Characteristics of the Level of Psychomotor Abilities of Female Handball Players

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Research Article

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RESEARCH

Characteristics of the level of psychomotor abilities of female handball players

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Abstract

Background: The study presents an analysis of selected psychomotor abilities of female handball players at different levels of experience.

Methods: Studies were performed using Test2Drive computer tests. The following four tests were used to measure psychomotor fitness: Simple Reaction Time, Choice Reaction Time, Hand-Eye Coordination and Spatial Anticipation. The study covered a group of 118 female handball players (age: 19.6 $\pm$ 3.16), who play in the PGNiG Polish Women's Superliga, Polish 1st and 2nd handball league, for the following positions: goalkeepers, centre players, pivot players and wing players. The study also included the body composition analysis and the aerobic capacity level with the use of the multistage 20 metre shuttle run test. In addition, the level of psychomotor abilities of female handball players has been analysed depending on their competition class (league), position on the court and dominant hand.

Results: The analysis of the reaction time and movement time showed statistically significant differences between the results (SIRT MT, CHORT RT, HECOR MT) obtained by the female handball players from different competition classes. Additionally, on the basis of the linear Pearson correlation were determined statistically significant relationship between psychomotor abilities and elements of body composition or the aerobic capacity level.

Conclusions: The analysis showed that the female players from Polish Women's Superliga had the highest level of reaction time (SIRT, CHORT and SPANT tests). The study also revealed a significant impact of the body mass index and the percentage of fat content on the movement time (SIRT, CHORT and SPANT tests). The aerobic capacity level (measured in the multistage 20 metre shuttle run test) had a significant influence on the reaction time.

Keywords: psychomotor abilities; female handball player; reaction time; movement time

Background

Handball is one of the most popular Olympic team games in the world [1, 2]. Nowadays handball is played by more than 19 million people and for the first time has been at the Olympic Games since 1972 for men [3]. Whether Women's Handball Teams went for the first time at the Olympic Games in 1976 [4]. Over the past few years, this discipline has seen a significant increase in the speed of male and female handball players. The possibility to quickly resume the game after a goal from opponent introduced in 2000 [5] or tactical changes consisting in combining a position attack with a quick attack [6, 7] influenced a more dynamic game play.

Being one of the fastest team sports games, handball is characterised by high intensity of game, during which players use sprint, direction change with or without the ball, interact with the opponent, and make different decisions in both offensive and defensive actions [8, 9, 10, 11, 12].

The high level of coordination capacities in today's sport is one of the important factors conditioning the achievement of sports mastery [13]. The results achieved in today's handball may depend on a number of factors. The literature includes studies on the motor abilities used by players in each match. These included the importance of explosive force, power, speed and agility of players [14, 12, 15, 16, 17].

The specificity of each player position on the court can also be crucial to sporting achievement [18]. Female players on pivot position are characterised by a high level of divisibility of attention, centre players by spatial orientation and divisibility of attention, while wing players by complex reaction time, frequency of movement and simple reaction time [19].

According to the authors, the psychomotor abilities of the players may also be crucial to the effectiveness of the game. In studies of this scope, the response time of the players was referred to the results [20, 21] or various aspects of the game [22, 23, 24, 25, 26, 27, 28, 17], for example. The impact of the speed and response time on the final outcome of the match was addressed by Rata [22], Cicma [23] and Marković [24]. Ohnjec et al. [25], while examining response times, timing and decision-making, combined them with the effectiveness of the rapid attack and the counterattack in handball. Curiţianu et al. by analysing matches of F.C. Barcelona examined the impact of reaction time and adequate systems of defence on the number of effective rapid attacks [20]. Another study from this scope [21], identified the impact of the ability to anticipate and reduce response times during goalkeeping interventions on the level of effectiveness of professional goalkeepers.

Player reaction time was also related to positions on the court [26, 27], seniority and experience [28], [29], as well as competition class (leagues) and the already mentioned motor abilities [17].

In this context, in order to increase knowledge about the importance and role of psychomotor abilities in female handball, the authors performed an assessment of the selected psychomotor abilities of female handball players.

Methods

Characteristics of the Study Group

The aim of this paper was an assessment of the selected psychomotor abilities of female handball players focusing on competition class (league), position on the court and the dominant hand, as well as selected components of body mass composition, body build types and aerobic capacity. The study covered a group of 118 female players at different fitness levels (age: 19.6 ± 3.16, training seniority: 7.69 ± 2.43). The study was performed on 17 female players from the Polish Women's Superliga, 63 from the 1st league and 38 from the 2nd league. Female players playing on the following positions were taken into account in the study group: goalkeeper GK (20 players), centre player CP (52 players), pivot player PP (14 players) and wing player WP (32 players). In addition, the measurement of height and mass and body composition (Bio-electrical Impedance Analysis) was performed. The aerobic

capacity was measured with the use of the multistage 20 metre shuttle run test. [30, 31]. The characteristics of the test group are presented in Table 1.

