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PSYCHOMOTOR ABILITIES AS PREDICTORS OF ACTIONS OF HANDBALL GOALKEEPERS DURING SAVES

PAWEŁ KRAWCZYK[1], SŁAWOMIR BODASIŃSKI[2]

[1]*Medical University of Warsaw, Division of Physical Education and Sport, Warsaw, Poland*
[2]*Józef Piłsudski University of Physical Education in Warsaw, Faculty of Physical Education and Health, Department of Sports Games, Biała Podlaska, Poland*

Mailing address: Paweł Krawczyk, Division of Physical Education and Sport, Medical University of Warsaw, Trojdena 2c Street, 02-109 Warsaw, tel. +48 22 57 20 528, e-mail: pawel.krawczyk@wum.edu.pl

Abstract

Introduction. The aim of this study was to determine whether the level of selected psychomotor abilities is a predictor of goalkeepers' actions performed when saving throws made by the attacker in and without contact with the defender depending on the court area from which the throws are made. ***Material and Methods.*** The study included ten leading goalkeepers of the Polish PGNiG Superleague. The research material was a video recording of 1369 goalkeeper saves during throws without contact between the attacking player and the defender and 898 with contact. To assess goalkeepers' actions, the observation method categorized according to Norkowski's concept was used. The level of selected psychomotor abilities was assessed using the Vienna Test System. RT (ver.S.1) – simple reaction time, RT (ver.S.3) – reaction time with choice; ZBA (ver.S.3) – time-space anticipation. The statistical test used was the regression analysis. ***Results.*** The research results presented indicate that selected psychomotor abilities are the predictors of goalkeepers' actions in the context of the court area from which a throw is made depending on the contact between the thrower and the defender. Predictors of the effectiveness of interventions during throws from pivot positions (without contact with the defender) are simple reaction time, motor time and time anticipation ($y = 0.40326_{RTSRT} - 0.66451_{MTSRT} - 0.62533TA - 0.18835_{RTCRT} + 69.58$). The predictor of the effectiveness of interventions during throws from backcourt position from the first line (without contact with the defender) is reaction time with choice ($y = -0.15796_{RTCRT} + 70.92$). ***Conclusions.*** Specific psychomotor abilities should be developed to increase goalkeepers' effective actions and reduce errors that result in ineffective saves, i.e. the loss of goals.

Key words: reaction time, anticipation, defender, regression, performance

Introduction

Previous analyses of handball goalkeepers' play have indicated differences in the effectiveness of goalkeepers' saves depending on the final result of the match (win-lose) [1, 2, 3], the court area from which a throw was made [4, 5], and the defence system used by teams [6]. The literature also shows that the effectiveness of goalkeepers' saves depends on the goal sector into which a throw is directed [7], and the court area from which it is made [8]. Hansen et al. [7] have additionally shown the relationship between the effectiveness of goalkeepers' saves and the place occupied by teams in top-level international competitions. The literature on the subject also includes works on the effectiveness of goalkeepers' saves during top-level international competitions and the search for historical differences and trends in recent years [9, 10, 11, 12].

According to Norkowski [13], Hatzimanouil [14] and Krawczyk et al. [15], analyses focusing on the effectiveness of goalkeepers only in percentage terms are insufficient and do not allow the causes of unsuccessful saves to be identified. The studies by Krawczyk et al. [15] and Krawczyk & Bodasiński [16] are examples of a holistic approach to the analysis of handball goalkeepers' play, indicating differences in the actions of goalkeepers depending on the court area from which a throw is performed and the contact between the thrower and the defender. These analyses also make it possible to identify the causes of unsuccessful saves.

In addition to research involving the analysis of handball goalkeepers' play, literature on the subject also includes works focusing on psychomotor abilities of handball players. The studies conducted so far have indicated that their abilities depend on age, gender and the nominal court area of the game [17], as well as professional experience and sports results [18, 19].

Research on psychomotor abilities involving handball goalkeepers indicates their high levels in terms of reaction time, motor time and moderate levels of anticipation [19, 20]. Studies involving goalkeepers' reaction time show that it depends on sports results of players [21], and the quality of sleep [22]. So far, scientific reports on goalkeepers' anticipation have indicated that it is higher in players with good sports results [18, 23], and that it depends on gender, the court area from which a throw is performed and the tactical situation of the throw made [24]. Cocić et al. [25] have proved that differences in anticipation levels depend on goalkeepers' sports results and that goalkeepers make decisions based on different sequences of movements. Alsharji & Wade [26] have proved that perceptual training influences a higher level of anticipation in penalty throws and that goalkeepers achieve higher anticipation results during direct throws than in those preceded by feint.

