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THE LEVEL OF PSYCHOMOTOR ABILITIES AS A FACTOR DIFFERENTIATING HANDBALL GOALKEEPERS' ACTIONS IN SAVES FROM THE WING POSITION

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Abstract

Introduction. The aim of the study was to determine whether the level of psychomotor skills differentiates the actions of handball goalkeepers in the situation of throws from the wing position. **Material and methods.** The research material was a video recording of goalkeepers' saves during throws from wing positions. The research covered 11 goalkeepers who play in PGNiG Men's Superleague (Poland). Psychomotor skills tests were conducted based on the Vienna Test System. The RT test version S.1 was used to measure simple reaction time, while the RT test version S.3 was used to measure choice reaction time. The ZBA test version S.3 in the linear form was used to measure time-space anticipation. The analysis of saves was carried out according to Norkowski's concept. **Results.** We showed a difference in the number of throws after reducing the defensive area between the goalkeepers with higher and lower reaction time values. A high correlation was found $r_s = 0.62$, $p < 0.05$ between reaction time (RT) and saves after reducing the defensive area with a step out/dive. There is a strong relationship between DT motor time and saves after reducing the defensive area with a step out/dive $r_s = 0.74$, $p < 0.05$. There is a high correlation between a fast-paced save after a delay and time anticipation $r_s = 0.64$, $p < 0.05$. **Conclusions.** The level of psychomotor abilities is a factor that differentiates handball goalkeepers' actions in saves from the wing position. The level of psychomotor skills and the actions of handball goalkeepers are interconnected.

Key words: handball, goalkeeper, reaction time, anticipation, psychomotor abilities, wing positions

Introduction

Analysis and evaluation of the quality of performance in team sports reveals general trends of the game and allows for the selection of appropriate training methods and strategies to optimize training. Game analysis is the subject of many studies in sports games: football [1, 2], basketball [3], and volleyball [4]. Research findings also suggest the need to search for appropriate variables for analyzing the quality of sports activities [5], building a system of analyses in sports clubs in the context of improving the quality of the game as well as optimizing youth training [6].

Handball performance analysis is the subject of scientific reports which focus on the analysis of mistakes depending on the stage of the game and the location of the match [7], a description of offensive and defensive actions during matches taking into account the effectiveness of goalkeepers' play [8, 9], the effectiveness of handball players according to their morpho-functional conditions [10] as well as evaluation of goalkeepers'

actions depending on the place and a tactical situation of the throw [11]. We can also distinguish publications by coaches who describe techniques and tactics of handball teams [12, 13, 14, 15]. The literature on the subject also covers studies on the actions of handball goalkeepers. These describe the behavior of goalkeepers in the situation of throws from different positions and the selection of appropriate defense techniques to block the ball's path. These studies indicate different behaviors of goalkeepers depending on the situation and a place of the throw [11].

Of the many issues explored in scientific research, the analysis of psychomotor skills in sport has gained significance, with findings showing that reaction time depends on age [16], gender [16], personality type [17] and training [18]. Research points to differences between the level of reaction time among individuals who practice and those who do not practice sport professionally [19]. Football players at a higher professional level have a shorter reaction time after a 12-minute run than players at a lower professional level [20]. The value of reaction time among female basketball players is above average, and time-space anticipation

is within the statistical norm [21]. Studies show that sprinters have better response time to an auditory stimulus, while volleyball players have higher anticipation [22].

There are numerous publications on the subject of psychomotor skills in handball. Zwierk indicates a difference between reaction time of the right and left hand between handball players and non-players [23]. The literature also highlights differences in the eye-dominant hand reaction time to a visual stimulus between footballers and handball players [24]. According to Krawczyk, Bodasiński, Bodasińska and Słupczyński, handball goalkeepers demonstrated a high level of reaction time and motor time in the RT test (simple reaction time), in choice reaction time, and DT motor time (choice response time), as well as normal ZBA anticipation (space time anticipation) [25]. Scientific reports demonstrate that the professional level of handball goalkeepers depends on their ability to anticipate as well as the ability to shorten reaction time, which is why it is worth investigating the relationships between the situation and the type of throw of an attack player, and the reaction of the goalkeeper [26].