Table 1 Sample characteristics

	Total N=118	Super league N=17	I league N=63	II league N=38	p	e.s.
Age$^{\diamond}$	19.60±3.16	17.24±1.25	20.83±3.39	18.63±2.35	0.001*	0.21
Body weight (kg)$^{\diamond}$	65.79±8.03	67.45±5.78	67.47±7.09	62.27±9.29	0.001*	0.13
Height (cm)$^{\diamond}$	170.84±6.23	173.00±6.76	172.29±6.25	167.47±4.49	0.001*	0.15
BMI$^{\diamond}$	22.46±2.38	22.56±1.80	22.62±2.18	22.16±2.90	0.213	0.03
FAT (%)$^{\diamond}$	26.66±5.31	27.65±4.39	27.56±4.95	24.75±5.85	0.018*	0.07
FFM (kg)$^{\diamond}$	47.72±3.94	48.65±3.31	48.21±3.38	46.48±4.78	0.005*	0.09
TBW (kg)$^{\diamond}$	34.57±2.93	35.19±2.29	34.84±2.55	33.86±3.63	0.025*	0.06
Distance (m)$^{\diamond}$	1695±317	1999±393	1744±248	1477±229	0.001*	0.28
Position†						
CP	52 (44.07)	8 (47.06)	32 (50.79)	12 (31.58)		
GK	20 (16.95)	3 (17.65)	9 (14.29)	8 (21.05)	0.818	0.16
PP	14 (11.86)	1 (5.88)	8 (12.70)	5 (13.16)		
WP	32 (27.12)	5 (29.41)	14 (22.22)	13 (34.21)		
Hand†						
Left	14 (11.86)	5 (29.41)	5 (7.94)	4 (10.53)	0.131	0.19
Right	104 (88.14)	12 (70.59)	58 (92.06)	34 (89.47)		

Data are expressed as: ⋄ mean±standard deviation; † n (%),
* statistical significance, e.s. – effect size.

Measurement of Psychomotor Abilities

Test2Drive system (ALTA, Siemianowice Slaskie, Poland) as a psychometric computer tests were the study method (Figure 1). The various studies were subjected by Test2Drive system. The review and characteristics of the conducted tests confirming the theoretical validity of the tests used in the system are described in the work of Tarnowski et al. [32]. The system fulfills all requirements of Regulation of the Minister of Health. Test2Drive system of the chosen four tests were used to measure the indicators of psychomotor abilities such as: simple reaction time test (SIRT). choice reaction time test (CHORT), hand-eye coordination test (HECOR) and spatial anticipation test (SPANT). The reaction times (RT) and movement times (MT) were the main indicators in all tests, while the percentage of correct responses was added and analysed in the CHORT and SPANT tests.

Figure 1 [Near here]

Figures

[h!]

Figure 1 Reaction panel of the Test2Drive system; (**a**) SIRT, (**b**) CHORT, (**c**) HECOR, (**d**) SPANT.

Each of the four tests were performed in a standing position facilitating access to the screen area. The screen was in a horizontal position during all four tests. Each study participant received detailed instructions at the beginning of each of the tests. Following the instructions, the exercise stage took place during which the study participants could learn the protocol of stimuli presentation and giving

responses. The exercise stage was followed by the proper testing stage. The study participants had to react as quickly as possible to the stimuli in all tests. The study consisted of the following tests:

- SIRT— reaction speed evaluation and its stability. The stimuli signalling field changed colours in the right moment of research time. The reaction to the stimuli involved moving the finger from the START field to the reaction time field marked in blue.
- CHORT—speed and adequacy of reaction in a complex situation evaluation. Horizontal (stimuli) benchmarks and vertical stimuli which require a reaction, and a slant benchmark (neutral stimuli) that does not require reaction were displayed in the top signalling row. The response to the stimuli involved moving one's finger from the START field to one of the two reaction fields (vertical or horizontal stimulus field). During the neutral stimulus, the finger was kept on the START field.
- HECOR—eye–hand coordination evaluation. The test required careful observation of the board and a quick reaction to the displayed red signalling field. The test participant was supposed to move his finger from the START field to the blue reaction field and return the finger to the START field.
- SPANT—eye-hand coordination evaluation using complex spatial information. On the top, left and right of the test board there were signalling fields two of which (on in the row and one in a column) turned red simultaneously. In response to the stimulus the test participant was supposed to indicate with his finger the field on the crossing of the lit row and column, and put the finger back to the START field.

In all performed tests the stimuli exposure time lasted 3 seconds. While the stimulation intervals lasted from 1 second, 1.5 seconds, till 2 seconds. Each of the test lasted 3 minutes. RT and MT were measured for each test, while in CHORT and SPANT test were also determined the % of correct responses. In SIRT, HECOR and SPANT tests 20 amounts of stimuli were used, while in CHORT 24 cases.

Statistical Methods

Basic statistical measures i.e., arithmetic mean, standard deviation and the size of individual groups were used in the study. For the analyzed dependent variables, the normality of the distribution was examined (The Shapiro-Wilk test). Due to the lack of a normal distribution of some variables, non-parametric tests were used in further analyzes. In order to identify the significance of differences between the groups the Kruskal-Wallis and U Mann-Whitney test was used. The effect size was calculated using formulas [33]:

- for Kruskal-Wallis – $E_R^2 = \dfrac{H(N+1)}{(N^2-1)}$,
- for U Mann-Whitney test – $r = \dfrac{Z}{\sqrt{N}}$,
- for chi-squared test – $\phi = \sqrt{\dfrac{x^2}{N}}$

where: H—the Kruskal-Wallis H-test statistic, N—the total number of observations, E_R^2—epsilon-squared coefficient assumes the value from 0 to 1.00, Z—standardized value for the U-value, r—correlation coefficient where r assumes the value ranging from -1.00 to 1.00. The analysis was performed with the GNU R software [34].

