Game criticality in male youth football: Situational and age-related effects on the goal-scoring period in Portuguese national championships

La criticalidad del juego en el fútbol juvenil masculino: Efectos situacionales y de la edad en el período de gol en los campeonatos nacionales portugueses

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Abstract. Research crossing the effects of situational variables with the temporal analysis of goals scored in football is scarce, particularly in youth football. Hence, the present study aimed to (1) analyse the effects of *match location*, *match status*, *team quality*, *goal criticality*, and *age group* on match periods in which goals are scored in male youth football, and (2) examine whether the *age group* (U17, U19, and U23) influences the emergence of critical moments in matches from the Portuguese national championships. The sample consisted of 2,591 goals scored in the U17, U19, and U23 Portuguese national championships during the 2019/2020 season. Chi-square tests revealed that *match location*, *match status*, *goal criticality*, and *age group* were significantly associated with the *goal-scoring period*. During the first halves, more goals were scored (1) when playing at home, (2) when teams were tied or losing by one goal (critical circumstances) and (3) by U17 teams. A multinomial logistic regression model revealed that the chances of scoring in the sixth period (*vs* the first) significantly decreased when playing at home, and in U17 and U19 matches. The U23 teams were more likely to score in the last period regardless of *goal criticality*. However, the interaction effect of *team quality* x *age group* suggests that U17 and U19 teams are more prone to score in later match periods when team ability is equated. These findings enable coaches to improve the tactical, physical, and psychological preparation for competitive youth matches depending on the target *age group*.
Keywords: goal, critical moments, contextual variables, temporal analysis, soccer.

Resumen. La investigación cruzando los efectos de variables situacionales con el análisis temporal de goles en fútbol escasea, particularmente en el fútbol juvenil. Por eso, este estudio pretendió (1) analizar los efectos de localización del partido, marcador, calidad del equipo, criticalidad de los goles y grupo de edad en los períodos del partido donde se marcan estos goles en el fútbol juvenil masculino, y (2) examinar si el grupo de edad (Sub-17, Sub-19, Sub-23) influye en el surgimiento de momentos críticos en partidos de campeonatos nacionales portugueses. La muestra consistió en 2,591 goles anotados en estas competiciones juveniles durante la temporada 2019/2020. Las pruebas de Chi-cuadrado revelaron que la localización del partido, el marcador, la criticalidad del gol y el grupo de edad se asociaron significativamente con el período de gol. Durante los primeros tiempos, se anotaron más goles (1) jugando en casa, (2) con los equipos empatados o perdiendo por un gol (circunstancias críticas) y (3) en Sub-17. Según un modelo de regresión logística multinomial las posibilidades de gol en el sexto período (vs el primero) fueron significativamente menores jugando en casa, y en Sub-17 y Sub-19. Los equipos Sub-23 tuvieran más probabilidades de marcar en el último período, independientemente de la criticalidad del gol. Sin embargo, la interacción entre calidad del equipo y grupo de edad sugiere que los equipos Sub-17 y Sub-19 son más propensos a marcar en períodos de juego posteriores cuando se equipara la habilidad del equipo. Estos hallazgos permiten a los entrenadores mejorar la preparación táctica, física y psicológica para las competiciones dependiendo de la edad.
Palabras clave: gol, momentos críticos, variables contextuales, análisis temporal, fútbol.

Introduction

The primary purpose of a football match is to obtain victory, which can only be achieved by outscoring the opponent. Since scoring goals is the ultimate determinant of a successful team, these match events have been widely examined in performance analysis research (Jones, et al., 2004; Sarmento, et al., 2014, 2018). However, most studies have used a static approach that analyses a range of performance indicators and outcome-based variables to identify the teams' success factors, but with little to no reference to match context (Pratas, et al., 2018). Less common in the literature is the dynamic approach, which provides information that considers the evolution of time throughout the match. According to Pratas and colleagues (2018), the combination of different kinds of data (variables) provides a better understanding of the dynamics that impact goal scoring, facilitating the prediction of future performances and outcomes based on past events.

Following a static approach, several studies have shown that goal scoring is time-dependent, with a more significant number of goals occurring in the second half, especially in the last 15-minute period of matches (Aguado-Méndez, et al., 2020; Armatas, et al., 2007, 2009; Njororai,

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2014; Evangelos, et al., 2018; Leite, 2017). Scoring more frequently towards the end of the match has been associated with two main reasons: (1) physical and mental fatigue accumulation, which impairs sport-specific physical, decision-making, tactical, and technical performances (Izzo, et al., 2020; Mohr, et al., 2003; Smith, et al., 2018), and (2) the adoption of riskier attacking strategies to change the scoreline (Njororai, 2014; Pratas, et al., 2018). Concurrently, this has led some researchers to claim that the last 15 minutes of the second half (plus additional time) represents the most critical phase of the game (Leite, 2013; Njororai, 2014). Nevertheless, such allegation stems from merely descriptive data without considering the influence of situational variables (e.g., *match location*, *match status*, *team quality*). Interestingly, the impact of such situational variables on actions leading to goal scoring has already been extensively evidenced (Fernández-Cortés, et al., 2022; González-Rodenas, et al., 2020; Sarmento, et al., 2018; Wunderlich, et al., 2021).