Krawczyk et al. [27] have indicated that the level of psychomotor abilities is a factor differentiating individual actions of handball goalkeepers and that there are relationships between these variables. Additionally, Krawczyk & Bodasiński [28] have shown strong correlations between the studied variables, and

the regression analysis points out that selected psychomotor abilities are the predictors of goalkeepers' actions.

In connection with the literature review presented, the aim of this study was to determine whether the level of selected psychomotor abilities is a predictor of goalkeepers' actions performed when saving throws made by the attacker in and without contact with the defender depending on the court area from which the throws are made.

Material and Methods

Participants

The study covered 10 goalkeepers who played in 88 matches in PGNiG Men's Superleague (top-class matches in Poland) in the 2015/2016 sports season. Three goalkeepers were members of the national team, while seven played in club teams only. A minimum of 8 and a maximum of 12 matches were analysed for one goalkeeper. On average, goalkeepers played 51.90 minutes in a single match (minimum 45 minutes, maximum 60 minutes). The goalkeepers made an average of 36.22 interventions per match. The average age of the subjects was 30.45 ± 5.45. The professional experience of the goalkeepers involved in the study was 19.82 ± 5.55 years. The participants gave their informed consent to participate in the study. The study was approved by the local ethics committee.

Measurements

The research material was a video recording of 1369 goalkeeper saves during throws without contact between the attacking player and the defender (wing positions [WP] n = 389, pivot positions [PP] n = 214, backcourt positions first line [BPIL] n = 191, backcourt positions second line [BPIIL] n = 548) and 898 with contact between the attacking player and the defender (wing positions [WP] n = 87, pivot positions [PP] n = 179, backcourt positions first line [BPIL] n = 251, backcourt positions second line [BPIIL] n = 378). 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 [13, 29]. 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-

Table 1. Goalkeepers' actions in the situation of throws without contact with the defender

Goalkeepers' actions	WP M ± SD [%]	PP M ± SD [%]	BPIL M ± SD [%]	BPIIL M ± SD [%]
Type of save				
A	83.87 ± 9.61	87.51 ± 9.69	74.72 ± 10.08	1.26 ± 1.45
B	11.86 ± 10.22	2.42 ± 2.50	2.03 ± 2.73	0.65 ± 1.21
C	2.99 ± 3.78	6.00 ± 6.82	11.33 ± 10.56	56.39 ± 13.61
D	1.28 ± 1.53	4.08 ± 4.96	11.92 ± 7.52	41.7 ± 13.41
The moment of the initiation of the save				
earlier (anticipation)	71.32 ± 8.06	74.09 ± 13.47	68.99 ± 13.98	6.67 ± 6.93
fast-paced save after a delay	12.57 ± 8.46	8.10 ± 7.44	12.01 ± 7.49	69.39 ± 10.47
late	16.11 ± 5.91	17.44 ± 10.80	18.80 ± 11.22	23.91 ± 7.48
The accuracy of the goalkeeper's movement relative to the ball's trajectory				
correct direction and height	56.65 ± 7.47	49.16 ± 10.14	46.41 ± 6.78	88.22 ± 4.60
correct direction, wrong height	15.09 ± 6.43	16.14 ± 8.61	15.35 ± 6.67	1.89 ± 1.59
wrong direction, right height	5.47 ± 2.70	5.74 ± 7.14	10.50 ± 5.46	6.24 ± 4.94
wrong direction and height	22.78 ± 9.04	28.96 ± 10.52	27.33 ± 9.80	3.65 ± 2.84
Range of goalkeeper's movement relative to the ball's trajectory				
optimal	81.32 ± 9.84	74.20 ± 15.61	78.21 ± 11.34	79.83 ± 7.23
too small	10.49 ± 6.36	13.93 ± 10.74	13.26 ± 7.30	19.50 ± 6.99
too wide	8.19 ± 8.41	11.87 ± 9.40	8.33 ± 6.65	0.67 ± 1.22
Save technique				
correct	48.39 ± 12.69	73.74 ± 15.11	73.81 ± 10.74	88.66 ± 5.79
inadequate	51.61 ± 12.69	26.26 ± 15.11	26.19 ± 10.74	11.34 ± 5.79
Effect of the save				
unsuccessful (goal)	66.59 ± 6.82	70.87 ± 10.79	76.61 ± 6.45	43.72 ± 9.07
successful (defended throw)	33.41 ± 6.28	23.19 ± 10.79	23.39 ± 6.45	56.28 ± 9.07

