

The moment of the initiation of the save as a factor differentiating the actions of handball goalkeepers during throws

PAWEŁ KRAWCZYK¹, ADAM DYJAS², ADAM SZELĄG³, MACIEJ CEDRO⁴

¹Division of Physical Education and Sport, Medical University of Warsaw, Warsaw, POLAND

^{2,3,4} Faculty of Medicine, Medical University of Warsaw, Warsaw, POLAND

Published online: February 28, 2022

(Accepted for publication February 15, 2022)

DOI:10.7752/jpes.2022.02065

Abstract

The aim of this study was to analyze the actions of goalkeepers with good sport results depending on the moment of the initiation of the save in the context of the place and tactical situation in which a throw was made. The research covered 11 goalkeepers who played in 96 matches in PGNiG Men's Superligue in the 2015/2016 sport season. Four goalkeepers were members of the national team, while seven of them played only in club teams. On average, goalkeepers played 52 minutes in a single match. The goalkeepers made an average of 36.34 interventions per match. The research material was a video recording of 3489 goalkeeper saves during throws from different positions (backcourt positions first line [BPIL], backcourt positions second line [BPIIL], pivot positions [PP], wing positions [WP], seven meter throw (penalty) [7M], fast break [FB]). The independent variable was the moment of the initiation of the save containing two parameters: earlier (anticipation) and fast-paced after a delay. Fast-paced interventions after a delay included saves late. The observation method categorized according to Norkowski's concept was used. The following parameters were registered: type of save, the accuracy of the goalkeeper's movement relative to the ball's trajectory, save technique, and effect of the save. The Mann-Whitney U test was performed to compare the parameters in two independent groups. The highest percentage of earlier saves occurs in the case of throws performed at a short distance to the goal (FB, 7M, WP, PP), and the lowest in the case of throws made at a long distance (BPIIL). A relatively even distribution was recorded for throws made from BPIL. The analysis of effectiveness throw from BPIIL shows that fast-paced saves after a delay are characterized by a significantly higher percentage of saved throws. The moment of the initiation of the save is a factor that differentiates goalkeepers' actions in the context of the place and tactical situation in which a throw is made. The distance between the throw and the goal is the factor that differentiates the moment of the initiation of the save. Fast-paced saves after a delay are more efficient during throws made from BPIIL. In specialized goalkeeper training, the moment of the initiation of the save should be optimized in the context of the place and tactical situation in which a throw is made in order to increase the effectiveness of the save by reducing the number of errors.

Key words: anticipation, save rated, effectiveness, backcourt, wing, pivot

Introduction

An analysis of the literature shows that the speed given to the ball during throws in handball is on average 22.25 m/s (Zapardiel et al., 2017). Research results obtained so far also indicate that the speed given to the ball by throwing players depends on the court area from which a throw is performed. Zapardiel et al. (2017) indicate that it is 23.93 m/s in the case of throws made from the central court area and 24.04 m/s in the case of throws made from the side court area. Puero et al. (2021) show that the average ball's speeds are about 21 m/s during throws performed from the wingers' positions and about 24 m/s in the case of throws made from the first line of offensive actions. In the case of throws made from the second line, the ball's speeds are around 26 m/s when a throw is performed from the side court area and around 28 m/s when it is made from the central court area. The analysis of the literature also shows that the speed given to the ball during a throw varies depending on the distance between the thrower and the goal, the throwing technique and the goal sector into which a throw is directed (Puero et al., 2021; Chiroso Rios et al., 2021; Saavedra et al., 2020; Skejo et al., 2020; Vila & Ferragut, 2019; Hermassi et al., 2015). On average, the ball's speeds are 19.3-20 m/s during throws made from seven meters, 23.08-26.06 m/s during throws performed while running or after jumping from nine meters, and about 23 m/s during jump throws made from nine meters.

The results of research conducted so far also indicate that the ball's speed during a throw differs depending on the position of a player, showing that the highest values are recorded for quarterbacks, followed by first-line wing players and pivot players (Puero et al., 2021). Similar results have been obtained by Zapardiel et al. (2019) and Rivilla-Garcia et al. (2016), who additionally indicate that the ball's speed differs depending on whether or not the thrower makes contact with the defender. The authors indicate that quarterbacks give the ball more speed (the ball's speeds are 25 m/s in the situation of throws without the thrower making contact with the

defender and 23.5 m/s when the thrower makes contact with the defender) compared to first-line attacking players (the ball's speeds are 22 m/s in the situation of throws without the thrower making contact with the defender and 20.5 m/s when the thrower makes contact with the defender).

The analysis of the effectiveness of throws depending on the ball's speed shows that throws in which the ball is given more speed are more effective, and the aforementioned speed is on average 24.04 m/s (and is within the range above 22 m/s) (Puero et al., 2021; Villa & Ferragut, 2019; Zapardiel et al., 2017). Vila et al. (2020) have obtained different results, indicating a negative correlation ($r = -0.48$, $p < 0.01$) between the speed and the effectiveness of throws, which may indicate that throws are performed with greater precision and in a technically advanced manner.

Research shows that the sum of (simple and choice) reaction time and motor time is higher than the time in which the ball covers the distance to the goal during throws performed from the first line of offensive actions (Krawczyk et al., 2018; Przednówek et al., 2019). This indicates that, in order to increase the probability of defending the goal, goalkeepers must initiate a save before the ball leaves the thrower's hand during throws performed from the first line of offensive actions. The situation is different in the case of throws made from the second line, where the sum of (simple and choice) reaction time and the motor time is lower than the time in which the ball covers the distance equal to or greater than nine meters. This allows the goalkeeper to initiate a save after the ball has left the thrower's hand.

