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Video telestration as a pedagogical tool for memory recall in youth male football: a case study

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ABSTRACT

Video telestration, overlaying visual annotations on video, is widely used in elite sport to enhance clarity during feedback, yet evidence in youth settings remains limited. This study evaluated the effect of telestration on delayed recall of session content among male youth football players. A 16-week within-subject intervention was conducted with 14 academy players (aged 14–16) viewing telestrated and non-telestrated clips across coach-led and player-led formats, with and without spaced "top-up" sessions. Recall was assessed using bespoke surveys aligned to eight academy game principles. Telestration produced higher recall scores than non-telestrated conditions (median = 54.41% vs. 43.75%), with the highest scores in player-led telestrated sessions with a top-up (median = 63.64%). Telestration reduced variability in recall, suggesting improved group understanding and tactical cohesion. Recall tended to be higher for structured principles (e.g. build-up, pressing) than reactive phases (e.g. defensive transitions). Players reported positive perceptions of telestration in terms of clarity and engagement. In an applied academy context, telestration was associated with improved delayed recall, with additional benefits from player-led delivery and spaced review. These findings support feedback designs that use clear visual cues and spaced retrieval opportunities to enhance retention of tactical information, with practical implications for session design and delivery.

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KEYWORDS
Cognitive load theory; retrieval practice; performance feedback; tactical learning; sports coaching

1. Introduction

Video feedback has become a central component of sports performance analysis (SPA), assisting in the translation of key insights to support tactical understanding and decision-making (Martin et al., 2021, 2024). For example, in football, short video clips are commonly used in pre-match or post-match meetings to review moments such as build-up play under opposition pressure, with coaches pausing footage to draw attention to player positioning, passing options, and/or distances between units to support player

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decision-making and learning. Its value lies in allowing players to visually review and reflect on their actions, aiding the interpretation of complex game situations and supporting perceptual-cognitive processes relevant to performance, such as pattern recognition and situational awareness (Nelson et al., 2014; Pearson et al., 2023). However, the effectiveness of video feedback is influenced not only by the technology employed but also by how feedback is designed and delivered. Specifically, beyond the hardware or software used to capture and display footage, the effectiveness of video feedback depends on pedagogical factors such as what information is selected, how it is structured and emphasised, when it is delivered, and how players are prompted to engage with it (Lewis et al., 2026).

From a learning perspective, these design considerations are particularly important. When delivered in structured and reflective settings, video feedback has been shown to improve motor learning and information retention (Vrbik & Vrbik, 2017), which is particularly relevant given the frequent inaccuracies in coach and player recall of key performance events (Laird & Waters, 2008; Nicholls & Worsfold, 2016). While recall alone does not equate to skilled performance, retaining task-relevant information is widely considered a necessary precursor for applying tactical concepts under time pressure in dynamic team sports contexts (Ashford et al., 2021; Voigt & Raab, 2024). Accordingly, evidence has increasingly shifted attention away from video itself and towards the conditions under which it supports learning, highlighting that factors such as delivery method, feedback environment, and the degree of athlete involvement shape the extent to which video feedback supports learning (Groom et al., 2011; Lewis et al., 2026; Pearson et al., 2023).

Alongside this pedagogical shift, SPA technologies have expanded beyond traditional notational analysis to include tools that enable granular, context-specific review of performance (Jayal et al., 2018; S. Robertson, 2020; S. Robertson et al., 2023). Among these tools, video telestration, which involves overlaying visual annotation on video clips, is widely used to clarify key cues, highlight positional or movement patterns, and support shared understanding during analysis sessions (Cullinane et al., 2024; Jones et al., 2020). For clarification, video feedback is used as an umbrella term referring to the use of video footage to support player learning and reflection, whilst video telestration refers to a specific form of video feedback in which information is overlayed directly onto the footage to guide attention to task-relevant content. Initially popularised in sport broadcast analysis, telestration has since been adopted by elite sports team environments to support match preparation and performance review (Cullinane et al., 2024). As a result, telestration is now embedded within routine SPA practice in many elite football environments. Survey data indicated that 93% of coaches, players and APAs perceive telestration as essential or very important, with 77% reporting frequent use in pre-match contexts (Jones et al., 2020). However, such findings primarily describe perceptions and usage patterns rather than learning outcomes, indicating the need for empirical evaluation to determine whether telestration meaningfully supports learning, for example, through improvements in the retention of session content.

To date, only a small number of studies have examined telestration using objective measures. Smith et al. (2022) address this gap, reporting that elite players who viewed telestrated video clips achieved higher delayed recall[1] of tactical information related to possession phases, chance creation, and set-piece situations, as well as higher overall

recall scores, compares with players who viewed non-telestrated video clips (78.29% ± 6.12% vs. 56.57% ± 7.89%), indicating a potential learning benefit in applied football settings. Evidence from healthcare training, where randomised and controlled studies have been undertaken, similarly shows that telestration can improve instructional communication and task performance, typically measured through accuracy during practical procedural tasks, and lower learner stress, offering a practical rationale for its use as a pedagogical aid (Kiani et al., 2024; Laborde et al., 2017; Neves Lopes et al., 2022). Collectively, these findings are consistent with theoretical mechanisms proposed in multimedia learning research, specifically, that signalling tools such as telestration can support learners by highlighting key cues and reducing unnecessary processing demands (Mayer, 2024). However, effects appear to be context- and learner-dependent, aligning with expertise-reversal accounts in which novices benefit from stronger guidance, whereas experienced performances may require selective, non-redundant cues (Kalyuga & Renkl, 2009; Wild et al., 2022). From a Dual Coding perspective (Paivio, 2007), learning is supported when information is processed through coordinated visual and verbal channels rather than a single representational format. In the context of video-based feedback, telestration supports this process by aligning visual information with concise verbal or symbolic cues, enabling learners to form integrated visual-verbal representations of tactical situations. When viewing unannotated match footage, players must independently search for and interpret multiple dynamic cues, increasing extraneous cognitive load through unnecessary visual search and cue competition. By selectively highlighting task-relevant information, telestration constrains irrelevant processing and reduces visual search demands, allowing working-memory resources to be allocated more efficiently, consistent with Cognitive Load Theory (Sweller, 2020).

These theoretical considerations apply directly to football, where the effectiveness of video feedback depends on how it is embedded within the learning environment (J. Robertson & Bearman, 2022). Delivery in elite settings remains predominantly coach-led (Mason et al., 2021; Wright et al., 2016), despite increased discussion and evidence of more interactive practices, such as dialogic feedback, guided questioning, and collaborative coach-athlete video review that actively involve players in interpreting footage (Pearson et al., 2023). While coach-led formats are effective for transmitting tactical information, they can position players as passive recipients, limiting deep learning and self-regulation (Groom et al., 2012; Wright et al., 2016). Subsequently, coaches and APAs are encouraged to scaffold interaction within video feedback sessions (De Martin Silva & Francis, 2021), for example, through guided questioning, brief player explanations, or short player-led segments, to increase engagement and support deeper processing of session content (Middlemas & Harwood, 2017; Wright et al., 2016).

