

Relationship between body composition and cognitive abilities among young female handball players

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Abstract:

The paper analyzes selected psychomotor abilities of female players practicing handball in club SPR Handball Rzeszów. Handball is a discipline characterized by fast play and high intensity. This sport requires from the player a high level of coordination and conditioning skills, which often determine the effectiveness of the athlete during the match. The speed of reaction is one of the key factors, because it makes it easier to predict the opponent's movement, pass, grip or throw the ball. The study included a group of 24 female handball players from the Polish 1st Handball League. The group was divided into two age categories (junior and senior). The research method was psychomotor computer tests in the Test2Drive system. To measure the indicators of psychomotor ability, 6 tests were used, during which the parameters of reaction time, movement time, parameters determining eye-hand coordination and anticipation were evaluated. A significant statistical difference was observed between the groups for movement time in the PUT n test. The analysis of correlations in individual groups of athletes showed that the level of selected motor skills might be affected by some parameters of body composition. In particular, it concerned the relationship between the reaction time in the SPANT test and total body water (TBW), skeletal muscle mass (SMM), body mass and height, and the CHORT test and BMI. The movement time of the subjects was affected by such parameters as higher body fat mass (FAT) and BMI (in the SIRT test), a higher basal metabolic rate index (BMR), greater skeletal muscle mass and a higher TBW (in the PUT test).

Key Words: psychomotor abilities, reaction time, movement time, body composition, female handball players

Introduction

Handball is one of the most dynamic team sports games, characterized by high intensity during play (Ziv & Lidor, 2009a; Krüger et al., 2014). In handball, the ability to anticipate the opponent's movement, to observe the ball, to change the direction of the opposing team's players is crucial (Maman et al., 2012). These elements are essential to gain an advantage over the opponent (Kioumourtoglou et al., 1998). It is observed that players in team sports games have got shorter reaction times than athletes in other sports (Doğan, 2009; Erickson, 2007; Zwierko et al., 2010; Aksoy & Agaoglu, 2017). In basketball (Ziv & Lidor, 2009b) football (Maman et al., 2012) or handball (Przednowek et al., 2019; Śliż et al., 2022), the game is based on offensive and defensive actions using technical elements such as rebounds, dribbling, passes, shots and throws. Therefore, the ability to react quickly results in gaining an advantage over the opponent in both offensive and defensive actions (Przednowek et al., 2019). During a match, the player, despite a lot of physical effort, has to constantly assess the situation on the pitch and anticipate the opponent's movements (Wagner et al., 2014; Sporiš et al., 2010). Reaction speed and decision-making can be particularly important in this sport, enabling decisions to be made during offensive as well as defensive actions, e.g. throws, passes, grabs, spins, curtains and interceptions. When playing on the field, the player must demonstrate quick reaction on external stimuli and adapt to the situation on the field, e.g. when deciding to throw or pass. If a player's reaction is delayed, this makes it difficult to resolve offensive actions in their favor (Maman et al., 2012; Blecharz et al., 2022). The study of reaction time is not new in the literature, there are many publications about reaction time or movement time in team sports (Kida et al., 2005; Skurvydas et al., 2009; Mańkowska et al., 2015; Mohammad et al., 2016; Przednowek et al., 2019; Krawczyk et al., 2020; Paśko et al., 2021; Śliż et al., 2022; Krawczyk et al., 2022). Atan and Akyol (2014) made an analysis of reaction time among athletes playing different sports. The fastest reaction values were found in football players. On the other hand, Aldo et al. (2001) compared the level of quick reaction ability in football players and non-athletes. Significant differences were found in the level of quick reaction ability between football players and non-trainees. Nakamoto and Mori (2008) also observed similar patterns confirming that team game athletes, in this case basketball and baseball players showed faster reaction times than non-trainees. In addition, there are many scientific publications in the literature on the relationship between body components,

somatic features, and reaction time in team sports games at the different age and training levels (Nikolaidis et al., 2013; Masanovic, 2018; Masanovic, 2019; Farley, 2020; Ari, 2021; Turkeri et al. 2021)

The main aim of the study was to assess selected psychomotor abilities of female handball players at the different level of competition and training seniority divided into two age categories (junior and senior) in handball club SPR Handball Rzeszów during 2020/2021 season. The following parameters were assessed using computerized tests (Test2Drive): Simple Reaction Time (SIRT), Choice Reaction Time (CHORT), Hand-eye Coordination (HECOR), Spatial Anticipation (SPANT), Pop-up (PUT) and Perception Anticipation Movement (PAMT). In addition, it was also analyzed the correlation between psychomotor abilities and body composition, somatic features and training seniority in junior and senior group of female handball players.

