

Multivariate analysis of goalkeeper actions in youth football

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International Journal of Sports Science
& Coaching

1–12

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DOI: 10.1177/17479541231173190

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Abstract

There is a lack of studies investigating youth goalkeepers that implement variables that can allow researchers and coaches to better understand the performances of the goalkeepers. For this reason, the aim of the present study was to identify key performance indicators of youth football goalkeepers both defense and attack. The sample was composed of 902 defensive and 896 offensive actions from a convenience sample of 32 matches of 19 teams from the Spanish National Championship of Regional Teams U12. A notational analysis was carried out using an ad hoc instrument to register the technical-tactical actions. Validity was higher than .84. In addition, intra-observer reliability was higher than .90. Classification tree analysis was used to investigate which variables were best predictors of technical actions in defense and precision in attack actions of the goalkeepers. Results showed that in the attacking phase the actions that achieve higher values of precision were those when the ball was played to zone A length and both right and left sides ($X^2_6 = 542.034$; $p = .000$). In defense, when the goalkeeper achieve higher values of saves were those when the shot was taken from out of the penalty area and no jump or drop was performed. The present findings contribute to evidence-based practice in fostering young goalkeepers.

Keywords

Performance analysis, soccer, technical-tactical actions

Introduction

The goalkeeper possesses a unique role in football in comparison with a field player, and is assumed to occupy a decisive role within the team.¹ The difference of the goalkeeping position in comparison to other field players requires that their respective actions are analyzed separately as different performance indicators are likely to contribute to success.² While performance analyses are wide spread in soccer, goalkeepers have been largely neglected.³ In this sense, a systematic review shows that most of the studies developed on goalkeepers focus on perceptual aspects, while there is a lack of studies that analyze sport performance. Moreover, it should be highlighted that most of these studies have been carried out on senior players.⁴

Football goalkeepers have been the subject of research attention over the past years.^{4–6} It can be found on literature studies about visual perception,⁷ anthropometric attributes,⁸ decision making⁹ among other topics. Many studies have been conducted using notational analysis aiming to identify key performance indicators of the goalkeeper. Some were focused on senior goalkeepers,^{10,11} and few were conducted on youth ages.^{12,13} In this sense, the performance of senior

goalkeepers has been related to actions performed in the penalty area, saves, foot control and perception of key information, while in junior goalkeepers, blocks, foot control and movements with the ball in the hands have been identified as performance factors.

The role of the goalkeeper in modern football has become more complex and he is no longer considered to be solely responsible for saving shots toward the goal.¹⁴ In this respect, the goalkeeper's performance can be

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considered reductionist if it only analyses defensive aspects.^{15,16} In this sense, it is necessary to analyze the actions of the goalkeeper both offensively and defensively.

In this way, the actions performed by under-17 (U-17) goalkeepers have been analyzed. Thus, the defensive actions of the goalkeeper highlight high lateral drop deviation while in the offensive phase their importance in the positional attack construction.¹⁷

On the other hand, it is necessary to analyze the goalkeeper's actions in the context of the game. In this way, it is necessary to consider situational variables. In this sense, analyzing a system in isolation will not allow a complete understanding of the performance due to multiple factors that a model of a football system can comprises.¹⁸ Hence, a performance analysis within the analysis of situational variables can be implemented, enhancing a better understanding of the performance when analyzing goalkeeper behavior. In this perspective, studies have been carried out which indicate that situational variables affect the goalkeeper's playing actions.¹⁹

According to this rationale, there is a lack of studies investigating youth goalkeepers that implement situational and offensive and defensive variables that can allow researchers and coaches to better understand the performances of the goalkeepers,⁴ being essential a first step which describes and shows the interactions of the performance indicators and in a second step a multivariate model that defines how the dynamics relations are performed in each dataset.¹⁵

In order to address this shortcoming, the present study aimed to identify predictors of success for both defensive and offensive actions of youth goalkeepers in relation to situational variables. The results of these analyses will help to shape training programs for youth football goalkeepers.

