

Article

Temporal Patterns of Advanced Shot-Quality Metrics in Elite Men's and Women's European Football

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Abstract

The temporal dynamics of shot quality in elite football remain poorly understood, despite well-documented declines in physical and technical performance during matches. This study aimed to analyze the evolution of advanced shot metrics across match halves and 15 min intervals in elite men's and women's international competitions. A total of 4074 shots from the UEFA European Championships were examined. To ensure methodological consistency among the three advanced shooting metrics (expected goals, xG; expected shot impact timing, xSIT; and expected goals on target, xGOT), analyses were restricted to shots on target (men: 775; women: 554), as xGOT can only be calculated for on-target attempts. Shot quality was assessed using xG, xSIT and xGOT. Differences between halves were evaluated using the Mann–Whitney U test, while temporal trends were analyzed through linear mixed-effects models. Results showed no significant differences between halves in shot distribution or quality metrics in either competition (all $p > 0.05$). Likewise, no significant temporal variations were found across the six match intervals for any metric. Women's football exhibited a largely stable quality of shots on target throughout the match. In men's competitions, although a significant difference in xG was observed ($p = 0.04$, effect sizes were trivial ($d = -0.17$), and no consistent patterns emerged in xSIT or xGOT. No sex-related differences were observed. Overall, shot quality remained stable despite match progression, suggesting that changes in goal frequency are not driven by variations in the intrinsic quality of shooting opportunities. Therefore, these findings suggest that optimizing the contextual conditions that facilitate the creation of shooting opportunities may be as important as, or more important than, focusing solely on shooting execution.

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1. Introduction

In this study, we addressed this by systematically analyzing the temporal evolution of advanced shot metrics (expected goals, xG; expected shot impact timing, xSIT; and expected goals on target, xGOT) across match halves and 15 min intervals in elite international football. Specifically, we examined whether shot quality varies across match progression and whether these temporal patterns differ between men's and women's UEFA European Championship tournaments. By integrating multiple advanced performance indicators within a fine-grained temporal framework, this study extends current knowledge by

moving beyond goal frequency and shot volume to focus on the quality of attacking opportunities across time and competitive contexts.

The analysis of goal-scoring opportunities has become a central focus in contemporary football performance research, largely driven by the growing availability of both event-based and tracking data. In this context, advanced metrics such as xG [1,2], xSIT [3], and xGOT [4–6] have been widely adopted to quantify the quality of shooting actions beyond traditional outcome-based indicators. These models provide a probabilistic framework to assess scoring likelihood and offer deeper insights into attacking performance and decision-making processes in elite competition [7–9]. Among these approaches, the xG model has become the most widely used metric in football analysis for estimating the probability of a shot resulting in a goal based on contextual pre-shot variables, primarily focusing on the evaluation of shot quality [1,2,10]. More recently, complementary indicators such as xSIT and xGOT have been developed to provide a more comprehensive assessment of shooting effectiveness through the incorporation of contextual post-shot information. Unlike xG, which is based exclusively on pre-shot characteristics, these metrics also consider what happens after the ball is struck. Specifically, xSIT is mainly oriented toward the evaluation of the shooter's performance, as it reflects the ability to direct the shot towards dangerous areas of the goal [3]. In contrast, xGOT focuses on the quality of shots on target after execution and is primarily used to assess goalkeeper (GK) performance by quantifying the likelihood that a shot on target results in a goal based on its initial placement [4–6]. Together, xSIT and xGOT provide additional insights into shooting execution and goalkeeping effectiveness that cannot be captured by traditional xG models alone.

Soccer is a team sport characterized by prolonged, high-intensity intermittent activity, in which both physical and technical performance may decline as the match progresses. Previous research has consistently shown that total distance covered and high-intensity running decrease in the second half, with reductions of 20–40% observed in the final 15 min compared with the initial phases of play [11]. Accordingly, both single and repeated sprint performance are impaired towards the end of matches [12,13], and fatigue has also been associated with reductions in technical performance, such as passing accuracy [14].

In parallel, early observational studies suggested that goal-scoring frequency tends to increase as matches progress, with the highest scoring rates occurring in the final stages of play [15]. This apparent paradox, declining physical and technical performance alongside increasing goal frequency, raises important questions regarding the underlying mechanisms of goal scoring. From a conceptual perspective, this phenomenon can be interpreted through the interaction between opportunity quantity and opportunity quality. Specifically, fatigue may alter the tactical structure of teams by increasing spatial dispersion, reducing compactness, and accelerating transitions, thereby affecting both the frequency and the probabilistic characteristics of attacking sequences.

Within this framework, a plausible explanation is that fatigue-induced defensive disorganization increases the quantity of goal-scoring opportunities through more frequent transitions and breakdowns in defensive organization [12–14]. However, contextual match-state effects (e.g., score-line pressure, game tempo, and risk-taking behaviors) may simultaneously modulate the quality of these opportunities by influencing defensive spacing, pressing intensity, and transition control. From a theoretical perspective, accumulated fatigue may affect tactical organization, which in turn alters the spatial and temporal constraints of attacking actions and ultimately influences probabilistic shot metrics such as xG-based indicators.

