

Linear speed and spatial dynamics as key determinants of goal creation in elite women's soccer

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Abstract:

Although the professionalization and athletic development of elite women's football have progressed rapidly, empirical knowledge of the high-intensity physical actions and spatial mechanics preceding goal-scoring opportunities remains limited. This study examined the physical demands, spatial origins, and tactical characteristics of all 83 goals scored during the 2022 UEFA Women's European Championship. Video footage was analyzed using Hudl Sportscode to classify explosive movements (including straight-line sprints, change-of-direction sprints, jumps, and rotations) and to identify the spatial zones occupied by assisting and scoring players. Multinomial goodness-of-fit tests and K-modes cluster analysis were performed to identify dominant scoring profiles. Results demonstrated that powerful physical actions were executed in 67.5% of assisting plays and 92.8% of finishing actions. Linear straight sprinting emerged as the predominant high-intensity action for both assisters (44.6%) and scorers (45.5%). Spatially, 57.8% of goals were finished from Zone 4 (central penalty area between 6 and 18 yards), with ground-based finishes following a straight sprint representing the most successful scoring method (59.0%). Cluster analysis identified five distinct tactical profiles, headed by first-half goals born from organized open play involving linear sprint finishes without a direct assist. Integrating recent international benchmarking data (2025–2026), these findings confirm that linear speed, explosive power, and rapid acceleration represent universal biomechanical triggers in modern elite football. Practitioners must design training protocols that couple maximal velocity and acceleration development with match-specific tactical scenarios, specifically targeting the generation and defense of central attacking opportunities.

Key Words: football, performance analysis, k-modes cluster analysis, high-intensity actions, linear sprinting.

Introduction

Women's international football has entered a transformative era characterized by exponential commercial growth, professionalization, and unprecedented technical-tactical refinement (Ayuso-Moreno et al., 2020; FIFA, 2023). Longitudinal analyses of over 13,000 professional matches from 2020 to 2025 indicate that elite women's football is undergoing a rapid modernization process, marked by higher passing volume, increased passing accuracy under defensive pressure, and greater physical intensity (Carstens et al., 2025). As playing standards escalate, identifying the precise mechanical, physical, and spatial determinants that lead to goal creation has become a central priority for sports scientists and performance analysts (Iván-Baragaño et al., 2025).

Early performance analysis research in women's football established that successful offensive strategies relied primarily on possession retention, structured team organization, and crossing from wide areas (Mara et al., 2012; Scanlan et al., 2020). Further analysis of international tournaments reinforced the importance of quick ball movement during open play, with successful attacking phases often developing rapidly within penalty box areas (Maneiro et al., 2022; Wang & Qin, 2020; Kubayi & Larkin, 2020). However, contemporary match-play places elevated physical demands on athletes, requiring a complex interplay of endurance, multidirectional agility, explosive power, and repeated sprint abilities (Soroka & Lago-Peñas, 2016).

While extensive literature in male football has identified linear sprinting and high-velocity movements as crucial precursors to goal-scoring (Faude et al., 2012; Schulze et al., 2022), research explicitly linking technical-tactical event tagging with high-intensity biomechanical actions in elite female international tournaments remains limited. Recent investigations in domestic leagues have underscored the frequency of explosive movement patterns in goal situations. Martínez-Hernández et al. (2023) discovered that linear advancing motion, decelerations, and turns constitute dominant player involvements immediately preceding goals. Furthermore, Martínez-Hernández and Jones (2024, 2026) revealed a stable biomechanical movement cycle preceding goals—characterized by linear advancing motion → deceleration → turning → linear advancing

motion—accounting for nearly a quarter of all pre-goal involvements in both the English Premier League and Women's Super League.

At the international level, multi-tournament evidence from six FIFA World Cups analyzed by Daly et al. (2025) established that while movement types leading to goals are remarkably consistent across biological sexes, female players perform a significantly higher proportion of these pre-goal actions at maximal high intensity compared to males. Despite these insights, a crucial knowledge gap persists regarding how specific high-intensity physical actions (e.g., straight linear sprints, change-in-direction sprints, jumps, rotations) interact with zonal origin, assist type, match timing, and overall tactical structure during major European international tournaments. Therefore, the primary objective of this study was to analyze the relationship between high-intensity physical demands and technical-spatial indicators across all 83 goals scored during the 2022 UEFA Women's European Championship, employing multinomial statistical modeling and unsupervised K-modes cluster analysis (Clavijo et al., 2024). A secondary objective was to contextualize these findings within the latest 2025–2026 empirical literature to provide an evidence-based blueprint for physical preparation and tactical periodization in elite women's football.