Materials and methods

A total of 902 offensive and 896 defensive goalkeepers' actions performed by 38 goalkeepers belonging to 19 regional teams in 35 matches of the Male Spanish National Championship of Regional Teams U12 in May 2018. It is scheduled to be played in 1 week where they will play a group stage (4 groups) and a knockout stage where the 2 first teams of every group will advance to this round. The goalkeepers were not substituted during the matches, and each goalkeeper played two matches, except for the goalkeepers of the four-team group. In that case, one goalkeeper from each team (4 goalkeepers) played two matches and another goalkeeper from each team (4 goalkeepers) played one match. All actions registered were performed in matches of the classification round of this championship where the only match that was not used in the analysis was the match used in the observer reliability process. Each match of the group stage lasted 30 min with a 5 min break at minute 15 and each match of the knockout round

lasted 20 min with a 5 min break at minute 20 which was the main reason to exclude those matches.

The matches were recorded with an HD standard camera that was located at 10 m above and lateral of the pitch center. The CX625 HANDYCAM with EXMOR R CMOS SENSOR with a video resolution of 1280 × 720; 25p was used. All files were analyzed using a notational analysis methodology with the Lince v12.30 software.²⁰ All process was performed under the methodology offered by Anguera et al.²¹ In this sense, observer training was carried out by analyzing different situations with the ad hoc instrument. After the observer training, the intra-observer reliability was analysed. Once the reliability was adequate, the observation process began.

Informed and written consent was asked and obtained from the parents of non-adults participants and from all adult participants about the current study. This research was authorized and the Ethics Committee of the University of Murcia granted ethics approval for all experimental procedures taken part in this study (Spain; Protocol Number 1944/2018).

Variables

A modified ad hoc observational instrument was used¹⁰ to record the following variables (Table 1; Figures 1 and 2).

In order to assess the validity of the observational instrument the technique of expert criteria was used. Twelve experts participated in this process and fulfilled at least 3 of the 5 criteria proposed (more than 10 years of experience in professional football; to be in possession of the GK Coach UEFA Pro License; to be specialist in performance analysis of the goalkeeper; to possess research knowledge in football performance; to have a PhD related with performance analysis in sport). Experts performed a quantitative and qualitative evaluation of each variable and Aiken's V test was used, achieving higher values than .84 in all cases.

A football expert observer (10 years as coach and with a degree in Sports Science) analyzed the matches after a training process.²² The test-retest was carried out under the same conditions (time, classroom, computer, monitor, etc.), with 12 days between the test and the retest. Intra-observer reliability was calculated using Cohen's Kappa coefficient. In all cases, higher values than .90 were achieved.

Statistical analysis

Two different analyses were performed. The first one was a univariate analysis and the second a multivariate analysis that not only offers a visual clarification of the data but which variables have more weight and predict the outcome.

Inferential analyses were performed using crosstabs. The Pearson's Chi-square test was used to analyze the effect between the technical-tactical defensive action carried out by the goalkeeper and the rest of the variables in defense and the precision of the offensive action and

Table 1. Variables used.

