Journal of Sports Sciences

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rjsp20

Player-labelling as a solution to overcome maturation selection biases in youth football

Dennis Lüdin, Lars Donath, Stephen Cobley, David Mann & Michael Romann

To cite this article: Dennis Lüdin, Lars Donath, Stephen Cobley, David Mann & Michael Romann (2022) Player-labelling as a solution to overcome maturation selection biases in youth football, Journal of Sports Sciences, 40:14, 1641-1647, DOI: 10.1080/02640414.2022.2099077

To link to this article: https://doi.org/10.1080/02640414.2022.2099077

Published online: 15 Aug 2022.

JOURNAL OF SPORTS SCIENCES
2022, VOL. 40, NO. 14, 1641–1647
https://doi.org/10.1080/02640414.2022.2099077

SPORTS PERFORMANCE

Player-labelling as a solution to overcome maturation selection biases in youth football

Dennis Lüdin[a], Lars Donath[b], Stephen Cobley[c], David Mann[d] and Michael Romann[a]

[a]Swiss Federal Institute of Sport Magglingen, Department of Elite Sport, Magglingen, Switzerland; [b]German Sport University Cologne, Department of Intervention Research in Exercise Training, Cologne, Germany; [c]University of Sydney, Department of Exercise and Sport Science, Sydney, Australia; [d]Vrije Universiteit Amsterdam, Faculty of Behavioural and Movement Sciences, Amsterdam, Netherlands

ABSTRACT

The fact that potentially skilled, but biologically later-maturing athletes are less likely to be selected into talent development programmes (TDP) can represent a failure of Talent Identification (TID) in sports. To overcome maturation selection biases, maturation independent TID should be established to include less mature, but talented athletes in TDP more frequently. Using a randomised parallel-group design, this study aimed to evaluate the effect of labelling under-11 (U_{11}) Swiss male youth football players (n = 24, age = 11.0 ± 0.3 years) via maturation-ordered shirt numbers during rank assessment by talent scouts (n = 83, scout experience = 4.8 ± 2.4 years). Following observation of video recorded selection tournaments, player-labelling "informed" scouts were significantly more likely to rank less mature players higher on their player potential, $t(81) = 2.57$, $p = .012$, $d = -0.6$, 95% CI [−1.00, −0.13], than "uninformed" scouts. As altered rankings assisted less mature players, player-labelling may offer a practical and feasible strategy to improve TID by removing possible maturation selection biases. To address maturation selection biases and the potential positive impact of player-labelling more broadly, further research on both male and female athletes in various age categories and sports contexts is recommended.

ARTICLE HISTORY
Accepted 3 July 2022

KEYWORDS
talent identification; talent development; maturation; selection bias; youth soccer

Introduction

Talent Identification (TID) and Development (TD) have increasingly become a central pillar of practice within sports organisations (De Bosscher et al., 2009; Johnston et al., 2018; Vaeyens et al., 2008). To stay competitive, football clubs implement TID processes to identify exceptional performers and enhance either team or club performance by optimising their TD (Ford et al., 2020; Williams & Reilly, 2000). Furthermore, scientific literature indicates that TID and TD approaches should be multi-dimensional in assessment and evaluation, dynamic in terms of prioritising different factors at different development time-points and be long-term orientated (Reilly et al., 2000; Unnithan et al., 2012). However, inter-individual differences in growth and maturation complicate TID and TD practices (Güllich & Cobley, 2017; Vandendriessche et al., 2012).

An over-representation of early maturing players is apparent in youth football academies (Hill et al., 2020; Johnson et al., 2017). A reason for this seems to be due to the temporary anthropometric and physiological advantages of those who enter puberty early and develop at high tempo (i.e., 11–16 years of age; Meylan et al., 2010). By comparison, skilled but late maturing players are less likely to be selected for academy programmes and/or more likely to be deselected (Unnithan et al., 2012). Such maturational inequalities in sports systems are also apparent across other physically demanding sports contexts (Baxter-Jones et al., 2020, 2002; Beunen & Malina, 2008; Malina, 1994).

In individual sports, applying corrective adjustment procedures has been shown to have the potential to eliminate the influence of maturation and chronological age differences in youth sports (S. Abbott et al., 2021; Romann & Cobley, 2015). When applying corrective adjustments for maturation differences, attention should be given to the choice of method for estimation of the individual's maturity status (Fransen et al., 2021). Unfortunately, due to the nature of team sports and inter-dependency between players, corrective adjustment procedures are not easily applicable in most cases. Thus, to date, efforts to minimise maturation biases in team sports consist of educating coaches and scouts to improve knowledge and raise awareness of the problem, measuring and evaluating maturation and adapting training and competition (Eisenmann et al., 2020). Most of these strategies were developed for national football associations (Cumming, 2018). However, to overcome maturation biases in team sports contexts, further strategies supporting maturation-independent selection in TID processes must be identified, and more effort is needed to embed best practices into youth sport programmes (Eisenmann et al., 2020; Vandendriessche et al., 2012).