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. WP = wing positions. PP = pivot positions. BPIL = backcourt positions first line. BPIIL = backcourt positions second line. M = mean. SD = standard deviation.

-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 the third level of EHF RINCK Convention, with experience in working with goalkeepers at various sports levels (senior, junior).

Handball goalkeepers' actions during throws without contact between the attacking player and the defender are shown in Table 1, and during throws with contact between the attacking player and the defender are shown in Table 2.

The level of psychomotor abilities was assessed using the Vienna Test System. RT test version S.1 was used to measure simple reaction time [RTSRT] and motor time [MTSRT]. RT test version S.3 was used to measure reaction time with choice [RTCRT] and motor time [MTCRT]. The following variables were recorded: reaction time and motor time. ZBA test version S.3 was used in the linear form to measure time-space anticipation. The recorded parameters were the median time deviation [TA] and the median direction deviation [MDD]. Psychomotor abilities were tested in the starting season, prior to the third training unit of the starting microcycle on the dominant upper limb. The measurements were preceded by a specialized 15-minute goalkeeper warm-up. Levels of psychomotor abilities of the examined goalkeepers are shown in Table 3.

Statistical analysis

The gathered data was subjected to statistical analysis. The analysis of the impact of the level of psychomotor abilities on the actions of goalkeepers was determined using multiple (stepwise-backward) regression analysis. Statistical significance

Table 3. Levels of psychomotor abilities of handball goalkeepers

Psychomotor abilities	M	SD	MIN	MAX
RTSRT [ms]	202.10	14.43	188	232
MTSRT [ms]	79.50	11.79	60	92
RTCRT [ms]	296.60	27.95	264	357
MTCRT [ms]	77.80	18.92	49	108
TA [s]	0.74	0.29	0,3	1.18
MDD [pixel]	23.2	11.91	12	43

RTSRT = reaction time in test SRT. MTSRT = motor time in test SRT. RTCRT = reaction time in test CRT. MTCRT = motor time in test CRT. TA = time anticipation in test ZBA. MDD = median direction deviation in test ZBA. ms = millisecond. s = second. M = mean. SD = standard deviation. MIN = minimum. MAX = maximum.

Table 2. Goalkeepers' actions in the situation of throws in contact with the defender

Goalkeepers' actions	WP M ± SD [%]	PP M ± SD [%]	BPIL M ± SD [%]	BPIIL M ± SD [%]
Type of save				
A	68.33 ± 11.81	67.93 ± 12.81	38.10 ± 10.07	3.37 ± 2.61
B	2.22 ± 6.67	0.93 ± 2.05	1.21 ± 2.03	0
C	29.44 ± 11.93	19.92 ± 8.34	48.18 ± 9.38	59.89 ± 13.16
D	0	11.16 ± 10.57	12.51 ± 7.36	36.43 ± 13.72
The moment of the initiation of the save				
earlier (anticipation)	47.65 ± 20.95	47.66 ± 14.71	32.34 ± 10.56	6.00 ± 6.23
fast-paced save after a delay	41.48 ± 18.29	21.27 ± 13.49	41.62 ± 12.95	67.53 ± 9.48
late	10.86 ± 11.79	31.08 ± 12.38	26.04 ± 5.72	26.14 ± 10.01
The accuracy of the goalkeeper's movement relative to the ball's trajectory				
correct direction and height	71.06 ± 10.28	65.10 ± 11.39	69.67 ± 8.67	86.76 ± 5.52
correct direction, wrong height	9.43 ± 10.48	9.11 ± 7.39	9.26 ± 6.74	1.15 ± 1.41
wrong direction, right height	7.05 ± 10.01	11.36 ± 7.37	9.71 ± 7.74	6.33 ± 3.75
wrong direction and height	12.45 ± 9.00	14.43 ± 7.20	11.35 ± 13.28	5.75 ± 4.33
Range of goalkeeper's movement relative to the ball's trajectory				
optimal	91.39 ± 10.69	80.87 ± 10.64	85.81 ± 6.44	83.61 ± 6.91
too small	6.44 ± 9.59	11.02 ± 8.53	11.63 ± 5.21	16.39 ± 6.91
too wide	2.18 ± 4.67	8.10 ± 7.41	2.65 ± 2.80	0
Save technique				
correct	70.14 ± 13.51	80.84 ± 13.67	83.58 ± 10.23	90.64 ± 4.88
inadequate	29.86 ± 13.51	19.16 ± 13.67	16.42 ± 10.23	9.36 ± 4.88
Effect of the save				
unsuccessful (goal)	44.26 ± 18.57	62.60 ± 17.00	55.93 ± 9.40	42.94 ± 10.06
successful (defended throw)	55.74 ± 18.57	37.40 ± 17.00	44.07 ± 9.40	57.06 ± 10.06

