# Players', coaches' and parents' perceptions on a single bio-banding training session in highly-trained female soccer players

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**Skeletal age | Talent development | Maturation | Female football**

## Headline

Individual differences in growth and biological maturation among youth athletes of the same chronological age are well documented (1–3). In male youth athletes, biological maturation has been shown to substantially influence physical performance (4), playing opportunities (5), and evaluation by coaches (6). Bio-banding is a strategy that attempts to address this variation by grouping athletes based on indicators of somatic or skeletal maturity instead of the traditional chronological age groups (7). In male youth soccer, several studies have examined the effect of bio-banding on players' (8–10) and practitioners' perceptions (11). The majority of these studies have reported positive perceptions of bio-banding among players, coaches, and parents (12). In addition, bio-banding has been shown to impact technical and tactical parameters (13) and match running performance 10 within male youth soccer players. However, it is unclear, whether these findings translate to female youth athletes, given the limited research in this area (14). As such, to date, no study specifically investigated players', coaches' and parents' perceptions of bio-banding in female youth soccer.

## Aim

This study examined how players, coaches, and parents perceived and evaluated a bio-banded training session involving highly trained female youth soccer players aged 9 to 15 years.

## Methods

### Partcipants

A total of 42 female youth soccer players from the U12 (n=18), U14 (n=12), and U15 (n=12) age groups of a professional German soccer club participated in the study (age: 12.3±1.4 years; body mass: 44.8±10.0 kg; standing height: 154.6±9.0 cm). Players typically completed two to three training sessions and one official match per week and occasionally trained and competed for their local home clubs. Goalkeepers (n=5) were excluded from the analyses as the player questionnaire was specifically designed for outfield players.

In addition, 6 coaches and the coordinator of the academy participated in the study, including head coaches (n=2; U14: n=1, U15: n=1; U12 head coach was absent due to sickness) and assistant coaches (n=4; U12: n=1, U14: n=2, U15: n=1). Coaches held UEFA C or B licences and had no prior experience with bio-banding training sessions, matches, or tournaments.

Finally, 30 parents who attended the bio-banding training session were invited to participate. This represented a convenience sample, as parents had been informed two weeks before the session that participation would be voluntary but encouraged. Written informed consent was obtained from all players and parents before data collection.

### Study design

This study followed an observational, cross-sectional approach. Prior to the session, players and coaches received information about the rationale and concept of bio-banding as well as the objectives of the training session. Parents received equivalent information during the session. Questionnaire data were collected during the session (parents) or immediately afterwards (players and coaches), whereas skeletal age assessments were conducted within the three weeks prior to the session. Questionnaires were custom-made and completed either online (coaches and parents) or on paper (players).

### Procedures

#### Anthropometry and Skeletal Age

Standing height and body mass were measured to the nearest 0.1 cm and 0.1 kg, respectively, using a portable stadiometer (seca 213, Seca GmbH, Hamburg, Germany) and scale (seca 813, Seca GmbH, Hamburg, Germany) following standardised ISAK procedures. Skeletal age was assessed using the BAUSport™ ultrasound system (SonicBone Medical Ltd, Tel-Aviv, Israel) by the same trained examiner within three weeks prior to the bio-banding training session. Details of the assessment procedure and its validity against the Fels method have been reported previously (15).

### Bio-banding training session

Based on the skeletal age assessments, players were allocated into four bio-banding groups of similar biological maturity while maintaining approximately equal group sizes (n=9, 11, 12, and 10). Two players were reassigned from bio-banding group 1 to bio-banding group 2 based on the head coaches' judgement that group 1 would not provide a sufficient developmental challenge. The training session comprised a 15-minute warm-up, a passing exercise for familiarisation with the bio-banding group teammates (15 min), an individual duel drill (1v1, 15 min), numerical mismatch games (2v1 and 3v2, 15 min), and a medium-sided game (30 min). Coaches were instructed to use large playing areas during the duel drill, mismatch games, and medium-sided game to allow physical capacities to be more fully expressed within the maturity-homogeneous groups. All four groups trained simultaneously on the same pitch. Head and assistant coaches were randomly assigned to the bio-banding groups to avoid systematic effects of coach allocation.

