Monitoring practices of training load and biological maturity in UK soccer academies

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Abstract

Purpose

Overuse injury risk increases during periods of accelerated growth which can subsequently impact development in academy soccer, suggesting a need to quantify training exposure. Non-prescriptive development scheme legislation could lead to inconsistent approaches to monitoring maturity and training load. Therefore, this study aims to communicate current practices of UK soccer academies towards biological maturity and training load.

Methods

Fourty-nine respondents completed an online survey representing support staff from male Premier League academies (n = 38) and female Regional Talent Clubs (n = 11). The survey included 16 questions covering maturity and training load monitoring. Questions were multiple-choice or unipolar scaled (agreement 0-100) with a magnitude-based decision approach used for interpretation.

Results

Injury prevention was deemed *highest* importance for maturity (83.0 ± 5.3, mean ±SD) and training load monitoring (80.0 ± 2.8). There were *large* differences in methods adopted for maturity estimation and *moderate* differences for training load monitoring between academies. Predictions of maturity were deemed *comparatively low* in importance for bio-banded (biological classification) training (61.0 ± 3.3) and *low* for bio-banded competition (56.0 ± 1.8) across academies. Few respondents reported maturity (42%) and training load (16%) to parent/guardians, and only 9% of medical staff were routinely provided this data.

Conclusions

Although consistencies between academies exist, disparities in monitoring approaches are likely reflective of environment-specific resource and logistical constraints. Designating consistent and qualified responsibility to staff will help promote fidelity, feedback and transparency to advise stakeholders of maturity-load relationships. Practitioners should consider biological categorisation to manage load prescription to promote maturity appropriate dose-responses and help reduce non-contact injury risk.

Keywords: *maturation, training load, monitoring, injury, adolescence, soccer*

Introduction

For academy soccer players, the pubertal growth period is a particularly sensitive time and should be managed with caution[1,2]. This period coincides with progressive, age specific increases in prescribed training exposure (hours), irrespective of individual biological maturation based on the development scheme legislation (policy)[3,4]. Elite Player Performance Pathway (EPPP)[3] and FA Women's Talent Pathway for Regional Talent Clubs (RTC)[4] policy provides recommendations for multifaceted components of player development, including minimum weekly training time, staff requirements, monitoring training load and biological maturity. The systematic increases in training exposure across both genders predominantly reflect development stage informed increases in weekly training load (20-50% depending on academy category) with adolescent players[5]. Most injuries within adolescent soccer are non-contact and soft tissue in nature[6,7] suggesting that these injuries may be attributable to inadequate training load prescription or growth-related physical and anthropometrical changes[8,9]. Significant time loss through injury, or illness may have major implications for (de)selection and long-term development[10].

Most (58-69%) injuries within professional soccer academies occur during training rather than match-play. Injuries peak following periods of relatively increased (relative risk of 3.5 following pre-season) or reduced training exposure (mid-season break)[6,11,12]. These findings are consistent with adult populations, where large (>10%) and sudden fluctuations in training load can amplify injury risk[15]. This highlights the importance of quantifying training load to mitigate injury risk[14], particularly during periods of accelerated biological development[1]. Consequently, to enhance long-term development and improve the sensitivity of (de)selection criteria, fluctuations in physical and functional attributes of players owing to maturity, and the associated response to training exposure, should be monitored and communicated to key stakeholders (e.g. coaches, medical staff and parents/guardians)[15].

EPPP and RTC policies aim to outline minimum standards for each category to facilitate adequate talent development environments for players. Adherence to these standards are assessed and used to classify each academy (e.g., category 1/tier 1) in return for financial investment and associated prestige helping with recruitment and retention. Yet, the extent of EPPP guidelines is somewhat non-prescriptive and open to interpretation (e.g. '188.2. anthropometric assessments' and '188.7. monitoring of physical exertion [Category 1 academies only][3]', with no minimum expected monitoring standards or guidelines provided in RTC legislation[4]. Although this ambiguity facilitates context and environment specific approaches which are warranted[16], it may subconsciously reduce consistency and generate opportunity for '*mixed-practice*' rather than '*best-practice'*.

Various methods to predict maturity status and timing exist with each having logistical, systematic or resource-based confines[17]. Similar limitations exist for training load monitoring which influences the methods adopted by academies[16]. As a result, debate remains around approaches to monitoring training load and which combination of internal (e.g. heart rate, rating of perceived exertion [RPE]) or externally derived metrics (e.g. total distance covered, activity profiles) offer most value for academy practitioners[16].