Situational variables	
Match status	Determined if the goalkeeper's team was <i>winning, losing, or drawing</i> when the action was performed
Match period	<i>1st half</i> and <i>2nd half</i>
Offensive action variables	
Obtaining the ball	<i>A ball from a team-mate; a ball from the opponent; other</i>
Goalkeeper action	<i>Goal kick; indirect kick; direct kick; hand pass; kick; other</i>
Physical action	Movement before the offensive action of goalkeeper: <i>dive: yes, or no; fly: yes, or no; drop: yes, or no; and jump: yes, or no</i>
Length	Distance of pass or kick (Figure 1; zone A; zone B; zone C; zone D)
Orientation	Zone where pass or kick ends up (Figure 1; zone 1: right side (zones 1, 4, 5, 9, 10, 14, 15); zone 2: central side (zones 2, 6, 11, 16); zone 3: left side (zones 3, 7, 8, 12, 13, 17, 18))
Precision	Effectiveness of the pass or kick. Three types: <i>direct</i> —when the ball is controlled immediately by the next team-mate who touches it; <i>indirect</i> —when the ball is controlled after being touched by another player first; <i>no success</i> —ball possession passes to the opposing team
Defensive action	
Zone of goalkeeper intervention	Zone from which the ball was passed or shot and goalkeeper's reactions. It can be the <i>goal area, penalty area, or outside of the penalty area</i>
Defensive technical actions	<i>Save: blocking a shot; foot control: controlling the ball with the feet; parry: tipping; clear out: technique to remove a ball that cannot be caught; punching, heading, or kicking the ball out with the foot; deflection: the ricocheting of the ball after coming into contact with the goalkeeper; open palm technique: guiding the ball over the crossbar; fly and/or dive: diving without contacting the ball; I-on-I situation: protecting the ball by keeping the body between the ball and the opponent; clear out by defensive player other than goalkeeper; or no action taken</i>
Intensity of action	<i>Submaximum: the situation is not causing immediate danger; maximum: immediate danger in the situation cause the goalkeeper to make a high effort intervention</i>
Goal	<i>Conceded; or not</i>
Opponent's action prior goalkeeper action	
Type of attack	<i>Positional opponent's attack: attack against organized defenders who have recovered; counter-attack: attack quickly after regaining possession, making 4 or fewer passes and not allowing time for defenders to recover and organize; set piece: direct free kick, indirect free kick, corner, penalty, throw-in</i>
Location where the last pass of attack was made	Pass location. Location where the last pass of attack was made (Figure 1; zones 1 to 19)
Body part with which the last pass of attack was made	<i>Foot; head; hand; other: chest, abdominal, knee, etc.; or no pass or cross made</i>
Field zone from where shots were made	Figure 2; field zone from where shots were made
Body part with which the shot was made	<i>Right foot; right foot with deflection; left foot; left foot with deflection; head; head with deflection; other: chest, abdominal, knee, hand of God, etc.; or no shot taken</i>

the rest of the variables in attack. When the expected frequency distribution was below 5 or below 1% the Fisher's exact test was applied. Effect sizes were calculated using Cramer's V test for each variable and its interpretation was based on the following criteria proposed by Volker (Volker, 2006): 0.10 = small effect; 0.30 = medium effect; 0.5 = large effect.

In a second step, a multivariate analysis was performed using a decision-tree classification model to determine both defensive and offensive actions classifications in relation to technical-tactical action variables in defense and precision of the attacking action in attack. The algorithm used was exhaustive CHAID (Chi-squared Interaction Detector).

This model allowed to classify with a reduced error range (77.5% in the first model; 59.7% in the second model). The following specifications were set for the data analysis: (a) significance level was set at $p < .05$; (b) Pearson's Chi-square test was used to determine the relation between independent and dependent variables; (c) the maximum number of iterations was 100; (d) the minimum value expected cell frequencies was .001; (e) the significance values adjustment was done using the Bonferroni method; and (f) the maximum tree depth was set at 3 nodes. The risk of misclassification was calculated as a measure of the reliability of the analysis.²³ All statistical analysis was performed using IBM SPSS Statistics v24.0 (Armonk, NY: IBM Corp.).

