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SPECIAL ISSUE PAPER

Bio-banding influences talent experts' ratings of psycho-social behaviours during 11 v 11 soccer match-play

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ABSTRACT

Selection into talent programmes is determined by perceptions of talent experts (i.e. professional academy scouts or coaches). Biological maturity status and/or timing can influence psycho-social behaviours in match-play. This study examined whether bio-banding (i.e. grouping players by biological maturity) influences talent experts' ratings of psycho-social behaviours. Using the Hull Soccer Behavioural Scoring Tool (HSBST), 14 talent experts rated 118 trained/developmental, male, adolescent (age: 13.7 ± 0.8 years) soccer players during six 20-minute, chronological age and bio-banded 11v11 matches. Players were bio-banded using percentage of predicted adult height (%PAH) using modified band thresholds relevant to peak height velocity (PHV; < 90%PAH, pre; 90–96%PAH, circa; and > 96%PAH, post-PHV). Dependent sample t-tests between the whole group ratings identified significant differences ($p < 0.05$) between formats. Decision-making and composure ratings increased in pre-PHV, with X-factor improving for circa-PHV players. Perceptions of resilience, competitiveness and confidence had *small* to *moderate* ($d = 0.26–0.65$) reductions for early maturers. Bio-banding significantly enhanced perceptions of competitiveness, confidence, composure and X-factor in on-time maturers ($p = 0.011–0.049$). Data indicates bio-banding positively influences perceptions of composure, competitiveness, decision-making and X-factor by talent experts, particularly for less biologically advanced players. Bio-banding may alter talent experts' observations of psycho-social behaviours, potentially improving (de)selection accuracy by assessing talent more holistically.

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Maturation; talent identification; technical performance; psychological

Introduction

The Elite Player Performance Plan (EPPP) was introduced in 2012 by the English Premier League to support the identification and development of homegrown players, with professional academies audited and ranked based on infrastructure and facilities (The Premier League, 2025). Clubs that do not meet these EPPP requirements, often those outside the football league or privatised, offer alternative development environments. The Junior Premier League, for example, offers similar youth development pathways to the EPPP (e.g., under 12–16 years) through competitive league fixtures and showcase events (League, 2025). Historically, (de)selection decisions in youth soccer have been influenced by perceptions of, and instinctual feelings around, a player's easily observable qualities (Bergkamp et al., 2021; Christensen, 2009; Meylan et al., 2010). Enhanced physical and anthropometric characteristics, such as increased speed and power for attacking players or greater height and weight for defending players, may permit an athlete to dominate peers (Deprez et al., 2015). However, the efficacy of selecting adolescent (i.e., ages between 11 and 16 years) players based on such maturity-dependent somatic attributes is often confounded by the naturally occurring, but highly individualised timing and tempo of biological maturation. Typically referred to as Peak Height Velocity (PHV), this period of development signifies the onset (~10.7 years), peak (8.6 cm/year) and cessation (~15.2 years) in stature growth (Towlson et al., 2018), which often varies up to 6 years (Parr et al., 2020; Philippaerts et al., 2006; Towlson et al., 2018) in timing between players who are grouped chronologically. Therefore, an early-maturing player who achieves PHV ahead of age-matched peers often possesses enhanced, yet transient physical and anthropometric qualities (Gastin & Bennett, 2013; Lovell

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et al., 2015; Meyers et al., 2015; Philippaerts et al., 2006; Towlson et al., 2018), which are often (sub)consciously considered desirable by talent experts identifying potential (Towlson et al., 2018).

Such maturity-related variations in player development are considered to be an underpinning mechanism for the overrepresentation of early maturing players in soccer academy programmes Deprez et al. (2015); Lovell et al. (2015); Towlson et al. (2018). Evidence presents an (un) conscious selection bias by talent experts, favouring players exhibiting temporary advanced physical and anthropometric qualities (Hill et al., 2020; Johnson et al., 2017; Malina, Eisenmann, et al., 2004). Yet, research also shows talent experts, who act as gatekeepers for talent development programmes, also place significant value on psychological qualities, rather than technical/tactical and physical factors (Towlson et al., 2019). The term "psychological" can be broken down into two distinct categories, characteristics (innate traits) or skills (learned strategies) (Dohme et al., 2017). Numerous psycho-social characteristics and/or skills like competitiveness, confidence, resilience, X-factor and positive attitude are identified as important for youth players to fulfil their potential (Gledhill et al., 2017; Harwood, 2008; Larkin & O'Connor, 2017; MacNamara et al., 2010a, 2010b; Robinson et al., 2024; Towlson et al., 2019). Interestingly, underrepresented late maturing players (often possessing inferior stature, body mass, power and speed) may also possess key psycho-social qualities, such as being achievement-oriented (motivation to guide actions towards goals) and possessing enhanced self-efficacy (high effort levels and beliefs in ability) and self-regulatory (control emotions and direct mental abilities towards the learning process) skills (Cumming, Searle, et al., 2018; Zuber et al., 2015). Although, it remains unclear whether these psycho-social attributes are the result of an adverse training environment (skills) or if these players possess innate psychological abilities (characteristics) (Cumming, Searle, et al., 2018; Dohme et al., 2017).

The advanced psycho-social qualities often seen in late maturing players may be of importance to talent experts, given that self-regulation enables players to become more motivationally and metacognitively involved in the learning process, which in turn, enables greater reflection and autonomy to improve performance and thereby generating superior benefits from practice (Mitchell et al., 2022; Ryan & Deci, 2000; Toering et al., 2011). In part, this theory may explain the "underdog hypothesis", where, to compete with their early maturing counterparts, late-maturing players must develop a range of enhanced psychological attributes to manage, problem solve and succeed during challenging environments (i.e., competing against bigger, stronger and faster peers) (Cumming, Searle, et al., 2018). Such selection phenomena are partially supported by longitudinal evidence by Ostojic et al. (2014), who demonstrated that 61.3% of the players who achieved professional senior soccer were late maturers. On the other hand, early maturing players that rely on enhanced transient physical capabilities may experience a less demanding training environment, which, as a result, could limit the opportunities to develop key psycho-social skills (Ostojic et al., 2014; Towlson, MacMaster, Gonçalves, Sampaio, Toner, MacFarlane, Barrett, Hamilton, Jack, Hunter, Myers, et al., 2021). Therefore, the accurate assessment of soccer-specific psycho-social behaviours is of paramount importance to talent experts responsible for identifying and developing youth players (Cumming, Searle, et al., 2018; Robinson et al., 2024) and has currently not been explored in conjunction with biological maturation.

