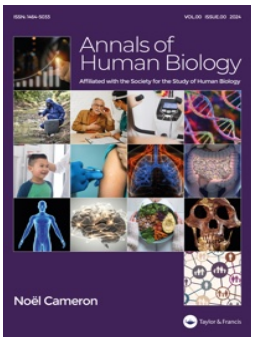

Taylor & Francis
Taylor & Francis Group

Annals of Human Biology

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/iahb20

Physical and perceptual demands of youth international team match-play in traditional and aged-matched future teams for biologically late maturing soccer players

Liam Sweeney, Lukas Sinkunas & Tommy R. Lundberg

To cite this article: Liam Sweeney, Lukas Sinkunas & Tommy R. Lundberg (2024) Physical and perceptual demands of youth international team match-play in traditional and aged-matched future teams for biologically late maturing soccer players, Annals of Human Biology, 51:1, 2437164, DOI: 10.1080/03014460.2024.2437164

To link to this article: https://doi.org/10.1080/03014460.2024.2437164

Published online: 09 Dec 2024.

ANNALS OF HUMAN BIOLOGY
2024, VOL. 51, NO. 1, 2437164
https://doi.org/10.1080/03014460.2024.2437164

HUMAN EXERCISE SCIENCE

Physical and perceptual demands of youth international team match-play in traditional and aged-matched future teams for biologically late maturing soccer players

Liam Sweeney[a], Lukas Sinkunas[b] and Tommy R. Lundberg[c,d]

[a]Department of Sport Science and Nutrition, Faculty of Science and Engineering, Maynooth University, Kildare, Ireland; [b]Swedish Football Association, Solna, Stockholm, Sweden; [c]Division of Clinical Physiology, Department of Laboratory Medicine, ANA Futura, Karolinska Institutet, Huddinge, Sweden; [d]Unit of Clinical Physiology, Karolinska University Hospital, Stockholm, Sweden

ABSTRACT

Background: Given the rapidly increasing interest in national futures programmes, and the associated significant increased resource investment, there is a pressing need for data specific to futures programmes to inform practice across world football.
Aim: To investigate the differences in the physical and perceptual demands of match-play using Global Positioning Software technology and Rating of Perceived Exertion (RPE) in traditional youth international team and age-matched international future teams for biologically late-maturing players over one in-season period.
Subjects and methods: A total of 18 U15 future team (FT) players and 21 national team (NT) players were examined.
Results: The results showed that FT players performed 9% greater total distances ($p=0.008$, Cohen's d 1.29) and accumulated 20% greater total player loads ($p<0.001$, Cohen's d 1.88) than NT players during matches. In contrast, NT players covered 113% greater sprinting distances ($p=0.033$, Cohen's d 0.63) and performed 62% more high-intensity accelerations ($p=0.015$, Cohen's d 0.90) than FT players. There were no differences in high-intensity and very high-intensity running distances, number of accelerations, number of decelerations or high-intensity decelerations, or match-play RPE. When accounting for biological maturation, the adjusted marginal means were not different between FT and NT players in any physical metric except for total player load ($p=0.046$) and high-intensity accelerations ($p<0.030$).
Conclusion: We conclude that while several physical performance metrics differ significantly between FT and NT match-play, the most robust differences after controlling for maturation are in sprint performance and high-intensity accelerations.

ARTICLE HISTORY
Received 17 March 2024
Accepted 12 November 2024

KEYWORDS
Biological maturation; growth and maturation; talent development; talent identification; youth soccer

Introduction

In the highly competitive world of professional football, Football Associations spend considerable resources identifying and nurturing young talent with the ultimate aim of developing players for the elite senior level (Sweeney et al. 2021). Reflecting this, thousands of young players across clubs and contexts are selected each year to engage in often well-resourced national talent development programmes (e.g. national emerging talent programmes, youth international teams) (Güllich 2014; Hill et al. 2020). The selection of young players into national and international development programmes often occurs at young ages, and for example, in some Football Associations, can take place from as young as twelve years of age (Sweeney et al., 2023). The selection of the highest potential players into such programmes is proposed to facilitate their long-term progress and increase the probability of senior success. Conversely, athletes who are not considered to show sufficient sporting promise at the time of selection are not recruited and are denied such experiences.

One of the most prominent factors holding young players back from selection into such programmes is delayed biological maturation (Ostojic et al. 2014; Johnson et al. 2017; Hill et al. 2020). Individuals of the same chronological age can show considerable differences in their biological maturation status, timing, and tempo, as evidenced by differences of up to six years in skeletal age and somatic growth among peers (Borms 1986; Johnson 2015; Gundersen et al. 2022; Towlson et al. 2022). It is, therefore, common to observe substantial differences in body weight, height, lean body mass and the proportion of mature adult height attained within age cohorts (Johnson et al. 2017; Hill et al. 2020; McAuley et al. 2023; Sweeney et al., 2023). Indeed, within chronological age groups, variations in male body mass (~50%), stature (~17%),

CONTACT Tommy R. Lundberg tommy.lundberg@ki.se Department of Laboratory Medicine, Division of Clinical Physiology, ANA Futura Karolinska Institutet, Huddinge 14152, Sweden

fat free mass (~21%) and percentage of predicted adult height (~10-15%) are not uncommon (Hannon et al. 2020; Salter et al. 2021). These maturity-related differences can provide early maturing individuals with significant physical advantages in terms of size, muscle mass and strength, and aerobic capacity (Meylan et al. 2010; Buchheit and Mendez-Villanueva 2014; Brown et al. 2017; Teixeira et al. 2018; Radnor et al. 2021), all of which are critical for performance in football (Sweeney et al., 2023).

