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# Training load and maturation monitoring: An investigation into the perceived knowledge, confidence, perceptions, and attitudes of UK-based youth academy soccer coaches

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## Abstract

Within youth soccer academies, sport scientists monitor training load and maturation to support data-informed decisions on player development and injury risk, yet the extent to which coaches integrate this data remains unclear. This study investigated youth academy soccer coaches' perceived knowledge, confidence, attitudes, and perceptions of training load and maturation monitoring. A mixed-methods, cross-sectional online survey was distributed via social media and to professional academy clubs, with 107 coaches responding. The 36-item survey gathered data on coaching backgrounds, perceived knowledge, confidence, attitudes, and perceptions toward monitoring practices. Significance was accepted at a $p < 0.05$. Perceived knowledge of training load monitoring was significantly influenced by academy category ($\eta^2 = 0.057$), employment status ($d = 0.673$), and coaching experience ($\eta^2 = 0.057$), with Category 1, full-time, and more experienced coaches (4–6 and ≧7yrs) reporting significantly greater perceived knowledge. For maturation monitoring, employment status ($d = 0.569$) and coaching experience ($\eta^2 = 0.091$) were significant factors, with full-time and more experienced (4–6 and ≧ 7yrs) coaches reporting greater perceived knowledge. Greater confidence in training load monitoring was reported by Category 2 ($\eta^2 = 0.064$) and full-time coaches ($d = 0.454$), while confidence in maturation monitoring was higher among full-time ($d = 0.550$) and more experienced coaches ($\eta^2 = 0.093$). Coaches valued training load monitoring for injury prevention and maturation monitoring for player development, but faced challenges with education, communication, and resources. Findings highlight the need for focused coach education for monitoring practices, particularly among part-time and less experienced coaches in lower-category academies

## Keywords

Association football, fatigue, game preparation, injury risk, player selection, well-being

## Introduction

Training load and maturational monitoring play a crucial role in evaluating the performance and development of young soccer athletes.[1] Training load can be categorised into either internal or external load. Internal training load refers to the physiological and psychological stress experienced by the athlete during training or competition (e.g., heart rate, blood lactate, session rate of perceived exertion), whereas external training load represents the objective work performed, measured independently of internal responses (e.g., speed, power output, global positioning system data).[1] Maturation refers to the process, tempo, and timing of becoming physically mature, with the tempo and

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progression toward maturity being inherently individualised, meaning that the path to adulthood can vary significantly between individuals.[2] Skeletal age is considered the clinical standard for assessing maturity status; however, non-invasive predictive methods, such as linear estimations of somatic maturity, are more commonly used to estimate biological maturity[3–5] and are widely implemented within professional soccer academies due to the practicality.[6]

The Elite Player Performance Plan (EPPP)[7] recommends that professional academy clubs systematically monitor growth and maturation, enabling coaches and sport scientists to make informed decisions to support athlete development and training load requirements. Professional academy clubs employ various methods to monitor training load and maturation[6]; however, coaches and sport scientists may face challenges in translating and contextualising this information into practice due to differences in knowledge and understanding.[8] Additionally, coaches who work in fast-paced environments could face time constraints when interpreting data that's been communicated by the support team.[9]

Coach buy-in has been identified as a barrier to effective training load monitoring in professional football clubs.[10] The underlying reasons for this lack of buy-in remain unclear; however, it has been suggested that coaches may acquire procedural sport science knowledge while lacking the declarative knowledge needed to apply it effectively in their practice.[11] This distinction between declarative knowledge (the *why* or conceptual understanding) and procedural knowledge (the *how* or practical application) is critical, as both forms are essential for effective implementation.[11] In training load and maturation monitoring, insufficient declarative knowledge can impede effective application, while reliance on procedural knowledge alone may restrict critical discussion and learning.[11]

Despite the potential challenges, research indicates strong agreement (84.1%) among coaches and practitioners that training load monitoring is beneficial for coaching, with the majority considering it advantageous for their club.[12] However, this research does not provide details of coaches' backgrounds, which may influence coaching practice,[11] and how they apply monitoring practices, nor does it explore whether suggested resource limitations or category (CAT) status affect the use of monitoring.[6]

Since training loads for academy players progressively increase with age, differences in load are systematically applied within youth soccer academies based on the specific age group throughout a player's development.[13,14] Given the considerable variation in physicality among players of similar age, maturity-specific load prescription has been recommended to help reduce injury risk.[15] This approach may involve managing load through reducing accelerations, decelerations, impacts, and ground contacts for players considered 'at risk' or experiencing rapid growth, defined as 88–92% of predicted adult stature, a growth rate exceeding 7.2 cm/year, and lower limb growth greater than 3.6 cm/year.[16]

Although training load and maturation monitoring may be considered beneficial, conservatism may exist among clubs and coaches who hold traditional values and beliefs that hinder the effective application of scientific practices.[17] In essence, the presence of conservatism within clubs may lead to coaches resisting change and favouring traditional methods over evidence-based, data-driven approaches. Coaching itself may be influenced by tradition, emulation, and historical precedence within the sport,[17] which may underpin how coaches implement monitoring data. Therefore, coaches with no prior exposure to sport science may demonstrate aspects of cultural reproduction within their coaching practice,[18] and use traditional methods without questioning their relevance or effectiveness.

It is often viewed that technical coaches are ultimately the decision-makers in soccer, with sport scientists providing a support role, translating their knowledge to stakeholders on performance, injury, illness, and talent identification.[19] Professional success in fulfilling societal expectations largely hinges on the knowledge they create and accumulate for their roles and responsibilities.[20] In the context of coaching, insufficient knowledge, whether procedural or declarative, of training load and maturation monitoring may hinder the effective implementation of these evidence-based practices. Consequently, sport scientists should carefully consider both the amount of information provided to coaches and players and the clarity with which data are communicated to ensure effective practical application.[21]

Monitoring the immediate and long-term effects of internal and external training stressors is essential for managing young soccer players, as injury patterns in youth athletes follow a distinct trajectory that corresponds with their stage of biological maturation.[22] A structured approach to training and exercise monitoring may help guide decisions on training and match exposure, promoting skill development and player welfare while reducing risks such as injury, illness, and overtraining.[23] Despite these obvious benefits, there is often scepticism from coaches/managers in their application.[24] The complex nature of deriving results from research and implementing them into practice has been well documented and has its benefits,[9] however, whether coaches have the required knowledge and confidence to apply load and maturation practices remains inconclusive.