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. WP = wing positions. PP = pivot positions. BPIL = backcourt positions first line. BPIIL = backcourt positions second line. M = mean. SD = standard deviation.

was set at $p < 0.05$. All statistical analyses were performed using Statistica and Microsoft Office Excel software.

Results

The results of the regression analyses in the situation of throws without the thrower making contact with the defender are presented in Table 4. The analyses indicate that there are three regression models in the situation of throws made from the WP. The first one covers saves without reducing the defensive area within the goalkeeper's stance ($F_{(1,8)} = 20.00073$, $p = 0.002077$, SE = 2.13%). TA has a significant impact on the number of saves without reducing the defensive area within the goalkeeper's stance ($\beta = 0.8452$, $t = 4.47$, $p = 0.002077$). A lower level of TA indicates a higher percentage of the type of save indicated ($y = 0.26676_{TA} - 3.58$). The second model includes a late start of the save ($F_{(1,8)} = 22.16393$, $p = 0.001526$, SE = 3.4%). RTSRT has a significant influence on the delayed start of the save [SRT] ($\beta = 0.8572$, $t = 4.71$, $p = 0.001526$). A lower level of RTSRT indicates higher values of delayed saves ($y = 0.3698_{RTSRT} - 58.62$). The third model includes the right direction and the wrong height of the save ($F_{(1,8)} = 50$, $p = 0.000105$, SE = 1.03). MTSRT ($\beta = 0.9285$, $t = 7.07$, $p = 0.000105$) has a significant influence on the studied variable. A lower level of MTSRT indicates higher values of the described variable ($y = 0.2065_{MTSRT} - 10.62$).

The regression analysis of throws made from the PP shows the existence of two statistically significant models. The first one includes an unsuccessful save ($F_{(4,5)} = 71.84665$, $p = 0.000132$, SE = 1.88%). An unsuccessful save is affected by simple RTSRT ($\beta = -0.5440$, $t = -7.98$, $p = 0.000499$), the higher level of which indicates lower values of the variable, and MTSRT ($\beta = 0.7321$, $t = 10.57$, $p = 0.000131$), TA ($\beta = 0.6958$, $t = 8,63$, $p = 0.000346$) and RTCRT ($\beta = 0.4920$, $t = 7.83$, $p = 0.000544$), whose lower levels indicate higher values of the described variable ($y = -0.40326_{RTSRT} + 0.66451_{MTSRT} + 0.62533_{TA} + 0.18835_{RTCRT} + 30.42$). The second model covers a successful save ($F_{(4,5)} = 71.84665$, $p = 0.000132$, SE = 1.88). A successful save is influenced by RTSRT ($\beta = 0.5440$, $t = 7.98$, $p = 0.000499$), the lower level of which indicates higher values of the variable, and MTSRT ($\beta = -0.7321$, $t = -10.57$, $p = 0.000131$), TA ($\beta = -0.6958$, $t = -8.63$, $p = 0.000346$) and RTCRT ($\beta = -0.4920$, $t = -7.83$, $p = 0.000544$), whose higher levels indicate higher values of the described variable ($y = 0.40326_{RTSRT} - 0.66451_{MTSRT} - 0.62533_{TA} - 0.18835_{RTCRT} + 69.58$).

