CRAIG, T.P., MAUGHAN, P., MCARDLE, M.P., CLARK, D.R. and REID, D. 2024. The physical progress of a professional Scottish soccer academy over a ten-year period. *Open access journal of sports medicine* [online], 15, pages 101-110. Available from: https://doi.org/10.2147/oajsm.s477808

# The physical progress of a professional Scottish soccer academy over a ten-year period.

CRAIG, T.P., MAUGHAN, P., MCARDLE, M.P., CLARK, D.R. and REID, D.

2024

Open Access Journal of Sports Medicine



Open Access Full Text Article

ORIGINAL RESEARCH

# The Physical Progress of a Professional Scottish Soccer Academy Over a Ten-Year Period

Thomas P Craig[1], Patrick Maughan[1], Michael Peter McArdle[2], David R Clark[1], Donald Reid[3]

[1]School of Health Sciences, Robert Gordon University, Aberdeen, UK; [2]The Scottish Football Association, Glasgow, UK; [3]School of Biodiversity, One Health and Veterinary Medicine, University of Glasgow, Glasgow, UK

Correspondence: Thomas P Craig, Email T.P.Craig@outlook.com

**Background:** Increases in high-intensity locomotor activity of match play have been recorded in elite soccer. This places an onus on academy practitioners to develop players for the future demands of the game. At an academy level, locomotor data are not available for analysis over a longitudinal period, and thus changes can only be assessed with physical attribute assessment. The aim of the present study is to establish if changes in physical capacity were observed in a professional Scottish soccer academy over a ten-year period.
**Methods:** A retrospective analysis was completed where linear mixed effect (LME) models were individually fitted to explain variation across each measure of physical capacity. Model selection was undertaken with likelihood ratio tests where the initial complex models were compared to simpler nested models to arrive at the final model by maximum likelihood.
**Results:** The main findings were that most recent players' sprint test data revealed a significant improvement in 5m, 10m and 20m sprint performance, greater increases in CMJ performance in older age groups, and greater increases in YYIR1 performance at U13 and U14. Most physical results showed increased performance with greater relative height and weight.
**Conclusion:** Players recruited more recently to academies are fitter than they were previously. Reference values within clubs that establish first team requirements will contribute to appropriate planning and implementation of training.
**Keywords:** player development, first team transition, talent development, soccer, football, physical profiles



## Introduction

Professional soccer academies aim to optimise the early detection and development of young players.[1,2] Talent identification practices are well established in soccer, as coaches and practitioners aim to utilise information regarding sociological, psychological, physiological, and physical development to inform recruitment and progression of young soccer players.[3] There is, however, a lack of longitudinal assessment to consider the validity of these practices across an academy cohort.[4,5] Previous research has identified physical differences between those in a professional academy and recreational academy players, highlighting the influence of physical attributes on successful progression.[6] Additionally, physical differences have been shown between selected and non-selected international U14–U17 players.[7] Despite the influence of physical attributes on success of academy players, there is limited evidence of this across an academy life cycle.[8] The influence of physical attributes on achieved level is also reflected in senior professional soccer where various physical differences exist between higher ranking and lower level teams.[9,10] Male elite soccer has observed a significant increase in locomotor demands at high intensities in recent years through analysis of physical match data[11,12] and physical testing results[10] whilst also showing increased technical development.[11] In youth players technical proficiency is correlated with physical fitness[12] and greater distances covered at high-speed running within academy small sided games.[13] There is further acknowledgement that the future of soccer will see increased locomotor demands and the associated increased physical demands of anticipated tactical changes.[14] To prepare players for this, soccer academy practitioners must have an intimate understanding of the determinants of performance.[1] However, it remains unclear as to whether physical development of academy soccer players has matched the improvements in physical attributes with time observed at senior level.



Received: 21 May 2024
Accepted: 23 July 2024
Published: 12 August 2024

The increase in physical performance of elite professional players has been assessed through locomotor analysis of match data. Retrospective analysis of match data from 2006–2013 demonstrated an increase in peak running velocity (PV), high intensity running (HIR), high intensity actions (HIA), sprint distance (SD), and number of sprints (TS) in the English Premier League.[15] High intensity running increased around 30% (890 ± 299 vs 1151 ± 337 m, $p<0.001$), sprint distance showed a 35% increase (232 ± 114 m vs 350 ± 139 m, $p<0.001$) attributed to an increase high intensity actions (118 ± 36 vs 176 ± 46, $p<0.001$) and number of sprints (31 ± 14 vs 57 ± 20, $p<0.001$). This was accompanied by a trivial variance in total distance covered throughout the same timeframe. Shorter, more frequent sprints and higher PV suggest an increase in acceleration ability and an increase in recovery anaerobic capacity.[15] Technical markers such as the number of successful passes and dribbles increased, lending support that the increases in physical capacity underpin reported increases in high intensity technical elements of match play across the same period.[15]

Although not assessed by Barnes et al or Bush et al, for the increase in high intensity match locomotor activities to occur[15–17] it is reasonable to expect an associated increase in physical performance tests. Krustrup et al[18] reported a correlation between YoYo Intermittent Recovery Test Level 1 (YYIR1) and match TD and HIR in elite male players ($r$=0.71, $p<0.05$). Similar results were observed for YoYo Intermittent Endurance Test Level 2 (YYIE2) and match TD ($r$=0.74, $p<0.01$), HIR ($r$=0.58, $p<0.05$), and Very High Intensity Running (VHIR) ($r$=0.56, $p<0.01$) in senior elite players.[19] Running speed over 20 m increased over a 15-year period in the professional Norwegian league, with those being assessed in 2006–2010 obtaining faster times than the 1995–1999 and 2000–2005 cohorts.[10,20] A similar group showed no change in $VO_2$max from 1989 to 2012, although the mechanism of assessment does not reflect the intermittent nature of the sport as would be the case when assessed by the YYIR1.[21] The collective research examining the changes in the English Premier League[15–17] attributes the changes observed to an increase in anaerobic capacity. Increased physical outputs at senior level place an onus on academy practitioners to develop players for the future demands of the game.[14] Research reporting locomotor demands of academy soccer over a full season has only recently been published,[20,22,23] thus the need to investigate any changes in physical capacity can be assessed by analysis of physical attributes from physiological testing sessions.