In consequence, early maturing male players have an increased probability of selection into national and international development programmes in football at the detriment of later maturing, aged-matched peers (Ostojic et al. 2014; Johnson et al. 2017; Hill et al. 2020; Sweeney et al., 2023, 2023). For example, data from Sweeney et al. in the Irish context suggests that there is a total exclusion of late maturing male players at the (inter)national level by the U15 cohort (Sweeney et al., 2023). Across the literature, these maturation biases in a male youth football context generally seem to emerge at around 11-12 years of age, coinciding with the onset of puberty, and increase in magnitude with chronological age and the level of competition (Johnson et al. 2017; Hill et al. 2020; Sweeney et al., 2023, 2023).

Various strategies such as bio-banding (Cumming et al. 2018), player labelling (Lüdin et al. 2022), discrete performance banding (Moran et al. 2022), and adjusting chronological age groups (i.e. playing up or down) (Kelly et al. 2021) have been proposed to mitigate maturity-related selection biases in youth football. One emerging intervention of interest in a football-specific context is national futures programmes (Royal Belgian Football Association 2019; Future Team: Svenska Fotbollförbundet 2022; Future National Team: Dansk Boldspil-Union 2023). National futures programmes enable opportunities for late-maturing players to be retained within the national system in a separate international team and experience training, competition, coaching, and travel as part of a national team (Sweeney et al., 2023). Crucially, however, the strategy still means that selection is based on players being identified as technically, tactically, and psychologically able for youth international football. Specifically, the Swedish Football Association invest significant resources into their Futures programme, with the ultimate aim being to retain more late biologically maturing players at the international level, and ultimately increase the number and quality of youth players transitioning to the senior international level (Future Team: Svenska Fotbollförbundet 2022).

Whilst the rationale for national futures programmes is well-intentioned, to the best of the authors' knowledge, there is currently no peer-reviewed published data relating to any aspect of national futures programmes. Indeed, whilst futures programmes are predominantly based upon bridging the physical disadvantages of biologically late maturing players, there are, therefore, no data to illustrate the physical demands of future-level football, nor are there any data relating to the perceived physical demands of future-level match-play from the players themselves. Given the rapidly increasing interest in national futures programmes e.g (Royal Belgian Football Association 2019; Future Team: Svenska Fotbollförbundet 2022; Future National Team: Dansk Boldspil-Union 2023), and the associated significant increased resource investment e.g (Taylor et al. 2022; Sweeney et al., 2023, 2023), there is a pressing need for data specific to futures programmes to inform practice across world football. Therefore, this study sought to examine the differences in the physical and perceptual demands of junior national team and aged-match international future team match-play, as well as to examine to what extent such physical differences are attributable to biological maturity-related factors.

Materials and methods

Research context

The Swedish Football Association is the National Governing Body for football in Sweden. As part of the Swedish Football Association's male national team pathway, at the Under 15 (U15) age group, those players considered the highest performing in the country are selected into the national team squad (e.g. the Swedish male U15 national team). At the same age group, those players who are considered equally capable for international youth soccer from a technical, tactical, and psychological perspective, but are delayed in biological maturity and deemed not yet physically ready for international youth soccer, are selected into the national future team squad. The current study focused on male U15 players selected into either the Swedish Football Association's national team or national futures team squads during the 2022/23 season over a six-month period.

Participants, ethics and consent

A total of 39 players were analysed during the study period, 18 of whom were future team players (14.9 ± 0.3 years) and 21 of whom were national team players (15.2 ± 0.2 years). All physical and perceptual match-play variables were recorded and analysed for each player. Of these players, we had complete information on date of birth, height, weight, biological parent height, and biological maturity for 17 future team players and 12 national team players. There were notable differences in biological maturation and anthropometrics between the two squads (Table 1). By participating in the Swedish Football Association's underage national teams and national futures teams, players and their parents/guardians are informed that anthropometric data, physical performance data, and other information will be collected as part of registration for, and participation in, the Association's national programmes. Their participation in these assessments is considered consent to routine data collection. Ethical approval

Table 1. Anthropometric characteristics and biological maturation data of the players relative to the national team and the future team.

	Future Team	National Team
Height (cm)	166.6 (4.9)	178.0 (7.9)
Weight (kg)	54.6 (6.0)	65.4 (6.6)
%PAH	94.4 (1.5)	97.5 (1.6)
Maturity Z-score (SD)	−0.19 (0.31)	0.31 (0.36)
Chronological age (yrs)	14.9 (0.3)	15.2 (0.2)

Note: Data are means (SD). All measurements were collected ~ 3 months prior to the first matches.

for the use of de-identified data for research purposes was granted by the Swedish Ethical Review Authority (2023-05881-01).