In a bid to mitigate against the confounding influence of biological maturity during talent selection, bio-banding has been implemented to mitigate the biological diversity within age-categorised groups (Abbott et al., 2019; Bradley et al., 2019; Lüdin et al., 2021; Romann et al., 2020; Towlson, MacMaster, Gonçalves, Sampaio, Toner, MacFarlane, Barrett, Hamilton, Jack, Hunter, Myers, et al., 2021; Towlson, MacMaster, Gonçalves, Sampaio, Toner, MacFarlane, Barrett, Hamilton, Jack, Hunter, Stringer, et al., 2021). There is well-documented evidence that the application of bio-banding allows the manipulation of physical, technical and tactical constraints, which can subsequently offer varied challenges for players (Abbott et al., 2019; Lüdin et al., 2021; Towlson, MacMaster, Gonçalves, Sampaio, Toner, MacFarlane, Barrett, Hamilton, Jack, Hunter, Myers, et al., 2021; Towlson, MacMaster, Gonçalves, Sampaio, Toner, MacFarlane, Barrett, Hamilton, Jack, Hunter, Stringer, et al., 2021). In turn, academy practitioners believe this could play an important role in the assessment and development of key psycho-social behaviours (Reeves et al., 2018; Towlson et al., 2023), as evidenced by the perceptions of players whilst playing in bio-banded competitions (Bradley et al., 2019; Cumming, Brown, et al., 2018).

To illustrate, increases in confidence, composure and communication were common attributes described amongst the participants, with late maturing players gaining confidence through expression, whereas early maturing players gained confidence through the afforded opportunity to compete against chronologically older players (Bradley et al., 2019; Cumming, Brown, et al., 2018). Towlson, MacMaster, Gonçalves, Sampaio, Toner, MacFarlane, Barrett, Hamilton, Jack, Hunter, Myers, et al. (2021) investigated coaches' perceptions of psycho-social behaviours during different bio-banding methods, finding that during mismatched (i.e., pre-PHV versus post-PHV) fixtures, late maturing players exhibited more positive

evaluations for positive attitude, confidence, and competitiveness. Further research exploring different bio-banding methods across various small-sided games (SSG) formats (4 v 4, 5 v 5, and 6 v 6), using the same psycho-social behaviours outlined by Towlson, MacMaster, Gonçalves, Sampaio, Toner, MacFarlane, Barrett, Hamilton, Jack, Hunter, Myers, et al. (2021), contrasted previous findings revealing late maturing players exhibited significantly greater psycho-social behaviours in maturity-matched 5 v 5 and 6 v 6 fixtures (King et al., 2025). Yet, despite promising insights, both studies were limited to SSG contexts, which can constrain performance, as evidenced in King et al. (2025) work showing key technical, physical, and psycho-social qualities altered depending on SSG format during mixed maturity assessments. While the utilisation of SSGs is not uncommon during the talent identification process (Fenner et al., 2016), players transition into, and are typically evaluated in, 11 v 11 match-play during the period most impacted by biological maturity (i.e., U12-U16). Given that various factors (e.g., pitch size, player numbers, and specific rules) can influence holistic performance characteristics (Sarmento et al., 2018), the evaluation of psycho-social behaviours during "11 v 11" bio-banded competition offers a highly representative environment to the competitive format. As such, this study aimed to assess whether (1) chronological age and bio-banded 11 v 11 formats influenced whole group ratings of each psycho-social behaviour, and (2) how biological maturity status and timing groups psycho-social behaviours were influenced during bio-banded formats.

Methods

Participants

Using a convenience sampling approach, 118 male trained/developmental (Tier 2) (McKay et al., 2022) soccer players, who train multiple times per week for a competitive purpose, aged 12–16 years, who represented four separate Junior Premier League (JPL) teams, were invited to participate in the study. Players registered with the U13, U14 and U15 age groups of each club were invited to participate through existing collaborative networks (Table 1). These ages were selected as they include the largest biological diversity and, therefore, offer the greatest utility of bio-banding (Figueiredo et al., 2010). Players were deemed eligible to participate if they were injury-free in the 14 days before the event and considered fit and healthy by their parents and coaches to attend. Following ethical approval from the (name omitted for review purposes) University Science, Technology and Health Ethics Committee (ETH2425-0017), parental consent and participant assent were obtained electronically following an online webinar by the research team to outline research objectives.

Table 1. Descriptive characteristics of chronological and bio-banded groups. Data is presented as mean ± standard deviation (SD) and range (in parenthesis).

	U13 Mean ± SD (Range) (*N* = 43)	U14 Mean ± SD (Range) (*N* = 42)	U15 Mean ± SD (Range) (*N* = 33)	All Mean ± SD (Range) (*N* = 118)
Age (years)	12.7 ± 0.3 (12.2 – 12.8)	13.7 ± 0.3 13.1 – 14.2)	14.7 ± 0.3 (14.2 – 15.1)	13.6 ± 0.8 (12.2 – 15.1)
Biological Age (years)	13.1 ± 0.7 (11.6 – 12.6)	13.8 ± 0.7 (12.3 – 15.5)	15.3 ± 0.6 (13.7 – 16.3)	14.01 ± 1.0 (11.6 – 16.3)
Stature (cm)	157.4 ± 8.4 (138.0 – 177.5)	163.1 ± 8.4 (146.0 – 178.8)	172.2 ± 6.8 (159.8 – 190.9)	163.6 ± 9.9 (130.0 – 190.9)
Body Mass (kg)	45.8 ± 7.6 (30.0 – 59.0)	50.7 ± 8.7 (35.6 – 71.4)	57.9 ± 6.4 (41.9 – 69.8)	50.9 ± 9.1 (30.0 – 71.4)
%PAH	88.1 ± 2.7 (82.7 – 94.1)	91.0 ± 2.7 (84.7 – 96.8)	95.5 ± 1.7 (90.7 – 98.2)	91.3 ± 4.0 (82.7 – 98.2)
	Pre-PHV (*N* = 54)	**Mid-PHV (*N* = 38)**	**Post-PHV (*N* = 26)**	
Age (years)	12.8 ± 0.4 (12.2 – 13.6)	13.6 ± 0.7 (12.4 – 15.1)	14.8 ± 0.3 (14.1 – 15.1)	
Biological Age (years)	12.6 ± 0.3 (11.6 – 13.1)	14.1 ± 0.5 (13.2 – 15.0)	15.7 ± 0.2 (15.3 – 16.3(	
Stature (cm)	152.1 ± 5.9 (130.0 – 164.3)	164.9 ± 6.3 (151.5 – 177.5)	176.3 ± 5.2 (167.6 – 190.9)	
Body Mass (kg)	41.9 ± 6.2 (30.0 – 57.2)	52.3 ± 7.5 (39.0 – 71.4)	60.2 ± 4.7 (51.7 – 69.8)	
%PAH	86.0 ± 1.2 (82.7 – 87.9)	91.9 ± 2.1 (88.2 – 95.5)	97.1 ± 0.5 (96.2 – 98.2)	