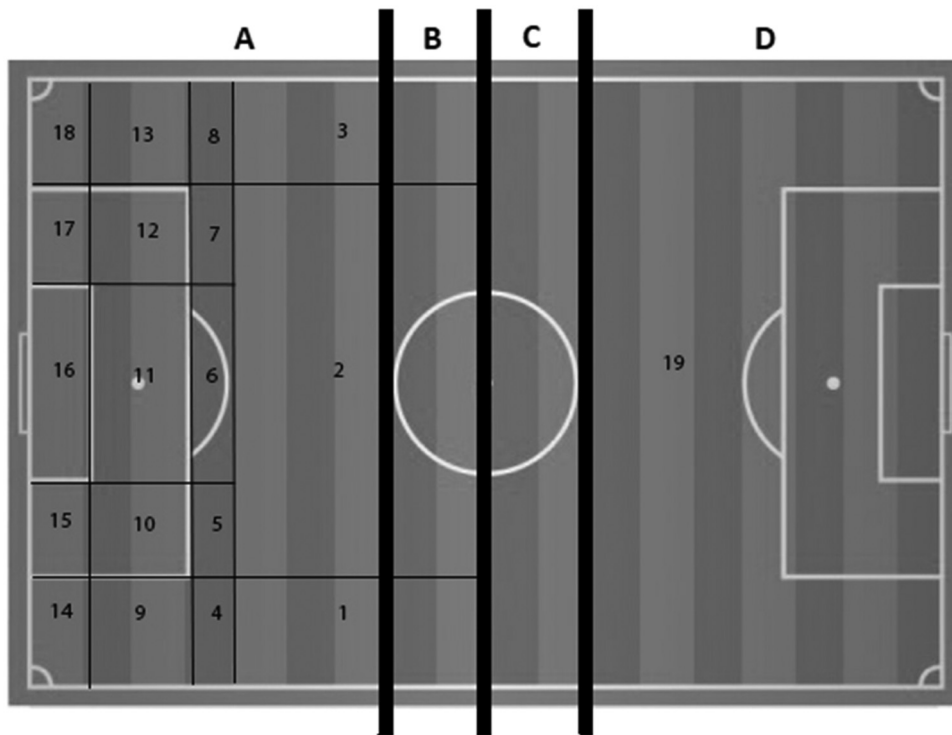


Figure 1. Length, orientation, and pass location.

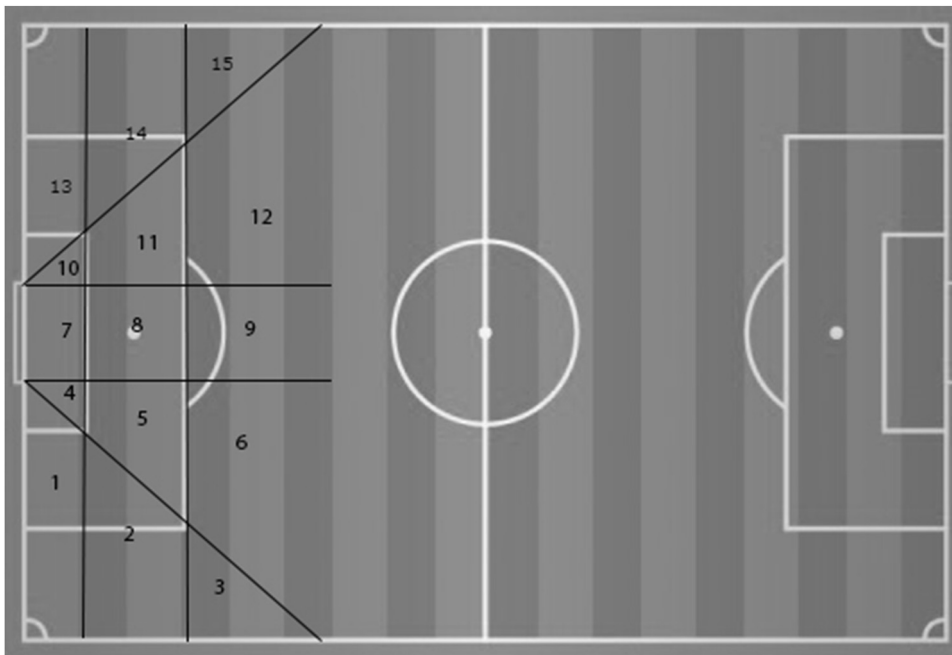


Figure 2. Shot zone.

Table 2. Frequency distribution (%) of technical action performed according to performance indicators.

Technical action performed															
Variables	No action			Save			Parry			Clear out			Deflection		
	n	%		n	%		n	%		n	%		n	%	
Zone of goalkeeper intervention															
Goal area	148	84.6	186	55	41	80.4	33	52.4	23	85.2	8	80	69	81.2	13
Penalty area	27	15.4	151	44.7	10	19.6	17	27	4	14.8	2	20	15	17.6	30
Outside penalty area	-	-	1	.3	-	-	13	20.6	-	-	-	1	1	1.2	3
Type of attack															
Positional attack	70	40	177	52.4	25	49	18	28.6	16	59.3	5	50	41	48.2	23
Counter attack	28	16	65	19.2	12	23.5	18	28.6	4	14.8	1	10	22	25.9	19
Set piece	77	44	96	28.4	14	27.5	27	42.9	7	25.9	4	40	22	25.9	4
Body part with which the last pass of attack was taken															
No pass made	37	21.1	47	13.9	10	19.6	5	7.9	6	22.2	4	40	19	22.4	5
Right foot	92	52.6	183	54.1	27	52.9	31	49.2	19	70.4	2	20	49	57.6	27
Left foot	40	22.9	73	21.6	5	9.8	22	34.9	2	7.4	3	30	13	15.3	13
Head	4	2.3	20	5.9	6	11.8	4	6.3	-	-	-	-	4	4.7	1
Other	2	1.1	15	4.4	3	5.9	1	1.6	-	-	-	1	-	-	-
Physical action—jump															
No	152	86.9	268	79.3	22	43.1	42	66.7	19	70.4	1	10	41	48.2	45
Yes	23	13.1	70	20.7	29	56.9	21	33.3	8	29.6	9	90	44	51.8	1
Physical action—drop															
No	165	94.3	222	65.7	4	7.8	45	74.4	3	11.1	6	60	15	17.6	2
Yes	10	5.7	116	34.3	47	92.2	18	28.6	24	88.9	4	40	70	82.4	44
Physical action—dive															
No	175	100	259	76.6	15	29.4	57	90.5	14	51.9	4	40	-	-	35
Yes	-	-	79	23.4	36	70.6	6	9.5	13	48.1	6	60	85	100	11

