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The importance of place-kicking in Women's International Rugby Union

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ABSTRACT

Despite the growing popularity of women's rugby, there is a lack of research understanding the contribution of place-kicking to match outcomes. This study aims to establish the characteristics and contribution of place-kicking to women's international Rugby Union and evaluate the performance of place-kickers while accounting for factors that contribute to kick difficulty. Data from 674 place-kicks across 80 matches were analysed. A binomial generalised linear mixed model (GLMM) was used to predict the probability of kick success. 60.5% of place-kicks were successful, and they contributed 23.9% of all points scored; conversions accounted for 16.8% and penalties 7.1%. Kick success percentages for conversions (56.9%) and penalties (78.3%) significantly differed ($p < 0.01$). Kick distance and angle were significant ($p < 0.01$) predictors of kick success and the GLMM had a prediction accuracy of 73.6%. The performance rankings of kickers changed when comparing observed and expected success, highlighting the need to consider contextual factors contributing to kick difficulty when evaluating performance. The GLMM results provide valuable insights for coaches and players to make informed decisions, for example, whether to attempt a place-kick when a penalty is awarded, by enabling predictions of place-kick success. This could enhance a team's chances of winning matches.

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Female; football; mixed model; performance analysis; performance indicators; women's sports

Introduction

As of 2018, women's Rugby Union (hereafter *rugby*) players account for over a quarter of the global playing population. Furthermore, the number of registered players in the women's game across World Rugby's member unions increased by 28% in 2018 alone (World Rugby, 2019). However, in comparison with the men's game, there has been a lack of research into women's rugby despite this growing popularity. Whilst there has been some recent research focusing on both women's player and match characteristics (e.g., Nolan et al., 2023; Sheppy et al., 2020; Tucker et al., 2021) and performance (e.g., Scott et al., 2023; Woodhouse et al., 2022), the importance of place-kicking in the women's game remains unknown, despite the fact that place-kicking is known to contribute nearly half of all points scored in men's international rugby (Quarrie & Hopkins, 2015).

A place-kick involves a player placing the ball on the ground, or more commonly on a kicking tee, and aiming to kick it through the posts and above the crossbar (World Rugby, 2023). Place-kicks consist of two types: conversions and penalties. Conversions are attempted after a try has been scored and are worth two points if successful. Penalties are attempted when a kick at goal is chosen following a penalty infringement by the opposing team and are worth three points if successful.

Place-kicking is highly important in men's rugby. Place-kicks contributed 45% of all points scored in 582 men's international matches studied over a 10-year period; penalties contributed 29% and conversions contributed 15% (Quarrie & Hopkins, 2015). Furthermore, the outcome of 5.7% of these matches was decided by a single kick (Quarrie & Hopkins, 2015). Factors have therefore been identified that contribute to place-kick difficulty in the men's game, and subsequently used in statistical models to predict kick success (Jones et al., 2022; Nel, 2013; Pocock et al., 2018; Quarrie & Hopkins, 2015). Kick distance and kick angle (i.e., relative to the goal posts with an angle of 0° corresponding to a kick taken from directly in front of the middle of the posts) have the greatest influence on kick difficulty, with both variables having a negative relationship with the probability of success (Jones et al., 2022; Nel, 2013; Pocock et al., 2018). In the men's game, a place-kick attempted from a mean distance of 32 m and directly in front of the posts (0°) was determined to have an expected success percentage of between 81% and 88% (Jones et al., 2022; Pocock et al., 2018; Quarrie & Hopkins, 2015). However, given the known differences in physical characteristics, namely body mass (Tucker et al., 2021), and biomechanical features of place-kicking technique, such as resultant kicking-foot velocity at ball contact (Atack & Bezodis, 2023), between elite men's and women's players, it is possible that such contextual factors may affect the performance outcomes of women's kickers differently to men's kickers.

Along with the overall importance of place-kicking in women's rugby, performance descriptors, including success probabilities from various pitch locations, remain unknown and likely differ from those in men's rugby. Establishing the influence of contextual factors, such as kick distance and angle,

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on the probability of success in women's place-kicking is important so that kickers and coaches have relevant evidence that can be used to inform training practices and decisions during matches. For example, decisions can be made about whether a player should attempt a place-kick when a penalty has been awarded, and which kicker should attempt each place-kick given that there are often multiple players capable of taking place-kicks on any given team. However, relying solely on observed kick success percentages when comparing kickers may be misleading as it can ignore differences in the difficulty of the kicks attempted by each kicker. This study therefore aimed to, firstly, establish the characteristics and contribution of place-kicking to women's international Rugby Union matches and, secondly, to evaluate the performance of place-kickers while accounting for contextual factors that may contribute to kick difficulty.