PHV, peak height velocity.
PAH, predicted adult height.

Research design

Due to logistical constraints with conducting such an event and the need to objectively assess biological maturity to accurately inform bio-banded groups, this study was conducted across a single-day event that consisted of six 20-minute 11 v 11 matches. Comparisons were between three chronological matches (AM) and three bio-banded matches (PM) for each player/team. Talent experts (i.e., employed as recruitment specialists within a football academy) were assigned to a specific pitch, where the assessment of psycho-social behaviours took place in both chronological (U13, U14, U15) and bio-banded (pre-, mid- and post-PHV) formats. Each talent expert was aware of each format, as it was not feasible to blind this process. Once assigned to a pitch, talent experts decided amongst themselves which four players each were to observe, thereby ensuring even distribution of player evaluations. Anthropometric assessments (i.e., standing stature and body mass) to permit somatic estimations of maturity status were conducted during the morning of the event between fixtures; therefore, it was not feasible to randomise chronological and bio-banded fixtures as in previous studies (Lüdin et al., 2021; Romann et al., 2020). The 20-minute format ensured no player participated in more than 120 minutes of soccer throughout the day, with each player roughly getting equal playing time (excluding injuries). All matches were played on full-size (100 ×64 m) artificial 3rd-generation, FIFA-approved soccer pitches at the same venue and refereed by Football Association-qualified officials. Talent experts ($N = 14$) were affiliated with local professional soccer academies in talent identification positions and held relevant qualifications.

In line with previous studies (King et al., 2025; Towlson, MacMaster, Gonçalves, Sampaio, Toner, MacFarlane, Barrett, Hamilton, Jack, Hunter, Myers, et al., 2021), talent experts used the Hull Soccer Behavioural Scoring Tool (HSBST), which requires scoring of players between 0 and 5 (1 = poor, 5 = excellent) across seven psycho-social behaviours (Table 2) (Robinson et al., 2024). In the mornings chronologically aged matches, players represented their registered age-group team (i.e., U13, U14 or U15) and were coached by their regular age-group coaches. In the afternoons bio-banded matches, age groups were replaced by modified maturity categories relative to peak height velocity (PHV; pre-PHV, circa-PHV and post-PHV). Therefore, coaches remained within their club and on the same pitch with players who either moved up (e.g., U13 moving into mid-PHV) and were considered early maturers, down (e.g., U14 moving to pre-PHV) and considered late maturers, or remained (e.g., U15 classified as post-PHV) with the majority of their chronological cohort based on their maturity status and considered on-time maturers. This way, to minimise disruption, players were coached by either the same or familiar coaches and represented their club but may be playing with players outside of their usual age group.

Measures

Anthropometry and biological maturity

The Khamis and Roche (1994) percentage of predicted adult height (%PAH) method was used to categorise players. Evidence suggests it possesses greater precision compared with other commonly used somatic methods (Parr et al., 2020). In addition, this method demonstrates almost perfect agreement ($r = 0.96$) with contemporary developments in maturity estimation technology (Cumming et al., 2024) and is the most used method to categorise players when implementing bio-banding (Towlson et al., 2023). Assessment of standing stature using the Frankfort plane and stretch-stature technique (217

Table 2. Hull Soccer Behaviorual Scoring Tool (HSBST) attribute definitions.

Attribute	Definition
Resilience	Positive attitude after a mistake; how they handle disappointments; ability to overcome adversities; not wanting to give up; remain strong-willed; strong work ethic
Competitiveness	Resolve; desire; hunger; strong-willed; determination; intense; fighting approach towards winning the ball; winning mentality; hard worker; committed dedicated to the cause; putting their body on the line to block/stop shots and crosses
Confidence	Confident within a group; brave; wants the ball; wants the ball under pressure; confident to be able to get into positions to receive the ball all the time; have the guts to try and fail and do something different; belief in themselves; no fear of failure
Decision Making	The ability of the performer to select and execute an appropriate action in each situation; and anticipate what is likely to happen before the event occurs
Maintaining composure	The ability to remain relaxed and handle pressure in different scenarios when performance begins
Communication	Can have dialogue with players and coaches; talks during the game; ability to listen to both players and coaches; have positive interactions with peers; prepared to ask questions of players and coaches; appropriate body language
X-Factor	The ability to be creative and produce work that is both novel (i.e., unexpected, original) and appropriate (i.e., useful)

Stable Stadiometer, Seca, Hamburg, Germany, to the nearest 0.1 cm) and body mass (Seca, Hamburg, Germany, to the nearest 0.1 kg) were measured by a member of the research team following published guidelines (Petri et al., 2024), consisting of a minimum of two measurements of standing stature and body mass for each player. As per previously published research (Massard et al., 2019), where significant deviations between these two readings were observed (i.e., 0.2 cm or 0.2 kg), a third measurement was conducted, and the median was selected. Since birth parent heights are self-reported (via the parental consent process), these were corrected for over-estimation (Epstein et al., 1995) and maturity status was calculated using equations using a customised spreadsheet (Towlson et al., 2020). To help illustrate the differences between chronological age and biological development, the biological age, determined as part of the Khamis-Roche estimation process in conjunction with historical UK growth data, is provided.

