

Performance analysis of professional soccer goalkeepers by Composition of Probabilistic Preferences

Análise de desempenho de goleiros do futebol profissional por Composição Probabilística de Preferências

Análisis del rendimiento de porteros de fútbol profesional por Composición Probabilística de Preferencias

Luiz Octávio Gavião^{a*} , Erick Vieira Gavião^b , Annibal Parracho Sant'Anna^c ,
Gilson Brito Alves Lima^c , Pauli Adriano de Almada Garcia^d 

Keywords:

Soccer;
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ABSTRACT

This research aims to assist managers and technical commissions to choose professional soccer goalkeepers. A sample of 64 goalkeepers playing in Argentina and Brazil was studied. Their performance in the matches of two seasons were analyzed considering three criteria: goals against per minute played, percentage of goals and percentage of matches without conceded goals. The Composition of Probabilistic Preferences (CPP) was the method chosen for modeling, considering the random variability in the problem data and in football, considered one of the most unpredictable sports. CPP allowed to compare the choice based on the data analysis to the latest goalkeeper call-ups for these countries' national teams. The selected goalkeepers corresponded to those presenting the best individual performance, which confirms the model.

Palavras-chave:

Futebol;
Avaliação;
Goleiros;
Composição
Probabilística de
Preferências.

RESUMO

Esta pesquisa teve como objetivo auxiliar gestores e comissões técnicas na escolha de goleiros do futebol profissional. Foi estudada uma amostra de 64 goleiros que atuam na Argentina e no Brasil. Foram analisados seus desempenhos em jogos de duas temporadas, considerando três critérios: gols sofridos por minutos jogados, percentual de gols evitados e percentual de partidas sem sofrer gols. A Composição Probabilística de Preferências foi o método escolhido para a modelagem, por considerar a variabilidade aleatória dos dados do problema e do futebol, considerado um dos esportes mais imprevisíveis. A aplicação comparou a escolha baseada na análise dos dados com as últimas convocações de goleiros para as seleções desses países. Os goleiros selecionados corresponderam aos de melhor desempenho individual, confirmando o modelo.

Palabras-clave:

Fútbol;
Evaluación;
Porteros;
Composición
Probabilística de
Preferencias.

RESUMEN

Esta investigación tuvo como objetivo ayudar a gerentes y comisiones técnicas para elegir a los porteros de fútbol profesional. Una muestra de 64 porteros de Argentina y Brasil fue estudiada. Las actuaciones en los partidos de dos temporadas fueron analizadas, considerando tres criterios: goles concedidos por minutos jugados, porcentaje de goles evitados y porcentaje de partidos en los que al portero no le encajaron goles. La Composición Probabilística de Preferencias fue el método elegido, considerando la variabilidad aleatoria de los datos del problema y del fútbol, considerado uno de los deportes más impredecibles. La aplicación comparó la muestra con las últimas convocatorias de porteros de las selecciones nacionales de estos países. Los porteros seleccionados correspondieron a los de mejor rendimiento individual, confirmando el modelo.

^aBrazilian War College, Rio de Janeiro, RJ, Brasil.

^bSport Club Corinthians Paulista, São Paulo, SP, Brasil.

^cFluminense Federal University, Niterói, RJ, Brasil.

^dFluminense Federal University, Volta Redonda, RJ, Brasil.

*Corresponding author:

Luiz Octávio Gavião
E-mail: luiz.gaviao67@gmail.com

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INTRODUCTION

The individual performance of players still prevails in the call-ups for national football teams. During a recent press conference, the Brazilian coach stated that “[...] the individual performance of the athletes transcends the collective moment of a team [...] the collective is of great help, but the analysis is individual” (UOL, 2020). This mindset is especially applied to goalkeepers, a sui generis position that requires the use of specific and individual-focused indicators rather than collective indicators used to evaluate line players. The rationale and personal preferences behind this decision-making process is relevant to clubs and players, and their benefits include improving training systems and internal performance analysis. However, the decision-making process used to select the best players as well as the criteria for individual performance are not normally disclosed in these press conferences or even published by the staff (Carling et al., 2018).