Material & methods

Sample

The study covered 24 female handball players who have played in the SPR Handball Rzeszów team in the 2020/2021 sports season from the Polish 1st Handball League. The player's group were divided into two subgroups – players below 20 years old (juniors) and older players (seniors). For subgroups, body composition, height and selected psychomotor abilities were evaluated. The characteristics of the handball players, considering factors like age, training seniority, body height, body mass and body composition parameters, are presented in Table 1. The study was conducted at the University Athletics Centre of the Innovative Research in Sport in November 2021.

Table 1. Characteristic of participants

Variable	$\bar{x} \pm sd$	Total (n=24)		$\bar{x} \pm sd$	Junior (n=15)		$\bar{x} \pm sd$	Senior (n=9)	
		min	max		min	max		min	max
Age	19.71 ± 1.9	17.00	24.00	18.47 ± 0.64	17.00	19.00	21.78 ± 1.39	20.00	24.00
Body height (cm)	166.42 ± 4.5	159.00	174.50	167.03 ± 4.76	159.00	174.50	165.39 ± 4.08	160.50	171.00
Body mass (cm)	64.1 ± 9.75	53.00	89.40	66.99 ± 10.87	53.00	89.40	59.28 ± 4.96	53.60	66.70
TBW (L)	35.37 ± 3.34	31.50	41.20	35.73 ± 3.52	31.50	41.20	34.76 ± 3.1	31.50	39.60
FAT (kg)	16.19 ± 6.63	7.70	32.90	17.99 ± 7.41	7.70	32.90	13.20 ± 3.74	7.70	17.90
SMM (kg)	26.83 ± 2.71	23.70	31.40	27.09 ± 2.86	23.70	31.40	26.40 ± 2.56	23.70	30.50
BMI (kg/m ²)	23.52 ± 2.91	17.90	30.80	23.96 ± 3.38	17.90	30.80	22.78 ± 1.84	20.20	24.80
FAT (%)	24.31 ± 6.77	13.20	36.80	25.96 ± 7.24	13.20	36.80	21.56 ± 5.16	13.20	27.60
BMR (kcal)	1421.46 ± 102.64	1305	1590	1435.2 ± 110.11	1305	1590	1398.56 ± 90.15	1305	1544

$\bar{x}$ – mean value, sd – standard deviation, n – number of participants, TBW – Total body water, FAT – Body fat mass, SMM – Skeletal muscle mass, BMI – Body Mass Index, BMR – Basal

Metabolic Rate

Methods

Bioelectrical impedance analysis (BIA) was used to analyze body composition and somatic features using the InBody770. The body height was measured with a stadiometer (SECA 213 Hamburg, Germany) with an accuracy of up to 1 mm.

The research method consisted of psychomotor computer tests in the Test2Drive system. Six computer tests were performed to assess selected psychomotor abilities: Simple Reaction Time Test (SIRT), Choice Reaction Time Test (CHORT), Hand-eye Coordination Test (HECOR), Spatial Anticipation Test (SPANT), Pop-up Test (PUT) and Perception Anticipation Movement Test (PAMT). During the test, participant was in a standing position and the dominant hand carried out given commands displayed on a monitor screen. Before each test, the participant was given detailed information on how to perform the test. Initially, a practice phase was performed, during which the subject had time to become familiar with the task. Then, after familiarization with the test, the actual testing phase was carried out. The testing included the following tests:

- SIRT – The speed of the simple reaction. The test subject started by placing finger on the "START" box. The task was then to move finger as quickly as possible to the blue field, after seeing red signal at the top of the screen, which was broadcast at different intervals.
- CHORT - The test subject was assessed on the speed and appropriateness of the response in a complex situation. One of three bar patterns (stimuli) - horizontal, vertical and diagonal - was displayed at the

- top of the screen. The response consisted of moving finger from the 'START' box to one of two boxes - vertical or horizontal, depending on the signal displayed. If the pattern was diagonal, the test finger remained on the initial "START" field
- HECOR – The examinee is subject to an assessment of eye-hand coordination. The main goal of the test was to move the finger located on the "START" box to the blue field when the red impulse located in the top row is signaled, and then move the finger to the starting position.
 - SPANT – At the top and left side of the screen were arranged signal boxes, two of which - one in a row and one in a column - simultaneously changed color to indicate a signal. The test subject's task was to point to the intersection of the two signal boxes displayed at the time and then return to the starting box.
 - PUT – A test assessing the subject's perceptiveness and attention by identifying salient objects in the visual field. The screen initially displayed triangles (stimuli) of two colors, black and white, with only one triangle requiring a response. Click on the screen the triangle in black pointing vertically up or down. Such one triangle or none will appear on the screen. If it was not on the screen, the participant could touch the box with the word 'NONE' located in the bottom right corner of the screen and thus move on to the next board. Critical matrix (PUT k) - there is a figure to which we react. Neutral matrix (PUT n) - no figure with the indicated characteristics. Requires selection of the "NONE" button.
 - PAMT – A test to assess anticipatory skills. The respondent, using the index finger, has to touch a designated object in such a way that the object, when passing horizontally across the board, does not collide with other objects moving at different speeds (Tarnowski, 2016).

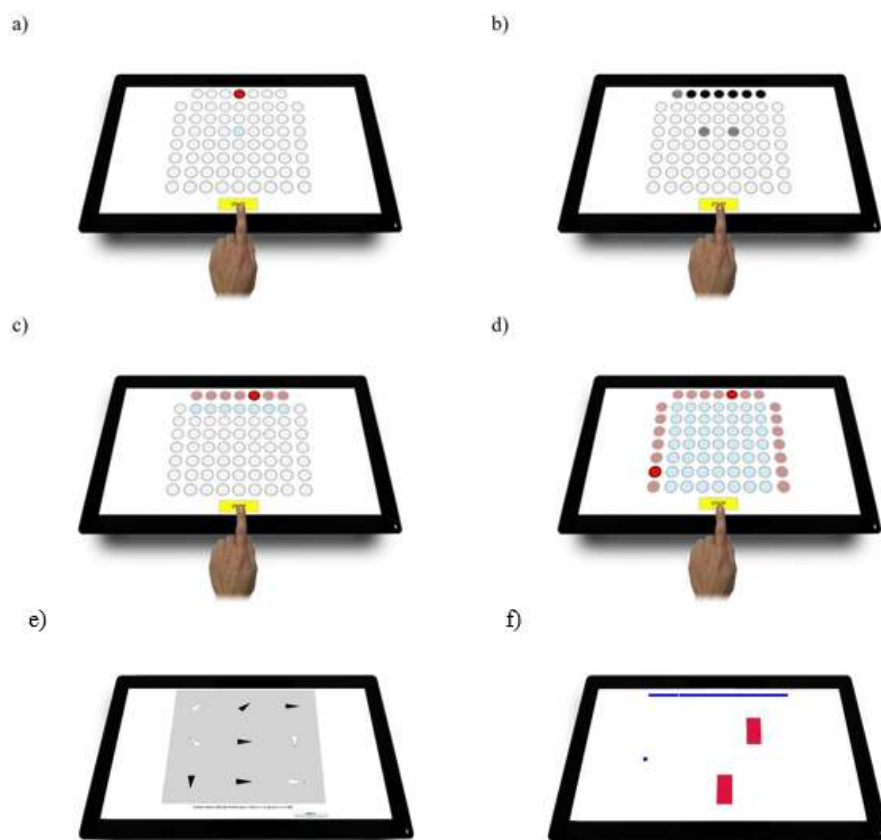


Figure 1. System panel of Test2drive (a) SIRT, (b) CHORT, (c) HECOR, (d) SPANT (e) PUT, (f) PAMT