A review of the literature shows that despite many studies that analyze the performance of goalkeepers and the level of psychomotor skills of handball goalkeepers, there are few articles which examine the correlations between these variables. In order to broaden the knowledge on the subject, the above-mentioned issues were discussed in this study.

The aim of the study was to determine whether the level of psychomotor skills differentiates the actions of handball goalkeepers in the situation of throws from the wing position.

Material and methods

The research material was a video recording of goalkeeper saves during throws from wing positions. Inaccurate throws were not included in the data analysis. This study included goalkeepers ($n = 11$) at a high professional level in men's PGNiG Superleague in handball (four of them played as members of their national teams). The observation method categorized according to Norkowski's concept was used [11, 27, 28]. The following parameters were registered: type of the 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), direction of the save (correct, incorrect), save technique (correct, inadequate) and effect of the save (successful, unsuccessful).

Psychomotor skills tests were carried out by means of the Vienna Test System. The RT test version S.1 was used to measure simple reaction time, and the RT test version S.3 was used to measure DT choice reaction time. The measurement allows for the registration of the variables such as reaction time and motor time. ZBA test version S.3 in the linear form was used to measure time-space anticipation. The recorded parameters were the median time deviation and the median direction deviation. Psychomotor skills tests were conducted in the starting season prior to afternoon training sessions and were preceded by a warm-up.

The gathered data were subjected to statistical analysis. We determined basic statistical characteristics: mean, median, standard deviation and percentage calculations. The median for the entire data set was used to divide the goalkeepers into groups with a higher and lower level of psychomotor skills. The median for individual tests on the Vienna Test System was as

follows: reaction time [RT] 199.5 m/s, motor time [RT] 84.5 m/s, reaction time [DT] 297 m/s, motor time [DT] 80 m/s, median deviation time [ZBA] 0.675 s, median direction deviation [ZBA] 17.5 pixels. The non-parametric Mann-Whitney U test was performed to compare the parameters in two independent groups. Spearman's Rho was used to establish the correlation between the variables. Statistical significance was set at $p < 0.05$. A statistical trend was defined as the significance level $p < 0.1$; $p > 0.05$.

Results

The data in table 1 show that of the analyzed defenses, the reaction time values most differentiate saves after reducing the defensive area with a step out/dive. The difference is statistically significant. The obtained outcomes also indicate that there are differences in the save method in some psychomotor parameters between goalkeepers with longer and shorter reaction time; however, they are not statistically significant.

The results presented in table 2 indicate that goalkeepers with longer motor time are more likely to perform a save after reducing the defensive area with a step out/dive. The trend can also be seen in choosing the direction of the save. Players with shorter motor times are more likely to choose the correct direction of the save. The presented data reveal that there is a trend for choosing the wrong direction of the save in the studied groups.

The data displayed in table 3 show that there are no statistically significant differences in the actions of goalkeepers with a higher and lower level of choice reaction time in all tested parameters.

The analysis of table 4 allows us to identify save trends after reducing the defensive area with a step out/dive in relation to DT motor time. Players with longer motor time perform such saves more than twice as often. There is also a noticeable difference in choosing the right and wrong direction of the save in the studied groups but it is not statistically significant.

The data presented in table 5 show that goalkeepers with higher values of time anticipation in 81.53% of the saves use the correct save technique, which is higher than in the second group of respondents. The difference is not statistically significant. From the analysis of table 5, it can be observed that there is a higher percentage of successful saves in the group of goalkeepers with better anticipation (38.07%). However, this is not a statistically significant difference.

The data shown in table 6 demonstrate the occurrence of trends in fast-paced saves after a delay in relation to anticipation of the direction. Goalkeepers with worse anticipation of direction make fast-paced saves after a delay in 21.54% of cases, while players with better anticipation perform this save in 11.15% of throws from the wing position. From the data shown below, it can be noticed that there is a difference in the number of saves between the compared groups. However, the difference is not statistically significant.