### Players', coaches' and parents' questionnaire

Three custom-made questionnaires assessed players', coaches', and parents' perceptions of the bio-banding training session compared with usual chronological age group training. All Likert-scale items were answered on a 5-point scale (-2=Strongly disagree, -1=Somewhat disagree, 0=Neither agree nor disagree, 1=Somewhat agree, 2=Strongly agree), with an additional "I am not sure" option. All questionnaires were administered in German and translated into English for reporting purposes. Some items were adapted from previous research evaluating perceptions of bio-banding formats in youth sport (11,16–18).

The player questionnaire consisted of 24 items covering social, psychological, technical/tactical, and physical perceptions, as well as players' conceptual understanding of bio-banding and their perceived developmental value of the format. Of these, 18 items were Likert-scaled and 6 were open-ended. The coach questionnaire consisted of 25 Likert-scale items and 2 open-ended items covering confidence in one-on-one situations, leadership and responsibility, coping with frustration and mistakes, physical and technical challenge, injury risk, and on-ball expression. Most items were presented from two perspectives: chronologically older players training with younger players due to their lesser biological maturity ("played down") and chronologically younger players training with older players due to their advanced biological maturity ("played up"). The parent questionnaire consisted of 9 Likert-scale items covering concerns about their child training with chronologically older or younger players, perceived effects on their child's confidence and emotional experience, and overall evaluation of bio-banding as a training format.

### Statistical analyses

Data are presented as frequencies as absolute numbers or percentages as well as mean with standard deviation (SD).

### Descriptive statistics

Frequency distributions of the Likert scale items were calculated for each questionnaire item to provide a descriptive overview of player, coach, and parent perceptions. Responses are presented as the percentage of respondents selecting each response category of the 5-point Likert scale per item.

### Maturity advantage/disadvantage and regression modelling

To illustrate the effect of the bio-banding grouping on each player's relative maturity position, two difference scores were calculated per player: the difference between her skeletal age and the mean skeletal age of her chronological age group, and the difference between her skeletal age and the mean skeletal age of her bio-banding group. The direction and magnitude of the shift between these two values were visualised for each player.

To examine whether these shifts in relative maturity were associated with players' perceptions of the bio-banding session, a separate linear regression model was fitted for each item of the player questionnaire. The Likert response was modelled as a function of two maturity reference frames and their interaction: a player's skeletal age difference from the mean chronological age of her chronological age group and from the mean skeletal age of her bio-banding group. The interaction tests whether the association between the within-bio-banding-group reference frame and the response differs depending on a player's within-chronological-age-group reference frame. Model fit is reported as $R^2$. Given the modest sample size, all models were re-fitted using Huber M-estimation (tuning constant k=1.345).

As a sensitivity analysis, an alternative model approach was computed for each item, treating the within-chronological-age-group reference frame as a covariate and a discrepancy score as the main predictor. The discrepancy score was calculated as the within-bio-banding-group reference frame minus the within-chronological-age-group reference frame, capturing the shift in relative maturity position induced by bio-banding. This approach offers a more accessible interpretation but does not allow the independent contribution of the two reference frames to be examined separately.

### Software

All statistical analyses were conducted in R (version 4.5.0) using RStudio (version 1.2.5033).

## Results

Given the number of questionnaire items, respondent groups, and regression models, we created an interactive web application to allow dynamic exploration and visualisation of all results. The application is available under this link.

### Player perceptions

The majority of players reported feeling comfortable in their bio-banded group (93% agreement, Q1), enjoying the training session (85% agreement, Q12), and understanding the concept of bio-banding (95% agreement, Q10). A majority indicated that the training helped them deal with mistakes better (69% agreement, Q3) and agreed that regular bio-banding would support their long-term development (76% agreement, Q23). Players largely disagreed with bio-banding weakening their self-confidence (60% disagreement, Q2), finding it difficult to be away from their usual teammates (69% disagreement, Q4), and feeling pressured by other players in the group (68% disagreement, Q7). Responses were more divided regarding physical assertion (52% disagreement vs. 35% agreement, Q5), the need to apply technique faster (35% disagreement vs. 40% agreement, Q6), and perceived physical (43% agreement, Q21) or technical challenge (38% agreement, Q22).