The recent literature in sports sciences presenting an approach similar to the one proposed in this paper is scarce in performance analysis of soccer goalkeepers. Some studies have analyzed individual metrics to assess the movement and motor skills of goalkeepers in their defenses (Ziyagil, 2017; Lamas et al., 2018; Rodríguez-Arce et al., 2019; Szwarc et al., 2019), performance and attitudes at penalties (Furley et al., 2017; Kolbinger and Stöckl, 2019), and dimensions other than technique, which include physical, psychological and tactical aspects, as well as training (Park et al., 2016; West, 2018).

Other studies evaluated goalkeeper performance in football with an observational methodology or notational analysis. An observational instrument was tested to measure the technical and tactical actions performed in the offensive phase by the player and team with the ball possession (Ortega-Toro et al., 2019). Other authors created instruments to collect information for the analysis of offensive action and interaction game (Sarmiento et al., 2009) or to detect behavioral patterns of goalkeepers during the defensive process in soccer (Esteves et al., 2009). All of these studies propose procedures and instruments to produce data of interest to coaches and performance analysts.

Another study brought together performance analysts and students of sports sciences to define sets of performance indicators for each position in soccer, including goalkeepers (Hughes et al., 2012). Goalkeepers’ performance was also investigated in different samples of professional male goalkeepers (e.g. different U-categories) and in women’s football (Ortega-Toro et al., 2018; Peráček et al., 2017; Sainz de Baranda et al., 2019).

Other studies explored a similar path to evaluate soccer goalkeepers, although they used different methods, variables and sources for data collection. Liu et al. (2015), using the ANOVA method and data from

the OPTA Sportsdata Spain Company, hypothesized that goalkeepers of high-level teams performed better than those of intermediate and low-level teams, and that goalkeepers of different team levels showed differential performance under different situational conditions. In Gil et al. (2014), the authors focused on a talent identification process of kids in a professional soccer club, analyzing anthropometric, maturity and performance measurements. Using a discriminant analysis, they studied a sample of 9-10-year-old goalkeepers by collecting data in training sessions, which included players’ velocity, agility, endurance and jump tests. Seaton and Campos (2011) tried to understand a goalkeeper’s performance through their performance in nine different zones of the pitch. They observed ten games from DVDs and camcorder video footage to compute the number of kicks, rolls, throws, heads and their outcome, such as attacks or loss of ball possession.

Soccer is considered one of the most unpredictable among all sports (Schokkaert and Swinnen, 2016; Pawlowski et al., 2018). In addition, performance data available from open sources are not systematized in all matches and competitions, while human observation procedures and manual notation are available for recording and posting data on web sites. These procedures can embed uncertainties in the data (Gavião et al., 2020).

The Composition of Probabilistic Preferences (CPP) is a multi-criteria decision aid method (MCDA) that considers uncertainty in its modeling based on decision makers’ preferences (Sant’Anna, 2015). MCDA methods are adequate tools to evaluate satisfactory solutions to the problem, considering the inexistence of an optimal alternative that performs perfectly under all criteria. CPP has also been applied to similar problems of assessing individual and collective performance in football (Gavião et al., 2020, 2017; Príncipe et al., 2017; Sant’Anna et al., 2010; Sant’Anna and de Mello, 2012).

The proposed methodology was applied for the goalkeeper position and compared to the last call-ups of the Brazilian and Argentinean soccer teams. Did the selected goalkeepers correspond to those with the best individual performance in their countries? Is it possible to compare the performance of Brazilian and Argentinean goalkeepers, to assist club managers in eventual transfers of these players? These research questions guided the modeling in the search for solutions aimed at assisting managers and technical commissions to choose professional soccer goalkeepers.

MATERIAL AND METHODS

SAMPLE

The data sample consisted of 64 goalkeepers with an average age of 30.3 years who played in the main football leagues in Brazil (*Serie A – Brasileiro*) and Argentina (*Superliga*). The data correspond to the last two seasons before the Covid-19 pandemic in South

America, considered in this study from March 2020. These competitions are played in straight points, with 20 teams in Brazil and 24 in Argentina. This research analyzed all players together, based on the premise of homogeneity of the level of competitiveness in these countries.