Despite the growing body of literature on physical and technical match dynamics, limited attention has been paid to the temporal evolution of shot quality per se. Specifically, whether the observed increase in goal-scoring frequency is driven by a greater number of

opportunities or by improvements in their quality. Moreover, although women's football has undergone substantial professionalization and increased scientific attention in recent years [16,17], research integrating advanced performance metrics in elite female competitions is still limited, particularly in direct comparison with men's tournaments [18,19].

Therefore, the aim of this study was to examine the temporal evolution of shot metrics (xG, xSIT, and xGOT) across match halves and 15 min intervals in elite international football, including both men's and women's UEFA European Championship tournaments. Based on the existing evidence, we hypothesized that, despite documented declines in physical performance and increases in goal-scoring frequency, shot quality would remain relatively stable throughout the match. Furthermore, we hypothesized that only trivial differences would emerge between men's and women's competitions in the temporal behavior of these metrics.

The novelty of this study lies in the integration of (i) multiple advanced shot metrics, (ii) a fine-grained temporal analysis across match intervals, and (iii) a direct comparison between elite men's and women's international tournaments. This approach offers new insights into whether match progression meaningfully influences the quality of attacking opportunities, thereby challenging the assumption that elevated goal-scoring rates in the later stages of matches are necessarily explained by improvements in the quality of scoring opportunities.

In this way, this paper was structured as follows. Section 2 describes the data collection process, performance metrics, and statistical procedures used to analyze the temporal evolution of shot quality. Section 3 presents the descriptive and inferential findings regarding differences across match halves, 15 min intervals, and between men's and women's competitions. Finally, Section 4 interprets the main findings in relation to existing literature, highlighting practical implications for performance analysis and coaching in elite football, as well as outlining potential limitations and directions for future research.

2. Materials and Methods

2.1. Data Collection

The sample for the present study comprised all national teams participating in the UEFA Women's Euro 2022, UEFA Women's Euro 2025, UEFA Men's Euro 2020, and UEFA Men's Euro 2024 tournaments. These competitions were selected as they represent elite-level international football contexts, characterized by high tactical standardization, comparable competitive environments, and the availability of detailed event-based performance data. Data were collected from 16 women's national teams per edition and 24 men's national teams per edition, including all matches from the group stage through to the final. Matches from the qualifying stages and penalty shootouts were excluded from the analysis. Shots occurring during extra time were also excluded because this period involves only a subset of matches and may be influenced by additional fatigue and context-specific tactical behaviors. Consequently, all analyses were restricted to the two regular halves of normal time. Stoppage time was retained within its corresponding half, with shots occurring beyond the 45th and 90th minutes assigned to the final 15 min interval of each half (30–45 and 75–90 min, respectively), in accordance with the interval methodology described by [20]. Match-state variables (e.g., scoreline dynamics) were not modeled explicitly; instead, contextual variability between matches was partially accounted for through the inclusion of a match-level random intercept in the mixed-effects models. This modeling strategy provided a broad representation of both sexes and facilitated robust comparisons across tournaments and competition cycles.

The study analyzed all shot events recorded across both sexes and all four tournaments. Shots on target, defined as attempts resulting in either a goal or a save by the goalkeeper

(GK), were selected as the primary unit of analysis. This approach included both goal-scoring and non-scoring shots on target, providing a comprehensive assessment of attacking performance regardless of the outcome. Shots off target (blocked, missed, or hitting the goal frame) were included in the descriptive counts but excluded from the analysis of quality metrics (xG, xSIT, xGOT). This decision was made because xGOT can only be calculated for on-target attempts, as it requires post-shot information related to GK performance and shot outcome. Restricting the dataset to shots on target ensured that all metrics were calculated from the same sample of events, allowing direct comparisons across indicators. In total, 652 shots on target were recorded in the women's tournaments (374 in 2022 and 278 in 2025) and 775 in the men's tournaments (370 in 2020 and 405 in 2024).

Team-level datasets were obtained from the open-access repository StatsBomb Open Data (<https://github.com/statsbomb/open-data>) (accessed on 5 March 2026). All event coding, including shot identification and classification, was performed by trained StatsBomb analysts following standardized internal protocols. The authors did not participate in the data collection or coding process, and the dataset was used in its validated and pre-processed form. StatsBomb event data has been widely adopted in peer-reviewed football research, supporting its validity and reliability for football performance analysis [21,22].

2.2. Design and Ethics Committee

The present study employed a retrospective observational design to examine performance data from the UEFA European Football Championships, encompassing both women's and men's tournaments (2022 and 2025 for women and 2020 and 2024 for men). In addition, comparative analysis was performed across tournaments and between sexes, with the data stratified according to competition type and sex. This approach enabled comparisons of performance variables within and between tournament editions while maintaining a consistent analytical framework across all competitions.

No personally identifiable information was collected or processed. The study protocol received approval from the corresponding local institutional ethics committee.