Previous surveys investigating training load monitoring have been conducted within professional populations[18,19] and identified varied approaches to collating and disseminating data to stakeholders, with resource and communication-based limitations apparent. Despite strong evidence outlining its relevance within academy settings, no such attempt to investigate current practices of maturity and training load monitoring within male or female academy soccer currently exists. Assessing the current extent of, and manner in which both male and female academies monitor these factors, would provide a platform to develop practice and subsequently optimise development. Therefore, given likely disparities in situational, logistical and environmental factors that govern both male and female academy practices, the aim of the current study was to establish and compare current perceptions and perceived barriers of practitioners to maturity and training load monitoring within UK soccer academies.

Methods

Design

A cross-sectional survey design was used to ascertain perceptions of staff from male (EPPP) and female (RTC) academies during the first trimester (August to December) of the 2017/18 soccer season. Following ethical approval from the University ethics committee and in accordance with the Declaration of Helsinki, voluntary informed consent was included prior to survey completion. No personal details of the respondent or club were requested to maintain respondent anonymity. Two eligibility questions 1) *Have you already completed the survey?* (Yes or No); 2) *Are you currently working with academy players within an EPPP or RTC setting?* (EPPP, RTC or No) followed the consent page to prevent duplicate responses and ensure construct validity respectively. Each respondent was required to state which professional league their club competed in, the academy category (e.g. Cat/RTC), job role, employment status accompanied by which age category (Foundation [<9 to <12 years], Youth Development [<13 to <16 years], Professional Development [<18 to <23 years]) they primarily worked with.

Subjects

118 respondents started the survey, however, there were 23 incomplete responses and 46 respondents failed eligibility criteria (question 2) and were excluded from analysis. In total, 49 respondents completed the survey (Cat1: n = 15 [31%]; Cat2: n = 13 [27%]; Cat3: n = 10 [20%]; RTC: n = 11 [22%]). Most respondents worked in the Youth Development Phase (YDP; 57%) or Professional Development Phase (PDP; 39%); with 4% working with the Foundation Phase (FP). Most responses were from sport science support staff (sport scientists, strength and conditioning coaches, athletic development or physical development coaches; 77%) with medical (physiotherapists, sports therapists, rehabilitation specialist or doctor; 15%) and technical coaching staff (lead or age group coach; 8%) providing the remainder of the responses. Most of the respondents were employed either full-time (57%) or part-time (23%), with a smaller number of responses coming from sessional staff (hourly paid; 14%) and internship students (6%). Most respondents worked for Championship (43%) or Premier

League (29%) clubs, but some responses were from League One (14%), League 2 (6%) and clubs within the National League or below (8%).

Methodology

Content validity[20] of the initial survey was reviewed via communications between the research team and practitioners (*n* = 5) and academics (*n* = 4) with experience of academy soccer and survey-based studies. This process removed five questions, combined six questions into three and had language amendments for clarity. The final survey consisted of 16 questions that included 2 unipolar (0 = *not important*; 100 = *highly important*) and 6 multiple choice questions each, covering two concepts: 1) *monitoring of biological maturity* and 2) *training load monitoring*. Response analysis to establish internal consistency of each concept using Cronbach's alpha[21] yielded alphas rated as '*good*', which ranged from 0.78 [95% confidence interval 0.72 to 0.86] (*monitoring of biological maturity*) to 0.83 [0.72 to 0.86] (*training load monitoring*). The survey was then published using an online survey tool (surveymonkey.com, California, Palo Alto, USA), with completion time of ~10 minutes. A web-link invite to participate was distributed to coaches, sport science support staff and medical practitioners within EPPP and RTC clubs via personal networks and social media.

Statistical Analysis

Responses from the multiple-choice questions were converted into a proportion of the total number of respondents from each academy category. Independent-group proportion differences for multiple choice questions were calculated with the following scale used to classify magnitudes of difference 10%, 30%, 50%, 70% and 90% as *small*, *moderate*, *large*, *very large* and *extremely large* respectively[22]. Given the small sample size and the large number of inferences, we elected to use moderate as our threshold for meaningful differences.

Numerical data from unipolar-scaled questions were rank ordered and presented as mean ±SD to qualitatively illustrate perceived importance. To facilitate distribution-based interpretations and overcome the limitations of few verbal anchors on the unipolar scale, four perception levels were devised based on percentage thresholds of the overall mean; *lowest* (<25%), *comparatively low (*25% to 50%), *comparatively high* (50% to 75%) and *highest* (>75%[23]). Inferential analysis (ANOVA) was conducted using JASP computer software (v0.11.1, Amsterdam, Netherlands) to establish independent group mean differences in perceived importance and 99% compatibility limits (CL) to reduce inferential error rates, which were subsequently translated into probabilistic terms using a customised Magnitude-Based Decisions (MBD) spreadsheet[24]. A clear standardised difference for non-clinical substantiveness of 10% was adopted, as this is considered the smallest important effect threshold for between-group differences[22]. Only those effects that were above the smallest important effect were reported and these were then interpreted against the following Bayesian scale: 0.5% *most unlikely* or *almost certainly not*; 0.5-5% *very unlikely*; 5-25% *unlikely* or *possibly not*; 25-75% *possibly*; 75-95% *likely* or *probably*; 95-99% *very likely*; and 99.5% *most likely*[24] to express uncertainty. For both approaches to analysis, all comparisons were made against EPPP Cat1 academies. In light of the EPPP infrastructure being more mature than RTC, and these Cat1 academies fulfilling significant requirements to be awarded this status, they should be regarded as the benchmark of best practice within UK academy football.