For the bio-banded matches, players were categorised using absolute %PAH thresholds (i.e., pre-PHV (< 90%), mid-PHV (90–96%) or post-PHV (> 96%). These modified thresholds differ slightly from those reported previously (Abbott et al., 2019; Bradley et al., 2019; Malina et al., 2019) but were selected to facilitate the numerical and positional needs of teams based on the distribution in the sample. Table 1 illustrates the utility of this approach to reduce the heterogeneity within groups, demonstrated by the reduced ranges in anthropometric measures between chronological and bio-banded groupings. Typically, PHV in boys occurs at approximately 91–92%PAH (~13.8 years), which would occur during the U14 season (Cumming et al., 2017; Malina, Bouchard, et al., 2004). Therefore, this was considered "on-time" timing, with most players (72.1%) aligning with this, 9.3% considered early (moved up) and 18.6% considered late developers (moved down) for the bio-banded format.

Psycho-social behaviours

The HSBST was used as a validated and reliable method for assessing each player's psycho-social behaviours (Robinson et al., 2024). Robinson et al. (2024) employed a five-stage process, comprising of a literature review, cross-sectional survey and applied coach feedback established the tool's content and face validity, whilst reliability was established through inter-rater and intra-rater reliability testing, with agreement levels ranging from 81.25% to 89.9% and 80.35%–99.4%, respectively. To optimise the accuracy and reliability ahead of the event, talent experts were invited to an online information session where the HSBST was explained and an opportunity to answer questions was provided, before a two-week familiarisation period to practice using the scale in their own environments (McKenzie & van der Mars, 2015). Before familiarisation, no talent expert had prior experience with the HSBST and therefore, the first author circulated each operator during the event to observe and verify the correct application of the tool. On the event day, the 14 talent experts were split equally across three pitches, where they remained for the day (chronological AM, bio-banded PM) and each scored different players. Each talent expert received physical copies of the HSBST (Supplementary file 1), which required experts to score players on seven categories (i.e., resilience, competitiveness, confidence, decision-making, maintaining composure under pressure, communication, X-Factor) using a 5-point Likert scale (1 = poor, 2 = below average, 3 = neutral, 4 = above average, 5 = excellent) (Robinson et al., 2024). Each psycho-social attribute had a validated operational definition (Table 2) that allowed talent experts to identify what actions should be attributed to each behaviour as well as help interpret the subsequent scores they provided (O'Donoghue & Hughes, 2019; Robinson et al., 2024). Talent experts were allowed to score a maximum of four players per match, aligning with the validation process by Robinson et al. (2024). Given that the present study was undertaken in an 11 v 11 game format, talent experts had to score a group of players within proximity (i.e., right-back, right-midfield, right centre-midfield, holding-midfield), which was decided amongst the talent experts themselves prior to each match to ensure no overlap in player grades.

Data analysis

Before analysis, data were visually screened for normal distribution using Q-Q plots (Ghasemi & Zahediasl, 2012). All data is presented per player per 20-minute game as mean ± standard deviation (mean ± SD). Due to some missing data from talent experts and/or player injuries, direct within-player comparisons between formats from the whole total sample were not possible. This resulted in 89 individual player comparisons containing ratings from both chronological and bio-banded formats. Dependent *t*-tests and Cohen's *d*-effect sizes (JASP, v0.19.3, Intel, Amsterdam) were used to determine

Table 3. Whole-group differences (mean ± SD) in HSBST ratings between chronological and bio-banded formats.

Attribute	Chronological ($N = 118$)	Bio-Banded ($N = 89$)	Mean Difference *(95% CI)*	*p*-value *Cohens-d; inference*
Resilience	3.06 ± 0.64	3.23 ± 0.63	−0.16	0.068
			-0.34 to 0.01	***0.20; small***
Competitiveness	2.95 ± 0.71	3.15 ± 0.68	−0.19	**0.036***
			-0.38 to −0.01	***0.23; small***
Confidence	3.11 ± 0.67	3.34 ± 0.65	−0.23	**0.012***
			-0.41 to −0.05	***0.28; small***
Decision Making	2.81 ± 0.58	3.13 ± 0.64	−0.31	**< 0.001***
			-0.47 to −0.14	***0.41; small***
Composure	3.02 ± 0.64	3.28 ± 0.63	−0.26	**0.003***
			-0.43 to −0.09	***0.33; small***
Communication	2.62 ± 0.75	2.80 ± 0.67	−0.18	0.086
			-0.38 to 0.02	*0.19; trivial*
X-factor	2.68 ± 0.72	2.94 ± 0.75	−0.25	**0.025***
			-0.47 to −0.03	***0.25; small***

* = $p < 0.05$.
CI, confidence interval.

whole-sample (Table 3) statistical and magnitude of mean differences between match formats (Cohen, 1988). Sub-group analysis for differences between biological maturity (i.e., status and timing) used analysis of variance (ANOVA) using the same software. Bonferroni corrected thresholds for statistical significance were set at $p \leq 0.05$, alongside 95% confidence intervals (95% CI) and thresholds for interpreting effect size difference magnitudes (Cohens *d*) adhered to published norms, < 0.2 (*trivial*), 0.2 (*small*), 0.5 (*moderate*), and 0.8 (*large*) (Lakens, 2013).