Methods

Data from place-kicks were provided by OPTA (www.optaprorugby.com) for all 80 international matches which had been coded between April 2021 and November 2022. The matches were part of one World Cup (26 matches), two Six Nations competitions (24 matches), and 30 other international test matches. A total of 51 kickers from 14 different countries, who each attempted at least one place-kick in any of the 80 matches, were included in the study. Data provided for each place-kick included: anonymous kicker ID, time in match, kick location defined by x and y coordinates on the pitch (*pitch* will be used throughout to refer to the field of play and therefore the in-goal areas will always be ignored; World Rugby, 2023), kick type (conversion or penalty), kick outcome (success or miss), and match score at the time of the kick. OPTA data have previously been reported to have high interobserver reliability within soccer (Liu et al., 2013). Whilst similar research has not yet been undertaken in rugby, OPTA data have been used in previous rugby research (e.g., Scott et al., 2023) and the data are used by professional clubs and broadcasters around the world. Ethical approval for this study was granted by the Science and Engineering Ethics Committee at Swansea University (approval number 1 2023 7857 6750), and additional participant consent was not required given the nature of the data.

The x and y coordinates of kick location were given based on a standardised pitch of length 100 m and width 68 m. It must be noted that the coordinates may have originally been scaled up in length or down in width since the length and width of pitches can range from 94–100 m and 68–70 m (World Rugby, 2023), respectively, although the effect of this for the current analysis was deemed to be negligible. The distance and angle of each kick were calculated from these kick location coordinates. Kick distance was determined between the centre of the goal posts and the kick location. Kick angle was determined as the angle between the line from the kick location to the centre of the goal posts and the centre line of the pitch running between the two sets of goal posts. A positive angle indicated that the kick location was to the right of the centre line (as viewed from the pitch, facing towards the posts), a negative angle indicated that the kick location was to the left of the centre line, and 0° corresponded to the kick being straight in front of the posts. Absolute kick angle was also determined to yield a value which was independent from the side of the pitch each kick was taken from.

A series of linear mixed models were used to test for significant differences in distance, angle, and absolute angle between the two kick types (conversions and penalties). Additionally, a binomial generalised linear mixed model (GLMM) with a logit link function was used to test for a significant difference in kick success between conversions and penalties. Briefly, the logit link function transforms linear combinations of predictor variables into a scale of log-odds, aiding the interpretation of their influence on binary outcomes (i.e., success or miss). The logistic function can then be used to transform these log-odds into probabilities. In each of these models, kick type (conversion or penalty) was included as the fixed factor, and kicker ID was included as a random factor to account for repeated measures in the dataset. Fixed factors are considered to be non-random and consistent across groups or individuals within data, whilst random factors account for the variability across groups or individuals within data (Harrison et al., 2018). These models were used to determine whether the success percentage between conversions and penalties was different and, if so, whether there were underlying factors that may have contributed to this difference.

A further binomial GLMM with a logit link function was developed to predict the probability of kick success. Kick distance and absolute angle were used as fixed factors in the model since these have previously been identified as having a significant effect on the probability of place-kick success in men's rugby (Jones et al., 2022; Nel, 2013; Pocock et al., 2018). Initial investigations using the current dataset revealed that time in match and score margin were not significant explanatory variables, similar to the findings of Jones et al. (2022) and Pocock et al. (2018) in men's rugby, and therefore they were not included in the final model. Kicker ID was included as a random factor to account for repeated measures in the dataset. Stratified group k-fold cross-validation (k = 5) was applied to the whole dataset to evaluate the model and provide a better understanding of the model's performance and generalisability to unseen data. This entailed randomly producing five folds so that training and testing datasets with approximate sizes of 80% and 20%, respectively, were used within each iteration of the procedure. Stratification based on kick outcome ensured that the training and testing datasets within each of the five iterations had success percentages comparable to that of the entire dataset (within ±1%). Folding using groups (kicker ID) ensured all the kicks from a single kicker were exclusively in either the training or testing datasets within each iteration to avoid data leakage and thus ensure that model evaluation truly reflected its ability to generalise to new data (Halilaj et al., 2018; Kapoor & Narayanan, 2023). Model results (coefficients, accuracy, sensitivity, specificity, precision, and F-1 score) were averaged across the five iterations to provide a more robust estimation of its performance.

