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Coach learning and club environment shape behaviour towards implementing training load and maturation monitoring practices in UK professional youth football academies

The objective of this study was to explore how UK professional youth football coaches construct knowledge and integrate training load and maturation monitoring into their coaching practice. Eleven experienced (≥5 yrs) coaches working with players in the youth development and/or foundation phase, from a range of elite player performance plan category clubs (1-3), were purposively sampled based on their coaching experience and qualifications. Semi-structured interviews were conducted, and coding was carried out using NVivo v12. An inductive, reflexive, thematic analysis was employed to analyse transcripts, and three themes were identified: 1. coach learning, 2. club environment, and 3. coach behaviour. Coaches predominantly constructed their knowledge through formal youth athlete coaching qualifications, sports-related higher education degrees, and informal learning opportunities facilitated within club environments that promoted interdisciplinary collaboration. How coaches learn, and the environments in which they operate, appear to shape behaviour, with effective communication playing a crucial role in supporting decision-making based on monitoring data. Category two and three status coaches reported a lack of human resources, poor knowledge exchange, and limited communication between coaches and sports scientists as a barrier to using training load and maturation monitoring data. Interdisciplinary practices, non-formal continuing professional development programmes and frequent communication facilitated the implementation of monitoring practices within category one clubs. These findings contribute a novel coach-centred perspective by revealing how formal, non-formal, and informal learning experiences shape coaches' monitoring knowledge, while identifying the environmental conditions and interdisciplinary practices that facilitate or constrain the implementation of training load and maturation monitoring.

Keywords: maturity; soccer; athlete monitoring; youth adolescence; coaching practice

Introduction

Training load monitoring is widely used within elite sport environments to help coaches and practitioners prescribe, adjust, and individualise training to optimise performance while reducing the potential risk of injury.[1] Training load monitoring is commonly divided into external and internal components, referring respectively to the physical work (external) completed by the athlete (e.g., distance covered, number of sprints) and the corresponding physiological responses (internal) (e.g., heart rate, perceived exertion).[2] Within football academies, maturation status has been shown to influence perceived training load, with a 5-10% increase in player maturity status associated with lower ratings of perceived exertion (6.9-13.9 AU), reflecting that age-specified training loads are potentially flawed.[3] Given their responsibility for training design and implementation, coaches exert considerable influence over player development and load management, with players largely following the training prescriptions and guidance they provide.[4]

Despite this, many youth football academy coaches still lack the knowledge and confidence needed to implement monitoring practices effectively.[5] Given the substantial individual variation in physical development across maturation stages,[3,6]youth football academy coaches play a crucial role in facilitating appropriate training loads to optimise performance, meet age-group competition demands, and help reduce the risk of growth-related injuries.[7] Failure to account for differences in biological maturation may result in training prescriptions that are either insufficient or excessive for an individual player's developmental status[3], potentially compromising both performance outcomes and athlete welfare.[7]

It has become common practice in elite sport to utilise data to support decision-making and to evaluate the contribution of coaches and support staff to performance outcomes.[8] Within professional football academies, monitoring data can inform coaches' decision-making by reducing the selection bias toward early-maturing players,[9] enhancing the ability for practitioners to assess academy players,[10] supporting training load management and injury

mitigation,[11] and helping coaches evaluate player performance in relation to their maturity status.[12]

Recent research in this area indicates that factors such as club category status, employment type, and coaching experience can influence a coach's perceived knowledge of monitoring practices, which in turn affects their confidence in implementing these in their coaching.[5] Furthermore, limited staff expertise, time constraints, and the complexity of data protection regulations may impede coach buy-in and the effective adoption of data-driven practices, resulting in a continued reliance on traditional coaching methods when making decisions.[13] However, to date, and to our knowledge, this has not been explored in UK professional football academies.

