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Original research

Evaluation of goal kicking performance in international rugby union matches

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ABSTRACT

Goal kicking is an important element in rugby but has been the subject of minimal research.
Objectives: To develop and apply a method to describe the on-field pattern of goal-kicking and rank the goal kicking performance of players in international rugby union matches.
Design: Longitudinal observational study.
Methods: A generalized linear mixed model was used to analyze goal-kicking performance in a sample of 582 international rugby matches played from 2002 to 2011. The model adjusted for kick distance, kick angle, a rating of the importance of each kick, and venue-related conditions.
Results: Overall, 72% of the 6769 kick attempts were successful. Forty-five percent of points scored during the matches resulted from goal kicks, and in 5.7% of the matches the result of the match hinged on the outcome of a kick attempt. There was an extremely large decrease in success with increasing distance (odds ratio for two SD distance 0.06, 90% confidence interval 0.05–0.07) and a small decrease with increasingly acute angle away from the mid-line of the goal posts (odds ratio for 2 SD angle, 0.44, 0.39–0.49). Differences between players were typically small (odds ratio for 2 between-player SD 0.53, 0.45–0.65).
Conclusions: The generalized linear mixed model with its random-effect solutions provides a tool for ranking the performance of goal kickers in rugby. This modelling approach could be applied to other performance indicators in rugby and in other sports in which discrete outcomes are measured repeatedly on players or teams.

1. Introduction

The performance of goal kickers can have a major bearing on team success in rugby union. Match results occasionally depend on the success or failure of a given kick attempt, and points derived from goal kicks generally contribute substantially to a team's overall score. In fact, match analysis reports of professional tournaments published by the International Rugby Board indicate that between 40% and 60% of points scored in international rugby matches result from goal kicks (http://tinyurl.com/mefot9f).

The importance of goal kicking to team success sometimes leads to debate among the media and rugby fans about the relative ability of goal kickers in international rugby (e.g., http://tinyurl.com/knxe3gx). The kicking proficiency of players in international rugby matches is typically evaluated in broadcast and print media by presenting percentages of successful kicks by player per match, or less frequently, per competition. Such measures do not account for factors such as the relative difficulty of kicking from different parts of the field, environmental effects, or the fact that some kickers are typically called upon for (or elect to take) easier or more difficult kicks.

In spite of the important role of goal kicking in rugby, little research analysing goal kicking performance in rugby union has been published. Of the eight studies we found, two examined pre-kick routines,[1,2] one investigated the effect of the contra-lateral arm on kicking,[3] one examined the reliability of tests of kicking performance,[4] and one quantified effects of kinematic variables on ball-movement speed after the kick.[5] The optimal point from which to take kicks has been the subject of several mathematical investigations (e.g., 6). With respect to ranking the goal kicking performance of players, we found one peer-reviewed study,[7] and one non-peer-reviewed web article (http://tinyurl.com/mamlmo7).

The purpose of our paper was to examine the prowess of international goal kickers over a 10-year period by examining their success rates, while accounting for various factors that may influence success, such as the venue, the position on the field from which kicks were taken, the relative scores of the teams at the time at which the kick was taken, and the amount of time remaining in the match. A

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major goal of the work was to develop a tool for ranking players in sports where data from events with discrete outcomes are repeatedly measured on individuals within matches and over series of matches. We also sought to describe the distribution and success of kicks by location on the field, and examine the effect of venue on kick success.

2. Methods

The study complied with the ethical guidelines for observational studies produced by AUT University, New Zealand. Data were obtained from 6769 kicks attempts (2967 conversions and 3802 penalties) in 582 international matches played from 2002 to 2011. The tournaments included were Six Nations (150 matches), Tri-Nations (72 matches), Rugby World Cup (144 matches) or 'other international' (216 matches). Information about each kick was coded by Verusco Technologies (Palmerston North, NZ). The data included information about the match (tournament, date, venue, city, country, teams, the final score), and details about the kick (name of the kicker, whether the kicker was right or left footed, location on the field from where the kick was taken, type of kick (penalty or conversion), whether or not the kick attempt was successful, the scores of the teams at the time the kick was taken, and time through the match at which the kick was taken).