Materials & methods

Match Sample

The sample of the current study consisted of a total of 83 goals from 31 matches scored in UEFA Women's Euro 2022 tournament (eight penalty kicks and four own goals were excluded). The competition was held in England during 6-31 July, 2022, and featured 16 teams, divided into four groups of four teams. The top two teams from each group advanced to the quarterfinals, which were followed by the semi-finals and the final.

Procedures

All matches were downloaded from Wyscout (Hudl, NE, USA). Game footage was analyzed using Hudl Sportscode software (Hudl, NE, USA) and a coding window was specifically designed within Sportscode to capture key game indicators (Figure 1). Following coding, each match's data was exported as an XML file containing all coded variables in chronological order. To ensure the coding system's reliability, a pilot test was conducted on a representative sample of ten goals scored, which constituted 10% of the total dataset. This pilot test allowed for the refinement of the coding scheme before full-scale data collection commenced. Based on the Belmont Report (1978), the use of publicly available images for research purposes does not require informed consent or ethical committee approval.

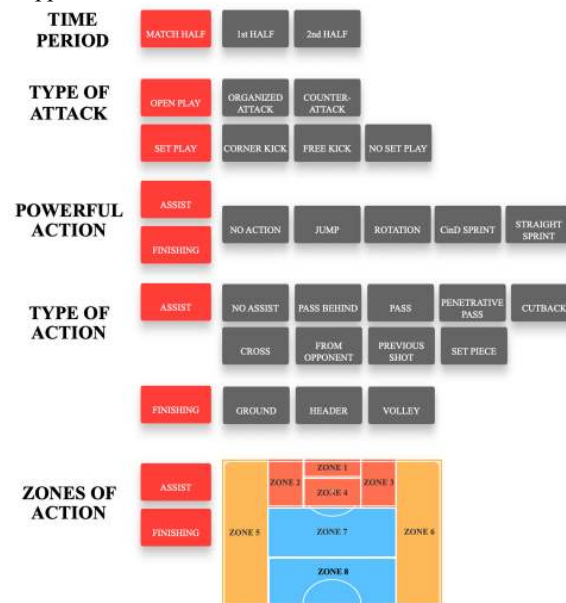


Figure 1. Interface of the Sportscode coding template utilized for the systematic observation of zonal origins, physical demands, and technical finishing characteristics

An observational instrument for analysis (Table 1) was developed based on previous theoretical framework, criteria and categories compiled empirically in other observational studies, and novel criteria tested in this work. Subsequently, an ad hoc observational instrument, consisting of field format and category systems (Anguera, Blanco & Losada, 2001). The following variables were recorded for each match: 1) type of attack, 2) type of open play, 3) type of set play, 4) time period, 5) type of powerful action for assist, 6) type of powerful action for finishing, 7) assist zone, 8) finishing zone, 9) type of assist and 10) type of finishing. Table 1 shows the criteria and definitions of these variables.

