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Abstract

We investigate the truth in the old German football myth which says that the fouled player should not try to take the resulting penalty himself, as he is at an increased risk of missing it. Previous analyses are improved on as we adjust for potential confounders which might influence self-taking as well as successful penalty conversion. Findings revealed some important predictors for self-taking, but, somewhat surprisingly, neither self-taking nor any of the potential confounders is predictive for successful scoring from a penalty.

Introduction

In modern football, penalty shot conversion is of vital importance. In fact, the world cup finals in 1990 and 1994 were both decided by penalties. Nevertheless, scientific investigations of penalty conversion are rare. Shooting techniques and tactics, ball speed, anticipation of the keeper and stress management of the shooter have been the most frequent objects of investigation (Kuhn, 1988; Loy, 1996; Savelsbergh et al., 2002, 2005; Morya et al., 2003). Mostly, however, these studies have been conducted in well-defined controlled environments, but rarely with actual league football data. Thus, it is not surprising that the old German football myth “The fouled player shouldn’t take the penalty himself!” which means that the player who was fouled in the penalty area should not try to take the resulting penalty himself as he is at an increased risk of missing the penalty, was investigated only twice and, both times, in a rather descriptive manner. Drösser (2003) analysed penalties from 10 years of the premier German football league and found a slightly higher proportion of goals (75.3% vs. 71.3%) in the group of the non-tackled players, however, he did not use any inferential statistical methods to check his findings. Eichler (2002) analysed five years (1993/94 – 1997/98) and found opposing results. That is, more conversions were observed in the group of tackled players (89.5% vs. 78.5%), but he did not apply inferential statistical methods to check if these findings might be due to random variation either. Indeed, a re-analysis of the penalties in his observation interval showed that the observed difference was not statistically significant (p=0.20).

What the previous analyses are especially lacking, in our opinion, is an adjustment for other factors that might influence the successful conversion of a penalty besides “self-taking“ (which we use here to denote the fact that the fouled player takes the penalty himself). For example, we might suspect that more experienced or older players are more successful in penalty shooting, or players who have been successful penalty shooters in the past might also be more successful in the future. In addition, we expect psychological constructs like self-confidence, self-efficacy, anxiety and stress to play an important role in successful penalty conversion. However, maturity, past success, or strong self-confidence might also influence the decision to take the penalty, even when one has been tackled oneself. Thus, these factors might influence both, the chances of successful scoring as well as the decision of self-taking. This concept of factors which might influence the outcome (successful conversion) as well as the risk factor (self-taking) is called confounding in epidemiological research (Rothman and Greenland, 1998).

Ideally, to check the asserted connection between penalty scoring and self-taking, we would like to set up a randomized trial. In this case, the decision of whether the tackled player would take the penalty himself after each foul in the penalty area would be decided randomly. This would be the only way to balance the suspected modifying factors or confounders between the groups of self-taking and non-self-taking players. Obviously, conducting such a study is impossible, and we therefore must rely on the methods of confounder adjustment from observational studies, that is, by regression modelling.

We present here the results of an empirical investigation of the prescribed old German football myth. In a first step we analyse which factors influence the decision of self-taking the penalty, and in a second step we adjust the connection between self-taking and successful penalty conversion for the respective factors. Proceeding this way we are able to gain a more realistic impression of the truth of the described myth.

Data

The data were made available for scientific research by IMP AG, München (www.impire.de), a German company that collects data for a commercial football data base. We used data on all 835 penalties for committed fouls in the premier German football league (1. Bundesliga) from August 1993 to February 2005. All penalties for committed handballs have been excluded as in this case self-taking is not possible. The following information was available for each penalty: scorer, team of scorer, opponent team, age of scorer, experience of scorer (in terms of number of played matches, converted penalties, missed penalties, and scored goals), home advantage, current score, current minute, team's league ranking at the time, day of season, and, of course, successful conversion of penalty and self-taking. We additionally calculated a penalty conversion ratio by dividing the number of successfully converted penalties by the number of total scored penalties. This ratio was set to 0.7437 (the average conversion ratio in the data set) for first time scorers. League ranking at the first day of season was set to the final position from the previous season, with promoted teams set to the last three positions.