Over the last few years, researchers have started to favour a dynamic approach to better grasp the underlying subtleties of goal scoring in football. These endeavours have commonly implied the application of multifactorial analyses with different context-related variables (González-Rodenas, et al., 2020). For instance, Baert and Amez (2018) deconstructed the myth that scoring a goal just before half-time is a great moment to achieve positive full-time results in UEFA Champions League and UEFA Europa League. In these European competitions, Amez et al. (2021) found that teams tend to experience an increased goal-scoring probability after their first and second substitutions and a decreased likelihood of scoring following the third substitution of their opponents. When a team was losing at the moment of the substitution, the chance of scoring afterwards increased. Wunderlich et al. (2021) unveiled substantial randomness in 46% of all goals scored in the English Premier League across seven seasons (2012-13 to 2018-19). Additionally, these authors observed a strong influence of randomness on goals for weaker teams and if the score was tied.

Given that football is a low-scoring sport, with ≈ 2.65 goals per match (Leite, 2017; Njororai, 2014; Wunderlich, et al., 2021), it is paramount to understand not only when, why and how goals are scored but also which are the most influential goals for the match outcome. To this end, combining the temporal analysis of goals scored with the effects of other situational variables can expand the limited knowledge about the game's critical moments (Carmo, et al., 2021). Based on the notion of "game criticality" presented by Ferreira and colleagues (2014), Carmo et al. (2021) distinguished two categories of goals: "critical goals", which change the competitive status of confronting teams during a match (e.g., a team is losing 1-0 and scores the equaliser, 1-1); "non-critical goals", which do not modify the competitive status of both teams during match-play (e.g., a team is winning 3-0 and scores again, 4-0). The subsequent analysis showed that playing at home (*vs* away) increased the odds of scoring "non-critical" goals in the last match periods (61 min–full-time) in the UEFA Champions League (Carmo, et al., 2021). This kind of information may aid the coaches' decision-making during competitive matches and better inform the design of practice tasks if the match contextual influences are properly pondered.

Irrespective of the methodological approach, most studies on situational variables and goal scoring, or competitive performance, have focused on professional football. Surprisingly, there is a striking paucity of research on youth football (Caballero, et al., 2017; Jaime, et al., 2022); as far as we are aware, only a handful of studies have tackled the issue. Staufenbiel et al. (2018) revealed the presence of the home advantage effect (i.e., teams are more successful playing at home than away) in high-level youth football in Germany, across all age groups (U11, U13, U15, U17, and U19), except for the U9. Remarkably, the home advantage magnitude increased with age. The importance of match location, scoring first, quality of opposition, the number of substitutions and cards received on match outcome was shown in a regional U18 football league in Spain (Caballero, et al., 2017). The quality of opposition also impacted some play patterns related to the beginning, build-up, and outcome of offensive sequences in a high-level U17 Brazilian team (Jaime, et al., 2022). Despite these earlier findings, more research is required to deepen our understanding of how context shapes performance and scoring dynamics in football across different age groups.

In order to fill the gaps in the literature, this study followed a dynamic approach with a dual purpose: (1) to analyse the effects of situational variables (*match location*, *match status*, *team quality*, and *goal criticality*) and *age group* on match periods in which goals are scored in male youth football; (2) to examine whether the age group (U17, U19, and U23) influences the emergence of critical moments in Portuguese national championship matches. We refrained from stating hypotheses due to the diversity of situational variables and the exploratory nature of this research; however, we approached this research with the initial assumption that the scoring dynamics of older teams (U23) are possibly less susceptible to situational influences.

Material and methods

Sample

The sample consisted of all goals scored (n = 2,591), during the 2019/2020 season, by male youth teams

competing in the U17, U19, and U23 national football championships organised by the Portuguese Football Association. Only the top tier national competitions for these age groups were analysed, whose official designations are as follows: (1) U17 National Championship (*Campeonato Nacional de Juvenis*); (2) U19 National Championship – 1st Division (*Campeonato Nacional de Juniores da 1.ª Divisão*); (3) U23 Revelation League (*Liga Revelação*). Match representativeness involving teams grouped by geographical location (*series*) was ensured by only considering data from the first and regular phases of U17, U19, and U23 championships. Therefore, subsequent stages of each competition were not included (e.g., top-ranked and bottom-ranked mini-leagues). Table 1 presents the sample-related details by age group and in general.

Table 1.
Sample-related details (series, teams, rounds, matches, and goals scored) retrieved from the regular phase of the Portuguese national football championships (U17, U19, and U23) during the season 2019/2020.