To prevent selection biases in football, it seems logical to address the selection or talent scouting process. Scouts are often the first to identify and recruit young developing players into academies, and thus play a key role in the selection process. Therefore, modifying scout evaluation processes at the time point of selection could be a feasible strategy in practice. For instance, Mann and van Ginneken (2017) illustrated how

CONTACT Dennis Lüdin dennis.luedin@baspo.admin.ch Swiss Federal Institute of Sport Magglingen, Department of Elite Sport, Magglingen, Switzerland

numbering youth player's shirts according to the relative ages of the players within an annual cohort during talent selection games, was associated with preventing relative age effects in selection; specifically referring to the over and under-representation of the relatively oldest and youngest in a given cohort (Cobley et al., 2009; K. L. Smith et al., 2018). Here, the differential feature of a label seemed to help by conveying clear, explicit information for scouts to consider and incorporate in their player evaluation process. Similarly, maturation-based "player-labelling" could hypothetically address maturation selection biases.

Given the need to better account for inter-individual maturation differences in player selection and TID and to identify strategies to address maturation biases, the aim of the present randomised parallel-group design study was to evaluate the effect of youth football player-labelling to reduce a maturation-related selection bias during a normative youth soccer player evaluation and selection process. It was hypothesised that a maturation-related selection bias would be present in the absence of any player-labelling and that player-labelling would reduce any bias.

Methods

Participants

Scouts. Conducted in accordance with the guidelines of the Declaration of Helsinki and following institutional ethical approval (Swiss Federal Institute of Sport; Nr. 2021/130), the participants were N = 83 voluntarily participating Swiss talent scouts. All scouts had received talent scout education and were certified by the Swiss Football Association (SFA) M = 4.8 years (SD = 2.4) prior to participation. The role of the participating scouts was to identify and select Under-11 (U_{11}) youth football players from local "grassroots" football clubs into regional talent academies within the SFA system. Talent scouts from similar regions to where player selection tournaments were held were excluded to prevent any a priori knowledge of observed players from influencing their assessments. Initial invitation emails to participate in the study stated no more than the anticipated task of "watching recorded selection tournaments and assessing the potential of participating players."

Table 1. Characteristics of participating youth football players.

	Tournament A (n = 12)		Tournament B (n = 12)	
Characteristic	[Min, Max]	M ± SD	[Min, Max]	M ± SD
Age	[10.5, 11.4]	11.08 ± 0.28	[10.5, 11.3]	10.88 ± 0.30
%PAH	[78.0, 83.6]	80.5 ± 1.8	[77.1, 84.7]	80.0 ± 2.0
Height	[130.9, 152.2]	142.5 ± 6.2	[133.3, 161.8]	144.7 ± 7.3
Body mass	[27.7, 48.4]	37.0 ± 6.1	[24.4, 41.5]	34.8 ± 5.5
Mid-parent height	[163.5, 178.5]	171.3 ± 4.3	[163.5, 184.5]	174.1 ± 5.8

Notes. %PAH = percentage of predicted adult height.

Youth players. In Swiss football, the first step into the elite talent pathway is the selection into a youth talent development programme (TDP), typically during the transition from the U_{11} to the U_{12} age-group. Of the approximately 15,000 youth football players, 2,000 are selected for regional TDPs. This is the largest selection transition cut until the transition from U_{21} to professional football (Knäbel, 2014). Participating players (N = 24) were between 10.4 and 11.4 years of age (M = 11.0, SD = 0.3) and competed in two selection tournaments of the U_{11} age category. Three to seven days prior to a tournament, player maturation status was anthropometrically assessed using the Khamis–Roche method to estimate the percentage of predicted adult height (%PAH) attained (Khamis & Roche, 1994). The equation utilises current height, weight and mid-parent height to estimate %PAH. Measurements of height and weight were performed with standardised protocols using a stadiometer (Seca 217, Seca, Hamburg, Germany) and body mass scales, respectively (Seca 803, Seca, Hamburg, Germany). Parental heights were self-reported and voluntarily provided together with the parent's declaration of consent for their child to be video-recorded. Self-reported parental heights were adjusted for over-estimation before the application of the Khamis–Roche method (Epstein et al., 1995). Table 1 summarises player characteristics according to tournament A & B.

Procedures

Study Design. A randomised parallel-group design was applied and is summarised in Figure 1. Participating scouts were randomly allocated to observe online video recordings of players in selection tournaments in a set order (i.e., Tournament A then Tournament B). Before observing video

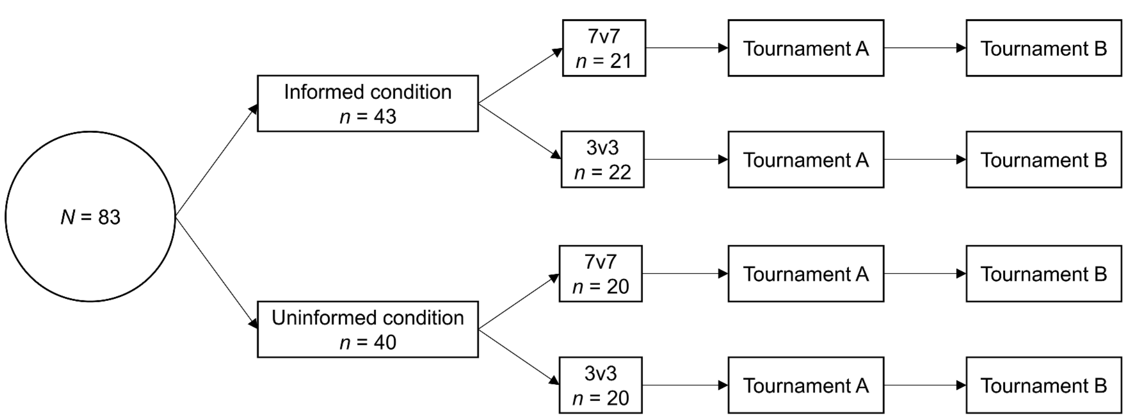

Figure 1. Summary overview of study design, participant conditions and experimental progression.

recordings, half of the scout sample was informed of the player-labelling procedure (=Informed condition), while the other half was not informed (=Uninformed condition).