Statistical Method

Basic statistical measures were calculated, including the arithmetic mean ($\bar{X}$), standard deviation (sd), abundance (n) and difference between groups (d). In addition, the normality of the distribution was assessed using the Shapiro-Wilk test. In the case of a normal distribution, the Student's t-test was used, while when the normal distribution deviated from the Gauss distribution, the U Mann-Whitney test was performed. In addition, analysis relationship between body composition, somatic features, training seniority and psychomotor abilities was performed using Pearson's correlation coefficient.

Results

Table 2 shows the results of selected psychomotor abilities. Analysis of the SIRT test showed that female athletes in the junior group achieved slightly shorter reaction times (351.40 ± 37.30 ms) than the senior. The difference between the senior female athletes and junior female athletes was only 1.27 ms. For the movement time, the shorter time was achieved by the senior group of female handball players (175.22 ± 28.28 ms). The difference between older (senior) and younger (junior) female handball players was -13.58 ms. It wasn't observed that the difference between the groups for SIRT MT was statistically significant ($p=0.342$). In the CHORT test, it was observed that the junior group characterized a minimally shorter reaction time (683.60 ± 60.19 ms). The difference between the study groups was 2.73 ms and wasn't statistically significant ($p>0.05$). The shorter movement time in the CHORT test was characterized by the younger group of female handball players (212.53 ± 49.48 ms), while the older players had a worse movement time of 6.80 ms. Analysis of the correct responses in the CHORT test showed that the junior group had 92.07% correct responses, which was 2.18% better than the senior group. The mean reaction time in the HECOR test in the junior female group was 424.67 ± 37.59 ms and was worse than the senior group (418.44 ± 35.71 ms). The difference between groups was 6.22 ms and wasn't statistically significant ($p=0.693$). In the case of the HECOR test, a shorter movement time was achieved by the older group of female players (218.44 ± 32.00 ms), while the rest part of the group (junior group) was characterized by a worse movement time of 14.49 ms. In the SPANT test, the younger group were characterized by worse reaction time and movement time. In addition, in the SPANT and PUT tests, this group of players obtained a higher level of correct responses. Assessing the subject's perceptiveness and attention (PUT test), the better reaction speed to neutral and critical visual stimuli were characterized by the older female players. For this group, the difference in the level of reaction speed for the neutral visual stimuli between the junior group was statistically significant ($p=0.037$) and amounted to $d=-411.67$ ms. In the PAMT test, a higher level of correctness answers was obtained by the group of senior women handball players and amounted to $85.78 \pm 13.59\%$.

Table 2. Numeral characteristics of psychomotor abilities of female handball players

Variable		Total $\bar{x} \pm sd$	min	max	Junior $\bar{x} \pm sd$	min	max	Senior $\bar{x} \pm sd$	min	max	d	p
SIRT	RT (ms)	351.88 ± 36.81	292	447	351.40 ± 37.30	292	438	352.67 ± 38.21	324	447	1.27	0.788
	MT (ms)	183.71 ± 33.14	135	253	188.80 ± 35.68	137	253	175.22 ± 28.28	135	218	-13.58	0.342
CHORT	RT (ms)	684.63 ± 62.48	567	818	683.60 ± 60.19	567	770	686.33 ± 69.84	586	818	2.73	0.920
	MT (ms)	215.08 ± 54.86	147	348	212.53 ± 49.48	147	312	219.33 ± 65.84	147	348	6.80	0.776
	cr (%)	91.25 ± 8.65	75	100	92.07 ± 7.30	79	100	89.89 ± 10.88	75	100	-2.18	0.721
HECOR	RT (ms)	422.33 ± 36.24	354	485	424.67 ± 37.59	354	469	418.44 ± 35.71	385	485	-6.22	0.693
	MT (ms)	227.50 ± 37.45	183	311	232.93 ± 40.43	183	311	218.44 ± 32.00	183	271	-14.49	0.438
SPANT	RT (ms)	586.25 ± 73.58	401	734	594.80 ± 64.55	493	734	572.00 ± 88.93	401	680	-22.80	0.475
	MT (ms)	245.88 ± 49.01	169	352	254.60 ± 49.49	174	352	231.33 ± 47.31	169	285	-23.27	0.269
	cr (%)	92.71 ± 7.80	75	100	93.00 ± 7.75	75	100	92.22 ± 8.33	75	100	-0.78	0.858
PUT	cr(%)	95.17 ± 3.28	88	100	95.73 ± 2.81	90	100	94.22 ± 3.93	88	100	-1.51	0.387
	n (ms)	2076.96 ± 475.88	1001	2815	2231.33 ± 445.47	1001	2815	1819.67 ± 429.70	1001	2396	-411.67	0.037*
	k (ms)	1344.29 ± 435.20	89	2046	1416.53 ± 421.06	89	2046	1223.89 ± 456.26	89	1610	-192.64	0.161
PAMT	cr (%)	82.58 ± 11.15	61	100	80.67 ± 9.40	61	100	85.78 ± 13.59	61	100	5.11	0.287