COBD: clear out by defender; Foot C: foot control; Open PT: open palm technique.

Results

The results showed a significant influence of period ($X^2(1) = 9.758$, $p = .008$), length ($X^2(3) = 542.034$, $p = .000$), orientation ($X^2(3) = 207.323$, $p = .000$), goalkeeper action ($X^2(5) = 104.354$, $p = .000$), and scoring opportunity on attacking technical-tactical action ($X^2(1) = 27.610$, $p = .000$).

Tables 2 to 4 summarize the data regarding the defensive actions of the goalkeepers. The results showed a significant influence of match status, location where the last pass of attack was made, field zone from where shots were taken, zone of the goalkeeper intervention, type of attack, body part with which the last pass of attack was taken, physical actions (jump, drop, and dive), intensity of action, body part with which the shot was taken, and goal conceded on defensive technical-tactical action.

Regarding the offensive actions presented by the exhaustive CHAID classification tree, two variables were highlighted as influencing variables on precision of the attacking action of the goalkeeper, length, and orientation. Figure 3 shows this final model presented.

The root node is defined by the dependent variable “precision” achieved by the offensive action, where “direct” precision was the most frequent category. “Length” had the greatest influence on precision, which gave rise to two nodes. Node 1 showed that “zone A” achieved the highest value in precision in comparison with “zones B, C, and D,” described in node 2. This node 1 gave rise to two new nodes where the “orientation” of the attacking action had the most influence in “precision” in relation with “zone 1”. Node 3 showed that when the action was aimed to “right” or “left” higher values of “precision” were achieved, where nodes 5 and 6 described that when the ball is aimed to “left” side higher values of “no success” are achieved in comparison with “right” side.

Focusing on the results of the exhaustive CHAID classification tree in relation to the defensive actions, five variables were highlighted. Figure 4 shows the final model presented by 11 nodes with 6 of them classified as final nodes.

The root node 0 is described by the dependent variable “technical action of the goalkeeper” where most frequent category was “save.” The first variable which has higher influence on the dependent variable was “field zone from where shots were taken” which gave rise to nodes 1, 2, and 3. Node 1 showed that when a shot was taken from “zones 9, 6, 12, 2, 3, and 15” higher values of “save” were found in comparison with nodes 2 and 3. This node 1 gave rise to two new nodes where the physical action “jump” was the most predictable variable in this case for technical action. In these nodes was found that when a jump was performed, lower values were recorded than

when no jump was performed. This node gave rise to two new nodes where physical action “drop” was the predictor of the technical action in this case, showing that when no drop is performed, higher values of save than when a drop was performed were achieved.

Node 2 showed that shots from “zones 14, 1, 8, 13, 11, 5, 10, and 7” increased “parry” as well as “1-on-1” actions in comparison with nodes 1 and 3, giving rise to nodes 6 and 7 where the “zone of goalkeeper intervention” was the most predictable variable for the “technical action” in those zones. In node 6, categories “penalty area” and “outside penalty area” showed higher values in “1-on-1” actions than node 7 which presented higher values of “save” and “parry” actions.

Node 3 described that when “no shot” was carried out and the shot was taken from “opposing half field” the technical actions “clear out” and “foot control” achieved higher values than others nodes, giving rise to nodes 8 and 9 where “intensity of action” was the predictor for the technical action in this case. Node 8 showed when the action was “maximal” higher values of “clear out” and lower values of “foot control” than node 9 were achieved.