The authors used ChatGPT (GPT-5-5, OpenAI, San Francisco, CA, USA) to assist with language refinement and figure generation. All scientific content, interpretation, and conclusions were developed by the authors.

2.3. Variables

The following performance metrics were analyzed across both competitions: xG, xSIT, and xGOT.

Expected Goals (xG) is a probabilistic metric designed to estimate the likelihood of a shot resulting in a goal based on the contextual characteristics of the attempt prior to ball contact. Traditional xG models incorporate variables such as shooting distance, shooting angle, body part used, type of assist, defensive pressure, and game situation. xG assigns each shot a value between 0 and 1, where values closer to 1 indicate a higher likelihood of scoring. Consequently, xG provides an objective assessment of chance quality and attacking efficiency, allowing analysts and researchers to evaluate offensive performance independently from the final outcome of the action [1,2].

Expected Shot Impact Timing (xSIT) represents the anticipated quality and effectiveness of a shooting opportunity by integrating both spatial and temporal information associated with the attacking sequence. Unlike traditional xG approaches, xSIT considers the dynamic interactions between the shooter, the goalkeeper, and surrounding outfield players, while also accounting for contextual variables such as ball velocity, player movement trajectories and reaction time constraints. By incorporating the temporal evolution of the action prior to the shot, xSIT provides additional insight into decision-making speed,

transition efficiency, and the degree of defensive organization at the moment of the attempt. Similarly to xG, xSIT is expressed on a scale from 0 and 1, with higher values representing situations with greater expected offensive effectiveness [3,18].

Expected goals on target (xGOT) reflects the probability of a shot resulting in a goal once the attempt is directed on target. In contrast to conventional xG models that only evaluate the quality of the opportunity before the shot is taken, xGOT incorporates post-shot characteristics such as shot placement, trajectory, speed, height, and the relative positioning of the GK at the moment of the strike. As a result, xGOT offers further insight into finishing quality and GK performance by quantifying the actual difficulty involved in saving the shot. Like xG and xSIT, xGOT is represented on a scale ranging from 0 to 1, where values approaching 1 indicate a greater probability of the shot ending in a goal after accounting for post-shot execution [4–6].

2.4. Statistical Analysis

Statistical analyses were performed using Python 3.12.3. Linear mixed-effects models were fitted using the MixedLM procedure from the statsmodels library (version 0.14.6), while non-parametric tests and the Kolmogorov–Smirnov test were conducted using scipy.stats (SciPy version 1.17.1). Data management and descriptive statistics were performed using pandas (version 3.0.2) and NumPy (version 2.4.4). Data normality was assessed using the Kolmogorov–Smirnov test, which revealed significant departures from normality for all variables (all $p < 0.05$). Consequently, non-parametric methods were employed for all between-group comparisons, and no assumption of homogeneity of variances was required. The total number of shots, shots on target (including goals and non-goals), and shots off target were recorded for both men’s and women’s matches. Descriptive statistics were subsequently calculated for xG, xSIT and xGOT, and were presented as mean $\pm$ standard deviation (SD) for both men’s and women’s competitions.

First, comparisons between the first and second halves were conducted to examine potential temporal differences in shooting performance throughout the match. The Mann–Whitney U test was applied, as it compares the rank distributions of two independent samples without assuming normality and is therefore robust to the skewed, non-normal distributions observed in the present data. Three comparisons were conducted per sex, one for each metric; no correction for multiple comparisons was applied to this set, as the three metrics represented distinct, pre-specified, and non-redundant hypotheses rather than an exploratory search. Moreover, applying family-wise error corrections to a small number of planned comparisons is often considered overly conservative and may inflate Type II error rates; nonetheless, the absence of correction implies that the reported p -values should be interpreted with appropriate caution. Effect sizes were calculated using Cohen’s d (standardized mean difference with pooled standard deviation), with 95% confidence intervals. Although Cohen’s d is formally a parametric index, its use alongside non-parametric tests is well established in sports science [23]; to provide a measure directly aligned with the Mann–Whitney test, the rank-biserial correlation was also computed. Cohen’s d was interpreted as trivial ($d < 0.20$), small ($0.20 \leq d < 0.50$), medium ($0.50 \leq d < 0.80$), and large ($d \geq 0.80$) according to Cohen’s conventions [24].

To investigate changes in xG, xSIT, and xGOT across the six predefined 15 min match intervals (0–15, 15–30, 30–45, 45–60, 60–75 and 75–90), linear mixed-effects models (LMMs) were employed. LMMs are particularly suitable for hierarchical or clustered data structures, where multiple observations are nested within the same match and therefore cannot be considered statistically independent. By including match as a random intercept, the model accounts for between-match variability and the intra-match correlation among shots, leading to more accurate parameter estimates and inference. Furthermore, mixed-effects

models offer greater flexibility than traditional repeated-measures approaches, particularly when dealing with unbalanced data and unequal numbers of observations across groups. For each metric and sex, the model was specified with the 15 min interval as a categorical fixed effect (six levels, with the 0–15 min interval as the reference category) and a random intercept for match, of the form $y(ij) = \beta_0 + \sum \beta(k) \cdot \text{Interval}(kij) + u(j) + \varepsilon(ij)$, where $u(j) \sim N(0, \sigma^2_u)$ represents the match-specific random intercept and $\varepsilon(ij) \sim N(0, \sigma^2_\varepsilon)$ denotes the residual error. A random-intercept (rather than random-slope) structure was selected because the limited number of shots per interval within individual matches would have rendered random-slope estimates unstable.