The averaged model coefficients were used in the logistic function to calculate the probability of kick success for every square metre across a pitch. These results were used to identify the perpendicular distance from the try line which provided the greatest probability of success for any try-scoring location given that players have this freedom of choice when taking a conversion. The probability of success (between 0 and 1) for every kick in the original dataset was also retrospectively calculated using the averaged model coefficients in the logistic function. The expected number of successful kicks for each kicker was calculated by summing the individual kick success probabilities. Each kicker's expected number of successful kicks was compared to their observed number of successful kicks to provide a modelled rank based on how many more kicks they scored than was expected from the model results. Such methods are commonly used in soccer to investigate expected goals (Green, 2012), and have also been recently used in Rugby League to evaluate player involvements (Mariano et al., 2023). The modelled rank and observed rank (based on observed kick success) were then compared and the Spearman's rank correlation coefficient was calculated to quantify the effect of considering kick difficulty on player performance rankings (Nel, 2013; Quarrie & Hopkins, 2015). All data analyses were completed using Python 3.8.17 (Python Software Foundation, python.org).

Results

Over the 80 matches, 674 place-kicks (559 conversions, 115 penalties) were attempted. The number of place-kicks per match ranged from three to 17. The maximum number of conversions in a single match was 17 and the maximum number of penalties in a single match was seven. At least one conversion was attempted in every match. The maximum number of place-kicks attempted by a single kicker was 83. The maximum number of conversions attempted by a single kicker was 73 and the maximum number of penalties was 19. The overall observed success percentage of the 674 place-kicks was 60.5%; 56.9% of conversions were successful and 78.3% of penalties were successful (Table 1). Place-kicks contributed 23.9% (906 points) of all points scored during the investigated matches; conversions contributed 16.8% (636 points) and penalties contributed 7.1% (270 points). Figure 1 shows the locations of all (a) conversions and all (b) penalties. Kick success, kick distance, and absolute kick angle were significantly different ($p < 0.01$) between the conversions and penalties (Table 1).

Conversions were attempted from a significantly greater absolute angle than penalties; 139/559 conversions (24.9%) were attempted from within 5 m from the touch lines. The success of these conversions was 30.2%. No penalties were attempted from within 5 m from the touch lines, whilst only three penalties were attempted from outside the 15 m lines and only one from past the 10 m line (Figure 1b). The score difference between the competing teams was three points or less (i.e., within one successful penalty) at the time of three of these four penalties. All three of these kicks were unsuccessful.

Based on the results of the GLMM for all kicks, both kick distance and absolute angle were significant predictors of kick success (Table 2). The mean accuracy, sensitivity, specificity, precision, and F-1 score determined from the testing datasets across the five cross-validation iterations was 73.6%, 77.2%, 68.1%, 79.2% and 78.0%, respectively. The probability of kick success was calculated using the mean model coefficients and overlaid on a pitch (Figure 2). The perpendicular distance from the try line which provided the highest probability of kick success for each metre along the try line was clearly not linear; it was closely approximated by the equation $y = 4.52x^{0.37}$, where y is the perpendicular distance from the try line and x is the distance from the centre of the posts (Figure 3). The number of observed and expected successful kicks differed for each kicker, as did most observed and modelled ranks (Table 3). The Spearman's rank correlation coefficient between the observed and modelled ranks was 0.81 (Figure 4).

Discussion

This study aimed to establish the characteristics and contribution of place-kicking to women's international Rugby Union matches. A second aim was to evaluate the performance of place-kickers while accounting for factors that may contribute to kick difficulty. The overall observed success percentage of the analysed kicks was 60.5%, and these kicks contributed 23.9% of all points scored during the 80 matches analysed. Kick distance and absolute angle were identified as significant ($p < 0.01$) predictors of kick success using a binomial GLMM. Subsequent use of the model outputs revealed that accounting for these contextual factors led to different rankings of kickers' performance compared to evaluations based simply on observed success percentage alone.

Place-kicks contributed nearly one quarter (23.9%) of all points scored in women's international Rugby Union matches, highlighting their importance within the women's game. However, their contribution to the total points scored is lower than the 45% in men's international Rugby Union (Quarrie & Hopkins, 2015). Whilst the contribution of conversions in the present study (16.8%) aligns closely with Quarrie and Hopkins (2015) (15%), there is a noticeable contrast in the contribution from penalties (7.1% vs. 29%). This disparity may be partly explained by decision making when penalties are awarded outside the 15 m lines (laterally) or beyond the 10 m line (up the pitch), although additional contextual information, such as the number of penalties awarded in women's rugby, and the subsequent options chosen and their outcomes, would provide further insight in future studies.