Anthropometric data and biological maturity

The Khamis-Roche method was used to predict each child's adult height (Khamis and Roche 1994, 1995), with each child's current height subsequently expressed as a percentage of their predicted adult height (hereafter, percentage of predicted adult height is referred to as "%PAH"). This method is based upon the presumption that within a cohort of chronologically aged-matched peers, those closer to their predicted adult height are more advanced in their biological maturation than those further from their predicted adult height (Khamis and Roche 1994, 1995). This method allows for the prediction of mature adult height using a regression formula based upon age, height, weight, biological mid-parent height, and sex-specific regression coefficients outlined by Khamis and Roche (Khamis and Roche 1994). Players had their body height measured to the closest 0.1 cm using a stadiometer (Seca 213i, Seca GmbH, Hamburg, Germany) and their body mass measured to the closest 0.1 kg using digital scales (Seca 803). These measurements for height and weight were taken approximately three months prior to the first international matches. Biological parents' heights were self-reported and then adjusted for overestimation as outlined by Epstein et al. (Epstein et al. 1995). Mean self-reported adjusted paternal and maternal heights (167 ± 6 cm and 180 ± 7 cm, respectively) were in line with sex-specific means for Swedish adults (Wikland et al. 2002). Biological maturity status was expressed as a Z-score for each individual player using the child's %PAH compared to age-specific means and standard deviations outlined in the Swedish population growth reference study (Wikland et al. 2002).

Physical performance variables

During the 2022/23 season, the national team played 5 matches composed of two 45-minute halves per match (total 450 match-play minutes), and the national futures team played 3 matches composed of two 40-minute halves per match (total 240 match-play minutes). The reason for these differences in the number of matches played are due to the international football calendar. Traditional national teams compete in international fixtures during the international fixture window, similar to those observed at the senior international level. In contrast, and given the relative infancy of national future's programmes, future fixtures are arranged on a case-by-case basis between Associations. These differences are reflective of the real-world nature and practical realities of youth international football and the logistical differences between national teams and the newly formed futures programmes.

All matches were against other national or national futures teams, respectively, with 11 players per team with matches played on natural grass. During the matches, the players wore a portable and validated global positioning systems (GPS) device (Catapult, Vector S7, Catapult Sports, Melbourne, Australia) (Scott et al. 2016), with a sampling frequency of 10 Hz. These units were placed in vests located between the players' scapula, as outlined in the manufacturer guidelines. Players wore the same GPS unit each game to limit inter-unit reliability issues and all GPS devices were turned on 30 min prior to the start of each match to ensure adequate satellite connection (Gundersen et al. 2022). Raw GPS data were synchronised at the end of each match and exported to Microsoft Excel (version 2312) for further analysis. The following physical performance variables were analysed: total distance (m), total player load (arbitrary units), high-intensity running (14.4-19.8 km/h) distance, very high-intensity running (19.8-25.2 km/h) distance, sprinting (>25.2 km/h) distance, number of accelerations (2-3 m/s^2), number of high-intensity accelerations (>3 m/s^2), number of decelerations (2-3 m/s^2), number of high-intensity decelerations (>3 m/s^2). Player load is a volume estimate of effort level and is derived from GPS by summing the acceleration recorded by a triaxial accelerometer in all directions. To facilitate analysis, the total acceleration is divided by 100, which simplifies the player Load value (Catapult Sports 2024).

Rate of perceived exertion

At the end of each match, players self-reported their Rate of Perceived Exertion (RPE) using the Borg 1-10 scale (Impellizzeri et al. 2004). RPE was collected within 30 min upon the completion of each match to ensure that the perceived effort was referred to as the whole match rather than the most recent event intensity. Players were familiarised with the procedures at the start of each tournament and RPE data were collected using the SAP Sports One (Walldorf, Germany) mobile app and then uploaded to Microsoft Excel for further analysis.

Data analysis

Data were analysed using mixed-effects models to account for the nested structure of repeated games within players. The "team" (future team vs. national team) was treated as a fixed effect to examine its influence on the dependent match variables. Players and matches were included as random effects to model intra-individual variability and repeated measures design. Marginal means (with standard errors) were calculated to obtain adjusted group-level summaries, and the fixed effect estimate of the mean difference (with 95% confidence intervals) between teams was reported to quantify the effect size, accounting for within-player and within-game correlation. Statistical analysis was performed using Jamovi and graphs were created using GraphPad. The significance level was set at $p < 0.05$. Effect sizes (Cohen's D) were also used to examine the magnitude of any significant differences (trivial = <0.2; small = 0.2 – 0.49; moderate = 0.5 – 0.79; large = 0.8 – 1.19; very large ≥ 1.2) (Sawilowsky 2009).

As the future team matches lasted 80 min and the national team matches 90 min, we adjusted all individual match times to 90 min using a conversion factor for each player. To confirm the appropriateness of this approach, we examined the correlation between the individual playing time and the outcome data with playing time extrapolated to 90 min. The only factor where individual playing time correlated significantly with the outcome was RPE (players who played full games reported a higher RPE than players with less playing time). Therefore, we included playing time as a covariate when analysing RPE. As the matches were spread over a six-month period, we also investigated whether there were any linear trends in the match data that might complicate the comparison (e.g. that certain metrics tended to increase over time due to the slightly increasing age of the players). However, this was not the case and there were metrics that peaked in both the first and last matches. Therefore, we did not adjust the mixed model for time.