For five items, greater perceived challenge and stronger endorsement of long-term developmental value were associated with higher relative maturity within the chronological age group and lower relative maturity within the bio-banded group (Q5: $\beta$=+0.54 and -1.18, $R^2$=0.24; Q6: $\beta$=+0.54 and -0.77, $R^2$=0.26; Q21: $\beta$=+0.60 and -0.65, $R^2$=0.31; Q22: $\beta$=+0.46 and -0.73, $R^2$=0.29; Q23: $\beta$=+0.45 and -0.79, $R^2$=0.30). In contrast, items capturing general acceptance and experience (Q1, $R^2$=0.07; Q4, $R^2$=0.04; Q7, $R^2$=0.04; Q10, $R^2$=0.02; Q12, $R^2$=0.08; Q20, $R^2$=0.07) showed no meaningful association with either reference frame.

The sensitivity analysis using the alternative specification with the discrepancy score yielded convergent results for all items and can be explored in the interactive web application.

### Coach perceptions

Coaches generally viewed bio-banding positively. Five of seven agreed that grouping by biological maturity was a positive challenge for the players (Q1), and six of seven supported integrating bio-banding into regular training (Q12). Coaches largely disagreed that age differences led to peer pressure (four of seven, Q3) and that chronologically older players faced a higher injury risk (six of seven, Q14). Five of seven coaches observed that chronologically older players were better able to compete physically due to similar biological maturity (Q11). For the dual-perspective items, coaches reported

predominantly neutral responses on leadership (four of seven neutral per item, Q6/Q7), coping with frustration and mistakes (five of seven neutral per item, Q8/Q9), and on-ball expression (four and three of seven neutral, Q16/Q22). Three of seven coaches indicated that the training session changed their perspective on one or more players, with the remaining four responding neutrally (Q13).