Beyond interaction, feedback must also be shaped to players' cognitive capacity, as designs that align with learners' cognitive demands can reduce overload and support retention (Sherwood et al., 2019; Smith et al., 2022). Memory research indicates rapid forgetting without revisitation (Ebbinghaus, 1880) and improved recall when information is re-encountered after the 24-hour mark, a process often described as relearning, whereby information is better understood or retained following a consolidation period (Murre & Dros, 2015). In football, where meetings often preceded matches by several days (Travis & Butterworth, 2024), feedback should engage players in the processing and revisiting key learnings at appropriate

intervals. Evidence shows that more frequent, prescriptive feedback boosts immediate performance yet can impair long-term retention, whereas reduced or summary feedback fosters durable learning by encouraging active retrieval; therefore, video feedback sessions should incorporate spaced opportunities for retrieval and align timing with consolidation processes to maximise retention and transfer (Carpenter et al., 2022).

Research in cognitive psychology has identified retrieval practice as a powerful countermeasure to the rapid decline in memory retention (Carpenter et al., 2022). Retrieval practice, the active recall of session content, strengthens memory traces and slows forgetting, particularly when spaced over time (Mguidich et al., 2025). Importantly, not all retrieval is equally beneficial. Deeper, more effortful retrieval that involves attaching semantic meaning and connecting new information to existing knowledge structures produces greater, longer-term retention than simple repetition or shallow recall attempts. In theoretical terms, spaced and retrieval act to counter the rapid decay in retention originally described in the Ebbinghaus (1880) forgetting function, providing a rationale for designing feedback that creates repeated, effortful recall opportunities at planned intervals (Murre & Dros, 2015). Applied football work shows this logic in practice when video feedback is paired with structured recall and brief reflection (Middlemas & Harwood, 2015), yet elite environments often deliver dense, coach-led messaging without such opportunities, with players remembering very little after 1 week (Mason et al., 2021). In this sense, telestration may act as a complementary design feature rather than a stand-alone solution. Consequently, learner, spaced, and interactive designs that prioritise retrieval opportunities and minimise extraneous load[2] are advisable. In this context, video telestration can assist by clarifying cues and reducing processing demands during review, thereby supporting subsequent retrieval of key tactical content.

Collectively, these insights emphasise that SPA effectiveness depends not only on what is delivered, but also on how and when feedback is structured and scheduled (e.g. delivery format, player involvement, spacing) (Groom et al., 2011; Pearson et al., 2023; J. Robertson & Bearman, 2022). In this context, video telestration represents a specific video-based feedback tool through, which visual signalling cues can be applied to guide attention, reduce extraneous load, and support recall. Integrating video telestration with deliberately structured delivery formats and spaced retrieval opportunities, therefore offers a plausible route to more retention-supportive learning environments in football (De Martin Silva & Francis, 2021; Pearson et al., 2023). However, the evidence base underpinning these claims remains uneven across populations and study designs. In elite senior football, existing research has primarily examined practitioners' perceptions of telestration, such as its perceived importance, usefulness, and typical usage contexts, rather than objectively measuring learning (Jones et al., 2020). In contrast, the limited experimental evidence that does exist has been conducted at the senior professional level, focusing on delayed recall following a series of self-guided non-audio telestration sessions (Smith et al., 2022). Importantly, the combined effects of video telestration, delivery format (coach-led vs. player-led), and spaced retrieval have yet to be examined within applied youth academy football environments.

This study addresses these gaps by examining how video telestration interacts with delivery format and spaced retrieval to influence delayed recall of session content among academy youth male football players. Specifically, it explores three research questions:

(1) Is telestration associated with higher delayed recall of tactical content?
(2) Does delivery format (coach-led vs. player-led) influence delayed recall?
(3) Does a brief spaced revisit ("top-up" session) further enhance recall?

Through this multifaceted approach, the study seeks to provide applied evidence on how SPA technologies can be structured to support retention of key session content, offering practical insights for coaches, analysts, and other practitioners.

2. Methods

This study conducted a collective case study in a single Category One football academy over 16 weeks, bounded by setting, squad, and time, to examine how video telestration relates to delayed recall within routine pre-match analysis sessions. The design was chosen to maximise ecological validity by embedding the intervention within the academy's existing SPA and coaching processes, allowing learning outcomes to be examined under authentic practice conditions. Guided by an interdisciplinary approach (cognitive psychology, motor learning theory, and pedagogical principles), the design combined within-subject repeated-measures comparisons of delayed recall across telestrated vs non-telestrated clips, coach-led vs player-led delivery, and with vs without a short spaced "top-up" session, alongside brief qualitative items to contextualise delivery and feasibility. Learning was operationalised as delayed recall of session-specific content. While this collective case study design limits statistical generalisability beyond the setting, it enables context-sensitive insights into how telestration and delivery formats function in applied youth academy environments, with findings intended to inform practice-relevant understanding rather than broad population-level inference.

2.1. Participants and research team

Participants were 22 male youth football players aged 14 to 16, registered with a Category One English Football League Championship Academy and actively competed in the Premier League Under 16's Games Programme. While highly skilled, these players are best described as academy-level athletes, not elite professionals. The study was conducted between August 2022 and February 2023 and was fully integrated into the club's existing SPA and coaching provision. This integration ensured ecological validity and avoided overloading players, who were also preparing for academic examinations, a period known to be associated with increased stress.

For analysis, only players who attended all sessions and were formally signed to the academy were included ($n = 14$). Trialists were excluded from the final dataset due to their incomplete attendance across the intervention period and their limited exposure to the club's playing philosophy and terminology used within analysis sessions. In this content, playing philosophy refers to the academy's shared tactical framework and language employed during video feedback, rather than evaluative judgements of player ability or suitability. Trialists continued to participate in all sessions to preserve their developmental opportunities and avoid any disruption to the progress within the club environment. Information on players' prior exposure to SPA and video-based feedback

was not collected; however, all signed academy players had a year of prior experience of PA and telestration.

The lead author was the embedded APA for the case study squad and delivered analysis sessions with the coach; the second author (Head of Academy Performance Analysis) provided operational oversight and helped with each week's survey design; the third author (academic supervisor) had no team-specific role.

Institutional ethical approval was obtained along with permission from the club acting as loco parentis. All procedures adhered to relevant safeguarding and research governance protocols, ensuring data confidentiality and participant anonymity. The project was presented as an internal service improvement study; pre-specified conditions and separation of operational oversight from analysis mitigated any dual-role risks. Only the first and third authors had access to responses for analysis, and no individual-level data were shared with coaching staff.

2.2. Intervention design

A non-randomised, non-counterbalanced within-subjects repeated-measures design with a fixed, pre-specified sequence order of conditions, exposing all participants to each condition across 16 weeks. The intervention was embedded in pre-match analysis sessions[3] to preserve routine and minimise disruption (Middlemas & Harwood, 2020).

The sequence of the conditions progressed from coach-led non-telestration delivery to player-led non-telestrated delivery, followed by coach-led telestration delivery, and finally player-led telestration delivery. This ordering reflected typical academy practice and operational constraints, which precluded randomisation or counterbalancing while maintaining ecological validity. Consequently, the design intended to examine associations between delivery formats, telestration, and recall outcomes within authentic practice contexts, rather than to isolate strict causal effects of individual components.

Over the 16 weeks, players attended structured SPA sessions that varied across three experimental conditions (see Tables 1 and 2). Each session covered the academy's eight

Table 1. Overview of the 16-week telestration intervention protocol.