Results

Table 1 Perceived importance (mean ± SD) of biological maturity estimations between clubs sorted by percentiles (sample mean ± SD), with chances that the true magnitude of difference is important. Effects below the smallest important threshold are not reported. All comparisons made against Category 1 academies (Cat1).

	Cat1 (*n* = 15)	Cat2 (*n* = 13)	Cat3 (*n* = 10)	RTC (*n* = 11)	Mean (*n* = 49)	Between-group differences and probability of important differences Mean difference ±99% CL
Perceived level of importance of the estimations of biological maturity for…						
[H]injury prevention	79 ± 13	84 ± 19	79 ± 11	91 ± 10	83 ± 14	*Possibly*, RTC 11%; ±11%
[CH]overall player development	74 ± 15	87 ± 14	80 ± 12	80 ± 12	80 ± 14	*Possibly*, Cat3 6%; ±15%
[CH]load management	79 ± 10	79 ± 20	75 ± 12	80 ± 21	78 ± 16	
[CH]coach feedback	75 ± 11	80 ± 12	72 ± 9	76 ± 10	76 ± 11	
[CH]player feedback	58 ± 18	73 ± 19	72 ± 14	81 ± 14	71 ± 19	*Likely*, Cat2 15%; ±17%; Cat3 14%; ±18%; *Very Likely*, 23%; ±19%
[CL]player retention	72 ± 13	78 ± 22	64 ± 22	59 ± 19	68 ± 19	*Possibly*, Cat3 -8%: ±21%; RTC -13%; ±20%
[CL]reports to parents	64 ± 13	75 ± 22	56 ± 22	75 ± 19	68 ± 17	*Possibly*, Cat2 11%; ±16%; Cat3 -8%; ±17%; RTC 11%; ±16%
[CL]player recruitment	71 ± 16	71 ± 22	67 ± 17	58 ± 24	67 ± 20	*Possibly*, RTC -14%; ±21%
[CL]bio-banded training	59 ± 27	64 ± 23	57 ± 21	63 ± 22	61 ± 23	
[L]club legislation	54 ± 17	60 ± 24	51 ± 26	64 ± 15	58 ± 21	
[L]bio-banded competition	53 ± 28	57 ± 32	55 ± 23	57 ± 21	56 ± 26	
[L]EPPP/RTC legislation	59 ± 15	50 ± 28	39 ± 25	52 ± 26	50 ± 23	*Likely*, Cat3 -20%; ±23%
What are the primary barriers to implementing estimations of biological maturity?						
[CH]time constraints	57 ± 23	65 ± 33	73 ± 28	66 ± 26	65 ± 27	*Possibly*, Cat3 16%; ±29%
[CH]staffing numbers	47 ± 27	42 ± 35	76 ± 33	47 ± 32	53 ± 33	*Likely*, Cat3 29%; ±34%
[CH]resource limitations	30 ± 19	31 ± 26	59 ± 29	45 ± 33	41 ± 28	*Possibly*, RTC 15%; ±28%; *Very Likely*, Cat3 29%; ±29%
[CH]staffing competency	41 ± 26	37 ± 28	32 ± 26	53 ± 32	41 ± 28	*Possibly*, RTC 12%; ±29%
[CL]coach support	37 ± 26	38 ± 35	42 ± 27	31 ± 23	37 ± 28	
[CL]financial budget limitations	25 ± 24	30 ± 31	53 ± 37	35 ± 27	36 ± 31	*Possibly*, Cat2 5%; ±30%; RTC 10%; ±32%; *Likely*, Cat3 28%; ±33%
[CL]management support	36 ± 28	36 ± 32	35 ± 26	26 ± 21	33 ± 27	*Possibly*, RTC - 10%; ±29%
[CL]Parent/guardian support	17 ± 16	26 ± 32	27 ± 22	29 ± 30	25 ± 25	*Possibly*, Cat3 10%; ±28% RTC 12%; ±27%

Perceived importance: 0 = not important, 100 = highly important; Perception level: L lowest; CL comparatively low; CH comparatively high; H highest
Probability of important differences: <0.5%, most unlikely; 0.5-5%, very unlikely; 5-25%, unlikely; 25-50%, possibly; 75-95%, likely; 95-99.5%, very likely; >99.5% most likely (Hopkins, 2019)
Cat1, Category 1 academy; Cat2, Category 2 academy, Cat3, Category 3 academy; RTC, Regional Talent Club.