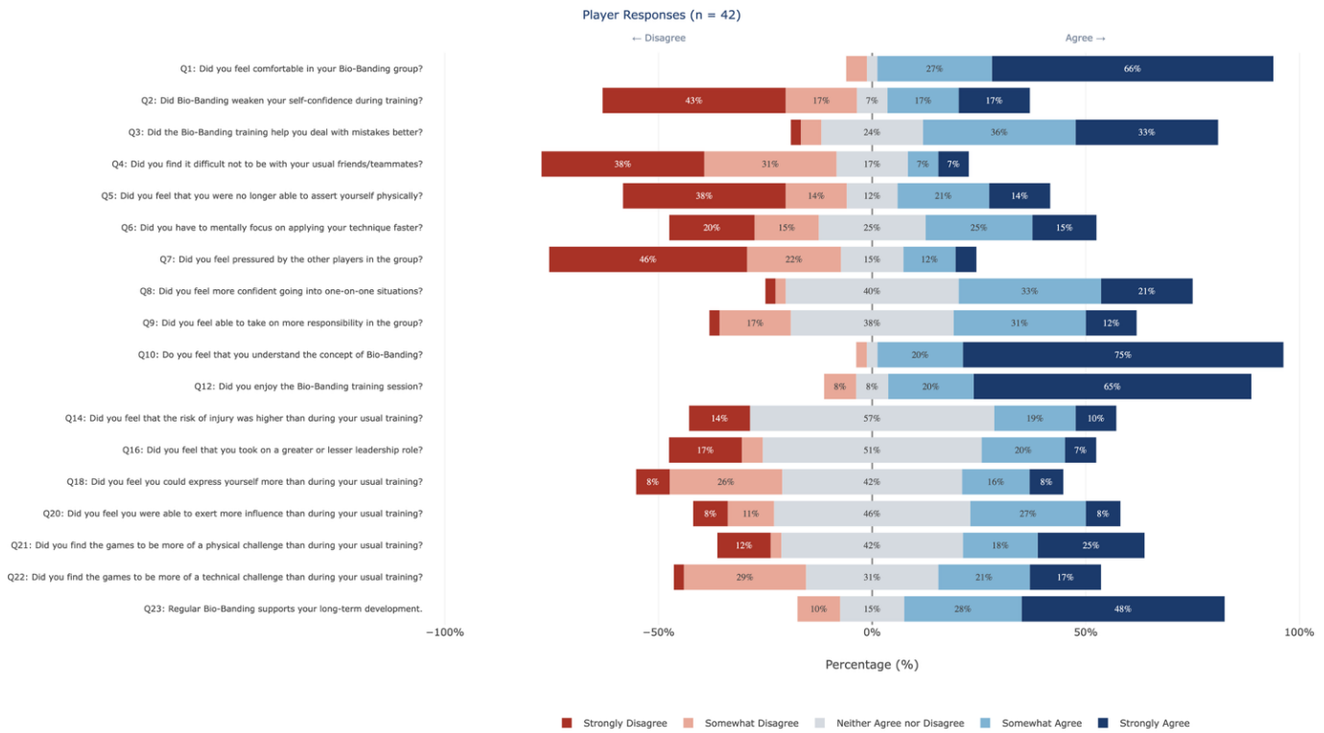


**Fig. 1. Frequency distribution of Likert-scale responses across all 18 items of the player questionnaire (n=42). Bars represent the percentage of respondents selecting each response category, centred at the neutral midpoint.**

### Parent perceptions

Parents reported few concerns about their child training with chronologically older (67% disagreement, Q1) or younger players (63% disagreement, Q2), and the majority viewed the bio-banding session as a positive training experience compared with regular age group training (63% agreement, Q3). Parents largely disagreed that their child found it difficult not being with her usual teammates (53% disagreement, Q4). Responses regarding observed confidence gains (Q5) and perceptions of mistakes being viewed as part of the learning process (Q6) were predominantly neutral (63% and 60% neutral, respectively, with 30% agreement each). Parents did not express notable concerns about negative effects on their child's self-confidence (63% disagreement, Q7), mental overload (73% disagreement, Q8), or frustration (60% disagreement, Q9).

## Discussion

The primary aim of the present study was to examine players', coaches', and parents' perceptions of a bio-banded training session in highly trained female youth soccer players aged 9 to 15 years. The first main finding of this study was that players generally reported positive perceptions across physical, technical/tactical, and social dimensions. Additionally, a player's relative maturity within her chronological age and within her bio-banded group were both meaningfully associated with her perceptions of the physical and technical demands as well as the long-term developmental value. Coaches viewed bio-banding positively and supported its integration into regular training. Lastly, parents reported few concerns about the bio-banded training format. Collectively, our findings show that players, coaches, and parents viewed a single bio-banded training session positively, although players' perceptions of the physical and technical demands were shaped by two distinct maturity reference frames.

Similar to previous research in male youth soccer (8,9), ice hockey (16), rugby union (18), and handball (17), players in the present study reported a positive overall experience of the bio-banded session. The high proportion of players agreeing that the session helped them deal with mistakes (Q3) and supported their long-term development (Q23) further highlights that bio-banding provides opportunities for psychological and soccer-specific development (12). In contrast, players largely disagreed with items capturing potential drawbacks raised in the bio-banding literature (i.e., weakened self-confidence (Q2), social discomfort from separation from usual teammates (Q4), pressure from other players (Q7)). This suggests that the bio-banded training session did not introduce notable psychosocial costs in the present sample (10,12). The most divided responses concerned the session's physical and technical demands (Q5, Q6, Q21, Q22). In male youth soccer and rugby union, perceptions of these demands varied systematically with players' maturity status, with more mature players reporting greater physical challenge and less mature players re-

porting greater opportunity to express technical and tactical skills (8,9,18). Given the large inter-individual variability in players' relative maturity within their chronological age group, the divided responses likely reflect opposing perceptions across the relative maturity range that cancel out at the group level.

To assess whether the divided responses on the physical and technical items indeed reflected opposing perceptions across the relative maturity range, we conducted exploratory regression analyses. Five items concerning perceived physical assertion, the perceived need to apply technique faster, perceived physical and technical challenge, and perceived support for long-term development (Q5, Q6, Q21, Q22, Q23) showed substantial trends along both maturity reference frames. Higher relative maturity within the chronological age group and lower relative maturity within the bio-banded group were each independently associated with greater perceived challenge and stronger endorsement of long-term developmental value. Effects were of similar magnitude across both reference frames, yet there was no significant interaction effect between them. Our data extend previous work (8,9,18) by suggesting that both a player's relative maturity within the chronological age group and within the bio-banded group may contribute to her perceptions. In contrast, items covering comfort within the group, enjoyment, conceptual understanding, perceived pressure, difficulty being away from usual teammates, and perceived influence showed flat slopes along both reference frames. These findings are in line with previous work in male and female youth populations (8,9,16–18) and suggest that acceptance and enjoyment of bio-banding are largely independent of players' relative maturity in either reference frame.