Model parameters were estimated using Restricted Maximum Likelihood (REML), and the omnibus effect of interval was assessed using a Wald chi-square test on the joint set of interval coefficients. The proportion of variance attributable to between-match differences was quantified using the intraclass correlation coefficient (ICC), with 95% confidence intervals obtained via cluster bootstrap (300 match-level resamples). Model assumptions were evaluated using quantile–quantile plots (for residual normality) and residuals-versus-fitted plots (for homoscedasticity). Minor deviations were observed; however, mixed-effects models are generally robust to such departures at the present sample size ($n = 1329$ shots on target).

Post hoc pairwise comparisons were performed using Tukey's Honest Significant Difference (HSD) adjustment to control the family-wise error rate associated with multiple comparisons. Statistical significance was established at $p < 0.05$, and effect sizes were reported to facilitate the interpretation of the practical significance of the findings beyond p -values alone.

3. Results

The results were presented in line with the aims and hypotheses of the present study, which focused on examining the temporal evolution of shot metrics (xG, xSIT, and xGOT) across match halves and 15 min intervals in elite international football, as well as comparing these patterns between men's and women's UEFA European Championship competitions.

Figure 1 presents the classification of shots across men's and women's competitions, including their distribution between halves. In the women's category, a total of 1669 shots were recorded, with 767 occurring in the first half and 902 in the second half. Of these, 554 were shots on target, comprising 174 goals (79 in the first half and 95 in the second half) and 380 non-goal shots on target (169 and 211, respectively). Additionally, 1115 shots were off target, with 519 in the first half and 596 in the second half. In the men's category, a total of 2405 shots were analyzed, with 1094 in the first half and 1311 in the second half. Among these, 775 were shots on target, including 211 goals (82 in the first half and 129 in the second half) and 564 non-goal shots on target (262 and 302, respectively). The remaining 1630 shots were off target, distributed as 750 in the first half and 880 in the second half. Statistical analysis indicated that the distribution of shot types did not differ significantly between halves in either the women's or men's competitions ($p > 0.05$).

Table 1 and Figure 2 present a comparison of advanced shot metrics (xG, xSIT, xGOT) between the first and second halves of matches, considering only shots on target for both categories. In the women's competitions, no significant differences were observed between halves for any of the analyzed metrics. Specifically, xG remained stable (first half: 0.14 ± 0.17 ; second half: 0.14 ± 0.15 ; $p = 0.79$), as did xSIT (0.24 ± 0.22 vs. 0.25 ± 0.24 ; $p = 0.46$) and xGOT (0.42 ± 0.29 vs. 0.44 ± 0.30 ; $p = 0.64$). In contrast, the men's competitions showed a small but statistically significant increase in xG from the first to the second half (0.12 ± 0.14 vs. 0.15 ± 0.18 ; $p = 0.04$, $d = -0.17$), although the magnitude of the effect

remained small. No significant differences were found for xSIT (0.31 ± 0.25 vs. 0.31 ± 0.26 ; $p = 0.88$) or xGOT (0.39 ± 0.28 vs. 0.41 ± 0.29 ; $p = 0.19$).