Biological Maturity

Injury prevention was identified as *highest* importance for estimation of maturity across academy groups, with overall athletic development, load management, coach and player feedback considered *comparatively high* (Table 1). Legislative expectations from clubs and governing bodies as well as bio-banded competition were considered *lowest* importance. Cat1 academies placed more importance on EPPP legislation than Cat3 academies and a *likely* to *very likely* lower importance on player feedback than all other academies. Time constraints, staff numbers, resource limitations and staff competency were all perceived to be *comparatively higher* barriers to implementing maturity predictions (Table 1). Staff numbers and resource limitations are *likely* to *very likely* bigger barriers in lower ranked academies than Cat1. Coach support, financial budget limitations, management and parental/guardian support were all perceived as *comparatively low* barriers, with differences between Cat1, Cat3 and RTC academies *possible* to *likely*.

Table 2 Number of responses (percentages) and qualitative differences magnitude for questions relating to biological maturation estimations. All comparisons made against Category 1 academies (Cat1) with only magnitudes of Small or greater reported.

Question and Responses	Cat1 (*n* = 15)	Cat2 (*n* = 13)	Cat3 (*n* = 10)	RTC (*n* = 11)	Proportion Difference Magnitude
Which approach is primarily adapted for estimating biological maturity?					
Predication of adult height	9 (60)	1 (8)	6 (60)	5 (46(	*Small: RTC; Large: Cat2*
Maturity offset	5 (33)	12 (92)	3 (30)	3 (27)	*Large: Cat2*
Skeletal maturity	0 (0)	0 (0)	0 (0)	2 (18)	*Small: RTC*
Other	1 (7)	0 (0)	1 (10)	1 (9)	
Who is primarily responsible for collecting biological maturation data?					
Medical staff	1 (7)	2 (15)	0 (0)	3 (28)	*Small: RTC*
Sport Science support staff	14 (93)	11 (85)	8 (80)	8 (72)	*Small: Cat3; RTC*
Other	0 (0)	0 (0)	2 (20)	0 (0)	*Small: Cat3*
**Who is biological maturity data reported to?*					
Academy manager	10 (67)	8 (62)	7 (70)	6 (55)	
Lead age group coach	12 (80)	12 (92)	8 (80)	9 (82)	*Small: Cat2*
Age group coaches	14 (93)	10 (77)	7 (70)	9 (82)	*Small: Cat2, Cat 3, RTC*
Medical staff	15 (100)	11 (85)	9 (90)	9 (82)	*Small: Cat2, Cat3, RTC*
Sport Science support staff	14 (93)	12 (92)	9 (90)	9 (82)	*Small: RTC*
Intern/student	2 (13)	6 (46)	2 (20)	2 (18)	*Large: Cat2*
Player	7 (47)	5 (39)	5 (50)	7 (64)	*Small: RTC*
Parent/guardian	1 (7)	5 (39)	4 (40)	9 (82)	*Moderate: Cat2, Cat3; Very large: RTC*
What is the primary method of feedback on biological maturation estimations?					
Infographic	1 (7)	0 (0)	0 (0)	0 (0)	
Verbal communication	1 (7)	2 (15)	1 (10)	8 (73)	*Large: RTC*
Visual presentation	9 (60)	8 (62)	6 (60)	2 (18)	*Moderate: RTC*
Written report	4 (27)	3 (23)	3 (30)	1 (9)	*Small: RTC*
**When using biological maturity to group players, what activities is this for?*					
Pitch-based sessions	8 (25)	8 (29)	4 (25)	2 (25)	*Small: Cat3; Moderate: RTC*
Gym-based sessions	7 (22)	8 (29)	4 (25)	4 (50)	*Small: Cat2, RTC*
Recovery sessions	0 (0)	0 (0)	0 (0)	1 (12.5)	
Competitive fixtures	5 (16)	2 (7)	1 (6)	0 (0)	*Small: Cat2, Cat3; Moderate: RTC*
Ad-hoc fixtures	7 (22)	6 (21)	3 (19)	1 (12.5)	*Small: Cat3; Moderate: RTC*
Specific fixtures	5 (16)	4 (14)	4 (25)	0 (0)	

**Question permitted multiple responses*

Scale of magnitudes: <10%, trivial; 10-30%, small; 30-50%, moderate; 50-70%, large, 70-90%, very large; >90%, huge[22]

Cat1, Category 1 academy; Cat2, Category 2 academy, Cat3, Category 3 academy; RTC, Regional Talent Club.

There were *large* differences between the methods of maturity estimation utilised by Cat1 and Cat2 academies (Table 2). Cat1, 3 and RTC academies preferred the prediction adult height whist Cat2 had a clear preference for maturity offset (i.e. time from peak height velocity). Sport Science support staff were primarily responsible for collection of maturity data consistently across all academies. There were no small to large differences in the methods used by academies communicate maturity feedback and *moderate* to *very large* differences suggesting that fewer Cat1 academies report this data to parents/guardians. There were small to moderate differences that suggests that academy status is linked to the activities influenced by maturity status monitoring (i.e. pitch-based training, competitive fixtures etc).