For coaches to implement training load and maturation monitoring data as part of their coaching practice, it is important to understand how coaches construct knowledge. One common method for coaches to construct knowledge is through formal coach education qualifications.[14] However, such qualifications have come under scrutiny for providing a toolbox for coaches to mimic course developers' behaviours and not meeting the needs of coaches.[15,16] Although recent developments in coach education curricula have begun to prioritise individual learning needs,[17] mainstream coaching certifications remain limited in their ability to prepare coaches to manage training load and monitor maturation effectively. Even with the availability of specialised youth athlete qualifications (Football Association (FA) Advanced Youth Award, Talent Identification pathways, and the Union of European Association Football (UEFA) Youth B and Elite Youth A Diplomas), and sport-related higher education programmes, significant gaps in coaches' knowledge and confidence persist.[5]

Alternatively, youth football coaches may construct knowledge through informal learning, which has been defined as 'the lifelong process by which every person acquires and accumulates knowledge, skills, attitudes and insights from daily experiences and exposure to the environment.[18] This type of learning is widely regarded as the preferred approach for

coaches to acquire new knowledge and ideas, [14,19,20] and may play a key role in helping coaches construct knowledge of monitoring practices. Increased exposure to daily social interactions with colleagues may provide coaches with opportunities for informal learning,[14] which may be one reason why more experienced coaches have been found to possess greater perceived knowledge of monitoring practices.[5] Through experience, coaches may use experiential knowledge over empirical knowledge,[21] typically acquired from formalised courses; however, this remains unclear.

Given the substantial resource disparities between clubs of different category (CAT) statuses,[22] and their potential influence on coaches' perceived knowledge and confidence in applying monitoring practices,[5] gaining insight into how clubs at varying category levels integrate monitoring practices within their club environment may offer valuable guidance for implementing these practices effectively within coaching. Therefore, this study aimed to explore how professional youth football coaches construct knowledge and implement training load and maturation monitoring practices into their coaching, to shape future coaching practices.

Methods

Study design

This study was guided by a constructivist paradigm, which emphasises the collaborative construction of meaning through language between the researcher and participants.[23] While coaching in professional football academies is largely a social endeavour involving the sharing of ideas and best practices,[24] coaches also operate independently as part of a multidisciplinary team (MDT)[25] when applying these approaches with different chronological age groups.

The epistemological assumption for this study was grounded in interpretivism,[26] and recognises that coaches' knowledge of training load and maturation monitoring may vary based on their existing biographies,[27,28] coaching experience, category and employment status.[5]

Adopting this perspective enabled us to derive interview questions based on available evidence in the literature and to move beyond surface-level conversations around how coaches construct knowledge of training load and maturation monitoring practices. Therefore, the initial exploratory phase used a deductive, literature-informed approach to construct the interview guide. Following the interviews, an inductive approach was used to develop patterns of shared meaning across participants' accounts.

Three strategies were employed to enhance rigour in this qualitative study. Firstly, the interview guide was developed by the first author and subsequently reviewed by the second, third and fourth authors to enhance clarity and relevance to the study aims. Throughout the analytic process, a critical friend approach was employed, whereby the second author challenged interpretations and contributed to the development and refinement of themes derived from the interview transcripts.[29] Regular discussions with an experienced qualitative researcher (second author) further supported reflexive engagement with the analysis by challenging coding decisions, theme boundaries, and underlying assumptions. Consistent with a reflexive thematic analysis approach, these discussions were not intended to achieve coding consensus but rather to deepen interpretation and enhance the rigour and credibility of the analytical process.

Secondly, pilot interviews were conducted to assess the credibility of the interview questions by ensuring they were clear, understandable, and meaningful to the coaches. The pilot interviews also informed revisions to the interview guide, thereby supporting the dependability of the data collection process.

Thirdly, in line with Braun and Clarke's reflexive thematic analysis,[23] the findings are intended to provide theoretically and contextually situated insights that may resonate with or apply to similar academy football environments. These thick descriptions were intended to enable readers to judge the relevance of the findings to other coaching contexts.[30]

Researchers' positioning

The first author, a higher education lecturer and researcher, led the study and had prior experience researching training load and maturation monitoring within UK football academies. The second author, an experienced football coach educator and academic, acted as a critical friend, challenging interpretations and enhancing the trustworthiness of the analysis.[29] The third and fourth authors contributed expertise in football academy research, particularly in relation to training load and maturation monitoring, providing methodological and analytical oversight throughout the study.