The results of the regression analysis during saves performed from the BPIL indicate the existence of two regression models. The first includes an unsuccessful save ($F_{(1,8)} = 16.19127$, $p = 0.003821$, SE = 3.29%). RTCRT has a significant influence on an unsuccessful save ($\beta = 0.8181$, $t = 4.02$, $p = 0.003821$). A lower level of the former indicates higher values of the described variable ($y = 0.15796_{RTCRT} + 29.08$). The second regression model includes a successful save ($F_{(1,8)} = 16.19127$, $p = 0.003821$, SE = 3.29%). A successful save is affected by RTCRT ($\beta = 0.8181$, $t = 4.02$, $p = 0.003821$), the higher level of which indicates higher values of the described variable ($y = -0.15796_{RTCRT} + 70.92$).

The presented results of the regression analysis in the case of throws from the BPIIL indicate the presence of one regression model covering an earlier moment of the initiation of the save ($F_{(3,6)} = 12.26267$, $p = 0.005705$, SE = 3.23%). Reaction time preceded by anticipation is significantly influenced by RTCRT ($\beta = 0.5308$, $t = 3.33$, $p = 0.015799$) and MDD ($\beta = 0.5248$, $t = 3.38$, $p = 0.014926$), the lower level of which indicates higher values of the described variable, as well as by MTCRT ($\beta = -0.6742$, $t = -4.27$, $p = 0.005267$), the higher level of which indicates a lower level of the analysed variable ($y = 0.1338_{RTCRT} + 12.6024_{MDD} - 0.251_{MTCRT} - 23.38$).

The results of the regression analysis of throws performed with the thrower making contact with the defender are present-

Table 4. Regression analysis during throws without contact with the defender

Situations of throw	Goalkeepers' actions	Adjusted R^2	Constant	Determinants	Standardized β Coefficient	p
WP	without reducing the defensive area within the stance	0.6786	-3.58	TA	0.8452	< 0.01
	late	0.7016	-58.62	RTSRT	0.8572	< 0.01
	correct direction, wrong height	0.8448	-10.62	MTSRT	0.9285	< 0.001
PP	unsuccessful (goal)	0.9692	30.42	RTSRT	-0.5440	< 0.001
				MTSRT	0.7321	< 0.001
				TA	0.6958	< 0.001
				RTCRT	0.4920	< 0.001
	successful (defended throw)	0.9692	69.58	RTSRT	0.5440	< 0.001
				MTSRT	-0.7321	< 0.001
				TA	-0.6958	< 0.001
				RTCRT	-0.4920	< 0.001
BPIL	unsuccessful (goal)	0.6280	29.08	RTCRT	0.8181	< 0.01
	successful (defended throw)	0.6280	70.92	RTCRT	-0.8181	< 0.01
BPIIL	earlier (anticipation)	0.7897	-23.38	RTCRT	0.5308	< 0.05
				MTCRT	-0.6742	< 0.01
				MDD	0.5248	< 0.05

WP = wing positions. PP = pivot positions. BPIL = backcourt positions first line. BPIIL = backcourt positions second line. RTSRT = reaction time in test SRT. MTSRT = motor time in test SRT. RTCRT = reaction time in test CRT. MTCRT = motor time in test CRT. TA = time anticipation in test ZBA. MDD = median direction deviation in test ZBA.

ed in Table 5. The analysis of the data presented indicates the existence of one regression model in the situation of throws made from the WP including the wrong direction and height of the save ($F_{(2,7)}$ = 17.67628, p = 0.0003, SE = 3.83%). The wrong direction and height of the save are significantly affected by MTCRT (β = -0.8433, t = -4.55, p = 0.00263) and TA (β = -1.0583, t = -5.71, p = 0.00073), whose lower levels indicate lower values of the discussed variable ($y = -0.37007_{MTCRT} - 0.73806_{TA} + 56.29$).