Finally, in the cases where there was a significant difference between future team and national team in the outcome variable, we included maturation (%PAH) and chronological age as a covariate in the mixed model to investigate whether maturation or chronological age moderated the difference between the teams.

Results

The mixed-effects model analysis revealed significant differences between the future team and the national team in several key variables (Figure 1). In terms of total distance covered, players in the future team covered a significantly greater distance compared to players in the national team ($F = 8.9$, $p = 0.008$, Cohen's d 1.29), with an adjusted mean difference of 890 m (95% CI: 303 to 1476 m). The players' total player load over 90 min was also significantly higher in the future team ($F = 19.6$, $p < 0.001$, Cohen's d 1.88) than in the national team, with a fixed effect size of 207 units (95% CI: 115 to 299 units).

Distance covered at sprint speeds above 25.2 km/h also showed a notable difference ($F = 5.2$, $p = 0.033$, Cohen's d 0.63), with the future team covering shorter distances in the highest speed zone, resulting in a mean difference of 81 m (95% CI: 11 to 150 m). During high-intensity accelerations (> 3 m/s^2) over 90 min, players in the future team performed less efforts than those in the national team ($F = 8.7$, $p = 0.015$, Cohen's d 0.90), with a mean difference of 10.7 efforts (95% CI: 3.6 to 17.9). Decelerations (> 3 m/s^2) also appeared to differ between the teams (31.6 vs. 37.8 for future team and national team, respectively), but this difference did not reach statistical significance ($p = 0.075$, Cohen's d 0.42). The other physical performance factors examined (i.e. the distance covered in the lower speed zones and the accelerations and decelerations within the 2-3 m/s^2 zone) did not differ between the teams. In terms of the perceptual demands, the RPE value of the game (7.2 for future team and 7.7 for national team, adjusted for individual playing time) also did not differ between the teams (Figure 2).

When accounting for biological maturation, the adjusted marginal means were no longer significantly different between future team and national team in terms of total distance covered ($p = 0.340$) and distance covered in sprint speeds >25.2 km/h ($p = 0.292$). In contrast, the difference between the future team and national team in terms of total player load ($p = 0.046$) and high-intensity accelerations > 3 m/s^2 ($p = 0.030$) remained significant despite adjustment for biological maturation. Taking chronological age into account only eliminated the difference between the teams in the distances covered at sprint speeds >25.2 km/h (p-value changed from 0.033 to 0.098).

Discussion

This study sought to examine the differences in the physical and perceptual demands of junior national team and aged-matched national future team match-play, as well as to examine to what extent such physical differences are attributable to biological maturity-related factors. Future team players covered greater total distances and accumulated greater loads than national team players. However, national team players covered greater sprint distances and performed more high-intensity accelerations per match (even when adjusting for biological maturity). Surprisingly, there were no statistical differences between teams in terms of high-intensity running, very high-intensity running, or the number of decelerations, nor were there any differences in match-play RPE between teams.

Although there is a lack of existing studies to directly compare to the current investigation, the general consensus across the literature is that the more biologically mature players tend to perform greater distances at the highest speed thresholds and perform more high-intensity actions during matches (Buchheit and Mendez-Villanueva 2014; Francini et al. 2019; Goto et al. 2019; Gundersen et al. 2022; Parr et al. 2022). For instance, Buchheit and Mendez-Villanueva (Buchheit and Mendez-Villanueva 2014) investigated physical performance outputs by biological maturity in U15 players from one professional academy, finding that the more biologically advanced players covered greater distances at >16 km/h, reached higher peak running speeds, and also performed more high-intensity (>19 km/h) and repeated high-intensity actions than less mature players during matches, with no differences in total distances covered. Similar findings have been observed by Francini et al. (Francini et al. 2019) in U14–17 Italian players, whereby differences in biological maturity appear to differentiate the distances covered at the highest-intensities between players (>18 and >23 km/h). These findings are largely consistent with the current study and could likely be attributed to the physical and physiological adaptations (and advantages) conferred by advanced biological maturity (Meylan et al. 2010; Buchheit and Mendez-Villanueva 2014; Brown et al. 2017; Teixeira et al. 2018; Radnor et al. 2021). Indeed, it is well established that early maturing male youths have a higher lean muscle mass, strength and power as well as a higher maximal oxygen consumption than their late maturing peers (Malina et al. 2004; Meylan et al. 2010; Brown et al. 2017; Teixeira et al. 2018; Radnor et al. 2021). These adaptations are generally advantageous when efforts requiring a high level of strength, power, high-speed running, or sprinting are required; all of which are key physical attributes for effective football performance

