Level of psychomotor abilities in handball goalkeepers

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

Paweł Krawczyk[1 ABCDEFG], Sławomir Bodasiński[2 ABCDE], Anna Bodasińska[2 ABCDE], Bogusław Słupczyński[3 CDE]

[1] Division of Physical Education and Sport, Medical University of Warsaw, Warsaw, Poland

[2] Institute of Sports Games, Józef Piłsudski University of Physical Education in Warsaw, Biała Podlaska Branch, Biała Podlaska, Poland

[3] Department of Track and Field Games and Sports Games, Józef Piłsudski University of Physical Education in Warsaw, Poland

abstract

Background:	The results of previous studies indicate on a higher level of psychomotor abilities among players with a high sports level. The aim of the study was to evaluate the ability of selected psychomotor handball goalkeepers with a high level of sports.
Material and methods:	The research involved 12 goalkeepers appearing in PGNiG Superleague. Psychomotor performance tests were conducted using the Vienna Test System. The following tests were carried out: RT version S1 measuring the simple reaction time, RT version S3 measuring reaction time with a choice. The ZBA test version S3-linear form was used to measure time-space anticipation.
Results:	The average time of the simple reaction was 200.33 ms, while the average motor time was 78.33 ms. These results are on the T scale near the upper limit of the scale. The average response time in the reaction time with the choice was 292.67 ms, while the average motor time was 75.50 ms. The results are above norm. The time anticipation was 0.78 s. The anticipation of the direction was 21.75.
Conclusions:	Handball goalkeepers indicate a high level of simple reaction time and reaction time with choice. Players anticipate a place better than the time the object appears.
Key words:	handball, time of reaction, motoric time, anticipation, goalkeeper.

INTRODUCTION

The recent years have seen a considerable increase in the speed of actions performed by handball players. Matches are played faster, and technical and tactical elements are performed more dynamically and within a shorter time. Players need both to react to and to anticipate their opponents' play faster. To do so, the players are forced to achieve faster reaction times to various stimuli.

Reaction time is composed of five constituent times, the sum of which gives the final result. **T1:** Time in which stimulation appears in a receptor. To a large extent it depends on attention processes, concentration and visual perception. **T2:** Time in which electric stimulation is transferred to the central nervous system. It depends on the conduction velocity of nerve fibres. **T3:** Time in which the stimulus is analysed and a performative signal is formed in the central nervous system. It depends on the degree of automation of movement and its plasticity. This constituent time is the longest and the most responsible for differences in the reaction time. **T4:** Time in which the stimulation is transferred to motor neurons. **T5:** Time in which a muscle is stimulated, leading to the start of a movement [1]. The final stage of human motor reactions is the motor time, which begins with the start of a movement and ends with the end of the movement.

Reaction times can be divided into:
- simple reaction time – a single motor response to an already-known, established stimulus;
- discriminatory reaction time – a response to a single stimulus out of many provided stimuli;
- choice reaction time – occurring when different stimuli correspond to different responses [2, 3].

One of psychomotor abilities is spatial anticipation. It denotes predicting the time and the location of a movement or the time and the location at which an object is going to appear, such as a kick in combat sports or the trajectory of the ball in team sports. Some authors state that anticipation is a key psychomotor ability that determines a high quality of play [4, 5]. Research indicates that players of team sports [2, 4, 6], including handball players [7, 8, 9, 10], show high levels of reaction time and motor time.

In handball, the goalkeeper is an unusual position in that it requires very quick responses to the opponents' handling of the ball. In addition to technical and tactical preparation, the effectiveness of intervention relies on a short reaction time, motor time and the anticipation of the opponent's throwing behaviour [11, 12]. The location and the type of throw determines the speed at which the ball directed towards the goal will move [13, 14, 15, 16] and how much time the goalkeeper has to react. For throws from 9 m away from the goal, the time for reaction is long enough [16] to allow the goalkeeper to make the decision to intervene. Conversely, for throws from 6 or 4 m, there is little time [16] for the goalkeeper to react. This is when anticipation of the direction and height of the throw takes place, as confirmed by studies on the quality of interventions on the part of handball goalkeepers. Such studies indicate that interventions for 9-m throws are made in what is referred to as tempos after waiting, while a large portion of 6-m or closer throws (made after jumping into the goal area) are anticipated by the goalkeeper [17, 18, 19].