Participants

Participants were eleven male UK professional youth football coaches employed across Elite Player Performance Plan (EPPP) CAT 1-3 academies, with a mean of 13.3 years (SD = 4.72) of coaching experience within professional football academies. Each coach was anonymised (Coach A-K) to ensure confidentiality, and their biographical backgrounds were subsequently included (Table 1). The sample size for the study was guided by the concept of "information power" framework. [31] Firstly, the research aim was relatively narrow, focusing specifically on monitoring practices in a clearly defined context. Furthermore, a highly specific purposive sample was recruited, consisting of coaches with extensive experience (>5 years) in professional football academies and "good" knowledge of athlete monitoring practices.[5] Consequently, participants were well positioned to provide information-rich data relevant to the research question. Additionally, the quality of the dialogue was expected to be high because participants had relevant experience and some expertise in the research topic. This was facilitated through the use of semi-structured interviews (including probing questions), which encouraged detailed reflection and discussion of monitoring practices within their football academies.

****insert table 1****

Interview Development

The interview guide was informed by the findings from a previous survey [5] and was peer-reviewed by academic experts (n = 3) to ensure face validity. Pilot interviews were conducted with three male individuals: a coach currently working at a CAT 3 academy club within the Youth Development Phase (YDP), with ≥ eight years of coaching experience; a sports scientist with ≥ 10 years of experience working at a CAT 2 club; and a higher education lecturer with ≥ 10 years of experience in qualitative research and interview methodology. Each participant provided detailed feedback on the interview guide, leading to revisions in the question structure and the inclusion of additional probing questions. The interview guide consisted of questions linked to 1) how coaches construct knowledge of monitoring practices (Q1-Q4), 2) their confidence in applying monitoring practices (Q5) and 3) their perceptions and attitudes towards monitoring practices (Q6-Q7). A final question (Q7) was asked for coaches to provide recommendations on improving monitoring practices. Each question was supported by a series of associated probing questions. A final version of the interview guide was subsequently developed and used for the initial stage of data collection (See supplementary materials).

The voluntary recruitment of coaches was guided by findings from a previous survey,[5] which informed the adoption of a criterion-based purposive sampling strategy.[32] Coaches were required to have a minimum of 5 years of professional coaching experience and to be actively coaching in either the foundation development phase (FDP) or the YDP. Eight coaches were currently coaching within the YDP, with two currently working in the FDP. One coach (Coach A) coached across the two development phases and specialised specifically in goalkeeper coaching. Before each interview, coaches were sent a copy of a consent form and a participant information sheet and were provided with the opportunity to ask questions before the interview.

Nine coaches held the UEFA 'A' coaching licence, with the remaining two obtaining a UEFA 'B' licence. Four coaches (Coach C, H, I and J) held no formal higher education degree or certificate in a sports-related field, with all seven other coaches obtaining these qualifications

in their careers. Three coaches (Coach B, I and J) had previously played football at a semi-professional level or higher, with the remaining nine coaches having no previous playing experience other than grassroots football. Nine coaches were employed on a 'full-time' basis, with two other coaches (Coach D and I) currently on a part-time contract. Given that all participants were male, the findings should be interpreted within the context of a predominantly male-dominated professional football coaching environment. Female coaches may experience and interpret similar phenomena differently due to distinct professional and social experiences. As such, the transferability of the findings beyond male academy coaches should be considered with caution.[33]

Interview process

Each coach was interviewed individually, and a semi-structured interview guide was implemented to provide the researcher with some structure and flexibility to explore specific areas of interest and insights from respondents.[34] All interviews were conducted and recorded on Microsoft Teams for transcription purposes (Microsoft Corporation, Washington, USA). Interviews were conducted online to maximise geographical reach and accommodate participants' professional coaching commitments. While this approach may have limited rapport development compared with in-person interviews, it facilitated access to coaches who may otherwise have been unable to participate.[35]

Analysis of data

Interviews were recorded using Microsoft Teams and exported into Otter AI (Otter.ai, Inc., California, USA) to be transcribed verbatim and then checked by members of the research team for accuracy before the analysis. Individual interview length ranged from 29.00 to 42.43 minutes [mean ± SD, 34.43 ± 4.70min]. Transcribed interviews were imported into NVivo software (V12.1.7.1; Nvivo 12, QSR International Pty, Australia) and analysed using a framework for thematic analysis.[23] Interview transcripts were analysed by the primary

researcher using an inductive coding approach. The primary researcher familiarised themselves with the transcripts through a process of immersion and repeated reading.[23] Semantic coding (participant-driven descriptive) was initially used to explore the meaning of the data at surface level in relation to the research question. Latent coding, interpreted by the researcher, was then adopted to explore underlying meanings, assumptions, ideas, or conceptual interpretations within the data, aligning with the study's constructivist and interpretivist paradigm. The researcher actively constructed codes and themes, and this supported reflexive engagement and deepening interpretation by the critical friend (second author) to enhance the trustworthiness of the analysis.[29] Data are reported through a series of subthemes that contribute to a broader theme, united by a shared central organising concept and characterised by conceptual coherence and meaningfulness (Figure 1).[23]