This number of goalkeepers was due to the need to consider, separately, a same player who played in both seasons. Thus, for modeling purposes, goalkeeper "X" of the 2018 season is considered different from the same goalkeeper "X" who served in the 2019 season. The initial sample of 84 goalkeepers was finally reduced to 64 goalkeepers. The players who served in the second division in any of these seasons or played a small number of matches were excluded.

On average, goalkeepers participated in 22 matches, with a maximum of 37 matches. The cut-off point was the first quartile (14) of the number of matches played. Thus, goalkeepers who participated in up to 13 matches (inclusive) were excluded from the study. This initial treatment was necessary to avoid distortions and biases caused by over- or undervalued performances in the modeling.

VARIABLES

The modeling considered three aggregate indicators widely used in the scientific literature to assess the players' performance. The first criterion, "GA/min", counts the goals against (GA) per minute played in the season, which is also explored in other studies (Clemente, 2018; Longo et al., 2019; Sainz de Baranda et al., 2019; Yam, 2019). GA is also called "goals conceded" in other databases of match analysis (i.e., Footystats, Soccerstats, Statista, Transfermarkt). This criterion has a negative impact on the performance evaluation because the lower the measure, the better the result compared to other goalkeepers. For this reason, this criterion had its signal changed to negative.

The second criterion, "Save%", represents the percentage of goals prevented by the goalkeeper obtained by dividing the difference between shots on goal and goals conceded by the total number of shots on

goal (Dicks et al., 2017; Liu et al., 2015; Montesano, 2016; Sainz de Baranda et al., 2019, 2008; White et al., 2018). This criterion has a positive impact on the result because the higher the index, the better for the goalkeeper.

The third criterion, "CS%" (clean sheets), calculates the percentage of matches in which the goalkeeper does not concede goals (Apostolou and Tjortjis, 2019; Schultze and Wellbrock, 2018; Singh and Lamba, 2019). CS is such a relevant criterion that a trophy is traditionally awarded for it in several tournaments, including the English Premier League and the FIFA World Cup. This criterion also has a positive impact.

COLLECTED DATA

The data were collected from the website *FBref.com*, which publishes several individual and collective performance indicators from the major sports leagues and tournaments in the world. This website currently covers 47 countries, 134 competitions, 4,625 squads, 165,635 players and 224,308 match reports (FBref.com, 2020). The *FBref* datasets have recently been explored by sports science researchers (Blumberg and Markovits, 2021; Bradbury, 2020; Iehl, 2020; Zaytseva and Shaposhnikov, 2020). Sports-Reference, which manages *FBRef.com*, authorized the authors to use all data available on the website for academic purposes.

Table 1 presents an extract of the data collected from the ten goalkeepers who obtained the best results after modeling. The seasons are found next their names, followed by their country and minutes played. The criteria columns show the aggregated indicators.

PROBABILISTIC MODELING

CPP associates the observed player's performance in each criterion with a probability of the value measured, which may vary. In soccer, disturbances are produced by a series of intangible factors, such as environmental conditions, game strategies and the psychological, physical, and technical state of players, among others. Thus, a performance measure is transformed into a continuous random variable related to the most probable

Table 1. Data sample.

GK / Season	Country	Min	Crit 1 GA/min	Crit 2 Save%	Crit 3 CS%
GK-1 '19-20	ARG	1800	0.0039	0.89	0.70
GK-1 '18-19	ARG	1620	0.0056	0.88	0.61
GK-2 '18-19	ARG	1800	0.0067	0.83	0.50
GK-3 '18	BR	2025	0.0069	0.81	0.53
GK-4 '19	BR	2520	0.0083	0.86	0.43
GK-5 '18-19	ARG	1800	0.0083	0.85	0.45
GK-6 '18	BR	2880	0.0097	0.84	0.47
GK-7 '18	BR	2790	0.0086	0.84	0.42
GK-3 '19	BR	2070	0.0077	0.80	0.48
GK-8 '18-19	ARG	1620	0.0074	0.78	0.50

ARG: Argentina; BR: Brazil; GK: goalkeeper; Min: minutes played in season; Crit: criterion; GA: goals against; CS: clean sheets.

value of a probability distribution (Sant'Anna, 2015). In this research, the measures were adjusted by Beta PERT distributions based on the data collected in each criterion. This type of asymmetric distribution is usually applied to randomize variables in risk analysis (Vose, 2008).

