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Morphological, Motor and Situation-Motor Characteristics of Elite Female Handball Players According to Playing Performance and Position

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A B S T R A C T

The aim of the study was to define biomotor characteristics that determine playing performance and position in female handball. A battery of 13 variables consisting of somatotype components (3 variables), basic motor abilities (5 variables) and specific motor abilities (5 variables) were applied in a sample of 52 elite female handball players. Differences in biomotor characteristics according to playing performance and position of female handball players were determined by use of the analysis of variance (ANOVA) and discriminative analysis. Study results showed the high-quality female handball players to predominantly differ from the less successful ones in the specific factor of throw strength and basic dash factor, followed by the specific abilities of movement without and with ball, basic coordination/agility and specific ability of ball manipulation, and a more pronounced mesomorphic component. Results also revealed the wing players to be superior in the speed of movement frequency (psychomotor speed), run (explosive strength) and speed of movement with ball as compared with players at other playing positions. Also, endomorphic component was less pronounced in players at the wing and back player positions as compared with goalkeeper and pivot positions, where endomorphic component was considerably more pronounced.

***Key words**: female handball players, somatotype, specific motoricity, handball performance*

Introduction

Long-term training processes in handball, along with appropriate selection, lead to the formation of optimal, i.e. specific biomotor structures responsible for achievement of top performance in handball[1,2]. Previous studies have revealed that handball is a very complex sports activity where successful performance depends on a number of basic motor abilities, mostly on the ability of cortical regulation of movement, explosive strength (of throwing type in particular), basic strength of the trunk, and psychomotor speed (Srhoj et al., 2006)[1–6]. The prognostic value of explosive strength tests to predict situation efficiency has been confirmed in many studies[1,4–8]. The accomplishment of specific motor skills is closely related to the development of specific motor abilities and basic motor abilities, which then results in the integration of specific and basic motor abilities into the locomotor system[1,4,7–8]. Results of the studies performed in elementary school fifth- to eighth-grade female students included in handball training[5–6], and in elite female handball players[1,4,7–8], as well as those obtained in the studies of motor development in general[9–18] are consistent with these statements.

The studies investigating the structures of morphological characteristics in handball by use of factor and taxonomic analyses[19,20] frequently employ the Heath-Carter method of somatotype determination[21], which is considerably less precise than taxonomic analysis (a great proportion of information is lost), but is likely to be more attractive because of its simplicity. The use of three components (endomorphy, mesomorphy and ectomorphy) has proved rather interesting for description of the athlete characteristics. So, Šibila and Pori[22] determined the somatotype of elite male Slovene handball players according to particular playing positions, whereas Hasan et al. (2007)[22] analyzed the somatotype of male handball players from various national teams and the somatotype to playing position relations. Of great value is the study by

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Srhoj (2002)[20], having identified the morphological-motor structures corresponding to playing positions in handball team in young female handball players, and developmental stages of optimal morphological-motor systems to solve typical types of tasks in handball. Another study by Srhoj et al. (2005)[8] should also be noted for having analyzed differences in the anthropologic characteristics of elite female handball players relative to particular playing positions.

Katić et al. (2007)[1] conducted a study to identify anthropometric characteristics and basic motor abilities of elite female handball players, and to determine the structures and their relations with manifest variables evaluating specific motor abilities in handball. Therefore, factor structures of morphological characteristics and basic motor abilities of elite female handball players were determined first, followed by determination of the relations of the morphological-motor space factors obtained with the set of criterion variables evaluating situation motor abilities in handball. This study has provided relevant information on the relations among the morphological, basic motor and specific motor spaces in elite female handball players, however, these data are not sufficient for reliable prediction of performance quality in female handball, primarily because the criterion of performance quality of individual players is lacking.

In their study, Čavala et al. (2008)[2] identified the factor structure that determines playing performance in female handball on the basis of differences between high--quality and lower quality female handball players in latent variables-factors of the morphological, basic motor and specific motor spaces as an integral set of variables. Results of regression analysis indicated the handball performance to be predominantly determined by the general specific motor factor based on specific agility and explosiveness, and by the morphological factor based on body mass and volume, i.e. muscle mass. Concerning basic motor abilities, the factor of movement frequency rate, which is associated with the ability of ball manipulation, was observed to predict significantly the handball players' performance.

The aim of the present study was to determine the role of the somatotype, motor ability and specific motor ability proportion in elite female handball players relative to their playing quality and position. For this purpose, the set of predictor variables was chosen first, then somatotype components were calculated by the Heath--Carter procedure, and tests were chosen which provide best assessment of the basic and specific motoricity factors and predominantly determine handball performance according to the results reported to date. This was followed by differentiation of the female handball players in thus formed set of variables according to two criteria, playing position and playing quality. Thus, a general system optimal for the overall performance in female handball and biomotor systems in female handball players for a particular playing position were obtained.

Subjects and Methods

Subject sample

Subject sample was defined as a group of female handball players playing in the Croatian Major Handball League for at least two years. The study included 52 subjects characterized as Croatian elite female handball players according to the level of handball technique training and experience.

Variable sample

Three groups of variables were employed, i.e. morphological, basic motor and situation-motor sets of variables.

- on assessment of somatotype components (by use of Heath-Carter procedure)[21], the following morphological measures were employed: body height (mm), elbow diameter (mm), knee diameter (mm), body weight (dkg), upper arm circumference in relaxation (mm), upper arm circumference in flexion (mm), lower leg circumference (mm), midarm skinfold (1/10 mm), back skinfold (1/10 mm), abdominal skinfold (1/10 mm) and lower leg skinfold (1/10 mm).