Age Group	*Series*	Rounds (n)	Teams (n)	Matches (n)	Goals (n)
U17	A	11	12	66	249
	B	11	12	66	323
	C	11	12	66	259
	D	11	12	66	265
U19	North	22	12	132	360
	South	22	12	132	480*
U23	*Liga Revelação*	30	16	240	655**
		Totals	88	768	2591

* Three goals were excluded from the sample because of a match result (round 16: CD Tondela 3 x 0 UD Vilafranquense F. SAD) that was administratively decided by the Portuguese Football Association.
** Three goals were excluded from the sample because of a match result (round 16: Vitória FC 0 x 3 CS Marítimo) that was administratively rectified by the Portuguese Football Association.

Variables and procedures

Five independent variables were proposed in this study: *match location*, *match status*, *team quality*, *goal criticality*, and *age group*. The dependent variable was the *goal-scoring period*. Table 2 exhibits the categories, the operational definitions, and the collection procedures of independent and dependent variables.

A retrospective observational study was conducted to examine how *match location*, *match status*, *team quality*, *goal criticality*, and *age group* influenced the *goal-scoring period* in Portuguese male youth football teams. All these variables, and the respective categories, were previously used in performance analysis research (e.g., Almeida, et al., 2014; Carmo, et al., 2021; Fernandez-Navarro, et al., 2018; García-Rubio, et al., 2015). Data regarding goals scored by all teams were collected from the publicly available website (zerozero.pt), which considers the official match results published on the website of the Portuguese Football Association (fpf.pt) – the organising entity of youth national championships. A Microsoft 365 Excel (Microsoft Corporation, USA) spreadsheet was arranged to code all elements of each goal-scoring event – the unit of analysis: *national competition (age group)*, *round*, *scoring team*, *conceding team*, *match location*, *match status*, *team quality*, *goal criticality*, and *match period*. The final database was exported to SPSS 27.0 (IBM SPSS Statistics, IBM Corp., Armonk) for statistical analysis. This investigation was conducted in compliance with the principles stated in the Declaration of Helsinki, and the methodological procedures conformed to the ethics guidelines of the first author's institution.

Table 2.
Categories, operational definitions, and collection procedures of independent and dependent variables.

Variable	Categories	Operational definition/collection procedures
Match location (independent)	1) Home 2) Away	Recorded as "home" or "away" depending on whether the scoring team was playing at its own ground or that of its opponent.
Match status (independent)	1) Losing by two or more goals 2) Losing by one goal 3) Tied 4) Winning by one goal 5) Winning by two or more goals	Represents the evolving score of a match immediately before the goal-scoring event. Categories were defined in relation to the number of goals scored and conceded by the scoring team at the time of data entry.
Team quality (independent)	1) Worse-ranked 2) Similar-ranked 3) Better-ranked	Represents the quality difference between the scoring team and its opponent. Considering the points earned by each team at the end of championships' regular phases, k-means cluster analyses were performed for grouping teams into quality categories (i.e., three quality groups for *series* with 12 teams, and four quality groups for the league with 16 teams). For example, if the scoring team was playing against an opponent from a lower quality group, it was recorded as "better-ranked".
Goal criticality (independent)	1) Critical goal (match status = 2 and 3) 2) Non-critical goal (match status = 1, 4 and 5)	Defines the goal-scoring nature, depending on whether the event changes (or not) the temporary competitive status between opposing teams (Ferreira, et al., 2014). It was computed from the variable "match status". For example, if the scoring team made the equaliser (1-1), the goal was deemed "critical". If the scoring team was losing 3-0 and made the 3-1, the goal was coded "as non-critical".
Age group (independent)	1) Under-17 (U17) 2) Under-19 (U19) 3) Under-23 (U23)	Coding of the scoring team as a function of the age-related competition in which it was participating.
Goal-scoring period (dependent)	1) 1–15 min 2) 16–30 min 3) 31 min–HT 4) 46–60 min 5) 61–75 min 6) 76 min–FT	Recorded as 1, 2, 3, 4, 5 or 6 depending on the period in which the goal was scored during the match. Note: HT – half-time; FT – full-time.

Statistical analysis

First, a descriptive statistical analysis was performed using contingency tables. Chi-square tests of independence were computed to measure the relationship between each independent variable and the *goal-scoring period*. Effect sizes were measured with Cramer's *V* statistic and interpreted using the benchmarks proposed by Cohen (1988) for different degrees of freedom. Considering R as Rows and C as Columns, the degrees of freedom for Cramer's *V* were always accounted for as the smallest number of (R-1) or (C-1) (Gravetter & Wallnau, 2013).

Afterwards, a multinomial logistic regression model was calculated to estimate the probabilities of occurrence for the *goal-scoring period* as a function of *match location*, *team quality*, *goal criticality*, and *age group*. According to Field (2018), these analyses break the dependent variable down into a series of comparisons between two categories, including the reference category. The first period (1–15 min) was chosen as the reference category as it depicts the initial conditions of matches played by teams during a points-based competition: equality on the scoreline (tie) and an equal numerical relation (Gk+10*vs*10+Gk). The best-fitted model retained the main effects of *match location*, *team quality*, *goal criticality*, and *age group* and included the interaction term *team quality* x *age group*. The level of statistical significance was set at $p \leq 0.05$.