Buchheit et al[2] conducted an analysis for elite level U13–U18 age groups and discovered that match running performance was correlated with Counter Movement Jump (CMJ), PV, Repeated Sprint Ability (RSA), and peak running speed during an incremental field test. As would be expected, physiological characteristics improve progressively with age and maturation in youth soccer players.[24,25] There are differences in physical capabilities across levels of academy players between elite and non-elite players,[6–8,26] and this is apparent at the academy entry level in elite programmes.[27] Whether academy soccer has reflected the changes during the same time period as the collective analysis in the English Premier League[15–17] remains unknown; however, in the absence of GPS locomotor data, it can only be assessed with physical attribute assessment.

By utilising a single annual testing session Gonaus et al established progression in speed, change of direction, lower body power, and endurance at various ages over a 10-year period in elite Austrian youths.[28] By grouping test results from 2002–2005 and 2012–2015 within national development programmes, the authors were able to analyse retrospective data at U13 ($n$ = 890 vs $n$ = 967), U14 (999 vs 906), U15 (769 vs 869), U16 (550 vs 742), U17 (474 vs 483), and U18 (261 vs 283) age groups. The most recent academy players were taller and heavier with no changes in BMI for U13 and U14s with the U16s' and U17s' lower BMI being explained by lower body weight.[28] Sprint time improved for all split times (5, 10, 20 m) and age groups except for the U18 group, and RSA improved for all age groups. Furthermore, the U18s age group is the only group that does not show improvement in the lactate assessed endurance tests, with all other groups showing a significant improvement ten years later whilst CMJ is improved in U13, U14, and U15s. When reassessing the 2019[28] data under statistical control for height, body weight, exact age, number of pretests, time interval between pretests, and location, Gonaus et al observed similar increases in physical performance with time.[29] These increases were less than the non-statistical control[28] as the size of the decade effects decreased.[29] Collectively in this elite Austrian group, there are different and significant parameters across the ages, with physical skills associated with neurological developments being a key factor throughout.[28,29]

Carling et al[30] investigated the physical development in academy players over time at entry level (age 13) from 1992–2003 in an elite French regional academy. There was a significant increase in predicted $VO_2$max for players grouped from 1999–2003 versus those grouped 1992–1995 and 1996–1998. There was no maturation age difference in the groups across this time and no difference in outcomes when assessed through playing positions, suggesting that the progression of predicted $VO_2$max was independent of any explanatory variables that were measured. The timeline (until 2003) associated with the French work,[30] however, does not associate with the significant changes previously discussed from 2006 to 2013 in the senior game.[15–17] Another decade's retrospective analysis from 2000 to 2010 in the elite Dutch academy system does offer some overlap in the timeframes previously discussed.[31] Attributed to an increase in hours of soccer practice within the academy environment, all age groups (U13-U19) with the exception of U14s showed on average an increase ($p<0.05$) in the interval shuttle run test of over 50%.[31] Unfortunately, Elferink-Gemser et al[31] assessed no other physical attribute, and the work completed by Haugen et al[10] from 1995 to 2010 that observed sprint performance increases with time was performed in senior professional players and not academy age groups.

The need to prepare academy soccer players for evolving senior professional demands whilst recognising a periodic change in academy soccer reference values is critical.[29] Alongside evolving locomotor demands at first team level,[15–17] it is likely that the physical characteristics of professional academy performers has evolved.[29] Greater knowledge of this in an academy context will allow practitioners to establish if the physical capacity of youth players has progressed simultaneously with the progression evidenced in first team soccer, providing essential evaluation, education, and design components for academy practitioners.[32] Therefore, the aims of the present study are to establish whether previously observed changes in adult physical capacity were observed in a full time professional Scottish soccer academy.

## Methodology

A retrospective analysis was conducted on data collected from physical testing batteries from 512 players from 2006–2016 comprising height, weight, sprint, CMJ, and YYIR1 scores that were collected from the soccer academy of a full time professional Scottish club. Due to the nature of the academy system, players were continuously entering cohorts and exiting if they were deemed not to have met the standard required for progression. Of the 512 players tracked in this analysis, 50 were still within the academy system within this club or others at the final point of data collection, a further 100 players had transitioned to first team with the award of professional contracts, and 362 players were released at various stages and were no longer in the academy system. A total of 56 testing sessions produced 2021 testing battery results. Data were collected as part of the standard sports science support received by the player with informed consent provided via the player registration process signed by the player or parent / guardian. Retrospective analysis data collected for the purpose of sports science support is accepted within the sports science disciplines for publication.[33] The retrospective analysis presented received ethical approval by the institutional review board at Robert Gordon University (Ethics approval ID SHS/19/44) in compliance with the Declaration of Helsinki.

The assessment battery comprised measurement of stature and body weight, followed by performance of CMJ with hands on hips, 20m sprints (with time intervals recorded at 5, 10, and 20 m) and the YoYo Intermittent Recovery Test Level 1 (YYIR1). Participants performed the same standardised warm-up comprising a progressive and intermittent dynamic structure. Stature was measured using a free-standing stadiometer (SECA Height Measure, Hamburg, Germany), and body weight was measured using digital scales recording to 0.1 kg (SECA floor scale, Hamburg, Germany). The greatest jump height was recorded of three CMJ trials on an infra-red jump mat (MuscleLab IR Jump MAT, Ergotest, Langonsund, Norway). Counter movement depth was self-selected, with additional trials being allocated to replace excluded trials that involved any flexion of the knees prior to landing, a pause during the counter movement, or landing away from the centre point of the jump mat. The sprint protocol which followed comprised warm-up runs initiated with one foot self-selected in front of the other (1×80%, 1×90%, 1×100% perceived PV over 15 m each) followed by 3 × 20m maximum sprint trials with a 1:10 recovery period starting 1 m behind the 0 m timing gate (Speed Trap Timing, Brower Timing Systems, Utah, USA). Split times were recorded at 5, 10, and 20 m to the nearest 0.01 s with the lowest 20m time dictating the 5 and 10m split time assessed. Lower sprint times indicate greater sprint performance.

A ten-minute recovery period was provided between sprints and the YYIR1 assessment using recommended criteria for test termination. Appropriate test validity and reliability for all equipment and protocols adopted in the testing battery have been established previously with similar age groups within soccer.[8,32,34] Reliability was ensured across the entire data collection period by standardising the surface, the order of tests, time of data collection, and consistent use of primary tester to lead testing for the full period of data collection.