Table 1. Observational instrument utilised for analysis

Variables	Criteria and definition
Type of attack (Mara et al., 2012; Scanlan, 2020)	Open play: Open play refers to all instances where the ball was in play and the possession developed organically through player actions such as passing, dribbling, or winning tackles. Open play encompassed any possession that did not originate from a free kick, corner kick, penalty kick, offside, kick-off, or throw-in. Additionally, it included possessions that, while originating from one of these set plays, occurred more than 10 seconds after the set play was executed. Set play: A set play refers to a possession that originated from a free kick (direct or indirect), corner kick, penalty kick, offside, kick-off, or throw-in. This definition includes possessions that occurred within 10 seconds of the set play being executed. Essentially, it encompasses any situation where the attacking phase directly stems from a pre-defined restart of play.
Type of open play (Mara et al., 2012; Scanlan, 2020)	Organized attack: 1) The possession started by winning the ball in play or restarting the game, 2) the progression towards the opponent's goal had high percentage of non-penetrative and short passes and long duration (evaluated qualitatively) or long passes, as well as 3) this kind of possession allowed the opponent to have more opportunity to minimize surprise, reorganize his system and be prepared defensively. Counter-attack: 1) The possession starts by winning the ball in play, 2) the first or second player in action tries to penetrate using penetrative passes or dribbles, 3) the progression towards the opponent's goal has high percentage of penetrative passes and short duration (evaluated qualitatively) as well as 3) this kind of possession tries not to allow the opponent to have opportunity to minimize surprise, reorganize his system and be prepared defensively.
Type of set play (Mara et al., 2012; Scanlan, 2020)	No Set Play: Goal was scored from open play, not a direct set piece. Corner Kick: Goal was scored from a direct attempt from a corner kick (including subsequent touches in quick succession). Free Kick: Goal was scored from a direct attempt from a free kick (including subsequent touches in quick succession).
Time period (Mara et al., 2012; Scanlan, 2020)	1st half: the goal was scored during the first half of the match, including stoppage time. 2nd half: the goal was scored during the second half of the match, including stoppage time.
Type of powerful action for assist and finishing (Faude et al., 2012)	Change-in-direction sprint (CinD sprint): This category defines a high-intensity run characterized by two distinct and rapid changes in direction. A true CinD sprint requires a clear shift in momentum exceeding 50 degrees from the initial sprint line. This shift must be accompanied by a second identifiable acceleration phase in the new direction. Slightly curved runs lacking a distinct second acceleration are not considered CinD sprints and fall under the category of linear sprints. Jump: This category defines a jump as a primary movement focused on gaining height with minimal horizontal movement (e.g., headers or jumping tackles). The jump should have a clearly identifiable take-off point where the player leaves the ground and a flight phase where they are airborne. Rotation: This category assessed rotations where a player's torso (including the hips) pivoted around their vertical center line. A complete rotation required at least 90 degrees of movement with the entire torso. Rotations involving only the upper body (without hip movement) were not counted. Straight (linear) sprint: This refers to a high-intensity run performed at near-maximal speed in a straight line following a clear acceleration phase.
Assist and finishing zone (Rathke, 2017)	Assist zone: The area of the field where the final pass leading to a goal is made. Finishing zone: The area of the field where a player attempts to score a goal. These variables are further categorized into 8 specific zones, as presented in Figure 3.
Type of assist (Durlík & Bieniek, 2014)	No assist: Goal was scored without a final pass from a teammate. This could include individual action, long shots etc. Pass behind: A pass played behind the defense for a teammate to run onto and score. Cross: Delivery of a ball from the side of the pitch across to the front of the goal to provide a direct final attempt. Cutback: a pass back from the near the goal line. Penetrative pass: a pass towards the opponent's goal past the opponent player(s). Pass: Any type of pass from a teammate that directly sets up a scoring opportunity, not included previously. Previous shot: A shot taken by a player that is saved or blocked by the goalkeeper or defender, but the rebound is collected by another player and scored. From opponent: A goal that is scored as a direct result of a mistake by an opposing player, such as a misplaced pass, a poor clearance etc. Set play: A goal that is scored directly from a restart of play, such as a free kick, corner kick, or penalty kick.
Type of finishing (Gonzalez-Rodenas et al., 2020)	Ground: the ball carrier shoots at the goal while the ball is on the ground. Header: the ball carrier shoots at the goal while the ball is in the air by heading the ball. Volley: the ball carrier shoots at goal while the ball is in the air by using one single contact to the ball.
No Action	A goal scored where an assisting pass is not made (goalkeeper spilling a shot into the path of another attacker) or where the goal scorer does not produce a powerful action (a static, unmarked player receives a pass and finishes past the goalkeeper).

Reliability

Prior to coding, four two-hour training sessions were conducted for the two observers to ensure consistency with respect to the coded definitions. In these sessions, 25 goals were recorded using the criteria of (Losada & Manolov, 2015) and mutual agreement (Arnau, Anguera & Gomez, 1990) was required, such that recording was only done when there was full agreement between the two observers. Four weeks after the initial recording, 25 randomly selected goals were re-recorded (Altman, 1990). This resulted in a percentage higher than the recommended 10% (Tabachnick, Fidell & Ullman, 2007). To ensure inter- and intra-observer reliability of the data, Cohen's kappa coefficient (Cohen, 1960) was calculated for each criterion (Table 2), revealing almost perfect agreement (Fleiss, Levin & Paik, 2013).