Week number	Monday	Tuesday	Thursday	Saturday
1		Coach-led No Telestration		Match Day 1
2	Match Day 1 Survey	Coach-led No Telestration		Match Day 2
3	Match Day 2 Survey	Player-led No Telestration		Match Day 3
4	Match Day 3 Survey	Player-led No Telestration		Match Day 4
5	Match Day 4 Survey	Coach-led No Telestration		Match Day 5
6	Match Day 5 Survey	Coach-led No Telestration		Match Day 6
7	Match Day 6 Survey	Player-led No Telestration	Top-up Session	Match Day 7
8	Match Day 7 Survey	Player-led No Telestration	Top-up Session	Match Day 8
9	Match Day 8 Survey	Coach-led Telestration		Match Day 9
10	Match Day 9 Survey	Coach-led Telestration		Match Day 10
11	Match Day 10 Survey	Player-led Telestration		Match Day 11
12	Match Day 11 Survey	Player-led Telestration		Match Day 12
13	Match Day 12 Survey	Coach-led Telestration	Top-up Session	Match Day 13
14	Match Day 13 Survey	Coach-led Telestration	Top-up Session	Match Day 14
15	Match Day 14 Survey	Player-led Telestration	Top-up Session	Match Day 15
16	Match Day 15 Survey	Player-led Telestration	Top-up Session	Match Day 16
17	Match Day 16 Survey	Post-Intervention Survey		

Table 2. Description of intervention conditions and delivery formats.

Category	Condition	Description
Telestration Format	Non-telestrated clips	Ten video clips were shown without annotations. Each clip was paused a maximum of three times with the deliverer sharing thoughts or asking guiding questions.
	Telestrated clips	Ten video clips were presented with telestrated annotations and overlays created in Hudl Studio (Hudl, Chicago, IL). A maximum of three tools was used per clip. The selected tools were: text annotations; arrows placed on the pitch to highlight suggested player movement or passing lanes; shapes were placed onto the pitch, to highlight space; player highlighting and tracking to highlight a particular player's run who was not on the ball and may have been missed if not highlighted; and player editor used to relocate the positioning of a player who the deliverer believed to have been out of position.
Delivery Format	Coach-led sessions	Coaches and performance analysts presented tactical clips and highlighted key tactical points.
	Player-led sessions	Players worked in small groups, each assigned to a specific principle of play. Groups analysed two pre-selected clips and pre-prepared key points. In the telestrated clip condition, the players first shared their notes with the performance analyst, who then applied relevant telestration tools to the clips. The telestrated clips were subsequently presented by the players to the wider group, allowing them to communicate their key insights and tactical interpretations. During these sessions, the role of the coach and performance analyst were intentionally passive, intervening only through probing questions when necessary to guide or deepen discussion. The length of these sessions was up to an hour due to the players identifying content, and the analyst telestrating before the players presented content.
Frequency of Sessions	Single video session	A 30-minute video session delivered on a Tuesday.
	Double video session (top-up)	A 30-minute video session on a Tuesday, followed by a 15-minute top-up session on a Thursday. The format of the top-up session mirrored the delivery approach used on the Tuesday session. In coach-led conditions, the top-up primarily involved a visual recap of the clips with brief prompts from the coach, whereas in player-led conditions the top-up combined visual recap with short player explanations and discussion. In both cases, the content of the top-up session was standardised to the tactical principles and clips presented on Tuesday, with no new information introduced.

game principles (build, midfield, final third, high press, mid press, low press, attacking transition, and defensive transition) using 10 video clips; one per principle, except for build and high press, which were each represented twice due to tactical emphasis.

2.3. Instrumentation

2.3.1. Recall survey

Sixteen bespoke recall surveys were developed to align with the content of each weekly video session. The design drew on established approaches to tactical recall assessment in sport (e.g. recognition and recall prompts) (Franks & Miller, 1986; Laird & Waters, 2008; Smith et al., 2022). Each survey consisted of 16 items (two questions per principle of play). Items combined multiple-choice questions (recognition) and at least one open-ended prompt per session to sample both surface and deeper understanding. Surveys were created in Microsoft Forms (Microsoft Corporation, Redmond, WA) and administered immediately before the following week's post-match review (Monday's) to provide a delayed recall interval consistent with the club's cycle.

To support content and face validity, a pilot version was reviewed by all three researchers and an academy coach to check clarity, age-appropriateness phrasing, and alignment with session content. Minor edits were made to reflect club terminology. Weekly surveys were then produced via a standardised template (constant structure and item types) with parallel forms tailored only to that week's tactical content. Item sets were finalised before the associated session to avoid post-hoc tailoring.

Inter-rater reliability was assessed between the first and second authors using Cohen (1960) Kappa. The first three survey responses from the 14 players ($n = 36$) were examined, including all tactical principles and open-ended questions, were double scored to assess inter-rater reliability. Agreement was almost perfect across all tactical phase questions (K = 0.918–1.000), with perfect agreement observed in Final Third, Attacking Transition and Defensive Transition questions. To further monitor scoring consistency across the remaining data collection period, an additional APA working in the professional development phase and not involved in the delivery or design of the intervention, undertook periodic independent scoring checks on two random responses per session survey ($n = 26$).

2.3.2. Post-intervention survey

An online survey (Microsoft Forms, Microsoft Corporation, Redmond, WA) was created to capture players' acceptability and delivery preferences. Items targeted perceived clarity and engagement of telestrated vs non-telestrated clips, experience of delivery format (coach-led vs player-led), and perceived recall and use of content during matches. The survey consisted of seven closed and 11 open-ended questions, designed to draw deeper qualitative insights. Wording was checked for clarity and relevance by all authors before distribution.

2.4. Procedure

Each week, players attend a 30-minute Tuesday video session delivered under one of the pre-specified experimental conditions. Depending on the condition, the session was coach-led or player-led. In player-led telestrated sessions, the meeting was occasionally extended by approximately 10 minutes to allow time for the APA and the presenting players to telestrate clips collaboratively. This additional time was attributed to the mechanics of producing telestrated material live rather than increased instructional content or learner exposure to feedback. In specific blocks, a second 15-minute Thursday "top-up" session was scheduled to revisit 3 to 5 key clips from Tuesday and prompt brief retrieval. The format of the top-up session mirrored the delivery approach used in the Tuesday session. In coach-led formats, the top-up primarily involved a visual recap of the clips with brief prompts from the coach, whereas in player-led conditions the top-up combined a visual recap with shorter player explanations and discussions. In both cases, the content of the top-up session was standardised to the tactical principles and clips presented on Tuesday, with no new information introduced.

Players completed the delayed-recall survey on the following Monday, before the team's post-match review. Completion took approximately 10–15 minutes via a Microsoft Forms link provided at the start of the session; responses were completed

individually. Staff were present only for room logistics; participation was voluntary and anonymised, and responses were not monitored during completion.

At week 16, all players ($n = 22$) who had experienced any components of the intervention were invited to complete a short post-intervention perceptions survey accessed via a QR code during a scheduled meeting. The survey was introduced by the lead researcher, and responses were completed independently. Players were reminded of voluntary participation and anonymity.

2.5. Data handling and analysis

Delayed recall survey responses were exported from Microsoft Forms (Microsoft Corporation, Redmond, WA) to Microsoft Excel (Microsoft Corporation, Redmond, WA) for initial handling and then prepared for analysis in R Studio (2022.07.01-Build 554). Multiple-choice (recognition) items were scored dichotomously (1 = correct, 0 = incorrect). Open (free-recall) responses were scored on a 0–3 rubric against a pre-specified model answer derived from that week's session content (the model answers were not available to the players), to index recall of session-specific information rather than general football knowledge. Scores reflected the presence and completeness of key points: 0 (no relevant content), 1 (minimal detail, e.g. one-word response), 2 (partial coverage), 3 (complete or near-complete match to the model answer). To assess score consistency, the first and third authors independently double-scored a random 20% sample of open responses and calculated agreement indices (kappa and percentage agreement); discrepancies were resolved by discussion before one rater scored the remaining responses.