Results

From the total sample of goals, 42.3% (n = 1,096) were scored by U17 teams, 32.4% (n = 840) by U19 teams, and 25.3% (n = 655) by U23 teams. The distribution of *goal-scoring period* data across categories of each independent variable (*match location*, *match status*, *team quality*, *goal critically*, and *age group*) can be found in Table 3.

Overall, there was a progressive increase of goals scored over the first three periods (first half) of matches. During the second half, a *plateau* was spotted in the fourth match period (46–60 min), followed by a slight decrease in the fifth period (61–75 min; -0.4%). The highest number of goals occurred in the sixth period (76 min–full-time; 22.6%), whilst the least was recorded in the first (1–15 min; 13.7%). According to the chi-square test of independence, there was a significant association between *match location* and *goal-scoring period*, $\chi2(5) = 11.172$, $p = 0.048$, $V = 0.066$, entailing a trivial effect. Visiting teams scored more frequently in the sixth (and final) match period, whereas home teams scored more in the first five periods.

The *match status* also impacted the goal distribution across match periods, $\chi2(20) = 574.600$, $p < 0.001$, $V = 0.235$ (medium-to-large effect). More goals were scored when teams were "tied" (37.4%), followed by "winning by two or more goals" (23.3%), "winning by one goal" (18.1%), "losing by one goal" (14.2%), and "losing by two or more goals" (6.9%). Although there was no association between *team quality* and *goal-scoring period*, $\chi2(10) = 9.535$, $p = 0.482$, $V = 0.043$ (trivial effect), "better-ranked" teams scored more goals (53.4%) than the "worse-ranked" ones (14.3%). The independent variable *goal criticality*, computed from the *match status*, was associated with the *goal-scoring period*, $\chi2(5) = 295.322$, $p < 0.001$, $V = 0.338$ (medium-sized effect). As matches progressed, a decrease in critical goals happened, except for the last match period, in which a slight increase was identified relative to the

Table 3.
Absolute (and relative: %) frequencies of the goal-scoring period according to match location, match status, team quality, goal criticality, and age group.

Independent variable and categories	Goal-scoring period					
	1–15	16–30	31–HT	46–60	6 –75	76–FT
Match location*	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Home	201 (7.8)	194 (7.5)	225 (8.7)	235 (9.1)	232 (9.0)	276 (10.7)
Away	154 (5.9)	168 (6.5)	209 (8.1)	197 (7.6)	190 (7.3)	310 (12.0)
Match status***	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Losing by two or more goals	0 (0.0)	9 (0.3)	24 (0.9)	29 (1.1)	50 (1.9)	68 (2.6)
Losing by one goal	14 (0.5)	50 (1.9)	78 (3.0)	71 (2.7)	75 (2.9)	80 (3.1)
Tied	285 (11.0)	189 (7.3)	157 (6.1)	136 (5.2)	94 (3.6)	109 (4.2)
Winning by one goal	46 (1.8)	80 (3.1)	90 (3.5)	85 (3.3)	72 (2.8)	96 (3.7)
Winning by two or more goals	10 (0.4)	34 (1.3)	85 (3.3)	111 (4.3)	131 (5.1)	233 (9.0)
Team quality	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Worse-ranked	48 (1.9)	63 (2.4)	61 (2.4)	55 (2.1)	61 (2.4)	82 (3.2)
Similar-ranked	118 (4.6)	108 (4.2)	142 (5.5)	157 (6.1)	140 (5.4)	173 (6.7)
Better-ranked	189 (7.3)	191 (7.4)	231 (9.0)	220 (8.5)	221 (8.5)	331 (12.8)
Goal criticality***	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Critical goal	299 (11.5)	239 (9.2)	235 (9.1)	207 (8.0)	169 (6.5)	189 (7.3)
Non-critical goal	56 (2.2)	123 (4.7)	199 (7.7)	225 (8.7)	253 (9.8)	397 (15.3)
Age group**	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Under-17	140 (5.4)	135 (5.2)	195 (7.5)	183 (7.1)	191 (7.4)	252 (9.7)
Under-19	123 (4.7)	143 (5.5)	118 (4.6)	156 (6.0)	131 (5.1)	169 (6.5)
Under-23	92 (3.6)	84 (3.2)	121 (4.7)	93 (3.6)	100 (3.9)	165 (6.4)
Totals	355 (13.7)	362 (14.0)	434 (16.8)	432 (16.7)	422 (16.3)	586 (22.6)

Note: * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.01$. HT – half-time; FT – full-time.

fifth period. Regarding non-critical goals, the scoring frequency increased throughout the matches. Therefore, when comparing both halves, more critical goals were scored in the first half (29.8% *vs* 21.8%), whereas more non-critical goals occurred in the second half (14.6% *vs* 33.8%).