The literature on the subject indicates that the analysis of goalkeepers' play focuses primarily on the effectiveness of goalkeepers' saves expressed in percentage points (Meletakos et al., 2020; Hatzimanouil et al., 2017; Daza et al., 2017; Saavedra et al., 2017; Hansen et al., 2017; Bilge, 2012). In the opinion of other authors, this approach to the analysis of goalkeepers' play is insufficient as it does not provide the possibility of making a holistic analysis of goalkeepers' actions and errors committed during ineffective saves (Krawczyk et al., 2020; Krawczyk & Bodasiński, 2020ab; Hatzimanouil, 2019; Norkowski, 1997).

The presented review of the research conducted so far indicates that the sum of the reaction time and motor time in the case of throw from a close distance from the goal is higher than the time in which the ball travels to the goal. In order to defend a throw, there is some need for the goalkeeper to start the intervention before the attacking player throws the ball and to intersect the ball's path. The situation is different for throws made from the second line of offensive actions. Such a state forces the goalkeeper to take actions increasing the possibility of defense in the field of intervention technique, selection of the direction and height of intervention, as well as determination of the optimal range of intervention. Research showing differences in the moment of starting the intervention by handball goalkeepers depending on the place and tactical situation of the throw also create grounds for undertaking the topic of analysis of actions and effectiveness depending on the moment of initiation of the intervention. In addition to the cognitive aspect, it also includes a practical aspect that will allow to optimize the training process at the level of children, juniors and seniors. An additional argument pointing to the substantively justified necessity of the above-mentioned analyzes is the fact that the handball goalkeeper is assessed solely on the basis of the effectiveness expressed as a percentage, which, in the opinion of the authors presented above, is insufficient. Determining the actions taken by goalkeepers depending on the moment of starting the intervention in the context of the place and tactical situation of the execution of the throw, allows to indicate the most effective ones, which, from the cognitive point of view as well as coaching practice, will allow for the optimization of the training process, which in turn may translate into achieving higher scores in terms of effectiveness, which may affect the achievement of sporting success in the context of individual matches as well as competitions at different levels.

In connection with the presented research results, the aim of this study was to analyze the actions of goalkeepers with good sport results depending on the moment of the initiation of the save in the context of the place and tactical situation in which a throw was made.

Methods

Participants

The research covered 11 goalkeepers who played in 96 matches in PGNiG Men's Superligue (top-class matches in Poland) in the 2015/2016 sport season. Four goalkeepers were members of the national team, while seven of them played only in club teams. Minimum analysed matches for one goalkeeper is 8, and a maximum is 12. On average, goalkeepers played 52 minutes in a single match (minimum 45 minutes, maximum 60 minutes). The goalkeepers made an average of 36.34 interventions per match. The average age of the subjects was 30.45 ± 5.45 . The professional experience of the goalkeepers involved in the research was 19.82 ± 5.55 years.

Measurements

The research material was a video recording of 3489 goalkeeper saves during throws from different positions (backcourt positions first line [BPIL], backcourt positions second line [BPIL], pivot positions [PP], wing positions [WP], seven meter throw (penalty) [7M], fast break [FB]). The independent variable was the moment of the initiation of the save containing two parameters: earlier (anticipation) and fast-paced after a delay. Fast-paced interventions after a delay included saves late. The number and proportion of the moment of the initiation of the save during throws are presented in Table 1. At the time the data was collected, inaccurate

throws and those in which the thrower was fouled with the referee stopping the game were not included. The video complies with the guidelines of the Handball Association in Poland.

The observation method categorized according to Norkowski's concept was used (Norkowski, 1996; 1997). The following parameters were registered: type of save (after reducing the defensive area within the stance, after reducing the defensive area with a step out/dive, without reducing the defensive area within the stance, without reducing the defensive area with a step out/dive), the moment of the initiation of the save (earlier (anticipation), fast-paced after a delay, and late), the accuracy of the goalkeeper's movement relative to the ball's trajectory (correct direction and height; correct direction, wrong height; wrong direction, right height; wrong direction and height), save technique (correct, inadequate) and effect of the save (unsuccessful (goal), successful (defended throw)). The analysis was done by a licensed handball coach of third level of EHF RINCK Convention, with experience in working with goalkeepers at various sports levels (senior, junior).

Statistical analysis

The gathered data was subjected to statistical analysis. We determined basic statistical characteristics: mean, standard deviation and percentage calculations. Due to the qualitative nature of the data, nonparametric tests were carried out for comparisons between the groups. The Mann-Whitney U test was performed to compare the parameters in two independent groups. Statistical significance was set at $p < 0.05$. The eta-square (η^2) was used to determine the effect size [ES] (< 0.01 -no effect, 0.01 - 0.059 -small effect, 0.06 - 0.139 -intermediate effect, > 0.14 -large effect) (Cohen, 1988). All statistical analyses were performed using Statistica and Microsoft Office Excel software.

Results

The results presented in Table 1 show that overall handball goalkeepers perform 8.62% more fast-paced saves after a delay than earlier saves. Moreover, it should be noted that about 40.05% of fast-paced saves after a delay are late.

The analysis of Table 1 shows that the highest percentage of earlier saves occurs during throws from FB and 7M, and the lowest during throws from BPIIL. The highest percentage of fast-paced save after a delay is performed from BPIIL and the lowest from FB. The highest percentage of late saves occurs during throws from 7M and the lowest from BPIIL.

It should be noted that the highest percentage of earlier saves occurs in the case of throws performed at a short distance to the goal (FB, 7M, WP, PP), and the lowest in the case of throws made at a long distance (BPIIL). A relatively even distribution was recorded for throws made from BPIL.

Table 1. The number and proportion of the moment of the initiation of the save during throws

The moment of the initiation of the save	Situation of throw						Total
	BPIL	BPIIL	PP	WP	7M	FB	
Earlier (anticipation)	n=246 (50.20%)	n=131 (10.24%)	n=292 (62.26%)	n=361 (68.89%)	n=229 (75.08%)	n=335 (79.38%)	n=1594 (45.69%)
Fast-paced save after delay	n=244 (49.80%)	n=1148 (89.76%)	n=177 (37.74%)	n=163 (31.11%)	n=76 (24.92%)	n=87 (20.62%)	n=1895 (54.31%)
including late	n=112 (45.90%)	n=339 (29.53%)	n=113 (63.84%)	n=77 (47.24%)	n=61 (80.26%)	n=57 (65.52%)	n=759 (40.05%)

BPIL=backcourt position first line. BPIIL=backcourt position second line. PP=pivot position. WP=wing position. 7M=seven meter throw (penalty). FB=fast break.