Statistical Methods

For descriptive purposes we summarized continuous data by means and standard deviations, and categorical data by absolute and relative frequencies. The Wilcoxon-test was used to compare means in two groups. Associations between categorical variables were assessed by odds ratios (ORs) and risk differences with corresponding 95%-confidence intervals, χ^2-tests were performed to judge statistical significance in the respective contingency tables. Logistic regression was used to measure the influence of several variables on binary responses. We accounted for the fact that (1) penalties might be correlated (or clustered) within the same player and (2) players within the same team by using a 3-level hierarchical (or random effects) logistic regression model (Diggle et al., 1995). In those models, random intercept terms are included into the common linear predictor of fixed effects to explicitly model the within-player and within-team correlation.

To check the robustness of the final model (Table 3) we additionally fitted (1) a model with all covariates included after a backward selection, and (2) a model with all covariates where both, the inclusion and the functional form of the covariates were judged by the multivariate fractional polynomial (MFP) algorithm (Sauerbrei and Royston, 1999). In this MFP algorithm, a backward elimination step is combined with a search of an optimal power transformation for all continuous covariates across a restricted set of powers. Each continuous covariate is allowed to have two separate model terms with potentially different powers and thus virtually all functional forms of these covariates are modelled and tested. The MFP algorithm was (due to lack of software) performed only on the model with the fixed effects included.
All calculations were performed with SAS (Cary, NC, USA), Version 9.1, the hierarchical logistic regression model was estimated with the PQL method via the %GLIMMIX macro (Kuss, 2002).

Results

The 835 penalties were taken by 229 different players from 30 different clubs. 621 (=74.4%) of the 835 penalties were converted; 102 (=12.2%) of all penalties were taken by the tackled player. Of these 102 penalties, 74 (=72.6%) were converted, compared to 547 conversions of the remaining 733 (=74.6%) penalties that were taken by another, non-tackled player. This difference of 2 percentage points was not significant (χ^2=0.20, p=0.65, 95%-confidence interval: [-7.1; 11.3]). Thus, at first glance, there is no relevant difference between self-taking and non-self-taking players. If we express this result as an odds ratio to ease later comparison to the results from the logistic models, this amounts to 0.90 with a 95%-confidence interval of [0.56; 1.43]. That means, the odds for successful conversion is reduced by 10% if the tackled player takes the penalty himself, but this effect is far from being significant.

Table 1 gives a description of several potential confounders in the two groups of self-taking and non-self-taking players together with the p-values for a comparison of the groups. Only two factors, the age and the experience of the player (modelled as the number of all played matches) are significantly different between self-taking and non-self-taking players, with younger and less experienced players taking penalties more frequently when they have been tackled themselves. Somewhat surprisingly, none of the external factors (minute, league ranking, day of season, home advantage, and even the current score of the match) seemed to influence self-taking.

**** PLACE TABLE 1 APPROXIMATELY HERE****

To judge any interdependencies between these factors as well as to assess an additional player and team effect on self-taking, we fitted a hierarchical logistic regression model with all the confounders from Table 1 as fixed effects covariates and random intercepts for the player and the team effect. Results from this model fit are given in Table 2.

**** PLACE TABLE 2 APPROXIMATELY HERE****

In general, the observations made from this regression model reflect the results from the simpler bivariate analyses in Table 1. Age and number of matches are still significant predictors for self-taking. The odds ratios for these predictors can be conveniently interpreted. Each additional year of life leads to a 9% (=1-0.91) reduction of the odds of self-taking and each 10 additional games to a 9% reduction in the odds. However, compared to the bivariate analyses, we found one additional significant predictor, which was the number of goals scored. Here, each 10 additional goals result in a 31% increase in the odds for self-taking. That is, players who have scored more goals in the past are more likely to take the penalty if they were tackled themselves.

Interestingly, we also found a significant random scorer effect. That is, self-taking is correlated within the same player, such that a player who previously took the penalty himself when he was tackled tended towards self-taking the next time a penalty occured. This can be illustrated, for example, if we consider the most extreme predicted values for self-taking in the respective players. Michael Preetz of Hertha BSC Berlin took 5 penalties during the observation time, four of which after he had been tackled himself. On the other hand, Ulf Kirsten of Bayer Leverkusen tried to convert 13 penalties, but not a single one was attempted when he was tackled himself. Jörg Butt, goal keeper of Bayer Leverkusen took 24 penalties, but, for obvious reasons, was never tackled in the opponent’s penalty area.