Table 3 Perceived importance (mean ± SD) of training load monitoring between clubs sorted by percentiles (sample mean ± SD), with chances that the true magnitude of difference is important. Effects below the smallest important threshold are not reported. All comparisons made against Category 1 academies (Cat1).

	Cat1 (*n* = 15)	Cat2 (*n* = 13)	Cat3 (*n* = 10)	RTC (*n* = 11)	Mean (*n* = 49)	Between-group differences and *probability* of important differences Mean difference ±99% CL
Perceived level of importance for monitoring training load for…						
[H]injury prevention	80 ± 17	80 ± 24	77 ± 16	84 ± 19	80 ± 19	
[CH]coach feedback	80 ± 10	72 ± 26	74 ± 7	66 ± 21	73 ± 19	*Possibly*, RTC -14%; ±19%
[CH]prescription of training	72 ± 18	70 ± 17	61 ± 23	80 ± 9	71 ± 19	*Possibly*, Cat3 -14%; ±20%
[CH]individualisation of training	71 ± 18	65 ± 21	71 ± 10	77 ± 13	71 ± 17	
[CH]overall player development	75 ± 18	65 ± 25	73 ± 12	68 ± 20	70 ± 20	*Possibly*, Cat2 -10%; ±20%
[CH]systematic progression	66 ± 22	68 ± 15	68 ± 15	63 ± 21	66 ± 21	
[CL]player feedback	62 ± 21	52 ± 26	69 ± 10	72 ± 7	64 ± 20	*Possibly*, Cat2 -10%; ±19%
[CL]EPPP/RTC legislation	57 ± 22	44 ± 26	53 ± 13	47 ± 28	50 ± 24	*Likely*, Cat2 -13%; ±24%
[CL]player retention	45 ± 26	44 ± 25	57 ± 24	48 ± 25	49 ± 25	*Possibly*, Cat3 12%; ±28%
[CL]Parent/guardian feedback	32 ± 18	47 ± 31	51 ± 15	56 ± 21	47 ± 24	*Likely*, Cat2 15%; ±23%; Cat3 19%; ±25%; RTC 24%; ±24%
[CL]club legislation	48 ± 19	39 ± 21	50 ± 13	45 ± 27	46 ± 21	
[CL]player recruitment	45 ± 26	27 ± 23	44 ± 25	40 ± 28	39 ± 26	*Possibly*, Cat2 -18%; ±26%
What are the primary barriers to implementing training load monitoring?						
[CH]resource limitations	54 ± 34	64 ± 29	84 ± 24	80 ± 9	71 ± 32	*Possibly*, Cat2 10%; ±31%; *Likely*, Cat3 30%; ±34%
[CH]staffing numbers	59 ± 28	69 ± 28	80 ± 26	63 ± 29	67 ± 28	*Possibly*, Cat2 10%; ±28%; *Likely*, Cat3 21%; ±31%
[CH]financial budget limitations	57 ± 31	72 ± 29	82 ± 18	50 ± 31	65 ± 30	*Possibly*, Cat2 15%; ±29%; *Likely*, Cat3 25%; ±31%
[CL]limited opportunity for intervention	48 ± 26	69 ± 33	63 ± 28	53 ± 28	58 ± 29	*Possibly*, Cat3 15% ±32%; *Likely*, Cat2 2%; 1 ±29%
[CL]staffing competency	38 ± 28	43 ± 27	44 ± 24	55 ± 32	45 ± 28	*Likely*, RTC 17%; ±30%
[CL]coach support	31 ± 20	51 ± 38	37 ± 24	42 ± 26	40 ± 28	*Possibly*, Cat3 6%; ±30%; RTC 11%; ±30%; *Likely*, 20%; ±28%
[CL]management support	43 ± 28	39 ± 38	34 ± 25	30 ± 22	36 ± 29	*Possibly*, Cat3 9%; ±32%; RTC 13%; ±32%

Perceived importance: 0 = not important, 100 = highly important; Perception level: [L] lowest; [CL] comparatively low; [CH] comparatively high; [H] highest
Probability of important differences: <0.5%, most unlikely; 0.5-5%, very unlikely; 5-25%, unlikely; 25-50%, possibly; 75-95%, likely; 95-99.5%, very likely; >99.5%, most likely (Hopkins, 2019)

Cat1, Category 1 academy; Cat2, Category 2 academy; Cat3, Category 3 academy, RTC, Regional Talent Club

Training Load

Monitoring training load is deemed *highest* importance for injury prevention (Table 3). Player recruitment, retention, parent/guardian and player feedback and legislative purposes were considered *comparatively low* importance. Responses suggest Cat 1 academies *likely* share load monitoring information with parent/guardians less often than other academies.