## Statistical Analysis

All analysis was undertaken utilising R (version 4.2.2) with R Studio IDE (version 2023.03.0). Linear mixed effect (LME) models were individually fitted to explain variation across each measure of physical capacity, specifically CMJ, YYIR1 distance, and 5m, 10m, and 20m times. Candidate explanatory variables considered in all models were Year, Age Group, the interaction between Year and Age Group, Height and Weight, with Individual being included as a random effect. Model selection was undertaken with likelihood ratio tests (LRT) where the aforementioned initial complex models were compared to simpler nested models (first by removal of interaction, then individual explanatory variables) to arrive at the final model by maximum likelihood. Results from the final model for each measure of physical capacity were then reported and plotted utilising ggplot2 (version 3.3.5). Where data were missing for individual variables (eg CMJ only), the data were analysed for variables that remained present for the other physical variables.

The assumptions of models (normality of residuals, independence of residuals, and homoscedasticity) were checked via diagnostics plots utilising the package ggfortify (version 0.4.16).

## Results

Summary statistics are presented in Table 1 with full analysis provided in the supplementary data within Supplementary Tables S1–S5. The final model explaining variation in 5m best time contained Year, Age Group, and Weight with no pairwise interaction (LRT: $\chi2$=12.984, df=1, $p$<0.001). The 5m best sprint performance time significantly improved by 0.0055 s per year (t=−11.8, $p$<0.001) and also improved with increasing player weight (t=−3.5, $p$<0.001) but was unaffected by player height. There was a significant improvement with increasing age group, with older cohorts having the fastest 5m time (t=−8.1, $p$<0.001). Similarly, the final model explaining variation in 10m best time contained Year, Age Group, and Weight with no pairwise interaction (LRT: $\chi2$=51.1, df=1, $p$<0.001). The 10m best time significantly improved by 0.008 s per year (t=−9.2, $p$<0.001) and also improved with increasing player weight (t=−5.01, $p$<0.001) but was unaffected by player height. There was a significant improvement with increasing age group, with older cohorts having the fastest 10m time (t=−10.5, $p$<0.001). The final model explaining variation in 20m best time retained all explanatory variables with no pairwise interaction (LRT: $\chi2$=13.0, df=1, $p$<0.001). The 20m best sprint performance time significantly improved by 0.011 s per year as shown in Figure 1 (t=−7.8, $p$<0.001) and also improved with increasing player weight (t=−4.8, $p$<0.001) and player height (t=−3.6, $p$=0.002). There was a significant improvement with increasing age group, with older cohorts having the fastest 10m time (t=−11.5, $p$<0.001).

**Table 1** Descriptive Physical Performance Characteristics of Elite Youth Players in a Scottish Soccer Academy from 2006 Until 2016. Results are Mean ± SD. Further Information Provided in Supplementary Tables

| Age Group | Year | 5 m (s) | 10 m (s) | 20 m (s) | CMJ (cm) | YYIR1 (m) |
|---|---|---|---|---|---|---|
| U11 | 2006 | 1.17 ± 0.1 | 2.05 ± 0.12 | 3.61 ± 0.15 | 23.5 ± 3.7 | 890 ± 415 |
| | 2016 | 1.1 ± 0.03 | 1.95 ± 0.07 | 3.51 ± 0.13 | 23.3 ± 3.4 | 1198 ± 297 |
| U12 | 2006 | 1.18 ± 0.09 | 2.05 ± 0.11 | 3.63 ± 0.16 | 24.9 ± 5.6 | 901 ± 361 |
| | 2016 | 1.08 ± 0.03 | 1.92 ± 0.05 | 3.41 ± 0.12 | 25.6 ± 4.7 | 1579 ± 485 |
| U13 | 2006 | 1.16 ± 0.1 | 1.99 ± 0.12 | 3.5 ± 0.17 | 28.8 ± 5.5 | 1040 ± 301 |
| | 2011 | 1.08 ± 0.03 | 1.86 ± 0.03 | 3.31 ± 0.06 | 29.4 ± 3.4 | 1617 ± 298 |
| | 2016 | 1.07 ± 0.04 | 1.88 ± 0.07 | 3.31 ± 0.12 | 26.6 ± 2.7 | 2095 ± 446 |
| U14 | 2006 | 1.12 ± 0.08 | 1.94 ± 0.12 | 3.35 ± 0.18 | 31.4 ± 5.2 | 1372 ± 381 |
| | 2011 | 1.04 ± 0.04 | 1.81 ± 0.07 | 3.22 ± 0.11 | 29.7 ± 2.5 | 1760 ± 373 |
| | 2016 | 1.04 ± 0.03 | 1.81 ± 0.05 | 3.1 ± 0.13 | 28.3 ± 3.2 | 2157 ± 452 |
| U15 | 2006 | 1.13 ± 0.09 | 1.9 ± 0.1 | 3.27 ± 0.16 | 29.7 ± 3.9 | 1677 ± 456 |
| | 2011 | 1.02 ± 0.06 | 1.78 ± 0.08 | 3.15 ± 0.14 | 32.0 ± 3.9 | 1920 ± 486 |
| | 2016 | 1.04 ± 0.06 | 1.81 ± 0.07 | 3.14 ± 0.16 | 31.7 ± 5.8 | 2255 ± 554 |
| U17 | 2006 | 1.1 ± 0.06 | 1.88 ± 0.12 | 3.21 ± 0.17 | 32.7 ± 5.4 | 1570 ± 642 |
| | 2011 | 0.97 ± 0.04 | 1.7 ± 0.05 | 2.99 ± 0.1 | 35.6 ± 5.0 | 2192 ± 289 |
| | 2016 | 0.96 ± 0.07 | 1.72 ± 0.06 | 2.95 ± 0.12 | 37.2 ± 4.0 | 2477 ± 443 |