Table 1. Descriptive statistics summarising the analysed place-kicks (mean ± SD).

Kick type	No. of kicks	Success (%)	Distance (m)	Angle (°)	Absolute angle (°)
All kicks	674	60.5	27.4 ± 8.8	−3.0 ± 41.4	37.6 ± 17.4
Conversions	559	56.9	28.1 ± 8.7	−3.6 ± 44.2	41.5 ± 15.5
Penalties	115	78.3*	24.0 ± 8.4*	0.0 ± 23.0	18.7 ± 13.3*

A positive angle indicates right of the posts, negative indicates left, and 0° indicates straight in front.
* Significantly different ($p < 0.01$) to the conversions.

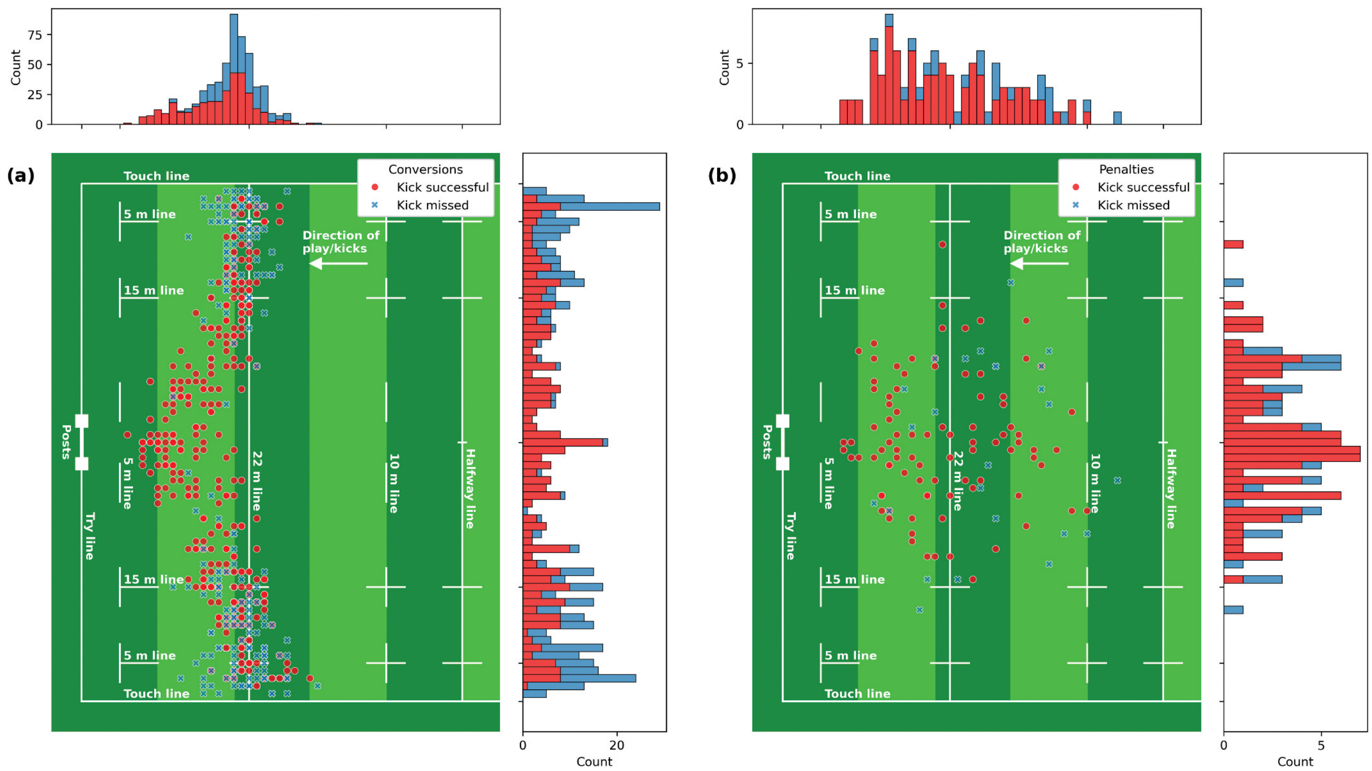

Figure 1. Locations of all analysed (a) conversions and (b) penalties. The stacked histograms on each axis show the number of kicks attempted at one metre increments across and along the pitch (note the different scales on the axes of these histograms between figures a and b). Red circular data points represent a successful kick and blue crosses represent a missed kick.

Table 2. Summary of the binomial generalised linear mixed model results (averaged across the five cross-validation iterations).