Table 2 contains data on goalkeepers' actions depending on the moment of the initiation of the save during throws from the quarterback positions.

BPIL

The presented results in the situation of throws from BPIL indicate differences in the percentage of A and C saves depending on the moment of the initiation of the save. A higher percentage of A saves occurs during earlier saves, and the difference is 44.45%. More C saves occur during fast-paced saves after a delay, with the difference being 41.48%.

The analysis of the accuracy of the goalkeeper's movement relative to the ball's trajectory shows differences between earlier saves and fast-paced saves after a delay. Namely, 80.74% of fast-paced saves after a delay are made in the right direction and at the right height, while this percentage is 36.99% in the case of earlier saves. The analysis of the collected research material shows that the percentage of errors consisting of incorrect determination of the direction and/or height of the save is statistically higher during earlier saves.

These results indicate that the percentage of correct save technique is significantly higher during fast-paced saves after a delay, while the percentage of incorrect save technique is higher in earlier saves.

The results indicate that the effectiveness of fast-paced saves after a delay is higher by 13.98%, and the significance is close to the adopted threshold value ($p = 0.055668$).

BPIIL

The data presented in Table 2 regarding throws performed from BPIIL show that there are significant differences in the percentage of C saves, which is higher during fast-paced saves after a delay than during earlier saves, and the difference is 38.04%. C save is the main type of earlier saves performed by goalkeepers and their percentage is higher by 36.66% relative to fast-paced saves after a delay. However, attention should be paid to the high standard deviation during C saves in the situation of anticipation, which indicates large differences between the goalkeepers included in the study.

Referring to the accuracy of the goalkeeper's movement relative to the ball's trajectory, it should be indicated that the percentage of saves made in the right direction and at the right height is significantly higher during fast-paced saves after a delay. The difference of 65.74% is statistically significant. During earlier saves, the standard deviation is also high and greater than the mean, indicating that the studied group is not homogeneous in this regard. The results show that a statistically significant difference in the optimal range of the goalkeeper's movement relative to the ball's trajectory depends on the moment of the initiation of the save. A higher percentage of the optimal range occurs in fast-paced saves after a delay and a lower percentage in earlier saves, with the difference being 41.6%. The standard deviation is high, indicating large differences between the goalkeepers included in the study.

The obtained results show a significant difference related to the correct save technique. A higher percentage of the correct save technique occurs during fast-paced saves after a delay, with the difference being 11.97%. The standard deviation is high during earlier saves, indicating large individual differences between the goalkeepers included in the study. The analysis of effectiveness shows that fast-paced saves after a delay are characterized by a significantly higher percentage of saved throws. The difference is 34.67%. The standard deviation is high during earlier saves, indicating intra-group differences.

Table 2. Handball goalkeepers' actions relative to the moment of the initiation of the save during throws from backcourt positions

Goalkeepers' actions	BPIL		U-MW test [Z]	ES	BPIIL		U-MW test [Z]	ES
	Earlier n=246	Fast-paced n=244			Earlier n=131	Fast-paced n=1148		
	M ± SD [%]	M ± SD [%]			M ± SD [%]	M ± SD [%]		
Type of save								
A	78.06±15.03	33.61±14.54	3.742***	0.648	2.29±2.51	2.26±1.19	-3.087**	0.388
B	2.44±3.07	0.82±3.88	1.409	0.071	1.53±1.09	0.17±0.47	0.146	0.001
C	10.16±9.32	51.64±15.07	3.885***	0.694	18.32±17.47	56.36±14.97	-3.357***	0.52
D	9.35±10.82	13.93±11.13	-0.829	0.033	77.86±27.92	41.20±14.90	2.696**	0.338
The accuracy of the goalkeeper's movement relative to the ball's trajectory								
correct direction and height	36.99±11.68	80.74±9.75	-3.939***	0.717	18.32±30.14	84.06±8.78	-3.221**	0.48
correct direction, wrong height	21.14±7.89	4.10±3.09	3.886***	0.694	4.58±15.73	1.52±1.02	-0.266	0.004
wrong direction, right height	14.63±8.46	5.33±5.16	2.354*	0.254	46.56±29.68	9.32±6.35	1.188	0.067
wrong direction and height	27.24±12.91	9.84±9.76	3.286**	0.5	30.53±22.69	5.05±3.27	1.775	0.148
Range of goalkeeper's movement relative to the ball's trajectory								
optimal	78.46±12.04	86.83±6.59	-0.952	0.044	36.14±33.14	77.74±7.21	-2.497*	0.291
too small	11.79±8.24	11.52±5.42	-0.394	0.008	61.83±33.88	21.91±7.14	1.774	0.148
too wide	9.76±7.70	1.65±2.65	1.824	0.138	1.53±2.57	0.35±0.65	0.334	0.004
Save technique								
correct	72.95±8.39	84.02±9.59	-2.298*	0.247	77.86±27.26	89.83±5.54	-2.298*	0.247
inadequate	27.05±8.39	15.98±9.59	2.298*	0.247	22.14±14.89	10.17±5.54	1.576	0.118
Effect of the save								
unsuccessful (goal)	72.76±9.49	58.78±15.81	1.871	0.165	83.97±36.45	49.30±9.21	2.135*	0.213
successful (defended throw)	27.24±9.49	41.22±15.81	-1.871	0.165	16.03±30.12	50.70±9.21	-2.860**	0.379

A=after reducing the defensive area within the stance. B=after reducing the defensive area with a step out/dive. C=without reducing the defensive area within the stance. D=without reducing the defensive area with a step out/dive. BPIL=backcourt position first line. BPIIL=backcourt position second line. *= $p < 0.05$. **= $p < 0.01$. ***= $p < 0.001$. ES=effect size.