For each player-week, recognition and free-recall scores were summed within the fixed 16-item template to generate a total delayed-recall score and principle-level subscores. The data was not normally distributed. Group differences were examined using Kruskal–Wallis tests with Dunn's post-hoc comparisons (where appropriate). Results are reported as medians and interquartile ranges (IQRs), $\alpha = 0.05$. Effect sizes are presented as epsilon-squared (ε^2) with threshold interpreted as trivial ($\varepsilon^2 < 0.01$), small ($\varepsilon^2 = 0.01$–0.059), medium ($\varepsilon^2 = 0.06$–0.139), and large ($\varepsilon^2 \geq 0.14$) effects. Analyses were conducted for overall delayed-recall scores and for principle-level subscores to test whether effects varied by tactical content and by condition (telestration, delivery, and spacing format). Full statistical results can be found in the supplementary table.

Although the data comprise repeated observations within players, linear mixed models or generalised estimating equations were not employed due to the small sample size ($n = 14$), the non-normal and bounded nature of the outcome variables, unequal observations across conditions, and the fixed, non-randomised sequence of intervention delivery. Under these conditions, random-effects estimation would be unstable and highly model-dependent, potentially overstating precision. Consistent with a post-positivist, applied case-study approach, non-parametric analyses were therefore selected to identify condition-like differences in delayed recall distributions while supporting cautious, associative interpretation rather than causal inference. Results are reported using medians and inter-quartile ranges, alongside effect sizes to describe the magnitude of observed differences, which should be interpreted as indicative rather than definitive.

Responses to the post-intervention perceptions survey were treated as contextual data. Closed-ended responses (e.g. perceived benefits of non-telestrated versus telestrated clips) were summarised using medians and interquartile ranges. Two authors independently coded the open-ended responses using a data-driven inductive content analysis (Elo et al., 2014), identifying recurring categories related to i) clarity and understanding, ii) engagement and enjoyment, iii) relatability or peer perspective, and iv) expertise and tactical insights. The agreed codes were then applied to all comments, with coded frequencies reported and illustrative quotations used to contextualise the quantitative results.

3. Results

3.1. Overall impact of telestration on player recall performance

Figure 1 illustrates the distribution of overall delayed-recall scores across telestrated and non-telestrated conditions for the 14 players. Scores were higher when telestration was used (Median = 54.41%, IQR = 13.84%) than when it was not (Median = 43.75%, IQR = 12.88%). A Kruskal–Wallis test identified a statistically significant difference between conditions (χ^2 (1) = 45.02, $p < .001$) with a large effect size ($\varepsilon^2 = 0.198$) within the sample and conditions studied. These results indicate that within the sample and the design, telestration was associated with higher delayed-recall scores.

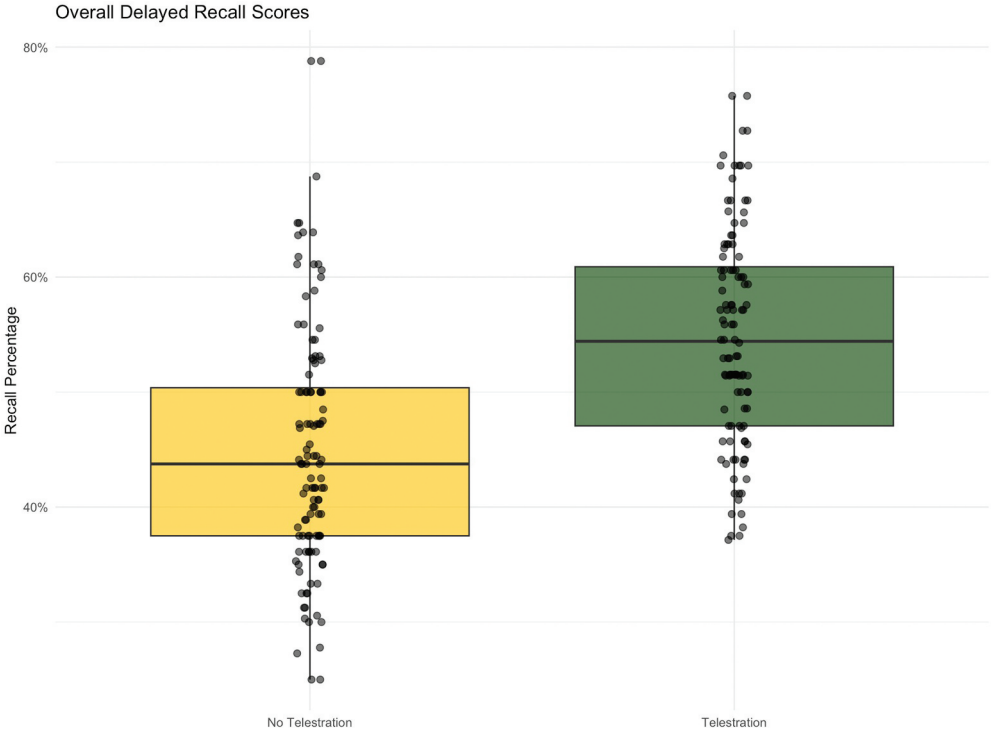

Figure 1. Overall recall performance between telestrated and non-telestrated video clips.

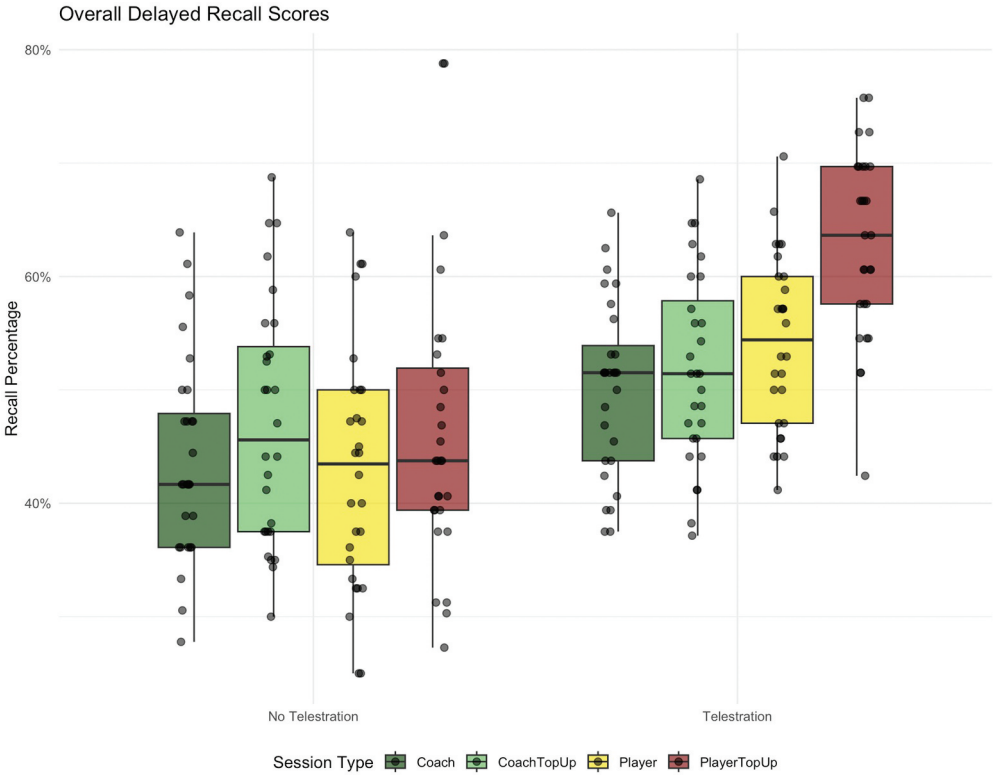

Figure 2. Recall performance between telestrated and non-telestrated video clips based on delivery format.