Table 2. Inter-observer and intra-observer agreement.

Variable	Inter-observer agreement	Intra-observer agreement
Type of attack	1.00	1.00
Type of open play	0.96	0.92
Type of set play	1.00	1.00
Time period	1.00	1.00
Type of powerful action for assist	0.84	0.77
Type of powerful action for finishing	0.82	0.75
Assist zone	0.94	0.88
Finishing zone	0.95	0.90
Type of assist	0.87	0.81
Type of finishing	0.93	0.89
K_{total}	0.93	0.89

Statistical analysis

To examine the distribution of categorical variables related to goal-scoring events, we employed a multinomial test, which allowed us to assess the distribution of variables such as the type of assist and the type of powerful action performed by the assisting and scoring players. For each categorical variable, expected frequencies were set to be equal across categories (i.e., uniform distribution), because we had no a priori reason to assume certain categories would be more frequent. To identify significant goal-scoring patterns, we conducted a K-modes cluster analysis in Python (kmodes, scikit-learn). K-modes is an unsupervised machine-learning technique well-suited for clustering categorical variables, enabling the identification of common patterns in goal-scoring characteristics based on categorical attributes.

The variables selected for use in the cluster analysis included, Type of attack (Open play /set play), Type of open play (Organised attack, counter-attack), Type of set play (No Set play, Corner kick, Free kick), Time period (1st half, 2nd half), Type of action - assist (Rotation, CinD Sprint, No action, Straight sprint), and Type of action – scorer (Jump, CinD, No action, Straight sprint). These variables were chosen because they represent the key tactical, situational, and primary physical actions that can form distinctive goal scoring patterns.

To determine the appropriate number of clusters, scree plots were used to visualize the total within-cluster distance for different cluster counts (k). The ‘elbow method’ was applied, allowing us to identify the point where further increases in k no longer significantly reduced within-cluster variance. We tested k from 2 to 8 clusters and plotted the total within-cluster distance.

We identified an ‘elbow’ at k=5, after which increasing the number of clusters produced minimal additional reduction in within-cluster variance. Of the 83 goals, four could not be assigned to the main clusters because they each formed a single-member outlier cluster. This approach enabled us to capture the key patterns in goal-scoring scenarios by grouping similar goal events to understand the typical combinations of play types, player actions, and timing that led to successful goals.

Results

A total of 83 goals were scored during the 2022 Women’s European Championships. Among these, 56 goals (67.46%) involved a powerful action by the assisting player, while 77 (92.77%) included a powerful action by the goal-scorer. A multinomial test revealed a statistically significant distribution in the type of action for assisting player ($\chi^2(4) = 52.241$, $p < 0.001$) (Figure 2).

Among the powerful actions performed by assisting players, straight sprints were most common, accounting for 44.64% (25/56) of actions, followed by rotations at 26.78% (15/56). Similarly, the type of action for finishing was statistically significant ($\chi^2(4) = 47.181$, $p < 0.001$). Straight sprints were again predominant, used by goal-scorers in 45.45% (35/77) of cases, followed by jumps at 33.76% (26/77) (Figure 2).

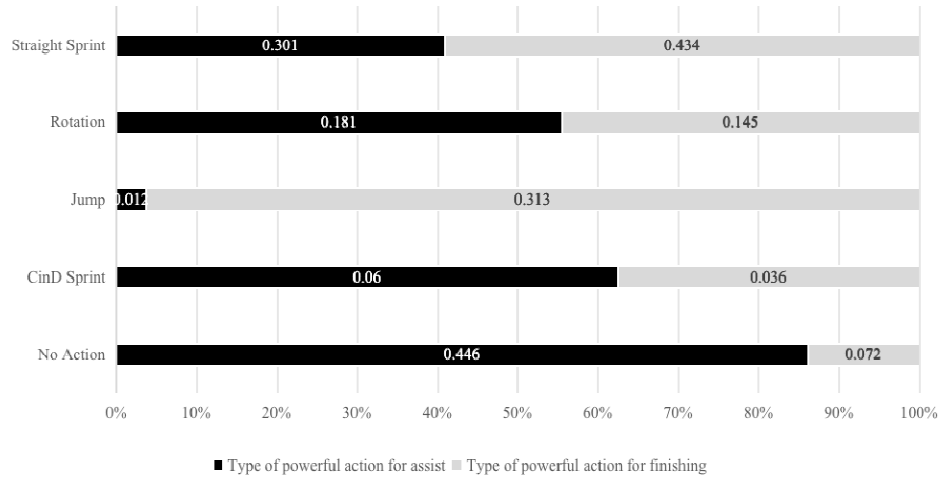


Figure 2. Frequency distribution of powerful physical actions performed by assisting and scoring players prior to goal achievement.