Formal coach education is one of the most common methods for coaches to construct knowledge.[11,25] However, these courses have been criticised for failing to meet the needs of coaches.[26,27] While they may offer a professional coaching toolbox of ideas,[28] it is unclear if these courses aid in the development of expertise (declarative and procedural knowledge),[29] as formal coach education courses often tend to focus on technical and tactical aspects of soccer and lack sufficient consideration of sports science. Recent updates to formal coach education include the introduction of the 4-Corner Model as a framework for holistic

player development, the implementation of the England DNA, and amendments to core coaching qualifications, including the addition of a youth-specific course (Advanced Youth Award).[30,31] These qualifications incorporate a dedicated section on physical development that underpins coaching. While training load and maturation monitoring are likely addressed within this physical block, the extent of their coverage and the effectiveness in imparting knowledge to coaches remain unclear.

Therefore, if coaching courses predominantly focus exclusively on technical and tactical elements, it is unclear whether coaches acquire adequate knowledge of sport science practices, such as training load and maturation monitoring and how this may influence their confidence in effectively implementing these practices within youth soccer academy settings. Furthermore, since coach buy-in can be a barrier to training load monitoring,[10] despite its perceived benefits,[12] investigating coaches' perceptions and attitudes toward these monitoring practices may offer valuable insights into their effectiveness and integration within coaching.

## Method

### Survey design and distribution

A mixed-methods, online cross-sectional survey was distributed using a snowball sampling method.[32] Survey content validity was established through expert feedback (two current professional youth soccer coaches), with revisions made accordingly before its distribution. Coaches reviewed the survey and recommended adding a question on employment status, as this could potentially influence the research aims (Q3), providing definitions of key terms, training load, and maturation monitoring within the participant information sheet to enhance coach understanding. It was also suggested to include questions on coaches' input in session planning using monitoring data (Q33 and Q34).

The final version was created on OnlineSurveys.com (http://onlinesurveys.ac.uk) and was shared via social media (LinkedIn and X, formerly Twitter) and sent directly via email to coaches to disseminate within their club. The survey consisted of 36 questions and were organised into four conceptual categories to align with the study's aims: (1) **Knowledge** (Q11–22) - questions assessing understanding of training load and maturation monitoring practices; (2) **Confidence** (Q23–28) **-** questions evaluating self-rated ability to apply these training load and maturation monitoring in coaching contexts; (3) **Perceptions** (Q29–30) - questions exploring perceived benefits, challenges, and feasibility of implementing monitoring strategies and (4) **Attitudes** (Q31–35) - questions reflecting willingness and openness to adopt training load and maturation monitoring within academy settings. Most items used multiple-choice or unipolar Likert scales, with open-ended questions included to provide qualitative data. Ethical approval was granted by the University of Gloucestershire, School of Sport and Exercise Research Ethics Panel - Application Number: (THOMPSON20–24). Data was collected between March and August 2021.

### Participants

UK-based male academy coaches ($n = 107$) from professional youth soccer clubs (Categories 1–4) participated. All were aged ≥18yrs, held at least an FA Level 2 qualification (or equivalent), and had ≥1 year of professional coaching experience and coached across a range of age groups from under-10 s to under-18 s, covering key maturation phases: pre-, circa-, and post-peak height velocity.[33]

### Data reduction and analysis

Demographic data was analysed using frequency analysis. Likert scales were treated as numeric variables and analysed using a parametric test[34] and presented as means and 95% confidence intervals. Likert scale data from small sample sizes, unequal variances, and non-normal distributions can be treated as parametric data, with minimal risk of incorrect conclusions due to the robust nature of parametric tests.[35] Between-group differences (club category, employment status, and coaching experience) were analysed using a one-way ANOVA with Least Significant Difference (LSD) post hoc correction, and effect sizes were reported using partial eta squared. Independent $t$ -t-tests were used to determine differences between employment statuses (full-time and part-time), with Cohen's $d$ used to determine effect size. Questions using a ranking scale were ordered by percentage of responses. A chi-square test was used to determine any associations between CAT status and qualifications. Coaches working in CAT 3 and CAT 4 clubs were combined to increase group size and statistical power.[36]

A Missing Completely at Random (MCAR) test was conducted to assess missing data, and a $p$-value > 0.05 was used to support the null hypothesis, confirming that the data were missing completely at random. MCAR mechanism occurs when the likelihood of data being missing is unrelated to both the observed data and the actual values of the missing variable.[37] Multiple imputation using a regression method (Markov Chain Monte Carlo) was used to replace any missing values from respondents and these were replaced with pooled results. Non-completers were only included in the results if there was > 60% completion of the total survey. Free-text answer questions were exported from Onlinesurveys.com and into a Microsoft Excel (Microsoft Corporation, Washington, USA) document for analysis. Data analysis was initially conducted by the lead researcher and followed an inductive, thematic analysis, and the following six-stage process: familiarisation, coding, theme selection, refining and defining themes,

and finalising the report.[38] To enhance trustworthiness and ensure confirmability, the data were peer-reviewed by other researchers involved in the study to minimise potential bias and validate the findings. The primary analysis was conducted by the lead researcher, and an additional researcher with expertise in qualitative research assisted in verifying and confirming the conclusions.

## Results and findings

### Demographic information

A total of 113 respondents completed the survey; 6 with incomplete responses (<60% completed) were excluded, leaving 107 valid cases (Table 1). Five missing values, including two incomplete responses (1.8%) to Q2 and Q27 and one (0.9%) to Q11, were addressed using a Markov Chain Monte Carlo multiple imputation method under the MCAR assumption.[37] All participating coaches identified as male (100%), and employment status was relatively balanced, with 52% employed full-time ($n = 56$) and 48% working part-time ($n = 51$). Most coaches who completed the survey worked at CAT 3/4 clubs ($n = 49$, 45%), with 34% of coaches ($n = 36$) working at CAT 1 clubs ($n = 36$) and 21% at CAT 2 ($n = 22$) clubs, respectively.

The majority of coaches held a FA Level 4 (UEFA A) (46%, $n = 49$) or FA Level 3 (UEFA B) (42%, $n = 45$) license, while only a few had an FA Level 2 (UEFA C) (7%, $n = 8$) or FA Level 5 (UEFA Pro) (5%, $n = 5$). Additionally, a large proportion of coaches held a formal sport-related academic qualification (74%, $n = 79$) with the majority obtaining a BSc or BA (Level 6) (57%, $n = 45$), while fewer had an MSc/MRes (Level 7) (32%, $n = 25$) or a Higher National Diploma (HND) (Level 5) (11%, $n = 9$). A chi-square test reported no association between CAT status and formal qualifications held ($x^2 = 3.735$, $p = 0.154$). Most coaches ($n = 54$, 51%) had ≥ 7 years of coaching experience in a professional soccer environment, while 28 coaches (26%) had 4–6 years of experience, and 25 coaches (23%) had 1–3 years of experience.