SIRT – Simple Reaction Time, CHORT – Choice Reaction Time, HECOR – Hand-Eye Coordination Test, SPANT–Spatial Anticipation Test, PUT – Perception and attention test, PAMT – Anticipation test, RT – reaction time, MT – movement time, cr – correct responses, n – neutral visual stimuli, k – critical visual stimuli, d (A-U) – difference between above 3 group and under 3 group, p – probability of testing,

* – statistical significance.

An analysis of the correlations between reaction time in the individual tests and body composition, somatic features and training seniority (Table 3) showed that statistically significant correlations were observed

in the CHORT and SPANT test. In the senior group, it was shown that the higher the BMI, the longer the reaction time in the CHORT test ($r=0.68$). In addition, for the senior group, statistically significant relationships were observed between SPANT RT and body height, body mass, TBW, SMM and BMR. This means that the higher the values of the above parameters, the longer the reaction time in the SPANT test. No statistically significant relationships were shown for SIRT RT and HECOR RT.

Table 3. Correlation analysis between body composition, somatic features, training seniority and reaction time

Variable	Group	SIRT RT (ms)	CHORT RT (ms)	HECOR RT (ms)	SPANT RT (ms)
Age	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	ns	ns	ns	ns
Training seniority (years)	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	ns	ns	ns	ns
Body height (cm)	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	ns	ns	ns	0.71*
Body mass (kg)	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	ns	ns	ns	0.71*
TBW (L)	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	ns	ns	ns	0.82*
FAT (kg)	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	ns	ns	ns	ns
SMM (kg)	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	ns	ns	ns	0.81*
BMI (kg/m ²)	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	ns	0.68*	ns	ns
FAT (%)	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	ns	ns	ns	ns
BMR (kcal)	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	ns	ns	ns	0.82*

Table 4 shows the correlation between body composition, body height and movement time. It was observed that the higher the female athlete, the longer the movement time in the SIRT test ($r=0.48$). For the SIRT test in the senior group, statistically significant relationships were observed between movement time and FAT (kg) and BMI. Higher body fat and higher BMI result in longer movement time in the SIRT test. In the CHORT test for the entire study group, a statistically significant relationship was observed between movement time and percent body fat ($r=0.43$). In addition, a significant relationship was shown in the junior group between movement time and FAT (%) and FAT (kg). Analysis of the SPANT test shows that the older the athletes, the shorter the movement time in the SPANT test ($r=-0.42$). In addition, it was observed that an increase in body mass, FAT (kg), BMI and FAT (%) causes an increase in movement time in the SPANT test. The SPANT MT test for female junior athletes also showed statistically significant correlations with FAT (kg) and FAT (%). For PUT n, only one statistically significant positive correlation was observed ($r=0.48$) and it occurs between FAT (%). It was shown that, the older the athlete is, the shorter the time in the PUT n test. For senior female athletes, strong negative correlations were observed between PUT n, and body height, TBW, SMM and BMR. Regardless of the group, the achieved time in the PUT k test significantly correlates with FAT (kg), SSM and FAT (%). An increase in FAT (kg) and FAT (%) results in a longer PUT k time, while an increase in SMM results in a shorter time. In the junior group, one statistically significant correlation was observed for PUT k with percent body fat ($r=0.54$). For the senior group, significant negative correlations were shown between PUT k and TBW, SMM and BMR. No statistically significant correlations were shown for the HECOR MT test.