With regards to the assist zone (Figure 3a), a multinomial test revealed a statistically significant distribution of goals across assist zones ($\chi^2(8) = 25.920$, $p < 0.001$), indicating that assists were not uniformly distributed. Notably, 63/83 (75.90%) of goals were scored without a direct assist (Table 3).

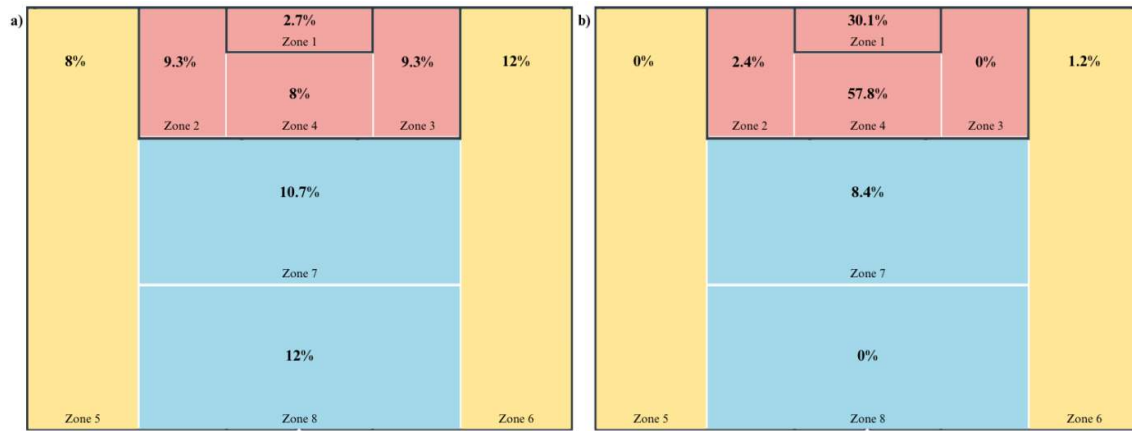


Figure 3. Spatial distribution of goal-scoring opportunities: (a) Zonal origin of the final assisting action and (b) Finishing zones of goals scored.

Table 3. Multinomial test results of assist zone and finishing zone.

	Assist zone	Finishing zone
No assist (0)	0.280	-
Zone 1	0.027	0.301
Zone 2	0.093	0.024
Zone 3	0.093	0.000
Zone 4	0.080	0.578
Zone 5	0.080	0.000
Zone 6	0.120	0.012
Zone 7	0.107	0.084
Zone 8	0.120	0.000

A multinomial test for the finishing zone (Figure 3b) also revealed statistical significance ($\chi^2(4) = 96.699$, $p < 0.001$). Centrality and proximity to goal meant that zone 4 was the most prevalent zone with 48/83 (57.83%) of the goals being scored from within this area, an area between 6 and 18 yards from goal. Zone 1 was the second most prevalent zone with 25/83 (30.12%) goals scored from within the 6-yard box (Table 3).

A multinomial test for the type of assist (Table 4) revealed statistical significance ($\chi^2(8) = 45.928$, $p < 0.001$). Set plays and crosses were the most common types of assists. 21 of the 83 goals (25.3%) were scored from set plays, and 21 of the 83 goals (25.3%) were scored from crosses. This highlights the importance of wide/wing play and set play situations at the tournament.

Table 4. Multinomial test results of type of assist.

Type of Assist	Observed	Expected	95% Confidence Interval	
			Lower	Upper
Set play	0.241	0.111	0.154	0.347
Cross	0.253	0.111	0.164	0.360
Cutback	0.072	0.111	0.027	0.151
From opponent	0.157	0.111	0.086	0.253
No assist	0.036	0.111	0.008	0.102
Pass	0.108	0.111	0.051	0.196
Pass behind	0.048	0.111	0.013	0.119
Penetrative	0.072	0.111	0.027	0.151
Previous shot	0.012	0.111	3.050x10 ⁻⁴	0.065

A multinomial test for the type of finishing (Table 5) revealed statistical significance ($\chi^2(2) = 30.530$, $p < 0.001$). Ground finishes were the most common, with 49/83 (59.03%) scored from this method.