Informed condition & player-labelling. Scouts in the informed group were specifically notified: "On game day, players were assigned numbers from 1 to 12 in order of their biological maturation. The player with the number 1 is biologically the oldest. The player with the number 12 is biologically the youngest." The shirt number assigned corresponded to the players' biological maturation in terms of %PAH relative to all players on both teams in the video observed. Shirt numbers were large and clearly printed (i.e., black on yellow or white on blue) on the front and back of player shirts. The %PAH-metric was explained, and an illustrated example was provided. In addition, the exact %PAH values of participating players in respective tournaments were provided in the ranking template, which was available during the ranking process. The "uninformed" scouts received the ranking template only, with no information on either shirt numbering or %PAH of players on the ranking template.

Player ranking procedure. Within each condition (informed and uninformed), half of the scouts were shown 7v7 matches and the other half 3v3 matches. A link was sent to scouts providing online access to standardised task instructions (i.e., how to navigate), the match recordings, and a player ranking template. Scouts were asked to rank observed players according to their potential within a tournament (i.e., from 1 to 12), resulting in a total of two rankings per scout (i.e., one for participating players of tournament A and one for players of tournament B). The specific task was "to evaluate players in selection games as similarly as when you are talent scouting". Scouts were instructed to: "Place the player you select first for a selection team at the top of the list. The player you select last for a selection team should be placed at the bottom of the ranking list." Informed scouts were only permitted video access after uninformed scouts had submitted their player rankings to prevent knowledge and awareness of the player-labelling process across the conditions.

Observed tournaments. Selection tournaments were held in accordance with the current practice of SFA youth football (Schweizerischer Fussballverband (Ed.), 2022). Each player participated in four 3v3 format and four 7v7 format games on a natural grass pitch. 3v3 games were conducted without goalkeepers and with two goals (0.8 m × 1.2 m) positioned three metres away from the sidelines. 3v3 games were played simultaneously on two pitches (20 × 28 m) and lasted 5 minutes, with 2 minute breaks between games. During the breaks, players rotated between pitches to change team composition. Subsequently, 7v7 games were played on one pitch (32 × 52 m) and lasted 10 minutes, with 2 minute breaks between games. During breaks, players rotated playing positions to ensure a variety of game situations. 7v7 games were played with goalkeepers, and one goal (2.0 × 5.0 m) was placed centrally at both ends of the field. Goalkeepers were not included in the scout evaluation process.

Video settings. Tournaments were filmed using four static mounted cameras located eight metres above the ground and four metres behind the side-lines. Additionally, two cameras were positioned on a tripod and were manually controlled by an operator to follow gameplay. Cameras were positioned to guarantee full game area coverage at any time during match play. For 3v3 games, static mounted cameras were placed both in the middle of one short-side and one long-side, and one manually controlled camera was positioned at the opposite long-side to the mounted camera. During 7v7 games, the four mounted cameras were placed on the long-side, a quarter of a way in from the corners. The two manually controlled cameras were placed diagonally across from each other, in front of two static cameras.

Data analysis

Quantification of the selection bias. A similar procedure to Mann and van Ginneken (2017) was applied to determine the presence of a maturation selection bias. Using Spearman's Rank correlation coefficient (r_s), scouts' rankings (i.e., ranking for tournaments A and B) were correlated with the ranking in descending order according to the player %PAH values (i.e., player's shirt numbers 1–12). First, the mean of the two calculated r_s was used to quantify a scout's individual selection bias. Subsequently, means of the scout biases were calculated according to each sub-group (informed, uninformed). An $r_s = 1$ corresponded to a scout ranking in descending order of player maturation (i.e., players' shirt numbers 1–12), thus indicating maturation bias. An $r_s = -1$ corresponded to a scout ranking in the ascending order of player maturation (i.e., players' shirt numbers 12 to 1), suggesting a reverse maturation bias. Meanwhile, $r_s = 0$ would indicate ranking being unrelated to player maturation. Further, according to Cohen (1988), r_s values were used to quantify the selection biases as small ($0.1 \le |r_s| < 0.3$), medium ($0.3 \le |r_s| < 0.5$) or large ($|r_s| \ge 0.5$).