Table 4. Correlation analysis between body composition, somatic features, training seniority and movement time

Variable	Group	SIRT MT (ms)	CHORT MT (ms)	HECOR MT (ms)	SPANT MT (ms)	PUT n (ms)	PUT k (ms)
Age	Total	ns	ns	ns	-0.42*	-0.46*	ns
	Junior	ns	ns	ns	ns	ns	ns
	Senior	ns	ns	ns	ns	ns	ns
Training seniority (years)	Total	ns	ns	ns	ns	ns	ns
	Junior	ns	ns	ns	ns	ns	ns
	Senior	ns	ns	ns	ns	ns	ns
Body height (cm)	Total	0.48	ns	ns	ns	ns	ns
	Junior	ns	ns	ns	ns	ns	ns
	Senior	ns	ns	ns	ns	-0.71*	ns
Body mass (kg)	Total	ns	ns	ns	0.44*	ns	ns
	Junior	ns	ns	ns	ns	ns	ns
	Senior	ns	ns	ns	ns	ns	ns
TBW (L)	Total	ns	ns	ns	ns	ns	ns
	Junior	ns	ns	ns	ns	ns	ns
	Senior	ns	ns	ns	ns	-0.81*	-0.73*
FAT (kg)	Total	ns	ns	ns	0.59*	ns	0.43*
	Junior	ns	0.54*	ns	0.65*	ns	ns
	Senior	0.69*	ns	ns	ns	ns	ns
SMM (kg)	Total	ns	ns	ns	ns	ns	-0.41*
	Junior	ns	ns	ns	ns	ns	ns
	Senior	ns	ns	ns	ns	-0.81*	-0.74*
BMI (kg/m ²)	Total	ns	ns	ns	0.43*	ns	ns
	Junior	ns	ns	ns	ns	ns	ns
	Senior	0.67*	ns	ns	ns	ns	ns
FAT (%)	Total	ns	0.43*	ns	0.65*	0.48*	0.55*
	Junior	ns	0.58*	ns	0.71*	ns	0.54*
	Senior	ns	ns	ns	ns	ns	ns
BMR (kcal)	Total	ns	ns	ns	ns	ns	ns
	Junior	ns	ns	ns	ns	ns	ns
	Senior	ns	ns	ns	ns	-0.82*	-0.75*

The relationship between body composition, body height and correct answers in selected psychomotor tests are shown in Table 5. It was observed that correct answers in the CHORT test correlate significantly with age ($r=0.76$). Such a correlation was shown in the senior group. In addition, in the junior group, a negative correlation coefficient was observed between CHORT cr, and FAT (kg) and BMI. In the entire study group, it was noted that the higher the body mass value, body fat content and higher the BMI, the correctness of the answers was at a lower level. In addition, a negative correlation coefficient for body mass, FAT (kg) and FAT (%) was also observed in the junior group. For correct answers in the PUT test, it was shown that the higher the training seniority and BMI, the lower the number of correct answers in the PUT test. No statistically significant correlations were observed for the PAMPT test (%).

Table 5. Correlation analysis between body composition, somatic features, training seniority and correct answers

Variable	Group	CHORT cr (%)	SPANT cr (%)	PUT (%)	PAMT (%)
Age	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	0.76*	ns	ns	ns
Training seniority (years)	Total	ns	ns	-0.41*	ns
	Junior	ns	ns	ns	ns
	Senior	ns	ns	ns	ns
Body height (cm)	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	ns	ns	ns	ns
Body mass (kg)	Total	ns	-0.44*	ns	ns
	Junior	ns	-0.55*	ns	ns
	Senior	ns	ns	ns	ns
TBW (L)	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	ns	ns	ns	ns