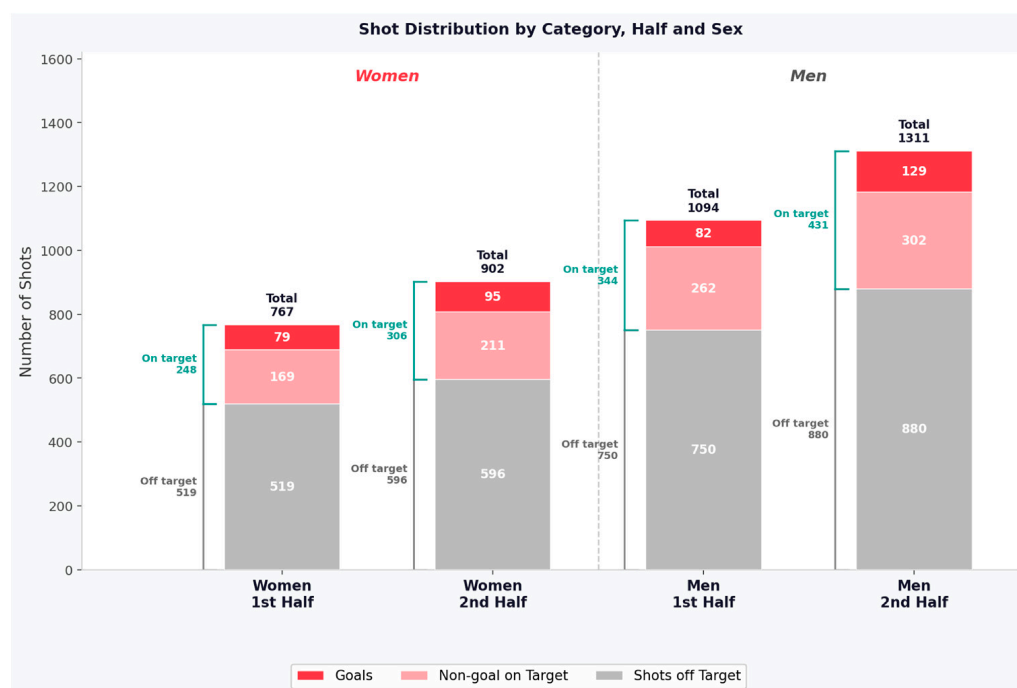


Figure 1. Distribution of total shots, shots on target (goals and non-goals), and shots off target across first and second halves in men’s and women’s competitions. Values were presented as absolute frequencies. (The figure was generated using AI-assisted software (ChatGPT (GPT-5-5, OpenAI, San Francisco, CA, USA) and reviewed by the authors).

Table 1. Comparison of advanced shot metrics (xG, xSIT, xGOT) between the first and second halves for shots on target. Values are presented as mean $\pm$ SD. Mann–Whitney U test p -values, Cohen’s d with 95% confidence intervals, and rank-biserial correlation (r_{rb}) are reported. * $p < 0.05$.

Metric	Sex	1st Half	2nd Half	Value	Cohen’s d	95% CI (d)	r_{rb}
xG	Women	0.14 ± 0.17	0.14 ± 0.15	0.79	-	$[-0.14, 0.20]$	0.013
	Men	0.12 ± 0.14	0.15 ± 0.18	0.04 *	-0.17	$[-0.32, -0.03]$	0.085
xSIT	Women	0.25 ± 0.22	0.25 ± 0.24	0.46	-	$[-0.18, 0.16]$	-0.036
	Men	0.31 ± 0.25	0.31 ± 0.26	0.88	-	$[-0.17, 0.12]$	0.006
xGOT	Women	0.42 ± 0.29	0.44 ± 0.30	0.64	-	$[-0.23, 0.10]$	0.023
	Men	0.39 ± 0.28	0.41 ± 0.29	0.19	-	$[-0.23, 0.05]$	0.055

Abbreviations: xG, expected goals; xSIT, expected shot impact timing; xGOT, expected goals on target; d, Cohen’s d effect sizes.

Table 2 presents the mean values of advanced shot metrics (xG, xSIT, xGOT) across six 15 min match intervals (0–15, 15–30, 30–45, 45–60, 60–75, and 75–90 min), considering exclusively shots on target. No significant differences were observed in the temporal evolution of xG, xSIT, or xGOT across the six match intervals in either competition, nor between sexes (all $p > 0.05$). The corresponding omnibus test statistics (Wald χ^2 , degrees of freedom, and intraclass correlation coefficients) were reported in Table 2, while the full mixed-model outputs, including fixed intercepts and random-effect variances, were presented in Table 3.

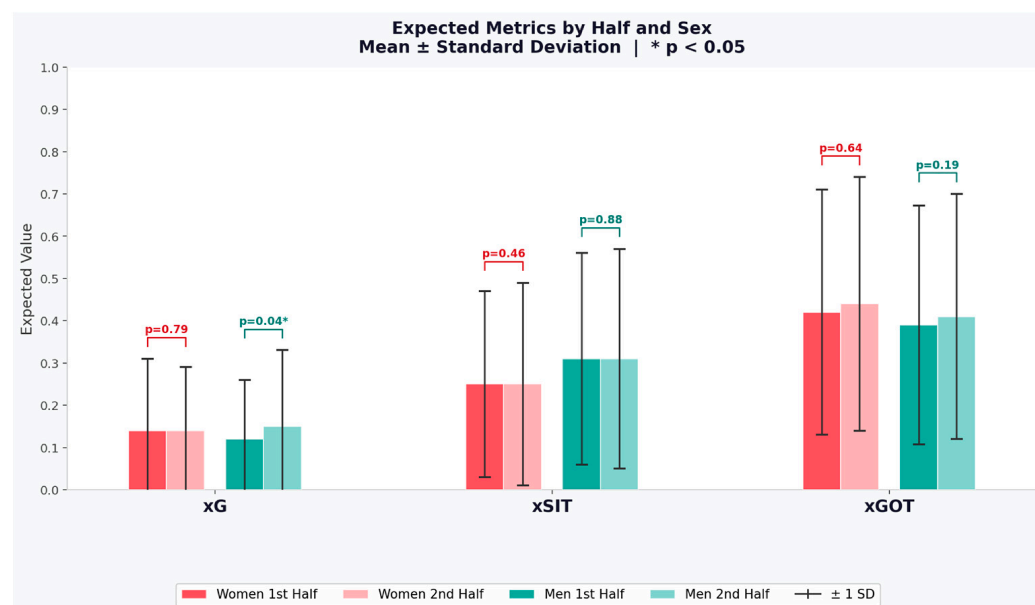


Figure 2. Comparative analysis of the advanced study metrics (xG, xSIT, xGOT) in the first and second halves for women and men (Mean $\pm$ SD). Asterisk (*) indicates statistically significant differences between halves ($p < 0.05$). (The figure was generated using AI-assisted software and reviewed by the authors).