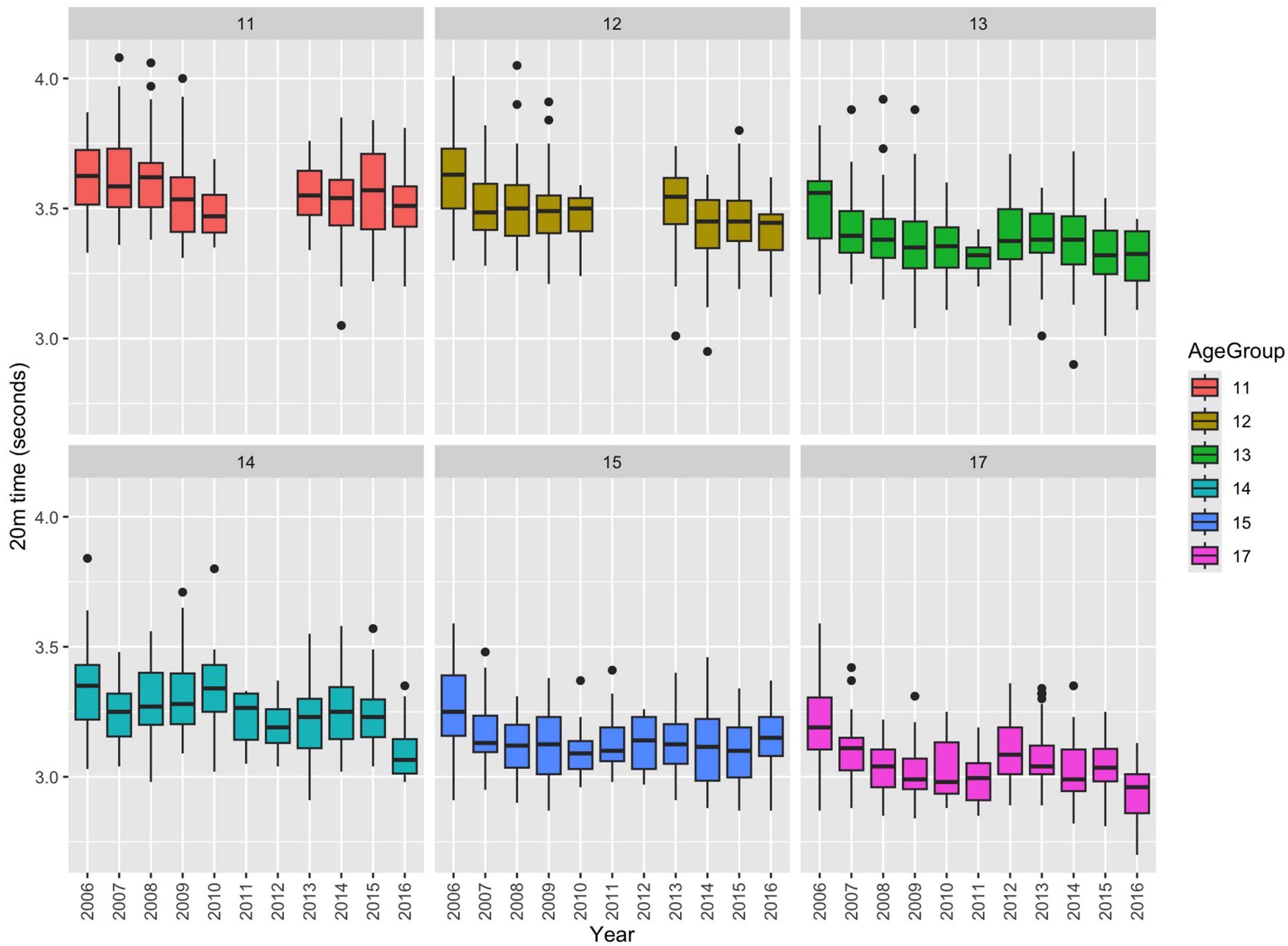


**Figure 1** Distribution of 20m sprint performance for all age groups U11–U17 from 2006 to 2016.

The final model for CMJ retained all explanatory variables including the pairwise interaction (LRT: $\chi 2=34.2$, df=5, $p<0.001$). CMJ increase each year (Figure 2) was dependent on age group, with the older cohorts showing more improvement over years (Interaction for Age Group 14, $p=0.003$; and Age Group 15, $p<0.001$; Age Group 17, $p=0.08$). CMJ was higher in taller players (t=3.13, $p=0.002$) and in heavier players (t=2.50, $p=0.01$).

YYIR1 distance was predicted by all explanatory variable, the two-way interaction but not weight (LRT: $\chi 2=14.3$, df=5, $p=0.01$). Taller players reached greater YYIR1 distances (t=3.63, $p<0.001$). The YYIR1 distance increase each year (Figure 3) depended on Age Group, with Age Group 13 improving fastest over years (t=3.31, $p<0.001$), and next closest was Age Group 14 (t=1.82, $p=0.067$). The 20m sprint (Figure 1), CMJ (Figure 2), and YYIR1 (Figure 3) progressions show the respective trends in sprint performance, power, and aerobic outputs with time, with alternative measures being presented in the supplementary information in Supplementary Figures S1–S2.

## Discussion

The main objective of this study was to establish whether changes in physical performance capacity observed over a decade in elite soccer academies were also observed in an elite Scottish academy. The main findings were that most recent players' sprint test data revealed a significant improvement in 5m, 10m, and 20m sprint performance time by 0.0055 s per year (t=−11.8, $p<0.001$), 0.008 s per year (t=−9.2, $p<0.001$), and 0.011 s per year (t=−7.8, $p<0.001$), respectively. The 20m sprint time, CMJ, and YYIR1 performances were enhanced with increased player height, whilst increased player weight showed positive interactions with all sprint measures and CMJ. The current study also observed greater increases in CMJ performance in older age groups and greater increases in YYIR1 performance at U13 and U14