			95% CI for coefficient	
Variable	Coefficient	p	Lower	Upper
Intercept	5.01	<0.01	4.01	6.01
Distance	−0.11	<0.01	−0.15	−0.07
Absolute angle	−0.04	<0.01	−0.05	−0.02

Coefficients are expressed as log-odds. This means that for a 1 m increase in distance the change in log-odds of success is −0.11 (if absolute angle is held constant). Likewise, for a 1° increase in absolute angle the change in log-odds of success is −0.04 (if distance is held constant). These coefficients were used in the logistic function to calculate probabilities.

The observed success of conversions (56.9%) and penalties (78.3%) in women's rugby significantly differed from each other ($p < 0.01$). This was likely due to conversions being attempted from a significantly greater mean distance and mean absolute angle compared to penalties ($p < 0.01$). Since distance and absolute angle were both significant predictors of kick success (Table 2), these differences in contextual factors between the kick types mostly account for the different success percentages (mean expected success from the GLMM results: conversions = 54.6%, penalties = 80.0%). As both kick types are essentially the same task, this suggests that place-kickers appear to perceive constraints based on the choices they make. For example, no penalty kicks were attempted within 5 m of the touch lines (Figure 1b). The evidence generally supports the decision not to take penalties from close to the touch lines as all conversions attempted from within 5 m of the touch lines ($n = 139$) had a success percentage of 30.2%, whereas all place-kicks attempted from inside the 5 m lines ($n = 535$) had a success percentage of 68.4%. Only three penalties were attempted from wider than the 15 m lines, and just one penalty was attempted from past the 40 m line (Figure 1b), suggesting that when penalties were awarded outside of these pitch margins, teams generally opted for an alternative option (i.e., kick to touch, scrum, or tap penalty). Future research could explore the alternative options chosen when penalties are awarded, and any points subsequently scored, particularly in these wider areas. Models quantifying the probability of scoring points from alternative penalty options could then be developed and compared with the results of the current study to inform more effective decision making after award of a penalty. Such decision making could be partly informed by the current heatmap (Figure 2), and the known abilities of a given kicker (Table 3); this would provide valuable data-informed insight for tactical decision making to select the option that offers the highest potential points benefit, ultimately enhancing the likelihood of winning matches.

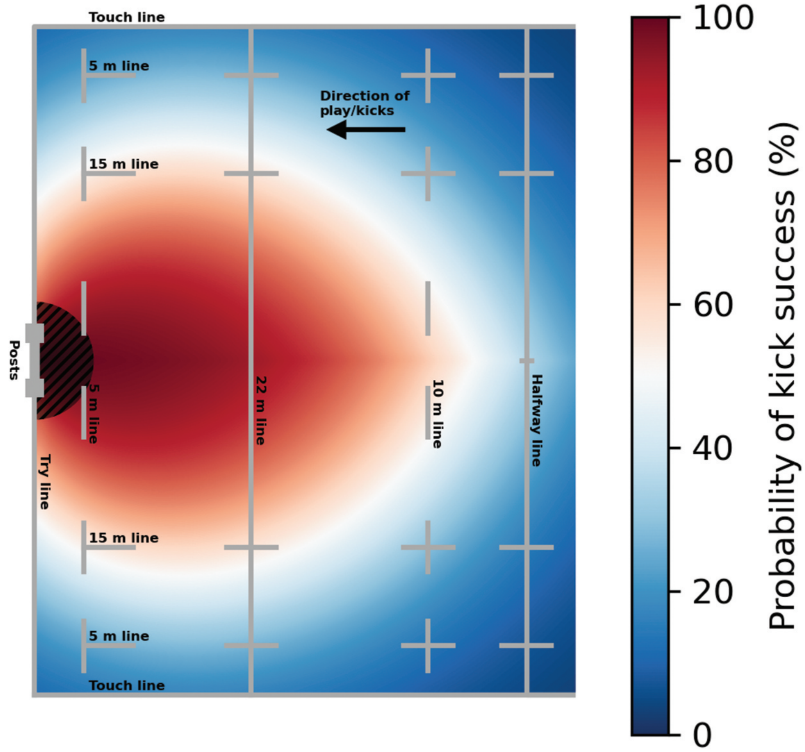

Figure 2. Probability of kick success on a pitch as calculated using the binomial generalised linear mixed model coefficients (averaged across the five cross-validation iterations). As no kicks were attempted from within 6 m of the centre of the posts, a shaded area has been added to indicate uncertainty in the model, particularly from very close distances.