**Table 1.** Demographic data of coaches, $n = 107$.

| | |
|---|---|
| Sex, *n* (%) | |
| Males | 107 (100) |
| Females | 0 (0) |
| Category status, *n* (%) | |
| CAT 1 | 36 (34) |
| CAT 2 | 22 (21) |
| CAT 3/4 | 49 (45) |
| Employment status, *n* (%) | |
| Full-time | 56 (52) |
| Part-time | 51 (48) |
| Coaching experience, years, *n* (%) | |
| 1–3 years | 25 (23) |
| 4–6 years | 28 (26) |
| ≥ 7 years | 54 (51) |
| Age group(s) current age group coached *n* (%) | |
| Under 7 to 9s | 30 (18) |
| Under 10 s to 12s | 52 (32) |
| Under 13 s to 16s | 56 (34) |
| Under 17 s + | 27 (16) |
| Highest coaching qualification, *n* (%) | |
| FA Level 2 (UEFA C) | 8 (7) |
| FA Level 3 (UEFA B) | 45 (42) |
| FA Level 4 (UEFA A) | 49 (46) |
| FA Level 5 (UEFA Pro) | 5 (5) |
| No formal qualification | 28 (26) |
| HND (Level 5) | 9 (11) |
| BSc or BA (Level 6) | 45 (57) |
| MSc/MRes (Level 7) | 25 (32) |
| Level of playing experience in soccer, *n* (%) | |
| No experience | 3 (3) |
| Amateur | 45 (42) |
| Semi-professional | 42 (39) |
| Professional | 17 (16) |
| Played another sport | 0 (0) |

CAT, category; FA, Football Association; UEFA, Union of European football associations; HND, Higher National Diploma; BSc, Bachelor of Science; BA, Bachelor of Arts; MSc, Master of Science; MRes, Master of Research. *Due to the option to coach across multiple age groups, this was calculated from the total number of responses and expressed as a percentage ($n = 165$).

### Coaches' perceived knowledge and confidence in training load and maturation monitoring

*Category status.* CAT status significantly influenced perceived knowledge of training load monitoring ($F(2, 103) = 3.12$, $p = 0.048$, $\eta^2 = 0.057$), with CAT 1 coaches reporting 'good' knowledge compared to CAT 3/4 coaches, who were 'undecided' ($p = 0.023$) (Table 2). However, CAT status had no significant effect on perceived knowledge of maturation monitoring ($F(2, 103) = 0.016$, $p = 0.900$, $\eta^2 = 0.002$), with all coaches reporting they were 'undecided'.

CAT status significantly influenced coaches' confidence in applying training load monitoring data ($F(2, 103) = 3.49$, $p = 0.034$, $\eta^2 = 0.064$), with CAT 2 coaches reporting a 'high' level of confidence, compared to a 'moderate' level among CAT 3/4 coaches ($p = 0.010$). CAT status did not significantly influence confidence in applying maturation monitoring practices ($F(2, 103) = 0.397$, $p = 0.673$, $\eta^2 = 0.008$), with all coaches reporting a 'moderate' level of confidence.

*Coach employability status.* Full-time coaches reported 'good' levels of knowledge of training load monitoring practices ($t(104) = 3.460$, $p = <0.001$, $d = 0.673$) compared to part-time staff who were 'undecided'. Despite a significant difference between full-time and part-time coaches ($t(104) = 2.927$, $p = 0.004$, $d = 0.569$), overall knowledge of maturation monitoring was rated as 'undecided'. Although there were significant differences between coach

**Table 2.** Mean (±95% % CI) coaches' responses to Likert scale questions (Q's11;17;23;26;24;27) on their perceived knowledge and confidence of training load and maturation monitoring.

| | Category club | | | | Coach employability status | | | Coaching experience (yrs) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cat 1 | Cat 2 | Cat 3/4 | *p* value | Full time | Part-time | *p* value | ≥7 | 4–6 | 1–3 | *p* value |
| [a]My overall knowledge of training load monitoring practices is | **3.65*** ± [3.45, 3.86] | **3.60** ± [3.29, 3.92] | **3.27** ± [3.01, 3.52] | **0.048*** | **3.70*** ± [3.53, 2.87] | **3.21** ± [2.98, 3.44] | **<0.001***** | **3.66*** ± [3.48, 3.83] | **3.53*** ± [3.22, 3.84] | **3.00** ± [2.66, 3.33] | **0.001***** |
| [b]My overall knowledge of maturation monitoring practices is | **3.14** ± [2.86, 3.42] | **3.04** ± [2.58, 3.50] | **3.06** ± [2.79, 3.33] | **0.900** | **3.32*** ± [3.10, 3.54] | **2.82** ± [2.55, 3.09] | **0.004**** | **3.28*** ± [3.05, 3.51] | **3.14*** ± [2.83, 3.45] | **2.60** ± [2.17, 3.02] | **0.007**** |
| [c]My overall confidence in applying training load monitoring data into my coaching practices is | **3.14** ± [2.92, 3.36] | **3.43*** ± [3.21, 3.65] | **2.89** ± [2.60, 3.19] | **0.034*** | **3.27*** ± [3.08, 3.46] | **2.90** ± [2.64, 3.16] | **0.021*** | **3.13** ± [2.93, 3.32] | **3.28** ± [2.92, 3.64] | **2.80** ± [2.42, 3.17] | **0.095** |
| [d]My overall confidence in applying maturation monitoring data into my coaching practices is | **2.85** ± [2.59, 3.12] | **2.86** ± [2.45, 3.28] | **2.70** ± [2.44, 2.97] | **0.673** | **3.01*** ± [2.79, 3.24] | **2.54** ± [2.30, 2.79] | **0.006**** | **2.98*** ± [2.75, 3.20] | **2.85** ± [2.52, 3.18] | **2.32** ± [1.94, 2.69] | **0.007**** |
| [e]Training load monitoring data effectively impacts my coaching practice | **3.54** ± [3.19, 3.88] | **3.56** ± [3.17, 3.95] | **3.22** ± [2.95, 3.49] | **0.224** | **3.63*** ± [3.40, 3.87] | **3.15** ± [2.87, 3.43] | **0.009**** | **3.49** ± [3.22, 3.75] | **3.35** ± [2.97, 3.74] | **3.28** ± [2.89, 3.66] | **0.634** |
| [f]Maturation monitoring data effectively impacts my coaching practice | **3.48** ± [3.13, 3.83] | **3.00** ± [2.63, 3.36] | **3.18** ± [2.92, 3.45] | **0.135** | **3.45*** ± [3.24, 3.66] | **3.01** ± [2.72, 3.31] | **0.017*** | **3.49*** ± [3.24, 3.73] | **3.35** ± [2.98, 3.72] | **2.60** ± [2.28, 2.91] | **<0.001***** |