Intervention on the part of a handball goalkeeper depends on many factors. These include technical and tactical training, motor preparation and adjustment to the location of the throw, the thrower's run-up, the defenders' actions, and the type of throw. All these factors constantly force the goalkeeper to gather information about the direction, height and technique of the intervention and to make a decision accordingly. The intervention should begin when the thrower is no longer able to change the direction of the throw [11]. By waiting for that moment, the goalkeeper reduces the time needed for the intervention, which forces the goalkeeper to perform the intervention very dynamically. This leads to the conclusion that a high level of psychomotor abilities, such as simple reaction time, choice reaction time, motor time and spatial anticipation, is a predictor of the quality of the goalkeeper's intervention.

The aim of this study was to assess selected psychomotor abilities (simple reaction time, choice reaction time, motor time and spatial anticipation) in handball goalkeepers with a high sports level.

MATERIAL AND METHODS

Study material comprised 12 goalkeepers who played in the PGNiG Superliga league in Poland. Four of the goalkeepers also played in the EHF Champions League. The goalkeepers' mean age was 28.67 ±5.68 years. The study was conducted during the competitive phase, in the afternoon, before training. The tests were conducted for the dominant limb using Vienna Test System equipment. Simple reaction time was measured using the RT test, S1 form, and choice reaction time was measured using the RT test, S3 form. The variables registered in RT tests are mean reaction time, mean motor time, distribution of reaction time, and distribution of motor time. Additionally, decision time was determined based on the difference in mean reaction time, RT S3 test, and mean reaction time, RT S1 test. Spatial anticipation was determined using the ZBA test, S3 linear form. The ZBA test registers the following variables: median deviation time and median direction deviation. Additionally, median deviation time was analysed quantitatively according to an earlier and later reaction.

The obtained results were compared to the T-Score, a scale available in the Vienna Test System software. The T-Score is the result of a comparison between the obtained results and a normalisation sample according to the participants' age and sex. A T-Score between 40 and 60 is considered to be the norm. A T-Score above 60 indicates above-average abilities with respect to a given trait. The T-Score ranges from 0 to 80. The higher the T-Score, the better the result compared to the normalisation sample [20].

The results were subjected to statistical analysis that established the basic statistical parameters, such as sum, mean value and percentages. The Student t-test for independent samples was used to compare the parameters in both groups.

RESULTS

Data analysis showed that handball goalkeepers performed very well in reaction time measurements. The data presented in Table 1 indicate that mean reaction time during the measurements amounted to 200.33 ms. This was a very good mean value, as indicated by the fact that it corresponded to the highest level of the T-Score, at its highest point. Mean motor time (78.33 ms) and reaction time

distribution (18.08 ms) were also located very high on the T-Score. Motor time distribution among the goalkeepers was 38.25 ms, which clearly indicated above-average results. Note, however, the very high standard deviation of motor time distribution (33.12 ms), which may indicate both that the results were above-average and that there were considerable individual differences within the group.

Analysis of choice reaction time indicates that 3 out of 4 variables on the T-Score are above the norm. Mean reaction time (292.67 ms) corresponded to a T-Score of 72, and mean motor time (75.50 ms) corresponded to a T-Score of 74.17. Mean motor time distribution amounted to 35.33 ms, with a very high standard deviation of 37.11 ms. These results correspond to a T-Score of 58.50, which was within the norm; however, the high standard deviation allows for the conclusion that some results were higher than the norm.

Analysis of spatial anticipation indicated that goalkeepers were better at predicting the place where an object was going to appear than the time at which it was going to appear. However, the corresponding T-scores showed that both variables were within the norm. Time anticipation was 0.78 s, and median direction deviation was 21.75 pixels.

Decision time among the study participants was 92.33 ms, and standard deviation from the mean was 26.28 ms.

Table 1. Selected psychomotor abilities in handball goalkeepers

		Unit	$\bar{x}$	SD	T-Score
Simple reaction time	mean reaction time	ms	200.33	13.69	80.00
	mean motor time	ms	78.33	11.01	79.25
	reaction time distribution	ms	18.08	4.78	79.42
	motor time distribution	ms	38.25	33.12	63.92
Choice reaction time	mean reaction time	ms	292.67	27.38	72.00
	mean motor time	ms	75.50	17.96	74.17
	reaction time distribution	ms	48.50	8.59	63.67
	motor time distribution	ms	35.33	37.11	58.50
Spatial anticipation	time anticipation	s	0.78	0.34	54.75
	median direction deviation	pixel	21.75	11.73	60.00

