Artículo original / Original Article

Effect of shooting distance and angular position in u'14 basketball players: an analysis of the Minicopa Endesa

Efecto de la distancia y posición angular de lanzamiento en jugadores u'14 de baloncesto. Análisis de la Minicopa Endesa

José Miguel Contreras García[1]*, Juan Manuel Fernández-Luna[1], Elena Molina Portillo[1], Javier Courel-Ibáñez[1], María Isabel Piñar López[1], Sergio José Ibáñez[2]

[1] Universidad de Granada [2] Universidad de Extremadura

*** Correspondence:** jmcontreras@ugr.es

DOI: 10.17398/1885-7019.22.209

Recibido: 19/09/2025; Aceptado: 25/02/2026; Publicado: 01/08/2026

OPEN ACCESS

Sección / Section:
Performance Analysis in Sport

Editor de Sección / Edited by:
Sebastián Feu
Universidad de Extremadura, España

Citación / Citation:
Contreras, J.M.; Fernández-Luna, J.M.; Molina, E.; Courel-Ibáñez, J.; Piñar, M.I. & Ibáñez, S.J. (2026). Effect of shooting distance and angular position in u'14 basketball players: an analysis of the Minicopa Endesa. E-balonmano Com, 22(2), 209-226

Fuentes de Financiación / Funding:
No funding reported by autor

Agradecimientos/ Acknowledgments:

Conflicto de intereses / Conflicts of Interest:
All authors declare no conflict of interest

Abstract

In youth basketball, understanding the factors that influence shooting effectiveness is key to optimizing the technical-tactical development of young players. This study aimed to analyze the influence of shooting distance and angular position on shot success in U'14 players participating in the Minicopa Endesa. A total of 19,420 shots were recorded and analyzed using descriptive analysis, statistical modeling (logistic regression, chi-square), and machine learning (Random Forest). The results showed that distance to the basket was the strongest predictor of shooting effectiveness, with a significant decrease in accuracy as distance increased, particularly beyond 6.75 meters. In contrast, the positional angle showed a moderate and secondary influence. Additionally, spatial patterns were identified in shot selection, with a clear preference for areas near the basket and beyond the three-point line, and a marked avoidance of intermediate zones. These findings suggest an early internalization of spatial models typical of professional basketball and highlight the need to design training tasks that promote shooting efficiency from a variety of distances and angles, thereby fostering player versatility and contextualized decision-making in youth development.

Keywords: Notational analysis; shooting effectiveness; youth basketball; spatial analysis; player development

Resumen

En el baloncesto formativo, comprender los factores que influyen en la eficacia del lanzamiento es clave para optimizar el desarrollo técnico-táctico de los jóvenes jugadores. El presente estudio tuvo como objetivo analizar la influencia de la distancia y la posición angular de lanzamiento en el éxito de los lanzamientos en jugadores U'14 participantes en la Minicopa Endesa. Se registraron y analizaron 19.420 lanzamientos mediante técnicas de análisis descriptivo, modelización estadística (regresión logística, chi-cuadrado) y aprendizaje automático (Random Forest). Los resultados mostraron que la distancia al aro es el principal predictor de la eficacia del tiro, con una disminución significativa del porcentaje de acierto a medida que aumenta la distancia, especialmente a partir de los 6,75 metros. Por el contrario, la posición angular de lanzamiento presentó una influencia moderada y secundaria. Además, se detectaron patrones espaciales en la selección de zonas de lanzamiento, con preferencia por áreas cercanas al aro y desde la línea de tres puntos, y una clara evitación de las zonas intermedias. Estos hallazgos sugieren una interiorización temprana de modelos espaciales propios del baloncesto profesional y refuerzan la necesidad de diseñar tareas de entrenamiento que fomenten la eficacia desde múltiples distancias y posiciones, promoviendo así la versatilidad y la toma de decisiones contextualizada en etapas formativas.

Palabras clave: Análisis notacional; eficacia; baloncesto formativo; análisis espacial; modelos estadísticos.

Introduction

Shooting is a decisive skill in basketball, as its accuracy directly affects both individual and collective performance. Various technical factors, such as distance, launch angle, release velocity, and release height, have been shown to significantly influence efficacy by altering error tolerance and movement stability (Min, 2016; Okazaki et al., 2007). Among the different types of shots, the free throw has been studied in particular for its experimental value: it is always performed from the same distance, without opposition, and under controlled conditions, enabling precise analysis of the biomechanical variables involved. Previous studies have modelled its execution, showing that a higher parabolic trajectory and backspin optimise the probascoring probability (Okubo & Hubbard, 2006). Moreover, factors such as sex and the player's tactical role also modulate performance in this type of shot (Ibáñez et al., 2015). The incorporation of advanced technologies, such as high-speed cameras and visual feedback systems, has improved the detection of technical errors and theffectivenessf training programmes (Olteanu et al., 2023). Although these results cannot be directly extrapolated to other shooting situations, the free throw represents a valuable model with a high degree of experimental control for studying shooting mechanics.

Notational analyses have shown that shooting efficacy is determined by multiple situational factors, including court zone, defensive pressure, match status, and the action preceding the shot (García et al., 2008; Gómez-Ruano et al., 2015; Ibáñez, García, et al., 2009). These studies indicate that expert players tend to prioritise high expected-value areas (at the rim and beyond the three-point line) and to avoid lower-efficiency mid-range zones, thereby optimising decision-making according to context (Ibáñez, Feu, et al., 2009; Wang & Zheng, 2022). Recent match-analysis research has further highlighted the relevance of collective ball circulation in creating favourable shooting conditions: ball reversal (i.e., changing the side of the ball during the possession) has been proposed as a performance indicator and is associated with higher offensive output, and specific three-point situations combining more passes/ball reversal with lower defensive pressure show higher success rates (Cotta-Ortega et al., 2025a, 2025b). In this context, spatial mapping techniques and density analyses help identify shot-distribution patterns and their relationship with efficacy, supporting both performance analysis and tactical planning (Fu & Stasko, 2024; Goldsberry, 2012; Zajac et al., 2023).

From a technical perspective, distance remains a major constraint, with accuracy typically decreasing as shots are taken farther from the basket across age groups (Erčulj & Supej, 2006; Hamilton & Reinschmidt, 1997; Ibáñez, Feu, et al., 2009; Arias et al., 2012; Cabarkapa et al., 2022). In addition to distance, shooting efficacy may vary by angular court position, with some evidence of reduced accuracy from lateral sectors compared with more central locations (Tran & Silverberg, 2008; Qu et al., 2024). Together, these spatial constraints, considered within the situational logic described above, justify focusing on distance and angular position as key determinants of shooting performance in formative categories. However, recent tracking-based and notational studies indicate that defender proximity/defensive pressure is a major determinant of shot-make probability and can partially offset the distance penalty when long-range attempts are generated under lower defensive pressure—particularly in elite contexts—through spacing, ball circulation, and ball reversal (Lucey et al., 2014; Daly-Grafstein & Bornn, 2020; Vencúrik et al., 2022; Cotta-Ortega et al., 2025a, 2025b).

Although shooting is one of the most decisive skills in basketball, most existing studies have focused on adult and professional players, with scant attention paid to its development during the formative stages. This lack of evidence is particularly notable for key variables, such as shooting distance and position, whose influence on efficacy has been widely demonstrated in professional contexts but scarcely explored in developing populations. The Minicopa Endesa, a flagship U14 competition in Spain, offers an ideal setting for analysing how young talent manages these spatial variables in real game situations. Understanding their shooting patterns can reveal the inherent strengths and shortcomings of the technical-tactical development process and contribute to the design of training programmes better aligned with their developmental needs and the specific demands of the game.

The aim of this study is to analyze how shooting distance and angular position condition shooting efficacy in under-14 players participating in the Minicopa Endesa, with a view to identifying the technical and decisional patterns characteristic of this stage. Specifically, we seek to: (i) quantify success rates in short-, mid-, and long-range zones to locate preferred or avoided areas; (ii) evaluate shot accuracy as a function of angular shooting position relative to the court's longitudinal axis (−90° to +90°) and describe the distribution of attempts in each sector; and (iii) determine which combinations of distance and positions enhance or diminish performance, so that the findings provide a basis for designing targeted training tasks in youth basketball.

Materials and Methods

Design

This study adopts a quantitative approach with an observational, non-experimental, descriptive, and retrospective design. An idiographic, multidimensional, and sequential follow-up approach was employed, in line with systematised observational methodology in sport (Anguera et al., 2011; Anguera & Hernández-Mendo, 2013). Data were obtained from public records of official matches available in the Asociación de Clubes de Baloncesto (ACB) database, corresponding to the 2021–2022, 2022–2023, and 2023–2024 editions of the Minicopa Endesa. As no variables were manipulated and the analysis focused on behavioural and performance patterns derived from real game situations, the design can be classified as indirect observation, with a molar unit of analysis (Usabiaga et al., 2013). A cross-sectional approach was also used for the visualisation and analysis of shots, complemented by statistical modelling techniques aimed at identifying trends or behavioural patterns associated with shooting distance and position.