Ethical Considerations

Ethical consent was approved by the University of Gloucestershire, School of Sport and Exercise Research Ethics Panel - Application Number: (THOMPSON20-24), conforming to the Declaration of Helsinki, and collected and stored according to GDPR. Participants were instructed not to disclose any personal or identifiable information during the interviews. Any identifying information that was inadvertently disclosed was removed during transcription to maintain participant anonymity. Audio recordings were transcribed using Otter AI (Otter.ai, Inc., California, USA), with all transcripts subsequently reviewed against the original recordings for accuracy. Following verification, transcripts were exported to Microsoft Word, and the original files were deleted from the Otter AI platform in accordance with data management procedures.

Results and discussion

The analysis of the results generated three themes that were discussed consistently by coaches (Figure 1): 1) coach learning, 2) club environment and 3) coach behaviour. Each theme is associated with sub-themes and has been supported by exemplary quotes.

****insert Figure 1****

Coach learning

Coach learning was identified as a theme, shaping how knowledge of training load and maturation monitoring is constructed within coaching practice. Coaches reported that their knowledge of these concepts was constructed predominantly through two primary learning pathways: formal education via youth athlete courses and informal learning through experience, social interaction and reflective practice.

Formal youth athlete courses and higher education qualifications aid in constructing new knowledge

Coaches (A, B, C, F, G, J) reported that the FA Advanced Youth Award (AYA) helped them construct knowledge of training load and maturation monitoring practices. The course delivery structure that included industry experts in growth and maturation was reported as a positive aspect of the course:

> 'I think the AYA was probably a really good experience. The whole block is dedicated to what they call the physical block, so we looked at several experts who came in, sharing their knowledge and research' (Coach C)

> 'I think, going onto coaching courses like the AYA and the physical block really opened your eyes to the amount of detail (pause) which has to go into your planning around area size, work-to-rest ratio, and then individualising it to the players' (Coach G)

Despite the positivity towards the AYA, coaches (A, B, D, E, F, I) indicated issues with other formal coach education courses (FA core modules or UEFA coaching licenses) in failing to

provide them with sufficient knowledge of training load and maturation monitoring practices. The UEFA A licence was reported by some coaches (A and D) to help construct knowledge of monitoring practices, with recommendations that training load and maturation monitoring practices should be discussed earlier in the FA/UEFA qualifications pathway. Coaches (B, D, H, I, K) noted that the delivery of the AYA was far superior to that of the other core FA modules or UEFA coaching licenses in embedding knowledge of training load and maturation monitoring practices:

> 'As great as the A license was ((unenthusiastic)), I didn't feel (.) I didn't feel I got as much brain ache, if you like, from the experts that came in; it was slightly different to the AYA'(Coach B)

> 'So, I think it's got to come into 'qualifications' a little bit earlier, obviously, without overloading them with the scientific technical stuff' (Coach D)

Finally, sports-related higher education degrees were reported by coaches (A, D, E, F, K) as a method of constructing knowledge:

> 'My degree played a massive part in the maturation side of things. You know stuff to do with peak height velocity and the differences between growth and maturation, bio-banding and chronological age vs biological age' (Coach D)

> 'As coaches that pass-through academia, I think you start to hear about things like relative age effect' (Coach A)

Informal learning through experience, social interaction, and reflective practice

Most coaches working at CAT 1 and CAT 2 clubs reported using informal education via social learning opportunities (A, C, D, F, G, I, J, K), experimental learning (B, C, D, G, H, I, J, K), and reflective practice (B and H) to help construct knowledge of monitoring practices. Coaches, with the exception of coach K, described frequently collaborating within a group that could be characterised as a *community of practice*, [36] engaging in ongoing, day-to-day interactions and knowledge exchange with other professionals:

> 'You start to meet people who specialise in or study other areas, such as sports science. That exposure only increases when you join professional clubs, largely because they

have multi-disciplinary teams made up of various specialists. In well-functioning multi-disciplinary teams, you're communicating regularly' (Coach A)