The data shown in Table 2 indicate that there were no statistically significant differences in simple reaction time, choice reaction time or spatial anticipation between the goalkeepers playing in the Champions League and the PGNiG Superliga. Table 2 shows a certain trend in the reaction time distribution for choice reaction time. Goalkeepers in the Champions League had a higher reaction time distribution (54.76 ms) than those in PGNiG Superliga (45.38 ms). Mean reaction time, both simple and choice, was better among the former than among the latter, although the difference was statistically insignificant. Both groups had the same level of mean motor time in simple reaction time. Mean motor time in choice reaction time was better among goalkeepers from the EHF Champions League (69.25 ms) than among goalkeepers from the PGNiG Superliga (78.63 ms). Table 2 indicates that Champions League players predicted time in the spatial anticipation test better than PGNiG Superliga players, although the difference was statistically insignificant. PGNiG Superliga goalkeepers obtained better results in spatial anticipation in terms of the

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median direction deviation (19 pixels) than Champions League goalkeepers (27.25 pixels); however, the difference was statistically insignificant.

Table 2. Psychomotor abilities in handball goalkeepers playing in the EHF Champions League and the Polish PGNiG Superliga

		Unit	Champions League		Superliga		*t*	*p*
			$\bar{x}$	SD	$\bar{x}$	SD		
Simple reaction time	mean reaction time	ms	194	4.08	203.5	15.91	-1.149	0.277
	mean motor time	ms	78.75	11.53	78.13	11.54	0.088	0.931
	reaction time distribution	ms	17	4.9	18.63	4.96	-0.537	0.603
	motor time distribution	ms	33.26	38.14	40.76	32.85	-0.355	0.73
Choice reaction time	mean reaction time	ms	277	20.7	300.5	28	-1.474	0.171
	mean motor time	ms	69.25	15.44	78.63	19.26	0.841	0.42
	reaction time distribution	ms	54.76	10.87	45.38	5.63	2.016	0.071
	motor time distribution	ms	17	26.2	44.5	39.77	-1.431	0.187
Spatial anticipation	time anticipation	s	0.65	0.25	0.84	0.37	-0.923	0.378
	median direction deviation	pixel	27.25	16.46	19	8.62	1.167	0.27

Figure 1 indicates that 90.32% of PGNiG Superliga goalkeepers anticipated the appearance of an object earlier than in reality, compared to 61.29% of Champions League goalkeepers. The difference was statistically significant and amounted to $t = 2.246$, $p < 0.05$. Conversely, 9.68% of PGNiG Superliga goalkeepers anticipated the appearance of an object later than in reality, compared to 38.75% of Champions League goalkeepers. The difference was statistically significant and amounted to $t = 2.3976$, $p < 0.05$.
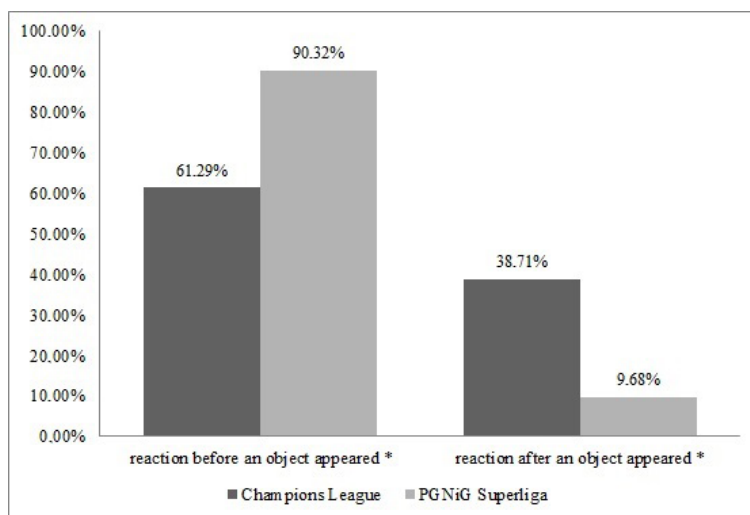