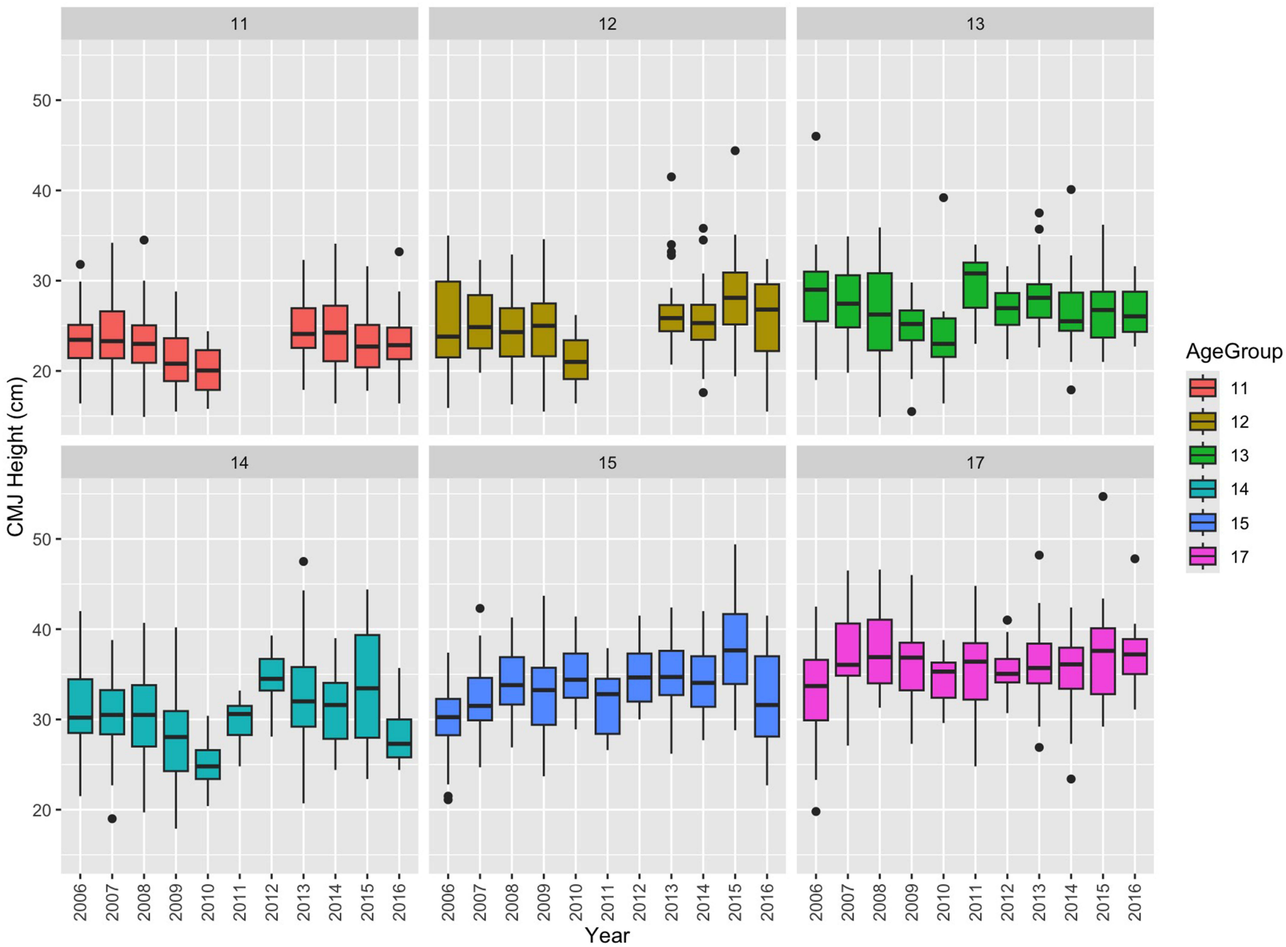


**Figure 2** Distribution of CMJ performance for all age groups U11–U17 from 2006 to 2016.

compared with other age groups. The increase in physical performance fits the narrative that academy soccer practitioners should consider the likely increases in physical demands that will be required for a faster future senior game.[14]

Carling et al[30] reported that estimated $VO_2$max in French elite academy entrants at U14 level increased significantly after five and ten years (1999–2003 59.7 ± 0.05 vs 1992–95 56.9 ± 0.5 mL/kg/min, $p$<0.01, ES=0.86; 1996–98 58.0 ± 0.04 mL/kg/min, $p$<0.05, ES=0.28). Although reported in distance covered during an YYIR1 assessment in the current study, a similar linear progression is observed when assessing the change in U14 aerobic capacity over a decade (2006 1372.41 ± 381.14; 2011 1760.00 ± 372.93; 2016 2157.14 ± 452.13 m), with the U13s and U14s experiencing the greatest positive YYIR1 increase. Over a decade from 2001 to 2010 elite Dutch players showed an increase of intermittent endurance capacity of 36.2–61.4%, with the greatest improvements being at the key academy transition periods.[31] These improvements were not always linear, however, with large year-to-year variations which may explain the decrease from the midway to the end point observed in the Dutch U14s group.[31] That the 57.2% improvement in the current study fits with that observed with elite Dutch youths,[31] but not with the 4.9% observed in the French cohort,[30] is likely due to the methodological choices of assessment.

A direct comparison with the comprehensive analysis presented in an elite Austrian environment is difficult to make due to methodological differences. Significant improvements in the endurance run are reported as final speed in km/h by Gonaus et al, which limits endurance comparisons.[28] Gonaus et al[28] grouped their participants and analysed collective years rather than the linear approach with time in the current study. In both the original Austrian 2019 analysis[28] and the follow-up 2023[29] analysis that utilised enhanced statistical control, Gonaus and colleagues evidenced an increase in physical performance, with the most recent players being taller (2.2–2.4 cm, $p$<0.001), and linear sprint times improved for all age groups (0.02–0.07 s,