The results of the research on the goalkeepers' actions during throws from PP and WP depending on the moment of the initiation of the save are presented in Table 3.

PP

The analysis of throws performed from PP shows a significant difference in the percentage of A saves, which is higher during earlier saves, and the observed difference is 29.84%. A higher percentage of C saves occurs during fast-paced saves after a delay, and the difference of 24.6% is statistically significant. During A and C fast-paced saves after a delay, attention should be paid to the high standard deviation, indicating a lack of group homogeneity. The obtained research results related to the accuracy of the goalkeeper's movement relative to the ball's trajectory indicate that a significantly higher percentage of fast-paced saves after a delay is made in the right direction and at the right height, and the difference between the examined variables is 20.88%. Data analysis indicates a significant difference in the percentage distribution of saves made at the wrong height. Higher values were recorded in the case of earlier saves, and the difference between the variables studied is 13.76%. The presented results related to the range of the goalkeeper's movement relative to the ball's trajectory indicate that the percentage of an excessive range of the goalkeeper's movement is significantly higher during earlier saves, and the difference is 10.99%. However, attention should be paid to the high standard deviation, indicating individual differences between the goalkeepers included in the study.

Although the effectiveness of earlier saves is higher by 7.47%, it is statistically insignificant.

WP

The analysis of the data on throws performed from WP presented in Table 3 shows differences in the type of saves and the accuracy of the goalkeeper's movement relative to the ball's trajectory during earlier saves and fast-paced saves after a delay. There is a statistically significant higher percentage of C saves during fast-paced saves after a delay than during earlier saves. The difference between the examined variables is 10.23%.

The analysis of the accuracy of the goalkeeper's movement relative to the ball's trajectory shows that a significantly higher percentage of fast-paced saves after a delay is performed in the right direction and at the right height, and the difference is 39.63%. There is also a noticeable higher percentage of earlier saves made in the wrong direction and/or at the wrong height. All differences are statistically significant.

In the remaining goalkeepers' actions depending on the moment of the initiation of the save, no statistically significant differences have been found, including in the effectiveness of saves.

Table 3. Handball goalkeepers' actions relative to the moment of the initiation of the save during throws from pivot and wing positions

Goalkeepers' actions	PP		U-MW test [Z]	ES	WP		U-MW test [Z]	ES
	Earlier n=292	Fast-paced n=177			Earlier n=361	Fast-paced n=163		
	M ± SD [%]	M ± SD [%]			M ± SD [%]	M ± SD [%]		
Type of save								
A	89.73±8.20	59.89±23.26	2.890**	0.388	84.21±11.32	77.30±7.81	1.610	0.122
B	3.08±3.52	0	2.719**	0.213	11.63±11.61	6.13±6.34	1.294	0.078
C	3.08±5.58	27.68±17.29	-3.397***	0.51	3.88±3.51	14.11±7.52	-3.335***	0.51
D	4.11±4.11	12.43±10.27	-1.602	0.118	0.28±0.66	2.45±4.03	-1.609	0.067
The accuracy of the goalkeeper's movement relative to the ball's trajectory								
correct direction and height	46.92±6.50	67.80±18.73	-2.766**	0.354	46.26±12.13	85.89±13.22	-3.743***	0.648
correct direction, wrong height	18.84±7.35	5.08±6.24	3.342***	0.5	19.67±7.26	3.07±4.72	3.871***	0.671
wrong direction, right height	9.59±6.63	5.08±5.83	1.593	0.118	9.42±5.70	0.61±1.31	3.930***	0.648
wrong direction and height	24.66±10.37	22.03±15.38	0	0	24.65±10.84	10.43±14.39	2.873**	0.379
Range of goalkeeper's movement relative to the ball's trajectory								
optimal	74.32±14.96	80.79±12.78	-1.380	0.091	81.44±9.00	85.28±14.97	-1.052	0.053
too small	11.30±8.89	15.82±13.64	-0.947	0	9.70±7.65	9.20±11.82	0.033	0
too wide	14.38±11.42	3.39±4.26	2.860**	0.362	8.86±8.30	5.52±5.74	0.544	0.014
Save technique								
correct	78.08±9.98	76.84±12.35	-0.361	0.007	80.89±6.37	79.75±18.30	-0.854	0.036
inadequate	21.92±9.98	23.16±12.35	0.361	0.007	19.11±6.37	20.25±18.30	0.854	0.036
Effect of the save								
unsuccessful (goal)	65.41±9.71	72.88±17.06	-1.182	0.067	64.27±8.11	58.28±20.11	0.787	0.031
successful (defended throw)	34.59±9.71	27.12±17.06	1.182	0.067	35.73±8.11	41.72±20.11	-0.787	0.031

A=after reducing the defensive area within the stance. B=after reducing the defensive area with a step out/dive. C=without reducing the defensive area within the stance. D=without reducing the defensive area with a step out/dive. PP=pivot position. WP=wing position. *= $p<0.05$. **= $p<0.01$. ***= $p<0.001$. ES=effect size.

The analysis of the goalkeepers' actions depending on the moment of the initiation of the save in the case of throws performed from 7M and FB is presented in Table 4.

7M

The analysis of throws performed from 7M indicates that there is a statistically significant higher percentage of A saves during fast-paced saves after a delay. Earlier saves include a significantly higher percentage of B saves. However, the observed differences are very small.

The presented results regarding the accuracy of the goalkeeper's movement relative to the ball's trajectory indicate that the percentage of fast-paced saves after a delay made in the right direction and at the right height is significantly higher, and the difference is 54.08%. The percentage of earlier saves performed in the wrong direction and/or at the wrong height is significantly higher.

No significant differences have been registered in the other examined variables. Although the effectiveness of earlier saves is higher by 10.43%, it is not statistically significant despite the presence of intermediate effect size. Large individual differences in the effectiveness of fast-paced saves after a delay are evidenced by the high standard deviation, which is greater than the mean.