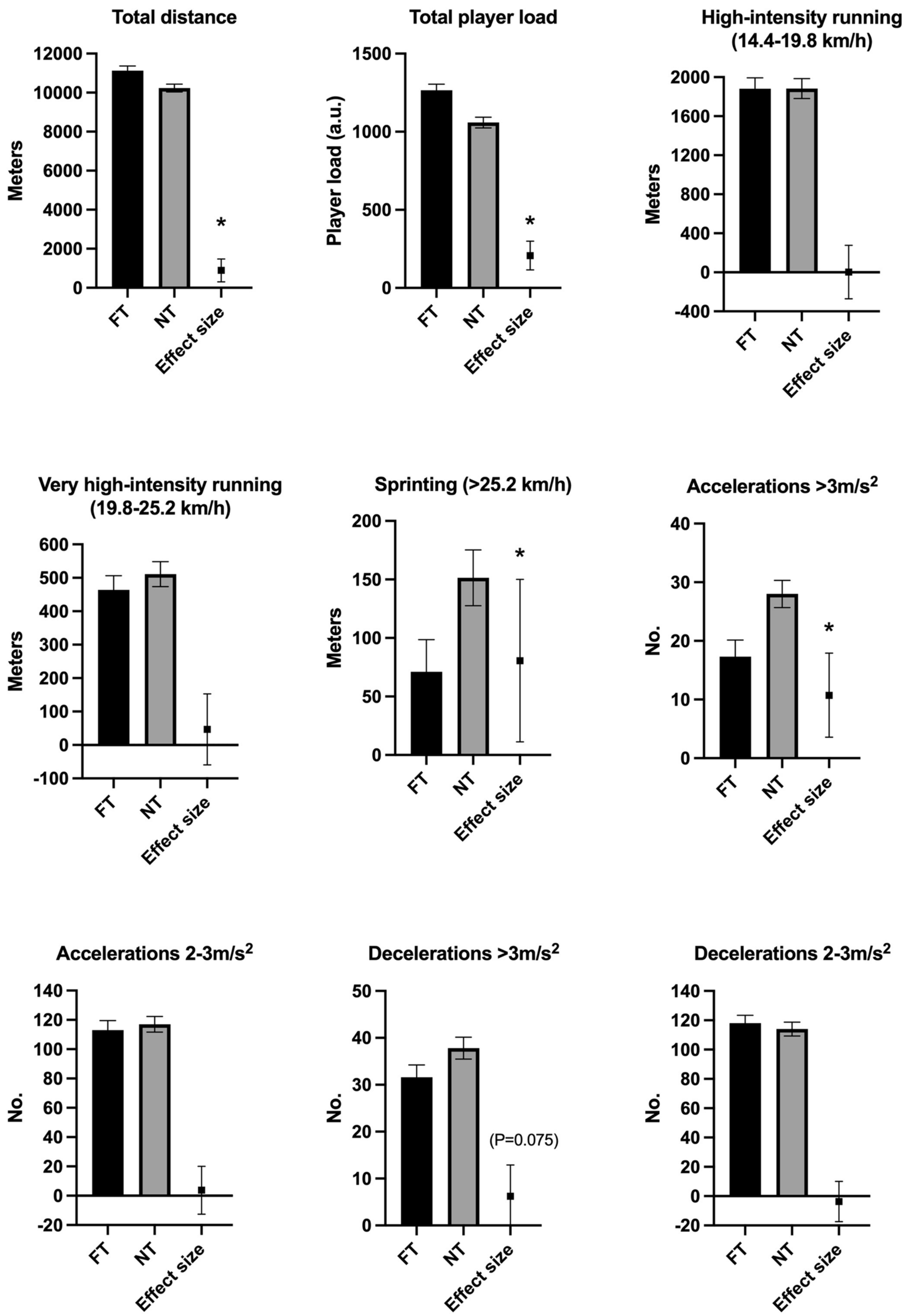

Figure 1. The physical performance demands between national team and future team match-play.

(Gundersen et al. 2022). Indeed, at the elite senior level, sprinting is the most frequent physical action preceding goal-scoring situations (Faude et al. 2012). However, it should be also noted that, across studies, varying methods have been used to calculate biological maturity (e.g. %PAH, skeletal x-rays, estimation of age at peak height velocity), meaning that inter-study comparison should be done with caution.

The primary aim of our study was to compare the physical and perceptual performance demands between national and future national team match-play. Whilst national team players were more biologically mature than chronologically aged-matched future team players (maturity Z-score 0.31 vs. −0.19, %PAH 97.5 vs. 94.4), during matches, there were no statistical differences in high or very-high intensity running, decelerations, or RPE between players. When adjusting for biological maturity, high-intensity accelerations and player load were the only metrics where statistical differences between team matches were observed. The differences in

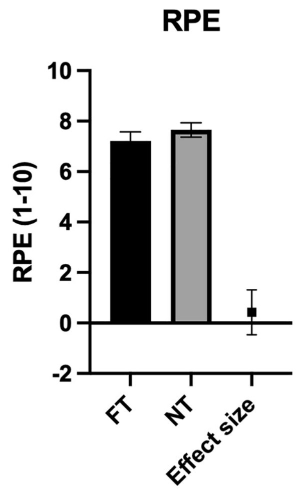

Figure 2. The Rate of Perceived Exertion (RPE) scores for match-play between national team and future team players.

high-intensity accelerations are perhaps unsurprising given the physiological adaptations conferred by advanced biological maturity as outlined in the preceding paragraph. Yet, the lack of statistical difference in any of the other high-intensity metrics is somewhat surprising given the literature in this regard (Buchheit and Mendez-Villanueva 2014; Francini et al. 2019; Goto et al. 2019; Gundersen et al. 2022; Parr et al. 2022). Despite being notably delayed in biological maturity relative to national team players, future team players performed similar amounts of high and very-high intensity running distances and a similar number of lower-speed accelerations and decelerations during matches, and yet did not perceive these demands to be any more physically exerting.