3.2. Influence of telestration, delivery format and number of sessions on overall recall performance

Figure 2 presents overall delayed-recall performance across the eight different intervention protocols, combining telestration use, delivery format, and the presence or absence of a top-up session. The highest delayed-recall scores were observed in the Player-Led Top-Up with Telestration condition (Median = 63.64%, IQR = 12.12%), whereas the lowest occurred in the Coach-Led without Telestration condition (Median = 41.67%, IQR = 11.81%). A statistically significant overall difference across protocols was observed ($\chi^2(7) = 65.76$, $p < .001$, $\varepsilon^2 = 0.176$), indicating a large effect within the sample and conditions studied. Post-hoc comparisons revealed several statistically significant differences, particularly between the Player-Led Top-Up with Telestration condition and all non-telestration conditions (e.g. vs Coach-Led without Telestration $Z = -6.29$, $p < 0.001$). Post-hoc comparisons were interpreted in conjunction with adjusted p-values to reduce the risk of Type 1 error arising from multiple comparisons. These observable findings indicate clear differences in delayed-recall performances across conditions, with telestration-based conditions yielding higher scores regardless of delivery format or the presence of a top-up session.

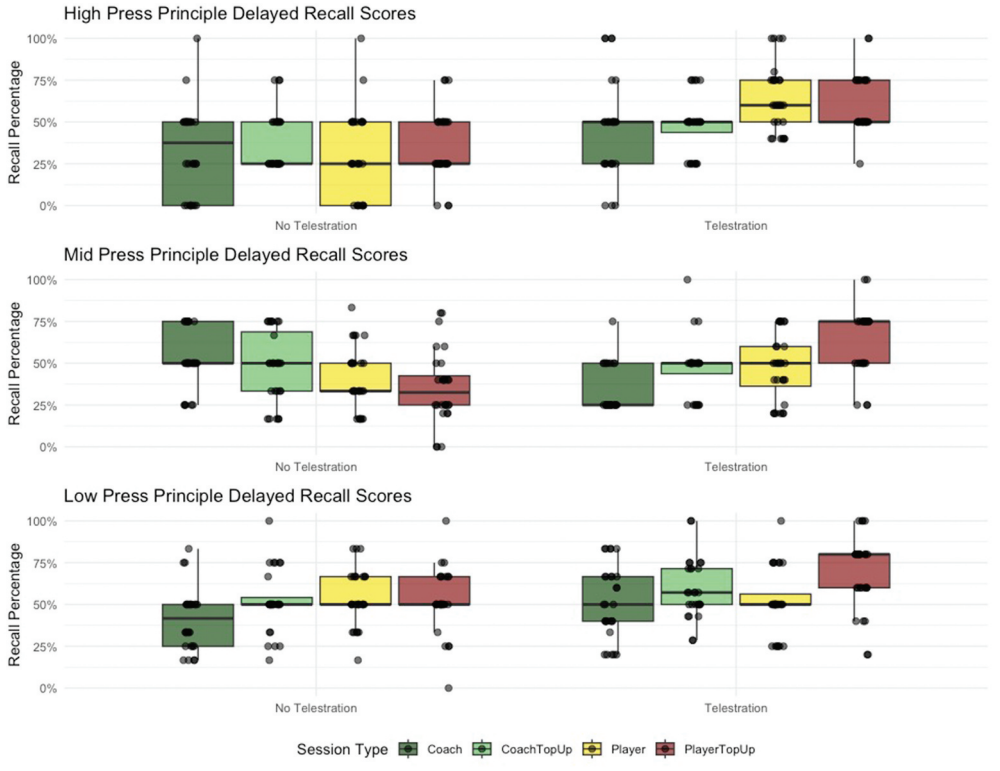

Figure 3. Recall performance for out-of-possession game principles (high press, mid press, low press) across telestrated and non-telestrated video clips, based on delivery format.

3.3. Recall performance aligned with academy game principles

Figures 3–5 present delayed recall across the academy's game principles under different delivery formats and telestration conditions. For the out-of-possession principles (high, mid, and low press), the Player-Led Top-Up with Telestration condition recorded the highest recall across all three game principles (High Press: Median = 50.00%, IQR = 25.00%; Mid Press: 75.00%, IQR = 25.00%; and Low Press: 80.00%, IQR = 20.00%) (see Figure 3). The Coach-Led without Telestration condition consistently showed the lowest recall scores, particularly in the High Press principle (Median = 37.50%, IQR = 50.00%). Intervention differences were statistically significant ($p < 0.001$) across all principles, with effect sizes indicating a large descriptive effect within this applied case study (High Press $\varepsilon^2 = 0.207$; Mid Press $\varepsilon^2 = 0.160$; and Low Press $\varepsilon^2 = 0.105$). Post-hoc comparisons indicated that Player-Led Top-Up with Telestration condition scored significantly higher than several non-telestrated conditions.

For in-possession principles (build, midfield and final third), the Player-Led Top-Up with Telestration condition showed the highest recall (Build: Median = 75.00%, IQR = 25.00%; Midfield: 50.00%, IQR = 31.25%; and Final Third: 75.00%, IQR = 25.00%) (see Figure 4). The Coach-Led without Telestration condition produced lower scores across all these principles, with medians between 41.67% to 50.00%. Differences across conditions were statistically significant for all principles ($p < 0.001$) with effect sizes ranging

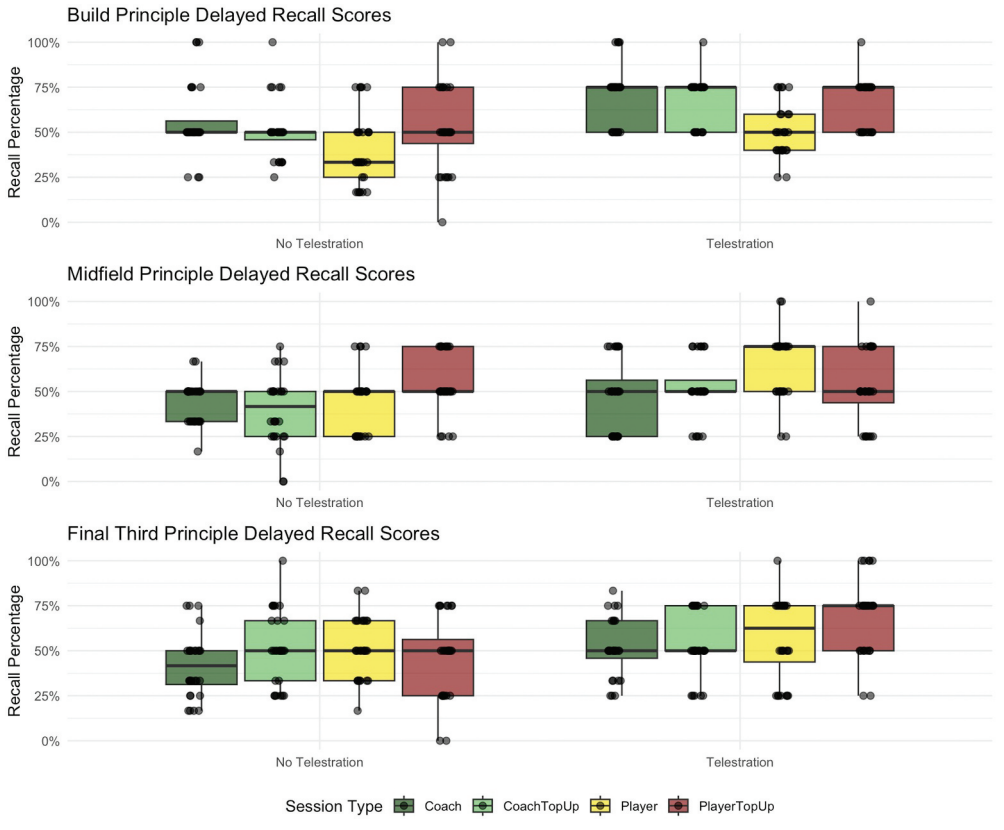

Figure 4. Recall performance for in-possession game principles (build, midfield, final third) across telestrated and non-telestrated video clips, based on delivery format.