'Just watching different people (coaches) deliver things in different ways has been really, really fascinating, also, fundamental to my own learning' (Coach C)

'The key then is that I then go back and reflect. I always put my reflections on the PMA; if I get it down afterwards, then I can refer back to it and remember it. So, everything that I do, I need to write down those kinds of critical reflections straight afterwards, so that if we do that kind of practice again, I can look back and go, okay, that's what we did there' (Coach B)

In contrast, coaches (I, J and K) with lower CAT statuses (2 and 3) reported challenges related to a lack of club staff. Furthermore, part-time coaches indicated that they were not involved in day-to-day interactions within the academy environment, which limited informal learning opportunities compared to full-time staff:

'In terms of part-time coaches, the full-time (coaches) might get a little bit more insight because we do testing with the boys. But we don't see much of what happens after that. So how is that information used? And what do you get out of it?' (Coach I)

'Most of our coaches are part-time and casual staff, and sports science provision up to under 16s is largely done by interns' (Coach J)

Club environment

Interdisciplinary collaboration, integration and expertise sharing between coaches and the support staff

Coaches working at clubs of a CAT 1 and 2 status discussed working together as part of a 'team' within their club environment. CAT 1 and some CAT 2 (A and J) coaches indicated that working closely with other professionals, such as sports scientists, enhanced their knowledge and understanding of monitoring practices. Additionally, terms such as *collaboration*, *integration*, and *sharing expertise* were reported and highlighted as defining

characteristics that differentiate interdisciplinary practice from (MDT) approaches. However, this was not reported by CAT 3 coaches except Coach B, whose club invested significantly in sports science support despite their CAT 3 status:

> 'I think it's taking the time to work with your sports scientists, and establishing a relationship with them where they don't feel threatened by me asking almost constant questions about stuff' (Coach B)

> 'We (coaches and support staff) developed a physical plan outlining what the players needed to progress through. This then started to inform the type and duration of practices. We considered factors such as work-to-rest ratios, but also the size of the playing area, the length of each practice, and positional demands' (Coach F)

> 'Erm, I'm in constant, well, I speak with my sports science team regularly, whether it's formally in a multidisciplinary meeting weekly, so we'll discuss players. And within that, then, myself as a member of staff oversees the phase, I'll ask the questions from them to like, try and get an understanding off of them' (Coach G)

Non-formal continuing professional development (CPD) programmes support monitoring competency

Coaches (B, E, F, H, I, J, K) from CAT 1 and CAT 2 clubs reported that the club environment supported the construction of knowledge of monitoring practices through academy-led CPD programmes. Coaches highlighted knowledge sharing with other professionals within the club, often facilitated by non-formal workshops that enhanced coaches' awareness of monitoring practices. It was clear that CAT 1 and some CAT 2 (C and J) clubs with greater levels of staffing invested significantly more in club CPD programmes to support coaches compared to CAT 3 clubs:

> 'We had the S and C (strength & conditioning) coaches do a workshop for players and staff in the 15s and 16s, where they explained all the data, and what it means. And I think that was helpful for both the players and coaches, who can interpret their data a little bit better' (Coach E)

Coach behaviour

Communication and relationship between coaches and support staff improves the interpretation of monitoring data

Coaches (excluding H, I, and J) reported that frequent communication with the MDT was an important behaviour for effectively implementing monitoring practices. Communication with members of the MDT was essential to aid in the interpretation of training load and maturation data. Opportunities to question and discuss the data were an important factor in implementing it as part of their coaching practice and constructing new knowledge. Regardless of the category club, coaches valued opportunities to question other professionals within their club:

> 'I believe that only happens through people sharing their expertise. As I've said before, the coach's role isn't to be a sports science expert, and the sports science expert isn't expected to be a coaching expert, nor is the analyst an expert in either of those areas. It's about bringing the right people together in the same room to combine their expertise, improve what you're doing, understand why you're doing it, and ultimately enhance player development' (Coach A)

> 'The club has a moment that involves a member of every department to share weekly on individuals; it's really important to be able to understand the different things that are happening in these young players' lives or maybe the levels on the pitch that people need to be aware of' (Coach C)

The relationship between the coaches and their support staff, such as sports scientists, was fundamental to implementing monitoring data into coaching practices:

> 'I think it's taking the time to work with your sports scientists, and establishing a relationship with them' (Coach B)

> 'The important bit is that the S and C (strength and conditioning) staff are involved, looking at the data. Looking at the practice and just marrying up the two, making sure it's the right load for each individual' (Coach C)

However, at CAT 3 academies, the limited availability of sports science staff meant that developing a relationship with support staff was more challenging:

> ‘We had a strength and conditioning culture at my previous CAT 3 club that only really worked with the eighteens and did a tiny little bit with that with the 16s down’ (Coach D)

Monitoring data supports coaching practice and decision-making

Training load and maturation monitoring data were considered important for decision-making by coaches of a CAT 1 and 2 status. Training load monitoring data were primarily used to determine the intensity of training sessions and to inform planning throughout the microcycle. Additionally, coaches used this data to adjust the intensity of training sessions based on a player's maturation status:

> ‘We've already made a plan, a physical plan and roughly what they need to go through. Then the data would inform the type of practices and the length of these practices. So, we talked about that kind of work-to-rest ratio, but also the size of the area, and how long they should be playing’ (Coach F)

> ‘It could be, for instance, if one of our central midfielders is going through a growth spurt, we can put him as a wall player in a possession practice so that we reduce the load on him’ (Coach E)

Coaches (A, B, C, E, F, H, J) reported that maturation monitoring data were primarily used to group players according to their biological maturity. This practice was far more common within CAT 1 and CAT 2 academies, with only one coach from a CAT 3 environment (Coach B) indicating its use. Biological maturity was used to assign players to appropriate bio-banding groups for both training and match play. Bio-banding was rarely used by CAT 3 coaches, except Coach B, whose club had invested substantially in developing and implementing bio-banding practices:

> ‘So, we'll have a breakdown of where they sit in the group in terms of their biological age and where they are in terms of their growth and maturation alongside that as well, and we can do it. So, I think they can look at their predicted height, and then they can put them in those biological ages’ (Coach H)

Despite the positivity towards bio-banding practices, its effectiveness was impacted by the limited number of clubs at the time using bio-banding, which made it difficult to arrange fixtures and club locations:

> 'We struggle ((pause)) trying to find clubs, we find the same old clubs that will play bio-banding fixtures against us' (Coach B)

Additionally, coaches (A, B, D, E, I, J, K) reported issues with using monitoring data. These mainly included issues relating to the amount or frequency of data from sports scientists and the reliability and accessibility of monitoring data:

> 'We used to measure height three times per year, including standing and sitting height, and this information was uploaded to the PMA. There would then be some discussion around birth dates and related factors. However, at that Category 3 club, it was quite difficult to locate this information within the PMA, as it was not particularly accessible' (Coach D)

Discussion

This study is the first to attempt to qualitatively establish how coaches construct knowledge and implement training load and maturation monitoring practices in UK professional youth football. Thematic analysis allowed the identification of three themes, namely: 1) coach learning, 2) club environment, and their combined influence on shaping 3) coach behaviour. Based on the findings, recommendations are provided to improve the practical application of monitoring practices.

Meeting the educational needs of coaches

Coaches reported that knowledge of training load and maturation monitoring practices was predominantly constructed via formal and informal coach education pathways. Coaches seeking to construct knowledge through formal education should prioritise youth athlete qualifications offered by governing bodies such as The FA's AYA or talent identification

courses, and consider sports-related higher education degrees to deepen their understanding of training load and maturation monitoring.

The FA has adopted a more constructivist epistemology of learning, enabling coaches to take control of their learning.[37] The recent changes in pedagogy within the FA qualifications have shifted from a more authoritarian approach, where coaches would replicate coach developers' behaviour, to a focus on the needs of the coach. [17] However, despite recent revisions to the FA Level 2 qualification designed to strengthen coaches' understanding of physiological and developmental concepts, including the relative age effect and the implications of early specialisation,[38] there remains uncertainty regarding the translation of this knowledge into practice. Indeed, the findings indicate that technical and tactical content continues to be prioritised within coach education, a finding consistent with previous literature, [39] potentially resulting in insufficient preparation for the effective implementation of athlete monitoring practices.

Moreover, the absence of any mention of FA or equivalent talent identification courses suggests uncertainty regarding whether coaches consider these courses valuable or view them as primarily intended for scouts. A more comprehensive understanding of the content and scope of formal coach education curricula is needed to evaluate their effectiveness and determine their impact on coaching practices.