These findings present several implications regarding the role of future programmes within national Football Associations. Players selected for national futures programmes are considered capable for international youth soccer from a technical, tactical, and psychological perspective but are delayed in biological maturity and are deemed not yet physically ready for international youth soccer. Yet, our findings demonstrate that aside from sprinting speed and high-intensity accelerations, there are little differences in the physical performance metrics between national team and future national team matches. These findings would suggest that, aside from sprinting speed and high-intensity accelerations, futures players can largely meet the physical demands of aged-matched international youth football. Thus, futures programmes do not necessarily provide an environment of reduced physical challenge for later maturing players.

Our findings support the thesis that futures programmes represent a promising part in the development of late maturing players and an important addition for Football Associations. The ultimate aim of futures programmes are to retain more late biologically maturing players at the international level (Future Team: Svenska Fotbollförbundet 2022). A consistent theme across the literature, particularly at the (inter)national level, is the underrepresentation (or complete absence) of late maturing male players from national systems circa age 13/14 years (Ostojic et al. 2014; Sweeney et al., 2023, 2023). By being excluded from such systems, late maturing players are denied access to the professional coaching, sports science and medical support, superior training equipment and facilities, and the high levels of competitive challenge that are typically associated with (inter)national youth football (Hill et al. 2020; Sweeney et al., 2023). Futures programmes provide an environment exclusively for late maturing players to experience such developmental provision, and players may not get such experiences outside of these programmes. These experiences *can* be a crucial part in the talent development process and help to facilitate junior to senior transitions (Ostojic et al. 2014; Sweeney et al., 2023; Niklasson et al. 2024). These experiences are facilitated by effectively doubling the playing pool of those selected at the national level; something deemed as advantageous for talent development (Erikstad et al. 2021), although resource intensive (Taylor et al. 2022; Sweeney et al., 2023). However, the relative infancy of national futures programmes means that there has been no research conducted to evidence the role of such programmes in long-term player development. Indeed, this was the first study to present empirical data relating to any aspect of national futures programmes. Such longitudinal research is a desirable next step for futures programmes.

In the more immediate term, whilst we evidence the physical and perceived demands of national team and future team match-play, no technical, tactical, or psychological data is provided for either cohort. Whilst physical performance is an important part of football performance, it is just one element that sits alongside a broad range of other biopsychosocial variables (Bailey et al. 2010). The collection of technical, tactical, and psychological data, in addition to the current physical performance metrics would be a desirable next step for research of this nature in the more immediate term. More broadly, it should be noted that our findings are specific to the national level for male youth from one age cohort within the Swedish Football Association over one competitive season and should be interpreted with caution when generalised to alternate contexts or age groups. We also acknowledge that we used a non-invasive method to estimate somatic maturity, and parental heights for the prediction of adult height were self-reported, rather than measured, and subsequently adjusted for overestimation (Epstein et al. 1995). We also appreciate that measurements for height and weight used to predict each player's adult height were taken approximately three months prior to the first match and such variables may have changed in some players over the course of the season.

Conclusion

This study compared the physical and perceptual performance demands between national team and aged-matched national future team match-play. The results show that high-intensity accelerations and high-speed sprints were the main differentiator of physical performance in favour of NT players, while FT players covered more distance overall and had higher externally estimated player loads. The most robust differences after controlling for maturation were noted in high-intensity accelerations. Interestingly, there were little differences in the high or very high intensity running performed, with players perceiving these demands as similarly strenuous. This was despite the notable differences in biological maturity between players. We encourage greater investigation into national futures programmes, incorporating more longitudinal designs and accounting for additional performance variables, including technical, tactical, and psychological data.

Acknowledgments

The authors would like to thank the Swedish Football Association for their assistance in this research.

Authors' contributions

All authors contributed to the conception of the manuscript. Liam Sweeney wrote the original draft introduction, sections of the methods, the discussion and conclusion, with Lukas Sinkunas and TRL contributing to manuscript revisions. TRL wrote the original draft results and sections of the methods, with Lukas Sinkunas and Liam Sweeney contributing to manuscript revisions. TRL conducted data analysis and created all figures and tables. Lukas Sinkunas wrote sections of the methods, with Liam Sweeney and TRL contributing to manuscript revisions. Lukas Sinkunas collected all physical and perceptual performance data. All authors have made a substantial, direct, and intellectual contribution to the work, and approved this manuscript for submission.

Disclosure statement

TRL and Lukas Sinkunas have received financial compensation from the Swedish Football Association for consultancy services related to the national junior team programmes and coach education. Liam Sweeney declares no conflict of interest.

Funding

The authors received no financial support for this research study.

ORCID

Liam Sweeney http://orcid.org/0000-0002-3443-2763
Lukas Sinkunas http://orcid.org/0009-0005-9419-9974
Tommy R. Lundberg http://orcid.org/0000-0002-6818-6230

Code availability statement

The codes used for the statistical analysis presented in this paper will be made available upon request to the corresponding author.

Data availability statement

The raw data supporting the conclusions of this article will be made available upon reasonable request to the corresponding author.

References

Bailey R, Collins D, Ford PR, et al. 2010. Participant development in sport: an academic literature review. Commissioned report for sports coach UK. UK sport.

Borms J. 1986. The child and exercise: an overview. J Sports Sci. 4(1):3–20. doi: 10.1080/02640418608732093.