FB

The results of the statistical analyzes of throws made from FB, which are presented in Table 4, indicate that a higher percentage of C saves occurs during fast-paced saves after a delay. The difference is 15.19%. It should also be noted that a higher percentage of A saves occurs during earlier saves, the statistical significance of which is $p = 0.056874$ and is close to the adopted threshold value.

The analysis of the accuracy of the goalkeeper's movement relative to the ball's trajectory shows that a significantly higher percentage of fast-paced saves after a delay are made in the right direction and at the right height, and the difference between the examined variables is 49.33%. The percentage of earlier saves made in the wrong direction and/or at the wrong height is significantly higher.

No statistically significant differences have been found in the other analyzed parameters, and the effectiveness of saves is comparable. The effectiveness of fast-paced saves after a delay is characterized by a high standard deviation, indicating individual differences between the goalkeepers included in the study.

Table 4. Handball goalkeepers' actions relative to the moment of the initiation of the save during throws from 7 metre and fast break

Goalkeepers' actions	7M		U-MW test [Z]	ES	FB		U-MW test [Z]	ES
	Earlier n=229	Fast-paced n=76			Earlier n=335	Fast-paced n=87		
	M ± SD [%]	M ± SD [%]			M ± SD [%]	M ± SD [%]		
Type of save								
A	94.32±7.07	97.37±4.64	-1.985*	0.127	92.84±5.77	73.56±19.13	1.916	0.171
B	3.06±5.46	0	2.097*	0.095	5.37±6.14	6.90±9.30	0.136	0.001
C	0	2.63±4.64	-0.909	0.006	0.90±1.68	16.09±15.78	-2.905**	0.329
D	2.62±4.21	0	1.760	0.053	0.90±1.37	3.45±6.13	0.178	0.001
The accuracy of the goalkeeper's movement relative to the ball's trajectory								
correct direction and height	30.13±11.60	84.21±29.82	-3.269**	0.49	33.43±10.44	82.76±13.54	-3.948***	0.717
correct direction, wrong height	16.16±7.40	1.32±2.15	3.789***	0.582	21.19±10.67	2.30±7.66	3.608***	0.561
wrong direction, right height	17.90±11.71	0	4.210***	0.717	8.06±6.22	0	3.609***	0.48
wrong direction and height	35.81±12.92	14.47±29.65	2.742**	0.346	37.31±9.41	14.94±14.39	3.153**	0.461
Range of goalkeeper's movement relative to the ball's trajectory								
optimal	76.86±9.00	72.37±29.14	-0.164	0.002	73.43±14.35	66.29±24.28	1.150	0.064
too small	13.97±6.64	19.74±29.86	-0.131	0.001	17.91±8.70	28.09±23.01	-0.886	0.038
too wide	9.17±9.03	7.89±11.93	0.932	0.036	8.66±8.01	5.62±8.62	0.612	0.018
Save technique								
correct	74.24±12.57	85.53±16.39	-1.713	0.138	76.83±10.87	72.41±17.32	0.788	0.031
inadequate	25.76±12.57	14.47±16.39	1.713	0.138	23.17±10.87	27.59±17.32	-0.788	0.031
Effect of the save								
unsuccessful (goal)	79.04±10.13	89.47±15.57	-1.627	0.122	77.98±5.22	81.61±16.07	-1.349	0.086
successful (defended throw)	20.96±10.13	10.53±15.57	1.627	0.122	22.02±5.22	18.39±16.07	1.349	0.086

A=after reducing the defensive area within the stance. B=after reducing the defensive area with a step out/dive. C=without reducing the defensive area within the stance. D=without reducing the defensive area with a step out/dive. 7M=seven meter throw (penalty). FB=fast break. *= $p<0.05$. **= $p<0.01$. ***= $p<0.001$. ES=effect size.

Discussion

The research results indicate that the moment of the initiation of the save differentiates goalkeepers' individual actions in the context of the place and tactical situation in which a throw is performed.

When discussing the overall number and percentage of the moment of the initiation of the save (Table 1), it should be indicated that the advantage of earlier saves occurs primarily in the situations of throws performed at short distances to the goal. In the case of throws from the second line of offensive actions, fast-paced saves after a delay are dominant. The reasons for such a distribution should be seen in the speed given to the ball during a throw, as well as the reaction time and motor time of the goalkeepers, which are described in the introduction to this article. It should also be pointed out that during specialized goalkeeper training, players should learn the ability to anticipate, react and optimize the moment of the initiation of the save in the context of the place and tactical situation in which a throw is performed. This corresponds to the opinions of Krawczyk et al. (2020) as well as Krawczyk and Bodasiński (2020ab). The results obtained show that the error of the delayed initiation of the save should be eliminated in the context of the place and tactical situation in which a throw is performed, which in total is responsible for the loss of about 40% of goals.