Statistical analysis. The assumptions for using parametric statistics were met. A two-way between-subjects factorial ANOVA, using match format (3v3, 7v7) and player-labelling (informed, uninformed) as independent variables and selection bias as dependent variable, was used to initially examine the effect of match format and player-labelling on the scouts' biases. No initial significant main effect, $F(1,79) = 0.47$ $p = .49$, $\eta_p^2 = 0.01$, or interaction effect, $F(1,79) = 0.53$, $p = .47$, $\eta_p^2 = 0.01$, was evident for match format. Subsequently, match format was removed from the statistical analysis, and the means of selection biases between the informed and uninformed groups were analysed for statistical difference by two-sample *t*-tests. Furthermore, one-sample *t*-tests were used to determine if the mean was statistically different from zero for each group. The α-level for statistical significance was set at a p-value < .05. Cohen's d effect sizes (ES) of the mean difference and corresponding 95% confidence intervals (CI) were calculated. Cohen's d was defined as either a trivial ($|d| < 0.2$), small ($0.2 \le |d| < 0.5$), medium ($0.5 \le |d| < 0.8$) or large ($|d| \ge 0.8$) ES (Cohen, 1988). Selection biases according to informed and uninformed conditions were visualized using box plots.

Results

The twelve youth football players from tournament A (M_A = 80.5, SD_A = 1.9) did not significantly differ from the twelve youth football players from tournament B (M_B = 80.0, SD_B = 2.1) in the mean of their percentage of predicted adult height attained, $t(22) = 0.71$, $p = .48$, $d = 0.3$, 95% CI [–.5, 1.1], nor in any other characteristics presented in Table 1. Therefore, the mean r_s for the two tournaments was used to calculate each scout's individual selection bias.

Box-plots of the selection biases for the scouts depending on player-labelling are visualized in Figure 2.

The selection bias of the uninformed group of scouts was not significantly different from zero, $t(39) = -0.20$, $p = .85$, $d = -0.0$, 95% CI [–0.4, 0.3], whereas the bias of the informed group was significantly less than zero, with a medium ES, $t(42) = -4.14$, $p < .001$, $d = -0.6$, 95% CI [–0.9, –0.3].

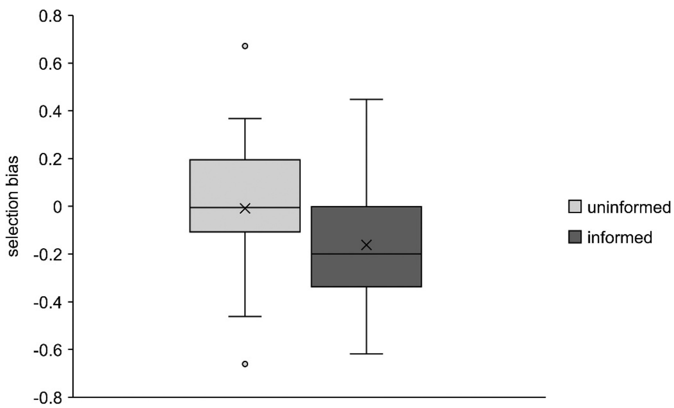

Figure 2. Box-plots of the mean (×), median, and interquartile range of the selection bias for the uninformed ($n = 40$) and informed ($n = 43$) group of scouts depending on player-labelling.

The 43 talent scouts who received information on player-labelling ($M_{\text{informed}} = -0.16$, $SD_{\text{informed}} = 0.27$) demonstrated a reversed mean selection bias significantly different from the mean selection bias of the 40 talent scouts with no information ($M_{\text{uninformed}} = -0.01$, $SD_{\text{uninformed}} = 0.29$) with a medium ES, $t(81) = 2.57$, $p = .01$, $d = -0.6$, 95% CI [–1.0, –0.1].

Discussion

The aim of the present study was to examine the effect of player-labelling on the magnitude of maturation selection bias when talent scouts evaluate the potential of youth football players. The results showed that talent scouts who were informed of the player-labelling were less likely to rank the more mature players as those with the most potential. However, it turned out that there was no maturation selection bias in the control group of scouts who had no information about the maturation of the players. Thus, scouts who were aware of the labelling ended up having a reverse maturation bias, whereby they were more likely to select less mature players. Nonetheless, the results of the study show that player-labelling is a powerful means of altering the rankings made by talent scouts and would likely be a useful strategy where a bias is present.