Participants

A total of 19,420 shot attempts were analysed across 132 matches contested by 624 players from 21 youth teams affiliated with professional clubs in the Liga Endesa/ACB (see Table 1). Of these, 14,100 were two-point attempts and 5,268 were three-point attempts. Analyses and figures were produced using RStudio, based on the R programming language (version 4.3.1).

Tabla 1. Participation by club in the three editions analyzed

Teams	*2021-2022*	*2022-2023*	*2023-2024*
Barça	x	x	x
Bilbao Basket	x	x	x
Bàsquet Girona		x	x
Cajasiete Canarias	x	x	x
Casademont Zaragoza	x	x	x
Bàsquet Manresa	x	x	x
Real Betis	x	x	
Coviran Granada		x	x
Fuenlabrada	x	x	
Fundación 5+11 Baskonia	x	x	x
Gran Canaria	x	x	x
Joventut Badalona	x	x	x
MoraBanc Andorra	x		x
Obradoiro CAB	x	x	x
Real Madrid	x	x	x
Río Breogán	x	x	x
San Pablo Burgos	x		
UCAM Murcia	x	x	x
Unicaja	x	x	x
Valencia Basket	x	x	x
Zunder Palencia			x

Variables

The dependent variable was shooting success, dichotomously coded (made = 1; missed = 0) and subsequently aggregated to obtain percentage accuracy.

The independent variables were: (a) distance to the basket, computed in metres from each shot's coordinates and treated both as a continuous variable (0.10 m intervals) and as a categorical variable via four zones: central circle (< 1.30 m), lower intermediate (1.30–4 m), upper intermediate (4–6.75 m), and three-point (> 6.75 m); and (b) angular shooting position, expressed in degrees from −90° (left corner) to +90° (right corner) relative to the court's longitudinal axis. This variable was examined both continuously (5° steps) and categorically by grouping shots into extreme, intermediate, and frontal sectors.

Both variables were extracted from official ACB play-by-play logs and shot maps, whose standardised protocols ensure the validity of spatial coordinates, shot outcomes, and the geometric computations employed.

Instruments

A structured coding system was employed based on official ACB play-by-play reports and shot charts for the Minicopa ACB competition, from which spatial coordinates and shot outcomes were obtained. These records are produced by the competition's official statistical service using standardised event-logging and shot-charting procedures; shot locations are registered on a fixed court template and exported through automated routines, which supports the validity and temporal reliability of spatial coordinates and outcomes. Similar ACB event datasets have been used in peer-reviewed performance analyses, supporting their suitability for research purposes (Bustamante-Sánchez & Jiménez-Saiz, 2024, Contreras-García et al., 2024). After transforming the original coordinates to the analysis reference system, we ran basic integrity checks (missing/out-of-range coordinates, duplicate records, and consistency of shot counts across sources) and then processed the final dataset in RStudio. Overall, the institutional provenance of the sources, together with standardised automated protocols and reproducible routines, ensures the authenticity of records, high ecological validity, and consistent temporal reliability, while minimising any potential observer-derived bias.

Procedure

The methodology comprised four sequential phases, each aligned with a specific analytical objective.

*Phase 1. Visualisation of shot distribution***.** Using tournament play-by-play logs, shot charts were generated to represent the location and outcome of every attempt. Visualisations were produced in R with ggplot2 (Wickham, 2016) and BasketballAnalyzeR (Sandri, 2020; Zuccolotto & Manisera, 2020), whose graphical functions clearly and aesthetically display spatial execution patterns.

*Phase 2. Identification of spatial voids***.** Bivariate kernel density estimation (2D-KDE) was applied (Scott, 2015) to characterise the concentration of shots in the distance/position plane. This non-parametric approach smooths the data distribution and reveals areas of high and low attempt density, facilitating the detection of underused or predominant zones (Wand & Jones, 1994).

Phase 3. Geometric computation of distance and angular position. Original coordinates were transformed to a metric system with the basket centre as origin. Using elementary trigonometry, the Euclidean distance (m) and polar angle (°) of each shot were obtained, enabling estimation of shooting frequency and distribution by both spatial variables.

Phase 4. Modelling shooting efficacy. To describe the relationship between accuracy, distance, and position, LOESS smoothing was employed (Cleveland & Devlin, 1988). Data were binned at 0.10 m for distance and 5° for position, over which local curves were fitted. This procedure reduced noise, highlighted underlying trends, and facilitated interpretation of complex variations in shooting performance.

Statistical Analysis

To assess the influence of distance and position on shooting efficacy, a combination of complementary statistical analyses was used. First, Pearson correlation analyses were conducted to examine the linear relationship between shooting distance/position and accuracy. Next, chi-square tests were employed to examine the association between court zones/distance and shot success. Subsequently, a binary logistic regression model was fitted to estimate the joint impact of both variables on the probability of a make. Finally, a Random Forest model was used to identify the relative importance of each predictor, using the IncNodePurity metric (Louppe, 2014), which quantifies each variable's contribution to node purity and thus to the model's predictive capacity. This multi-technique approach not only tests the statistical significance of effects but also estimates their magnitude and relative importance in more complex predictive contexts.

Results

Descriptive Results

Visualisation of Shot Attempts

A total of 19,420 shot attempts by U14 players were analysed during the Minicopa Endesa, of which 7,057 were successful, corresponding to an overall accuracy of 36.3%. Disaggregating by shot type, two-point attempts showed an effectiveness of 41.3% (5,817 makes from 14,100 attempts), while three-point attempts yielded 22.6% (1,189 makes from 5,268 attempts). Figure 1 presents a spatial map of field-goal percentage by zone, revealing a peak efficacy of 59% directly beneath the basket. As distance from the rim increases, there is a progressive decline in shooting effectiveness, reaching minimum values of around 21–23% in the most distant areas. This decreasing pattern suggests a clear influence of shooting distance on performance.

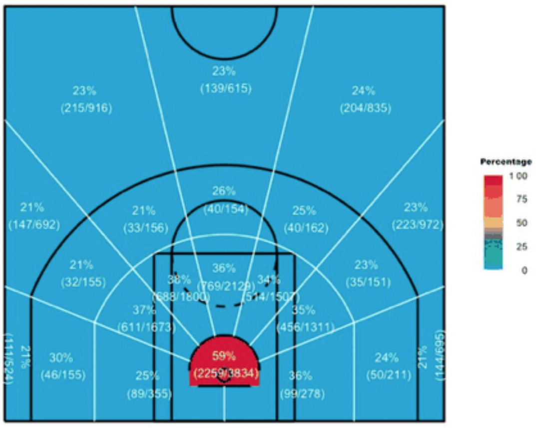


Figure 1. Shot percentage and attempt frequency by zone

Note. The figure excludes shots taken from the opposite half-court.

Figure 2 depicts a scatter plot of the shot attempts (shot map), visually distinguishing successful attempts (in green) from misses (in red). This visualisation reveals clear spatial patterns: there is a higher concentration of missed shots beyond the three-point line, whereas attempts taken near the basket show a markedly higher proportion of makes.