FAT (kg)	Total	ns	-0.45*	ns	ns
	Junior	-0.55*	-0.60*	ns	ns
	Senior	ns	ns	ns	ns
SMM (kg)	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	ns	ns	ns	ns
BMI (kg/m2)	Total	ns	-0.43*	ns	ns
	Junior	-0.53*	ns	-0.52*	ns
	Senior	ns	ns	ns	ns
FAT (%)	Total	ns	-0.41*	ns	ns
	Junior	ns	-0.55*	ns	ns
	Senior	ns	ns	ns	ns
BMR (kcal)	Total	ns	ns	ns	ns
	Junior	ns	ns	ns	ns
	Senior	ns	ns	ns	ns

Discussion

The main purpose of the study was to evaluate selected psychomotor abilities in female handball players using computerized tests. In addition, the junior and senior group of female handball players were compared and an analysis of the correlation between psychomotor abilities and body composition, somatic features and training seniority was conducted. The analysis of reaction time, movement time and choice of correct answers between the studied two groups of female handball players (junior and senior) showed statistically significant differences only in PUT n test (for neutral matrices). In this test, the senior female handball players were quicker to recognize the lack of the required object in the matrix. The other tests showed no statistically significant differences between the groups in the levels of the examined psychomotor abilities. The group of players with longer training seniority (senior) was characterized by slightly better results in the SIRT MT, HECOR RT and MT, SPANT RT and MT tests and the mentioned PUT n test. In the study of Przednowek et al (2019), it was observed that the shortest reaction time (RT) in the SIRT, CHORT, HECOR and SPANT tests had athletes with the longest seniority (more than 14 years), while the movement time (MT) was the shortest among a group of handball players with a seniority between 10-14 years. Similar conclusions had Kaur and Zwierko (2006, 2007, 2010) who found statistically significant between shorter simple reaction times and more experienced athletes than in novice athletes or non-athletes. However in other studies (Mori et al., 2002; Paterson, 2010) there were no significant differences between different level of experience (Justin et al., 2013).

In the case of anticipation, it has been observed that shorter reaction time in the SPANT test characterized the senior group. Jackson and Morgan (2007) also found that athletes at a higher level are characterized by better levels of anticipation as opposed to amateurs. Also it was observe by Mohammed and Tareq (2016) no significant relationship between level of body fat and reaction time in young players training football. In addition, the results of the correlation analysis determined for the examined group of SPR Handball Rzeszów players showed that the results in the SPANT test might depend on body height, body mass, TBW, muscle mass and BMR.

The results also suggest that the higher the values of body height, body mass, TBW, muscle mass, and BMR, the players obtained a shorter reaction time in the eye-hand coordination test. A relationship was also shown between CHORT RT and BMI in the senior women's group, while no relationship was observed for the other reaction times and the junior women's group. Similar results were obtained by Ari and Sözen (2021), in a study of young football players on the evaluation of reaction time and body composition found no significant correlation between visual and auditory reaction time with body composition parameters and anaerobic power. Therefore, it can be concluded that the reaction time parameter is not closely related to body composition parameters and anaerobic power, as it is more closely related to neural mechanisms than physical ones. Also Sreejisha and Basheer (2022) showed that reaction time has a weak positive correlation with BMI ($r=0.24$, $p=0.24$) and percent body fat ($r=0.3$; $p=0.13$) in children aged 9-12. On the other hand, Jyothi and Sujaya (2016) study where body mass index and skinfold thickness were analyzed with reaction time in the group of runners. The study group was divided into two groups, group A (>2 years and < 3 years of training) and group B (>3 years and < 10 years of training). Reaction time was significantly shorter in runners ($p<0.05$) compared to the control group, as well as in group B. Correlation analysis showed a negative correlation of BMI with reaction time with a statistically significant value in runners. The results obtained for skinfold thickness also showed a negative correlation with reaction time (Jyothi & Sujaya, 2016). Other studies have also shown that more fit individuals have shorter reaction times (Luque-Casado et al., 2016; Westfall et al., 2018). A study by Reigal et al. (2019) on the relationship between simple and complex reaction times (RT) and physical activity performed per week and physical fitness showed that the group that performed more weekly physical activity achieved shorter simple and complex reaction times. The results also showed that simple RT reaction time was significantly related to physical fitness, while complex was significantly related to attention capacity and physical fitness (Reigal, 2019).