Sample size estimation and justification

As a result of the logistical complications surrounding the delivery of the bio-banding event (i.e., facilitated by JPL, unknown player numbers and/or injuries/drop-outs), it was impractical for the research team to conduct a sample size estimation a priori. Although the research team recognised an approximate number required for suitable statistical power, it was deemed more appropriate to conduct a sensitivity analysis a posteriori to illustrate the statistical power achieved. Using G*Power (3.1.9.6, Dusseldorf), we examined the power to detect a meaningful difference in HSBST (e.g., resilience) between chronologically aged and bio-banded fixtures using a post-hoc dependent two-sample t-test. The error rate ($p < 0.05$) was selected based on this being widely regarded as typical for similar studies (King et al., 2025; Towlson, MacMaster, Gonçalves, Sampaio, Toner, MacFarlane, Barrett, Hamilton, Jack, Hunter, Myers, et al., 2021). The smallest effect size of interest (Cohen's $d = 0.4$) was based on a similar study from Bradley et al. (2019), who reported a standardised mean difference (95% confidence interval) of 0.52 (0.39 to 0.87) in the ability to take on different responsibility (i.e., leadership) in bio-banded matches in a similar population to the current study. We chose the lower boundary of the 95% confidence interval (rounded to 0.4) as our smallest effect size of interest. We opted for a two-tailed test because the difference could be positive or negative, in that particular behaviours may be rated higher or lower with the bio-banded format (Reeves et al., 2018; Towlson et al., 2023). The achieved power for the whole group sample based on group parameters for the minimum number of paired samples in each format across both formats ($N = 89$) was 0.96 (very high). To assess the power in sub-group analysis, we conducted a post-hoc F-test (ANOVA: Fixed effects, main effects and interactions) and using the same effect size of interest and specified three groups (e.g., maturity status or maturity timing) and total sample size of comparisons ($N = 89$) to determine a power of 0.92.

Results

Whole group findings (Table 3) show consistently *small* ($d = 0.20 - 0.41$) improvements in player ratings across six of the seven HSBST attributes, with competitiveness ($p = 0.036$), confidence ($p = 0.012$), decision-making ($p = < 0.001$), composure ($p = 0.003$) and x-factor ($p = 0.025$) all rated significantly higher in the bio-banded format.

Sub-group analysis identified that talent experts consistently rated players more favourably in bio-banded formats, across all maturity status groups (pre-PHV, circa-PHV, post-PHV). Differences ranged from *trivial* to *large* ($d = 0.06 - 1.07$), and with decision-making ($p = 0.013$) and composure ($p = 0.014$) being statistically better for pre-PHV players in bio-banded formats, and circa-PHV players rated as having better x-factor ($p = 0.047$) when bio-banded (Table 4; Figure 1).

Table 4. Differences between maturity status groups (mean ± SD) in HSBST between chronological and bio-banded formats.

Attribute	Maturity Group	Chronological (*N* = 118)	Bio-Banded (*N* = 89)	Mean Difference *(95% CI)*	*p*-value *(Cohens-d; inference)*
Resilience	Pre-PHV	3.00 ± 0.74	3.11 ± 0.64	−0.11	1.000
				-0.50 to 0.29	*0.16; trivial*
	Circa-PHV	2.94 ± 0.53	3.18 ± 0.64	−0.24	1.000
				-0.63 to 0.15	***0.37; small***
	Post-PHV	3.15 ± 0.64	3.83 ± 0.35	−0.68	0.105
				-2.2 to 0.10	***1.07; large***
Competitiveness	Pre-PHV	2.77 ± 0.75	3.11 ± 0.77	−0.34	0.259
				-0.76 to 0.08	***0.50; moderate***
	Circa-PHV	3.05 ± 0.58	3.09 ± 0.53	−0.04	1.000
				-0.46 to 0.38	*0.06; trivial*
	Post-PHV	3.11 ± 0.69	3.46 ± 0.47	−0.34	1.000
				-1.12 to 0.43	***0.52; moderate***
Confidence	Pre-PHV	2.98 ± 0.73	3.30 ± 0.69	−0.31	0.440
				0.0–4 to 0.11	***0.46; small***
	Circa-PHV	3.00 ± 0.70	3.23 ± 0.61	−0.23	1.000
				-0.66 to 0.19	***0.34; small***
	Post-PHV	3.26 ± 0.63	3.77 ± 0.44	−0.51	0.814
				-1.31 to 0.27	***0.76; moderate***
Decision Making	Pre-PHV	2.69 ± 0.62	3.13 ± 0.70	−0.43	**0.013***
				-0.81 to −0.05	***0.71; moderate***
	Circa-PHV	2.80 ± 0.53	3.05 ± 0.54	−0.25	0.722
				-0.64 to 0.12	***0.42; small***
	Post-PHV	3.01 ± 0.60	3.51 ± 0.50	−0.50	0.514
				-1.20 to 0.19	***0.83; large***
Composure	Pre-PHV	2.88 ± 0.67	3.33 ± 0.79	−0.45	**0.014***
				-0.86 to −0.05	***0.71; moderate***
	Circa-PHV	2.96 ± 0.57	3.23 ± 0.40	−0.27	0.690
				-0.68 to 0.13	***0.42; small***
	Post-PHV	3.17 ± 0.74	3.31 ± 0.42	−0.14	1.000
				-0.88 to 0.60	***0.21; small***
Communication	Pre-PHV	2.52 ± 0.76	2.85 ± 0.63	−0.33	0.597
				-0.81 to 0.14	***0.44; small***
	Circa-PHV	2.67 ± 0.87	2.75 ± 0.64	−0.08	1.000
				-0.56 to 0.39	*0.11; trivial*
	Post-PHV	2.64 ± 0.76	2.83 ± 0.86	−0.19	1.000
				-1.07 to 0.69	***0.24; small***
X-factor	Pre-PHV	2.64 ± 0.82	2.95 ± 0.80	−0.31	0.717
				-0.77 to 0.15	***0.42; small***
	Circa-PHV	2.55 ± 0.58	3.02 ± 0.68	−0.47	**0.047***
				-0.94 to −0.00	***0.64; moderate***
	Post-PHV	2.68 ± 0.74	2.74 ± 0.70	−0.06	1.000
				-0.91 to 0.79	*0.08; trivial*

* = $p < 0.05$
CI, confidence interval.

Comparisons between maturity timing groups (early, on-time, late) presented a similar, generally higher rating for all players in bio-banded formats, although there were *small* to *moderate* ($d = 0.26$ 0.74) reductions in ratings of resilience, competitiveness and confidence for early maturers, albeit not statistically significant (p = 0.061 to 1.000) (Table 5). There were, however, significantly higher ratings of competitiveness ($p = 0.049$; $d = 0.49$), confidence ($p = 0.011$; $d = 0.55$), composure ($p = 0.028$; $d = 0.42$) and x-factor ($p = 0.038$; $d = 0.38$) for on-time maturers.