When discussing the results regarding the type of save, it should be pointed out that there are clear differences in the number of A saves (a higher percentage in the case of earlier saves) during throws performed from BPIL and PP. Despite the statistical significance, these differences between throws performed from BPIL and 7M are small. Large differences were also indicated for C saves, the higher values of which were recorded during fast-paced saves after a delay performed from BPIL, BPIL, PP, WP and FB. It should be assumed that the situation results from the fact that during earlier saves, goalkeepers shorten the area of defense by going forward, thus preventing the throwing player from shooting into certain goal sectors. In the way, the goalkeepers' intention is to cover as much of the goal area as possible with their postures. During fast-paced saves after a delay, it should be presumed that goalkeepers, by not going forward, give themselves more time to correctly determine the direction and height of a throw. It should also be noted that during throws made at short distances to the goal (BPIL, PP, WP, FB), as a result of quick offensive actions, goalkeepers have little time to shorten the area of defense by going forward and so they intervene without shortening it. This situation can also be influenced by the actions of defensive players. Studies on the speed given to the ball during a throw show that it is lower when the thrower is in contact with the defender and higher when there is no contact (Zapardiel et al., 2019; Rivilla-Garcia et al., 2016), which enables the goalkeeper to react to the pace of the throw. This is also confirmed by the studies by Krawczyk et al. (2020) as well as Krawczyk and Bodasiński (2020a), who indicate a higher percentage of A saves during throws performed without contact with the defender and a higher percentage of C saves during throws made in contact with the defensive player. This includes throws made from BPIL, PP and WP. The observed differences in time between C and D saves in the situation of throws from BPIL may also be influenced by the goalkeeper's cooperation with the defensive player who blocks the throw. Krawczyk et al. (2020) indicate that there are a lower percentage of C saves and a higher percentage of D saves when throws are made over the defensive player's block. The overwhelming advantage of saves without shortening the area of defense (C and D) during throws from BPIL corresponds with the results of Yang and Lee (2016). They indicate that, from a biomechanical point of view, the optimal position of the goalkeeper should be about 1.44 m from the goal line. There are also noticeable differences in the number of saves when throws are performed from PP and 7M: it is higher in the case of earlier saves. Although the differences are statistically significant, they are small. The high standard deviation which is greater than the mean indicates that the studied group is not homogeneous and thus there are large individual differences in this respect. The results obtained during throws made from 7M (more A saves) correspond with the results of Yang et al. (2019), who indicate a similar tendency and the fact that, by going forward (shortening the areas of defense), the goalkeeper may mislead the throwers who may thus make errors.

It should also be noted that the results obtained for throws from BPIL and BPIL may be influenced by the court area from which throws were made. Krawczyk et al. (2021) show that saves performed from the side court area are characterized by a higher percentage of A saves. During throws from BPIL, there are more C saves of throws performed from the side court area, while D saves are dominant in the case of throws made from the central court area.

Referring to the type of saves in the case of throws made from FB, it should be noted that direction anticipation is a factor that differentiates the numbers of A and B saves, and that there is a very significant correlation between these variables (approximately $r = 0.91$). The regression results show that low time anticipation increases the number of earlier saves (Krawczyk & Bodasiński, 2020b). These authors also show that goalkeepers with lower time anticipation are characterized by a higher percentage of C saves; however, these differences are low and oscillate around 3%.

When discussing the accuracy of the goalkeeper's movement relative to the ball's trajectory, it should be noted that in all the analyzed situations of throws, a higher percentage of fast-paced saves after a delay are made in the right direction and at the right height. Earlier saves are characterized by higher numbers of errors

related to incorrect anticipation of direction and/or height, which results in ineffective saves. A study by Löffing and Hagemann (2014) shows that highly qualified goalkeepers use more stimuli to determine the ball's trajectory. It can therefore be assumed that in the situation of fast-paced saves after a delay, goalkeepers have more time to observe the thrower and make decisions about the direction and height of the save, which may translate into a lower percentage of committed errors. Additionally, it should be noted that the results obtained may also be influenced by the contact of the throwing player with the defender. Zapardiel et al. (2019) and Rivilla-Garcia et al. (2016) indicate that the ball's speed decreases when a throw is made in contact with the defender, which gives the goalkeeper more time to observe the thrower and make a decision about the direction and height of the throw based on more stimuli. In combination with their reaction time and motor time, this in a way explains the observed results. Krawczyk et al. (2020) as well as Krawczyk and Bodasiński (2020a) indicate that during throws made in contact with the defender (BPIL, PP and WP), goalkeepers make more saves in the right direction and at the right height, while they make more saves in the wrong direction and at the wrong height in the absence of contact. The same authors also show that there is a higher percentage of fast-paced saves after a delay when the throwing player is in contact with the defender. It should therefore be pointed out that contact with the defender makes it difficult for the player to perform a free throw by preventing the ball from being thrown into certain goal sectors. As a result, the goalkeeper has a smaller area of defense and can better determine the direction and height of the save. Krawczyk et al. (2020) indicate that during throws performed from BPIL, there is a lower percentage of fast-paced saves after a delay when throws are made over the defenders' block. During throws over the block in the discussed situation, goalkeepers also make more errors regarding the wrong direction and height of the save, which somehow explains the results obtained in this study. Additionally, in the case of throws from the side court areas, there is a higher percentage of saves in the right direction and at the right height relative to the ball's trajectory than in the case of throws made from the central court area, which may also have an impact on the presented results (Krawczyk et al., 2021). It should also be pointed out that in the case of throws from FB, there is a strong correlation between choice reaction time and wrong determination of the direction of the save (the right height), indicating that goalkeepers with a lower level of this psychomotor ability perform more saves in the wrong direction. This may also have an impact on the presented results and should be taken into account in further analyzes (Krawczyk & Bodasiński, 2020b).

The results on the range of the goalkeeper's movement relative to the ball's trajectory indicate that the moment of the initiation of the save differentiates the percentage of this movement in two situations of throws (from BPIL and PP). During throws made from BPIL, a much higher percentage of the optimal range of movement occurs in past-paced saves after a delay than in earlier saves. The reasons for these differences should be seen in the tactical situation of a throw. Krawczyk et al. (2020) indicate that throws performed over the block are characterized by a lower percentage of fast-paced saves after a delay and, at the same time, a lower percentage of the optimal range of the goalkeeper's movement. During the goalkeeper's cooperation with the throwers, the goalkeeper is responsible for defending the ball heading towards a specific goal sector, which may involve an earlier save in a specific direction. Throws performed over an ineffective block may be directed to the goal sectors, for which the blocking players are responsible, which may result in a lower percentage of the optimal range of the goalkeeper's movement relative to the ball's trajectory. Moreover, the court area from which a throw is made may also affect the results obtained. Krawczyk et al. (2021) indicate a higher percentage of the optimal range of the goalkeeper's movement relative to the ball's trajectory during throws made from the side court area than during those made from the central court area. During throws from PP, there is a higher percentage of saves with an excessive movement of the goalkeeper relative to the ball's trajectory during earlier saves. The observed differences are related to A saves that are dominant in earlier saves. By going forward, the goalkeeper maximizes the area of defense in order to defend as much of the goal as possible by increasing the angle and thus reduce the throwing possibilities of the offensive players and introduce an element of surprise. If the goalkeeper goes too far forward, the range of his movement goes beyond the light of the defended goal and the ball may be thrown over his head.