The *age group* affected the distribution of goal-scoring events across the different match periods, $\chi 2(10) = 25.252$, $p = 0.005$, $V = 0.07$ (small-sized effect). Although U17, U19, and U23 teams scored more goals in the sixth period, the distribution of goals scored over the matches differed between age groups. For instance, while U17 teams scored less in the second period, the U19 and U23 teams did so in the third and first periods, respectively.

Table 4 depicts regression coefficients (*B*), standard errors (SE), odds ratios (OR), and 95% confidence intervals (CI) for odds ratios (i.e., parameter estimates) for each factor and interaction term included in the best-fitted model estimated through multinomial logistic regression. The predicted values did not differ significantly from the observed values (Pearson = 0.781; Deviance = 0.679), indicating the model is a good fit.

In general, the *goal-scoring period* was influenced by *match location* ($p = 0.014$), *goal criticality* ($p \leq 0.001$), *age group*, and the interaction *team quality* x *age group* ($p \leq 0.05$). As previously pointed out in the bivariate analysis, the main effect of *team quality* was non-significant ($p > 0.05$). Specifically, taking the first period (1–15 min) as

Table 4.
Parameter estimates for the multinomial logistic regression of goal-scoring period as a function of match location, team quality, goal criticality, and age group.

Variables / Categories		*B* (SE)	95% CI for Odds Ratio		
			Lower	OR	Upper
16–30 min (*vs* 1–15 min)					
Intercept***		1.110 (0.303)			
Match Location:	Home *vs* Away	-0.175 (0.152)	0.623	0.840	1.131
Team Quality:	Lower *vs* Better-ranked	-0.109 (0.362)	0.441	0.897	1.825
	Similar *vs* Better-ranked	-0.211 (0.370)	0.392	0.810	1.671
Goal Criticality:	Critical *vs* Non-critical***	-1.149 (0.192)	0.217	0.317	0.462
Age Group:	U17 *vs* U23	-0.466 (0.287)	0.357	0.628	1.103
	U19 *vs* U23	-0.096 (0.293)	0.512	0.909	1.613
Team Quality x Age Group:	Worse-ranked x U17 *vs* Worse-ranked x U23**	1.605 (0.621)	1.475	4.978	16.799
	Worse-ranked x U19 *vs* Worse-ranked x U23	0.584 (0.531)	0.634	1.794	5.077
	Similar-ranked x U17 *vs* Similar-ranked x U23	0.425 (0.459)	0.622	1.529	3.757
	Similar-ranked x U19 *vs* Similar-ranked x U23	0.372 (0.460)	0.589	1.451	3.573
31 min–HT (*vs* 1–15 min)					
Intercept***		2.062 (0.279)			
Match Location:	Home *vs* Away	-0.248 (0.147)	0.585	0.781	1.042
Team Quality:	Lower *vs* Better-ranked	-0.470 (0.344)	0.319	0.625	1.227
	Similar *vs* Better-ranked	-0.288 (0.337)	0.388	0.750	1.452
Goal Criticality:	Critical *vs* Non-critical***	-1.720 (0.185)	0.125	0.179	0.257
Age Group:	U17 *vs* U23**	-0.813 (0.264)	0.264	0.444	0.744
	U19 *vs* U23***	-1.012 (0.285)	0.208	0.363	0.636
Team Quality x Age Group:	Worse-ranked x U17 *vs* Worse-ranked x U23**	1.823 (0.609)	1.877	6.193	20.435
	Worse-ranked x U19 *vs* Worse-ranked x U23*	1.093 (0.540)	1.036	2.983	8.589
	Similar-ranked x U17 *vs* Similar-ranked x U23	0.815 (0.418)	0.996	2.260	5.127
	Similar-ranked x U19 *vs* Similar-ranked x U23	0.846 (0.442)	0.980	2.329	5.536
46–60 min (*vs* 1–15 min)					
Intercept***		1.783 (0.293)			
Match Location:	Home *vs* Away	-0.155 (0.149)	0.640	0.856	1.146
Team Quality:	Lower *vs* Better-ranked	-0.210 (0.365)	0.396	0.810	1.658
	Similar *vs* Better-ranked	0.001 (0.357)	0.498	1.001	2.013
Goal Criticality:	Critical *vs* Non-critical***	-1.984 (0.185)	0.096	0.138	0.198
Age Group:	U17 *vs* U23	-0.546 (0.281)	0.334	0.579	1.005
	U19 *vs* U23	-0.486 (0.295)	0.345	0.615	1.098
Team Quality x Age Group:	Worse-ranked x U17 *vs* Worse-ranked x U23*	1.350 (0.643)	1.095	3.857	13.589
	Worse-ranked x U19 *vs* Worse-ranked x U23	0.883 (0.544)	0.833	2.419	7.019
	Similar-ranked x U17 *vs* Similar-ranked x U23	0.593 (0.436)	0.770	1.810	4.257
	Similar-ranked x U19 *vs* Similar-ranked x U23	0.842 (0.446)	0.968	2.322	5.568
61–75 min (*vs* 1–15 min)					
Intercept***		2.276 (0.284)			
Match Location:	Home *vs* Away	-0.138 (0.151)	0.648	0.871	1.172
Team Quality:	Lower *vs* Better-ranked	-0.523 (0.365)	0.291	0.593	1.207
	Similar *vs* Better-ranked	-0.493 (0.365)	0.299	0.611	1.248
Goal Criticality:	Critical *vs* Non-critical***	-2.358 (0.187)	0.065	0.095	0.137
Age Group:	U17 *vs* U23***	-0.958 (0.273)	0.225	0.383	0.655
	U19 *vs* U23***	-1.102 (0.295)	0.186	0.332	0.592
Team Quality x Age Group:	Worse-ranked x U17 *vs* Worse-ranked x U23***	2.349 (0.616)	3.132	10.477	35.047
	Worse-ranked x U19 *vs* Worse-ranked x U23*	1.414 (0.555)	1.385	4.110	12.195
	Similar-ranked x U17 *vs* Similar-ranked x U23**	1.144 (0.446)	1.311	3.139	7.516
	Similar-ranked x U19 *vs* Similar-ranked x U23***	1.537 (0.462)	1.881	4.649	11.492