**[a/b]1 to 1.80 represents (very poor); 1.81 to 2.60 represents (poor); 2.61 to 3.40 represents (undecided); 3.41 to 4.20 represents (good); 4.21 to 5 represents (excellent)**
**[c/d]1 to 1.80 represents (very low); 1.81 to 2.60 represents (low); 2.61 to 3.40 represents (moderate); 3.41 to 4.20 represents (high); 4.21 to 5 represents (very high)**
**[e/f]1 to 1.80 represents (strongly disagree); 1.81 to 2.60 represents (disagree); 2.61 to 3.40 represents (undecided); 3.41 to 4.20 represents (agree); 4.21 to 5 represents (strongly agree).**

employment statuses ($t(104) = 2.334$, $p = 0.021$, $d = 0.454$), both full-time and part-time coaches reported only 'moderate' confidence in applying training load monitoring. For maturation monitoring, full-time coaches reported 'moderate' confidence, while part-time coaches reported 'low' confidence ($t(104) = 2.831$, $p = 0.006$, $d = 0.550$).

*Coaching experience.* Coaching experience significantly affected perceived knowledge of training load monitoring ($F(2, 103) = 7.10$, $p = 0.001$, $\eta^2 = 0.057$). Coaches with 4–6 years ($p = 0.009$) and ≥7 years ($p < 0.001$) of experience reported 'good' knowledge, whereas those with 1–3 years remained 'undecided'. Similarly, knowledge of maturation monitoring practices varied significantly according to the level of coaching experience ($F(2, 103) = 5.17$, $p = 0.007$, $\eta^2 = 0.091$). Coaches with 4–6 years ($p = 0.028$) and ≥7 years ($p = 0.002$) of experience were 'undecided' but reported significantly greater perceived knowledge than less experienced coaches (1–3 years), who reported 'poor' knowledge. Coaching experience did not significantly affect confidence in applying training load monitoring ($F(2, 103) = 2.411$, $p = 0.095$, $\eta^2 = 0.045$) but significantly influenced confidence in maturation monitoring ($F(2, 103) = 5.289$, $p = 0.007$, $\eta^2 = 0.093$). Coaches with 4–6 years ($p = 0.023$) and ≥7 years ($p = 0.002$) of experience reported significantly greater confidence, rated as 'moderate,' compared to the 'low' confidence reported by less experienced coaches (1–3yrs).

## Perceived impact of monitoring data on coaching practice

Full-time coaches reported a significantly greater perceived impact of training load ($t(104) = 2.659$, $p = 0.009$, $d = 0.517$) and maturation monitoring ($t(104) = 2.424$, $p = .017$, $d = 0.471$) on their coaching practices compared to part-time coaches. Full-time coaches 'agreed' these practices were effective, while part-time coaches were 'undecided'. Similarly, coaching experience significantly influenced the perceived effectiveness of maturation monitoring on coaching practices ($F(2, 103) = 0.46$, $p < 0.001$, $\eta^2 = 0.009$). Coaches with ≥7 years' experience 'agreed' it was effective, those with 4–6 years were 'undecided' ($p = 0.002$), and those with 1–3 years 'disagreed' ($p < 0.001$).

## Coaches' perceptions and attitudes of training load and maturation monitoring practices

Preventing 'injury and fatigue' was identified as the most important aspect of training load monitoring by 60% of coaches, followed by monitoring 'player welfare and well-being' (30%) (Figure 1). Conversely, the least important aspect of training load monitoring was aiding match preparation tactics, with 57% of coaches reporting it did not influence their coaching practice.

The most important aspects of maturation monitoring were aiding player development (45%) and preventing growth-related injuries (44%). Assisting with player selection was viewed as the least important (54%) (Figure 2).

## Perceived benefits

Of the 107 respondents, 81% were aware of the benefits of training load monitoring, and 70% recognised the benefits of maturation monitoring. For training load monitoring, the most frequently reported benefits were 'injury prevention' (56%) and 'game preparation' (38%), with the least reported benefit (Table 3). For maturation monitoring, 'player development' (48%) was the most frequently reported and 'decision-making' (20%) was the least (Table 4).

*Coaching attitudes.* Coaches were asked a series of closed questions (Q31–35) on their attitudes towards training load and maturation monitoring (Table 5). A high percentage of coaches indicated that they should understand both training load monitoring (97%) and maturation monitoring (96%). In the context of session planning, 53% of coaches reported having sufficient input from training load monitoring data, whereas only 45% reported adequate input from maturation monitoring data. Overall, 57% of coaches reported that training load and/or maturation data were successfully used at their club.

## Challenges in implementing training load and maturation monitoring data

Of the 43% of coaches who reported unsuccessful use of training load and/or maturation data (Table 5), 46 qualitative responses were able to be coded, and four were excluded due to insufficient content. Three higher-order themes emerged: issues with coach education, communication, and limited resources.

*Issues with coach education.* From the total amount of responses, 19% of coaches indicated that 'coach education' was a challenge faced when implementing training load and/or maturation data. It was suggested that some coaches may continue to use '*traditional coaching practices'*, '*reproduce a coaching culture*' in their career and be '*resistant to change'*.

> *'Coaches and recruiters struggling to see past the 'right now'*
> (CAT 3 coach, full-time employment, ≥7 years' experience)

Additionally, several coaches indicated that knowledge and understanding were a challenge in implementing training load and/or maturation data.