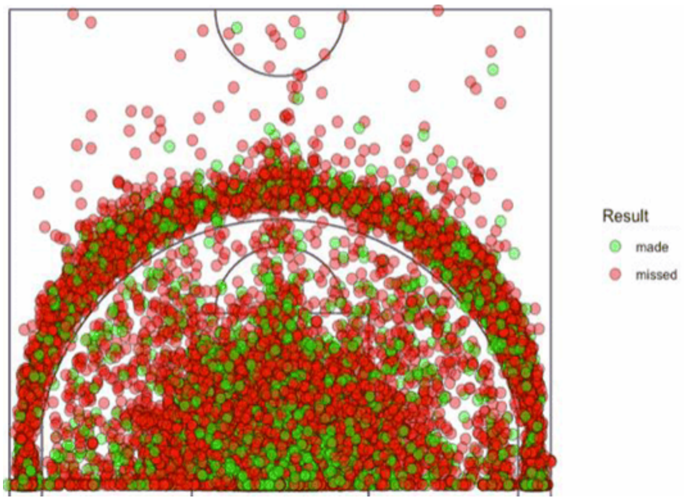
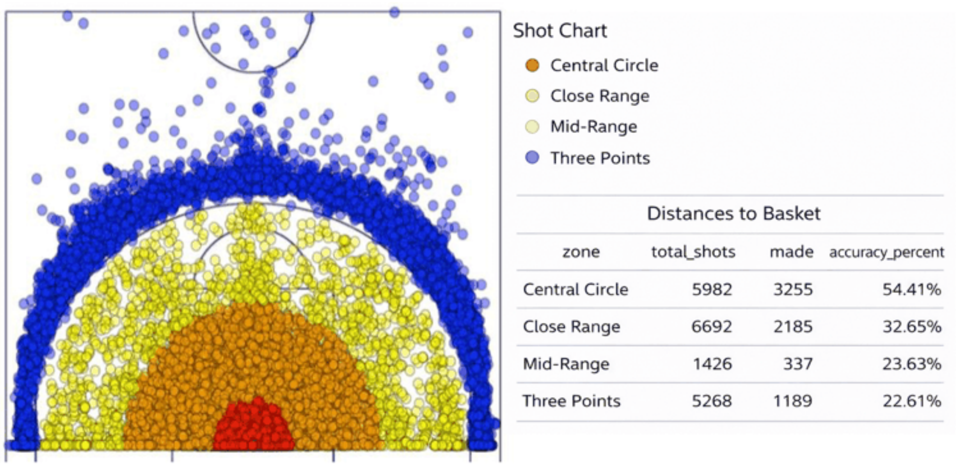


Figure 2. Shot map by outcome

Note. The figure excludes shots taken from the opposite half-court.

Visualisation of shot attempts by distance and angular position

The analysis of the spatial distribution of shots by distance to the basket, shown in Figure 3, reveals a high concentration of attempts in the area closest to the hoop (central circle, < 1.30 m), with a high proportion of makes. The lower intermediate zone (1.30–4 m) recorded the greatest volume of shots, albeit with lower efficacy. By contrast, the upper intermediate zone (4–6.75 m) showed the fewest attempts, indicating a tendency to avoid this area. The three-point zone (> 6.75 m) exhibited a substantial number of attempts despite its low success rate (22%), with notable clustering in the corners and at the top of the arc.

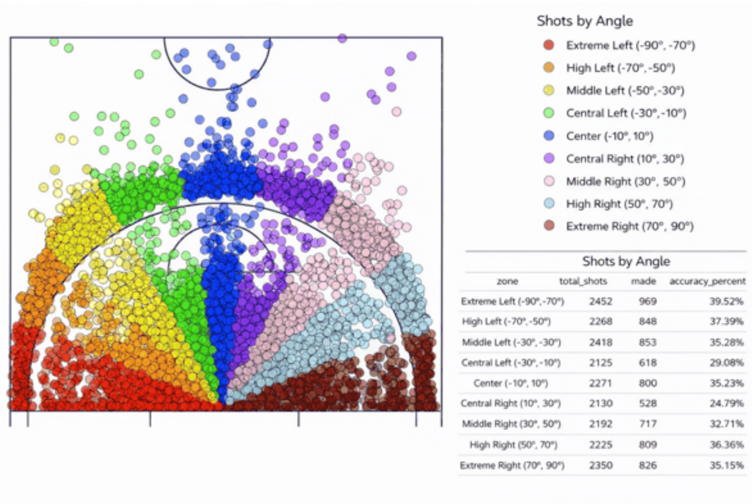


zone	total_shots	made	accuracy_percent
Central Circle	5982	3255	54.41%
Close Range	6692	2185	32.65%
Mid-Range	1426	337	23.63%
Three Points	5268	1189	22.61%

Figure 3. Shot distribution by distance to the basket and results table

Note. The figure excludes shots taken from the opposite half-court.

With regard to angular shooting position (Figure 4), the data indicate that the most extreme angular sectors, especially the left (−90° to −70°), were the most frequently used and recorded the highest accuracy (39.52%). In contrast, the "right-central" sector (30° to 50°) showed the lowest effectiveness (32.71%), while areas close to the longitudinal axis (−10° to 10°) displayed moderate rates of around 35%.



Shots by Angle

zone	total_shots	made	accuracy_percent
Extreme Left (-90°,-70°)	2452	969	39.52%
High Left (-70°,-50°)	2268	848	37.39%
Middle Left (-30°,-30°)	2418	853	35.28%
Central Left (-30°,-10°)	2125	618	29.08%
Center (-10°, 10°)	2271	800	35.23%
Central Right (10°, 30°)	2130	528	24.79%
Middle Right (30°, 50°)	2192	717	32.71%
High Right (50°, 70°)	2225	809	36.36%
Extreme Right (70°, 90°)	2350	826	35.15%

Figure 4. Shot distribution by angular position relative to the basket and results table.

Comparison of Variables

The joint examination of distance and angular shooting position, shown in Figures 5–8, enables analysis of the distribution and efficacy of shots as a function of these two variables. The results indicate that the most accurate attempts tend to be taken from extreme lateral positions (−90° and +90°) and from short distances (< 5 m), yielding higher success rates. By contrast, shots from greater distances display lower accuracy, with variability increasing as distance from the basket grows. Regarding lateral position, higher success rates are observed at the extreme sectors (−90° and +90°), whereas intermediate positions near the longitudinal axis show lower values, particularly when combined with distances beyond 6 metres.

The two-dimensional kernel density plot reveals that shot attempts are most densely concentrated in the frontal zone (angles near 0°) at distances under 8 metres. The univariate KDEs show two prominent peaks in the distance distribution: one close to 1 metre (near-basket attempts) and another around 7.5 metres (three-point range). For angles, peaks occur at −90°, −45°, 0°, 45°, and 90°, aligning with common offensive locations. Areas between −30° and 30°, and between 5 and 7 metres, exhibit lower shot density, indicating a systematic avoidance of these intermediate regions.

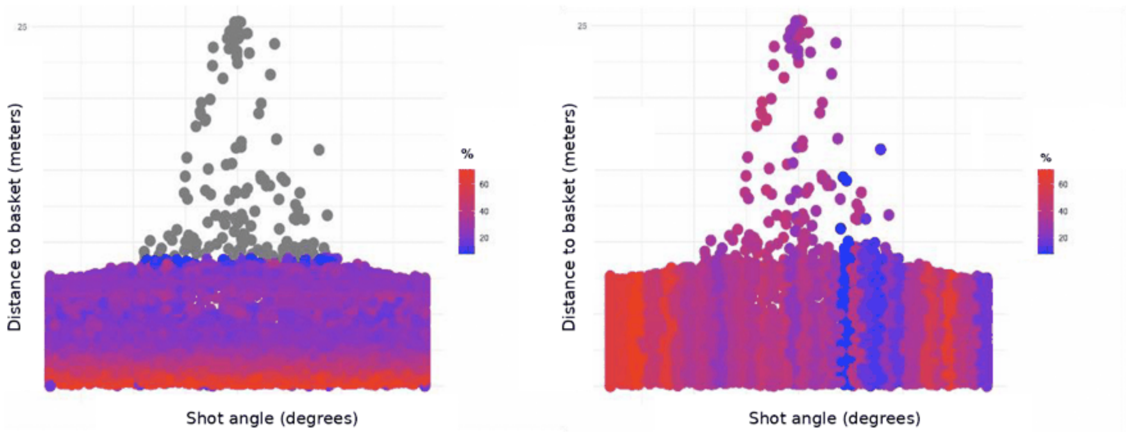


Figure 5. Heat map of accuracy by distance and angular position (distance × position).

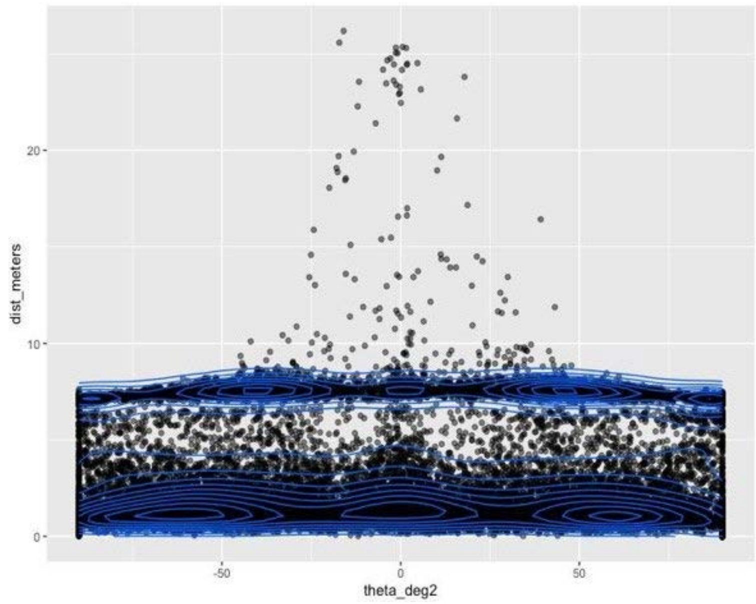


Figure 6. Two-dimensional kernel density estimate (distance × position).