Sports-related higher education degrees were valued by coaches and helped construct knowledge of monitoring practices. Higher education degrees may help coaches develop personal and professional skills,[40] but their effectiveness in constructing knowledge of monitoring practices remains unclear and requires further research. One potential solution is for coaches to obtain a minimum qualification in sports science, similar to the requirements for other professionals (e.g. General Practitioners), to better support their roles and help support the athlete.[41]

Our findings also highlight the importance of informal learning as a method of constructing knowledge, which is consistent with findings from other studies. [19,20,42] A survey examining coaches' preferred methods of knowledge acquisition found that informal sources were favoured, with self-directed learning through interactions with other coaches and colleagues identified as the primary approach (38.6%).[14] The primary method of gaining new knowledge was through self-directed learning actions resulting from social interactions in everyday coaching experiences.

Informal learning may be classed as 'unmediated'[43] or 'incidental', occurring without conscious awareness[42] as coaches in this research were rarely aware of informal learning taking place. In professional youth football environments, informal learning could be deliberately structured to help improve the knowledge acquisition of coaches by creating informal learning opportunities. A concept such as guided informal learning[42] may help clubs create opportunities to increase exposure to these learning experiences and consequently improve how coaches learn. Guided learning refers to coach development activities that are facilitated by a mentor, coach developer, or experienced peer, whereby learning is intentionally supported through discussion, feedback, reflection, and guided practice rather than through formal instruction alone.[42]

Create an interdisciplinary environment

Coaches from higher CAT clubs (CAT 1 and CAT 2) consistently reported close collaboration with their team to integrate and share expertise on training load and maturation monitoring practices. However, apart from one CAT 3 coach whose club invest significantly in sports science, this was not evident in lower CAT clubs. Athlete development necessitates the input of multiple disciplines (coaches, physiotherapists, sports scientists, etc.) within a club environment. To achieve a tangible outcome, these professionals must collaborate in an integrated manner within their environment.[45]

Firstly, it is essential to distinguish between multidisciplinary and interdisciplinary practices. A multidisciplinary approach involves the '*combination of several disciplines and methods, where each discipline works in parallel with limited interaction*'.[46] In contrast, an interdisciplinary approach denotes a '*deeper level of integration, characterized by reciprocal collaboration and the creation of connections among disciplines to achieve shared objectives'*.[46] Coaches from CAT 1 and CAT 2 clubs frequently emphasised '*collaboration*' and '*strong interpersonal relationships*' with other members of their club environment, reflecting characteristics of interdisciplinary practice.

While evidence examining the role of club environments in the effectiveness of monitoring practices remains limited, interdisciplinary interventions developed through collaboration among key stakeholders have demonstrated effectiveness.[47] Such interventions typically include modified training loads, football-specific technical activities, balance and coordination training, improving landing mechanics, and creating individualised strength programmes.[47] This approach led to substantial reductions in both injury incidence (from 5.2 to 0.8 per 1000 h, $p = 0.05$) and injury burden (from 216 to 17 per 1000 h, $p = 0.02$) among players identified as being at elevated risk of injury. However, the category status of the professional football academy was not reported and given the substantial differences in human resources between higher and lower CAT clubs, it remains unclear whether CAT 3 academies, where limited resources are often perceived as a barrier,[22] can foster interdisciplinary practices.

From our evidence, characteristics associated with interdisciplinary practices were rarely reported among CAT 3 coaches, except for one whose club invested significantly in sports science support. Despite the clear benefits of interdisciplinary collaboration, such as enhancing performance and reducing injury risk, MDT environments can sometimes hinder athlete development by fostering siloed working practices and limited cooperation.[25] Conflicting coaching philosophies and differing approaches to utilising monitoring data may further contribute to tension and fragmented decision-making within the MDT.[48]

Given that professional higher CAT academy clubs require substantially more contact hours (approximately 8,500 for CAT 1 clubs),[49] there is an increased need for human resources and structured opportunities to enable interdisciplinary practices. Conversely, the potential reliance on part-time staff and interns in lower CAT clubs presents a significant barrier to creating and sustaining an effective collaborative interdisciplinary environment, making it unclear whether these clubs can implement such practices successfully. Frequent communication between the coach and MDT was a common behaviour discussed by CAT 1 and CAT 2 coaches. Informal coach communication with other professionals within the club environment may be a preferable method of knowledge transfer due to its simplicity when compared to more formalised education.[14,50] This was evident throughout our research, and coaches valued the opportunities to create open dialogue and pose questions to the sports science staff regarding monitoring practices.