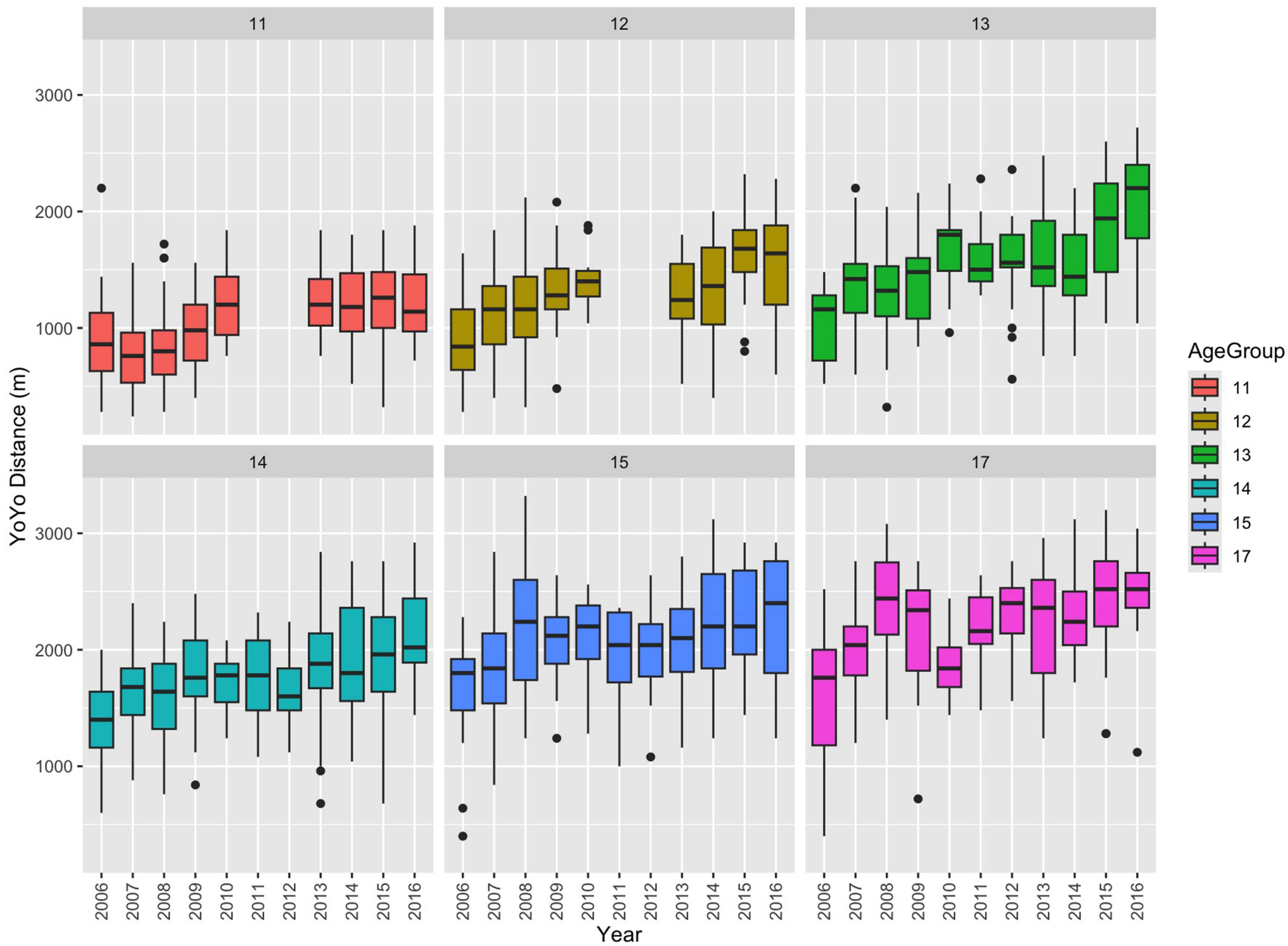


**Figure 3** Distribution of YYIR1 performance for all age groups U11–U17 from 2006 to 2016.

$p<0.001$, ES=0.26–0.58).[28,29] When these are broken down to annual improvements of 0.002 s for 5m and 0.007 s for 20m, this would be comparative with the current analysis (5m, 10m, and 20m sprint time improvement by 0.0055 s per year (t=−11.8, $p<0.001$), 0.008 s per year (t=−9.2, $p<0.001$), and 0.011 s per year (t=−7.8, $p<0.001$). In the Austrian sample, CMJ scores improved in the U13 to U15 group by 1.0–1.2 cm, with no improvements in U16-U18 groups.[28] The current Scottish sample observed the greatest CMJ improvement in older age groups, which may be down to the strength and conditioning prescription.[35]

Potential explanations may be related to recruitment and training strategies. The current participants undertook a systematic strength and conditioning programme which focused on functional movement in the early phase "children's academy" (U11–U13s) before loading strategies were introduced at "intermediate academy" stage (U14/U15) and "youth academy" stage (U17s) S&C programming and overall training themes mirroring first team activities. The age-associated increase in the current study may be linked to involvement in the S&C pathway associated with the current academy's periodised training regime.[36] Although no analysis has been completed relative to changes within this academy, for example changes within the staff or governing body requirements, it is also possible that, with more training knowledge and expertise involved, there has been a change in training quality including a focus on small-sided games within this time period.[35,37]

It is entirely possible, however, that the changes in the current study are due to club recruitment strategies. Transition periods reflect key decision-making time periods for soccer clubs, with players more likely to exit in these periods.[38] It is possible that these recruitment transitions lead to relatively older players[29] or more early matured players being recruited.[39] Although it is established that early matured players would more likely lead to an increase in physical capacity,[39,40] there is also an established relative age effect within the current group.[41] It would thus be prudent to establish if the relative age bias or maturation bias has improved across the same time period as within the current Scottish sample CMJ was higher in taller players (t=3.13, $p$=0.002) and in heavier players (t=2.50, $p$=0.01) and taller players reached greater YYIR1 distances (t=3.63, $p$<0.001). It is possible that recruiters are either consciously or subconsciously recruiting taller and heavier players into the academy system on the basis of enhanced physical attributes.

There are a number of limitations within the current study which should be considered. Firstly, Gonaus et al[29] have recently presented a reanalysis of their earlier work[28] integrating greater statistical control. A number of the factors engaged into the 2023 reanalysis[29] (eg testing location and academy status) remained consistent in the current study, and in the current study participant has been treated as a random effect. Although the results reflect the patterns observed in similar work in France, the Netherlands, and Austria,[28–31] any research that investigates a single club should be interpreted with some degree of caution. Within soccer academy strategies, however, it is important that clubs review how their data can positively impact efficiency and productivity. Unfortunately, maturation data have not been included. Although the Years from Peak Height Velocity method proposed by Moore et al[43] could have been utilised, the requirement for 3 data points for each individual participant would have reduced the overall sample size to 304, a reduction of 38.7%, and impacted the ability to examine the main aims of this study. Finally, the current study presents no locomotor activity analysis for a direct comparison with the higher match physical outputs presented from 2006 to 2013.[15–17] The Premier League Elite Player Performance Plan (EPPP) was established in 2011 with requirements that included monitoring of GPS locomotor activity at senior academy level. Given the time period that has since passed, it would be recommended that those practitioners who hold locomotor activity data not only begin to present comparative analysis between first team and academy,[20] but also establish the patterns observed in the time since EPPP inception to help plan what the next decade may hold.[14]

Williams and Reilly acknowledged the lack of longitudinal analysis in their 2000 review,[3] requesting that researchers embraced such data where available. The follow-on systematic review 23 years later[44] identified that the typical approach of researchers remains largely cross-sectional, and the current longitudinal study, although retrospective, adds a meaningful contribution to help guide practitioners to develop the future generations of soccer players.[14,44] Increased physical outputs at a senior level[15–17] place an onus on academy coaches and practitioners to develop players for the future demands of the professional soccer player.[14] Superior levels of aerobic fitness will theoretically allow players to work at a higher intensity and produce greater high intensity locomotor activities during match play. Outfield players aged 12–14 years old showed significant ($p$<0.05) correlations between $VO_2max$ and YYIR1 scores against HIR ($r$=0.73, 0.64), relative HIR ($r$=0.7, $r$=0.61), very high intensity running (VHIR) ($r$=0.57, $r$=0.59), and number of HIR and VHIR efforts (r=0.6–0.74) in 11v11 match play averaged over 3×40 minute matches.[45] This was also reflected in competitive matches where YYIR1 and MSFT results for 18 outfield U15 players showed large to very large significant correlations ($r$=0.65–0.76, $p$<0.01) with HIR and SD.[42] The correlations discussed[42,45] provide further support that any monitored changes in physical tests will likely be a correlated increase in high intensity match locomotor activities.