Table 2. Linear mixed-effects model omnibus tests of the effect of 15 min interval on each advanced shot metric (shots on target). Wald χ^2 tests the joint interval effect; ICC = intraclass correlation coefficient.

Metric	Sex	Wald χ^2	df	p Value	ICC
xG	Women	1.21	5	0.94	0.027
	Men	8.14	5	0.15	0.000
xSIT	Women	5.49	5	0.36	0.000
	Men	1.51	5	0.91	0.000
xGOT	Women	4.24	5	0.51	0.039
	Men	4.81	5	0.44	0.000

Table 3. Linear mixed-effects model outputs: fixed intercept (mean of the 0–15 min reference interval), match-level random-effect variance and SD, residual variance and SD, number of shots and matches.

Metric	Sex	Intercept (β_0)	σ^2 Match	SD Match	σ^2 Resid.	SD Resid.	N	Matches
xG	Women	0.142	0.00067	0.0260	0.02391	0.1546	554	32
	Men	0.114	0.00001	0.0029	0.02588	0.1609	775	48
xSIT	Women	0.253	0.00000	0.0000	0.05074	0.2253	554	32
	Men	0.309	0.00000	0.0000	0.06582	0.2566	775	48
xGOT	Women	0.397	0.00341	0.0584	0.08393	0.2897	554	32
	Men	0.359	0.00000	0.0000	0.07537	0.2745	775	48

Note. Small match-level variances relative to residual variances confirm the low ICC values in Table 2, indicating limited between-match clustering. The random intercept was retained to satisfy the independence assumption.

The low match-level variances (and correspondingly low ICC values, all ≤ 0.04) indicated that very little of the total variance in shot quality was attributable to between-match differences, although the random intercept was retained to satisfy the independence assumption. Fixed-effect coefficients with 95% confidence intervals, bootstrap con-

fidence intervals for the ICC, and Tukey HSD pairwise comparisons were reported in Supplementary Tables S1–S3. Across all models, all coefficients and pairwise-difference intervals included zero, consistent with the absence of any temporal effect.

Figure 3 displays the mean value of each metric per 15 min interval across the four competitions. The visual pattern corroborated the statistical results: the competition lines remained broadly flat across intervals, without a systematic increase or decrease as the match progressed. The only consistent feature was that the men's competitions exhibited higher xSIT values than the women's across virtually all intervals, while between-competition dispersion was greatest around the half-time period (30–45 and 45–60 min), reflecting tournament heterogeneity rather than a systematic temporal trend.

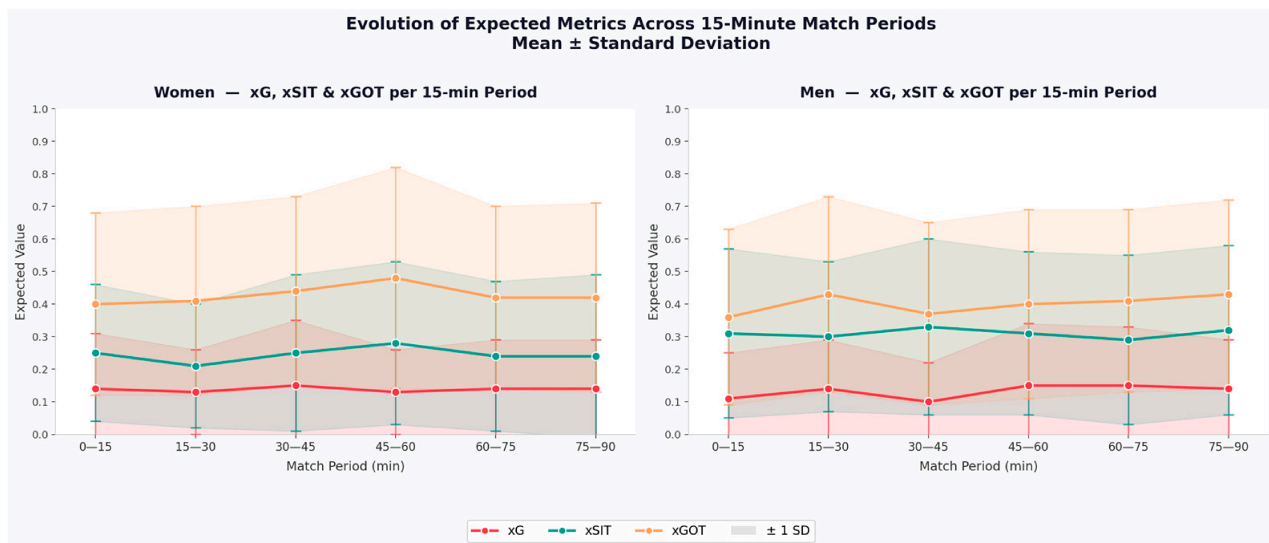


Figure 3. Advanced metrics across the six 15 min match intervals for each competition. (The figure was generated using AI-assisted software ChatGPT (GPT-5-5, OpenAI, San Francisco, CA, USA, and reviewed by the authors).