After randomizing the variables, CPP makes the relative comparison among the goalkeepers' performance in each criterion (Sant'Anna, 2015). It is possible to verify, for example, to what extent each player could exceed all the others given the random character of their performance. This is measured by the probability that the player will perform above the median of the other players in the criterion considered. The calculation, for each criterion, is performed by integrating a function that corresponds to the product of the probability density of the player considered and the cumulative function of the median of the other players. The R software version 4.0.3 with the CPP package was used in these calculations (Gavião et al., 2018).

The probabilities of each goalkeeper maximizing the performance in each criterion can be combined in different ways, providing different points of view for decision-making, as detailed by Sant'Anna (2015). In this research, a model by axis was applied, adopting progressive approaches. The progressive-pessimistic (PP) axis composes the probabilities of maximizing seeking the best performance under all criteria simultaneously by multiplying these probabilities. The progressive-optimistic (PO) axis composes the probabilities of maximizing seeking the best performance in at least one of the criteria by complementing the multiplication of the complements of the probabilities of maximizing.

The PP and PO axes generated two goalkeepers' rankings. The sum of these rankings by Borda's method configured the final ranking where the lowest sum corresponds to the best overall performance.

Statistical tests checked the results of Brazilian and Argentinean goalkeepers, grouped in six data sets. The non-parametric Mann-Whitney U test was used to

indicate whether one set of observations was superior to the other. It considers the null hypothesis that the two groups are sampled from populations with identical distributions against the alternative hypothesis that the populations have different distributions.

RESULTS

Table 2 presents an extract of the ten best goalkeepers' evaluations. The "P Max" columns indicate the probabilities of maximizing the goalkeepers' performances. The "PP Axis" and "PO Axis" columns show the results of taking these points of view, with their specific rankings, based on the highest numerical value. The "Borda" column adds the axes rankings, leading to the results in the "Final rank" column.

Table 3 summarizes the players' performances aggregating the two seasons and ranks the top ten Brazilian and Argentinian goalkeepers. The columns indicate the results by axis and the best overall performance in the "Final rank" column, which shows the most relevant results to answer the research questions.

Initially, the results obtained with the complete sample (64 goalkeepers) were displayed in a boxplot to compare the performances of the goalkeepers of both countries. Based on Figure 1, it is notable that the performance of Brazilian goalkeepers was markedly superior to that of Argentinians in two scenarios: global, without distinction of season (two boxes on the left) and in seasons 2019 (BR) and 2019-2020 (ARG) (two boxes on the right). However, the two central boxes do not clearly indicate superiority of one set over the other. They may be then preliminarily evaluated as equivalent.

For the global data scenario in Figure 1, the Mann-Whitney U test rejected the null hypothesis, confirming the visual conclusion that Brazilians' performance is statistically superior for a significance level of 5% ($W = 335$, $p\text{-value} = 0.05$). The same occurred in relation to the 2019 (BR) and 2019-2020 (ARG) seasons scenario ($W = 219$, $p\text{-value} = 0.04$). On the other hand, the test of the 2018 (BR) and 2018-2019 (ARG) seasons

Table 2. Extract of results.