Analysis of the collected data also indicates a correlation between goalkeepers' actions and their level of psychomotor skills. A high correlation was found $r_s = 0.62$, $p < 0.05$ between reaction time (RT) and saves after reducing the defensive area with a step out/dive. There is a strong relationship between DT motor time and saves after reducing the defensive area with a step out/dive $r_s = 0.74$, $p < 0.05$. Statistical analysis of the research material suggests a high correlation between a fast-paced save after a delay and anticipation of time $r_s = 0.64$, $p < 0.05$.

Table 1. Handball goalkeepers' actions and simple reaction time RT

Goalkeepers' actions		Higher level of reaction time X-191 ms SD -2 ms	Lower level of reaction time X-207.9 ms SD-14.1 ms	U Mann-Whitney Test
		X [%]	X [%]	
Type of save	after reducing the defensive area within the stance	89.72 ± 8.01	88.37 ± 3.06	-0.45748
	after reducing the defensive area with a step out/dive	1.49 ± 2.05	6.79 ± 4.37	-2.49325**
	without reducing the defensive area within the stance	7.65 ± 6.46	3.64 ± 4.11	1.12122
	without reducing the defensive area with a step out/dive	1.14 ± 1.76	3.63 ± 2.07	-0.10573
The moment of the initiation of the save	earlier (anticipation)	67.60 ± 8.74	71.40 ± 7.35	-0.82158
	fast-paced save after a delay	19.20 ± 10.47	13.11 ± 8.15	1.18944
	late	12.86 ± 5.52	13.65 ± 6.76	-0.27386
The accuracy of the goalkeeper's movement	correct	60.18 ± 7.16	55.33 ± 10.10	0.82158
	wrong	39.82 ± 7.16	44.67 ± 10.10	-0.82158
Save technique	correct	80.73 ± 9.97	76.01 ± 8.78	0.82158
	inadequate	18.67 ± 10.03	23.99 ± 8.78	-1.00416
Effect of the save	unsuccessful (goal)	63.62 ± 12.67	67.81 ± 8.98	-0.45644
	successful (defended throw)	35.38 ± 12.90	32.19 ± 8.98	0.45644

** - p < 0.05; * - p < 0.10.

Table 2. Handball goalkeepers' actions and motor time RT

Goalkeepers' actions		Higher level of motor time X-68 ms SD -6.6 ms	Lower level of motor time X-87.3 ms SD-3.3 ms	U Mann-Whitney Test
		X [%]	X [%]	
Type of save	after reducing the defensive area within the stance	90.92 ± 7.36	87.37 ± 3.38	0.27449
	after reducing the defensive area with a step out/dive	1.69 ± 2.38	6.62 ± 4.47	-1.93919*
	without reducing the defensive area within the stance	6.05 ± 7.29	4.96 ± 3.99	0.09344
	without reducing the defensive area with a step out/dive	1.34 ± 2.17	1.05 ± 1.71	0.10573
The moment of the initiation of the save	earlier (anticipation)	69.80 ± 8.99	69.56 ± 7.63	-0.27386
	fast-paced save after a delay	15.40 ± 11.67	16.27 ± 8.06	-0.09150
	late	14.46 ± 6.32	12.32 ± 6.01	0.45644
The accuracy of the goalkeeper's movement	correct	62.78 ± 5.65	53.17 ± 8.94	1.91703*
	wrong	37.22 ± 5.65	46.83 ± 8.94	-1.91703*
Save technique	correct	75.33 ± 9.65	80.51 ± 8.93	-0.63901
	inadequate	24.07 ± 10.12	19.49 ± 8.92	0.45644
Effect of the save	unsuccessful (goal)	65.82 ± 13.68	65.98 ± 8.31	-0.09129
	successful (defended throw)	33.18 ± 13.68	34.02 ± 8.31	-0.09129