Results

Table 2 shows the results of individual psychomotor abilities of handball female players depending on their fitness level. The analysis showed that Superliga female handball players had the lowest scores and thus the highest RT, SIRT, CHORT and SPANT levels compared to 1st and 2nd leagues female players. In addition, in the case of CHORT and SPANT, this group of subjects was characterized by the highest percentage of correct answers (CHORT - 95.29%; SPANT - 91.76%). In the case of MT, the situation was different. In this group of subjects (Superliga), the highest results were recorded in MT SIRT (216.29 ms), MT CHORT (234 ms), MT HECOR (259.71 ms) and MT SPANT (277.18 ms). It should also be noted that the highest RT values in individual psychomotor tests were recorded in the group of women with the lowest fitness level – 2nd league (RT SIRT – 352.79 ms; RT CHORT – 698.71 ms; RT HECOR – 414.61 ms; RT SPANT – 642.82 ms). In addition, a statistical relationship between the fitness level of players and the psychomotor test results was noted for MT SIRT and HECOR and RT CHORT.

Table 2 Characteristics of psychomotor abilities of female handball players

Variable	Total (N=118)	Super league (N=17)	1st league (N=63)	2nd league (N=38)	p	E_R^2
Simple Reaction Time Test (SIRT)						
RT [ms]	347.22±36.26	333.88±26.24	347.46±37.34	352.79±37.54	0.268	0.02
MT [ms]	198.44±36.95	216.29±32.71	201.54±37.4	185.32±34.23	0.017*	0.07
Choice Reaction Time Test (CHORT)						
RT [ms]	676.58±65.63	650.82±45.07	670.17±70.85	698.71±58.77	0.014*	0.07
MT [ms]	217.41±40.96	234±34.6	218.94±43.06	207.45±38.05	0.092	0.04
C.R. [%]	93.89±6.12	95.29±3.24	92.95±7.27	94.82±4.71	0.419	0.01
Hand-Eye Coordination Test (HECOR)						
RT [ms]	408.78±45.52	406.29±73.67	405.94±39.08	414.61±39.95	0.245	0.02
MT [ms]	240.5±36.39	259.71±27.95	241.73±39.15	229.87±31.52	0.017*	0.07
Spatial Anticipation Test (SPANT)						
RT [ms]	617.65±102.6	603.82±79.52	606.21±103.69	642.82±107.58	0.265	0.02
MT [ms]	266.63±62.77	277.18±46.7	264.68±60.29	265.13±73.26	0.552	0.01
C.R. [%]	90.34±9.1	91.76±7.28	90.87±9	88.82±9.96	0.487	0.01

RT—reaction time, MT—movement time , C.R.—correct responses
p—probability of testing, E_R^2—effect size, *—statistical significance.

In the next step, the correlations between the various variables (Age, Height (cm), Body weight (kg), BMI, FAT%, FFM (kg), TBW (kg), Distance) and psychomotor test results were analysed according to the fitness level of the female players (Table 3). No relevant dependencies were shown for age and height variables in any of the study groups. This was observed in the case of SIRT, CHORT and HECOR. Only during the last attempt to anticipate the analysis showed a significantly negative age correlation with MT SPANT (total and 2nd league). In addition, it is noted that body weight, BMI and FAT% were significantly positively correlated with MT SIRT, CHORT and SPANT. It should be added that this phenomenon was observed for the entire population under study, as well as for the 2nd league (MT CHORT and SPANT). The performed studies also showed a significant link between distance and RT CHORT (total and Superliga), RT HECOR (1st league), RT SPANT (total) and MT SPANT (2nd league). In each of these cases, the correlation took a negative direction.

Table 3 Correlations between the selected of body composition and distance variables and psychomotor test results

VARIABLE	Group	SIRT RT	SIRT MT	CHORT RT	CHORT MT	HECOR RT	HECOR MT	SPANT RT	SPANT MT
Age	Total	ns	ns	ns	ns	ns	ns	ns	-0.20
	II	ns	ns	ns	ns	ns	ns	ns	-0.33
Height (cm)	Total	ns	ns	ns	ns	ns	ns	ns	ns
Body weight (kg)	Total	ns	0.26	ns	0.24	ns	ns	ns	0.22
	I	ns	ns	ns	ns	0.25	ns	ns	ns
	II	ns	0.33	ns	0.37	ns	ns	ns	0.34
BMI	Total	ns	0.20	ns	0.31	ns	ns	ns	0.24
	I	ns	ns	0.25	0.26	ns	ns	ns	ns
	II	ns	ns	ns	0.40	ns	ns	ns	0.37
FAT (%)	Total	ns	0.22	ns	0.24	ns	ns	ns	0.22
	II	ns	ns	ns	ns	ns	ns	ns	0.35
FFM (kg)	Total	ns	0.19	ns	ns	ns	ns	ns	ns
	I	ns	ns	ns	ns	0.35	ns	ns	ns
	II	ns	0.36	ns	0.36	ns	ns	ns	ns
TBW (kg)	Total	ns	0.18	ns	ns	ns	ns	ns	ns
	I	ns	ns	ns	ns	0.35	ns	ns	ns
	II	ns	0.35	ns	0.39	ns	ns	ns	ns
Distance (m)	Total	ns	ns	-0.32	ns	ns	ns	-0.22	ns
	Super	ns	ns	-0.72	ns	ns	ns	ns	ns
	I	ns	ns	ns	ns	-0.28	ns	ns	ns
	II	ns	ns	ns	ns	ns	ns	ns	-0.37