Discussion

The aim of the present study was to analyze the actions of goalkeepers in relation to situational variables. More specifically, we aimed to identify situational predictors of the technical-tactical actions in defense and the precision of the offensive action performed by the goalkeepers. The main results showed that in defense the technical-tactical actions of the goalkeeper mainly depend on the zone of the field from where the shot was taken. Specific physical actions such as jump or drop performed by the goalkeeper were conditioned when shots were taken from outside the penalty area, and shots taken inside the penalty area influenced the intervention zone of the goalkeeper. In attack, the precision of the attacking action depended on the length of the prior delivery. Deliveries from zone A were associated with higher values of precision than other zones. In addition, left and right side zones of the pitch had higher values in precision than the center zone.

Results from the study revealed that the zones from where the shot was taken, the physical action performed by the goalkeeper prior to the shot, and the zone of intervention of the goalkeeper in defense significantly influenced the technical actions of the goalkeeper. Not surprisingly, saves were the most performed action of goalkeepers which is in line with previous research, which may be due to the fact this is the only player who can perform this technical action, which is also decisive for the result.¹⁰ Moreover, it was evident that when a physical action was performed (jump or drop), the number of saves decreased. These results are helpful for coaches and goalkeeper trainers in shaping the training process for

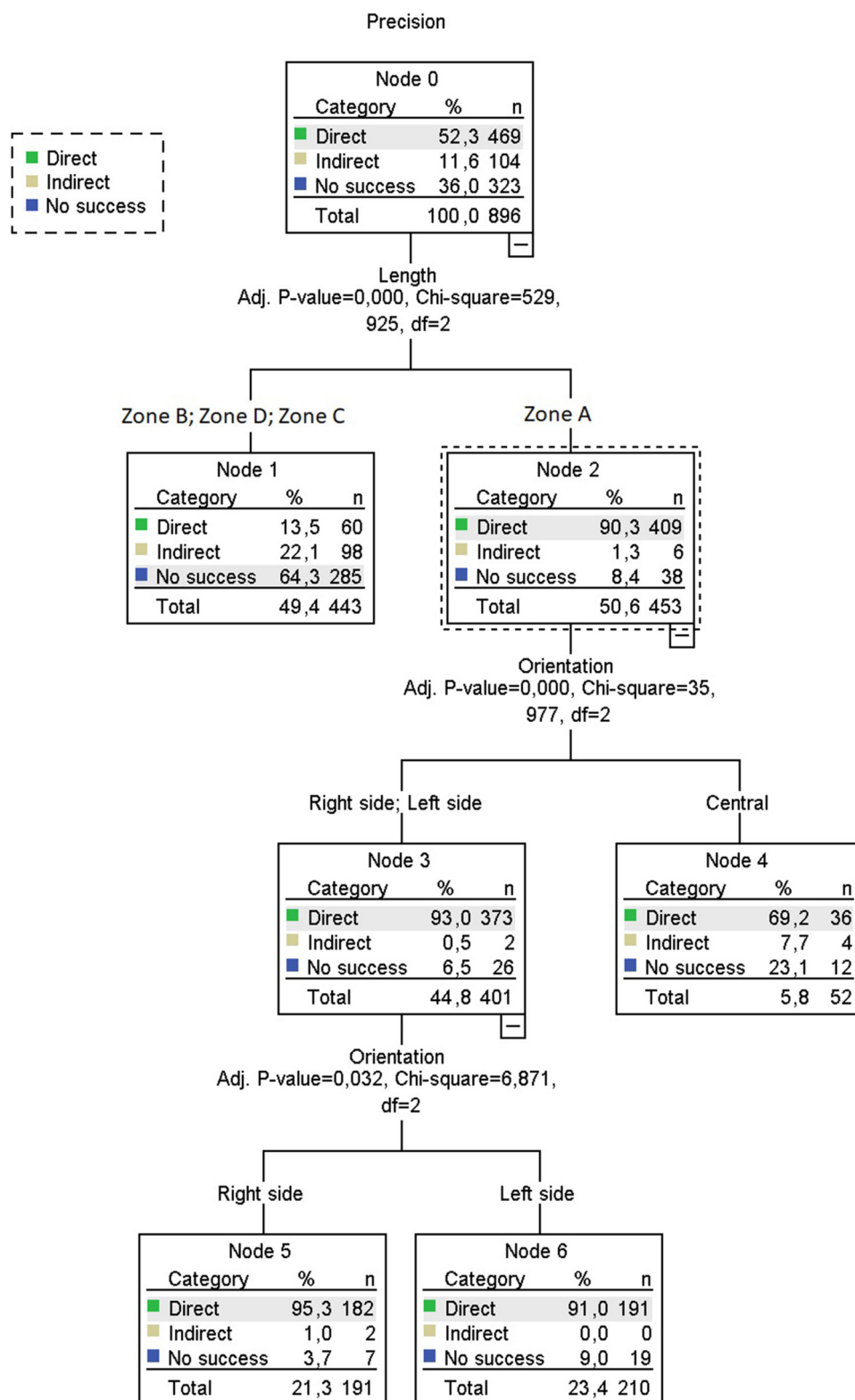


Figure 3. Classification tree analysis of precision of the attacking action of the goalkeeper.

goalkeepers as these variables can be considered as basics in achieving a good technical-tactical development. According to the principles of motor development, it is

difficult to teach advanced technical actions where a great number of capacities are needed if they do not learn the basics at early developmental stages.²⁴ Thus, a proper