The results offer insights into the potential to mitigate biases in talent selection in sport. Besides the present study, only one previous paper has investigated the effect of player-labelling on talent selection decisions by 25 Dutch youth football talent scouts from a single talent academy (Mann & van Ginneken, 2017). In our study, we extended this by examining the effect of player-labelling in a sample of 83 Swiss youth football scouts from around the country. In contrast to the present study, however, the aim of Mann & van Ginneken's study was to mitigate the selection bias associated with the relative age effect (RAE). Mann and van Ginneken (2017) observed a large effect size for reduction in the bias to select players born earlier in a chronological age category, when using player-labelling (i.e., age-order shirt numbering). As in the Dutch study, the presented data showed a significant effect of player-labelling whereby scouts were more likely to select players with higher shirt numbers (i.e., those who were less mature), albeit with only a medium effect size. This discrepancy between the two studies could be explained by differences between the uninformed control groups. There was a large bias associated with the RAE in the Dutch football academy, whereas no maturation bias was found in the uninformed group of scouts in the present study. The lack of any bias in the present control group is in contrast to existing studies where maturation selection biases have been found in the transition from the U_{11} to U_{12} age category (Hill et al., 2020; Johnson et al., 2017; Müller et al., 2017). The player characteristics shown in Table 1 correspond to the expected values observed in the normal population for that age group (Sanders et al., 2017), as such the sample of players was not biased towards early or late maturing players. It may be that any performance advantages for early maturing players may be relatively smaller for the U_{11} boys when compared to older age. This may be due to the fact that most U_{11} boys were unlikely to have reached their growth spurt, and thus, the relative differences in maturation may be small (Malina et al., 2005; Sanders et al., 2017). In boys, the onset of puberty (85.0 to 89.0 percentage of predicted adult height (% PAH)), the period of growth spurt (89.0% to 95.0% PAH) and the age at peak height velocity (90.0% PAH), which are associated with the greatest individual biological maturation differences, normally occur later than U_{11} (i.e., U_{12} to U_{16} age categories; Cumming et al., 2017; Sanders et al., 2017). Another reason could be that the more maturing players in their very early stages of the onset of puberty experienced a negative impact on their skill performance due to delays or regressions in some sensorimotor mechanisms (i.e., adolescent motor awkwardness; Quatman-Yates et al., 2012). Therefore, the maturation selection bias should be expected to more likely occur in older age categories than U_{11}. Indeed, this assumption is supported by a study by Hill et al. (2020), who studied the development of maturation selection bias throughout the age categories of an English football academy. The bias in the academy increased steadily from the U_{11} to the U_{16} age category, where over 50% of players were classified as early maturing. Thus, future studies on the effectiveness of player-labelling in those age categories are needed.

Previous data indicated that scouts manage to correctly incorporate player-labelling to provide an efficient Talent Identification (TID), i.e., that the selection bias is absent when applied (Mann & van Ginneken, 2017). However, the present results show that player-labelling can lead not only to a mitigation but even a reverse selection bias in talent scouts. The highly subjective nature of TID (Bergkamp et al., 2021; Larkin & Reeves, 2018; Roberts et al., 2019) may complicate the generally valid explanation of how player-labelling could work. Possibly, a range of cognitive biases affect a scout's evaluation of sports potential because their ability to process all actions during a game is limited (Plessner & Haar, 2006). This limitation may be exaggerated by other factors associated with scouting such as time pressure, social comparisons, or the scout's viewing position next to the pitch (Plessner & Haar, 2006). In the current study, the informed scouts were told about player-labelling just before watching the games and ranking the players. Therefore, the players' inter-individual maturation differences were the most *recent* indicators relevant for their upcoming task. Further, the meaning of the shirt numbers ensured a continuous presence of the associated relative biological maturation of the players during the games. While watching those selection games, informed scouts were *frequently* made aware of the inter-individual differences of the participating players (e.g., duels for the ball). *Recent and frequent* knowledge related to TID may dominate the decision-making of talent scouts (Bergus et al., 2002; Plessner & Haar, 2006; Smith et al., 2009). Frequency and recency effects could therefore explain why player-labelling is effective. All participating scouts from Mann & van Ginneken's study knew that it was a study about the RAE with two of the groups of scouts told the birth dates of the participating players prior to their evaluations. And yet, only the group who was additionally informed about the player-labelling showed no selection bias. These findings suggest that a frequency rather than a recency effect was primarily responsible for the impact that player-labelling had on the scouts' selections.

The findings of the present study are limited to the sample where player-labelling was applied. Participating players were between 10.5 and 11.4 years of age with a %PAH spread of 77.1% to 84.7%. Caution should be taken with the expected effects of player-labelling applied for older age ranges and/or wider spreads of %PAH. Future studies about the application of player-labelling in other sports and older age categories would be interesting as it offers a rare measure to potentially overcome selection biases linked to talent scouting. Furthermore, the differences of the shirt numbers do not correspond one-to-one to the differences of the corresponding %PAH values because the individual %PAH values are a non-linear ascending function compared to the linear ascending function of the shirt numbers. Thus, the difference between consecutive %PAH may not be constant as the shirt numbers would suggest. As such, a proposed, however not perfect solution to counteract this misconception, would be to miss out numbers if a %PAH difference between two consecutive players exceeded a predefined threshold value.

In practice, staff responsible for TID, such as coaches and talent scouts, should consider inter-individual maturation differences in youth athletes. Thus, applicable tools are needed, such as bio-banding, a novel, promising approach to account for inter-individual differences in biological development in team sports (Cumming et al., 2017; Malina et al., 2019). This classification system is based on player maturation rather than just chronological age and thereby creates an environment in training and competition, in which late as well as early maturing players can train and compete with and against others with comparable maturation (Abbott et al., 2019; Bradley et al., 2019; Cumming et al., 2018; Lüdin et al., 2021; MacMaster et al., 2021; Romann et al., 2020; Towlson et al., 2021a, 2021b). Player-labelling adds a practical measure that can be applied to consider maturation-related differences and an associated maturation bias during TID. Whereas bio-banding can be used as a tool to enhance talent development programmes (TDP), by retaining late maturing players, player-labelling offers a possibility to consider inter-individual maturation differences during selection decisions. However, it cannot simply be supposed that the application of player-labelling helps talent scouts to accurately incorporate inter-individual maturation differences, as this could cause a reverse bias to select less mature players. Therefore, clarifying whether or not there is a selection bias at the affected transition stage is recommended, before applying player-labelling. Player-labelling and bio-banding could then be used by staff responsible for TID and TDP as complementary tools to retain, develop and select late maturing, but potentially talented players.