RT—reaction time, MT—movement time, ns—not significant
Total—all female handball players , Super—Super league, I—1st league, II—2nd league

Table 4 presents the performance of the player's response times, depending on the position of the player on the court. The study showed that the central player (CP) scored the lowest RT values in each psychomotor test compared to GK, PP, WP. In addition, it is noted that the highest RT SIRT values were recorded among WP (353.25 ms), and the highest RT CHORT and RT HECOR values were obtained by GK (RT CHORT – 703.95 ms; RT HECOR – 419.80 ms). However, in the case of RT SPANT the worst results were observed for PP (640.86 ms). At the same time, it is concluded that the results did not show any statistical significance.

Table 4 Basic statistics of psychomotor abilities of handball players - Position

	CP (N=52)	GK (N=20)	PP (N=14)	WP (N=32)	p	E_R^2
SIRT						
RT [ms]	339.08±35.38	354.65±32.61	353.07±39.01	353.25±37.57	0.176	0.04
MT [ms]	200.29±34.49	207.45±37.45	200.29±34.41	189±41.1	0.272	0.03
CHORT						
RT [ms]	667.06±62.23	703.95±67.51	673±67.63	676.5±67.33	0.155	0.04
MT [ms]	219.79±40.03	228.4±43.12	219.36±44.69	205.81±38.61	0.264	0.03
C.R. [%]	94.67±5.68	91.9±7.46	96±3.84	92.94±6.44	0.117	0.05
HECOR						
RT [ms]	406.23±49.84	419.8±35.1	407.14±39.71	406.75±47.16	0.408	0.02
MT [ms]	242.42±36.42	245.35±33.82	243.14±38.27	233.19±37.7	0.653	0.01
SPANT						
RT [ms]	604.94±103.53	622.1±96.9	640.86±108.22	625.38±104.1	0.594	0.02
MT [ms]	265.58±64.53	263±60.97	282.93±67.52	263.47±60.75	0.857	0.01
C.R. [%]	91.15±8.2	90±10	86.79±12.34	90.78±8.34	0.706	0.01

RT—reaction time, MT—movement time , c.r.—correct responses
p—probability of testing, E_R^2—effect size, *—statistical significance.

Table 5 Basic statistics of psychomotor abilities of female handball players - hand

	Left (N=14)	Right (N=104)	p	r
SIRT				
RT [ms]	342.36±26.86	347.88±37.40	0.829	-0.02
MT [ms]	202.36±59.81	197.91±33.12	0.777	0.03
CHORT				
RT [ms]	679.43±60.28	676.19±66.58	0.924	0.01
MT [ms]	217.14±52.66	217.44±39.44	0.825	0.02
C.R. [%]	96.21±4.51	93.58±6.26	0.059	0.17
HECOR				
RT [ms]	415.79±33.74	407.84±46.94	0.324	0.09
MT [ms]	248.71±52.03	239.39±33.95	0.234	0.11
SPANT				
RT [ms]	614.21±74.67	618.12±106.07	0.954	-0.01
MT [ms]	273.21±76.56	265.74±61.07	0.662	0.04
C.R. [%]	90.00±7.60	90.38±9.31	0.614	-0.05

RT—reaction time, MT—movement time , c.r.—correct responses
p—probability of testing, r—effect size, *—statistical significance.

There were no statistically significant differences in the relationship between the dominant hand and psychomotor abilities (Table 5). The analysis shows that lower values of RT SIRT (342.36 ms) and RT SPANT (614.21 ms) were observed for left-handed female players in comparison with right-handed female players (RT SIRT – 347.88 ms and RT SPANT – 618.12 ms). In the remaining tests, RT CHORT and HECOR, the right-handed test showed a slight dominance.

Discussion

The aim of the study was to assess the selected psychomotor abilities (simple reaction time, choice reaction time, eye-hand coordination and anticipation) depending on the league, position on the court, dominant hand and selected body composition parameters among the female handball players. The research clearly shows that the highest level of psychomotor abilities characterised female handball players from PGNiG Polish Women's Superliga (except for HECOR). This conclusion is confirmed by studies carried out on a group of men who also were professional handball players [35]. The results of this study correspond to the results of research for different sport disciplines. Similar dependencies were also found in the environment of fencers [36, 37]. Also among football players with a high fitness level, the reaction time after a 12-minute run was much shorter than for players with a low fitness level [29].The results of the studies conducted by Kida et al. [38] indicate that, among the players (baseball players, tennis players, non-athletes), the response time with a higher fitness level was lower than for the players with a lower level of fitness. Studies on the impact of significant physical effort on choice reaction time may confirm these relationships [39]. The authors concluded that the choice reaction time improves together with the increase in energy expenditure (related to physical effort). This study also revealed a statistically significant relationship between the fitness level of handball players and the CHORT. Apart from the fitness level of female players, the position of the player on the court is an important factor influencing the reaction time. In the studies of Przednowek et al. [35] it has been observed that for the results of the SIRT, CHORT, HECOR and SPANT tests, central players were

at lower levels compared to goalkeepers, wing and pivot players. It should be noted that these studies were carried out on a group of men. However, this phenomenon has been observed in these studies performed on a group of women. The obtained results were not found to be statistically significant, though. Similarly, Polluveer observed this phenomenon among female volleyball players [40]. The results of simple and complex reaction time and anticipation time did not differ significantly between players on different positions on the court.