Discussion

This study examined whether grouping adolescent soccer players by biological maturity (i.e., bio-banding) rather than chronological age alters talent expert perceptions of key psycho-social behaviours during 11 v 11 match play. The main findings are three-fold: 1) bio-banding resulted in *small* and/or significant whole-group HSBST ratings across all attributes, except for communication, compared to chronological matches (Table 3); 2) pre-PHV players were considered to be significantly better at maintaining composure and having better decision-making in bio-banded matches (Table 4), and 3) on-time developers seemed to benefit the most from bio-banding with significantly better confidence, competitiveness and X-factor (Table 5).

The primary finding of the present study was that talent experts' perceptions of all psychosocial attributes on the HSBST were positively altered in bio-banded competition, with significant effects for decision-making, composure, confidence, X-factor, and competitiveness (Table 3). Our findings suggest that bio-banding can be a useful addition to challenge the psycho-social

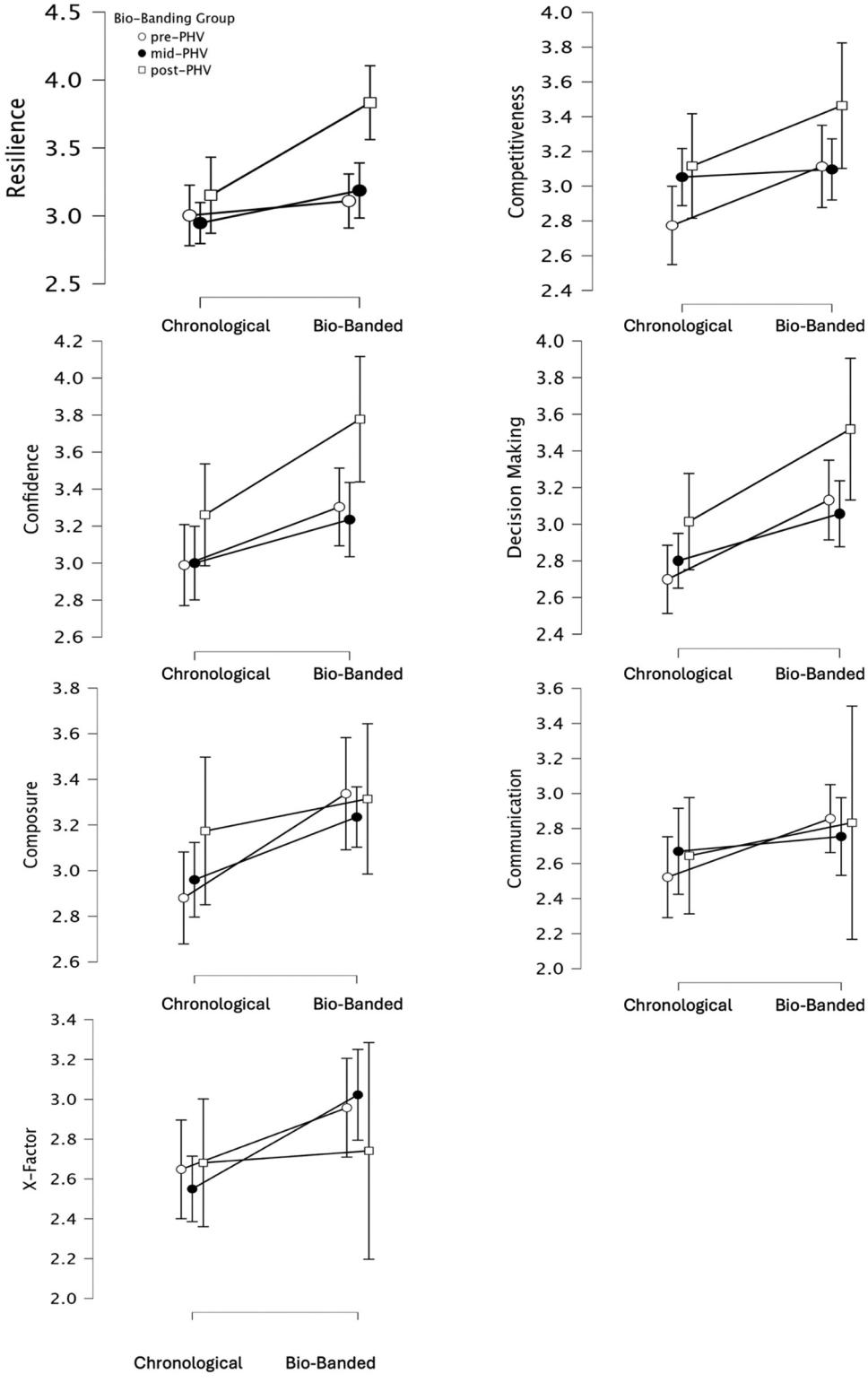

Figure 1. Differences in HSBST ratings between formats for each maturity group.

attributes of young players. Results corroborate the qualitative findings of Reeves et al. (2018), who found key stakeholders consistently felt bio-banding enhanced psychological development through exposure to different challenges, allowing diversity in psycho-social skill (in this instance: confidence, leadership, self-regulation, self-efficacy, positive attitude). Towlson et al. (2023) mixed-method study added that academy staff also perceived bio-banding to be useful for developing psycho-social skills, although, despite perceptions of its application being effective for enhancing psycho-social skills (75%), responders placed this as a lower

Table 5. Differences between maturity timing groups (mean ± SD) in HSBST between chronological and bio-banded formats.