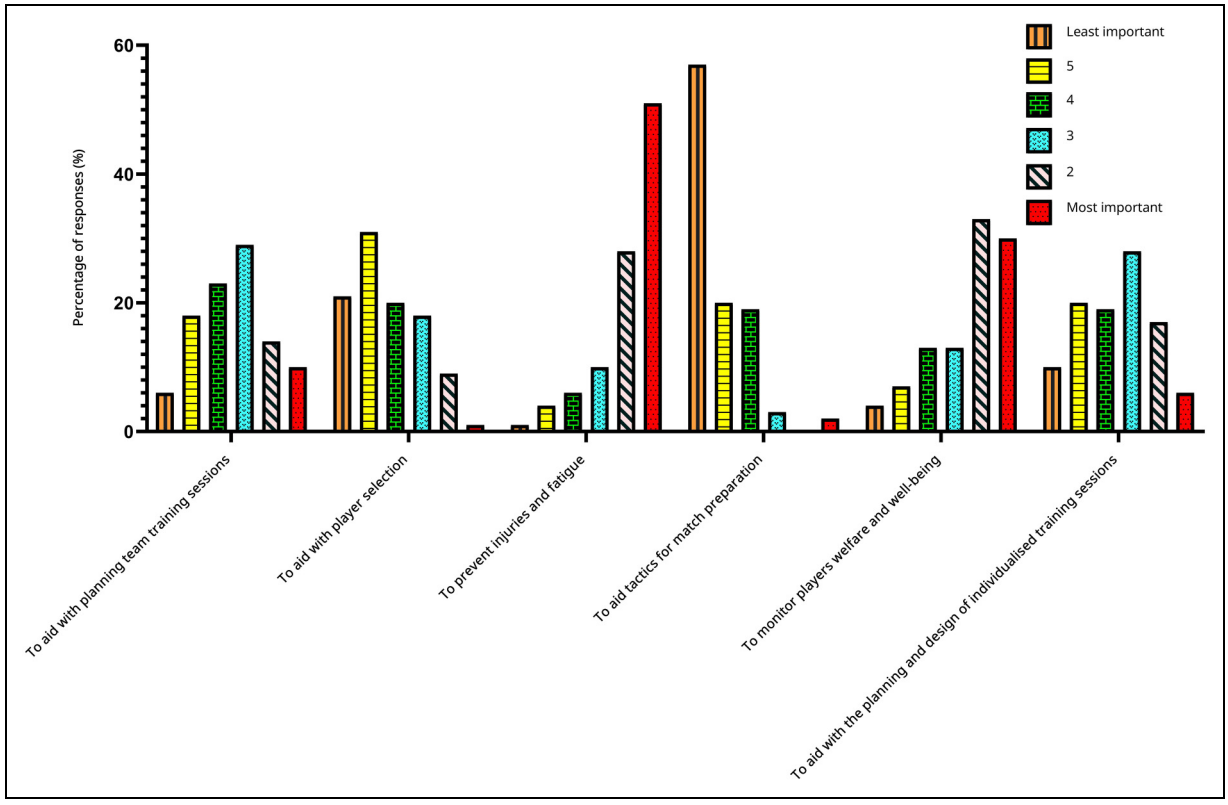


**Figure 1.** Percentage (%) of ranked coaches' responses indicating the influence of training load monitoring on coaching practice ($n$ = 107).

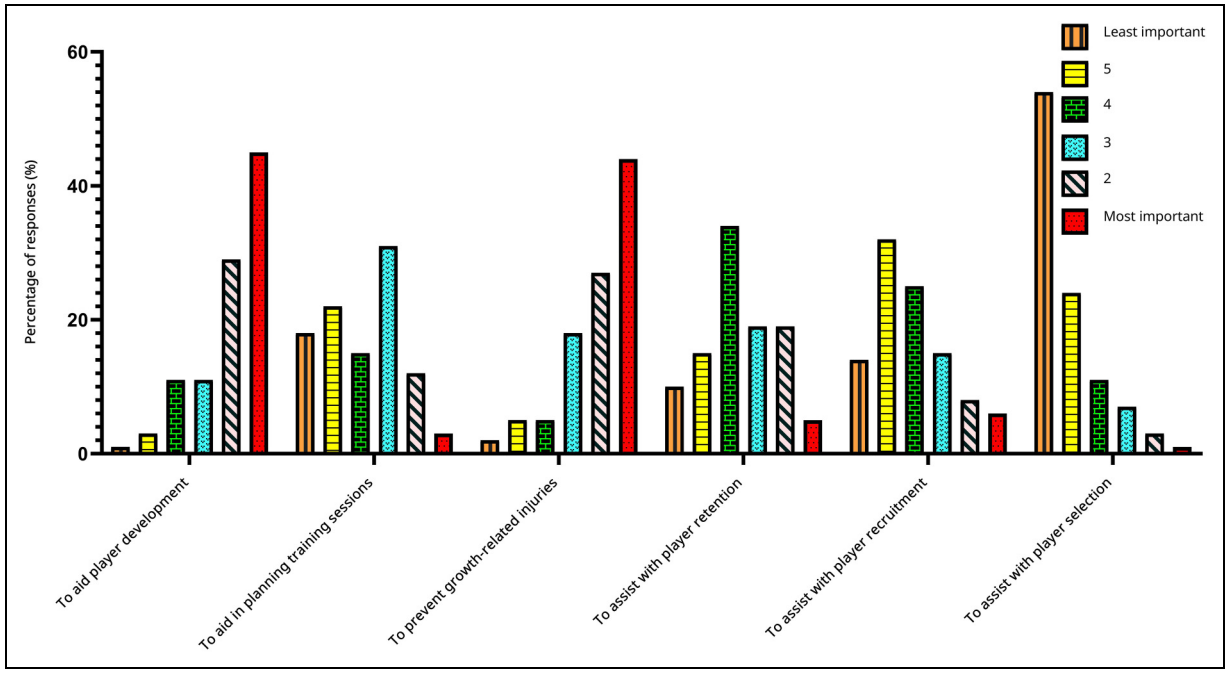


**Figure 2.** Percentage (%) of ranked coaches' responses indicating the influence of maturation monitoring on coaching practice ($n$ = 107).