There are a large number of papers where we can observe relationships between movement time and body composition in the group of young female or male players practicing team sports (Skurvydas_2009, Jyothi et al., 2016, Paśko_2021, Śliż_2022, Ari and Sözen_2021, Sreejisha and Basheer_2022, Luque-Casado et al., 2016; Westfall et al., 2018, Reigal et al. 2019). Our studies have shown that higher body fat content can significantly increase movement time. In the research of Luque-Casado et al., (2016) and Westfall et al., (2018) also it was observed that more fit individuals have shorter reaction times. It should also be mentioned that in the literature there are some papers which show no significant correlation between visual reaction time with body composition parameters and anaerobic power. Such an example are the football players research of Ari and Sözen (2021). Thus, it can be concluded that reaction time and body composition may show a statistical relationship in a larger population, so further research on this topic is needed.

In addition, in the PUT and SPANT test, it was observed that athletes achieve shorter movement times with age. Similar conclusions were drawn by Śliż et al. (2022), who showed that the higher the level of competition (leagues) and the age of the players, the shorter the reaction times of the handball players. It was also observed that there is a significant relationship between the PUT test and the water content in the body, body height and muscle mass, the increase of which may shorten the time of movement. The study of Śliż et al. (2022) also revealed that the players' body mass index and percentage of fat content were reassociated with movement times.

Taking into account the correct answers, it was found that they can be influenced by lower body fat. It has been also shown that the senior group of female handball players are more likely to select the correct answer, and those with longer training experience are prone to more errors in the PUT test however, the strength of the correlation is at a moderate level. In team sports games such as soccer basketball and handball, reaction time is essential in many field situations during a game, with quick decisions leading to successful completion of offensive as well as defensive actions (Horniková et al., 2019; Mudric et al., 2015; van de Water et al., 2017, Przednowek et al., 2019, Śliż et al., 2022). However, a number of studies show that there is insufficient evidence to demonstrate a relationship between body fat percentage and the speed, agility and reaction time of basketball and handball players (Mohammed & Tareq, 2016; Śliż et al., 2022). In contrast, analysis of the correlation with movement time in the SPANT test showed that higher levels of body mass, body fat content and BMI resulted in longer movement time. In addition, statistically significant correlation coefficients were observed for the CHORT and PUT k test with body fat percentage. In addition, it was shown that body height could increase movement time in the SIRT and HECOR test. It is confirmed by the research of Mores et al. (2019) who proved that being overweight has a negative impact on pupils motor skills. Therefore, it should be concluded that there are relationships between body composition and motor performance in students aged 11 to 14 years.

Conclusions

Based on the analysis of the data, the following conclusions were formulated. Female athletes in the group of seniors were characterized by shorter movement time in SIRT, HECOR, SPANT and PUT tests. Statistically significant differences between the groups were observed only in the PUT n test. No statistically significant differences were found between the groups for reaction time and number of correct answers. In the senior group, the highest relationships between reaction time and body composition parameters were observed in the SPANT test for TBW, SMM, body mass and height and the CHORT test for BMI index. In the group of juniors, the highest relationship with the time of movement had fat mass (CHORT and SPANT tests) and its percentage in the whole body (CHORT, SPANT and PUT k tests). Correlation analysis in the senior group showed that poorer movement time in the SIRT test was characterised by players with a higher body fat mass and BMI. In turn, in the PUT test, better results were obtained by players with a higher basal metabolic rate (BMR), greater muscle mass (SMM) and better hydrated (TBW). In the senior group, the strongest relationship with the number of correct answers was found between the CHORT test and age, where the older players achieved better results. In the second group (juniors), the players' body fat mass (FAT (kg)) had a negative and the greatest influence on the percentage of correct answers in the SPANT test.

Conflicts of interest - The authors declare no conflict of interest for the research.

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