Brown KA, Patel DR, Darmawan D. 2017. Participation in sports in relation to adolescent growth and development. Transl Pediatr. 6(3):150–159. doi: 10.21037/tp.2017.04.03.

Buchheit M, Mendez-Villanueva A. 2014. Effects of age, maturity and body dimensions on match running performance in highly trained under-15 soccer players. J Sports Sci. 32(13):1271–1278. doi: 10.1080/02640414.2014.884721.

Catapult Sports. 2024. https://support.catapultsports.com/hc/en-us/articles/360000510795-What-is-Player-Load.

Cumming SP, Brown DJ, Mitchell S, Bunce J, Hunt D, Hedges C, Crane G, Gross A, Scott S, Franklin E, et al. 2018. Premier League academy soccer players' experiences of competing in a tournament bio-banded for biological maturation. J Sports Sci. 36(7):757–765. doi: 10.1080/02640414.2017.1340656.

Epstein LH, Valoski AM, Kalarchian MA, 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. Obes Res. 3(5):411–417. doi: 10.1002/j.1550-8528.1995.tb00170.x.

Erikstad MK, Tore Johansen B, Johnsen M, Haugen T, Côté J. 2021. "As many as possible for as long as possible"—a case study of a soccer team that fosters multiple outcomes. Sport Psychol. 35(2):131–141. doi: 10.1123/tsp.2020-0107.

Faude O, Koch T, Meyer T. 2012. Straight sprinting is the most frequent action in goal situations in professional football. J Sports Sci. 30(7):625–631. doi: 10.1080/02640414.2012.665940.

Francini L, Rampinini E, Bosio A, Connolly D, Carlomagno D, Castagna C. 2019. Association between match activity, endurance levels and maturity in youth football players. Int J Sports Med. 40(9):576–584. doi: 10.1055/a-0938-5431.

Future National Team: Dansk Boldspil-Union. 2023. https://www.dbu.dk/landshold/talentudvikling/specifikt-drenge/future/.

Future Team: Svenska Fotbollförbundet. 2022. https://www.svenskfotboll.se/div/2022/future-team/.

Goto H, Morris JG, Nevill ME. 2019. Influence of biological maturity on the match performance of 8- to 16-year-old, elite, male, youth soccer players. J Strength Cond Res. 33(11):3078–3084. doi: 10.1519/JSC.0000000000002510.

Güllich A. 2014. Selection, de-selection and progression in German football talent promotion. Eur J Sport Sci. 14(6):530–537. doi: 10.1080/17461391.2013.858371.

Gundersen H, Riiser A, Algroy E, Vestbøstad M, Saeterbakken AH, Clemm HH, Grendstad H, Hafstad A, Kristoffersen M, Rygh CB, et al. 2022. Associations between biological maturity level, match locomotion, and physical capacities in youth male soccer players. Scand J Med Sci Sports. 32(11):1592–1601. doi: 10.1111/sms.14225.

Hannon MP, Close GL, Morton JP. 2020. Energy and macronutrient considerations for young athletes. Strength Cond J. 42(6):109–119. doi: 10.1519/SSC.0000000000000570.

Hill M, Scott S, Malina RM, McGee D, Cumming SP. 2020. Relative age and maturation selection biases in academy football. J Sports Sci. 38(11-12):1359–1367. doi: 10.1080/02640414.2019.1649524.

Impellizzeri FM, Rampinini E, Coutts AJ, Sassi A, Marcora SM. 2004. Use of RPE-based training load in soccer. Med Sci Sports Exerc. 36(6):1042–1047. doi: 10.1249/01.mss.0000128199.23901.2f.

Johnson A, Farooq A, Whiteley R. 2017. Skeletal maturation status is more strongly associated with academy selection than birth quarter. Sci Med Footb. 1(2):157–163. doi: 10.1080/24733938.2017.1283434.

Johnson A. 2015. Monitoring the immature athlete. Aspetar Sports Med J. 4:114–118.

Kelly A, Wilson MR, Jackson DT, Goldman DE, Turnnidge J, Côté J, Williams CA. 2021. A multidisciplinary investigation into "playing-up" in academy football according to age phase. J Sports Sci. 39(8):854–864. doi: 10.1080/02640414.2020.1848117.

Khamis H, Roche A. 1994. Predicting adult stature without using skeletal age: the Khamis–Roche method. Pediatrics. 94(4 Pt 1):504–507.

Khamis H, Roche A. 1995. Predicting adult stature without using skeletal age: the Khamis-Roche method erratum. Pediatrics. 95:457.

Lüdin D, Donath L, Cobley S, Mann D, Romann M. 2022. Player-labelling as a solution to overcome maturation selection biases in youth football. J Sports Sci. 40(14):1641–1647. doi: 10.1080/02640414.2022.2099077.

Malina RM, Eisenmann JC, Cumming SP, Ribeiro B, Aroso J. 2004. Maturity-associated variation in the growth and functional capacities of youth football (soccer) players 13?15-years. Eur J Appl Physiol. 91(5-6):555–562. doi: 10.1007/s00421-003-0995-z.