Resource limitations, staffing numbers, financial budget limitations and limited intervention opportunity were all considered *comparatively high* barriers to training load monitoring (Table

3). Cat3 academies *likely* find these barriers more prominent than Cat1. Management and coach support, staff competency and limited opportunity for intervention were *comparatively low* barriers to training load monitoring. A *possible to likely* differences in coach support may infer greater coach buy-in within Cat1 academies than others. Additionally, it is *likely* that RTC academies perceived staff competency as a greater barrier than Cat1 academies.

Moderate differences suggest that Cat1 academies utilise RPE and coach perception less than other academies in preference for external training load measures (Table 4). *Small to moderate* differences suggest that Cat1 academies favour customised spreadsheets to the Performance Management Application (PMA), conversely it is worth noting that the PMA is not available for RTC academies which likely influenced between-group comparisons. Training load data was mostly collated by Sport Science support staff with *moderate* differences between Cat1 and RTC academies. *Moderate* differences suggest Cat1 academies report training load data to age group coaches more frequently than other academies, but less to lead age group coaches than Cat2 academies.

Table 4 Number of responses (percentages) and qualitative differences magnitude for questions relating to training load monitoring. All comparisons made against Category 1 academies (Cat1) with only magnitudes of Small or greater reported.

Question and Responses	Cat1 (n = 15)	Cat2 (n = 13)	Cat3 (n = 10)	RTC (n = 11)	Proportion Difference Magnitudes
What is the primary approach to training load monitoring?					
GPS devices	7 (47)	4 (31)	0 (0)	0 (0)	*Small: Cat2; Moderate: Cat3, RTC*
Rating of Perceived Exertion	6 (40)	3 (23)	7 (70)	8 (73)	*Small: Cat2; Moderate: Cat3; RTC*
Physiological (TRIMP)	1 (7)	0 (0)	0 (0)	0 (0)	
Coach perceptions	1 (7)	4 (31)	2 (20)	1 (9)	*Small: Cat2, RTC*
Support staff perceptions	0 (0)	0 (0)	1 (10)	0 (0)	*Small: Cat3*
Wellness data	0 (0)	0 (0)	0 (0)	2 (18)	*Small: RTC*
Verbal discussion	0 (0)	2 (15)	0 (0)	0 (0)	*Small: Cat2*
How is your training load data compiled?					
Player Management Application	4 (27)	4 (31)	5 (50)	0 (0)	*Small: Cat2, RTC*
Customised spreadsheet	9 (60)	8 (62)	3 (30)	9 (82)	*Small:RTC; Moderate: Cat3*
Monitoring application	1 (7)	0 (0)	0 (0)	1 (9)	
Other	1 (7)	1 (8)	2 (20)	1 (9)	*Small: Cat3*
Who is primarily responsible for collating training load data?					
Academy manager	0 (0)	0 (0)	1 (10)	0 (0)	*Small: Cat3*
Lead age group coach	0 (0)	1 (7)	1 (10)	1 (9)	*Small: Cat3*
Age group coaches	0 (0)	1 (7)	0 (0)	1 (9)	
Medical staff	0 (0)	1 (7)	1 (10)	2 (18)	*Small: Cat3, RTC*
Sport Sciences support staff	14 (93)	9 (69)	7 (70)	6 (55)	*Small: Cat2, Cat3; Moderate: RTC*
Intern/student	1 (7)	1 (7)	0 (0)	1 (9)	
Players	0 (0)	0 (0)	0 (0)	0 (0)	
Who is training load data reported to?					
Academy manager	0 (0)	0 (0)	2 (20)	3 (27)	*Small: Cat3, RTC*
Lead age group coach	4 (27)	8 (62)	2 (20)	0 (0)	*Small: RTC; Moderate: Cat2*
Age group coach	8 (53)	1 (8)	2 (20)	4 (36)	*Small: RTC; Moderate: Cat2, Cat3*
Medical staff	0 (0)	0 (0)	0 (0)	1 (9)	
Sport Science support staff	1 (7)	2 (15)	1 (10)	0 (0)	
Player	1 (7)	1 (8)	0 (0)	1 (9)	
Other	1 (7)	1 (8)	3 (30)	2 (18)	*Small: Cat3, RTC*
How frequently are training load reports compiled?					
Daily	9 (60)	6 (46)	2 (20)	2 (18)	*Small: Cat2; Moderate: Cat3, RTC*
Weekly	5 (33)	2 (15)	2 (20)	5 (46)	*Small: Cat2, Cat3, RTC*
Monthly	0 (0)	1 (8)	1 (10)	1 (9)	*Small: Cat3*
Quarterly	0 (0)	0 (0)	0 (0)	2 (18)	*Small: RTC*
Bi-annually	0 (0)	0 (0)	1 (10)	0 (0)	
Annually	1 (7)	0 (0)	1 (10)	0 (0)	
Other	0 (0)	4 (31)	3 (30)	1 (9)	*Moderate: Cat2*