from moderate to large within the sample and conditions studied (Build $\varepsilon^2 = 0.215$; Midfield $\varepsilon^2 = 0.102$; and Final Third $\varepsilon^2 = 0.101$). Post-hoc tests indicated higher delayed-recall scores for the Player-Led Top-Up with Telestration condition compared to several non-telestrated conditions, particularly in the build and final third principles.

For the attacking and defensive transition principles (see Figure 5), the highest delayed-recall scores were found in the Player-Led Top-Up with Telestration condition (Attacking Transition: Median = 75.00%, IQR = 50.00%; Defensive Transition: Median = 50.00%, IQR = 25.00%). The Coach-Led without Telestration produced lower scores (Attacking Transition: 50.00%, IQR = 25.00%; and Defensive Transition: 41.67%, IQR = 16.67%). Significant differences were observed across intervention conditions in both principles, with a large effect size for attacking transition ($\varepsilon^2 = 0.176$, $p < .001$) and a smaller but statistically significant effect for defensive transition ($\varepsilon^2 = 0.059$, $p = .006$) within this applied case. Post-hoc comparisons showed that the Player-Led Top-Up with Telestration condition produced significantly higher scores than several non-telestrated conditions.

Across all eight game principles, conditions that incorporated telestration, particularly with player-led delivery and a top-up session, produced higher delayed-recall scores than non-telestration principles. Moreover, the magnitude of recall differences appeared to

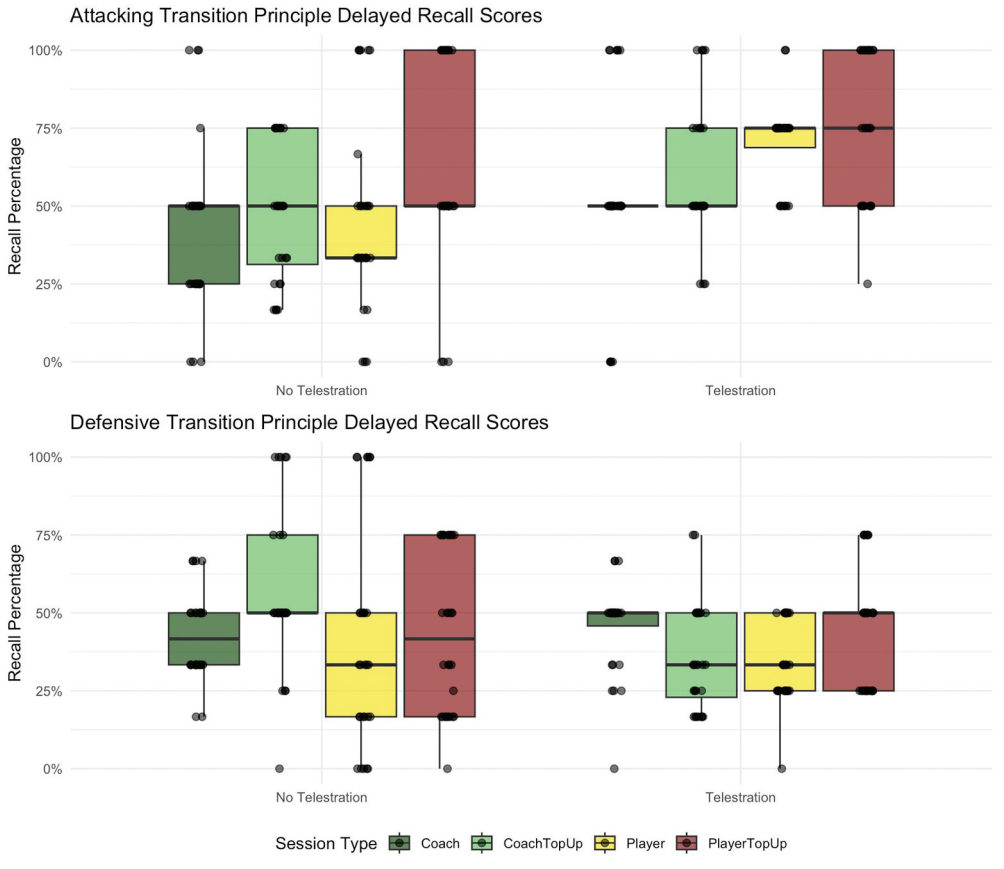

Figure 5. Recall performance for transition game principles across telestrated and non-telestrated video clips, based on delivery format.

align with the tactical structure of each game principle, with more predictable and rehearsed principles, such as build-up play and high pressing, producing higher delayed recall than reactive, less structured principles like defensive transitions.

3.4. Player post-intervention reflections

Participants expressed their views on telestration, particularly surrounding its role in enhancing tactical clarity. While all players valued non-telestrated clips as beneficial (100%), telestrated video clips were described as very beneficial by 57% of players and 43% as beneficial. Several players described specific aspects of telestration they found useful. For example, one goalkeeper commented that "the arrows showed direction of players and play", while a defensive player commented that "highlighting and the writing tool on the clips make it clear what's being said and what to understand about the opposition or our clips". Similarly, a forward found the "text on screen beneficial as I can remember it and take it on board". These comments illustrate the types of features players associate with clarity during video review.

Participants expressed varied views regarding the delivery format. While 43% prefer coach-led delivery, 43% reported no strong preference, and 14% preferred play-led delivery. Some players referenced familiarity or relatability when describing their preferences for player-led sessions, while others emphasised perceived expertise when describing their preference for coach-led delivery. For example, one player stated that player input "comes from your own voice and teammates", whereas another noted that "the coach has experience and puts more input, which means more to take from it". Additionally, 57% of players reported that they "very often" or "often" thought about the analysis content during the matches. These reflections suggest that while telestration was welcomed for its clarity, preferences for session delivery were more individualised and often linked to perceived credibility and personal connection with the session deliverer.

4. Discussion

This study examined whether video telestration was associated with higher delayed recall of session content in academy youth football players, and whether this association varied by delivery format (coach-led vs. player-led) and the inclusion of a brief, spaced "top-up" sessions. Across conditions, telestration was consistently associated with higher delayed recall scores, with the clearest differences appearing when telestration was combined with a short, spaced top-up revisit and player-led delivery. These patterns align with existing work showing that visually highlighted tactical cues can support the retention of complex performance information, including the recall advantage reported in senior football by Smith et al. (2022). Taken together, the present results show that the conditions differed in how well players retained session content and can therefore offer actionable guidance for feedback at the level of cognitive understanding, specifically around the use of visual signalling, brief spaced revisits, and delivery format.