The aim of the study was also to observe the differences between particular psychomotor abilities and handedness of female handball players. There were no statistically significant differences observed in this respect. Left-handed female handball players in comparison to right-handed players recorded similar results in all tests. The results of the study are partly reflected in the study by Al et al. [41]. The authors observed that there were no significant differences between right- and left-handed female handball players in the case of eye-hand coordination test. In contrast, left-handed female handball players, compared to right-handed ones, were characterized by lower simple reaction time results. It should be noted, however, that the tests they used were based on auditory stimuli, not visual ones. A comparison of visual and auditory reaction time was carried out by Shelton and Kumar [42]. The results of the studies clearly show that auditory reaction time is faster than visual reaction time.

There are few studies that examine the relationship between psychomotor capacities and body composition among athletes. Most of studies from this scope has been carried out on the group of young, adult or older non-athletic people [43, 44, 45, 46]. The results of the studies of Moradi and Esmaeilzadeh on a group of children do not indicate any significant relationship between clinical reaction time and individual obesity indicators, such as BMI and body fat [47, 46, 48]. A significant positive correlation between BMI and visual and auditory reaction times was observed in the study by Nikam and Gadkari [49]. This is confirmed by the studies by Skurvydas [43]. People with a higher BMI react significantly slower than others. Deore et al. has observed that the results of the auditory and visual reaction time is higher for people who are overweight compared to girls with normal body weight. In addition, a statistically significant relationship was recorded for visual reaction time [50]. This study has shown a positive correlation between the body mass index of female handball players and individual psychomotor tests. Namely, it was observed that those players with a higher body mass, a higher BMI or a FAT, FFM and TBW content have higher values of SIRT and CHORT, for example. Studies on a group of tennis players have shown that visual reaction time negatively correlates with BMI. However, it should be noted that the correlation of visual reaction time and BMI has been performed across the study population (tennis players and healthy controls) [51].Similar phenomena have been observed among runners [52]. Mohammad [53] has not confirmed this phenomenon. The results of studies performed on a group of male football players show that there is no relationship between body fat and reaction time.

This study has also shown that there is a significant correlation between aerobic strength and certain psychomotor abilities. In each of these cases, a negative relationship was recorded. It was observed that with increases in the distance travelled

during the multistage 20 metre shuttle run test, lower response time values were recorded. This phenomenon was noticed for CHORT and SPANT (total), CHORT (Super league), HECOR (1st league) and SPANT (2nd league). The results of the tests are confirmed in the study by Maghsoudipour et al. [54]. The reaction time and aerobic capacity were significantly correlated with the strength of female track and field athletes, It has been observed that the higher the aerobic capacity, the lower the values of individual tests.

Conclusions

The results of the analyzes allowed to formulate the following conclusions:

- Considering the fitness level of the female handball players' (competition class), the highest level of reaction time (RT) had female handball players from Superliga (SIRT, CHORT and SPANT tests) and the shortest movement times (MT) were observed among the female handball players with the lowest fitness level (II league).
- The assessment of psychomotor abilities according to the position on the court showed no statistically significant differences between the results obtained in the tests. Despite this fact, it was found that the highest level of reaction time (RT) had central players (CP).
- The lateralization of female handball players (dominant hand) do not significantly differentiate the results obtained in particular psychomotor tests.
- The analysis of the Person linear correlation between the elements of body mass composition and the results of the psychomotor tests showed a significant impact of the body mass index and the percentage of fat content on the movement time (SIRT, CHORT and SPANT) of the female handball players. In addition the aerobic capacity level (Distance) of female handball player's had a significant impact on the reaction time (CHORT and SPANT).
- The data of female handball players can be helpful for coaches to develope their handball training systems and make an appropriate selection of individual abilities of female players.

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Availability of data and materials
The data used to support the findings of this study are available from the corresponding author upon request.The data sets generated and analysed during the current study are available.

Ethics approval and consent to participate
The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the University of Rzeszow / Poland (resolution 10/02/2020). Before the study was initiated, the parents / legal guardians gave their informed consent to participate in the study of their children.

Competing interests
The authors report no conflicts of interest.

Consent for publication
All authors agree with publication of the manuscript.

Authors' contributions
M.S. - Writting manuscript, Conceptuaulization, Methodology; K.H.P - Writting manuscript, Data analysis; P. K. - Research investigation; B. D. - Writting manuscript, Data analysis; Ł. G. - Research investigation; K.W. - Review and editing; J. Z. - Review and editing; K. P. - Writting manuscript, Conceptuaulization, Data analysis, Methodology.