GK / Season	Country	PMax Crit 1	PMax Crit 2	PMax Crit 3	PP Axis	PP Rank	PO Axis	PP Rank	Borda	Final Rank
GK-1 '19-20	ARG	0.87	0.91	0.90	0.7183	1	0.9989	1	2	1
GK-1 '18-19	ARG	0.81	0.89	0.82	0.5874	2	0.9961	2	4	2
GK-2 '18-19	ARG	0.75	0.76	0.70	0.3961	3	0.9817	3	6	3
GK-3 '18	BR	0.74	0.72	0.74	0.3949	4	0.9811	4	8	4
GK-4 '19	BR	0.67	0.84	0.60	0.3407	6	0.9794	5	11	5
GK-5 '18-19	ARG	0.67	0.82	0.63	0.3485	5	0.9786	6	11	5
GK-6 '18	BR	0.59	0.80	0.66	0.3114	8	0.9719	7	15	7
GK-7 '18	BR	0.70	0.68	0.67	0.3194	7	0.9684	9	16	8
GK-3 '19	BR	0.65	0.80	0.59	0.3097	9	0.9717	8	17	9
GK-8 '18-19	ARG	0.72	0.62	0.70	0.3084	10	0.9671	10	20	10

GK: Goalkeeper; ARG: Argentina; BR: Brazil; PMax: probability of maximizing; Crit: criterion; PP: Progressive-Pessimist; PO: Progressive-Optimist; Rank: relevance order.

Table 3. Extract of the overall performance of Brazilians.

GK	PP-'18	Rank	PP-'19	Rank	PO-'18	Rank	PO-'19	Rank	Borda	Final rank
GK-3	0.3949	4	0.3097	9	0.9811	4	0.9717	8	25	1
GK-6	0.3114	8	0.2147	18	0.9719	7	0.9386	18	51	2
GK-7	0.3194	7	0.1837	22	0.9684	9	0.9197	22	60	3
GK-4	0.1319	30	0.3407	6	0.9018	25	0.9794	5	66	4
GK-9	0.1854	21	0.2217	17	0.9317	20	0.9400	17	75	5
GK-10	0.2770	12	0.1412	26	0.9596	12	0.8981	27	77	6
GK-11	0.1290	31	0.1954	20	0.8802	34	0.9283	21	106	7
GK-12	0.0879	37	0.1251	34	0.8389	37	0.8900	30	138	8
GK-13	0.0771	39	0.1289	32	0.8276	40	0.8813	33	144	9
GK-14	0.1381	28	0.0541	46	0.8983	26	0.7764	48	148	10

GK: Goalkeeper; PP: Progressive-Pessimist; PO: Progressive-Optimist; Rank: relevance order.

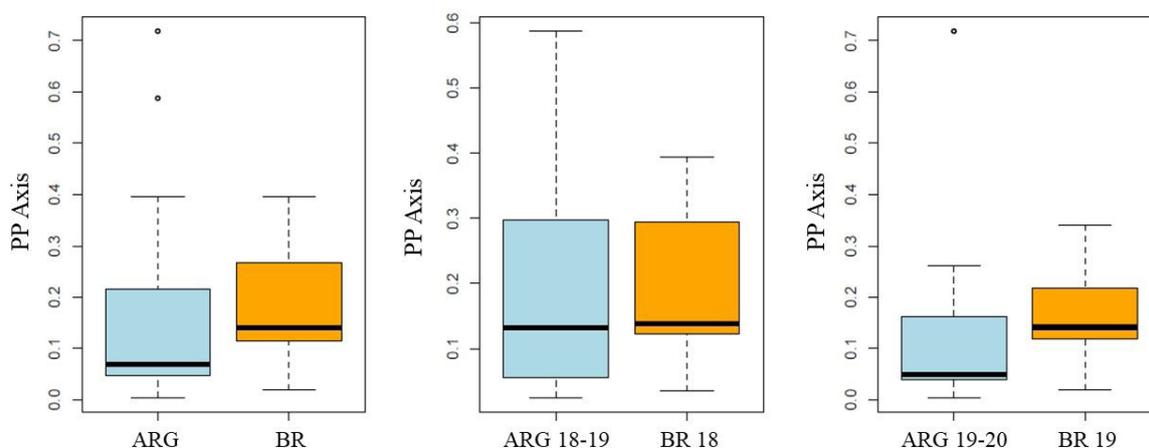


Figure 1. Results in boxplots. PP: Progressive-Pessimist; ARG: Argentineans (in blue); BR: Brazilians (in orange).

scenario did not allow us to reject the null hypothesis, indicating that the performances may belong to the same probability distribution ($W = 94$, p -value = 0.57).