Knowledge exchange could occur through non-formal coach education, such as academy CPD programmes, which was a practice highlighted in CAT 1 and 2 environments. These opportunities were identified as important methods to share knowledge, communicate data and use expertise from other sub-disciplines to help facilitate coaching practice. It could be recommended that non-formal workshops may help bridge the gap between science and coaching, allowing coaches and sports scientists to co-create educational programmes.[51,52] Non-formal CPD workshops may provide opportunities to facilitate the exchange of new ideas and practices[53] and help embed data into coaching.

In football, the sport's governing body appears to foster a learning culture[54] that may inherently prioritise technical and tactical content within coach education programmes, and consequently, coaches appear not to have a high perceived level of knowledge and confidence in applying training load and maturation monitoring practices.[5] However, as indicated within this research, if communication with the MDT is frequent and contextualised to the coaches' needs, it can shape the behaviour of coaches and aid decision-making. Therefore, if non-formal

CPD programmes are used as a method to engage coaches and enhance their learning, the content must be perceived as relevant and demonstrate how monitoring practices can be applied in real-world coaching contexts, rather than focusing solely on theoretical understanding.[14]

In summary, effective communication is clearly fundamental to the implementation of monitoring practices. Therefore, it is recommended that a communication feedback loop between the athlete, coach and the MDT is part of a training load and maturation monitoring programme.[55] However, it remains unclear how lower-category clubs, often constrained by limited resources such as reduced staffing, smaller financial budgets,[22] and potentially a reliance on part-time coaches or interns, manage communication between coaches and the MDT and how these constraints impact the effectiveness of monitoring practices.

Limitations

While the data collected in this study provided rich insights into coaches' experiences, the findings reflect the specific contexts of the participating UK professional youth football academies and are based on coaches' self-reported accounts. Consequently, the themes represent participants' perceptions and experiences, rather than direct observations of coaching practice. Despite having similar constraints, clubs with the same CAT status can differ in their environments and approaches to training load and maturation monitoring. Additionally, the findings were based exclusively on male coaches; therefore, caution should be exercised when transferring these insights to female coaches, who may experience and interpret similar phenomena differently due to distinct professional and social experiences. Further research should examine the environmental constraints faced by lower-category status clubs and how these constraints influence the integration of monitoring practices.

Conclusion

This study is the first to explore how coaches construct knowledge and implement training load and maturation monitoring practices within their coaching. The findings demonstrate that

coach learning and the club environment play a key role in shaping behaviour towards implementing monitoring practices. Youth athlete formal coaching qualifications obtained by coaches, together with informal learning opportunities embedded in interdisciplinary club environments, were reported by coaches of CAT 1 status and play an important role in implementing monitoring data. Key disparities exist between clubs of different CAT statuses, and these differences are particularly pronounced in CAT 3 academies, where lower perceived knowledge and confidence among coaches[5] are coupled with broader resource constraints,[22] may limit the effective implementation of monitoring practices. Therefore, future research should prioritise supporting coaches within these lower-resourced clubs.

Practical Implications

From a practical perspective, several key implications emerge. First, professional youth football clubs should evaluate how coaches construct knowledge of training load and maturation monitoring practices. Where formal education does not provide sufficient understanding, clubs should shape their environments to foster interdisciplinary collaboration with the MDT, creating greater opportunities for informal and non-formal learning. Second, strengthening communication between coaches and the MDT is critical for effectively interpreting and applying monitoring data to support informed decision-making. Third, simplifying and contextualising monitoring data may help make it more accessible and meaningful for coaches, particularly those working part-time. Finally, creating structured informal opportunities for coaches and MDT members to reflect on training load and maturation data may foster shared understanding and support the development of evidence-informed coaching practice.

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Ethical considerations

This study was approved by the University of Gloucestershire Research Ethics Committee (approval no. THOMPSON20-24) on November 11, 2020.

Consent to participate

All participants have agreed to participate in the research by providing written and verbal consent during the interview.

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Data availability statement

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