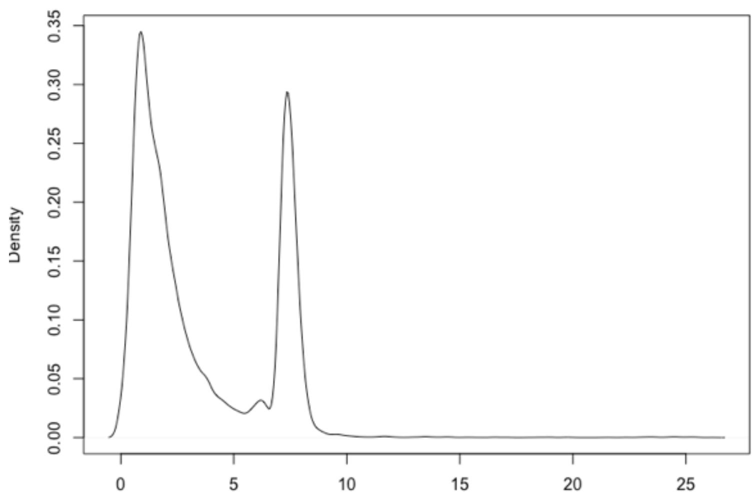


Figure 7. Kernel density estimate (KDE) for shooting distance.

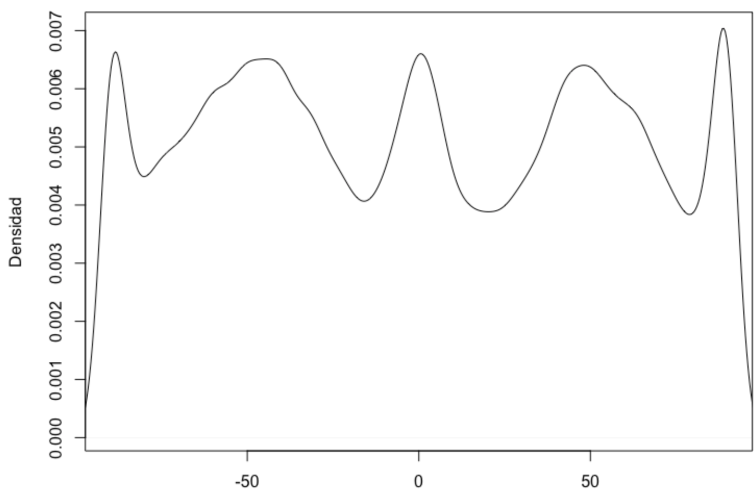


Figure 8. Kernel density estimate (KDE) for angular shooting position.

Modelling of shots by distance and position

Modelling the shots using smoothing curves and density-estimation plots enabled analysis of the relationship between accuracy and the variables of distance and angular position relative to the basket. The smoothed curve in Figure 9 shows that short-range attempts, particularly within 1.5 metres, exhibit success rates above 70%, highlighting the high efficacy of lay-ups and near-basket finishes. However, there is a pronounced decline in precision between 2 and 6 metres, with accuracy ranging from 30% to 40%. From 6.75 metres, the three-point line, onwards, the curve stabilises at around 25–30% accuracy.

Table 2 reports values disaggregated in 10-centimetre intervals, evidencing this progressive decline in efficacy as distance increases. Table 3 confirms the substantial volume of attempts from short distances and from the three-point line.

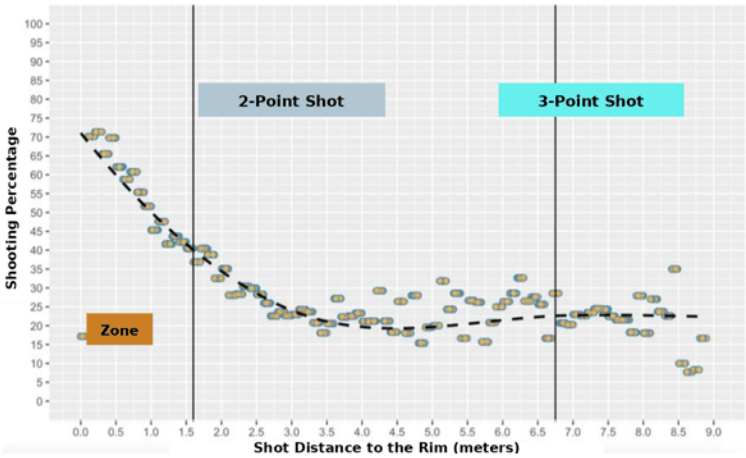


Figure 9. Smoothed curve of shooting percentages as a function of distance to the basket.

Table 2. Summary of made and missed shots and accuracy by distance (10-cm intervals)

Distances to the basket	Accuracy													
Interval	Makes	Misses	%	n	Interval	Makes	Misses	%	n	Interval	Makes	Misses	%	n
[0,0.1)	23	111	17.16%	134	[2.4,2.5)	70	164	29.91%	234	[4.6,4.7)	11	50	18.03%	61
[0.1,0.2)	54	23	70.13%	77	[2.5,2.6)	58	147	28.29%	205	[4.7,4.8)	14	36	28.00%	50
[0.2,0.3)	122	49	71.35%	171	[2.6,2.7)	54	154	25.96%	208	[4.8,4.9)	8	44	15.38%	52
[0.3,0.4)	135	71	65.53%	206	[2.7,2.8)	44	151	22.56%	195	[4.9,5)	9	37	19.57%	46
[0.4,0.5)	240	104	69.77%	344	[2.8,2.9)	40	129	23.67%	169	[5,5.1)	10	40	20.00%	50
[0.5,0.6)	324	198	62.07%	522	[2.9,3)	39	133	22.67%	172	[5.1,5.2)	14	30	31.82%	44
[0.6,0.7)	352	247	58.76%	599	[3,3.1)	31	104	22.96%	135	[5.2,5.3)	9	28	24.32%	37
[0.7,0.8)	429	277	60.76%	706	[3.1,3.2)	33	103	24.26%	136	[5.3,5.4)	12	30	28.57%	42
[0.8,0.9)	420	339	55.34%	759	[3.2,3.3)	31	100	23.66%	131	[5.4,5.5)	7	35	16.67%	42
[0.9,1)	377	353	51.64%	730	[3.3,3.4)	26	99	20.80%	125	[5.5,5.6)	8	22	26.67%	30
[1,1.1)	288	347	45.35%	635	[3.4,3.5)	19	86	18.10%	105	[5.6,5.7)	11	31	26.19%	42
[1.1,1.2)	267	294	47.59%	561	[3.5,3.6)	22	85	20.56%	107	[5.7,5.8)	8	43	15.69%	51
[1.2,1.3)	224	314	41.64%	538	[3.6,3.7)	28	75	27.18%	103	[5.8,5.9)	10	38	20.83%	48
[1.3,1.4)	211	272	43.69%	483	[3.7,3.8)	25	87	22.32%	112	[5.9,6)	12	36	25.00%	48
[1.4,1.5)	205	281	42.18%	486	[3.8,3.9)	23	79	22.55%	102	[6,6.1)	19	53	26.39%	72
[1.5,1.6)	198	291	40.49%	489	[3.9,4)	21	69	23.33%	90	[6.1,6.2)	18	45	28.57%	63
[1.6,1.7)	163	279	36.88%	442	[4,4.1)	15	56	21.13%	71	[6.2,6.3)	16	33	32.65%	49
[1.7,1.8)	194	286	40.42%	480	[4.1,4.2)	14	52	21.21%	66	[6.3,6.4)	22	61	26.51%	83
[1.8,1.9)	166	262	38.79%	428	[4.2,4.3)	19	46	29.23%	65	[6.4,6.5)	16	42	27.59%	58
[1.9,2)	114	236	32.57%	350	[4.3,4.4)	14	52	21.21%	66	[6.5,6.6)	10	29	25.64%	39
[2,2.1)	121	224	35.07%	345	[4.4,4.5)	13	58	18.31%	66	[6.6,6.7)	3	15	16.67%	18
[2.3,2.4)	89	204	30.38%	293	[4.5,4.6)	14	39	26.42%	53	Mayor a 9m	1	9	10.00%	10

Table 3 confirms the substantial volume of attempts from short distances and from the three-point line.