## Conclusion / Practical Applications

The players of a professional Scottish soccer academy have increased physical performance attributes with time. In order to ensure effective transition to first team strategies for clubs, reference values within each club that establish first team requirements will contribute to appropriate planning and implementation of training interventions to achieve transitions. Being able to quantify the progression of physical qualities over specific periods of time may also provide valuable understanding of the impact this may have on technical proficiency.[31] Recruiters should be aware that they may be consciously or subconsciously recruiting related to anthropometry and physicality rather than technical ability. In the future, we encourage clubs to collect and evaluate longitudinal changes through a collective annual analysis that integrates match and training locomotor activities with physical testing capacity that will allow practitioners to evaluate the impact of their practices, preparing the next generation for the future physical demands of the game. By planning the data requirements prospectively each season, this would allow integration of new methods and technologies whilst catering for the expected evolution over the next decade.[14]

## Data Sharing Statement

Anonymised data are available upon reasonable request, and the primary club have provided their permission for this.

## Acknowledgments

The authors would like to thank the primary club for the permission to conduct the retrospective analysis.

## Disclosure

The authors report no conflicts of interest in this work.

## References

1. Reilly T, Morris T, Whyte G. The specificity of training prescription and physiological assessment: a review. *J Sports Sci*. 2009;27(6):575–589. doi:10.1080/02640410902729741
2. Buchheit M, Mendez-Villanueva A, Simpson BM, Bourdon PC. Match running performance and fitness in youth soccer. *Int J Sports Med*. 2010;31 (11):818–825. doi:10.1055/s-0030-1262838
3. Williams AM, Reilly T. Talent identification and development in soccer. *J Sports Sci*. 2000;18(9):657–667. doi:10.1080/02640410050120041
4. Larkin P, Reeves MJ. Junior-elite football: time to re-position talent identification? *Soccer Soc*. 2018;19(8):1183–1192.
5. Bergkamp TL, Niessen ASM, den Hartigh RJ, Frencken WG, Meijer RR. Methodological issues in soccer talent identification research. *Sports Med*. 2019;49(9):1317–1335. doi:10.1007/s40279-019-01113-w
6. Slimani M, Nikolaidis PT. Anthropometric and physiological characteristics of male Soccer players according to their competitive level, playing position and age group: a systematic review. *J Sports Med Phys Fitness*. 2017;59(1):141–163. doi:10.23736/S0022-4707.17.07950-6
7. Gonaus C, Müller E. Using physiological data to predict future career progression in 14-to 17-year-old Austrian soccer academy players. *J Sports Sci*. 2012;30(15):1673–1682. doi:10.1080/02640414.2012.713980
8. Deprez DN, Fransen J, Lenoir M, Philippaerts RM, Vaeyens R. A retrospective study on anthropometrical, physical fitness, and motor coordination characteristics that influence dropout, contract status, and first-team playing time in high-level soccer players aged eight to eighteen years. *J Strength Cond Res*. 2015;29(6):1692–1704. doi:10.1519/JSC.0000000000000806
9. Longo UG, Sofi F, Candela V, et al. Performance activities and match outcomes of professional soccer teams during the 2016/2017 Serie A season. *Medicina*. 2019;55(8):469. doi:10.3390/medicina55080469
10. Haugen TA, Tønnessen E, Seiler S. Anaerobic performance testing of professional soccer players 1995–2010. *Int J Sports Physiol Perform*. 2013;8 (2):148–156. doi:10.1123/ijspp.8.2.148
11. Konefał M, Chmura P, Zając T, Chmura J, Kowalczuk E, Andrzejewski M. Evolution of technical activity in various playing positions, in relation to match outcomes in professional soccer. *Biol Sport*. 2019;36(2):181–189. doi:10.5114/biolsport.2019.83958
12. Rampinini E, Impellizzeri FM, Castagna C, Azzalin A, Bravo DF, Wisløff U. Effect of match-related fatigue on short-passing ability in young soccer players. *Med Sci Sports Exercise*. 2008;40(5):934–942. doi:10.1249/MSS.0b013e3181666eb8
13. Fenner JS, Iga J, Unnithan V. The evaluation of small-sided games as a talent identification tool in highly trained prepubertal soccer players. *J Sports Sci*. 2016;34(20):1983–1990. doi:10.1080/02640414.2016.1149602
14. Nassis GP, Massey A, Jacobsen P, et al. Elite football of 2030 will not be the same as that of 2020: preparing players, coaches, and support staff for the evolution. *Scand J Med Sci Sports*. 2020;30(6):962–964. doi:10.1111/sms.13681
15. Barnes C, Archer DT, Hogg B, Bush M, Bradley P. The evolution of physical and technical performance parameters in the English Premier League. *Int J Sports Med*. 2014;35(13):1095–1100. doi:10.1055/s-0034-1375695
16. Bush M, Archer DT, Barnes C, Hogg B, Bradley PS. Longitudinal match performance characteristics of UK and non-UK players in the English Premier League. *Sci Med Football*. 2017;1(1):2–9. doi:10.1080/02640414.2016.1233347
17. Bush M, Barnes C, Archer DT, Hogg B, Bradley PS. Evolution of match performance parameters for various playing positions in the English Premier League. *Hum Mov Sci*. 2015;39:1–11. doi:10.1016/j.humov.2014.10.003
18. Krustrup P, Mohr M, Amstrup T, et al. The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Med Sci Sports Exercise*. 2003;35(4):697–705. doi:10.1249/01.MSS.0000058441.94520.32
19. Bradley PS, Mohr M, Bendiksen M, et al. Sub-maximal and maximal Yo–Yo intermittent endurance test level 2: heart rate response, reproducibility and application to elite soccer. *Eur J Appl Physiol*. 2011;111(6):969–978. doi:10.1007/s00421-010-1721-2
20. Craig TP, Swinton P, Barrett S, Maughan P. Locomotor activities and subjective load differences between professional youth soccer players and professional development loans: a comparative analysis. *Int J Sports Sci Coach*. 2024;19(1):214–220. doi:10.1177/17479541221141145
21. Tønnessen E, Hem E, Leirstein S, Haugen T, Seiler S. Maximal aerobic power characteristics of male professional soccer players, 1989–2012. *Int J Sports Physiol Perform*. 2013;8(3):323–329. doi:10.1123/ijspp.8.3.323
22. Houtmeyers KC, Jaspers A, Brink MS, Vanrenterghem J, Varley MC, Helsen WF. External load differences between elite youth and professional football players: ready for take-off? *Sci Med Football*. 2021;5(1):1–5. doi:10.1080/24733938.2020.1789201
23. Hannon MP, Coleman NM, Parker LJ, et al. Seasonal training and match load and micro-cycle periodization in male Premier League academy soccer players. *J Sports Sci*. 2021;39(16):1838–1849. doi:10.1080/02640414.2021.1899610
24. Valente-dos-Santos J, Coelho-e-Silva MJ, Simões F, et al. Modeling developmental changes in functional capacities and soccer-specific skills in male players aged 11–17 years. *Pediatr Exerc Sci*. 2012;24(4):603–621. doi:10.1123/pes.24.4.603
25. Bellistri G, Marzorati M, Sodero L, Sforza C, Bradley PS, Porcelli S. Match running performance and physical capacity profiles of U8 and U10 soccer players. *Sport Sci Health*. 2017;13(2):273–280. doi:10.1007/s11332-016-0328-3
26. Grendstad H, Nilsen A, Rygh CB, et al. Physical capacity, not skeletal maturity, distinguishes competitive levels in male Norwegian U14 soccer players. *Scand J Med Sci Sports*. 2020;30(2):254–263. doi:10.1111/sms.13572
27. Leyhr D, Kelava A, Raabe J, Höner O. Longitudinal motor performance development in early adolescence and its relationship to adult success: an 8-year prospective study of highly talented soccer players. *PLoS One*. 2018;13(5):e0196324. doi:10.1371/journal.pone.0196324
28. Gonaus C, Birklbauer J, Lindinger SJ, Stöggl TL, Müller E. Changes over a decade in anthropometry and fitness of elite Austrian youth soccer players. *Front Physiol*. 2019;10:428397. doi:10.3389/fphys.2019.00333