Conclusion

By labelling under-11 youth football players via maturation-ordered shirt numbers, Swiss talent scouts were more likely to rank less mature youth football players as those with the most potential. During the process of scout evaluations, frequent information about inter-individual maturation differences seems promising as a means to alter the scouts' perceptions of player potential. Thus, player-labelling adds a much-needed practical solution to address maturation selection biases in sports Talent Identification (TID). Besides the use of player-labelling to improve sports TID, grouping players according to maturation-related indicators other than just chronological age, so-called bio-banding, can be applied in talent development programmes (TDP). Combining player-labelling and bio-banding could be used to retain, develop and select late maturing, but potentially talented athletes into sports TDP.

Acknowledgments

The authors would like to thank all talent scouts for their participation in the study. We also thank the coaches, staff and players of the clubs for their efforts during the selection tournaments. Furthermore, we want to acknowledge Stefan Brunner and Patrick Bruggmann of the Swiss Football Association for their support and cooperation during the project.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The author(s) reported that there is no funding associated with the work featured in this article.

ORCID

Dennis Lüdin http://orcid.org/0000-0002-7960-8160
Stephen Cobley http://orcid.org/0000-0001-6099-392X
Michael Romann http://orcid.org/0000-0003-4139-2955

References

Abbott, W., Williams, S., Brickley, G., & Smeeton, N. (2019). Effects of bio-banding upon physical and technical performance during soccer competition: a preliminary analysis. *Sports*, *7*(8), 193. https://doi.org/10.3390/sports7080193

Abbott, S., Castiglioni, M., Cobley, S., Halaki, M., Hogan, C., Mitchell, L., Romann, M., Salter, J., & Yamauchi, G. (2021). Removing maturational influences from female youth swimming: The application of corrective adjustment procedures. *Journal of Science and Medicine in Sport*, *24* (1) , S38. https://doi.org/10.1016/j.jsams.2021.09.098

Baxter-Jones, A. D. G., Thompson, A. M., & Malina, R. M. (2002). Growth and maturation in elite young female athletes. *Sports Medicine and Arthroscopy Review*, *10*(1), 42–49. https://doi.org/10.1097/00132585-200210010-00007

Baxter-Jones, A. D. G., Barbour-Tuck, E. N., Dale, D., Sherar, L. B., Knight, C. J., Cumming, S. P., Ferguson, L. J., Kowalski, K. C., & Humbert, M. L. (2020). The role of growth and maturation during adolescence on team-selection and short-term sports participation. *Annals of Human Biology*, *47*(4), 316–323. https://doi.org/10.1080/03014460.2019.1707870

Bergkamp, T. L. G., Frencken, W. G. P., Niessen, A. S. M., Meijer, R. R., & den Hartigh, R. J. R. (2021). How soccer scouts identify talented players. *European Journal of Sport Science*, 28, 1–11. https://doi.org/10.1080/17461391.2021.1916081

Bergus, G. R., Levin, I. P., & Elstein, A. S. (2002). Presenting risks and benefits to patients: The effect of information order on decision making. *Journal of General Internal Medicine*, *17*(8), 612–617. https://doi.org/10.1046/j.1525-1497.2002.11001.x

Beunen, G., & Malina, R. M. (2008). Growth and biologic maturation: Relevance to athletic performance . In Helge Hebestreit, Oded Bar-Or, *The Young Athlete* (pp. 3–17). Blackwell Publishing Ltd.

Bradley, B., Johnson, D., Hill, M., McGee, D., Kana-ah, A., Sharpin, C., Sharp, P., Kelly, A., Cumming, S. P., & Malina, R. M. (2019). Bio-banding in academy football: Player's perceptions of a maturity matched tournament. *Annals of Human Biology*, *46*(5), 400–408. https://doi.org/10.1080/03014460.2019.1640284

Cobley, S., Baker, J., Wattie, N., & McKenna, J. (2009). Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports Medicine*, *39*(3), 235–256. https://doi.org/10.2165/00007256-200939030-00005

Cohen, J. (1988). *Statistical power analysis for the behavioural sciences (2nd edn)(Hillsdale*. NJ, Lawrence Earlbaum).

Cumming, S. P., Lloyd, R. S., Oliver, J. L., Eisenmann, J. C., & Malina, R. M. (2017). Bio-banding in sport: Applications to competition, talent identification, and strength and conditioning of youth athletes. *Strength & Conditioning Journal*, *39*(2), 34–47. https://doi.org/10.1519/SSC.0000000000000281

Cumming, S. P. (2018). A game plan for growth: How football is leading the way in the consideration of biological maturation in young male athletes. *Annals of Human Biology*, *45*(5), 373–375. https://doi.org/10.1080/03014460.2018.1513560

Cumming, S. P., Brown, D. J., Mitchell, S., Bunce, J., Hunt, D., Hedges, C., Crane, G., Gross, A., Scott, S., Franklin, E., Breakspear, D., Dennison, L., White, P., Cain, A., Eisenmann, J. C., & Malina, R. M. (2018). Premier League Academy soccer players' experiences of competing in a tournament bio-banded for biological maturation. *Journal of Sports Sciences*, *36*(7), 757–765. https://doi.org/10.1080/02640414.2017.1340656