The distance and angle of the kick from the mid-point of the goal posts were derived from the *x* and *y* coordinates of the kick. To describe the distribution of kicks on the field, the angle was calculated by measuring counterclockwise from the Tryline, with 90° being directly in front of the mid-point of the goal posts. For the purposes of modelling the effect of angle on kick success, we used the acute angle measured from the try line (measured counterclockwise on the left side of the field, clockwise on the right) regardless of the side of the field from which the kick was taken, and included the side of the field as a covariate. A grid dividing the playing area into five-metre squares was used to show the distribution of kick attempts and the predicted goal kicking success from various points on the field. Verusco reported a 'range' of error in the location of the kicks based on the coding method of zero to 50 cm in the y direction (down the field) and 0–150 cm in the *x* direction. The degree of error in the location had a negligible effect on the modelled results.

We developed a measure of kick importance to reflect the likelihood that the outcome of the kick would affect the outcome of the match. Score difference at the time of the kick and time remaining in the match were taken into account for this measure. For the model we developed, kick importance was the product of score importance multiplied by time importance. Kick importance was based on the following precepts:

- As long as the outcome of the match remains in doubt, the kick importance increases as the time left in the match decreases. In the series of matches analyzed, the largest deficit overcome by a team that was losing and went on to win was 13 points (although we have seen larger deficits overcome in other matches at lower levels of play). Once the outcome is essentially a foregone conclusion, kick importance begins to decrease as a function of time remaining in the match.
- For a given absolute score difference, kicks taken when trailing are more important than kicks taken when winning. In other words, there is more pressure on the losing team than on the winning team.
- Kicks taken when the scores are close together are generally more important than kicks taken when the scores are further apart.
- Kicks taken that change the team leading are considered the most important, on the basis that if no further points are scored following the kick they result in a winning result for the kicker's team.

Although time importance and score importance were not modelled separately, the calculation of each is explained separately below for clarity. Score importance was calculated as follows:

- For kicks where the kicker's team was leading, score importance = 1/(score difference + 3).
- For penalties where the kicker's team was behind, score importance = 1 if the kicker's team was one point behind, otherwise score importance = 1/(absolute score difference − 1).
- For conversions where the kicker's team was behind, score importance = 1/(absolute score difference).
- For no difference between teams, score importance = 0.5.

The calculation of time importance was as follows:

- For kicks where the absolute difference between team scores was less than the time remaining plus 10, time importance = 0.2 + (percent of match elapsed/50).
- For kicks where the absolute difference between team scores before the kick was greater than the time remaining plus 10, time importance = (percent of match remaining/50).

Based on the importance scale above, the most important kick was one that, if successful, won the match – for example, a penalty taken when a team was one or two points down with no further time to play. We did not include adjustment for tournament importance when calculating the importance of kicks within matches, nor did we take into account the fact that in some matches over the series teams were awarded a bonus point in the tournament if they lost by a margin of seven points or fewer.

Data were analyzed with a generalized linear mixed model using the SAS Glimmix procedure (SAS Version 9.3, SAS Institute, Cary, NC, USA). Only players who attempted 10 kicks or more in the series of matches were included in the model. This removed 97 players and 341 kick attempts from the dataset, leaving 101 players and 6428 attempts. An overdispersed binomial distribution with a logit link function was used to model the success or failure of each kick attempt. Fixed effects in the model were: kick distance, kick angle interacted with the side of the field, preferred kicking foot of the player interacted with side of the field, and importance of the kick. Random effects were the player, the venue, the match, and the importance of the kick interacted with the player. We evaluated the magnitude of odds ratios for covariates in the model at a difference of two standard deviations (i.e. from a typically small value to a typically large value). Interpretation of the magnitude and clarity of effects was done with reference to the guidelines provided by Hopkins et al.[8] Odds ratios from the random effects solutions were transformed into percentage success rates with 90% confidence limits. The random effects solution for player and its interaction with kick importance were combined with fixed effects to derive each player's predicted success rate and thereby rank the players. The random effects solution for venue was produced to evaluate success by stadium. The relationship between kicker success for kicks of mean importance and for kicks of high importance (two standard deviations above the mean importance), and that between the raw rank of players and the modelled rank were evaluated using the Pearson correlation coefficient.

The distribution of kicks and kick success over the field, and kick success by venue has been included in a supplementary Microsoft Excel workbook (*SW*). Where relevant, the tabs of the workbook