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References

1. Bilge, M.: Game analysis of olympic, world and european championships in men's handball. Journal of Human Kinetics **35**(1), 109–118 (2012)
2. Pueo, B., Jimenez-Olmedo, J.M., Penichet-Tomas, A., Becerra, M.O., Agullo, J.J.E.: Analysis of time-motion and heart rate in elite male and female beach handball. Journal of sports science & medicine **16**(4), 450 (2017)
3. Milanese, C., Piscitelli, F., Lampis, C., Zancanaro, C.: Effect of a competitive season on anthropometry and three-compartment body composition in female handball players. Biology of Sport **29**(3) (2012)
4. Saavedra, J.M.: Handball research: state of the art. Journal of human kinetics **63**(1), 5–8 (2018)
5. Karcher, C., Ahmaidi, S., Buchheit, M.: Effect of birth date on playing time during international handball competitions with respect to playing positions. Kinesiology **46**(1) (2014)
6. Wagner, H., Finkenzeller, T., Würth, S., Von Duvillard, S.P.: Individual and team performance in team-handball: A review. Journal of sports science & medicine **13**(4), 808 (2014)
7. Krawczyk, P., Bodasinski, S., Bodasinska, A., Slupczynski, B.: Level of psychomotor abilities in handball goalkeepers. Journal of Health and Physical Activity **10**, 64–71 (2018)
8. Gorostiaga, E.M., Granados, C., Ibañez, J., González-Badillo, J.J., Izquierdo, M.: Effects of an entire season on physical fitness changes in elite male handball players. Medicine and science in sports and exercise **38**(2), 357–366 (2006)
9. Meletakos, P., Bayios, I.: General trends in european men's handball: a longitudinal study. International Journal of Performance Analysis in Sport **10**(3), 221–228 (2010)
10. Ziv, G., Lidor, R.: Physical characteristics, physiological attributes, and on-court performances of handball players: A review. European Journal of Sport Science **9**(6), 375–386 (2009)
11. Krüger, K., Pilat, C., Ückert, K., Frech, T., Mooren, F.C.: Physical performance profile of handball players is related to playing position and playing class. The Journal of Strength & Conditioning Research **28**(1), 117–125 (2014)
12. Shahbazi, M., Rahimizadeh, M., Rajabi, M.R., Abdolmaleki, H.: Mental and physical characteristics in iranian men's handball national team, winner of silver medal in asian games-2010. Procedia-Social and Behavioral Sciences **30**, 2268–2271 (2011)
13. Jaworski, J.: Possibilities of applying in handsaw the author's suggestion of a set of computer tests for research of chosen coordination motor abilities – the description and methodological remarks. In: Żak, S., Spieszny, M. (eds.) The Analysis of Training Process and Competition in Sport Games (handball), pp. 59–65. Międzynarodowe Towarzystwo Naukowe Gier Sportowych, Wrocław (2009). Chap. 7
14. Jensen, J., Jacobsen, S., Hetland, S., Tveit, P.: Effect of combined endurance, strength and sprint training on maximal oxygen uptake, isometric strength and sprint performance in female elite handball players during a season. International journal of sports medicine **18**(05), 354–358 (1997)
15. Srhoj, V., Rogulj, N., Zagorac, N., Katić, R.: A new model of selection in women's handball. Collegium antropologicum **30**(3), 601–605 (2006)
16. Čavala, M., Rogulj, N., Srhoj, V., Srhoj, L., Katić, R.: Biomotor structures in elite female handball players according to performance. Collegium antropologicum **32**(1), 231–239 (2008)
17. Waghmare, A.R., Bondade, A.K., Surdi, A.D.: Study of flexibility, agility and reaction time in handball players. Indian Medical Gazette **145**(1), 23–31 (2012)
18. Manchado, C., Tortosa Martínez, J., Pueo, B., Cortell Tormo, J.M., Vila, H., Ferragut, C., Sánchez Sánchez, F., Busquier, S., Amat, S., Chirosa Ríos, L.J.: High-performance handball player's time-motion analysis by playing positions. International Journal of Environmental Research and Public Health **17**(18), 6768 (2020)
19. Spieszny, M.: W poszukiwaniu czynników determinujących efektywność szkolenia młodych piłkarek i piłkarzy ręcznych. In: Sozański, H., K. Perkowski, D. (eds.) Efektywność Systemów Szkolenia W Różnych Dyscyplinach Sportu : Międzynarodowa Konferencja naukowo-metodyczna, pp. 119–122. AWF Warszawa Zakład Teorii Sportu, Warszawa (2000). Chap. 9
20. Curițianu, I., Neamțu, M.: A comparative study on the evolution of left wings, right wings and pivots at male handball teams hcm constanta and fc barcelona in "champions league" 2011-2012. Procedia-Social and Behavioral Sciences **116**, 3859–3863 (2014)
21. Bideau, B., Multon, F., Kulpa, R., Fradet, L., Arnaldi, B., Delamarche, P.: Using virtual reality to analyze links between handball thrower kinematics and goalkeeper's reactions. Neuroscience letters **372**(1-2), 119–122 (2004)
22. Rață, G.: Didactica Educației Fizice Și sportului. Pim, Romania (2008)
23. Cicma, I.T.: The increase of the development indices of the reaction speed, using specific means of the handball game (viith grade). Ovidius University Annals, Series Physical Education and Sport/Science, Movement and Health **16**(2 SI), 343–349 (2016)
24. Marković, S., Valdevit, Z., Bon, M., Pavlović, L., Ivanović, J., Dopsaj, M.: Differences in visual reaction characteristics in national level cadet and junior female handball players. Facta Universitatis, Series: Physical Education and Sport, 069–078 (2019)
25. Ohnjec, K., Vuleta, D., Milanović, D., Gruić, I.: Performance indicators of teams at the 2003 world handball championship for women in croatia. Kinesiology **40**(1) (2008)
26. Marković, S., Valdevit, Z., Bon, M., Pavlović, L., Ivanović, J., Dopsaj, M.: Differences in visual reaction characteristics in national level cadet and junior female handball players. Facta Universitatis, Series: Physical Education and Sport, 069–078 (2019)