**Table 3.** Benefits of training load practices.

| Higher order themes | Percentage of responses ($n = 87$) | Examples of quotes related to the higher-order themes |
|---|---|---|
| Injury Prevention | 56% | 'Managing player training load to identify load that may be excessive and lead to the risk of injury' (CAT 3 coach, full-time employment, ≥7 years' experience)<br>'Reduced risk of injury, reduced risk of overuse injuries, increased development time due to less frequent or prevention of time off due to injury' (CAT 2 coach, part-time employment, 1–3 years' experience) |
| Player Development | 38% | 'You can adapt the intensity/demands of the practices to suit the individual or the outcome you are looking for' (CAT 3 coach, full-time employment, 4–6 years' experience)<br>'Helps coaches understand how hard the players have worked and how that may have a deteriorating effect on peak performance during training and games' (CAT 3 coach, part-time employment, 4–6 years' experience) |
| Monitoring fatigue and recovery | 16% | 'Understanding when players are in danger of injury through fatigue' (CAT 2 coach, part-time employment, ≥7 years' experience)<br>'Aid recovery and monitors training-based loads relating to high-intensity, low-intensity runs and movements' (CAT 1 coach, part-time employment, ≥7 years' experience) |
| Training and planning | 15% | 'Planning for future sessions and games and planning what players need in specific positions' (CAT 1 coach, full-time employment, ≥7 years' experience)<br>'We would periodise the week and this would influence how we designed our practices and the timings of the session' (CAT 3 coach, full-time employment, ≥7 years' experience) |
| Player welfare | 6% | 'We use data for wellness and healthcare player monitoring' (CAT 2 coach, full-time employment, ≥7 years' experience)<br>'Mental well-being of athletes' (CAT 1 coach, part-time employment, 1–3 years' experience) |
| Game preparation | 3% | 'Additional planning/game strategy' (CAT 1, part-time employment, 4–6 years' experience)<br>'Helps work towards a match day with workload levels, session duration, etc' (CAT 3 coach, full-time employment, ≥7 years' experience) |

*This was calculated from the total number of responses and expressed as a percentage.

**Table 4.** Benefits of maturation monitoring practices.

| Higher order themes | Percentage of responses ($n = 75$) | Examples of quotes related to the higher-order themes |
|---|---|---|
| Player development | 48% | 'Understanding players' stage of growth/maturation can play a significant part in the development and training plans to maintain performance for players' (CAT 2 coach, full-time employment, ≥7 years' experience)<br>'To help players develop within correct biological environments at key critical times' (CAT 1 coach, part-time employment, ≥7 years' experience) |
| Planning training | 29% | 'Informs individual training loads' (CAT 1, full-time employment, ≥7 years' experience)<br>'Session design, pitch space and bio banding are all in the thought process when planning' (CAT 3 coach, full-time employment, ≥7 years' experience) |
| Prevention of growth-related injuries | 25% | 'Prediction of future injury risk and ability to put measures in place to combat these risks' (CAT 2, part-time employment, 1–3 years' experience)<br>'Adolescents may be prone to overuse injuries during periods of rapid growth. Measuring youth athletes can help monitor their growth and well-being' (CAT 1 coach, full-time employment, ≥7 years' experience) |
| Talent identification and selection | 23% | 'It can help us predict height, and PHV, which can help us remain patient with players regarding their technical and physical capability' (CAT 3 coach, part-time employment, 4–6 years' experience)<br>'Informs decision-making and assists with recruitment of players' (CAT 3 coach, full-time employment, ≥7 years' experience) |
| Decision-making | 20% | 'We can better understand our perceptions of player wellbeing/performance based on growth and external factors. We can make more informed decisions with context' (CAT 1 coach, full-time employment, 4–6 years' experience)<br>'Performance reviews, - this is very important within our environment to ensure subjective opinions are informed. i.e., a child may be within a PHV period' (CAT 2 coach, full-time employment, ≥7 years' experience) |

*This was calculated from the total number of responses and expressed as a percentage.

**Table 5.** Frequency (%) of responses to closed questions on coaches' attitudes towards training load and maturation monitoring.

| Questions (31–35) | Response (Yes/No) total responses ($n = 46$) | |
|---|---|---|
| | Yes (%) | No (%) |
| Do you think coaches should understand training load monitoring data? | 97 | 3 |
| Do you think you have enough input when planning coaching sessions based on training load monitoring data? | 53 | 47 |
| Do you think coaches should have an understanding of maturation monitoring data? | 96 | 4 |
| Do you think you have enough input when planning coaching sessions based on maturation monitoring data? | 45 | 55 |
| Do you think that training load and/or maturation monitoring data are used successfully at your club? | 57 | 43 |

*This was calculated from the total number of responses and expressed as a percentage.

> '*Recent club structure has left that side of the sport in a situation where sport science isn't a huge priority. A lack of understanding as well between coaches affects this'* (CAT 2 coach, part-time employment, 1–3 years' experience)

Of the 107 respondents, 54% reported that their education provided knowledge of training load monitoring, with higher education programmes being the most common source (55%). Notably, 74% of coaches held a sport-related higher education degree or equivalent. In contrast, 70% indicated that the formal coach education they received did not provide knowledge of maturation monitoring, and only 39% agreed it had equipped them with knowledge in this area. However, 54% reported that FA qualifications (or equivalent), particularly the Advanced Youth Award (AYA), contributed to their understanding of maturation monitoring practices. The majority of coaches expressed a need for additional education, with 94% seeking further training in load monitoring and 90% in maturation monitoring, highlighting a substantial demand for improvements in coach education.

### *Communication*

Communication was identified by 17% of coaches as a challenge in implementing training load and/or maturation data, with delays in communicating data limiting its impact on coaching practice. Coaches emphasised the need for simplified data and improved interdisciplinary communication from practitioners.

> '*Slow to report data and not simplified for the coaching department - what does it mean for the player on the pitch now'* (CAT 1 coach, full-time employment, ≥7 years' experience)

*Limited resources.* Resources were identified as a challenge by 39% of respondents, with a common issue being the limited availability of sport science staff within soccer academies. This represents a significant barrier to implementing training load and maturation data.

> '*I am currently working at a category 3 club that is under-resourced. At my previous club, which was CAT 1, we were heavily influenced by data and had many full-time sport scientists in place to support and educate coaches'* (CAT 3 coach, full-time employment, ≥7 years' experience)

## Discussion

This survey is the first to investigate coaches' perceived level of knowledge, confidence, and attitudes towards training load and maturation monitoring within professional youth soccer academies. Additionally, this survey furthers our knowledge of the perceptions of coaches towards training load monitoring practices,[10,12] and adds to our understanding of coaches' knowledge from different disciplines.[39] Coaches' perceived knowledge and confidence in training load and maturation monitoring practices may be associated with club category, employability status, and coaching experience, but due to the study design, it does not permit causal inference or directional influence. A large majority of coaches perceived training load monitoring to be beneficial for reducing injury and fatigue, whilst maturation monitoring was perceived to be useful to aid player development and reduce growth-related injuries. Although there was a general agreement that coaches should understand both monitoring practices, several challenges (issues with coach education, communication, and limited resources) were reported when implementing them into club environments.