4. Discussion

The main finding of the present study was that the quality of shots on target, quantified through xG, xSIT, and xGOT, appeared to remain relatively stable across match halves and 15 min intervals in both men's and women's elite international football. Across the full match duration, the distribution of these metrics did not show consistent temporal trends, suggesting that the probability quality of shooting opportunities did not systematically vary as matches progressed. When the analysis was segmented into match halves and 15 min intervals, the values of xG, xSIT, and xGOT generally remained consistent within and between periods. This pattern was observed in both the first and second halves, as well as across early, middle, and late phases of matches, although minor variations were present. Similarly, comparisons between men's and women's competitions did not reveal clear or consistent differences in the temporal evolution of these shot-quality indicators, with both groups showing broadly comparable distributions of offensive opportunity quality over time. Taken together, these findings suggest that, within the competitive contexts analyzed, the probabilistic quality of shooting situations did not appear to exhibit systematic variation associated with match timing or sex category at the elite international level.

These results contrast with the well-established evidence showing a progressive decline in physical performance indicators, such as high-intensity running and sprint capacity, throughout match play [11,14]. Likewise, reductions in technical proficiency under fatigue, including passing accuracy and decision-making efficiency, have been

consistently reported [13]. From a physiological and cognitive perspective, these declines were typically attributed to a combination of peripheral and central fatigue mechanisms, which collectively impair neuromuscular efficiency and perceptual-cognitive function [25,26]. In parallel, previous observational studies had reported an increase in goal-scoring frequency during the final stages of matches [15], a phenomenon often attributed to fatigue-induced reductions in defensive organization, increased error rates, and changes in risk-taking behaviors.

However, the present findings provided a more nuanced interpretation of this temporal pattern by demonstrating that the quality of scoring opportunities remained stable throughout match play. Specifically, the absence of meaningful temporal variation in xG, xSIT, and xGOT suggested that the estimated value of shooting opportunities was largely preserved despite accumulated fatigue. Importantly, these findings should be interpreted with caution, as the present study did not directly assess underlying causal mechanisms, but rather described temporal patterns in probabilistic shot metrics. This challenged the assumption that late-match increases in goal scoring are driven by deteriorations in technical execution or improvements in chance quality per se.

These results support a more cautious and structurally system-level interpretation, in which goal frequency was primarily modulated by contextual and systemic factors, such as increased transition frequency, game-state effects, and progressive defensive disorganization rather than by changes in the quality of goal-scoring opportunities [27–29]. From a tactical perspective, match progression effects were likely embedded within broader strategic and contextual constraints, including tactical organization, spatial control, and team management across different phases of play. In this regard, alternative explanations could account for the observed stability in shot-quality metrics, including tactical pacing strategies that regulated intensity and risk exposure, substitution strategies that reintroduced physical and tactical balance in later phases, scoreline effects that modified pressing intensity and spatial organization, and selective shot-taking behaviors that prioritized higher-value opportunities as match constraints evolved [13–15].

From this perspective, it may exclude compensatory mechanisms at the team level rather than a true absence of fatigue effects, whereby contextual and tactical adaptations preserved the probabilistic structure of shooting opportunities across match phases. Consistent with recent performance analysis research, late-match phases were characterized by increased transitional volatility and spatial disorganization, which may have elevated the volume of opportunities without necessarily altering their per-shot probabilistic value [30,31].

Notably, no substantial differences were observed between men's and women's competitions, supporting the robustness of these temporal patterns across elite football contexts. Although a statistically significant difference in xG was identified in men's football, the associated effect size was trivial ($d = -0.17$), indicating limited practical relevance despite statistical significance. This distinction is particularly relevant in elite sport contexts, where small numerical differences may not translate into meaningful performance advantages. These findings were consistent with the recent literature suggesting that, despite well-documented differences in technical demands and match performance characteristics between men's and women's football [32], the underlying structural dynamics of performance appeared comparable when analyses were contextualized within each sex-specific competitive category [33].