Table 3. Summary of made and missed shots and accuracy by distance (75-cm intervals)

Distances to the basket	Accuracy			
Interval	Makes	Misses	%	n
[0,0.75)	1441	922	60.98%	2363
[0.75,1.5)	2230	2358	48.61%	4588
[1.5,2.25)	1079	1874	36.54%	2953
[2.25,3)	431	1193	26.54%	1624
[3,3.75)	199	694	22.28%	893
[3.75,4.5)	135	457	22.80%	592
[4.5,5.25)	87	289	23.14%	376
[5.25,6)	70	250	21.88%	320
[6,6.75)	105	286	26.85%	391
[6.75,7.5)	713	2320	23.51%	3033
[7.5,8.25)	442	1561	22.07%	2003
[8.25,9)	24	114	17.39%	138
Mayor a 9m	5	33	13.16%	38

With respect to angular shooting position, the smoothed curve shown in Figure 10 indicates marked stability in accuracy across the entire angular spectrum from −90° to +90°. Values remain mostly between 35% and 45%, with no pronounced peaks or troughs in any lateral sector of the court. This relatively even distribution suggests that, unlike distance, spatial shooting position exerts a more limited influence on overall shooting performance, particularly when considered in isolation.

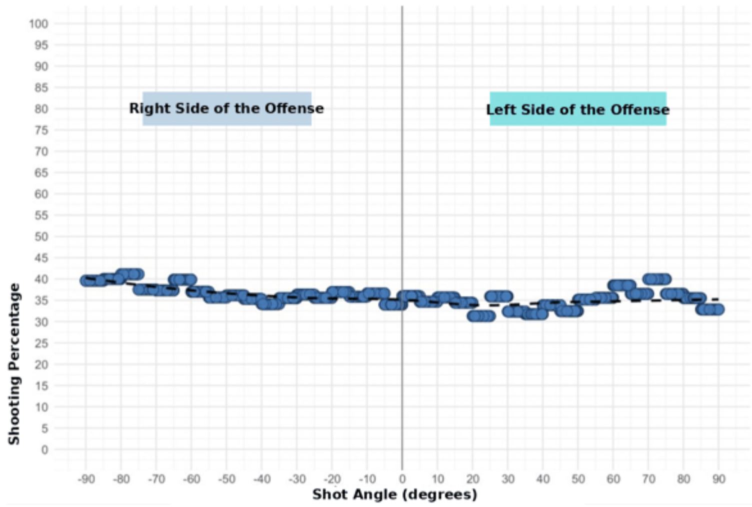


Figure 10. Smoothed curve of shooting percentages as a function of angular position relative to the basket.

Table 4 presents the breakdown of accuracy by shooting position, grouped into symmetric 5-degree intervals from −90° to +90°. The results confirm that shots taken from the extreme positions, both on the left (−90°) and the right (+90°), maintain accuracy rates comparable to those from more central locations. For example, in the extreme intervals (−90.2°, −85°] and (85°, 90.2°], success rates of 39.6% and 32.9% were recorded, respectively, figures comparable to those near the frontal axis, such as (−10°, −5°] at 36.6% or (0°, 5°] at 36.0%.

No significant efficacy peaks are observed in the central zone of the court (around 0°), indicating that shooting from the axis does not confer a substantial advantage in terms of effectiveness. This relatively uniform pattern suggests that lateral position, by itself, does not determine shooting success, in contrast to the more pronounced influence of distance. The general trend shows only moderate fluctuations in accuracy across the angular spectrum, with neither abrupt declines nor sustained increases, reinforcing the conclusion that efficacy does not depend linearly on shooting position.

Table 4. Shooting Accuracy by Angular Position

Angular position	Accuracy								
Interval	Makes	Misses	%	n	Interval	Makes	Misses	%	n
(-90.2,-85]	441	673	39.59%	1114	(0,5]	232	413	35.97%	645
(-85,-80]	162	243	40.00%	405	(5,10]	175	330	34.65%	505
(-80,-75]	183	262	41.12%	445	(10,15]	138	249	35.66%	387
(-75,-70]	183	305	37.50%	488	(15,20]	128	244	34.41%	372
(-70,-65]	191	321	37.30%	512	(20,25]	118	259	31.30%	377
(-65,-60]	218	329	39.85%	547	(25,30]	144	257	35.91%	401
(-60,-55]	216	368	36.99%	584	(30,35]	146	305	32.37%	451
(-55,-50]	222	401	35.63%	623	(35,40]	161	346	31.76%	507
(-50,-45]	231	408	36.15%	639	(40,45]	210	410	33.87%	620
(-45,-40]	220	403	35.31%	623	(45,50]	199	414	32.46%	613
(-40,-35]	201	388	34.13%	589	(50,55]	214	395	35.14%	609
(-35,-30]	202	367	35.50%	569	(55,60]	201	364	35.58%	565
(-30,-25]	174	305	36.33%	479	(60,65]	219	350	38.49%	569
(-25,-20]	160	290	35.56%	450	(65,70]	176	306	36.51%	482
(-20,-15]	137	234	36.93%	371	(70,75]	171	257	39.95%	428
(-15,-10]	146	261	35.87%	407	(75,80]	130	226	36.52%	356
(-10,-5]	182	315	36.62%	497	(80,85]	136	247	35.51%	383
(-5,0]	212	412	33.97%	624	(85,90.2]	389	795	32.85%	1184

Statistical analysis of the influence of distance and position on shooting success

Correlation analysis between distance/position and shot success

A Pearson correlation analysis was conducted to assess the relationship between shooting distance and accuracy. Using 0.75-metre intervals, a strong negative correlation was observed ($r = -0.8385$), indicating that accuracy decreases markedly as distance from the basket increases. Repeating the analysis with finer 0.1-metre bins yielded a similarly high negative correlation ($r = -0.7763$), albeit slightly smaller, possibly reflecting the greater variability introduced by narrower intervals. In both cases, distance is confirmed as a critical factor in the probability of a successful shot.

With respect to shooting position, a Pearson correlation using 5-degree intervals across the −90° to +90° range produced a moderate negative correlation ($r = -0.5418$). This suggests that, while position is related to success, its effect is less decisive than that of distance. These findings align with the visual evidence from the figures, which show greater dispersion in accuracy by angle than by distance.

Assessing the association between shooting zones and success using the chi-square test

The association between shooting zone and success, examined via chi-square tests, yielded statistically significant results for both distance and angular position. For distance, the result was $\chi^2 = 1437.4$ with 3 degrees of freedom and $p < 2.2e{-16}$, indicating a highly significant association between shooting distance and the likelihood of success. For angular position, the result was $\chi^2 = 29.086$ with 8 degrees of freedom and $p = 0.0003063$, also indicating a statistically significant association. Nevertheless, the smaller chi-square value in the latter case suggests a more moderate strength of association compared with distance. Taken together, these results reinforce the conclusion that both distance and position influence the probability of success, but distance exerts the more substantial effect, consistent with the correlation analyses.

Combined impact of distance and shooting position on success: logistic regression

To examine the joint effect of distance and angular position on the probability of a make, a binary logistic regression model was fitted. The dependent variable was shot outcome (made = 1; missed = 0), with distance and position entered as continuous predictors. The coefficient for distance was negative and statistically significant ($\beta = -0.474702$; $p < 2e{-16}$), indicating that greater distance reduces the likelihood of success. By contrast, the coefficient for angular position was also negative but not statistically significant ($p = 0.235$), suggesting that, once distance is controlled for, angular position does not exert a meaningful effect on shooting efficacy. These findings corroborate the correlation and association analyses, underscoring distance as the decisive predictor of success, while position shows a more limited influence when analysed jointly.

Variable importance in the Random Forest model

To complement the regression analysis, a Random Forest model was applied to evaluate the relative importance of the predictors in classifying shot outcomes. The IncNodePurity metric, quantifying the increase in node purity attributable to each variable, was used. Distance to the basket emerged as, by far, the most influential variable (importance = 309.67). In contrast, angular position showed a much smaller importance value (8.15), indicating only a marginal contribution to the model's predictive capability. These results are consistent with the logistic regression findings, consolidating the evidence that distance is the principal determinant of shooting success among U14 players, whereas angular position exerts a considerably more limited influence.

Discussion

The principal aim of this study was to analyse the influence of distance and position on the success of field-goal attempts among under-14 players participating in the Minicopa Endesa. To this end, shot efficacy was examined as a function of spatial location through a combination of descriptive and inferential analyses and machine-learning techniques. The results consistently show that distance to the basket is the main factor conditioning the probability of success, with a clear decline in efficacy as shooting distance increases. By contrast, angular position exerted a more limited, context-dependent influence, without a uniform pattern of impact on accuracy. Spatial patterns were also identified in shot-selection that mirror behaviours characteristic of professional basketball, namely, a preference for attempts near the rim and from the three-point line, avoidance of intermediate zones, and reliance on reference positions (−90°, −45°, 0°, 45°, 90°).