### *Factors influencing coaches' knowledge and confidence*

*Club category status.* Survey results showed that coaches at higher CAT clubs perceived themselves as more knowledgeable and confident in training load monitoring; however, only CAT 2 coaches reported a 'high' level of confidence. Research has shown moderate differences in the methods used for training load monitoring between CAT 1 and CAT 3 clubs, with higher CAT clubs favouring

external load measures like Global Positioning Systems.[6] It may be hypothesised that coaches at higher CAT status clubs have greater exposure to monitoring technologies, and therefore have greater expectations to integrate data into their coaching practices; however, this warrants further research. At CAT 1 clubs, external monitoring (GPS) is likely standard practice throughout the academy, with coaches expected to use it to support decision-making.

The EPPP requires clubs to employ support staff based on their category status.[7] Higher CAT clubs typically require more full-time staff to manage increased contact hours,[40] and often make greater use of technological monitoring practices.[6] In contrast, lower CAT clubs may depend more on part-time staff or interns for support. A larger staff base may enhance opportunities for informal knowledge sharing, a key way coaches develop sport science expertise, which can, in turn, improve their perceived knowledge and confidence in applying monitoring practices.[11]

*Coach employability status.* Full-time coaches reported significantly greater perceived knowledge and higher confidence in training load and maturation monitoring practices compared to part-time coaches, despite no association with qualifications and employment status. Therefore, one must consider the potentially greater number of opportunities full-time coaches have to develop their knowledge and confidence through the environment from social and informal interactions in their club's day-to-day environment, compared to part-time staff.

Frequent reflection and evaluation of training load monitoring data with other coaches have been reported to enhance its application in coaching practices; however, this process is often informal and limited to reflections within departments between coaches.[21] Informal learning facilitated through social interaction has been widely acknowledged as a primary mechanism by which coaches acquire knowledge within their day-to-day professional environments.[11,41,42] Although coaches often prefer informal learning, formal coach education courses remain a common method of knowledge acquisition, even if they are sometimes perceived less positively due to concerns about their effectiveness.[11] Nonetheless, this concept was beyond the scope of the current study, leaving it unclear whether the potentially reduced interactions and engagements of part-time coaches influence their knowledge and confidence regarding training load and maturation monitoring practices.

A lack of inter-departmental reflection opportunities and poor data sharing between coaches and practitioners may result in siloed approaches, which can be characteristic of working within a multi-disciplinary environment.[43] One solution suggested to enhance both monitoring practices is for clubs to operate using interdisciplinary practices when planning schedules and training loads.[44] To improve knowledge and confidence, a trans-disciplinary environment, such as a Department of Methodology (DOM), has been recommended to enhance learning opportunities and facilitate co-learning between coaches and practitioners.[45,46]

However, the successful implementation of such environments requires the integrated efforts of all professional staff to collaborate and co-design monitoring practices.[45] For example, this could be achieved by 1) sport scientists and coaches both co-designing and developing a shared goal for the use of monitoring data, 2) coaches and sport scientists co-delivering on training sessions based on monitoring data and 3) creating opportunities for all professional staff to collaboratively discuss data to inform decision-making (e.g., retain and release decisions, loading requirements for players based on maturation status and grouping based on biological maturity). This challenges clubs to better integrate part-time staff, who are often less embedded in daily operations, to support knowledge and improve confidence in using training load and maturation monitoring practices.

*Coaching experience.* Another key finding of this study was that greater coaching experience significantly increased perceived knowledge of training load and maturation monitoring practices. However, coaching experience influenced confidence only in relation to maturation monitoring, with all coaches reporting only moderate confidence in applying both training load and maturation monitoring practices. Coaches may develop expertise through experience and observation,[47] potentially explaining the higher knowledge levels among more experienced coaches. Models such as Kolb's experiential learning theory[48,49] may support the idea that coaching experience plays a significant part in the learning process of training load and maturation monitoring practices. Coaches with greater experience may have accumulated numerous practical experiences and opportunities for reflection, enabling them to conceptualise and apply training load and maturation monitoring more effectively within their practice. This could explain why experienced coaches in the current study reported higher perceived knowledge of monitoring practices compared to less experienced coaches. However, the moderate confidence levels indicated suggest that while experiential learning supports knowledge acquisition, it may not be enough for coaches to competently apply these practices in coaching. One key facet of this model is that coaches have the time to reflect, theorise and apply their learning[50] which can be challenging in professional soccer clubs, given the high turnover of staff.[51]

Alternatively, ongoing cycles of reflection through coaching experience, such as the use of Schon's theory of reflection,,[52,53] support the use of reflection to develop knowledge through professional practice. When combined with experiential learning, reflective practice provides coaches with a powerful method to deepen their knowledge

through observation and critical inquiry, effectively bridging the gap between theory and practice.[42] Therefore, reflective practice provides coaches with a valuable learning opportunity to connect their experiences with the ongoing development of their coaching practice.[54,55] However, this reflective model is coach-centred and overlooks the influence of social structures and organisational pressures within football academies, as well as how discourses (our patterns of thinking and reflection) are shaped by broader societal ideas and contexts.[56] Additionally, coaches may reflect within the constraints of their club's dominant norms,[57] and when monitoring practices are not embedded in the club's culture, these constraints may limit a coach's ability to critically evaluate or adapt training load and maturation monitoring strategies. Further research is needed to examine how the club environment may influence coaches' application of monitoring practices.

Experienced youth soccer coaches may be able to identify visual indicators of growth through observation; however, this ability appears to be limited to those with over eight years of experience working in CAT 1 academy settings.[58] Despite this, the accuracy with which coaches can use their experience to assess maturation status remains uncertain, as findings across studies are inconsistent.[58–60] As a result, maturation monitoring data can offer valuable support by providing a more objective basis for decision-making, particularly for coaches with less experience or confidence in managing training loads across varying stages of maturation.

### *Perceptions and attitudes of coaches*

Coaches reported that the most important aspect of training load monitoring was to 'prevent injury and fatigue'. Given that the majority of injuries in adolescent youth soccer are non-contact in nature, and inadequate training load prescription may be a contributing factor,[61] it is unsurprising that training load monitoring is perceived to be an important aspect of coaching. Training load can be strategically modified throughout different phases of the training cycle, such as during preparatory or competitive periods,[62] with training load often systematically applied to specific chronological age groups.[13] A 5% increase in maturity status has been associated with a 6.9 arbitrary unit (AU) reduction in session ratings perceived exertion (sRPE) training session workload, while a 10% maturity shift corresponds to a 13.9 AU decrease,[63] therefore, indicating players of an advanced maturation status may correspond with a reduction in training intensity. These findings highlight the limitations of age-based training load prescription, which may be inadequate given the substantial individual variability in physical and maturational development among youth athletes.[64]

Additionally, coaches reported that the most important aspect of maturation monitoring was to 'aid player development' and 'reduce growth-related injuries'. Maturation monitoring data has been used in various contexts within soccer academies, from the grouping of players based on biological maturity,[64,65] to help objectively identify players that are due to reach critical periods of growth, such as peak height velocity and adolescent awkwardness.[66] As such, maturation data can support coaches in making informed decisions within their practice, provided they possess the knowledge and confidence to effectively apply it.