4.1. Limitations

Notwithstanding the novel insights generated, this study has several important limitations that should be explicitly acknowledged. First, the analysis was restricted to shots on target, with all other shooting attempts excluded from the dataset. This methodological

decision was necessary because xGOT can only be calculated for on-target shots, as it relies on post-shot information related to both goalkeeper performance and shot outcome. By restricting the analysis to shots on target, all performance indicators were derived from the same set of events, ensuring methodological consistency and allowing direct comparisons across metrics. Consequently, the findings reflect the characteristics of shooting actions that reached the target and should therefore not be generalized to all types of shots or to overall shooting performance. Second, the use of aggregated event data represents a methodological constraint, as it does not allow the inclusion of key contextual micro-variables such as defensive pressure at the moment of the shot on target or the specific tactical structures preceding each action. This limitation may be addressed in future studies by using tracking data or enriched event data providers that include spatial–temporal coordinates of players and the ball. The integration of these data sources would allow researchers to quantify contextual factors at the moment of the shot, enabling a more precise and valid assessment of shooting quality. Third, the absence of contextual match state variables, such as scoreline, match importance, and phase-specific tactical adjustments, limits the interpretation of how situational factors influence shooting behavior. This limitation could be overcome by incorporating time-dependent contextual variables into the analytical framework, including score differentials, game state (winning, drawing, losing), and competition phase indicators. Furthermore, the use of advanced modeling approaches such as hierarchical or state-dependent models would allow the dynamic interaction between match context and quality of shot on target to be more accurately captured. Fourth, the restriction of the analysis to elite international tournaments limits the generalizability of the findings to other competitive levels. This limitation could be addressed by extending future research to include domestic leagues and lower-tier professional football. A multi-level comparative design across different competitive standards would enable researchers to examine whether the observed consistency of chance quality was maintained across contexts or whether it varied according to playing level, tactical sophistication, and competitive balance. Finally, the use of event-data-based metrics presents certain limitations. Although xG, xSIT, and xGOT provide useful probabilistic estimates of shot-on-target outcomes, these measures are model-dependent and may not fully capture key contextual and tactical factors such as defensive pressure, team tactical organization, or in-possession dynamics. Therefore, while informative, they should be interpreted with caution as they do not fully reflect the complexity of the match context. Notwithstanding these limitations, the study used a StatsBomb event-data dataset, which is widely recognized as one of the most robust and commonly used sources in football analytics.

4.2. Practical Application

From a practical perspective, the present findings indicated that xG, xSIT, and xGOT remained stable across match phases in both men's and women's elite football, with no clear temporal variation in shot-quality metrics. This suggested that changes in goal-scoring patterns over time were not accompanied by systematic changes in the probabilistic value of shooting opportunities.

For performance analysts, this indicated that temporal fluctuations in goals should not be interpreted as changes in shot quality but rather as variations in opportunity volume or contextual factors not captured by event-level shot metrics.

For coaches, the findings suggested that differences in scoring rates across match phases were not necessarily associated with changes in the intrinsic quality of shots. In this regard, training tasks such as small-sided games with manipulated game states (e.g., 3v3+3 under fatigue or time-constraint rules) or transition-based finishing drills following

high-intensity repeated sprint actions may better reflect the contextual conditions under which shot opportunities are generated, rather than isolated finishing practice alone.

For performance staff, these findings suggested that temporal variations in match outcomes should not be interpreted as changes in shot-quality profiles. Instead, post-match analysis should integrate shot-quality metrics with contextual indicators such as match status and transition frequency to better differentiate between changes in opportunity volume and stable probabilistic shot quality.

Overall, practical interpretation of these findings should remain strictly aligned with the observed stability of event-based shot-quality metrics across match phases.

5. Conclusions

The conclusion of this study indicated that advanced shot metrics (xG, xSIT, and xGOT) remained relatively stable throughout the match, with no statistically significant differences observed between halves or 15 min intervals in either men's or women's competitions, nor between the two. Overall, these findings suggested that the probabilistic quality of shots on target was largely consistent across the duration of elite football matches, with no clear evidence of systematic temporal fluctuations associated with match progression.

Beyond this descriptive evidence, the study contributes to a more nuanced understanding of how advanced shot-quality metrics behave over time in elite football. Specifically, the findings extend current performance analysis knowledge by demonstrating that temporal stability in probabilistic shooting indicators can be observed across both men's and women's elite competitions, thereby reinforcing the robustness of these metrics across competitive contexts.

These results also have important implications for football analytics research. First, they highlight the value of temporal approaches when interpreting advanced performance indicators, suggesting that aggregate match-level evaluations may obscure stable underlying probabilistic structures. Second, they support the need to further integrate contextual and tactical dimensions into the interpretation of shot-quality metrics, particularly when assessing how match dynamics influence opportunity creation over time. Finally, they reinforce the importance of distinguishing between outcome-based interpretations (e.g., goals scored) and process-based probabilistic evaluations (e.g., xG-derived metrics) in elite football analysis.

From a performance analysis perspective, these findings may reflect the combined influence of high physical conditioning, tactical organization, and contextual adaptation strategies that help maintain the probabilistic structure of attacking opportunities across match phases.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/bdcc10070214/s1>, Table S1: Fixed-effect coefficients of the linear mixed-effects models (each interval relative to the 0–15 min reference), with 95% confidence intervals; Table S2: Interclass correlation coefficient (ICC) with 95% confidence intervals from cluster bootstrap (300 match-level resamples); Table S3: Turkey HSD pairwise comparisons between 15-min intervals, with mean difference and 95% confidence interval. No comparison reached significance.

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