The results obtained indicate that the moment of the initiation of the save is differentiated by the save technique only during saves made from the quarterback positions (BPIL, BPIL). A higher percentage of correct technique was obtained in fast-paced saves after a delay. It should be noted that this may be related to the fact that goalkeepers with good sport results use a greater number of stimuli (Löffing & Hagemann, 2014), which in combination with the level of their psychomotor abilities (Przednówek et al., 2019; Krawczyk et al., 2018) and the possibility of observing the thrower for a longer period of time in fast-paced saves after a delay may help them determine the technique correctly.

When discussing the effectiveness of saves, it should be pointed out that the moment of the initiation of the save differentiates it in the situation of throws made from BPIL and is close to statistical significance in the case of throws from BPIL. In both cases, a higher percentage of successful defenses occurs in past-paced saves after a delay. The higher efficiency of fast-paced saves after a delay in the context of the analyzed goalkeepers' actions is the result of the lower number of errors that are the cause of ineffective saves. The obtained results should also be associated with the actions of defense players who, through contact with the throwing player, make it difficult to perform a free throw, which translates into a lower speed of the thrown ball (Zapardiel et al., 2019; Rivilla-Garcia et al., 2016). In combination with a high level of the goalkeepers' reaction time and motor

time, this may indicate a higher percentage of effective defenses (Przednówek et al., 2019; Krawczyk et al., 2018). Research also indicates that during the save of throws performed in contact with the defender from BPIL, there is a higher percentage of fast-paced saves after a delay and they are characterized by higher effectiveness, which may explain the obtained results (Krawczyk et al., 2020). It should also be pointed out that during throws made from BPIL, throws performed over the block are characterized by a higher percentage of earlier saves and lower effectiveness, which also corresponds to the results obtained (Krawczyk et al., 2020).

The results of the research on the effectiveness of saves indicate the need to shape and optimize the moment of the initiation of the save, with particular emphasis on throws performed from BPIL and BPIL. The research results so far indicate that the effectiveness of saves during throws performed from BPIL is a factor that differentiates the match result (win-lose) and, therefore, increasing the number of fast-paced saves after a delay may contribute to achieving sports success during a single match and also during league games and tournaments (Daza et al., 2017; Karastergios et al., 2017; Saavedra et al., 2017).

Limitations

The study included goalkeepers (n = 11) at a high sports level and at one level of competition (PGNiG Superliga). In order to analyse in depth and generalise conclusions, research should be carried out on a larger sample of goalkeepers and at various levels of competition, including major international events and lower leagues.

Conclusions

The moment of the initiation of the save is a factor that differentiates goalkeepers' actions in the context of the place and tactical situation in which a throw is made. The distance between the throw and the goal is the factor that differentiates the moment of the initiation of the save. The moment of the initiation of the save differentiates errors in ineffective saves. Fast-paced saves after a delay are more efficient during throws made from BPIL. In specialized goalkeeper training, the moment of the initiation of the save should be optimized in the context of the place and tactical situation in which a throw is made in order to increase the effectiveness of the save by reducing the number of errors. In sports training, the goalkeeper-defender cooperation should be improved in order to maximize the effectiveness of saves. Further factors differentiating and influencing the content and effectiveness of handball goalkeepers' actions should be sought.

Conflict of interest

Authors have declared that no competing interest exists.

References

- Chirosa Rios, L.J., Cuevas-Aburto, J., Martinez-Garcia, D., Ulloa-Diaz, D., Ramirez, A.A., Martin, I.M., Ramos, A.G. (2021). Reliability of throwing velocity during non-specific and specific handball throwing tests. *International Journal of Sports Medicine*, 42(09), 825-832. <https://doi.org/10.1055/a-1273-8630>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences (2nd ed.)*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Daza, G., Andres, A., & Tarrago, R. (2017). Match statistics as predictors of team's performance in elite competitive handball. *RICYDE. Revista internacional de ciencias del deporte*, 13(48), 149-161. <https://doi.org/10.5232/ricyde2017.04805>
- Hansen, C., Sanz-Lopez, F., Whiteley, R., Popovic, N., Ahmed, H.A., & Cardinale, M. (2017). Performance analysis of male handball goalkeepers at the World Handball championship 2015. *Biology of Sport*, 34(4), 393-400. <https://doi.org/10.5114/biolSport.2017.69828>
- Hatzimanouil, D. (2019). Goalkeepers' rating, evaluation and classification, according to the number of games, participation time and effectiveness at the Women's European Handball Championship in 2018. *International Journal of Performance Analysis in Sport*, 19(3), 595-607. <https://doi.org/10.1080/24748668.2019.1642676>
- Hatzimanouil, D., Giatsis, G., Kepesidou, M., Kanioglu, A., & Loizos, N. (2017). Shot effectiveness by playing position with regard to goalkeeper's efficiency in team handball. *Journal of Physical Education and Sport*, 17(2), 656-662. <https://doi.org/10.7752/jpes.2017.02098>
- Hermassi, S., van den Tillaar, R., Khelifa, R., Chelly, M.S., & Chamari, K. (2015). Comparison of in-season-specific resistance vs. a regular throwing training program on throwing velocity, anthropometry, and power performance in elite handball players. *Journal of Strength and Conditioning Research*, 29(8), 2105-2114. <https://doi.org/10.1519/JSC.0000000000000855>
- Karastergios, A., Skandalis, V., Zapartidis, I., & Hatzimanouil, D. (2017). Determination of technical actions that differentiate winning from losing teams in woman's handball. *Journal of Physical Education and Sport*, 17(3), 1996-1969. <https://doi.org/10.7752/jpes.2017.03194>
- Krawczyk, P., & Bodasiński, S. (2020a). The participation of the defender and the actions of handball goalkeepers' during throws from pivot and wing positions. *Journal of Physical Education and Sport*, 20(supl.6), 3298-3305. <https://doi.org/10.7752/jpes.2020.s6447>