** - p < 0.05; * - p < 0.10.

Table 3. Handball goalkeepers' actions and choice reaction time DT

Goalkeepers' action		Higher level of reaction time X-272.2 ms SD -9.3 ms	Lower level of reaction time X-313.3 ms SD-22.9 ms	U Mann-Whitney Test
		X [%]	X [%]	
Type of save	after reducing the defensive area within the stance	91.36 ± 7.49	87.00 ± 2.53	0.45748
	after reducing the defensive area with a step out/dive	2.26 ± 3.31	6.14 ± 4.56	-1.38514
	without reducing the defensive area within the stance	5.58 ± 7.01	5.35 ± 4.44	-0.09344
	without reducing the defensive area with a step out/dive	0.80 ± 1.79	1.50 ± 1.98	-0.74011
The moment of the initiation of the save	earlier (anticipation)	67.83 ± 9.14	71.20 ± 7.06	-0.63901
	fast-paced save after a delay	17.62 ± 12.53	14.42 ± 6.57	0.64047
	late	13.57 ± 5.05	13.06 ± 7.07	-0.09129
The accuracy of the goalkeeper's movement	correct	58.35 ± 8.20	56.85 ± 10.04	-0.09129
	wrong	41.65 ± 8.20	43.15 ± 10.04	0.09129
Save technique	correct	77.35 ± 11.81	78.82 ± 7.48	-0.09129
	inadequate	22.05 ± 12.07	21.18 ± 7.48	-0.27386
Effect of the save	unsuccessful (goal)	65.01 ± 13.08	66.66 ± 8.97	0.09129
	successful (defended throw)	34.99 ± 13.08	32.51 ± 8.88	0.09129

Table 4. Handball goalkeepers' actions and motor time DT

Goalkeepers' action		Higher level of motor time X-63.3 ms SD -12.1 ms	Lower level of motor time X-92 ms SD-10.9 ms	U Mann-Whitney Test
		X [%]	X [%]	
Type of save	after reducing the defensive area within the stance	89.76 ± 7.36	88.04 ± 3.38	-0.27449
	after reducing the defensive area with a step out/dive	2.07 ± 2.38	7.14 ± 4.47	-1.93919*
	without reducing the defensive area within the stance	6.37 ± 7.29	4.36 ± 3.99	0.46718
	without reducing the defensive area with a step out/dive	1.79 ± 2.17	0.45 ± 1.71	0.95157
The moment of the initiation of the save	earlier (anticipation)	68.83 ± 8.99	70.68 ± 7.63	-0.45644
	fast-paced save after a delay	16.83 ± 11.67	14.73 ± 8.06	0.45748
	late	14.05 ± 6.32	12.38 ± 6.01	0.27386
The accuracy of the goalkeeper's movement	correct	60.98 ± 5.65	53.40 ± 8.94	1.36931
	wrong	39.02 ± 5.65	46.60 ± 8.94	-1.36931
Save technique	correct	78.11 ± 9.65	78.21 ± 8.92	0.09129
	inadequate	21.39 ± 10.12	21.79 ± 8.92	-0.27386
Effect of the save	unsuccessful (goal)	65.52 ± 13.68	66.38 ± 8.31	0.09129
	successful (defended throw)	33.65 ± 13.68	33.62 ± 8.31	0.09129