Fig. 1. Time anticipation in handball goalkeepers

DISCUSSION

The results of this study indicate a certain trend in the motor abilities of handball goalkeepers. An analysis of simple reaction time allows for the conclusion that goalkeepers should display a short simple reaction time, as all variables related to this parameter were above average, with three of them showing the highest level. This trend may stem from the nature of play as a goalkeeper. After throws, during which the ball travels at a high speed, goalkeepers have

little time to make a decision and begin an intervention. This may mean that only the goalkeepers who have good predispositions to simple reaction time are able to compete on a high sports level. The results of this study correlate with those obtained by other authors in that they indicate a good reaction time of the players [4, 8, 10]. Sports training also improves the parameters of reaction time and motor time [21]. Notably, the results pertaining to mean reaction time, mean motor time and reaction time distribution were similar; all these parameters displayed a high level, which demonstrates that the players were adjusted to or trained for achieving the repeatability of results. Motor time distribution may indicate that the players were not adjusted to performing multiple, consecutive, very fast movements, which was part of the test. Interventions on the part of handball goalkeepers are interspaced by long periods of rest. This means that during the test, which involved short periods of rest, the goalkeepers were unable to repeat several tens of quick movements within a short time. Differences in reaction time may also be related to the goalkeeper's body height. A correlation was found between body height and reaction time, i.e. short players obtained lower reaction times than tall players [9]. This may result from a prolonged travel of a neural impulse within the nervous system due to elongated axons.

The obtained data concerning choice reaction time allow for the conclusion that this parameter showed a high, above-average level. Furthermore, the results obtained by the goalkeepers indicate a clear drop in the parameters compared to simple reaction time. The prolonged mean reaction time is, in fact, a normal occurrence related to the need to analyse a stimulus. Standard deviation of this parameter indicates that some goalkeepers analyse the situation quickly, while others do it more slowly, which may depend on psychological traits, the efficiency of the central nervous system and many other variables that affect reaction time. Thus, considerable differences between different study participants were revealed. Mean motor time is shorter compared to simple reaction time. This may result from the testing procedure, i.e. from the rest periods between movements. In the RT S3 test, the time between the stimuli that the participant has to react to is longer, which may indicate that handball goalkeepers need a longer time to concentrate and fully engage the processes related to focus and attention. Motor time distribution is close to the upper threshold of the norm (a T-Score of 58.50). Such a low level may have been caused by the players failing to hit the key on the keyboard during the test and opting out of the trial if they reacted late to the stimulus. This may also be considered a characteristic feature, as during a match, if the goalkeeper decides that he or she has no chance to cross the trajectory of the ball, he or she opts out of an intervention and accepts its futility.

The lack of statistically significant differences in the studied parameters between players of the EHF Champions League and the Polish PGNiG Superliga indicates that in addition to top-level psychomotor abilities, other variables are also important. These variables include technical and tactical skills, the defensive skills of the goalkeeper's team, physical preparation and volitional traits. In order to establish the differences between players in top-tier European cups and tournaments in Poland, the aforementioned parameters should be researched in detail.

The results pertaining to anticipation indicate that two of the studied parameters were within the norm, but close to its upper threshold. Anticipation is the subject of numerous scientific reports [10, 22, 23, 24, 25]. Research suggests

a correlation between sports level and results obtained in anticipation tests. Players with a high sports level display better results [22] than those with a low sports level. This study correlates with the results obtained by other authors who indicate that goalkeepers better anticipate the place than the time at which an object is going to appear [10]. This may stem from the nature of play as a goalkeeper. Goalkeepers are frequently forced to anticipate the target of a throw, especially for throws made from a short distance. Such a situation may, over many years of training, affect the development of object anticipation. Research on the quality of intervention also indicates that a high percentage of interventions are preceded by the anticipation of the opponent's actions [17, 18, 19]. The prevalence of premature reactions in the ZBA test may also indicate that goalkeepers rely to a significant extent on anticipating the actions of throwers. The differences in time anticipation between Champions League and the PGNiG Superliga goalkeepers suggest that top-level goalkeepers wait until the last second before interfering, which makes them more effective. Consequently, Champions League goalkeepers may wait before interfering and intervene a pace after waiting, which may translate into a higher effectiveness of intervention. By interfering earlier, PGNiG Superliga goalkeepers give the thrower an opportunity to change the target of the throw, which may translate into a lower effectiveness of intervention.

CONCLUSIONS

1. Statistically significant differences were found between the earlier and later predictions of the appearance of an object in the ZBA test between the goalkeepers playing in the EHF Champion League and the Polish PGNIG Superliga.

2. The goalkeepers anticipated the place at which an object was going to appear than the time at which it was going to appear.

3. The obtained results indicate very high requirements in terms of reaction time, motor time and spatial anticipation among handball goalkeepers. Specialist goalkeeper training should develop these abilities from the very early stages, and recruiters should look for persons with a high level of these abilities, especially in the context of a high sports level.

4. Selection for the position of the goalkeeper should involve psychomotor tests (simple reaction time, choice reaction time and spatial anticipation).

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