Question permitted multiple responses
Scale of magnitudes: <10%, trivial; 10-30%, small; 30-50%, moderate; 50-70%, large; 70-90%, very large; >90%, huge[22]

Cat1, Category 1 academy; Cat2, Category 2 academy; Cat3, Category 3 academy, RTC, Regional Talent Club

Discussion

This study represents the first attempt to establish perceptions of monitoring of maturity and training load in UK soccer academies. Given inherent differences between the two constructs, findings are discussed individually.

Biological Maturity

Practitioners agreed that injury prevention was of *highest* importance for predicting maturity characteristics. Responses indicate that practitioners recognise associations between maturity characteristics and amplified injury risk, and that monitoring maturity positively influences long-term outcomes[1]. Yet, there is disparity concerning protocols employed to predict maturity between academies, with indicators of timing (offset) and status (percentage of predicted adult height) prominent. '*Other*' responses may include a maturity ratio, growth velocity curves or skeletally derived methods (e.g. body dimensions)[25]. Both dominant protocols are advocated by the legislative bodies, however Cat1, Cat3 and RTC academies demonstrated a greater reliance on the prediction of adult height, with C2 favouring maturity offset (Table 2). Their prevalence is likely attributable to the 'non-invasive' and logistically simple algorithm-based protocols, yet evidence has previously outlined limitations in somatic assessment of maturity in comparison with more invasive skeletal protocols[17]. Consequently, it is imperative that practitioners are cognisant of the relevant methodological limitations and accommodate for this when informing decision making to ensure appropriate classification and accurate (de)selection evaluations.

Despite being pivotal for categorisation, practitioners unanimously perceived maturity prediction of *comparatively low* importance for biologically classified training and *lowest* for competitions. This is perhaps surprising given the recent rise of bio-banded male soccer tournaments supported by the EPPP, in which players are categorised by their current biological maturity[26]. The relative immaturity of the Women's FA Talent Pathway could explain the *comparatively low* importance placed on this by RTC clubs. Bio-banding is largely considered "an alternative method of categorising players, according to maturity status rather than their chronological age category, with the assumption that this will alleviate (de)selection bias associated with earlier and/or later maturing players."[27]

Bio-banding is a relatively new concept that has until recently traditionally adopted a talent development and selection focus, and therefore the relevance of bio-banding for managing load and injury was possibly overlooked within survey responses. It is reasonable to think that biological constraints within training and match-play would reduce physical variation and help coaches adequately stimulate players to reduce the typically increased injury incidence around biological growth spurts[2,26]. Evidence suggests trends in injury type throughout maturation, with late maturers having more osteochondral disorders and earlier maturers having more tendinopathies[11]. These non-traumatic injuries are largely preventable, which supports that biologically appropriate training prescription may help reduce the incidence of certain injuries through more effective manipulation of intensity. Therefore, practitioners are encouraged to consider the wider benefits of biological categorisation to optimise training load to facilitate biologically relevant content[1].

Time constraints, resource limitations, staff number and competency were considered as *comparatively high* barriers particularly in lower ranked academies, which could negatively impact validity of maturity predictions, [28]. Even when maturity assessments are stringently controlled, prediction equations can vary 0.1 to 0.2 years between weekly measures[29]. Therefore, anthropometric data collection requires precise measurements to reduce systematic error, which may be compromised in the absence of adequately trained or experienced staff, equipment or time. Whether these data are sport science led as prevalent in the survey, or medical staff led, consistency is paramount to reduce systematic error and thus safeguard data fidelity (i.e. inter-rater reliability)[25]. Importantly, the quality of internal communication between support, medical and technical staff within soccer clubs has been linked with injury rates and match availability[15]. Therefore, academies that designate responsibility of maturity monitoring to specifically trained staff will likely enhance transfer to positively influence athletic performance and associated caveats (i.e. reduction of injury risk).

There were *moderate* to *very large* differences between the low number of Cat1 respondents reporting maturity data to players and parent/guardians. This is surprising considering Cat1 academies perceive resources as comparatively lower barriers than Cat3 and RTC and therefore likely have better mechanisms to communicate this information effectively. Being transparent with maturity data and informing parent/guardians of the associated transient physical and functional turbulence related to growth, disadvantages (i.e. stress or anxiety) may be alleviated and may even lead to an autonomy supportive bio-psychosocial environment, reducing the likelihood of drop-out or injury[30]. In contrast, failure to involve stakeholders or providing a clear rationale for decision-making has been termed as '*autonomy-thwarting'* behaviour and linked to failed career progression and behavioural disengagement within soccer[31].