** - p < 0.05; * - p < 0.10.

Table 5. Handball goalkeepers' actions and time anticipation ZB

Goalkeepers' action		Higher level of time anticipation X-0.70 s SD -0.31 s	Lower level of time anticipation X-0.92 s SD-0.38 s	U Mann-Whitney Test
		X [%]	X [%]	
Type of save	after reducing the defensive area within the stance	89.23 ± 5.30	88.77 ± 6.24	-0.27449
	after reducing the defensive area with a step out/dive	4.08 ± 2.63	4.62 ± 5.66	-0.46171
	without reducing the defensive area within the stance	5.43 ± 3.75	5.48 ± 6.91	-0.18687
	without reducing the defensive area with a step out/dive	1.25 ± 1.82	1.12 ± 2.02	-0.10573
The moment of the initiation of the save	earlier (anticipation)	71.92 ± 7.72	67.80 ± 8.12	-1.00416
	fast-paced save after a delay	13.85 ± 9.02	17.56 ± 10.09	0.45748
	late	12.80 ± 5.51	13.70 ± 6.76	0.27386
The accuracy of the goalkeeper's movement	correct	56.35 ± 5.97	58.53 ± 11.16	0.82158
	wrong	43.65 ± 5.97	41.47 ± 11.16	-0.82158
Save technique	correct	81.53 ± 9.85	75.35 ± 8.38	-1.36931
	inadequate	18.47 ± 9.85	24.65 ± 8.82	1.36931
Effect of the save	unsuccessful (goal)	61.93 ± 6.01	70.82 ± 12.69	1.36931
	successful (defended throw)	38.07 ± 6.01	29.18 ± 12.42	-1.36931

Table 6. Handball goalkeepers' actions and direct anticipation ZBA

Goalkeepers' action		Higher level of direct anticipation X-15.17 pixels SD -2.14	Lower level of direct anticipation X-32.60 pixels SD-10.31 pixels	U Mann-Whitney Test
		X [%]	X [%]	
Type of save	after reducing the defensive area within the stance	90.11 ± 4.36	87.63 ± 7.00	-1.28093
	after reducing the defensive area with a step out/dive	6.03 ± 5.16	2.40 ± 2.23	-1.47748
	without reducing the defensive area within the stance	3.03 ± 3.81	8.37 ± 6.03	1.49497
	without reducing the defensive area with a step out/dive	0.83 ± 2.04	1.60 ± 1.68	0.95157
The moment of the initiation of the save	earlier (anticipation)	73.16 ± 6.31	65.49 ± 8.00	-1.36931
	fast-paced save after a delay	11.15 ± 8.10	21.54 ± 7.90	1.82991*
	late	14.23 ± 7.13	12.17 ± 4.66	-0.63901
The accuracy of the goalkeeper's movement	correct	54.03 ± 8.89	61.75 ± 7.44	1.55188
	wrong	45.98 ± 8.89	38.25 ± 7.44	-1.55188
Save technique	correct	76.73 ± 9.29	79.87 ± 9.82	0.09129
	inadequate	23.28 ± 9.29	19.53 ± 9.94	-0.27386
Effect of the save	unsuccessful (goal)	68.18 ± 8.58	63.18 ± 12.82	-0.63901
	successful (defended throw)	31.82 ± 8.58	35.82 ± 13.8	0.63901

** - p < 0.05; * - p < 0.10.

Discussion

Based on the presented findings, there is a statistical difference between the studied groups in the case of saves after reducing the defensive area with a step out/dive. The percentage share of this type of save in goalkeepers with better RT (reaction time) is lower than in the second studied group. Also, the correlation approach indicates that there is a high statistically significant correlation between these parameters at $r_s = 0.62$. We can presume that this is because in order to defend a ball going towards the goal, goalkeepers with a lower level of reaction time must intervene with a step out/dive to overcome longer reaction and perform the save using additional leg muscle strength. This is consistent with the studies done by other authors who point out the differences at the beginning of the save between goalkeepers at a very high and lower professional level. Players at a higher professional level wait longer for the save than players at a lower level [29]. In order to properly analyze the differences between these parameters, further research should also be carried out taking into account the height of the subjects, as some reports reveal a correlation between body height and reaction time of handball goalkeepers [30]. To explain the analyzed differences, professional experience of the players should be ruled out as a variable, because the professional level of the studied goalkeepers is high and the results of other authors do not indicate a link between professional experience and reaction time [31].