**** PLACE TABLE 3 APPROXIMATELY HERE****

In Table 3 we give the results of the hierarchical random effects logistic regression model for successful conversion of a penalty. Corresponding to our intention of adjusting the connection between successful conversion and self-taking by important confounders, we included all available covariates in the model. We again allowed for the fact that conversions might be correlated within the same scorer and the same team. Surprisingly, besides a marginal significance of conversion ratio, none of the factors, fixed or random, was found to be an important predictor. The odds ratio for self-taking was 0.94 [0.58; 1.52] and also non-significant, and as such it compares closely to the raw, unadjusted odds ratio reported above (0.90 [0.56; 1.43]). Applying backward elimination to the full model with all possible covariates, none of the predictors met the inclusion criterion of $p=0.05$. The same result (no predictors were included in the model) was seen when the backward elimination was combined with the search of an optimal power transformation of all continuous covariates via the MFP algorithm. Thus, none of the continuous covariates (e.g., age or number of matches) was found to have a significant influence even if we allow two model terms with different powers (e.g., linear or quadratic) for each of those. We are thus very confident that none of the covariates has a significant influence on penalty conversion, at least in our data set.

Discussion

Our empirical investigation of the old German football myth “The fouled player shouldn’t take the penalty himself!” yielded a clear result: No association between the successful conversion of a penalty and the fact, that the tackled player himself takes the penalty could be found, even after adjustment for relevant predictors of self-taking.

Besides this lack of truth in the old myth, we were surprised that no other relevant factors for successful penalty conversion could be found.

How can this be explained? In principle it can be assumed that there is a strong selection process operating such that penalties are typically executed by players who seem to be very similar with regard to their mental attributes. More specifically, this type of player is very resistant to external influences like current score, current minute, club’s current league ranking and day of season.

Another point is that players are often selected before the game to take a possible penalty. This is normally decided by the team coach, similarly to the penalty shoot-out and, of course, this *a priori* decision is independent of all external factors, especially independent of the fact that the chosen player was tackled himself.

It is also interesting that we found no indication of a home advantage for successful penalty conversion. The odds ratio for home advantage in the hierarchical logistic model for conversion was found to be 0.90 [0.64; 1.27]. This is far from being statistically significant (p=0.54) and actually contradicted our expectations of an odds ratio larger than 1 as an indication for an actual home advantage. Home advantage is a well known and well documented phenomenon in sports. Recently a editorial of Nevill et al. (2005) opened a whole issue of the *Journal of Sports Sciences* (Volume 23, Number 4) devoted to this topic.

It is possible that a fouled player might be unable to take the penalty himself, even if he would like to due to receiving medical treatment. Unfortunately, we have no information on this issue in our data set and could not correct for that fact, but we would expect the respective bias in our results to be minor.

The mental factors which influence the decision to take a penalty cannot be explained by the given data. Surely factors like self-efficacy, a concept by Bandura (1977), which means the subjective appraisal of one´s ability to perform a task successfully against obstacles such as over-arousal or distractions from the task (e.g. noise from spectators) play an important role in the selection process. Furthermore, effective coping and action-control strategies (Stoll and Ziemainz, 2003) influence successful performance in sports. These factors were often investigated in specific sport situations, but as far as we know, never in penalty shooting in football.

The type of player who will be most successful in converting the penalty cannot be determined with our observational design due to the self-determination of the execution. Maybe a comparison with the scoring of free throws in basketball would give additional insight. There the fouled players must shoot the free throw themselves, so that an unbiased comparison of successful and unsuccessful players would be possible.

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Table 1: Distribution of confounders in the groups of self-taking and non-self-taking players which took the penalties in the observation period. Data are given as mean ± *s* for the continuous confounders and as absolute (relative) frequencies for categorical(*) confounders. P-values are calculated from Wilcoxon-tests for continuous and from χ^2-tests for categorical confounders.