The analysis of throws from the PP shows the existence of four regression models. The first one includes the right direction and wrong height of the save ($F_{(1,8)}$ = 14.76683, p = 0.0091, SE = 5.02%). The right direction and wrong height of the save are significantly affected by RTSRT (β = 0.8054, t = 3.84, p = 0.00493), the lower level of which indicates higher values of the discussed variable ($y = 0.4452_{RTSRT} - 80.18$). The second model includes the wrong direction and height of the save ($F_{(1,8)}$ = 10.4065, p = 0.0011, SE = 10.21). The wrong direction and height of the save are significantly influenced by TA (β = -0.7519, t = -3.23, p = 0.01213), whose lower level indicates lower values of the discussed variable (y = -37.4312MDD + 45.51). The third model includes the correct save technique ($F_{(1,8)}$ = 13.36249, p = 0.0035, SE = 11.48%). Right save technique is significantly affected by MDD (β = 0.7909, t = 3.65, p = 0.00644), the lower level of which indicates higher values of the discussed variable ($y = 47.7022_{MDD} + 42.15$). The fourth model includes wrong save technique ($F_{(1,8)}$ = 13.36249, p = 0.005, SE = 11.48%). MDD (β = -0.7909, t= -3.65, p = 0.00644) has a significant influence on right intervention technique, the lower level of which indicates lower values of the discussed variable ($y = -47.7022_{MDD} + 57.85$).

The analysis of throws from the BPIL indicates one regression model with the right direction and height of the save ($F_{(2,7)}$ = 18.60131, p = 0.00158, SE = 6.18%). The right direction and height of the save are significantly influenced by MTSRT (β = 0.8873, t = 5.12, p = 0.00137) and TA (β = 0.9401, t = 5.42, p = 0.00098), the lower levels of which indicate higher values of the discussed variable ($y = 1.0311_{MTSRT} + 1.0817_{TA} - 39.91$).

The results in the situation of throws from the BPIIL indicate one regression model including the right direction and height of the save ($F_{(1,8)}$ = 10.70767, p = 0.0002, SE = 4.02%). The right direction and height of the save are significantly affected by MTSRT (β = 0.7565, t = 3.27, p = 0.01132), the lower level of which indicates higher values of the discussed variable ($y = 0.37204_{MTSRT} + 57.34$).

Discussion

The research results presented indicate that selected psychomotor abilities are the predictors of goalkeepers' actions in the context of the court area from which a throw is made depending on the contact between the thrower and the defender.

When discussing the results obtained in the situation of throws without contact with the defender, it should be pointed out that significant regression models are in all situations of throws. In the case of throws from the WP, three models have been indicated. The first concerns the type of save. Goalkeepers with a lower level of time anticipation perform a higher percentage of saves without reducing the defensive area within the stance. This could be explained by the fact that they compensate for the lower ability to anticipate time by not going towards the thrower, thus giving themselves more time to react and define the direction of the save. Similar results have been obtained by Krawczyk & Bodasiński [28] in the case of throws in quick breaks, which are characterised by a decisive advantage of the lack of contact with the defender. The research results obtained also indicate that the levels of simple reaction time and motor time are strongly related to the mistakes made by goalkeepers, who thus fail to save the goal. This indicates that in the specialised training of goalkeepers, these abilities should be emphasised and developed in order to eliminate the risk of making a mistake and thus increase the effectiveness of defences. Previous studies have also shown that reaction time depends on professional experience [21, 30] and its higher level occurs in experienced players, which indicates the need for this type of training among goalkeepers.

The results obtained in the case of throws made from the PP indicate a relationship between the level of psychomotor abilities and the overall effectiveness of saves. The regression model includes four psychomotor abilities. A lower level of RTSRT increases the effectiveness of the save. The reasons for this can be seen in the characteristics of a throw performed at a close distance from the goal. The goalkeeper's quick reaction combined with the decision on the direction and height of the save gives the thrower the opportunity to change the direction or height of the throw in the last phase. When the goalkeeper's reaction is

Table 5. Regression analysis during throws in contact with the defender

Situations of throw	Goalkeepers' actions	Adjusted R^2	Constant	Determinants	Standardized β Coefficient	p
WP	wrong direction and height	0.7875	56.29	MTCRT	-0.8433	<0.01
				TA	-1.0583	<0.001
PP	correct direction, wrong height	0.6047	-80.18	RTSRT	0.8054	<0.01
	wrong direction and height	0.5110	45.51	MDD	-0.7519	<0.05
	correct	0.5787	42.15	MDD	0.7909	<0.01
	inadequate	0.5787	57.85	MDD	-07909	<.0.01
BPIL	correct direction and height	0.7964	-39.91	MTSRT	0.8873	<0.01
				TA	0.9401	<0.001
BPIIL	correct direction and height	0.5189	57.34	MTSRT	0.7565	<0.05