4.1. Telestration and delayed recall

Although recall is not synonymous with on-pitch decision-making, memory accessibility is considered a prerequisite for recognising tactical patterns under pressure (Habekost et al., 2024). Research in team sports shows that players' ability to access task-relevant information supports perceptual attunement, anticipation, and coordinated action (Ashford et al., 2021; Voigt & Raab, 2024). Recall was therefore used here as a proxy for the stability of tactical knowledge, recognising that knowledge alone does not determine performance. Within this framing, the observed recall differences offer a useful lens for interpreting how specific design features shaped players' cognitive processing. The consistent advantage for telestration aligns with Cognitive Load Theory (Sweller, 2020), which proposes that reduced extraneous cognitive demands enable more efficient encoding of task-relevant information. When engaging with video footage, players must often integrate numerous spatial and temporal cues from unannotated clips, increasing visual-search demands and working-memory load. Telestration mitigates this by providing explicit signalling cues, such as arrows, highlights, and concise labels, that direct attention to key tactical elements and segment complex situations into cognitively manageable units. This interpretation is also consistent with multimedia learning and signalling principles (Mayer, 2024), which emphasise

that cued displays enhance the organisation of information in working memory and strengthen subsequent retrieval. Additionally, telestration may have supported recall by visually pairing dynamic visual cues with concurrent verbal explanation (Paivio, 2007), strengthening integrated verbal-visual representation of tactical situations.

These cognitive mechanisms mirror findings in elite football, where telestration significantly improved delayed recall of sessions (Smith et al., 2022), and align with evidence from healthcare education showing that annotated video enhances instructional clarity and task performance (Laborde et al., 2017; Neves Lopes et al., 2022). Collectively, this supports the interpretation of telestration as an instructional aid, designed to optimise encoding and increase the likelihood that explicitly tactical messages are later retrievable. Its function is not to promote exploratory learning or conceptual learning, but to make key tactical cues more explicit and stabilise the information players are intended to retain. Given this role, telestration strengthens the clarity and accessibility of coaches' material, making it more likely that players can retrieve key content and access shared tactical concepts. Importantly, while improved recall reflects more accessible and stable tactical knowledge, it does not guarantee coordinated action, decision-making under pressure, or shared cognitive understanding, which were not assessed in this study.

4.2. Spaced review and retrieval as a design principle

The recall benefits observed in the spaced "top-up" conditions are consistent with well-established retrieval practice and spacing effects. Research demonstrates that retrieval after a delay strengthens memory traces and slows the rate of forgetting (Carpenter et al., 2022), while Ebbinghaus (1880) forgetting curve, and later replicated by Murre and Dros (2015), shows that a 24–72-hour interval typically allows sufficient partial decay to make retravel more effortful, and therefore more effective. In this study, the timing of the top-up session (approximately 48 hours after initial delivery) likely capitalised on this window, enhancing the durability of recall.

Importantly, retrieval practice should not be understood as a theory of learning (Carpenter et al., 2022). The effect does not offer an overarching explanation of how learning occurs, nor does it offer a philosophy for structuring player development or coaching. Instead, it is a robust empirical effect. When information is recalled, the act of retrieval reliably strengthens later memory. Within this study, spaced retrieval should therefore be understood as a design principle. A way of structuring information delivery so that key tactical content is more likely to be remembered. This clarification is relevant in applied football environments. For example, pre-match meetings are typically information-dense, delivered once, and rarely revisited, meaning players receive little opportunity to retrieve and consolidate critical messages. Evidence from elite environments shows that such "one-off" meetings lead to limited retention (Travis & Butterworth, 2024), reinforcing the importance of intentionally structured opportunities for players to revisit key messages.

The effectiveness of the top-up session highlights how two complementary cognitive processes operate in combination. Telestration, therefore support the initial encoding of key tactical information, while the spaced revisit strengthens consolidation through effortful retrieval (Carpenter et al., 2022; Ebbinghaus, 1880; Murre & Dros, 2015). This complementary interplay between encoding and consolidation provides an acceptable

mechanism for improving the durability of recall in academy performance environments and highlights how relatively small adjustments to feedback design could yield meaningful cognitive benefits.

4.3. Delivery format and engagement with content

Player-led delivery was associated with higher recall, particularly when combined with telestration and "top-up" sessions. This effect is best interpreted as a function of increased cognitive engagement, with active participation prompting players to generate semantic meaning from the material, thereby enhancing the quality of encoding and supporting later retrieval, rather than as evidence for autonomy-driven or constructivist learning processes. In the player-led condition, players analysed the game footage, sometimes directed the analyst on what to telestrated, or telestrated the video themselves, and then delivered the tactical messages back to the group, while the coach and analyst posed probing questions during the delivery. This sequence demands the players to select, organise, and verbalise information, forms of generative processing known to support deeper encoding and stronger later retrieval (Mayer, 2024). Football-specific research similarly shows that guided questioning and brief player explanations during video work increase engagement with session content (Middlemas & Harwood, 2015, 2017, 2020).

The mechanisms underpinning this effect are unlikely to be singular. Higher recall in player-led conditions may reflect increased cognitive effort through generative processing, heightened attentional engagement due to peer delivery, or social learning processes whereby players attend more closely to explanations offered by teammates (De Martin Silva & Francis, 2021). These mechanisms are not mutually exclusive and may interact differently depending on player maturity, group dynamics, and task familiarity. As such, the present study cannot isolate the causal contribution of engagement, generative processing, or social factors, but demonstrates that delivery format meaningfully shaped how players process and retain tactical information (Lewis et al., 2026).

This pattern of higher recall in player-led conditions, despite mixed preferences for delivery format, also reflects a common applied observation. Players often express a preference for coach-led sessions for their perceived efficiency and authority, yet such meetings typically allow limited opportunities for active processing and are associated with poorer retrieval (Pearson et al., 2023; Wright et al., 2016). Our findings mirror this tension, with 43% of players reporting a preference for coach-led delivery; their recall was higher in player-led conditions, and their reflections highlighted the value of engaging directly with the material. These observations align with evidence that coach-led formats can position players as relatively passive recipients (Wright et al., 2016), whereas opportunities to explain or justify tactical points support deeper engagement (De Martin Silva & Francis, 2021; Middlemas & Harwood, 2017). Furthermore, elite football players report preferring to receive key content with time to process it, rather than in compressed, single-exposure formats (Travis & Butterworth, 2024). In practice, retention gains do not require a new coaching philosophy. Simple additions, such as brief player explanations, targeted prompts, clear telestration and quick spaced top-ups, are enough to create the mental effort that strengthens memory.

4.4. Variation across game principles

Recall differed across game principles, with structured and rehearsed phases, such as build-up player and pressing, showing higher retention than reactive phases like defensive transitions. This pattern is consistent with the broader cognitive mechanisms discussed earlier. When a phase of play has a stable, recognisable structure, players can form stronger cognitive schemas, which support efficient encoding, reduce working-memory demands, and make later retrieval more reliable (Roca et al., 2020; Williams et al., 2012). These schemas also make players more responsive to visual signalling, meaning that telestration is more effective when learners can attach new cues to existing knowledge structures (Kalyuga & Renkl, 2009; Mezghanni et al., 2022).