Descriptive results

Visualisation of shot attempts

The descriptive results confirm that shooting efficacy decreases progressively with distance, peaking in the vicinity of the basket and dropping sharply for long-range attempts, a pattern widely documented in biomechanical research (Hamilton & Reinschmidt, 1997; Okubo & Hubbard, 2006). Spatial visualisation further shows that U14 players concentrate their attempts in high-probability areas (near the rim) or high-value areas (the three-point line), while avoiding intermediate zones between 5 and 6.75 metres. This distribution reflects a strategic behaviour similar to that observed in professional contexts such as the NBA, where three-point usage has risen markedly over the last decade (Wang & Zheng, 2022) and mid-range shooting has been progressively abandoned (Ibáñez et al., 2018; Kilcoyne, 2020). The tendency to relegate these areas suggests decision-making oriented towards maximising expected efficiency, even at formative stages. This behaviour aligns with Goldsberry (2012), who highlighted the tactical value of the corners and the rim as optimal zones in risk–return terms, and with Slegers et al. (2021), who underscore the role of intra-individual control of the movement in maintaining accuracy at longer distances. Zajac et al. (2023) show how elite players have consolidated a pattern of specialisation in high-value zones, with increasing concentration of attempts either at the rim or beyond the arc and the progressive marginalisation of the mid-range, trends seemingly replicated in our U14 sample. These results point to an early internalisation of professional spatial models, with implications for task design aimed at fostering functional exploration of all court areas.

From a developmental perspective, the early replication of professional shot-selection patterns in U14 players deserves critical consideration. On one hand, prioritising high-value areas (rim and three-point line) may reflect an emerging form of efficiency-oriented decision-making consistent with the contemporary, data-informed evolution of the game (Zajac et al., 2023), and it may help young players understand basic risk–return trade-offs (Ibáñez et al., 2018). On the other hand, an excessive avoidance of intermediate zones may indicate premature specialisation and reduced functional exploration, potentially constraining the acquisition of adaptable shooting solutions across angles and distances (Contreras-García et al., 2024; Slegers et al., 2021). In formative categories, where tactical roles and technical patterns are still consolidating (Escudero-Tena et al., 2021; Fernández-Cortés et al., 2021), coaches may therefore need to balance efficiency-driven models with developmental priorities by designing tasks that deliberately include underused spaces, varied angular demands, and realistic defensive pressure (Ibáñez, Feu, et al., 2009; Gómez-Ruano et al., 2015). This approach may reduce the risk of over-adapting to professional templates while promoting broader tactical and motor flexibility.

Visualisation of shots by distance and shooting position

When the spatial distribution is examined jointly by distance and angular position, the results show a clear preference and higher efficacy in the corners, particularly the “extreme left” sector, which may reflect lower defensive pressure (Ibáñez, Feu, et al., 2009; Slegers et al., 2021). While position does not appear to drastically condition efficacy once the technical pattern is consolidated, spatial decision-making remains key, especially under pressure. Prior studies have shown that expert players not only shoot from longer distances but also manage the pre-shot context more effectively (Ibáñez, Feu, et al., 2009), underscoring the importance, in formative training, of tasks that incorporate realistic defensive pressure, angular diversity, and situational variability to foster more robust technical-tactical development.

Comparison of variables

The joint analysis of distance and shooting position reveals spatial patterns shaped by expected efficiency, with systematic underuse of intermediate areas. The KDE graphics show that the most frequently used areas coincide with key positions in offensive systems associated with specific roles (e.g., point guards, shooting guards, or interior players), reinforcing the idea of tactical profiling conditioned by playing position (Escudero-Tena et al., 2021; Fernández-Cortés et al., 2021). In line with this finding, recent work on passing networks in U14 offensive structures demonstrates the influence of cooperative dynamics among players (Pereira et al., 2025), supporting the need to develop positional diversification and interaction through tactics. The low density of attempts at angles between −30° and 30° and at distances of 5 to 6.75 metres evidences strategic disuse of these areas, possibly due to lower immediate returns and their limited presence in formative schemes. This omission poses a challenge for task design aimed at promoting tactical versatility: developing players who can perform in less common spaces requires introducing spatial variability, defensive pressure, and technical work from underutilised zones (Ibáñez, Feu, et al., 2009). As Slegers et al. (2021) note, success on long-range shots depends not only on position but also on individual technical stability, reinforcing the need to train through diversity rather than efficiency alone.

Modelling of shots by distance and position

Modelling confirms that distance to the basket is the most influential variable for shooting efficacy, with high success rates for close-range attempts and a marked decline at intermediate distances, replicating professional-level patterns in which such attempts have lost prominence owing to their low return (Hamilton & Reinschmidt, 1997; Okazaki & Rodacki, 2012). Despite lower efficacy, there is a notable volume of attempts from the three-point line, indicating early adoption of strategies oriented more towards shot value than probability of success (Plakias et al., 2024). Similar results have been observed in elite 3×3 competitions, where choosing the three-point attempt is associated with specific patterns, reduced dribble use, exploitation of the shot clock, and the need to close scoring gaps, further highlighting the influence of situational factors on offensive decision-making (Morillo et al., 2025). As for lateral position, its influence is limited and stable, possibly due to a homogenisation of the shooting technique and to motor or structural preferences within the game (Slegers et al., 2021). Under-used intermediate angular sectors may reflect tactical biases, training gaps, or positional specialisation (Fernández-Cortés et al., 2021). At elite levels, shooting efficacy depends not only on distance or zone but also on contextual variables such as possession time, pre-shot action, and defensive pressure. Gómez-Ruano et al. (2015) found that the most effective attempts occurred inside the paint and following collective sequences with multiple passes, particularly when the score was unbalanced. These findings suggest that, beyond shot location, it is the combination of temporal, spatial, and tactical factors that determines the probability of success, an approach that should inform task design in formative contexts. Coaches should design training that exposes players to decision-making from less common areas to develop greater spatial adaptability (Contreras-García et al., 2024). This finding is consistent with studies in handball, where distance has been identified as the principal determinant of shooting efficacy, surpassing technical factors such as the final step or take-off leg (Tuquet et al., 2021). Convergence across team sports highlights the importance of training decision-making and technical execution as a function of real distance to target, irrespective of the specific sport.

Finally, our results accord with prior research evidencing biomechanical adjustments as a function of shooting distance. Okazaki and Rodacki (2012) observed that efficacy drops sharply when moving from near-basket attempts to distances beyond 6 metres, a finding also confirmed by Podmenik et al. (2017), who reported increased body angular velocities with distance, compromising the stability of the shooting pattern. In addition, Sławiński et al. (2018) showed that fatigue induced by repeated sprints adversely affects shooting kinematics, reducing accuracy even on three-point attempts. These biomechanical and physiological factors may help explain the pronounced declines observed for mid- and long-range shots.

Statistical analysis of the influence of distance and position on shot success

Correlation analysis between distance/position and shot success

In our U14 sample, distance showed the strongest negative association with shot success, whereas angular position had a weaker effect. This pattern is consistent with prior professional and biomechanical evidence indicating that distance to the basket is a principal constraint on shooting efficacy (Hamilton & Reinschmidt, 1997; Ibáñez, García, et al., 2009; Okazaki & Rodacki, 2012). This finding suggests that the distance–efficacy relationship persists even in formative categories, where an imitation of professional spatial patterns is already evident (Contreras-García et al., 2024). By contrast, position showed a weaker correlation, indicating a lesser direct relevance for precision. A plausible explanation is the stabilisation of the technical pattern or tactical configurations that minimise its impact. Nevertheless, its influence may vary by player role; therefore, training should prioritise efficacy at different distances while still exposing players to diverse angles to foster greater tactical adaptability (Escudero-Tena et al., 2021; Fernández-Cortés et al., 2021). From an applied perspective, these results indicate that training should prioritise situational tasks centred on distance, without neglecting development of efficacy from varied positions as a pathway to greater tactical flexibility.

Association between shooting zones and success: chi-square tests

Our zone-based tests indicate that distance explains success more consistently than position. Consistent with the correlational evidence, chi-square analyses show a stronger association between efficacy and distance than between efficacy and position. This aligns with prior research documenting declining accuracy with increasing distance from the rim (Ibáñez, García, et al., 2009; Okazaki & Rodacki, 2012; Wang & Zheng, 2022). Although position was also significant, its effect appears more moderate. This pattern may reflect players' technical adaptations and offensive structures that prioritise specific shooting zones (Escudero-Tena et al., 2021; Slegers et al., 2021). Taken together, these results reinforce the need to focus training on consolidating shooting at different distances and on exploring less-used areas to improve versatility and tactical adaptability in developing players (Contreras-García et al., 2024; Ibáñez et al., 2018).