29. Gonaus C, Müller E, Stöggl T, Birklbauer J. Determining the effect of one decade on fitness of elite Austrian youth soccer players using propensity score matching. *Front Sport Active Liv.* 2023;5:1186199.
30. Carling C, Le Gall F, Malina RM. Body size, skeletal maturity, and functional characteristics of elite academy soccer players on entry between 1992 and 2003. *J Sports Sci*. 2012;30(15):1683–1693. doi:10.1080/02640414.2011.637950
31. Elferink-Gemser MT, Huijgen BC, Coelho-e-Silva M, Lemmink KA, Visscher C. The changing characteristics of talented soccer players–a decade of work in Groningen. *J Sports Sci*. 2012;30(15):1581–1591. doi:10.1080/02640414.2012.725854
32. Paul DJ, Nassis GP. Physical fitness testing in youth soccer: issues and considerations regarding reliability, validity, and sensitivity. *Pediatr Exerc Sci*. 2015;27(3):301–313. doi:10.1123/pes.2014-0085
33. Winter EM, Maughan RJ. Requirements for ethics approvals. *J Sports Sci*. 2009;27(10):985. doi:10.1080/02640410903178344
34. Bosquet L, Berryman N, Dupuy O. A comparison of 2 optical timing systems designed to measure flight time and contact time during jumping and hopping. *J Strength Cond Res*. 2009;23(9):2660–2665. doi:10.1519/JSC.0b013e3181b1f4ff
35. McQuilliam SJ, Clark DR, Erskine RM, Brownlee TE. Free-weight resistance training in youth athletes: a narrative review. *Sports Med*. 2020;50(9):1567–1580. doi:10.1007/s40279-020-01307-7
36. Douchet T, Paizis C, Carling C, Cometti C, Babault N. Typical weekly physical periodization in French academy soccer teams: a survey. *Biol Sport*. 2023;40(3):731–740. doi:10.5114/biolsport.2023.119988
37. Bujalance-Moreno P, Latorre-Román PÁ, García-Pinillos F. A systematic review on small-sided games in football players: acute and chronic adaptations. *J Sports Sci*. 2019;37(8):921–949. doi:10.1080/02640414.2018.1535821
38. Stambulova NB, Pehrson S, Olsson K. Phases in the junior-to-senior transition of Swedish ice hockey players: from a conceptual framework to an empirical model. *Int J Sports Sci Coach*. 2017;12(2):231–244. doi:10.1177/1747954117694928
39. Johnson A, Farooq A, Whiteley R. Skeletal maturation status is more strongly associated with academy selection than birth quarter. *Sci Med Football*. 2017;1(2):157–163. doi:10.1080/24733938.2017.1283434
40. Parr J, Winwood K, Hodson-Tole E, et al. The main and interactive effects of biological maturity and relative age on physical performance in elite youth soccer players. *J Sports Med*. 2020;2020:1–11. doi:10.1155/2020/1957636
41. Craig, TP, Swinton P. Anthropometric and physical performance profiling does not predict professional contracts awarded in an elite Scottish soccer academy over a 10-year period. *European journal of sport science*. 2021;21(8):1101–1110.
42. Castagna C, Manzi V, Impellizzeri F, Weston M, Alvarez JCB. Relationship between endurance field tests and match performance in young soccer players. *J Strength Cond Res*. 2010;24(12):3227–3233. doi:10.1519/JSC.0b013e3181e72709
43. Moore SA, McKay HA, Macdonald H, et al. Enhancing a somatic maturity prediction model. *Med Sci Sports Exercise*. 2015;47(8):1755–1764. doi:10.1249/MSS.0000000000000588
44. Williams AM, Ford PR, Drust B. Talent identification and development in soccer since the millennium. *Sci Footb*. 2023:3–14.
45. Doncaster G, Iga J, Unnithan V. Influence of cardio-respiratory fitness on physical performance in elite youth soccer. *J Phys Fitness Med Treat Sports*. 2018;4(5):1–8. doi:10.19080/JPFMTS.2018.04.555646