From the analysis of the results of RT motor time, it can be seen that there is a trend in the number of defenses after reducing the defensive area with a step out/dive in both examined groups. This is a difference of $p < 0.1$. The reasons for this may be the same as in the case of RT response time. Goalkeepers with shorter response time make the move faster and do not have to move at the time of the save to block the ball's path. Differences in the percentage distribution can also be seen in the selection of the direction of the save. Goalkeepers with shorter motor time are more likely to choose the correct direction of the save than goalkeepers with longer motor time. There is a trend ($p < 0.1$); however, the difference is not statistically significant. It can be posited that this is due to the fact that players with a higher level of RT motor time are able to initiate movement later than the moment the attacker throws the ball, which allows them to make a save in the right direction and at the right height. Studies by other authors indicate that there is a negative statistically significant correlation at the level of $p < 0.05$ between the speed of movements and the quality of handball players, which may explain the results obtained in our study [32].

From the analysis of the DT choice reaction time, no statistically significant differences were found in the actions of goalkeepers, which suggests that this parameter in the group of highly professional players does not affect the behavior of goalkeepers during saves from a wing position. However, this is important from the point of view of recruitment and selection in sport, because goalkeepers from the PGNiG Superleague demonstrate a high level of this psychomotor ability [25].

This study indicates that there is a trend ($p < 0.1$) in the examined groups in saves after reducing the defensive area with a step out/dive. Goalkeepers with shorter DT motor time are more likely to intervene after reducing the defensive area with a step out/dive than players with a higher level of this ability. There is also a strong correlation at $r_s = 0.74$, which is statistically significant. Similar to RT motor time, the differences stem from the fact that the speed of movement enables the goalkeeper to block the ball faster. Goalkeepers with lower values of psy-

chomotor ability compensate for it with a step out/dive which increases the likelihood of effective defense.

Analysis of the presented data on ZBA time anticipation does not show statistically significant differences in the save method in the studied groups. However, it can be seen that there are differences in the technique and the effect of the save. Players with better parameters of time anticipation use the correct save technique more often, which can be explained by the fact that they wait longer for the start of movement and are able to better predict the type and direction of the throw based on the movements of the thrower. In the studied groups, we can also notice the difference in the effect of the save depending on the level of ZBA time anticipation. In the group of goalkeepers who anticipate time better on the ZBA test, the effectiveness of the save is higher by about 9%; however, this difference is not statistically significant. This study also shows a high significant correlation ($r_s = 0.64$) between ZBA time anticipation and the initiation of a fast-paced save after a delay. Our research confirms that goalkeepers at a high professional level use time anticipation and begin the save later [29, 33]. Other studies indicate that athletes at a higher professional level can better anticipate the opponent's behavior [34]. The above-mentioned reports may suggest that initiating the save as late as possible, even despite anticipation, gives little possibility for the thrower to change the direction and type of throw and hinders the attacker's task, giving the goalkeeper an opportunity to use the correct save technique, which may increase the probability of defense.

The analysis of the quality of handball goalkeepers' saves depending on place anticipation shows that there is a trend in the number of fast-paced defenses after a delay in the examined groups. For players with worse ZBA anticipation, fast-paced saves after a delay make up a higher percentage of saves. We can assume that a lower level of anticipation does not allow for the correct evaluation of the place and direction of the throw, which makes these goalkeepers delay their save until the last moment in order to increase the likelihood of defense.

The obtained and presented results suggest the need for further research of handball goalkeepers' actions depending on the level of psychomotor abilities in situations of throws from offensive positions, pivot positions, in fast attacks and penalty throws. The results will contribute to empirical knowledge of the goalkeepers' actions depending on the level of psychomotor skills, and may indicate the directions of specialist training in this position.

Conclusions

1. The results as well as their careful analysis allow us to conclude that the level of psychomotor abilities (RT reaction time and RT motor time, DT motor time and ZBA time anticipation) differentiates the actions of goalkeepers when defending throws from wing positions.
2. The correlations and the tendencies in the relationship between the level of psychomotor skills and the type of save suggest that goalkeepers' training programs should support the development of psychomotor skills and that coaches should treat these skills as an indispensable element of comprehensive preparation of the goalkeeper.

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