Combined impact of distance and position: logistic regression

When both predictors are controlled jointly, our model indicates that distance retains significance while position loses explanatory power. This result is consistent with prior work highlighting the biomechanical and tactical penalty of long-range attempts (Ibáñez, García, et al., 2009; Okazaki & Rodacki, 2012; Wang & Zheng, 2022), as well as studies reporting greater stability of the shooting pattern in the face of angular variation, particularly among players with a certain level of consolidation (Slegers et al., 2021). In line with this interpretation, research on positional specialisation and offensive design at formative stages suggests that the influence of position is more conditioned by tactics and player profile than by the position per se (Contreras-García et al., 2024; Ibáñez et al., 2018). Accordingly, these findings support training approaches aimed at consolidating efficacy at different distances while maintaining functional variability in shooting.

Variable importance in the Random Forest model

Across machine-learning validation, distance emerges as the dominant predictor, with position contributing marginally. This hierarchy converges with the logistic-regression and chi-square findings and aligns with existing literature establishing that shooting performance declines sharply with increasing distance due to higher technical and biomechanical demands (Hamilton & Reinschmidt, 1997; Ibáñez, García, et al., 2009; Okazaki & Rodacki, 2012). Moreover, the low relative importance of position supports Slegers et al. (2021), who note that once the shooting pattern is consolidated, angular variability has minimal impact. At the same time, studies centred on positional and contextual differences (Escudero-Tena et al., 2021; Fernández-Cortés et al., 2021) maintain that the tactical value of position depends more on player profile or game situation than on its isolated effect on accuracy. Therefore, the Random Forest results reinforce the need, in formative contexts, to prioritise training in technical control and decision-making across distances, rather than treating position as the primary criterion of intervention (Contreras-García et al., 2024).

A principal limitation of this study is that the analysis focused exclusively on spatial variables (distance and position), without considering contextual factors such as defensive opposition, shot type, or game period, which may also exert a substantial influence on shooting efficacy. Nor were specific playing positions differentiated, which might have afforded a more nuanced view of tactical behaviour. These limitations suggest avenues for future research integrating situational variables and functional profiles to achieve a more complete and applied understanding of shooting performance at formative stages.

Conclusions

This study examined the impact of shooting distance and position on field-goal efficacy among U14 players competing in the Minicopa Endesa. The results confirm that distance to the basket is the most decisive factor for success, with a clear decline in accuracy as distance increases, especially beyond 6.75 metres. By contrast, attempts taken near the rim showed efficacy above 70%, consolidating these areas as high-performance zones. Although angular position also influenced efficacy, its effect was moderate and secondary to distance, particularly when both variables were analysed jointly using multivariate models. Spatial decision-making patterns were also identified, with a marked preference for attempts near the rim or from the three-point line and systematic avoidance of intermediate areas, indicative of an early internalisation of professional basketball strategies. Observable even at formative stages, this behaviour suggests the influence of modern basketball's logic of spatial efficiency. Taken together, these findings reinforce the need for training in youth categories not only to prioritise immediate efficacy but also to promote tactical versatility and technical development in underused areas, through situational tasks incorporating defensive pressure, angular diversity, and contextual variability. Such an approach would support better decision-making in real game scenarios and contribute to players' holistic development.

Future directions

Building on these findings, future research could examine additional contextual variables, such as game period, scoreline, and similar factors, to analyse their interaction with distance and shooting position. It would also be pertinent to include analyses differentiated by players' specific roles to identify efficacy profiles and decision-making patterns according to functional responsibilities within the team.

Another promising avenue is the application of longitudinal models to observe how spatial shooting patterns evolve throughout the development pathway, and how early specialisation and exposure to different competitive contexts shape that evolution. Finally, integrating spatial-tracking and biomechanical technologies (e.g., optical tracking or 3D kinematics) would refine our understanding of the technical and perceptual–decisional mechanisms that condition shooting efficacy, opening new possibilities for more personalised, data-informed interventions.

Practical applications

The findings of this study offer concrete guidance for task design in youth basketball settings. First, they reinforce the need for intensive work on technical mastery of shooting in areas close to the rim, where efficacy is highest and the movement pattern can be consolidated under greater motor control. Nevertheless, given the clear preference observed for attempts from the three-point line, it is equally important to include specific training situations that simulate real decision-making at that distance, paying close attention to the balance between volume of attempts and quality of execution.

Secondly, the limited use of intermediate and angular zones underscores the importance of designing tasks that encourage exploration of these areas, not only to broaden players' technical–tactical repertoire, but also to enhance their ability to adapt to different game situations. Incorporating variability in shooting positions, defensive-pressure conditions, and pre-shot actions can help develop more versatile players with greater decision-making capacity in less frequently exploited spaces. Finally, coaches should remain aware of the influence that professional game models exert on shooting decisions at early stages. This trend can be leveraged as an opportunity to develop well-founded tactical habits within a framework of integral, progressive training adapted to the needs of the developing player.

References

Anguera, M. T., Blanco, A., Hernández, A., & Losada, J. L. (2011). Diseños observacionales: ajuste y aplicación en psicología del deporte. *Cuadernos de Psicología del Deporte*, *11,*(2).

Anguera, M. T., & Hernández-Mendo, A. (2013). La metodología observacional en el ámbito del deporte. *E-Balonmano Com*, *9*(3), 135-160.

Arias, J. L., Argudo, F. M., & Alonso, J. I. (2012). Distances and shooting zones as a function of mass of basketball among 9-to 11-year-old male players. *South African Journal for Research in Sport, Physical Education and Recreation*, *34*(1), 1-11.

Asadi, A., Daneshfar, A., Maleki, B., & Aiken, C. A. (2023). Effects of attentional focus and gaze instruction during observational learning of a basketball free-throw. *Hum Mov Sci*, *87*, 103038. https://doi.org/10.1016/j.humov.2022.103038

Bustamante-Sánchez, Á., & Jiménez-Saiz, S. L. (2024). Game location effect in game-related statistics and pre-shot combination differences between winners and losers during the basketball ACB COVID-19 season. *PLOS ONE, 19*(7), e0303908. https://doi.org/10.1371/journal.pone.0303908

Cabarkapa, D., Cabarkapa, D. V., Philipp, N. M., Eserhaut, D. A., Downey, G. G., & Fry, A. C. (2022). Impact of Distance and Proficiency on Shooting Kinematics in Professional Male Basketball Players. *J Funct Morphol Kinesiol*, *7*(4). https://doi.org/10.3390/jfmk7040078

Cleveland, W. S., & Devlin, S. J. (1988). Locally weighted regression: an approach to regression analysis by local fitting. *Journal of the American statistical association*, *83*(403), 596-610.

Contreras-Garcia, J. M., Courel-Ibanez, J., Pinar-Lopez, M. I., & Ibanez, S. J. (2024). Early specialization in formative basketball: A machine learning analysis of shooting patterns in U14 and professional players. *J Sports Sci*, *42*(24), 2443-2450. https://doi.org/10.1080/02640414.2024.2436809

Cotta-Ortega, A., Contreras-García, J. M., López-Sierra, P., Gutiérrez-Capote, A., & Piñar-López, M. I. (2025a). Analysis of game situations in the 3-point shot in women's basketball: A case study. *E-balonmano com, Journal of Sports Science, 21*(3, special issue), 347–362. https://doi.org/10.17398/1885-7019.21.347

Cotta-Ortega, A., Gutiérrez-Capote, A., Contreras-García, J. M., & Piñar, M. I. (2025b). Ball reversal as performance indicator in female basketball. *E-balonmano com, Journal of Sports Science, 21*(1), 49–64. https://doi.org/10.17398/1885-7019.21.49

Daly-Grafstein, D., & Bornn, L. (2020). Using in-game shot trajectories to better understand defensive impact in the NBA. *Journal of Sports Analytics, 6*, 235–242. https://doi.org/10.3233/JSA-200400

Escudero-Tena, A., Rodríguez-Galan, V., García-Rubio, J., & Ibáñez, S. J. (2021). Influence of the Specific Position on The Final Result of The Match in Professional Basketball. *Revista de Psicología del deporte*, *30*(3), 19-24.

Fernández-Cortés, J. A., Mandly, M. G., García-Rubio, J., & Ibáñez, S. J. (2021). Contribution of professional basketball players according to the specific position and the competition phase. *E-Balonmano Com*, *17*(3), 223-232.