76 min–FT (*vs* 1–15 min)					
Intercept***		2.957 (0.273)			
Match Location:	Home *vs* Away***	-0.480 (0.144)	0.467	0.619	0.821
Team Quality:	Lower *vs* Better-ranked	-0.154 (0.330)	0.449	0.857	1.635
	Similar *vs* Better-ranked	-0.131 (0.331)	0.458	0.877	1.679
Goal Criticality:	Critical *vs* Non-critical***	-2.719 (0.182)	0.046	0.066	0.094
Age Group:	U17 *vs* U23***	-0.971 (0.260)	0.228	0.379	0.631
	U19 *vs* U23***	-1.094 (0.279)	0.194	0.335	0.578
Team Quality x Age Group:	Worse-ranked x U17 *vs* Worse-ranked x U23**	1.709 (0.596)	1.717	5.526	17.783
	Worse-ranked x U19 *vs* Worse-ranked x U23	0.493 (0.544)	0.563	1.638	4.760
	Similar-ranked x U17 *vs* Similar-ranked x U23	0.412 (0.417)	0.667	1.510	3.416
	Similar-ranked x U19 *vs* Similar-ranked x U23*	1.043 (0.427)	1.228	2.837	6.556

Model $\chi^2(50) = 416.888$, $p \leq 0.001$. Pseudo $R^2 = 0.149$ (Cox & Snell), 0.153 (Nagelkerke), 0.045 (McFadden).
Note: * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.

the reference, the likelihood of scoring a goal at home decreased by 38.1% in the last period (76 min–full-time) when compared to playing away ($p = 0.001$), which suggests that home teams tend to score more goals in the early stages of matches. The chances of scoring critical goals (*vs* non-critical) decreased throughout the matches, as youth Portuguese teams were 68.3%, 82.1%, 86.2%, 90.5%, and 93.4% less likely of scoring critical goals in the second, third, fourth, fifth, and sixth match periods ($p < 0.001$), respectively.

Regarding the *age group*, the scoring probabilities of younger teams (U17) decreased by 55.6% in the third period ($p = 0.002$), 61.7% in the fifth period ($p < 0.001$), and 62.1% in the last period ($p < 0.001$), when comparing with the older teams from this sample (U23). Similar results were found for the U19 teams (*vs* U23 teams) since the odds of goal-scoring events decreased by 63.7%, 66.8%, and 66.5% in the third, fifth, and sixth match periods ($p < 0.001$), respectively. In short, the U23 teams seem more propense to score in the last 15 minutes (plus additional time) than in the initial stages of matches.

Noteworthy, the effect of *age group* was superseded by the interaction of this factor with *team quality*. This interaction disclosed that, when in the presence of worse-ranked teams, the U17s had significantly greater chances of scoring than the U23s in all match periods comparing with the first one, i.e., 397.8%% in the second period ($p = 0.01$), 519.3% in the third ($p = 0.003$), 285.7% in the fourth ($p = 0.036$), 947.7% in the fifth ($p < 0.001$), and 452.6% in the last period ($p = 0.004$). The probabilities of scoring in the third and fifth periods also increased by 198.3% ($p = 0.043$) and 211% ($p = 0.011$), respectively, for worse-ranked U19 teams relative to worse-ranked U23s. When the analysis was restricted to teams with similar strength, the U17 teams were 213.9% more likely to score in the fifth period than the U23s ($p = 0.01$). At the same time, the U19s were 364.9% and 183.7% more likely to score in the fifth ($p = 0.001$) and sixth ($p = 0.015$) match periods, respectively, than the U23 teams of identical quality.