McAuley ABT, Varley I, Herbert AJ, Suraci B, Baker J, Johnston K, Kelly AL. 2023. Maturity-associated polygenic profiles of under 12–16-compared to under 17–23-year-old male English academy football players. Genes (Basel). 14(7):1431. doi: 10.3390/genes14071431.

Meylan C, Cronin J, Oliver J, Hughes M. 2010. Talent identification in soccer: the role of maturity status on physical, physiological and technical characteristics. Int J Sports Sci Coach. 5(4):571–592. doi: 10.1260/1747-9541.5.4.571.

Moran J, Cervera V, Jones B, Hope E, Drury B, Sandercock G. 2022. Can discreet performance banding, as compared to bio-banding, discriminate technical skills in male adolescent soccer players? A preliminary investigation. Int J Sports Sci Coach. 17(2):325–333. doi: 10.1177/17479541211031170.

Niklasson E, Lindholm O, Rietz M, Lind J, Johnson D, Lundberg TR. 2024. Who reaches the NHL? A 20-year retrospective analysis of junior and adult ice hockey success in relation to biological maturation in male swedish players. Sports Med. 54 (5):1317–1326. doi: 10.1007/s40279-023-01985-z.

Ostojic SM, Castagna C, Calleja-González J, Jukic I, Idrizovic K, Stojanovic M. 2014. The biological age of 14-year-old boys and success in adult soccer: do early maturers predominate in the top-level game? Res Sports Med. 22(4):398–407. doi: 10.1080/15438627.2014.944303.

Parr J, Winwood K, Hodson-Tole E, Deconinck FJA, Hill JP, Cumming SP. 2022. Maturity-associated differences in match running performance in elite male youth soccer players. Int J Sports Physiol Perform. 17(9):1352–1360. doi: 10.1123/ijspp.2020-0950.

Radnor JM, Staines J, Bevan J, Cumming SP, Kelly AL, Lloyd RS, Oliver JL. 2021. Maturity has a greater association than relative age with physical performance in English male academy soccer players. Sports. 9(12):171. doi: 10.3390/sports9120171.

Royal Belgian Football Association. 2019. https://s3.eu-central-1.amazonaws.com/belgianfootball/s3fs-public/rbfa/docs/pdf/U16futures_fournationstournament_2019.pdf.

Salter J, Johnson D, Towlson C. 2021. A stitch in time saves nine: the importance of biological maturation for talented athlete development [Internet]. The Sport and Exercise Scientist, British Association of Sport and Exercise Sciences. https://www.bases.org.uk/imgs/_real_world___pg20_21___bases_tses_autumn_2021_online764.pdf.

Sawilowsky SS. 2009. New effect size rules of thumb. J Mod App Stat Meth. 8(2):597–599. doi: 10.22237/jmasm/1257035100.

Scott MTU, Scott TJ, Kelly VG. 2016. The validity and reliability of global positioning systems in team sport: a brief review. J Strength Cond Res. 30(5):1470–1490. doi: 10.1519/JSC.0000000000001221.

Sweeney L, Cumming SP, MacNamara Á, Horan D. 2023. A tale of two selection biases: the independent effects of relative age and biological maturity on player selection in the Football Association of Ireland's national talent pathway. Int J Sports Sci Coach. 18(6):1992–2003. doi: 10.1177/17479541221126152.

Sweeney L, Cumming SP, MacNamara Á, Horan D. 2023. The selection advantages associated with advanced biological maturation vary according to playing position in national-level youth soccer. Biol Sport. 40(3):715–722. doi: 10.5114/biolsport.2023.119983.

Sweeney L, Horan D, MacNamara Á. 2021. Premature professionalisation or early engagement? Examining practise in football player pathways. Front Sports Act Living. 3:660167. https://www.frontiersin.org/articles/.

Sweeney L, MacNamara Á, Taylor J. 2023. International selection and competition in youth sport: pin the tail on the donkey or targeted intervention? Front Sports Act Living. 5:1298909. doi: 10.3389/fspor.2023.1298909.

Sweeney L, Taylor J, MacNamara Á. 2023. Push and pull factors: contextualising biological maturation and relative age in talent development systems. Children. 10(1):130. doi: 10.3390/children10010130.

Taylor J, MacNamara Á, Taylor RD. 2022. Strategy in talent systems: top-down and bottom-up approaches. Front Sports Act Living. 4:988631. https://www.frontiersin.org/articles/10.3389/fspor.2022.988631/full.

Teixeira AS, Guglielmo LGA, Fernandes-da-Silva J, Konarski JM, Costa D, Duarte JP, Conde J, Valente-dos-Santos J, Coelho-e-Silva MJ, Malina RM, et al. 2018. Skeletal maturity and oxygen uptake in youth soccer controlling for concurrent size descriptors. Barbosa TM, editor. PLoS One. 13(10):e0205976. doi: 10.1371/journal.pone.0205976.

Towlson C, MacMaster C, Parr J, Cumming S. 2022. One of these things is not like the other: time to differentiate between relative age and biological maturity selection biases in soccer? Sci Med Footb. 6(3):273–276. doi: 10.1080/24733938.2021.1946133.

Wikland KA, Luo ZC, Niklasson A, Karlberg J. 2002. Swedish population-based longitudinal reference values from birth to 18 years of age for height, weight and head circumference. Acta Paediatr. 91(7):739–754. doi: 10.1111/j.1651-2227.2002.tb03322.x.