DISCUSSION

Two research questions guided the modeling aimed at assisting managers and technical commissions to choose professional soccer goalkeepers: “Did the selected goalkeepers correspond to those with the best individual performance in their countries?” and “Is it possible to compare the performance of Brazilian and Argentinian goalkeepers in order to assist club managers in eventual transfers of these players?” The proposed model returned the best performing goalkeepers in recent seasons and corresponded to those chosen for the national teams. The model allowed comparing the performance of the two groups with useful information for decision making by soccer managers.

Although the set of Brazilian goalkeepers presented a better overall performance, two Argentine goalkeepers occupied the first three positions in the ranking, as shown in Table 2. GK-1 remained at the top in the two seasons analyzed. Together with GK-2, both have been frequently called up for the national team, a fact that was repeated

for the resumption of the South American qualifiers. Regarding the Brazilian goalkeepers, Table 3 indicates the best overall performance of GK-3 and GK-6. They were also called up to the World Cup qualifiers.

Although the CPP model applied to the performance analysis of players is similar to those used in other studies, the focus on selected goalkeepers for national teams is original. In [Gavião et al. \(2020, 2017\)](#), the Moneyball approach explored the CPP method with different criteria to suggest good bargains for the transfer market of defenders. In [Príncipe et al. \(2017\)](#), the CPP model focused on team performance in the English Premier League using 23 variables, which included the goalkeeper’s criteria explored in this study (i.e. saves, clean sheets and goals conceded). Other applications of CPP aimed at evaluating soccer championships and teams are found in the sports literature ([Sant’Anna et al., 2010](#); [Sant’Anna and de Mello, 2012](#)).

CPP has the limitations of any multi-criteria decision aid method — different criteria, alternatives and data can change results. In addition, the validation of the model requires the approval of any person responsible for the final decision, which in the case of this study, would be the national coaches themselves. It is possible to assume

that these limitations were overcome, in a way, as the modeling confirmed that the final ranking of the best goalkeepers corresponded to the list of players called up for the Brazilian and Argentinean teams. The alignment of the model results with the final choice of goalkeepers may be due to the limited number of variables for the analysis of goalkeeper performance. Line players have dozens of indicators, while goalkeepers are assessed in matches using a few variables. Thus, performance analyses should not show significant variance.

For future research, new data can be included for coming seasons, after the 2020 season. These results can be compared to those obtained in the 2018 and 2019 seasons to verify the trend of performance improvement or decrease in relation to historical results. It is also possible to expand the search to other field positions to assist technical commissions with the replacement of players frequently transferred to the European and Asian markets. Finally, it is possible as well to further study the adequacy of the variables used in the assessment. For example, the third variable (CS%) might exclude goalless matches from the calculation. This score can indicate a strategy of the team favoring the defense and the goalkeeper. Perhaps the fact that Argentine football presently goes through a more offensive phase explains the better results of Brazilian goalkeepers in the study.

CONCLUSION

This research aimed to present a probabilistic method to support managers and analysts in selecting soccer players, focusing on individual performance. The results indicated that the questions were satisfactorily answered. The data confirm the effectiveness of the probabilistic model as it coincides with the goalkeepers selected by the national teams.

The use of this model can also benefit other national team coaches and football clubs in general. A similar model that translates the national coach's preferences can be useful for clubs to choose their best goalkeepers. National coaches remain in this position for a World Cup cycle (four years) or even longer, as is the case of the German and Brazilian teams. In this context, emulating the decision-making process of a coach who makes call-ups for four or more years is relevant to the club's managers and players. Football managers can adapt their resource planning based on similar decision-making processes. Likewise, players can focus their training on reaching the benchmarks made available. Finally, the transparency of this process benefits fans and the specialized press.

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CONFLICTS OF INTEREST

Conflicts of interest declaration not received.

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