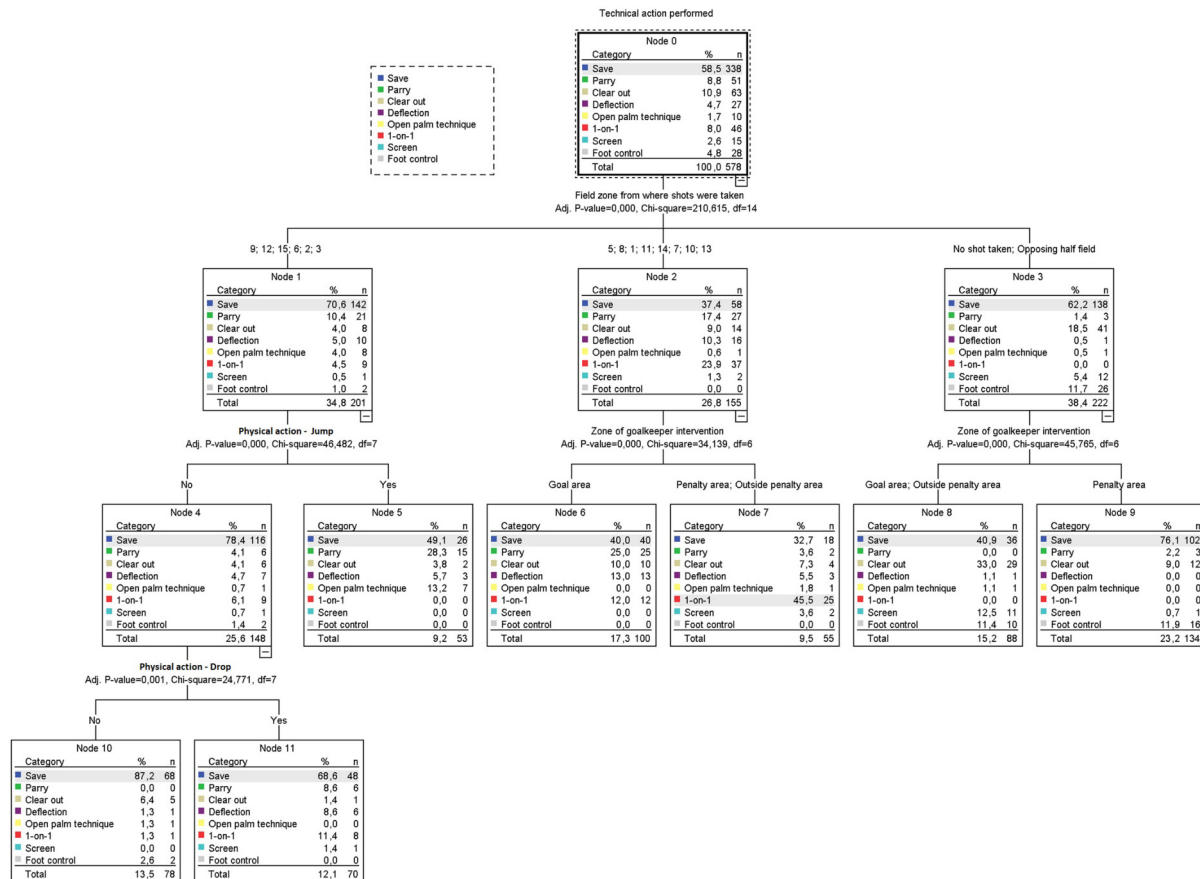


Figure 4. Classification tree analysis of defensive technical action of the goalkeeper.

progression in training should be based on mastering saves with a drop performed before designing task where jumping is necessary to perform.

Regarding precision of the attacking action, the most precise actions were performed in zone A and the right and left side zones. This is mainly due to two facts. Firstly, the main objective of football is to score a goal, while defensively the main objective is to prevent a goal. In this dynamic, the team that does not have the ball tends to protect and accumulate defenders close to their own area, freeing up space for the opposition. This explains why goalkeepers are more effective in attacking close to their own area.^{25,26} Moreover, due to muscular differences with adults, young goalkeepers lack the strength to perform a long-distance kick.²⁷ It is important where the goalkeeper is positioned in relation to his/her teammates to achieve precision when initiating offensive actions. Hence, training should incorporate drills in which young goalkeepers learn to position themselves accordingly when initiating offensive actions.

This study also revealed that context variables such as match status or period had no strong relations with the dependent variables selected. Due to the lack of studies on

young goalkeepers, these data have been compared with football players. This finding stands in contrast to studies on performance analyses in senior football.²⁸ The consistency of performance in 12-year-old goalkeepers may be limited by two factors. The first of these factors relates to the unique characteristics of the goalkeeping role. The second factor that may have an influence is maturation development. It can be stated that youth players are more focused on the task execution than on the context, and the effects of situational variables might not be as relevant as in senior and professional competitions.²⁹ However, future research is necessary to determine the influence of further contextual variables on goalkeeping performance.

Goalkeepers play an important role in opening up offensive actions in modern football. Hence, this basic fact has to be taken seriously by coaches in developing goalkeepers. The results of this study can be considered useful in this regard as they can inform evidence-based practice in the teaching-learning process and in formulating pedagogic principles for training youth goalkeepers.³⁰ In this regard, training situations should be prepared in which goalkeepers participate in the offensive phase by making passes to the near side areas. In this way, the goalkeeper can be integrated