Fu, Y., & Stasko, J. (2024). HoopInSight: Analyzing and Comparing Basketball Shooting Performance Through Visualization. *IEEE Trans Vis Comput Graph*, *30*(1), 858-868. https://doi.org/10.1109/TVCG.2023.3326910

García, J., Ibáñez, S. J., Feu, S., Cañadas, M., & Parejo, I. (2008). Estudio de la gestoforma del lanzamiento a canasta en la liga E.B.A. *Retos*, *14*, 17-21.

Goldsberry, K. (2012). Courtvision: New visual and spatial analytics for the nba. 2012 MIT Sloan sports analytics conference,

Gómez-Ruano, M. Á., Alarcón, F., & Ortega, E. (2015). Analysis of shooting effectiveness in elite basketball according to match status. *Revista de Psicología del deporte*, *24*(3), 0037-0041.

Hamilton, G. R., & Reinschmidt, C. (1997). Optimal trajectory for the basketball free throw. *Journal of sports sciences*, *15*(5), 491-504.

Ibáñez, S. J., Feu, S., García, J., Parejo, I., & Cañadas, M. (2009). Shot differences between professional (ACB) and amateur (EBA) basketball teams. Multifactorial study. *Revista de Psicología del deporte*(Supl. 18), 313-317.

Ibañez, S. J., García-Rubio, J., Gómez, M.-Á., & Gonzalez-Espinosa, S. (2018). The impact of rule modifications on elite basketball teams' performance. *Journal of human kinetics*, *18*(2), 318. https://doi.org/10.1080/24748668.2018.1475197

Ibáñez, S. J., García, J., Feu, S., Parejo, I., & Cañadas, M. (2009). Shot efficacy in the NBA: A multifactorial analysis. *Cultura, Ciencia y Deporte*, *10*, 39-47.

Ibáñez, S. J., Mazo, A., Nascimento, J., & García-Rubio, J. (2018). The Relative Age Effect in under-18 basketball: Effects on performance according to playing position. *Plos One*, *13*(7), Article e0200408. https://doi.org/10.1371/journal.pone.0200408

Ibáñez, S. J., Santos, J. A., & García, J. (2015). Multifactorial analysis of free throw shooting in eliminatory basketball games. *International Journal of Performance Analysis in Sport*, *15*(3), 897-912. <Go to ISI>://WOS:000370807100012

Kilcoyne, S. (2020). *The decline of the mid-range jump shot in basketball: A study of the impact of data analytics on shooting habits in the NBA* [Graduation Thesis, Bryant University].

Louppe, G. (2014). *Understanding random forests: From theory to practice* [Doctoral Thesis, Universite de Liege (Belgium)].

Miller, S., & Bartlett, R. (1996). The relationship between basketball shooting kinematics, distance and playing position [Article]. *Journal of sports sciences*, *14*(3), 243-253. https://doi.org/10.1080/02640419608727708

Lucey, P., Bialkowski, A., Carr, P., Yue, Y., & Matthews, I. (2014, February). How to get an open shot: Analyzing team movement in basketball using tracking data. In Proceedings of the 8th annual MIT SLOAN sports analytics conference.

Min, B. J. (2016). Application of Monte Carlo simulations to improve basketball shooting strategy. *Journal of the Korean Physical Society*, *69*(7), 1139-1143.

Morillo, J. P., Rivera-Gálvez, A., Quiñones-Rodríguez, Y., Caballero-Cerbán, M., Hernández-Mendo, A., & Reigal, R. E. (2025). Análisis de las conductas de los lanzamientos triples en Baloncesto 3x3. *E-Balonmano Com*, *21*(3), 471-484. https://doi.org/10.17398/1885-7019.21.471

Okazaki, V. H. A., Okazaki, F. H. A., Sasaki, J. E., & Keller, B. (2007). Speed-accuracy relationship in basketball shoot. *The Fiep Bulletin*, *77*, 745-747.

Okazaki, V. H. A., & Rodacki, A. L. F. (2012). Increased distance of shooting on basketball jump shot. *Journal of sports science & medicine*, *11*(2), 231.

Okubo, H., & Hubbard, M. (2006). Dynamics of the basketball shot with application to the free throw. *J Sports Sci*, *24*(12), 1303-1314. https://doi.org/10.1080/02640410500520401

Olteanu, M., Oancea, B. M., & Badau, D. (2023). Improving Effectiveness of Basketball Free Throws through the Implementation of Technologies in the Technical Training Process. *Applied Sciences*, *13*(4). https://doi.org/10.3390/app13042650

Pereira, M., Graça, A., & Estriga, L. (2025). Estruturas táticas ofensivas (1-2-2 e 2-2-1) no basquetebol feminino Sub-14: estudo exploratório das interações na rede de passes. . *E-Balonmano Com*, *21*(3), 459-470. https://doi.org/10.17398/1885-7019.21.459

Podmenik, N., Supej, M., Čoh, M., & Erčulj, F. (2017). The effect of shooting range on the dynamics of limbs angular velocities of the basketball shot. *Kinesiology, 49*(1), 92-100.

Plakias, S., Kokkotis, C., Pantazis, D., & Tsatalas, T. (2024). Comparative analysis of key performance indicators in Euroleague and national basketball leagues. *Journal of Physical Education and Sport*, *24*(6), 1360-1372. https://doi.org/10.7752/jpes.2024.06154

Qu, Q., Li, M., Li, K., Zhang, J., & Kim, S. (2024). Effects of Basketball Shooting Distance on Release Angle. *International Journal of Innovative Research in Computer Science and Technology*, *12*(2), 70-71. https://doi.org/10.55524/ijircst.2024.12.2.11

Sampaio, J., Janeira, M., Ibanez, S. J., & Lorenzo, A. (2006). Discriminant analysis of game-related statistics between basketball guards, forwards and centres in three professional leagues. *European Journal of Sport Science*, *6*(3), 173-178. https://doi.org/10.1080/17461390600676200

Sandri, M. (2020). The R package BasketballAnalyzeR. In *Basketball Data Science* (pp. 185-196). Chapman and Hall/CRC.

Scott, D. W. (2015). *Multivariate density estimation: Theory, practice, and visualization (2nd ed.).* John Wiley & Sons. https://doi.org/10.1002/9781118575574

Slawinski, J., Louis, J., Poli, J., Tiollier, E., Khazoom, C., & Dinu, D. (2018). The effects of repeated sprints on the kinematics of 3-point shooting in basketball. Journal of human kinetics, 62, 5-14. https://doi.org/10.1515/hukin-2017-0156

Slegers, N., Lee, D., & Wong, G. (2021). The Relationship of Intra-Individual Release Variability with Distance and Shooting Performance in Basketball. *Journal of Sports Science and Medicine*, 508-515. https://doi.org/10.52082/jssm.2021.508

Tran, C. M., & Silverberg, L. M. (2008). Optimal release conditions for the free throw in men's basketball. *J Sports Sci*, *26*(11), 1147-1155. https://doi.org/10.1080/02640410802004948

Tuquet, J., Lozano, D., Antunez, A., Larroy, J., & Mainer-Pardos, E. (2021). Determinant Factors for Throwing in Competition in Male Elite Handball. *Sustainability*, *13*(19). https://doi.org/10.3390/su131910913

Vencúrik, T., Milanović, Z., Lazić, A., Li, F., Matulaitis, K., & Rupčić, T. (2022). Performance factors that negatively influence shooting efficiency in women's basketball. *Frontiers in Physiology, 13,* 1042718. https://doi.org/10.3389/fphys.2022.1042718

Usabiaga, O., Castellano, J., Blanco-Villaseñor, Á., & Casamichana, D. (2013). La Teoría de la Generalizabilidad en las primeras fases del método observacional aplicado en el ámbito de la iniciación deportiva: calidad del dato y estimación de la muestra. *Revista de Psicología del deporte*, *22*(1), 0103-0109.

Wand, M. P., & Jones, M. C. (1994). *Kernel smoothing*. CRC press.

Wang, F., & Zheng, G. (2022). What are the changes in basketball shooting pattern and accuracy in National Basketball Association in the past decade? *Front Psychol*, *13*, 917980. https://doi.org/10.3389/fpsyg.2022.917980

Wickham, H. (2016). *ggplot2: Elegant graphics for data analysis (2nd ed.)*. Springer.

Zajac, T., Mikolajec, K., Chmura, P., Konefal, M., Krzysztofik, M., & Makar, P. (2023). Long-Term Trends in Shooting Performance in the NBA: An Analysis of Two- and Three-Point Shooting across 40 Consecutive Seasons. *Int J Environ Res Public Health*, *20*(3). https://doi.org/10.3390/ijerph20031924

Zuccolotto, P., & Manisera, M. (2020). *Basketball data science: with applications in R.* . CRC Press, Taylor & Francis Group.