De Bosscher, V., De Knop, P., Van Bottenburg, M., Shibli, S., & Bingham, J. (2009). Explaining international sporting success: An international comparison of elite sport systems and policies in six countries. *Sport Management Review*, *12*(3), 113–136. https://doi.org/10.1016/j.smr.2009.01.001

Eisenmann, J. C., Till, K., & Baker, J. (2020). Growth, maturation and youth sports: Issues and practical solutions. *Annals of Human Biology*, *47*(4), 324–327. https://doi.org/10.1080/03014460.2020.1764099

Epstein, L. H., Valoski, A. M., Kalarchian, M. A., & McCurley, J. (1995). Do children lose and maintain weight easier than adults: A comparison of child and parent weight changes from six months to ten years. *Obesity Research*, *3*(5), 411–417. https://doi.org/10.1002/j.1550-8528.1995.tb00170.x

Ford, P. R., Bordonau, J. L. D., Bonanno, D., Tavares, J., Groenendijk, C., Fink, C., Gualtieri, D., Gregson, W., Varley, M. C., Weston, M., Lolli, L., Platt, D., & Di Salvo, V. (2020). A survey of talent identification and development processes in the youth academies of professional soccer clubs from around the world. *Journal of Sports Sciences*, *38*(11–12), 1269–1278. https://doi.org/10.1080/02640414.2020.1752440

Fransen, J., Skorski, S., & Baxter-Jones, A. D. G. (2021). Estimating is not measuring. The use of non-invasive estimations of somatic maturity in youth football. *Science and Medicine in Football*, *5*(4), 262. doi:10.1080/24733938.2021.1975808

Güllich, A., & Cobley, S. (2017). On the efficacy of talent identification and talent development programmes. In Joseph Baker, Stephen Cobley, Jörg Schorer, Nick Wattie(Eds.), *Routledge Handbook of Talent Identification and Development in Sport* (pp. 80–98). Routledge.

Hill, M., Scott, S., Malina, R. M., McGee, D., & Cumming, S. P. (2020). Relative age and maturation selection biases in academy football. *Journal of Sports Sciences*, *38*(11–12), 1359–1367. https://doi.org/10.1080/02640414.2019.1649524

Johnson, A., Farooq, A., & Whiteley, R. (2017). Skeletal maturation status is more strongly associated with academy selection than birth quarter. *Science and Medicine in Football*, *1*(2), 157–163. https://doi.org/10.1080/24733938.2017.1283434

Johnston, K., Wattie, N., Schorer, J., & Baker, J. (2018). Talent identification in sport: A systematic review. *Sports Medicine*, *48*(1), 97–109. https://doi.org/10.1007/s40279-017-0803-2

Khamis, H. J., & Roche, A. F. (1994). Predicting adult stature without using skeletal age: the Khamis-Roche method. *Pediatrics*, *94*(4), 504–507. doi:10.1542/peds.94.4.504

Knäbel, P. (2014). *Das Nachwuchsförderungskonzept des Schweizerischen Fussballverbandes*. https://www.football.ch/portaldata/27/Resources/dokumente/nachwuchsfoerderung/footeco/de/5.35._Nachwuchsfoerderungskonzept.pdf

Larkin, P., & Reeves, M. J. (2018). Junior-elite football: Time to re-position talent identification? *Soccer & Society*, 19(8), 1–10. https://doi.org/10.1080/14660970.2018.1432389

Lüdin, D., Donath, L., Cobley, S., & Romann, M. (2021). Effect of bio-banding on physiological and technical-tactical key performance indicators in youth elite soccer. *European Journal of Sport Science*, 1–9. https://doi.org/10.1080/17461391.2021.1974100

MacMaster, C., Portas, M., Parkin, G., Cumming, S., Wilcox, C., & Towlson, C. (2021). The effect of bio-banding on the anthropometric, physical fitness and functional movement characteristics of academy soccer players. *PLOS ONE*, *16*(11), e0260136. doi:10.1371/journal.pone.0260136

Malina, R. M. (1994). Physical Growth and biological maturation of young athletes. *Exercise and Sports Sciences Reviews*, *22*(1), 280–284. https://doi.org/10.1249/00003677-199401000-00012

Malina, R. M., Cumming, S. P., Morano, P. J., Barron, M., & Miller, S. J. (2005). Maturity status of youth football players: a noninvasive estimate. *Medicine & Science in Sports & Exercise*, *37*(6) 1044–1052. doi:10.1249/01.mss.0000171622.45134.cb

Malina, R. M., Cumming, S. P., Rogol, A. D., Coelho-e-Silva, M. J., Figueiredo, A. J., Konarski, J. M., & Kozieł, S. M. (2019). Bio-banding in youth sports: background, concept, and application. *Sports Medicine*, *49* (11), 1671–1685. https://doi.org/10.1007/s40279-019-01166-x

Mann, D. L., & van Ginneken, P. J. M. A. (2017). Age-ordered shirt numbering reduces the selection bias associated with the relative age effect. *Journal of Sports Sciences*, *35*(8), 784–790. https://doi.org/10.1080/02640414.2016.1189588