Training Load monitoring

Injury prevention perceived to be of *highest* importance for monitoring training load within academies. This is likely influenced by recent associations between training exposure and injury in both adult and adolescent populations[32,33]. Despite being of *highest* importance for injury prevention, remarkably almost no medical staff were routinely provided training load data (Table 4). This may suggest a reactive approach to injury management, opposed to a proactive approach whereby medical staff are actively involved in load management decisions. By routinely sharing training load data with medical staff (e.g. multidisciplinary team meetings), a more unified approach could better inform the process and help reduce injury incidence[15]. This suggests a communication breakdown in lower ranked academies, negating the purpose of monitoring training load and possibly the impact on reducing injury burden[15].

In addition, responses suggest coach and player feedback, overall development, systematic progression and individualisation and prescription of future training activities were considered of *comparatively high* importance. Although Cat1 academies reported training load to coaches 80% of the time, other academies reported this data to coaches less. On a positive note, this implies that active engagement in training load monitoring is accepted across academies, but the communication, interpretation and application of this appears to be negating impact, likely attributable to the resources available. Although these findings outline reduced impact of monitoring strategies, they correspond with similar conclusions from professional soccer[18,19]. These studies identified coach buy-in and discipline as prominent barriers to the effective impact of training load monitoring, implying that this problem is not an academy-isolated problem. In resolution, academies are encouraged to employ a routine load monitoring strategy enabling consistent collation and interpretation of data in line with context specific and resource appropriate objectives that fit their structure[16]. This should be combined with an education programme to involve all stakeholders and subsequently establish palatable dissemination strategies to enhance its application[16], potentially supported by a local academic institution.

Cat1 academies utilise external training loads more than other academies, which is unsurprising based on the resource investment associated with this. This potentially explains why other academies (Cat3) perceive staff numbers, financial budgets and resource limitations, as *comparatively high* barriers to training load monitoring. Although microelectromechanical systems (MEMS) may provide a wealth of data, it does not automatically result in better monitoring outcomes as some ambiguity exists around the precision of devices and metrics to monitor[33]. Research suggests combining internal and external loads offer best practice and better dose-response outcomes[16] to appropriately quantify the magnitude of internal response in light of the external stimulus[32]. This is crucial during periods of accelerated growth, considering likely fluctuations of the dose-response within adolescent soccer.

In the absence of resources to facilitate MEMS, RPE has been shown to be a suitable and valid surrogate gauge of relative psychophysical training intensity[34]. The application of RPE derived training load values are accessible and cost-effective, which may explain the dominant use of this within academies that reported financial and resource barriers (Cat2, Cat3 & RTC). RPE correlates well with physiological and some MEMS derived metrics, and they can be collated retrospectively with suitable validity in adolescent populations, although an approach utilising multiple markers of training load is preferable if resources permit[14,34].

Limitations

Although 49 responses are comparative to other soccer surveys (*n* = 19-41[18,29,35]), it is below that of others (*n* = 182-242[19]). It is acknowledged responses from the study represent a portion of the population and the opportunity for multiple responses from academies could lead to clustering[19]. The smaller sample size is somewhat negated as responses were from high-performance environments from a finite pool of UK-based academies. From anecdotal estimations, this study includes responses from approximately 38% of registered academies, from which a statistically conservative approach to inference was adopted to minimise false positive risk with power and precision results indicated by the 99% compatibility intervals for smallest important effects only. It is also acknowledged that engagement in this survey is more likely from those academies actively engaged in load and maturity monitoring, which may have influenced findings.

Finally, it is noted differences between the more established EPPP and developing FA Women's Talent Pathway academies exist, and that legislations for these pathways may influence differences in responses. However, this survey provides the first comparison between the professional practices of male and female adolescent academies and was therefore considered a novel facet to the study.

Practical Applications

Designating consistent responsibility for data collation to suitably qualified staff may enhance maturity and training load data dependability, engagement and help establish palatable dissemination strategies. Through this more effective feedback loop, academies will promote transparency of data and better inform stakeholders of maturity-load relationships leading to enhanced impact at group and individual levels. This interdisciplinary approach will require a more proactive, and targeted style of monitoring, to facilitate early intervention around accelerated growth periods. Finally, practitioners should consider using biological categorisation to help manage load prescription and maturity appropriate dose-response to help reduce non-contact injury risk.

Conclusion

Survey responses suggest that routine monitoring of biological maturity and training load is commonplace within adolescent soccer and that clubs adopt monitoring practices to primarily prevent injury. But, resource and environmental constraints create natural diversity around the methodologies and success of the monitoring process which may nullify impact. Without positively impacting player development or reducing injury risk, the monitoring process is futile. Therefore, practitioners are encouraged to identify a context-specific monitoring system that can be reliably and consistently applied and communicated to players, coaches and parent/guardians efficiently.

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