The results indicate the importance that coaches place on understanding training load and maturation monitoring practices. Despite previous research highlighting inconsistencies in coach buy-in to training load monitoring,[10] and some potential scepticism regarding its practical application,[24] our findings align with Weston (2018),[12] who reported a broad consensus on the usefulness of training load monitoring among coaches and practitioners. Notably, this study is the first to assess coaches' perceived knowledge of these monitoring practices, highlighting the need for further research. Additionally, the mixed responses regarding the successful implementation of training load and maturation monitoring within clubs emphasise the potential challenges in its practical application.

### *Challenges in implementing training load and maturation monitoring data*

One of the main challenges reported by coaches was issues with coach education, with the vast majority reporting a need for further education on both training load and maturation monitoring. Similar to a previous survey,[11] formal coach education, specifically university degrees, was the most common method for acquiring knowledge of training load and maturation monitoring. University sport degree programmes have grown in popularity as formal learning pathways into coaching in the UK since 2009.[67] While such degrees may enhance employability within soccer academies,[68] there is currently no evidence that they contribute to the development of coaching practices related to training load and maturation monitoring.

Formal coach education courses have come under criticism, with courses suggested as being decontextualised, inadequate and bureaucratic.[26,27] Additionally, there appears to be a lack of suitability for course content and a failure of courses to replicate everyday practices observed in youth soccer academy environments.[25,69] Formal coach education courses, such as the AYA, were reported to support knowledge of maturation monitoring. Emerging qualifications, such as the Elite Heads of Coaching (Premier League) and Elite Youth A Diploma (UEFA), which were not available at the time of data collection, may offer additional options for coach education in this area. However, given that formal education may appear to have minimal

impact on coaching behaviour,[70,71] this approach to knowledge acquisition may warrant further consideration.

Communication and limited resources were both reported by coaches as significant challenges in implementing training load and maturation monitoring data. Given the potentially different educational backgrounds of coaches and sport scientists,[17] and the tendency for them to operate at different paces,[9] delays in the delivery of data to coaches for planning and training may be explained. The language communicated around data should be contextualised and simplified to meet the needs of coaches. In agreement with previous research,[12,21] there is a suggestion that training data is useful for guiding coaching practice. A lack of a common goal underpinning the use of training data has been previously reported,[21] and our findings reflect this, with coaches offering mixed responses regarding their level of input in planning training sessions informed by such data. While efforts such as colour-coded systems have improved data visualisation for coaches,[72] greater emphasis is needed on frequent interdepartmental communication, reflective evaluation of data,[21] and co-creating practices between coaches and sport scientists.

Limited resources were identified as a barrier to implementing training load and maturation monitoring, consistent with findings that lower-CAT clubs often face greater challenges in adopting such practices.[6] Although session rate perceived exertion is a cost-effective method for monitoring training load across age groups[14] and estimated maturity assessments (e.g., predicted adult height, maturity offset) are widely used in academies and require minimal equipment,[6] implementation may be hindered primarily by a lack of adequate human resources. Given the role of monitoring in supporting coaching decisions and the resource disparities governed by EPPP CAT status, lower CAT clubs (e.g., CAT 3) may need to explore strategies for implementing monitoring practices with limited staff availability. One potential solution is for clubs to adopt an interdisciplinary approach to monitoring as used within a previous study,[44] that fosters collaboration between coaches and sport scientists to integrate knowledge from multiple disciplines into a unified practice. Alternatively, academy clubs could deliver non-formal workshops to bridge the gap between science and coaching,[73] providing continuing professional development for coaches and facilitating the co-creation of educational programmes in resource-limited clubs.

## Practical application

This study highlights the need to enhance formal coach education to improve knowledge and confidence in training load and maturation monitoring, particularly for part-time coaches and those in lower CAT academies (CAT 3). Clubs could develop interdisciplinary practices that improve collaboration between coaches and sport scientists and strategically integrate informal learning opportunities within their environments. Developing a club environment that fosters transdisciplinary practices may strengthen coach learning and coach-scientist integration, ultimately improving the implementation of monitoring practices.

### *Limitations and future research*

This study relied on coaches' self-assessed knowledge and confidence, yet research suggests that individuals with limited expertise may overestimate their abilities due to poor metacognitive awareness.[74] Consequently, self-reported measures may not reliably reflect actual competence, particularly when confidence is high, but knowledge is low. Additionally, although a wide, representative sample of UK academy coaches was evident in the study, a snowball sampling strategy was used, which is often criticised for failing to produce samples that meet the standards of true random sampling (i.e., it deviates from probability-based approaches).[75] While this study provides valuable insights into why coaches perceive monitoring practices as 'unsuccessfully' implemented within their clubs (Q35), we acknowledge that it does not define what constitutes successful monitoring and primarily focuses on the challenges and barriers to implementation. Finally, although means and confidence intervals are commonly used for Likert-type ordinal data, this approach assumes interval-level properties that may not fully reflect the underlying scale. Future research should incorporate qualitative methods, such as interviews, to explore the contextual and behavioural factors influencing data use. Additionally, as education appears to underpin perceived knowledge and confidence, future work should investigate how formal and informal learning opportunities within club environments can be optimised to enhance coaching practice.

## Conclusion

This study is the first to aim to investigate coaches' perceived knowledge, confidence, and attitudes toward training load and maturation monitoring within professional youth soccer academies. Greater perceived levels of knowledge and confidence were associated with full-time coaches, those in higher-category clubs, and those with a greater number of years of coaching experience. While coaches recognised the value of monitoring for injury prevention and player development, challenges such as decontextualised coach education, poor communication, and resource constraints, especially in lower-category academies, hindered implementation. Enhancing formal coach education, embedding informal learning opportunities, and fostering inter- and transdisciplinary club environments may improve the implementation of monitoring practices. Future research should utilise qualitative approaches to

better understand how coaches engage with monitoring data in applied settings.

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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 consent within the survey.

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## Data availability statement

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

## Supplemental material

Supplemental material for this article is available online.

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