Discussion

Scoring goals is the only way to win a game in football; we can state that the goal constitutes the apogee of this sport and should be the object of detailed research. The scarcity of studies discussing this topic in youth football led to this work. Furthermore, the evident deficit of literature regarding the effects of situational variables on the temporal distribution of goal-scoring events in football also presents challenges to understanding the goal-scoring phenomenon at all levels of play. Hence, the present study aimed to analyse how situational variables affect the goal-scoring period in the regular phases of Portuguese U17, U19, and U23 national championships, contested during the 2019/2020 season. Subsequently, considering the notion of "game criticality" initially proposed by Ferreira et al. (2014), the distinction between "critical goal" and "non-critical goal" allowed us to examine whether the critical moments of the football game vary according to the *age group*.

Overall, there were more goals in the last match period (76 min–full-time), while the opposite was observed in the opening period (1–15 min). This result is in line with previous research (Aguado-Méndez, et al., 2020; Armatas, et al., 2009; Evangelos, et al., 2018; Njororai, 2014; Leite, 2017), and it has been attributed to the onset of physical and mental fatigue (Izzo, et al., 2020; Mohr, et al., 2003; Smith, et al., 2018), and to the need to change the scoreline by applying riskier attacking approaches (González-Rodenas, et al., 2020; Njororai, 2014; Pratas, et al., 2018). Interestingly, the highest proportion of critical goals occurred in the first half (57.8%), particularly during the first 15 minutes (22.3%); in turn, the frequency of non-critical goals progressively increased across the six periods. An identical trend was found in the UEFA Champions League (Carmo, et al., 2021) with the "effect of scoring first" supporting its relevance, i.e., teams that scored the first goal won approximately 62–76% of matches in major European

leagues (Armatas, et al., 2009; Fernández-Cortés, et al., 2022; Lago-Peñas, et al., 2016; Martínez & González-García, 2019). At the very least, these findings challenge the common belief that the last 15 minutes (plus additional time) is the most critical phase of the game (Leite, 2013; Njororai, 2014).

In this study, we employed different inferential statistics (bivariate and multivariate) so that the results attained were as robust as possible. Home teams scored more goals throughout the matches, except in the last period. Both statistical methods revealed a significant effect of *match location* on the *goal-scoring period*. Our results showed that home teams scored more goals in the early stages of matches, which tend to be more critical for the match outcome (Caballero, et al., 2017; Carmo, et al., 2021; Martínez & González-García, 2019), and that is when players experience the most demanding passages of play (Oliva-Lozano, et al., 2021). Recent studies have indicated that home teams are more likely to score goals and win matches irrespective of their age group or competitive level (amateur, semi-professional, and professional), a phenomenon known as the "home advantage effect" (Almeida & Volossovitch, 2017; Fernández-Cortés, et al., 2022; Staufenbiel, et al., 2018). As expected, the number of home goals surpassed the away goals in the analysed age groups (U17, 51%; U19, 54.4%; U23, 53%); however, the extent to which the home advantage effect increases with age (Staufenbiel, et al., 2018) should be scrutinised in future studies.

Usually, playing against even teams determines more goals being scored in the last match periods due to the accumulated fatigue and loss of concentration (Njororai, 2014), while better-ranked teams tend to score more goals in the early stages of matches. Prior research that analogously defined the variable *team quality* (e.g., Lago-Peñas, et al., 2016; Zhou, et al., 2019) showed that the best teams had more offensive behaviours and goal-scoring opportunities. Even though the *team quality* (relative to the opponent) by itself did not affect the distribution of goals across the match periods, the strength differential between teams is typically a relevant predictor of match outcome, final league standings and team performance, both at high-performance levels (Fernandez-Navarro, et al., 2018; García-Rúbio, et al., 2015; González-Rodenas, et al., 2020) and in youth football (Caballero, et al., 2017; Jaime, et al., 2022). In high-performance football, the quality of opposition seems to have less impact on match outcome when compared to youth football (Caballero, et al., 2017), a trend that may derive from the lower competitive balance characterising younger football competitions. At higher competitive levels (e.g., professional), each match is prepared to the smallest detail, including a considerable knowledge of the opposing team's strengths and weaknesses and the adversities expected in a competitive match environment (Almeida & Volossovitch, 2017). The underdeveloped tactical and psychological skills probably make younger footballers more predisposed to performance variations due to contextual interferences.