Coaches in the present study supported bio-banding as a positive challenge for players (Q1) and supported its integration into regular training (Q12). This is consistent with previous research in male soccer academies 11. In addition, the lack of concern about elevated injury risk for chronologically older players (Q14) is in line with the broader literature which positions bio-banding as a tool to reduce maturity related injury risk (8,12,18). Interestingly, coaches mostly responded neutrally to items on specific player behaviours (i.e., leadership, frustration tolerance, on ball expression). As a single training session offers limited scope for players to adopt different behaviours and for coaches to observe meaningful behavioural change, multiple sessions might be needed to allow coaches to evaluate potential changes in player behaviour.

To our knowledge, the present study is the first to systematically examine parental perceptions of a bio-banded training format in highly trained female youth soccer. Parents reported few concerns about their child training with chronologically older (Q1) or younger players (Q2) and the majority viewed the session as a positive training experience compared with regular chronological age group training (Q3). These findings are in contrast to previous reports of hesitation towards children "playing down" during bio-banding formats (11). This favourable evaluation likely reflects that parents received information about the rationale and format of the bio-banded training session beforehand, which has been recommended as a key facilitator of acceptance (12). In addition, parents largely responded neutrally to items asking them to evaluate their child's internal experience (i.e., observed confidence gains (Q5), the framing of mistakes as learning opportunities (Q6)). This likely reflects the difficulty parents have in observing their child's internal psychological experiences during a training session. Collectively, our findings show that parents accepted the bio-banded format without expressing concerns.

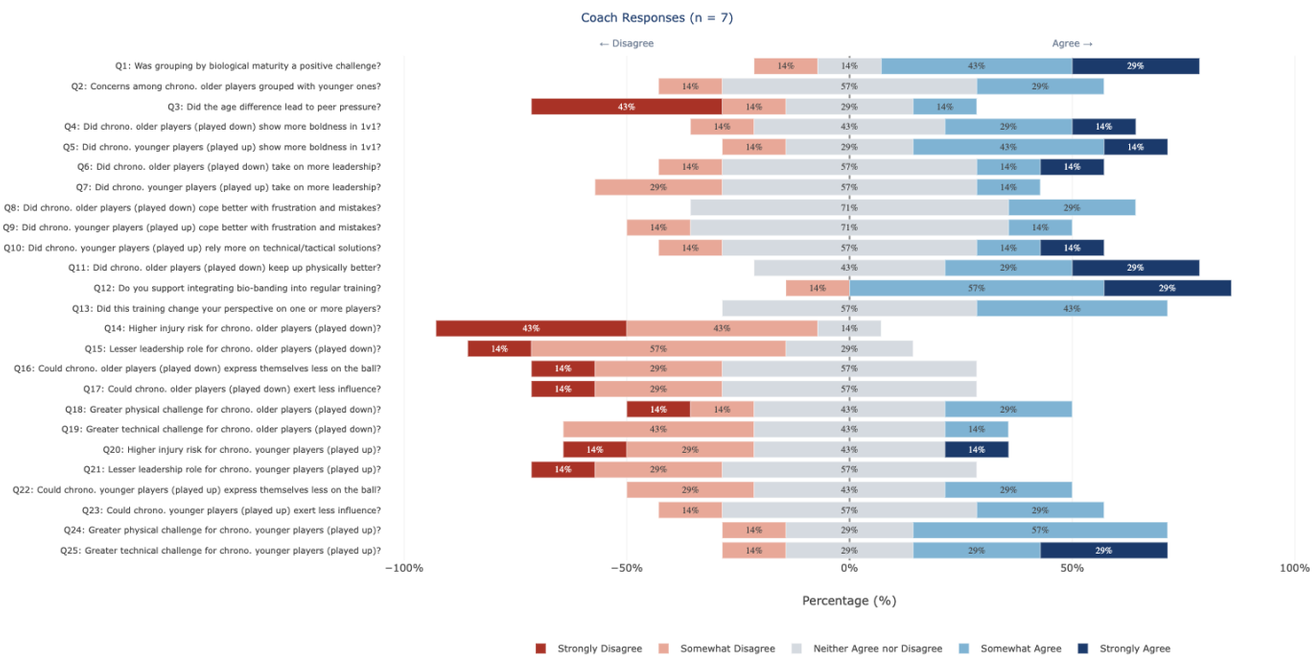


**Fig. 2. Frequency distribution of Likert-scale responses across all 25 items of the coach questionnaire (n=7). Bars represent the percentage of respondents selecting each response category, centred at the neutral midpoint.**