Table 5. Multinomial test results of type of finishing.

Type of Finishing	Observed	Expected	95% Confidence interval	
			Lower	Upper
Ground	0.590	0.333	0.477	0.697
Header	0.313	0.333	0.216	0.424
Volley	0.096	0.333	0.043	0.181

A K-modes cluster analysis, visualized in Figure 4, revealed five distinct clusters of goal-scoring patterns based on categorical variables. Cluster 1, the most frequent, comprised goals from organized open play in the first half, typically involving a straight sprint finish and no assisting action. Conversely, Cluster 5, the least frequent, featured goals from counter-attacks in the second half, where the assister made a straight sprint and the scorer finished with a jump. Set-piece goals, specifically from corners in the second half, characterized Cluster 4, while Clusters 2 and 3 highlighted variations of open play goals in different halves and play phases. These clusters underscore the diverse tactical scenarios leading to goals and emphasize the impact of play type, timing, and player actions on goal-scoring patterns within the tournament.

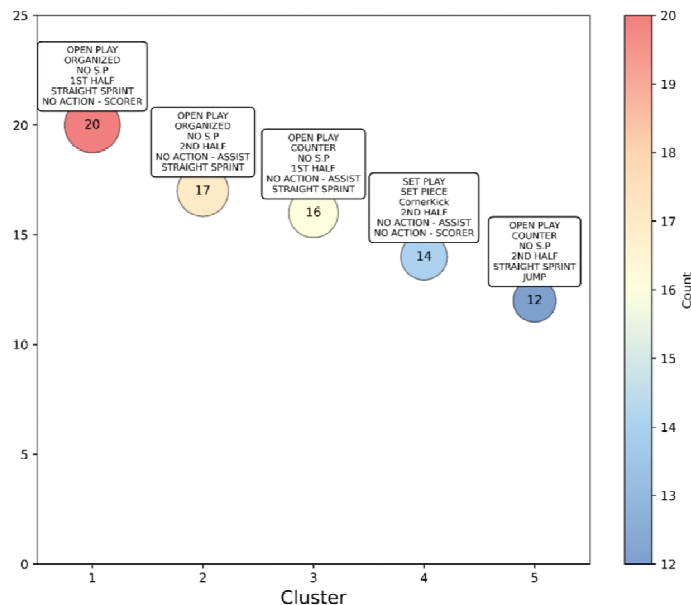


Figure 4. K-modes cluster analysis of goal-scoring patterns, categorizing tactical scenarios by match half, phase of play, and physical actions of assisting and scoring players.

Discussion

The primary objective of this investigation was to identify and analyze the powerful physical actions associated with assisting and scoring goals at UEFA Women's Euro 2022. A central finding is that elite women's international football is defined by explosive, high-intensity physical outputs during decisive offensive moments. Of the 83 goals scored at the tournament, 56 (67.46%) involved a powerful physical action during the assist phase, highlighting the vital necessity of developing explosive qualities in attacking players to create goal-scoring opportunities. Furthermore, an overwhelming majority of finishing actions, 77 out of 83 goals (92.77%), required a powerful physical action by the goal-scorer immediately prior to shooting. Among these, straight sprinting was the single most prevalent action performed by both assisting players (44.64%) and goal-scorers (45.45%). This indicates that the linear speed of an attack is a paramount determinant of success in women's international football. These findings align closely with foundational research in male professional football, where straight sprinting was identified as the dominant physical action preceding open-play goals (Faude et al., 2012; Schulze et al., 2022). Furthermore, our results strongly mirror recent benchmark data across six FIFA World Cups by Daly et al. (2025), who demonstrated that linear advancing movement (~41%) is the predominant action preceding goals in elite football across both sexes. Crucially, Daly et al. (2025) established that female players execute a significantly higher proportion of their pre-goal actions at maximal high intensity (53.0%) compared to male counterparts (47.9%), underscoring that top-speed sprinting and acceleration capacity are fundamental triggers for goal creation in modern women's football.