Attribute	Maturity Group	Chronological (*N* = 118)	Bio-Banded (*N* = 89)	Mean Difference *(95% CI)*	*p*-value *(Cohens-d; inference)*
Resilience	Early	3.12 ± 0.47	2.95 ± 0.49	0.17	0.1000
				-0.66 to 1.01	***0.26; small***
	On-Time	2.95 ± 0.67	3.23 ± 0.67	−0.28	0.134
				-0.59 to 0.03	***0.43; small***
	Late	3.15 ± 0.58	3.27 ± 0.66	−0.11	1.000
				-0.73 to 0.49	*0.18; trivial*
Competitiveness	Early	3.12 ± 0.69	2.68 ± 0.45	0.43	1.000
				-0.48 to 1.35	***0.65; moderate***
	On-Time	2.87 ± 0.69	3.19 ± 0.53	−0.32	**0.049***
				-0.65 to 0.87	***0.49; small***
	Late	3.22 ± 0.52	3.13 ± 0.77	0.08	1.000
				-0.54 to 0.70	*0.12; trivial*
Confidence	Early	3.21 ± 0.78	2.81 ± 0.65	0.43	1.000
				-0.48 to 1.35	***0.58; moderate***
	On-Time	3.02 ± 0.67	3.40 ± 0.63	−0.38	**0.011***
				-0.71 to 0.05	***0.55; moderate***
	Late	3.03 ± 0.82	3.22 ± 0.64	−0.19	1.000
				-0.83 to 0.45	***0.28; small***
Decision Making	Early	2.60 ± 0.54	3.06 ± 0.67	−0.45	1.000
				-1.30 to 0.38	***0.74; moderate***
	On-Time	2.82 ± 0.59	3.11 ± 0.63	−0.29	0.061
				-0.58 to 0.06	***0.47; small***
	Late	2.82 ± 0.58	3.27 ± 0.62	−0.44	0.359
				-1.03 to 0.13	***0.73; moderate***
Composure	Early	3.00 ± 0.74	3.33 ± 0.43	−0.33	1.000
				-1.19 to 0.52	***0.51; moderate***
	On-Time	2.94 ± 0.66	3.27 ± 0.66	−0.33	**0.028***
				-0.65 to −0.02	***0.42; small***
	Late	3.06 ± 0.59	3.32 ± 0.55	−0.25	1.000
				-0.87 to 0.36	***0.51; moderate***
Communication	Early	2.66 ± 0.58	2.75 ± 0.46	−0.08	1.000
				-1.13 to 0.96	*0.11; trivial*
	On-Time	2.63 ± 0.81	2.83 ± 0.70	−0.19	1.000
				-0.56 to 0.17	*0.04; trivial*
	Late	2.45 ± 0.92	2.75 ± 0.46	−0.29	1.000
				-1.00 to 0.44	***0.36; small***
X-factor	Early	2.78 ± 0.63	3.06 ± 0.67	0.31	0.717
				-0.77 to 0.15	***0.42; small***
	On-Time	2.57 ± 0.74	2.94 ± 0.71	−0.37	**0.038***
				-0.72 to −0.01	***0.50; moderate***
	Late	2.66 ± 0.60	2.98 ± 0.71	−0.27	1.000
				-1.28 to 0.73	***0.37; small***

* = $p < 0.05$.
CI, confidence interval.

priority than other aspects of performance (physical [95%]; technical [85%]; psycho-social [75%]; tactical [60%]).

Despite not always being statistically significant, there were consistently *small* to *large* differences between chronological and bio-banded formats for each attribute across all maturity groups. Pre-PHV players' decision-making and maintaining composure under pressure were rated significantly better in bio-banded matches (Table 4). This is supported by previous findings in that bio-banding can enhance player evaluations for pre-PHV players, having previously demonstrated similar results when mismatched bio-banding was conducted (Towlson, MacMaster, Gonçalves, Sampaio, Toner, MacFarlane, Barrett, Hamilton, Jack, Hunter, Myers, et al., 2021). The ability to maintain composure under pressure is underpinned by effective coping strategies to regulate emotions and, in turn, adapt to the game's contextual differences (Kent et al., 2020). Variations in time on the ball can adjust the amount of pressure induced onto a player (Kent et al., 2020), which bio-banding seems to positively influence (Salter et al., under review). Without advanced coping strategies, later maturing players may experience greater anxiety within chronologically aged matches as the physical mismatch is too diverse for them (Reeves et al., 2018). Conversely, focus groups following bio-banded matches identified that less mature players feel increased pressure during bio-banding, but also this format affords them greater opportunity to develop coping strategies and remain composed (Cumming, Brown, et al., 2018). Subsequently, pre-PHV players' perceptions of pressure and personal performance could be positively influenced to permit superior decisions (Levi & Jackson, 2018). This could explain the combined improvement in maintaining composure under pressure and decision-

making during bio-banded match-play for less mature players. This is of importance because the identification of such psycho-social skills could influence those who progress within the talent pathway, with learning to cope and thrive under pressure being deemed as essential for navigating the youth to senior transition (Holt & Dunn, 2004), and those with superior decision-making having a 6.6 times higher chance of professional soccer (Kannekens et al., 2011).

Our findings suggest that when post-PHV players play in bio-banded matches, they are perceived to exhibit more resilient behaviours. These findings could be explained by a reduction in physical variations during bio-banding (MacMaster et al., 2021; Towlson et al., 2023), resulting in post-PHV players no longer holding advanced physicality (Gastin & Bennett, 2013; Lovell et al., 2015; Philippaerts et al., 2006; Towlson et al., 2018) and therefore having to adapt their technical-tactical game, which can subsequently result in higher rates of failure (Abbott et al., 2019; Cumming, Brown, et al., 2018; Lüdin et al., 2021). In this case, as the challenge and likelihood of failure increase, there becomes an opportunity for players to be more resourceful and display underpinning elements of resilience (e.g., positive responses to setbacks) (Collins & MacNamara, 2012; Lüdin et al., 2021; Mills et al., 2012). Thus, our findings suggest that playing in bio-banded competition, at least for post-PHV players, may provide an opportunity to foster resilience-like behaviours over time, provided that increased challenge is accompanied by appropriate player support and guidance (Sarkar & Page, 2022). This is important because resilience is essential for raising self-awareness and increasing self-regulatory learning, where a player can identify strengths and weaknesses whilst controlling their emotions to proactively exert more effort into the learning process (Collins & MacNamara, 2012; Cumming, Searle, et al., 2018; Gledhill et al., 2017; Mills et al., 2012; Toering et al., 2011). Players' reflective accounts confirm this notion that bio-banded play affords greater learning opportunities in comparison to normal, chronological competition (Cumming, Searle, et al., 2018).