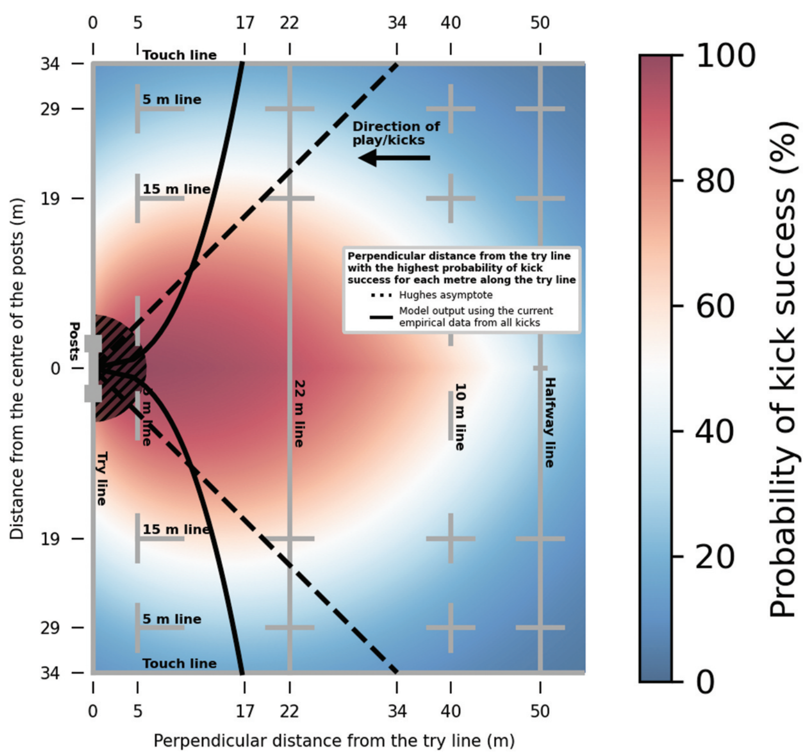

Figure 3. Probability of kick success on a pitch as calculated using the binomial generalised linear mixed model coefficients (averaged across the five cross-validation iterations). The perpendicular distance from the try line with the highest probability of kick success for each metre along the try line was identified (solid black line – this line can be closely approximated by the equation $y = 4.52x^{0.37}$, where y is the perpendicular distance from the try line and x is the distance from the centre of the posts), and this was compared to the Hughes asymptote (dashed black line; Hughes, 1978; Worsnup, 1989). As no kicks were attempted from within 6 m of the centre of the posts, a shaded area has been added to indicate uncertainty in the model, particularly from very close distances. The heatmap is faded compared with Figure 2 to highlight the Hughes asymptote and lines representing the highest probability of kick success, and scales have been added to the axes to aid in the interpretability of these lines.

Given that players have the freedom of choice to attempt conversions from any distance perpendicular to the try line along a line through which the try was scored, the locations of the attempted conversions (Figure 1a) indicate the existence of perceived constraints in kick distance. Conversions generally exhibited a progressively greater perpendicular distance to the try line for wider attempts, before this appeared to plateau around the 15 m lines. Beyond this, kickers instead typically chose to increase kick angle rather than add additional distance (Figure 1a), suggesting a perceived distance limit to the posts where they consequently tolerate the greater difficulty associated with a more acute angle. The perpendicular distance from the try line with the highest probability of kick success for each metre along the try line was identified using the current data (Figure 3). This was closely approximated by the equation $y = 4.52x^{0.37}$, and clearly differs from the Hughes asymptote (Figure 3) that is a straight line at 45° from the centre of the goal posts which closely approximates the locations where the angle subtended by the line between the posts is maximised for any given try-scoring location (Hughes, 1978; Worsnup, 1989). The observed curvilinear relationship based on the current empirical data more closely matches the mathematical model of Polster and Ross (2010), which also considered ball launch angle and velocity (as well as crossbar height). Based on the model of Polster and Ross (2010), the curvature of the relationship increases for lower ball launch velocities, and thus it may be more apparent for international women's place-kickers given their lower values compared with kickers in

Table 3. Observed success and rank, and expected success and modelled rank for each kicker. Each row represents a different kicker.