into the offensive phase of the game. In relation to defensive actions, the defensive organization of teammates will condition the goalkeeper's response. Therefore, depending on the goalkeeper's own skills, one type of defense or another should be chosen, considering that in mid-distance positions the most repeated action by the goalkeeper is the save.

Further multivariate performance analysis research is needed youth soccer that includes the goalkeeper. This will allow, defining successful behaviors and performances from a global perspective, which will allow coaches to shape the training process accordingly.

This study presents some limitations. Our study was conducted on a limited number of children and the observations should be reproduced in different categories on a larger number of subjects. Female football could have been scope of interest too, in order to describe any possible difference between players. Another limiting factor of the study was not paying attention to the maturational development of the subjects. For future studies, it is recommended that the actions of the subjects be analyzed according to their degree of maturity. As methodological limitations, it is necessary to highlight the lack of an instrument that has already been used in the scientific literature. As none of the existing instruments have been used, it was necessary to carry out a validation. Furthermore, it was not possible to compare the study data with other studies that have used the same observation instrument.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship and/or publication of this article: This work was supported by Fundación Séneca—Agencia de Ciencia y Tecnología de la Región de Murcia (Regional Program for Mobility, Collaboration, and Knowledge Exchange), under the Jiménez de la Espada Mobility Grant 21726/EE/22 (E.O.) and 21735 (P.S.B.), during the research stay at the University of Wisconsin-Parkside between April and August 2023. This work is the result of the collaboration of Football Club Cartagena S.A.D. and the University of Murcia's Human Movement and Sports Science Research Group (E0B5-06) and its Sport and Musculoskeletal System Research Group (E0B5-07), which began in 2019.

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