27. Weber, J., Wegner, M.: Constitutional demands for different playing positions in female team handball. Sportwissenschaft **46**(4), 305–314 (2016)
28. Kajtna, T., Vuleta, D., Pori, M., Justin, I., Pori, P.: Psychological characteristics of slovene handball goalkeepers. Kinesiology: International journal of fundamental and applied kinesiology **44**(2), 209–217 (2012)
29. Junge, A., Dvorak, J., Rosch, D., Graf-Baumann, T., Chomiak, J., Peterson, L.: Psychological and sport-specific characteristics of football players. The American Journal of Sports Medicine **28**(5_suppl), 22–28 (2000)
30. Leger, L.A., Mercier, D., Gadoury, C., Lambert, J.: The multistage 20 metre shuttle run test for aerobic fitness. Journal of sports sciences **6**(2), 93–101 (1988)
31. Stickland, M.K., Petersen, S.R., Bouffard, M.: Prediction of maximal aerobic power from the 20-m multi-stage shuttle run test. Canadian Journal of Applied Physiology **28**(2), 272–282 (2003)
32. Tarnowski, A.: TEST2DRIVE: Podręcznik Użytkownika. ALTA, Katowice (2016)
33. Tomczak, M., Tomczak, E.: The need to report effect size estimates revisited. an overview of some recommended measures of effect size. Trends in Sport Sciences **21**(1) (2014)
34. R Core Team: R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria (2020). R Foundation for Statistical Computing. https://www.R-project.org/
35. Przednowek, K., Śliż, M., Lenik, J., Dziadek, B., Cieszkowski, S., Lenik, P., Kopeć, D., Wardak, K., Przednowek, K.H.: Psychomotor abilities of professional handball players. International journal of environmental research and public health **16**(11), 1909 (2019)
36. Williams, L., Walmsley, A.: Response amendment in fencing: differences between elite and novice subjects. Perceptual and Motor Skills **91**(1), 131–142 (2000)
37. Gutierrez-Davila, M., Rojas, F.J., Antonio, R., Navarro, E.: Response timing in the lunge and target change in elite versus medium-level fencers. European Journal of Sport Science **13**(4), 364–371 (2013)
38. Kida, N., Oda, S., Matsumura, M.: Intensive baseball practice improves the go/nogo reaction time, but not the simple reaction time. Cognitive brain research **22**(2), 257–264 (2005)
39. Delignières, D., Brisswalter, J., Legros, P.: Influence of physical exercise on choice reaction time in sports experts: the mediating role of resource allocation. Journal of Human Movement Studies **27**(4), 173–188 (1994)
40. Põlluveer, K., Stamm, R., Stamm, M.: Anthropometric and psychophysiological characteristics of top female volleyballers in relation to the players' position on the court. Papers on Anthropology **21**, 232–245 (2012)
41. Al Awamleh, A.A., Mansi, T., Alkhaldi, H.: Handedness differences in eye-hand coordination and, choices, simple reaction time of international handball players. Journal of Physical Education and Sport **13**(1), 78 (2013)
42. Jose, S., Gideon Praveen, K.: Comparison between auditory and visual simple reaction times. Neuroscience & Medicine **2010** (2010)
43. Skurvydas, A., Gutnik, B., Zuoza, A., Nash, D., Zuoziene, I., Mickeviciene, D.: Relationship between simple reaction time and body mass index. Homo **60**(1), 77–85 (2009)
44. Gunstad, J., Paul, R., Cohen, R., Tate, D., Gordon, E.: Obesity is associated with memory deficits in young and middle-aged adults. Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity **11**(1), 15–19 (2006)
45. Nene, A.S., Pazare, P.A., Sharma, K.D.: A study of relation between body mass index and simple reaction time in healthy young females. Indian J Physiol Pharmacol **55**(3), 288–91 (2011)
46. Moradi, A., Esmaeilzadeh, S.: Simple reaction time and obesity in children: whether there is a relationship? Environmental Health and Preventive Medicine **22**(1), 1–6 (2017)
47. Moradi, A., Esmaeilzadeh, S.: Association between reaction time, speed and agility in schoolboys. Sport Sciences for Health **11**(3), 251–256 (2015)
48. Esmaeilzadeh, S.: Reaction time: does it relate to weight status in children? Homo **65**(2), 171–178 (2014)
49. Nikam, L.H., Gadkari, J.V.: Effect of age, gender and body mass index on visual and auditory reaction times in indian population. Indian J Physiol Pharmacol **56**(1), 94–99 (2012)
50. Deore, D.N., Surwase, S.P., Masroor, S., Khan, S.T., Kathore, V.: A cross sectional study on the relationship between the body mass index (bmi) and the audiovisual reaction time (art). Journal of clinical and diagnostic research: JCDR **6**(9), 1466 (2012)
51. Bhabhor, M.K., Vidja, K., Bhanderi, P., Dodhia, S., Kathrotia, R., Joshi, V.: Short communication a comparative study of visual reaction time in table tennis players and healthy controls. Indian J Physiol Pharmacol **57**(4), 439–442 (2013)
52. Jyothi, S., Vernekar, S.S., Manishankar, S., Jayalakshmi, L., Vinothkumar, S., Rashmi, R.: Correlation of audio-visual reaction time with body mass index & skin fold thickness between runners and healthy controls. Indian J Physiol Pharmacol **60**(3), 239–246 (2016)
53. Mohammad, A., Tareq, A.: The relationship between body fat percentage with speed, agility and reaction time of male football players of bangladesh. International Journal of Science Culture and Sport **4**(4), 453–460 (2016)
54. Maghsoudipour, M., Shabani, H., Najafabadi, M.G., Bakhshi, E., Coh, P.: The relationship between emotional intelligence, reaction time, aerobic capacity and performance in female track and field athletes at the universities of tehran. Work **61**(2), 173–179 (2018)