In fact, the distribution of goals throughout the match was not homogeneous across the different age groups. Although more goals were scored in the last period in U17, U19, and U23 national championships, the proportion of goals scored in the other periods differed. For example, while the U17s scored fewer goals in the second period (16–30 min), the U19s and U23s did so in the third (31 min–half-time) and first periods, respectively. The older teams tended to score more often during the last period relative to the early minutes of matches. Distinct levels of competitive balance and players' expertise might have originated such disparity, even acknowledging the non-significant interactive effect of *goal criticality* and *age group* on the distribution of goals scored in Portuguese youth football. Bearing in mind the image of a funnel can help to illustrate part of these results; as the funnel narrows, the least competent players in coping with increasing competitive demands (and associated contextual pressure) are weeded out of the path to professional football (Almeida & Volossovitch, 2017; Pollard & Gómez, 2015). In other words, as players progress through their careers, success during competitive matches is apparently more challenging.

The interaction *team quality* x *age group* significantly affected the *goal-scoring period*. This finding suggests that when team ability is equated, U17 and U19 worse- and similar-ranked teams are more prone to score (critical and non-critical goals) as the match unfolds and, mainly, in later match periods in comparison with the first one. On the other hand, the scoring dynamics of U23 teams against stronger or even opponents were more homogenous over the six periods. Data also showed that U23 teams of lower or similar quality scored more often during the match, further substantiating our supposition that the competitive balance increases with age. Regardless of situational circumstances, it is plausible to assume that U23 lower-ranked teams might be technically, tactically, physically, and mentally capable of keeping the match open (tied

or losing/winning by one goal) for longer periods of time (Izzo, et al., 2020; Smith, et al., 2018), enhancing the uncertainty associated with the match outcome. Together, all facts confirmed our initial expectation: the goal-scoring events produced by U23 teams seem to rely less on situational influences during competitive match-play.

This study merits due to its dynamic multifactorial approach to the problem of goal-scoring criticality in youth football. It furthers the comprehension of the underlying subtleties of football performance and scoring dynamics across different age groups, hopefully translating into improved coaching practices. Nonetheless, the present findings should be weighed in light of a few limitations. First, we only analysed one season of youth national championships in Portugal. Given that the features of goal-scoring events may change over several seasons (Wunderlich, et al., 2021), the generalisation of these findings to other seasons in this and other countries must be exercised with caution. Second, the *goal criticality* was defined by only considering the evolving scoreline in a match. Thus, the extent to which a non-critical goal can affect the final league tables (e.g., goals for, goal difference) was not addressed. Third, the proposed categories for the *match period* could not have the same length (15-min) as the third and sixth periods included the additional time awarded by the match officials. While a methodological bias might arise, this classification is popular amongst researchers (e.g., Carmo, et al., 2021; Evangelos, et al., 2018; Wunderlich, et al., 2021), and the statistical comparisons performed are robust to differences in absolute frequencies across the match periods.

Given the aforesaid limitations, future research should comprise a larger sample of goals from multiple seasons and youth domestic or international competitions. Additionally, forthcoming studies should not only set the *match outcome* as the dependent variable, but also comprise performance-related data. The use of number of passes, shots, crosses, ball possession, match situations leading to goals (open play or set piece; numerical relations), among other aspects, can contribute decisively to unveil new insights on how criticality emerges in football.

Practical implications

Based on the current findings, several practical recommendations can be provided to youth football coaches:

- Regardless of *age group* and *match location*, youth teams – particularly the stronger ones – should try to score the opening goal as soon as possible, since scoring first (critical goal) is highly correlated with favourable match outcomes.
- When teams face clearly superior opponents, adopting a more defensive playing style in the early stages of matches is recommended, yet never disregarding the intention to exploit adversaries' defensive imbalances or distractions through counterattacks or set pieces.
- At younger ages, the development of attentional strategies (e.g., awareness of teammates/opponents' positioning through scanning, identification of key environmental cues – where is the free space? –, recognition of possible affordances in different playing areas), team cohesion, aggressiveness, and proper use of substitutions can diminish the adverse effects of fatigue and other external influences in competitive matches.
- Particularly in older age groups, where the competitive balance appears to increase, it seems paramount to better prepare (technically, tactically, physically, and mentally) the players to maintain high-performance levels towards the end of matches.
- Playing-form practice tasks, such as small-, medium- or large-sided and/or conditioned games, should resemble the contextual environment encountered in competitive match-play (principle of specificity) so that achieving/preventing a critical goal is grounded on individual and collective behaviours adapted to the game demands.

Conclusion

We found that critical goals were mostly scored during the first match periods by analysing the effects of multiple situational variables on the temporal distribution of goals in Portugal's U17, U19, and U23 national football competitions. However, the chances of scoring (critical and non-critical goals) in the last match period were significantly greater for the U23 teams, which possibly reflects a higher competitive balance and a noticeable detrimental effect of fatigue in this age group. The effect of *age group* associated with *team quality* showed a more irregular scoring pattern throughout the match in U17 and U19 worse- and similar-ranked teams than in the U23s. Apparently, older teams rely less on contextual influences during competitive match-play. Furthermore, teams playing at home or against weaker

opponents tend to score more critical goals early in the match, making these teams more likely to win. The present results have implications for football training at the development stages since national-level competitive matches can present distinct goal-scoring dynamics as a function of *age group*.

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