No. of kicks attempted	No. of successful kicks	Expected no. of successful kicks	Proportion of successful kicks compared to expected	Observed rank	Modelled rank
3	2	1.27	1.58	=15	1
5	4	2.60	1.54	=8	2
10	8	5.89	1.36	=8	3
21	15	12.03	1.25	=11	4
39	19	15.55	1.22	35	5
9	6	5.02	1.20	=15	6
21	18	15.56	1.16	=5	7
55	34	29.46	1.15	19	8
22	13	11.45	1.14	24	9
6	4	3.53	1.13	=15	10
15	13	11.52	1.13	4	11
7	5	4.45	1.12	=11	12
1	1	0.89	1.12	=1	13
5	3	2.69	1.12	=22	14
71	48	43.23	1.11	14	15
83	57	51.65	1.10	13	16
6	5	4.53	1.10	7	17
18	11	9.99	1.10	21	18
29	19	17.69	1.07	18	19
11	6	5.59	1.07	27	20
39	24	22.72	1.06	20	21
1	1	0.96	1.04	=1	22
7	6	5.80	1.04	=5	23
5	4	3.90	1.03	=8	24
1	1	0.98	1.02	=1	25
10	6	5.95	1.01	=22	26
29	17	17.33	0.98	25	27
3	1	1.04	0.96	=40	28
7	3	3.15	0.95	37	29
23	13	13.91	0.93	26	30
2	1	1.15	0.87	=28	31
15	7	8.68	0.81	36	32
10	5	6.26	0.80	=28	33
8	3	4.10	0.73	39	34
4	2	2.84	0.71	=28	35
2	1	1.43	0.70	=28	36
6	3	4.53	0.66	=28	37
4	2	3.28	0.61	=28	38
3	1	1.65	0.61	=40	39
19	8	13.38	0.60	38	40
2	1	1.70	0.59	=28	41
9	3	5.46	0.55	=40	42
3	1	1.94	0.52	=40	43
4	1	1.98	0.50	=44	44
8	2	4.73	0.42	=44	45
4	0	1.09	0	=46	=46
4	0	1.32	0	=46	=46
2	0	0.45	0	=46	=46
1	0	0.21	0	=46	=46
1	0	0.21	0	=46	=46
1	0	0.20	0	=46	=46

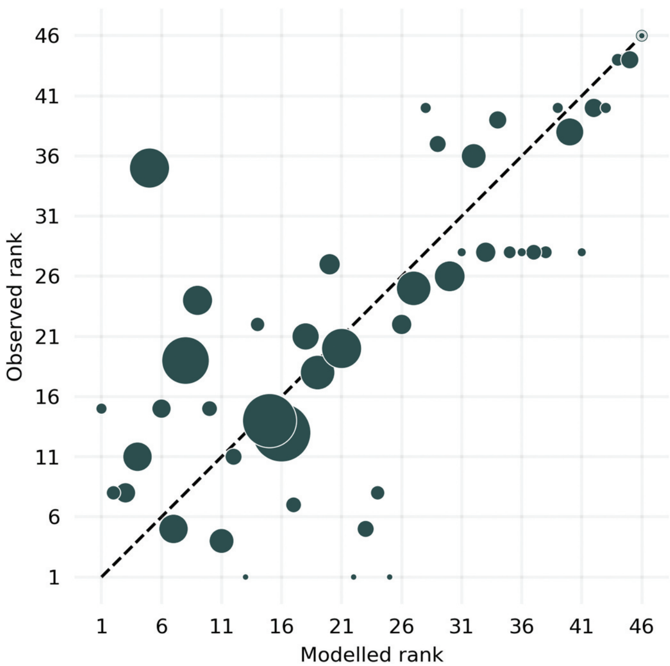

Figure 4. Observed rank plotted against modelled rank. Each marker represents a different kicker, and the marker size is proportional to the number of kicks they attempted. The black dashed line represents a reference for a hypothetical perfect positive correlation.

men's international rugby (Atack & Bezodis, 2023). With sufficient data, coaches could develop "optimal distance" plots for an individual kicker to establish where a conversion should be attempted from in order to maximise the chances of success for any given try-scoring location.