These patterns align with wider evidence on how players process tactical information. As recent cognitive models highlight, elite players rely on stable perceptual-cognitive structures when interpreting tactical situations, drawing on stored representations and pattern-based regularities to guide situational assessment (Habekost et al., 2024). Consistent with this, football-specific research shows that the coordinated visual-verbal cues are most effective when the underlying tactical structure is stable and recognisable (Mezghanni et al., 2022). In contrast, reactive phases involve greater temporal variability and less predictable cue–action relationships, giving players fewer consistent features to organise and encode. When tactical situations change rapidly and lack repeatable patterns, it becomes harder for players to build or activate schemas that support recall. This inherent variability likely contributed to the lower recall observed in these principles and highlights the need for careful content-specific feedback design to support players' understanding of tactical situations, particularly in less structured phases of play.

Comparisons with existing telestration and video feedback research also require consideration of context (Groom et al., 2011; Lewis et al., 2026; O'Brien et al., 2024). Research on dynamic football visualisations indicated that learners' level of expertise influences the effectiveness of visual guidance, with less-experienced players typically benefiting from visual guidance that helps organise tactical information, whereas expert players rely more heavily on internalised representations (Khacharem et al., 2013). Similarly, coordinated visual-verbal cueing has been shown to enhance tactical learning in football when learners are supported in structuring complex spatiotemporal information (Mezghanni et al., 2022). In the present study, player-led telestration sessions may have provided organisational support through active explanation, selection, and verbalisation of key cues, encouraging learners to construct and stabilise their own tactical representations rather than receiving pre-segmented instructions. Youth players may therefore benefit not only from explicit visual cues, but also from opportunities to actively organise and articulate tactical information. However, applied delivery introduces variability in session timing, player engagement, and exposure (O'Brien et al., 2024) that would typically be controlled in experimental design. Collectively, these contextual differences suggest that the present findings are best interpreted as ecologically grounded rather than directly comparable in magnitude to effects observed in elite or laboratory environments.

5. Limitations and future directions

While these findings offer valuable applied insights into how telestration can support retention of tactical information, they should be interpreted within the constraints of the study design and setting. The research was conducted within a single male youth academy and involved a small sample ($n = 14$) from one team, prioritising ecological validity over statistical generalisability. As such, the observed patterns should be understood as context-specific rather than a representation of youth football more broadly. Replication across different clubs, competition levels, and organisational structures would strengthen confidence in the transferability of these findings. In particular, the exclusive focus on male academy players limits applicability to the broader football population, particularly given evidence that women's football pathways differ in structure, context and engagement with PA (Harkness-Armstrong et al., 2025).

The intervention followed a fixed, non-randomised sequence aligned with routine academy practice. Although the design preserved authenticity, it introduces the potential for order effects, maturation, and cumulative learning across the 16-week period. Improvements in recall may therefore partly reflect increased familiarity with the academy's tactical principles, video preview processes, or seasonal development rather than the isolated effects of telestration or delivery format. Future studies employing counterbalanced or randomised designs would help disentangle these limitations, albeit with inevitable trade-offs in ecological validity.

The first author was the embedded academy APA for the team during the intervention period. While this facilitated access, consistency of delivery, and ecological validity, it may also introduce potential bias related to the researcher's positionality. Players' familiarity with the APA and the existing professional relationship may have influenced engagement during sessions or responses to recall and the overall perception survey. To mitigate this risk, recall surveys were finalised in advance, scoring procedures were standardised, and responses were anonymised. In addition, inter-rater reliability checks and independent scoring checks were undertaken by researchers and practitioners not involved in session delivery. Nevertheless, the potential influence of dual-role involvement cannot be entirely eliminated and should be considered when interpreting the findings. Future research may benefit from separating intervention delivery and data collection roles or incorporating externally delivered sessions to further reduce positional influence.

Recall was assessed at a single delayed time point, 6-days post initial session, reflecting practical constraints imposed by training and match schedules. While this interval aligns with applied practice, it offers a limited view of longer-term retention dynamics. Future research incorporating multiple recall assessments over extended periods could provide a more detailed understanding of forgetting, consolidation, and the role of spaced revisiting in applied football environments.

Although delayed recall provided a useful indicator of cognitive accessibility and stability of tactical knowledge, it does not capture how that knowledge translates into on-pitch decision-making, movement coordination, or tactical execution. The present findings, therefore, relate to cognitive availability rather than behavioural performance. Future research could integrate match analysis, positional data, or expert coach

evaluations to assess whether telestration-enhanced recall is associated with observable performance behaviours.

The telestration format used in this study was deliberately standardised to maintain consistency across sessions. However, visual cuing practices vary widely in applied settings. Exploring variations in annotation style (e.g. use of text, arrows, player tracking or layered visuals) and differing levels of cue density may help determine how visual design interacts with player expertise, cognitive load, or task demands. Similarly, the positive effects observed in player-led delivery require further investigation. Their underlying mechanisms, whether stemming from cognitive demands of explanation, the social dynamics of peer delivery, or perceived presenter relatability, remain uncertain. These mechanisms could not be isolated within the research design but present an important direction for future research aimed at refining delivery strategies in team-based analysis contexts.

More broadly, future work should consider how telestration interacts with other pedagogical tools, such as tactical decision games or scenario-based learning, or virtual reality, to support holistic development and adaptive expertise in football. Rather than identifying universally optimal methods, such work should aim to develop context-sensitive principles that account for learner characteristics, delivery format, and organisational constraints.

6. Practical implications for video-based telestration feedback design

The findings offer several applied design considerations for coaches and APAs working in youth football academies. First, when video is used to support learning, selective visual telestration cues can help direct attention to key tactical information and reduce unnecessary visual search. Second, incorporating brief opportunities for player explanation, rather than relying solely on coach-led delivery, may enhance engagement and help players organise and interpret information. Third, short, spaced revisits of key clips can be implemented within existing schedules to support retention without increasing overall meeting duration. Collectively, these adjustments to routine video telestration workflows are intended to support recall or tactical content rather than to replace existing coaching practices.

7. Conclusion

This study provides the first empirical examination of video telestration on delayed recall in male youth football. Within this applied context, telestration, particularly when combined with player-led delivery and spaced retrieval, was associated with more accessible encoding of tactical information and higher delayed-recall scores. These findings extend current understanding of SPA practice by demonstrating how simple, cognitively informed design features can shape the effectiveness of video-based feedback at a cognitive level. While the findings are necessarily shaped by the specific academy context, they highlight the potential value of integrating deliberate visual cueing, structured opportunities for player explanation, and brief spaced retrieval within routine SPA workflows. More broadly, the study reinforces the need for context-sensitive

investigation into how feedback design supports tactical learning across different football environments and playing populations.

Notes

1. Delayed recall is the retrieval of tactical information several days after the initial video session, reflecting longer-term retention rather than immediate memory.
2. The avoidable cognitive effort imposed by information that is unclear, cluttered, or irrelevant to the learning goal.
3. Pre-match analysis sessions – video-based feedback sessions delivered to players in the days preceding competition, focusing on team tactical principles and opposition scenarios relevant to the upcoming match, while also supporting longer-term development tactical understanding and player development.

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Author contributions

CRediT: **Callum Simmons:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing; **George Buckley:** Conceptualization, Formal analysis, Investigation, Methodology, Resources, Software, Supervision, Visualization, Writing – review & editing; **John William Francis:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

Survey data accessible from FigShare: doi.org/10.6084/m9.figshare.30157633.

Consent to participate and publication

Permission for the use of anonymised player data was granted by the academy gatekeeper, and parental/guardian consent for the use of anonymised performance analysis data in research is obtained as part of the club's registration process. No additional data collection or participant recruitment occurred, and all information used in this study was generated through routine academy performance analysis activities.

Ethical considerations

Institutional ethical approval was obtained from the University of Worcester.

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