Interestingly, given pre-PHV players spend a large proportion of their exposure banded by age group, their typical, regular battle with physical challenge may contribute to advanced resilience and self-regulation (Cumming, Searle, et al., 2018). Yet, conversely, our study suggests that pre-PHV players were perceived to demonstrate reduced resilience (3.00 ± 0.74) compared to post-PHV players (3.15 ± 0.64) in chronological age-banded competition. Results here contradict previous bio-banded research by Towlson, MacMaster, Gonçalves, Sampaio, Toner, MacFarlane, Barrett, Hamilton, Jack, Hunter, Myers, et al. (2021), who found that when mis-matched (e.g., pre-PHV versus post-PHV), less mature players displayed more evidence of total psychological variables, including resilience. One potential reason could be attributed to the studies methodological differences, where the use of small-sided games compared to 11 v 11 game formats can alter the nature and number of game actions (e.g., decisions made; defensive duels; total balls contacts; shots; dribbles) (Aguiar et al., 2012; Owen et al., 2011; Rumpf et al., 2025; Silva et al., 2014), which in turn, could affect the opportunity to display and/or engage in resilient behaviours. Furthermore, match play time motion analysis shows advanced maturing individuals can significantly outperform later maturing counterparts in total distance, high-speed running distance and high-intensity efforts (Gastin & Bennett, 2013). It may be that, during 11 v 11 chronologically aged matches, post-PHV players benefit from enhanced locomotive activity and become more involved with the game, which subsequently allows them to display a great number of resilient behaviours.

Regardless of maturity timing, players were considered to show *small* to *moderate* increases in confidence, competitiveness, decision-making, composure and X-factor in bio-banded matches (Table 5). This could be explained by the subjective views of key stakeholders from focus groups, who identified that late and on-time maturing players felt they were more able to express their technical ability to influence the game in bio-banded formats (Bradley et al., 2019; Cumming, Brown, et al., 2018; Reeves et al., 2018), with our data suggesting bio-banding influenced ratings of early maturing players. Thus, all players may exhibit enhanced underpinning qualities with greater involvement in higher-pressure situations, controlled for biological maturity. X-factor-like behaviour, defined as producing creative solutions, was perceived to be more visible for early (*small*) and on-time (*moderate*) developing players during bio-banding, as they showed a belief in their ability to attempt creative actions (Larkin & O'Connor, 2017; Robinson et al., 2024), a key feature for talent identification and retention. However, despite consistent increases in confidence and related attributes, research could suggest altered underlying mechanisms for post-PHV players. For example, early maturers may increase their confidence and self-belief as they are allowed to play with, or compete against, relatively advanced peers (Bradley et al., 2019; Cumming, Brown, et al., 2018; Reeves et al., 2018), potentially instilling a belief to treat the challenge as an opportunity display technical skills rather than a threat to performance (Bandura, 1997; Höner & Feichtinger, 2016). Furthermore, this may coincide with the perceived increase in resilience in bio-banded formats, as while two separate entities, the aforementioned underpinning qualities of confidence may better equip players for coping with setbacks

and displaying "bouncebackability" (Mills et al., 2012). The identification and development of confidence for all adolescent players is valued as an important quality that can aid the youth to senior transition and can influence the level an individual plays (Danielsen et al., 2017; Larkin & O'Connor, 2017; Mills et al., 2012). Therefore, bio-banding may offer a useful method to manipulate the playing environment for players to display and/or develop confidence and related psycho-social behaviours (i.e., composure, X-factor and decision-making).

To accurately assess psycho-social behaviours, talent experts used the HSBST (Robinson et al., 2024) and undertook a familiarisation period to increase application accuracy (McKenzie & van der Mars, 2015). Despite this, the HSBST was previously validated using 4 v 4 SSGs (Robinson et al., 2024), and as such, caution should be applied when interpreting talent experts' ratings of the psycho-social behaviours in the present study from an 11 v 11 format. Although the research team attempted to mitigate this risk through the allocation of four neighbouring players, it is appreciated that this may compromise findings somewhat. In addition, we acknowledge that a reduction in talent experts' observations in the bio-banding format due to injuries, departures and incomplete data reduced the total comparisons considerably; however, this is still the largest bio-banding study ever completed with 11 v 11 match play. Therefore, while we may have found *small*, *moderate* or *large* effect sizes for various attributes, the uncertainty, influenced by small sample sizes in some groups (i.e., post-PHV), meant they lacked the statistical power to offer more robust findings. Additionally, due to logistical complications as outlined previously, we were forced to complete the event on a single day, which may have convoluted findings and negatively influenced the impartiality of the talent experts due to observer drift (coding over prolonged periods of time causing mental fatigue and the misinterpretation of attributes) (Mars, 1989). Future research should consider using recording equipment (e.g., Veo cameras), to allow talent experts to retrospectively watch each game independently to reduce observer drift. Moreover, this would permit inter- and intra-rater reliability tests to be conducted amongst talent experts, which would enhance the credibility of the results (Mars, 1989; O'Donoghue & Hughes, 2019; Robinson et al., 2024).

In summary, our study shows that 11 v 11 bio-banded matches offer players greater opportunity to display a range of key psycho-social attributes, which are deemed important for talent identification in youth soccer. More specifically, pre-PHV players were perceived to demonstrate greater composure under pressure and decision-making skills, which may aid talent identification and support retention and continued progression in development pathways. Whereas for post-PHV players, bio-banding may alter the challenge points by removing the reliance on enhanced transient physical advantages, thereby encouraging the development of alternative skills, as evidenced by our findings of potentially displaying higher resilience and confidence. This may support post-PHV players later in the development pathway, as their current physical advantages dissipate. Results here suggest practitioners should consider bio-banding as a regular addition to chronological match-play to inform decisions on (de)selection, as there is greater diversity of psycho-social behaviours, which may be hidden during chronologically aged exposures. However, given evidence of psycho-social behaviours was enhanced during a single bio-banding event; further investigation is required to assess whether regular, longitudinal exposure to bio-banded play could be used as a development strategy for psycho-social attributes.

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Investigation – JR, JS, CT, MK, NM, SB
Writing (Original Draft) – JR, JS, CT
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Data availability statement

Data file available via a reserved DOI via YSJU open repository (RayDar): 10.25421/yorksj.29172011.

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