WP = wing positions. PP = pivot positions. BPIL = backcourt positions first line. BPIIL = backcourt positions second line. RTSRT = reaction time in test SRT. MTSRT = motor time in test SRT. RTCRT = reaction time in test CRT. MTCRT = motor time in test CRT. TA = time anticipation in test ZBA. MDD = median direction deviation in test ZBA.

slower, the thrower has a limited ability to change the direction or height of the throw, which may translate into an effective save. It is also noticeable that a high level of MTSRT increases the effectiveness of the save, which could be explained by the fact that the goalkeeper has the ability to wait as much as possible and start moving when the thrower cannot change the direction or height of the throw. Different results have been obtained during throws saved in fast breaks, where the percentage of effective saves goes up with an increase in motor time.28 The discussed regression model also includes the ability to TA, the higher level of which indicates higher effectiveness. This is because a better defined moment of throwing the ball allows the goalkeeper to start the save when the thrower is unable to change the direction and height of the throw, which may translate into an increased percentage of successful defences. RTCRT is the last motor ability in the model. It should also be pointed out that its higher level increases the effectiveness of the save. This may result from the fact that goalkeepers with a higher level of the discussed ability make a choice regarding the direction and height of the save faster and so they can prepare appropriately for the save in the preceding phase and wait until the thrower throws the ball. This, as in the regression model discussed here, deprives him of the ability to change the throwing direction, height and technique and may increase the effectiveness of defences.

The literature on the subject contains reports with similar results. Research by Szwarc et al. [31] indicates a significant correlation between the time taken to make a decision and the level of technical abilities among football players. The research results so far have also indicated higher levels of simple reaction time, motor time and anticipation in players with greater experience in competition and better sport results [32, 33].

Referring to the results obtained in the situation of throws from the BPIL, it should be noted that one significant regression model has been obtained, indicating that the effectiveness of handball goalkeepers' saves decreases with an increase in RTCRT. This may be due to the fact that goalkeepers with a high level of the described ability decide to make saves in a shorter time and can thus delay the moment of starting the movement until the thrower is unable to change the direction or height of the throw, which may translate into more effective defences. Similar results have been obtained by Szwarc et al. [31] who have shown a correlation between the time in which decisions are made and the level of technical and tactical actions in a group of footballers.

Considering the results obtained in the context of throws performed from the BPIIL, it should be noted that there is one significant regression model relating to an earlier moment of the initiation of the save, including three variables. The first variable is RTCRT, the lower level of which increases the percentage of earlier saves. The reasons for the observed state should be sought in the fact that goalkeepers with longer RTCRT start moving earlier to eliminate deficits in the range of movement and at the same time increase the probability of an effective save. The second variable is MTCRT, the higher level of which reduces the number of earlier saves. It should be noted that goalkeepers with a high level of the discussed ability wait longer to start a save, which is fast-paced after a delay, while players with a lower level start their movement earlier in order to perform an effective save, compensate for its deficits and thus increase the probability of successful defence. The third variable included in the model is the ability to TA. The results obtained indicate that its higher level is related to a reduced percentage of earlier saves, which could be explained by the fact that players who more accurately define the direction of a throw wait longer to start a save so that the thrower is unable to change the direction or height of the throw. Goalkeepers with a lower level of the discussed ability perform the save earlier in order to eliminate its deficits and increase the probability of successful defence. The research conducted so far has shown that during anticipation actions, goalkeepers with a longer professional experience and better sports results show a higher level of anticipation and use a greater number of incentives to determine it [34]. Krawczyk & Bodasiński [28] have indicated that the level of TA is the predictor of earlier saves during throws made in fast breaks. The indicated differences may result primarily from the distance between the thrower and the goal, which is over 9 meters in the case of throws from the second line and 6 meters or less in the case of throws in fast breaks.

When discussing the results obtained in the situation of throws performed in contact with the defender, it should be indicated that the statistically significant regression models obtained relate primarily to the direction and height of the save.

