted. Evidence collated here and reported by MacMaster et al. (2021) suggests that bio-banding is an effective method to alleviate maturity-related anthropometric differences, which are closely associated to biological maturation pathways. However, the further removed the primary characteristic is from biological maturation pathways, the less effective bio-banding will be for reducing the within group variation of the target characteristic (figure 1). We strongly advise that practitioners use bio-banding as an adjunct to, and not a replacement for, chronological age-ordered group competition and should exist as part of a diverse games programme.

******Figure 1 about here******

Figure 1. A summary schematic to show the proposed diminishing magnitude of effect that bio-banding has on academy soccer player match-play characteristics (anthropometric, physical, psychological, technical, and tactical) distal to biological maturity.

Disclosure of interest

The authors report no conflict of interest.

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