Figures

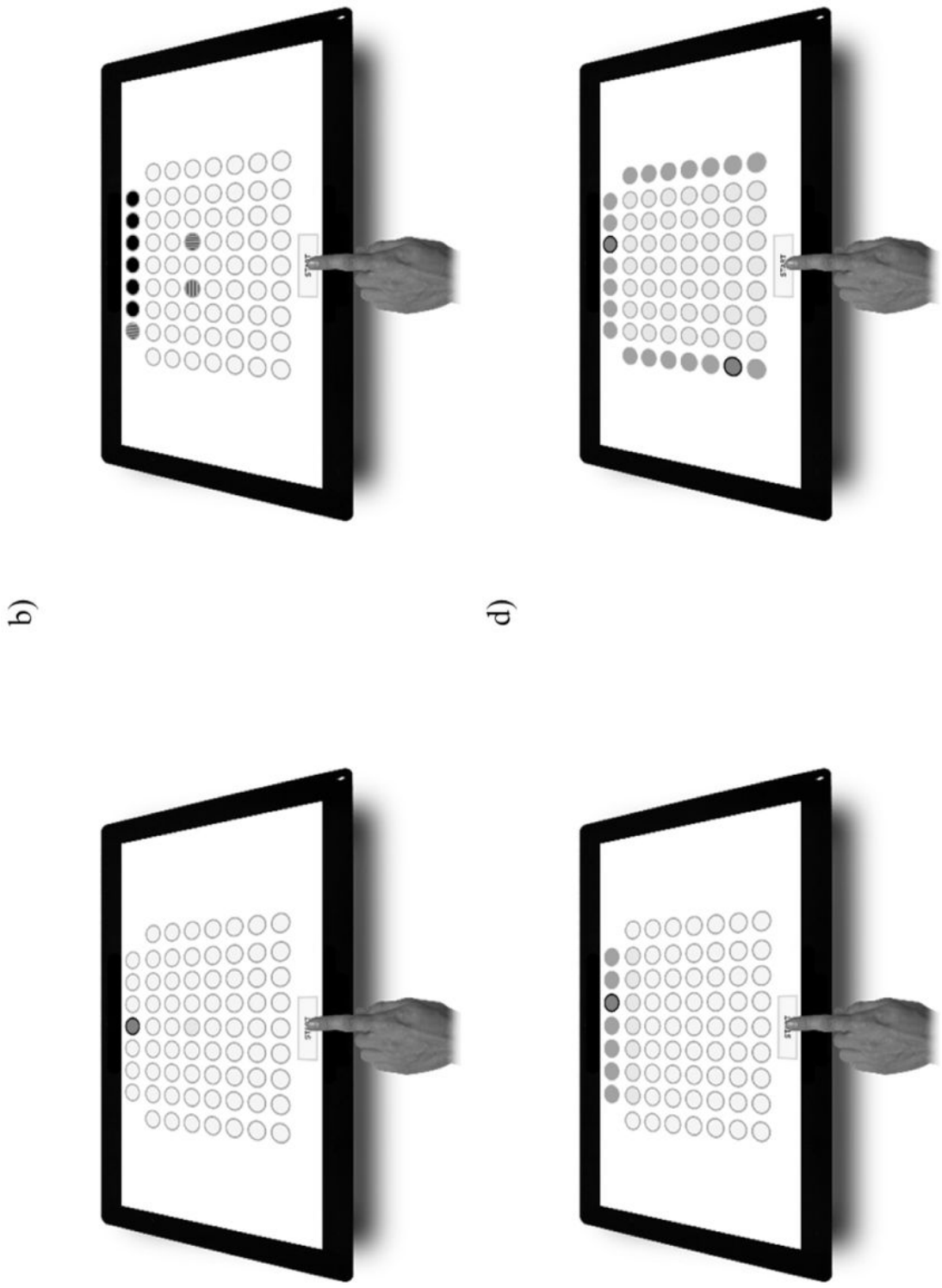

Figure 1

Reaction panel of the Test2Drive system; (a) SIRT, (b) CHORT, (c) HECOR, (d) SPANT.