Kick difficulty should be accounted for when evaluating the performance of place-kickers. There are clear differences in performance rankings among kickers when comparing their observed success to the expected success of the "typical" kicker that considers the contextual factors of the kick (i.e., distance and angle) and provides a consistent reference for comparisons (Table 3; Figure 4). These findings align with similar studies conducted in men's rugby (Nel, 2013; Quarrie & Hopkins, 2015). In the current study, the kicker who had the greatest change in ranks (from 35/51 to 5/51) had an observed success percentage of 48.7% from their 39 attempted kicks. However, when retrospectively predicting and summing kick success probabilities using the binomial GLMM, if the "typical" kicker attempted the same kicks they would be expected to have a success percentage of 39.9% (Table 3). The kicker was therefore successful with 1.22 times as many kicks as expected of the "typical" kicker, resulting in more place-kicking points scored than expected, ultimately contributing to an improved likelihood of team success. In contrast, some kickers who attempted multiple kicks were successful with approximately half as many as expected of the "typical" kicker. Table 3 and Figure 4 additionally indicate that kickers with poorer observed ranks generally also have poorer modelled ranks, whereas there is greater disparity between rankings for kickers with better observed ranks. It is important to note that the model coefficients (Table 2) used to calculate expected success are based on the "typical" kicker across the dataset. Consequently, the probability of kick success for some kickers may be too high or low based on their individual ability and the representation of their kicks within the dataset. Given the disparity in professionalism among teams in women's rugby, with England and France being offered professional contracts in 2019 (Cavil, 2022), while other teams in the dataset consisted primarily of semi-professional or amateur players when the data were recorded with likely comparatively limited practice time for place-kicking, it is probable that there exists a greater range of place-kicking abilities among women's kickers than in the largely professional men's game.

It should be noted that an average of 26.4% of kicks in the current study were incorrectly classified across the cross-validation iterations, indicating room for improvement in the model's predictive accuracy. This predictive accuracy is quantified based on the "typical" kicker attempting the kicks to provide a performance measure of the model's generalisability to unseen data. In the future, if sufficient data can be collected, individualised models could be developed using data from a single kicker and these models would likely have improved predictive accuracy. Kick outcomes were also predicted as successful if the probability of success was over 50%, otherwise they were predicted as missed. Future research could look at alterations to this threshold and investigate the effects on the predictive accuracy of kick outcomes. Model performance may also have been influenced by kickers each attempting a different number of kicks. For example, one of the kickers attempted 83 kicks meaning that this kicker contributed 63.4% of the kicks in one of the testing datasets. If only a single set of training and testing datasets were used to assess model performance and this kicker was in the testing dataset then the model performance results would likely be biased by the large contribution of kicks from this kicker. However, the use of stratified group k-fold cross-validation (with k = 5) means that five different sets of training and datasets were used. The accuracy across the cross-validation iterations ranged from 68.7% to 81.5%. Using cross-validation and taking the average model performance across the five iterations (accuracy = 73.6%) helps to reduce any biases towards kickers with more attempted kicks and thus provides a more robust estimation of model performance.

Previous place-kicking models have explored additional contextual factors such as the time in the match and the score margin at the time of each kick (Jones et al., 2022; Pocock et al., 2018), but these were found to be non-significant predictors in both men's rugby studies and in the present study. Future exploration of other contextual factors, such as weather and pitch conditions, may enhance the performance of similar models. The kicking foot used by each kicker and its interaction with side of the pitch are further contextual factors that could be considered. However, success percentages in the current study were nearly equal between left (37.8%, $n = 172$) and right (37.2%, $n = 145$) sides of the pitch for place-kicks wider than the 15 m lines (Figure 1). Given that approximately 79% of the general population and international men's soccer players have been identified as right footed (Carey et al., 2001), the same could be assumed of women's rugby kickers and it thus appears that footedness and its interaction with side of the pitch does not influence success. This result also supports the use of absolute angle in the model that ignores side of the pitch and produces symmetrical probabilities of kick success for the left and right sides (Figure 2; Figure 3). By only focusing on distance and absolute angle as predictors, the current model maintains simplicity and avoids unnecessary complexity. This approach helps to improve the model's generalisability to unseen data by reducing the risk of overfitting.

This is the first study to investigate place-kicking performance in women's international Rugby Union. There was a success percentage of 60.5% over 80 matches, and place-kicking contributed 23.9% of the total points scored in these matches. Conversions exhibited a significantly lower success percentage than penalties, which can be largely attributed to the fact that conversions were attempted from significantly greater mean distances and absolute angles to the goal posts as kickers tended not to attempt penalty place-kicks from outside of the 15 m lines or beyond the 10 m line. The choices surrounding place-kick locations indicate perceived constraints among place-kickers, including the existence of perceived distance limits and a consequent willingness to tolerate greater difficulty owing to more acute angles during conversions from wider regions of the pitch. The results of the binomial GLMM, and consequent kick success probability heatmaps and relationships, can serve as valuable resources for coaches and kickers, enabling them to make informed decisions regarding both penalties and conversions during matches. Furthermore, the model outcomes have been used to demonstrate the importance of considering contextual factors (distance and angle) on kick difficulty in women's international Rugby Union, thereby providing a more comprehensive evaluation of place-kicker performance.

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