Meylan, C., Cronin, J., Oliver, J., & Hughes, M. (2010). Talent identification in soccer: The role of maturity status on physical, physiological and technical characteristics. *International Journal of Sports Science & Coaching*, *5* (4), 571–592. https://doi.org/10.1260/1747-9541.5.4.571

Müller, L., Gonaus, C., Perner, C., Müller, E., & Raschner, C. (2017). Maturity status influences the relative age effect in national top level youth alpine ski racing and soccer. *Plos One*, *12*(7), e0181810. https://doi.org/10.1371/journal.pone.0181810

Plessner, H., & Haar, T. (2006). Sports performance judgments from a social cognitive perspective. *Psychology of Sport and Exercise*, *7*(6), 555–575. https://doi.org/10.1016/j.psychsport.2006.03.007

Quatman-Yates, C. C., Quatman, C. E., Meszaros, A. J., Paterno, M. V., & Hewett, T. E. (2012). A systematic review of sensorimotor function during adolescence: A developmental stage of increased motor awkwardness? *British Journal of Sports Medicine*, *46*(9), 649–655. doi:10.1136/bjsm.2010.079616

Reilly, T., Williams, A. M., Nevill, A., & Franks, A. (2000). A multidisciplinary approach to talent identification in soccer. *Journal of Sports Sciences*, *18*(9), 695–702. https://doi.org/10.1080/02640410050120078

Roberts, A. H., Greenwood, D. A., Stanley, M., Humberstone, C., Iredale, F., & Raynor, A. (2019). Coach knowledge in talent identification: A systematic review and meta-synthesis. *Journal of Science and Medicine in Sport*, *22*(10), 1163–1172. https://doi.org/10.1016/j.jsams.2019.05.008

Romann, M., & Cobley, S. (2015). Relative age effects in athletic sprinting and corrective adjustments as a solution for their removal. *PLOS ONE*, *10*(4), e0122988. doi:10.1371/journal.pone.0122988

Romann, M., Lüdin, D., & Born, D.-P. (2020). Bio-banding in junior soccer players: A pilot study. *BMC Research Notes*, *13*(1), 1–5. https://doi.org/10.1186/s13104-020-05083-5

Sanders, J. O., Qiu, X., Lu, X., Duren, D. L., Liu,R. W., Dang, D., , and Cooperman, D. R. (2017). The uniform pattern of growth and skeletal maturation during the human adolescent growth spurt. *Scientific Reports*, *7*(1), 1–9. doi:10.1038/s41598-017-16996-w

Schweizerischer Fussballverband (Ed.). (2022). *Ausführungsbestimmungen der Technischen Abteilung zu den Spielfeldgrössen in der Préformation (Junioren D) und im Kinderfussball (Junioren E und F)*. https://org.football.ch/portaldata/28/Resources/Dokumente/DE/05_Junioren_Breitenfussball/5.5_Ausfuehrungsbestimmungen_Spielfeldgroessen.pdf

Smith, M. J., Greenlees, I., & Manley, A. (2009). Influence of order effects and mode of judgement on assessments of ability in sport. *Journal of Sports Sciences*, *27*(7), 745–752. https://doi.org/10.1080/02640410902939647

Smith, K. L., Weir, P. L., Till, K., Romann, M., & Cobley, S. (2018). Relative age effects across and within female sport contexts: A systematic review and meta-analysis. *Sports Medicine*, *48*(6), 1451–1478. https://doi.org/10.1007/s40279-018-0890-8

Towlson, C., MacMaster, C., Gonçalves, B., Sampaio, J., Toner, J., MacFarlane, N., , and Abt, G. (2021a). The effect of bio-banding on physical and psychological indicators of talent identification in academy soccer players. *Science and Medicine in Football*, *5*(4), 280–292. doi:10.1080/24733938.2020.1862419

Towlson, C., MacMaster, C., Gonçalves, B., Sampaio, J., Toner, J., MacFarlane, N., . . . Abt, G. (2021b). The effect of bio-banding on technical and tactical indicators of talent identification in academy soccer players. *Science and Medicine in Football*, 1–14. https://doi.org/10.1080/24733938.2021.2013522

Unnithan, V., White, J., Georgiou, A., Iga, J., & Drust, B. (2012). Talent identification in youth soccer. *Journal of Sports Sciences*, *30*(15), 1719–1726. https://doi.org/10.1080/02640414.2012.731515

Vaeyens, R., Lenoir, M., Williams, A. M., & Philippaerts, R. M. (2008). Talent identification and development programmes in sport: current models and future directions. *Sports Medicine*, *38*(9), 703–714. https://doi.org/10.2165/00007256-200838090-00001

Vandendriessche, J. B., Vaeyens, R., Vandorpe, B., Lenoir, M., Lefevre, J., & Philippaerts, R. M. (2012). Biological maturation, morphology, fitness, and motor coordination as part of a selection strategy in the search for international youth soccer players (age 15–16 years). *Journal of Sports Sciences*, *30*(15), 1695–1703. https://doi.org/10.1080/02640414.2011.652654

Williams, A. M., & Reilly, T. (2000). Talent identification and development in soccer. *Journal of Sports Sciences*, *18*(9), 657–667. https://doi.org/10.1080/02640410050120041