Confounder	**Self-taking (N=102)**	**Non-self-taking (N=733)**	**p-Value**
Age	28.4±3.7	29.3±3.4	0.03
Number of matches	105.5±103.8	137.3±103.7	<0.01
Conversion ratio	0.81±0.23	0.81±0.19	0.45
Number of goals	32.1±35.0	30.8±34.6	0.58
Minute	50.0±25.3	53.9±24.9	0.15
League ranking	9.2±5.0	9.2±5.2	0.93
Day of season	16.0±9.3	17.3±10.2	0.26
Home advantage*	70 (68.6%)	485 (66.2%)	0.62
Current score*			0.98
Scorer's team leads			
+1	23 (22.6%)	131 (17.9%)	
+2	7 (6.9%)	46 (6.3%)	
+3	2 (2.0%)	26 (3.6%)	
+4	1 (1.0%)	6 (0.8%)	
+5	0	3 (0.4%)	
+6	0	1 (0.1%)	
Scorer's team is back			
+1	21 (20.6%)	149 (20.3%)	
+2	6 (5.9%)	51 (7.0%)	
+3	2 (2.0%)	19 (2.6%)	
+4	1 (1.0%)	3 (0.4%)	
+5	0	1 (0.1%)	
Draw			
	39 (38.2%)	297 (40.5%)	

Table 2: Results from a hierarchical logistic regression model for the response Self-taking. Given are the effects in terms of odds ratios with their respective 95%-confidence intervals and a p-value from the corresponding Wald test. Due to sparseness of data, categories of the covariate Current score have been amalgamated. Reference categories are “No” for Home advantage and “Draw” for Current score. Interpretation of the odds ratios for Number of matches, Number of goals, Minute, League ranking, and Day of season should be in 10 units of the respective covariate.

	Fixed Effects	
Confounder	**OR [95%-CI]**	**p-Value**
Age	0.91 [0.84; 0.99]	0.04
Number of matches	0.91 [0.86; 0.95]	<0.01
Conversion ratio	1.16 [0.40; 3.35]	0.78
Number of goals	1.31 [1.14; 1.50]	<0.01
Minute	0.94 [0.87; 1.02]	0.14
League ranking	0.79 [0.51; 1.24]	0.31
Day of season	0.90 [0.74; 1.09]	0.27
Home advantage	1.03 [0.68; 1.55]	0.90
Current score		0.62
Scorer’s team leads		
+1	1.60 [0.94; 2.73]	0.09
+2	1.22 [0.53; 2.79]	0.65
>=3	0.80 [0.26; 2.49]	0.70

Scorer’s team is back		
+1	1.35 [0.80; 2.30]	0.26
+2	0.99 [0.43; 2.30]	0.99
>=3	0.94 [0.29; 3.09]	0.92

	Random Effects	
Variance Components	**Estimate [95%-CI]**	**p-Value**
Scorer	1.04 [0.46; 1.62]	<0.01
Team	0.16 [0.00*; 0.49]	0.18
Residual	0.65 [0.58; 0.72]	<.001

* Confidence intervals for the variance components are truncated at zero as no negative values are allowed.

Table 3: Results from a hierarchical logistic regression model for the response Conversion. Given are the effects in terms of odds ratios with their respective 95%-confidence intervals and a p-value from the corresponding Wald test. Due to sparseness of data, categories of the covariate Current score have been amalgamated. Reference categories are “No” for Home advantage and “Draw” for Current score. Interpretation of the odds ratios for Number of matches, Number of goals, Minute, League ranking, and Day of season should be in 10 units of the respective covariate.

	Fixed Effects	
Confounder	**OR [95%-CI]**	**p-Value**
Self-taking	0.94 [0.58; 1.52]	0.79
Age	0.98 [0.92; 1.05]	0.61
Number of matches	1.00 [0.97; 1.03]	0.83
Conversion ratio	0.42 [0.18; 1.01]	0.05
Number of goals	1.01 [0.92; 1.10]	0.90
Minute	1.05 [0.98; 1.13]	0.13
League ranking	0.77 [0.55; 1.09]	0.14
Day of season	0.90 [0.77; 1.05]	0.54
Home advantage	0.90 [0.64; 1.27]	0.54
Current score		0.26
Scorer’s team leads		
+1	0.97 [0.62; 1.53]	0.90
+2	0.82 [0.42; 1.61]	0.56
>=3	1.01 [0.44; 2.28]	0.99

Scorer’s team is back		
+1	0.94 [0.61; 1.45]	0.79
+2	1.54 [0.73; 3.23]	0.26
>=3	0.37 [0.16; 0.87]	0.02
	Random Effects	
Variance Components	**Estimate [95%-CI]**	**p-Value**
Scorer	0.48 [0.00*; 1.13]	0.07
Team	0	.
Residual	0.90 [0.78; 1.02]	<.01

* Confidence intervals for the variance components are truncated at zero as no negative values are allowed.