The physical mechanics of goal creation must also be evaluated within the broader context of fluid movement, curvilinear sprints, and multidirectional agility (Caldbeck & Dos' Santos, 2022). Attackers frequently execute high-velocity accelerations to create separation from defenders or to sprint onto final passes in tight spaces. Physiological World Cup validation data by Vasquez-Bonilla et al. (2026) provide direct physiological support for our observational findings: 40-meter laboratory sprint velocity was strongly predictive of both top match speed and distance covered at velocities exceeding 23 km/h ($r^2 = 0.751 - 0.872$), while short 10-meter acceleration times associated significantly with decisive tactical actions on the pitch, such as 'step-ins' and defensive interceptions ($r^2 = 0.488 - 0.758$). This provides empirical confirmation that an athlete's physical speed reserve directly dictates their capacity to execute decisive high-intensity match actions. From a movement sequencing perspective, Martínez-Hernández & Jones (2026) analyzed goal-scoring involvements in professional football, identifying a highly stable movement cycle, linear advancing motion > deceleration > turn > linear advancing motion, that accounts for nearly a quarter of all pre-goal involvements, illustrating how attackers evade defensive pressure before re-accelerating to finish.

Regarding the spatial origin of goal creation, 63 of the 83 goals (75.90%) in UEFA Euro 2022 involved a direct, quantifiable assist. Zonal analysis revealed that assisting passes were distributed across the attacking half, though Zones 6 and 8 (the right-wing and central-midfield attacking areas, respectively) emerged as the most frequent assist origins, each accounting for 12.00% of direct assists. Delivering the final pass from a deep midfield or right-wing position affords the goal-scorer sufficient space and time to execute a 'sprint-onto' run. These findings complement prior research in women's international football, which demonstrated that successful attacking possessions frequently originate from central and attacking midfield sectors, where ball retention and spatial manipulation create favorable conditions for penetrating passes (Maneiro et al., 2021, 2022; Scanlan et al., 2020). Conversely, wider assist zones inside the final third require precise delivery to bypass organized defensive blocks.

In terms of finishing location, centrality and proximity to the goal were the decisive factors for goal achievement. Zone 4, the central penalty area between 6 and 18 yards from the goal line, was by far the most prevalent finishing zone, accounting for 57.83% (48/83) of all goals scored. Zone 1 (the 6-yard box) produced 30.12% (25/83). Combined, central penalty area finishes represented 87.95% of all tournament goals, whereas wide areas yielded virtually no goals (Zone 2: 2.41%; Zone 3: 0.00%). This extreme spatial concentration reinforces the principle that central proximity maximizes shooting angles and reduces reaction time for goalkeepers, significantly increasing shot efficiency. This spatial pattern is strongly supported by domestic league analyses in elite European women's clubs (Mesquita et al., 2023), international women's tournament studies (Wang & Qin, 2020; Iván-Baragaño et al., 2025), and men's tournament research (Cerdeña et al., 2021; Smith & Bedwell, 2021). Tactical periodization must therefore prioritize manipulating opposition defensive structures to penetrate central penalty box areas.

Analysis of assist types revealed that set plays and crosses were the two most prominent delivery mechanisms, each accounting for 25.30% (21/83) of total tournament goals (and collectively representing 65.08% of directly assisted goals). The high efficacy of crosses and set-piece routines highlights the critical role of wing play, delivery quality, and aerial coordination in elite women's international competitions. This mirrors findings from men's Euro 2020, where central penalty area finishes following wide deliveries or restarts represented the primary scoring pathway (Smith & Bedwell, 2021). Additionally, goals resulting directly from opposition turnovers ('from opponent') accounted for 10.84% of assists, emphasizing the utility of high-intensity defensive pressing to force unforced errors in the opposition's defensive third.

Ground finishes emerged as the most successful shooting technique, accounting for 59.03% (49/83) of all goals, significantly outperforming headers (31.33%) and volleys (9.64%). When ground finishing is analyzed in conjunction with physical action and zonal origin, a clear mechanical coupling emerges: ground shots executed following a straight linear sprint into central Zone 4 represent the most lethal goal-scoring sequence in elite women's football. Because attackers are sprinting at high velocity when approaching the ball, ground finishes allow for controlled power and directional placement into the corners of the net, making them particularly difficult for goalkeepers to save. Rapid ground-based ball progression and linear velocity, rather than aerial bombardment, drive goal-scoring success in modern international tournaments.