- Krawczyk, P., & Bodasiński, S. (2020b). Level of psychomotor abilities and handball goalkeepers' actions during throws in fast break. *Journal of Physical Education and Sport*, 20(supl.6), 3306-3315. <https://doi.org/10.7752/jpes.2020.s6448>
- Krawczyk, P., Bodasiński, S., Bodasinska, A., & Słupczynski, B. (2018). Level of psychomotor abilities in handball goalkeepers. *Baltic Journal of Health and Physical Activity*, 10(3), 64-71. <https://doi.org/10.29359/BJHPA.10.3.07>
- Krawczyk, P., Cackowski, M., & Dziubek, Ł. (2020). The participation of the defender and the actions of handball goalkeepers in the situation of throws from backcourt positions. *International Journal of Performance Analysis in Sport*, 20(3), 445-455. <https://doi.org/10.1080/24748668.2020.1753966>
- Krawczyk, P., Dziubek, Ł., & Pielas, M. (2021). Handball goalkeepers' actions during throws from central and side areas of the court. *Journal of Physical Education and Sport*, 21(3), 1294-1301. <https://doi.org/10.7752/jpes.2021.03164>
- Loffing, F., & Hagemann, N. (2014). Skill differences in visual anticipation of type of throw in team-handball penalties. *Psychology of Sport and Exercise*, 15(3), 260-267. <https://doi.org/10.1016/j.psychsport.2014.01.006>
- Meletakos, G.P., Noutsos, S.K., & Bayios A.I. (2020). Stable and changing characteristics of high-level handball as evidenced from World Men's Championship. *Journal of Physical Education and Sport*, 20(3), 1354-1361. <https://doi.org/10.7752/jpes.2020.03187>
- Norkowski, H. (1996). Handball – goalkeeper, rules, technique, tactics, training. Polish. Warsaw: AWF.
- Norkowski, H. (1997). Goalkeeping in handball throwing situations. Polish. Trening, 1(33), 59–70.
- Przednówek, K., Śliz, M., Lenik, J., Dziadek, B., Cieszkowski, S., Lenik, P., Kopeć, D., Wardak, K., & Przednówek, K. H. (2019). Psychomotor abilities of professional handball players. *International Journal of Environmental Research and Public Health*, 16, 1909. <https://doi.org/10.3390/ijerph16111909>
- Puerto, B., Tortosa-Martinez, J., Chiroso-Rios, L.J., & Manchado, C. (2021). Throwing performance by playing positions of male handball players during the European Championship 2020. *Scandinavian Journal of Medicine & Science in Sport*, Published online 18 November, <https://doi.org/10.1111/sms.14100>.
- Rivilla-Garcia, J., Calvo, J.L., & van den Tillaar, R. (2016). Comparison of throwing velocity between first and second offensive line handball players. *Kinesiology Slovenica*, 22, 5-15.
- Saavedra, J.M., Halldorson, K., Porgeirsson, S., Einarsson, I.P., & Gudmundsdottir, M. (2020). Prediction of handball players' performance on the basis of kinanthropometric variables, conditioning abilities, and handball skills. *Journal of Human Kinetics*, 73(1), 229-239. <https://doi.org/10.2478/hukin-2019-0147>
- Saavedra, J.M., Porgeirsson, S., Kristjansdottir, H., Chang, M., & Halldorsson, K. (2017). Handball game-related statistics in men at Olympic Games (2004-2016): Differences and discriminatory power. *Retos: nuevas tendencias en educación física, deporte y recreación*, 32(2), 260-263. <https://doi.org/10.47197/retos.v0i32.56542>
- Skejo, S.D., Bencke, J., Moller, M., Sorensen, H. (2020). Estimating throwing speed in handball using a wearable device. *Sensors*, 20(17), 4925. <https://doi.org/10.3390/s20174925>
- Vila Suárez, M.E., Zapardiel Cortés, J.C., & Ferragut, C. (2020). The relationship between effectiveness and throwing velocity in a handball match. *International Journal of Performance Analysis in Sport*, 20(2), 180-188. <https://doi.org/10.1080/24748668.2020.1726159>
- Vila, H., & Ferragut, C. (2019). Throwing speed in team handball: A systematic review. *International Journal of Performance Analysis in Sport*, 19(6), 1-13. <https://doi.org/10.1080/24748668.2019.1649344>
- Yang, J., Koo, D., & Lee, G. (2019). Searching for ideal defensive position of female handball goalkeeper at 7m throw. *The Korean Journal of Physical Education*, 58(6), 441-447. <https://doi.org/10.23949/kjpe.2019.11.58.6.35>
- Yang, J.H., & Lee, Y.S. (2016). A study on the defensive stance and position of handball goalkeepers: Facing a forward jump shot made from 9 m. *Journal of Applied Biomechanics*, 32(5), 504-512. <https://doi.org/10.1123/jab.2015-0317>
- Zapardiel Cortes, J.C., Ferragut, C., Manchado, C., Abraldes, J.A., & Vila Suarez, M.E. (2017). Difference of the speed of handball throwing during the competition in relation to efficiency: Analysis between the first and the second half. *Journal of Human Sport and Exercise*, 12(3), 872-881. <https://doi.org/10.14198/jhse.2017.12.Proc3.11>
- Zapardiel Cortes, J.C., Vila Suárez, M.E., Manchado, C., Rivilla-García, J., Ferragut, C., & van den Tillaar, R. (2019). Effect of opposition and effectiveness of throwing from first and second line in male elite handball during competition. *Kinesiology Slovenica*, 25(1), 35-44.