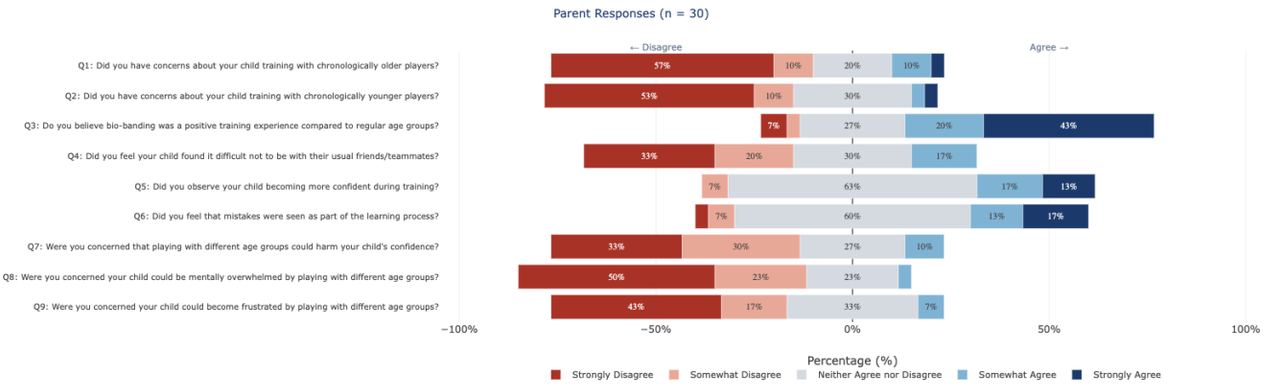


**Fig. 3. Frequency distribution of Likert-scale responses across all 9 items of the parent questionnaire (n=30). Bars represent the percentage of respondents selecting each response category, centred at the neutral midpoint.**

### Limitations and further research

Several limitations should be acknowledged. First, this study evaluated a single bio-banded training session. To date, no longitudinal research on bio-banding exists, which limits the conclusions that can be drawn regarding its long-term developmental value. Future studies should therefore incorporate multiple bio-banding sessions to examine whether perceptions as well as physical, psychological and soccer-specific indicators of technical and tactical performance changes emerge with repeated exposure. Second, the questionnaire items relied on retrospective comparisons to normal training, which introduces the possibility of recall bias. A within-subject design in which the same players complete both a bio-banding and a chronological age group session would allow for direct comparison without dependence on general retrospective judgement. Third, the sample size was small, particularly for coaches (n=7), which restricts the generalisability of our findings. Replication across different clubs and competitive playing levels is warranted. Fourth, no objective physical, technical and tactical performance data were collected. As subjective perceptions do not necessarily reflect actual behaviour or physical and physiological outcomes, future research should consider a holistic approach by integrating objective performance measures alongside subjective perceptions.

### Practical Applications

- Bio-banding can be considered a viable complement to regular chronological age group training in female youth soccer academies, as it was positively received by players, coaches, and parents alike.
- Practitioners are encouraged to evaluate bio-banding across multiple sessions, as a single session may not provide sufficient opportunity to observe meaningful changes in player performance and/or behaviour.
- Proactive communication with parents prior to implementation may support acceptance of bio-banded formats, as reflected in the low levels of concern reported in our study.

### Acknowledgements

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### Disclosure statement

The authors declare no conflict of interest involved with the present study.

### AI Use Statement

Language and editing: Claude was used to check and correct grammar and language, and to refine specific wording and suggest shortened rewordings of sentences.

### Data and analysis

Claude was used to support writing R code for the integration of the Shiny App; the code and outputs were checked by the first and second author.

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