To identify complex interaction patterns among tactical, situational, and physical variables, an unsupervised K-modes cluster analysis was conducted (Clavijo et al., 2024). The algorithm revealed five distinct goal-scoring profiles. Clusters 1 and 2, which represented the most frequent scoring patterns, were both characterized by organized open-play attacks featuring straight sprint actions. Overall, 81.93% of goals originated from open-play situations across Clusters 1, 2, 3, and 5, with straight sprinting serving as the primary physical catalyst.

This open-play dominance aligns with longitudinal data across 13,000 professional matches from 2020 to 2025 (Carstens et al., 2025), which demonstrated a sport-wide shift toward possession-based build-up and high-pressure tactics in women's football. It is also consistent with continental analyses by Zakarneh et al. (2026), who reported that open play accounted for 70.42% of goals in major international championships. Notably, Zakarneh et al. (2026) demonstrated that reliance on set-piece situations increases significantly during knockout stages ($p = 0.005$) and second halves ($p = 0.010$) due to heightened competitive pressure, a contextual dynamic reflected in our Cluster 4 profile (second-half set pieces).

Several methodological limitations of the present study should be acknowledged. First, the identification of 'powerful' physical actions relied on systematic visual video inspection. While this visual notation methodology is well-established in football performance literature (Faude et al., 2012; Schulze et al., 2022), subjective interpretation was minimized through a rigorous reliability protocol yielding near-perfect agreement ($\kappa = 0.82 - 1.00$; Casal et al., 2023). Second, the sample was restricted to a single international tournament (UEFA Women's Euro 2022), which may limit the direct generalizability of the findings to other confederations or World Cup competitions. Third, goals represent rare events in match-play and do not capture all offensive chances created. Future research should integrate broader performance metrics, such as expected goals (xG), shot execution uplift, and final-third entries, while leveraging multi-tournament longitudinal tracking to further illuminate the evolving physical and tactical landscape of women's football.

The empirical findings of this study offer clear, actionable recommendations for strength and conditioning practitioners, sports scientists, and technical coaches in elite women's football. Given that straight sprinting is the predominant action in goal situations (45.5%) and correlates directly with match physical-technical output (Vasquez-Bonilla et al., 2026), strength and conditioning coaches must prioritize linear sprint acceleration (10 - 20m) and maximal velocity mechanics (30 - 40m) within weekly microcycles, as exposure to near-maximal speed (>90–95% top speed) is essential for both performance enhancement and hamstring injury mitigation.

Additionally, drill design should move beyond isolated running to recreate the sequential, perception-action demands of match-play by coupling linear sprinting with rapid decelerations, sharp turns, and immediate re-accelerations into central attacking zones (Zone 4) to receive crosses or cutbacks (Martínez-Hernández & Jones, 2026). From a spatial standpoint, offensive periodization should emphasize creating 'sprint-onto' passing lanes into the central penalty box between 6 and 18 yards, whereas defensive organization must focus on denying central penetration, forcing opposition build-up into low-yield wide areas (Zones 2 and 3), and managing the space behind the backline to neutralize high-velocity attackers. Finally, because excess fat mass significantly impairs high-speed running performance (>23 km/h) and acceleration capacity in international female players (Vasquez-Bonilla et al., 2026), periodized nutritional strategies and body composition monitoring (DEXA) should be integrated to optimize power-to-mass ratios.

Conclusions

In conclusion, elite women's international football at the UEFA Euro 2022 was characterized by high physical demands during decisive scoring moments, with linear straight sprinting representing the fundamental physical trigger for both assisting and scoring players. Goal creation is heavily concentrated in central penalty area zones (Zone 4), driven predominantly by ground finishes following organized open-play build-up. Integrating recent multi-tournament and laboratory benchmarking data (Daly et al., 2025; Vasquez-Bonilla et al., 2026; Zakarneh et al., 2026), these findings confirm that maximal linear speed, explosive power, and acceleration are direct facilitators of elite technical-tactical performance.

Adopting an integrated physical-tactical conditioning framework will enable coaches and sports scientists to better prepare female footballers for the intense physical and spatial realities of modern international competition.

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