Considering the results obtained in the case of throws from the WP, it should be noted that lower levels of MTCRT and TA reduce the wrong direction and height of saves. The observed fact indicates that goalkeepers start the save relatively later, when the thrower is unable to change the direction or height of the throw, which may result in a lower number of unsuccessful saves. It should also be added that the speed of the ball's flight in throws performed in contact with the defender is lower [35, 36]. Therefore, the maximally delayed initiation of the goalkeeper's movement allows the correct height and direction of the save to be determined.

Considering the results obtained during throws from the PP, it should be noted that four significant regression models have been obtained. The first concerns the right direction and the wrong height of the save. A lower level of RTSRT indicates a higher percentage of this error. It could be presumed that the cause results from the nature of the throw in contact with the defender, who exerts pressure on the thrower and thus prevents him from throwing or makes it difficult for him to throw the ball at certain sectors of the goal, thanks to which the goalkeeper can more accurately determine the direction of the save. Throws from the PP are made from a short distance and so a low level of RTSRT may cause slower processing of stimuli, which may result in a save at a wrong altitude. Referring to the wrong direction and height of the save, it should be noted that a lower ability to MDD decreases the percentage of this error. Therefore, it can be presumed that goalkeepers with a lower level of the discussed ability wait longer to start the save, which allows them to correctly determine the direction and height of the save. This can be confirmed by the results obtained by Krawczyk & Bodasiński [16], who have indicated that when the thrower is in contact with the defender, goalkeepers make more fast-paced saves after a delay. The research results obtained indicate that the percentage of the right save technique increases with the decrease in the ability to MDD. The results obtained in this respect should be combined and similar reasons should be sought as in the case of wrong direction and height of the save, where the anticipation of direction is a predictor of the goalkeepers' actions discussed.

The results obtained in the situation of throws performed from the BPIL and BPIIL indicate that MTSRT (first and second line) and TA (first line) are the predictors of the number of saves made in the right direction and at the right height. The reasons for this can be seen in the fact that goalkeepers with a lower level of the motor abilities start the save relatively later, which makes it easier for them to determine the correct height and direction of the save. This and the action of the defender, who hinders

a free throw at certain sectors of the goal, are the reasons for the results. An additional argument confirming the results is the fact that in the case of throws performed in contact with the defender, the average speed of the ball flight is lower than in the situation without contact [35, 36], which may also affect the right direction and height of saves. Regarding the moment of the initiation of the save, previous research has indicated that during throws performed from the BPIL, a higher percentage of fast-paced saves occurs when the attacker is in physical contact with the defender [15].

The research results presented indicate that specialist goalkeeper training should focus on teaching and improving technical and tactical abilities in the context of both the court area from which a throw is made and the contact between the thrower and the defender, which has also been indicated by other authors [15, 16]. The results also show the necessity of developing psychomotor abilities in goalkeepers and using their potential depending on the court area from which a throw is performed in the context of the attacker's contact with the defender. Specific psychomotor abilities should be developed to increase goalkeepers' effective actions and reduce errors that result in ineffective saves, i.e. the loss of goals. This problem has also been taken up by other authors [15, 28].

Huesmann et al. [37] have emphasised the importance of representative research methods in learning perceptual and cognitive skills. The results described in this article are consistent with the opinion of the above-mentioned authors as they concern psychomotor abilities and their relationship with the actions of goalkeepers with good sports results in real time, in specific tactical situations resulting from the game of handball.

Limitations

The research was conducted at the second-highest level of play (Polish PGNiG Superleague). The psychomotor tests were carried out only on the dominant upper limb. In order to verify and generalize the conclusions and the possibility of presenting the practical application for training and matches, further research should be conducted on a larger group of players with different professional levels, at different tournament levels, also taking into account tests on the non-dominant upper limb and on the lower limbs.

Conclusions

1. The level of psychomotor abilities is a predictor of the actions of handball goalkeepers during throws without and in contact with the defender.
2. The level of selected psychomotor abilities is a predictor of the effectiveness of interventions during throws without contact with the defender during throws from pivot positions and backcourt players from the first line.
3. In specialized goalkeeper training, goalkeepers' actions should be improved depending on the level of psychomotor skills in the context of the place where the throw is performed and the contact between the throwing player and the defender.
4. Testing with Vienna Test Systems can be used in the process of recruitment and selection for the goalkeeper position and during training control of advanced players.

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