Fifteen motor tests were chosen for assessment of basic motor abilities[1]:

- for assessment of agility (coordination factor): sidesteps, 8 with bending, and shuttle-run test
- for assessment of movement frequency: hand tapping, foot tapping, wall foot tapping
- for assessment of jumping explosive strength: standing long jump, standing high jump, and standing triple jump
- for assessment of throwing strength: 2-kg medicine ball supine throw; 2-kg medicine ball standing chest throw, and 2-kg medicine ball bow throw
- for assessment of running strength (sprint): high start sprint 20 m, high start sprint 30 m, and high start sprint 40 m.

The choice of specific motor variables was based on the presumed existence of five handball factors: situation precision, ball manipulation, speed of movement with ball, speed of movement without ball, and explosive strength of handball pass (Pavlin et al., 1982)[24]. In line with this study, a test defining best the respective factor was chosen for each handball factor, as follows:

- 9-m jump throw for precision
- wall throwing and catching ball with one hand for ball manipulation
- start speed with ball at 20 m for speed of movement with ball
- speed of shuttle-run for speed of movement without ball
- handball distance jump throw for strength of throw.

Situation performance of female handball players was assessed by one variable based on team quality and individual player quality within the team[1]:

- team quality – teams were ranked according to quality into 3 groups (Table 1, column 1) as follows: group 1 including elite teams of the respective age group (with contest placing as the criterion); group 2 including medium quality teams; and group 3 including low ranking teams.
- individual player's quality within the team – according to this criterion, the coaches categorize their team players into 3 groups: group 1 including leading team players (1–3); group 2 including the rest of A team players and players entering the game, thus contributing to team result (3–6); and group 3 including players who very rarely or never enter the game.

Using a combination of these assessments, i.e. team quality and individual player's team quality, each player's performance is scored 1–5, as illustrated in Table 1.

TABLE 1
CRITERIA FOR RANKING PLAYERS ACCORDING TO QUALITY

Team quality	Player's quality within the team (evaluated by coaches)		
	Group 1	Group 2	Group 3
Group 1	5	4	3
Group 2	4	3	2
Group 3	3	2	1

The players taking active part in national team of the respective age group are scored 5 and 4, even if ranked as group 3 members. Table 1 shows that there is only one combination for a player to be scored 5 and 1, two combinations to be scored 4 and 2, and three combinations to be scored 3; thus, the variable obtained can be presumed to have normal distribution. This method of performance evaluation is simple, reliable and objective, therefore this original approach to quality assessment has also been proposed for use in other sports[25,26].

Statistical analysis

Arithmetic mean ($\overline{X}$), standard deviation (SD), minimal (MIN) and maximal (MAX) results were calculated by standard descriptive statistics methods. Normality of distribution was tested by Kolmogorov-Smirnov procedure; and maximal differences between real and theoretical cumulative frequencies (MAXD) were calculated.

In order to properly select one test and one variable, the first main component of the intercorrelation matrix of the respective subset was calculated to assess a particular factor of basic motoricity over each subset of basic motoricity variables.

Depending on the player's team rank, the players were divided into high-quality and moderate quality groups; those scored 1, 2 and 3 were classified in the moderate quality group (n=27) and those scored 4 and 5 in the high quality group (n=25). Between-group differences (based on performance quality) in the preset variables (somatotype, basic and specific motor parameters) were determined by the analysis of variance (ANOVA) and canonic discriminative analysis. Differences in somatotype, basic motoricity and specific motoricity according to playing position were also determined by the analysis of variance (ANOVA) and canonic discriminative analysis.

Results

The basic descriptive parameters showed all the variables to exhibit normal distribution, without any extreme dispersion of data, which was of upmost importance for subsequent statistical analysis (Table 2).

Table 3 illustrates test projections upon the first main component for each hypothetic factor of basic motoricity evaluated. The following tests were chosen according to the level of test projection upon the first main component: side steps for assessment of coordination/agility; wall foot tapping for speed of movements; standing long jump for explosive strength of jump type; medicine ball bow throw for explosive strength of throw type; and high start 40 m sprint for explosive strength of running type.

Differences in somatotype components and variables-factors of basic and specific motoricity between average and high quality female handball players are presented in Table 4. Analysis of variance revealed the mesomorphic component to be more pronounced in high quality players, whereas ectomorphic component predominated in average quality players. Considering basic motoricity variables-factors, high quality players were by far superior in the explosive strength of running type (40 m sprint) and coordination/agility (side steps). In addition, high quality players were also superior in all factors of specific motoricity except for the factor of throw precision, as follows (in descending order): throw strength, speed of movement without ball, speed of movement with ball, and ability of ball manipulation.

In line with the results yielded by the analysis of variance, discriminative function clearly differentiated high quality from moderate quality female handball players, the former being predominantly characterized by the following: first, pronounced specific factor of throw strength and basic sprint factor, which underlie manifestation of the specific abilities of the speed of movement without and with ball; second, pronounced basic coordination/agility, which underlies the specific ability of ball manipulation; and third, pronounced mesomorphic component relative to ectomorphic component.

Results on differences in somatotype components, basic and specific motor abilities among female handball players at different playing positions are presented in Table 5. Analysis of variance indicated the players to differ according to playing position mostly in the basic abilities of movement speed (movement frequency) and running speed (40 m sprint), then in the specific ability of the speed of movement with ball, and in endomorphic component. So, the female handball players at the wing posi-

TABLE 2
DESCRIPTIVE STATISTICS

Variable	$\overline{X}$	Min	Max	SD	MaxD
Body height	179.27	168.27	193.60	5.96	0.14
Elbow diameter	6.76	6.13	7.47	0.38	0.11
Knee diameter	9.87	8.93	11.37	0.56	0.19
Body weight	70.98	59.00	87.00	7.23	0.11
Upper arm circumference in relaxation	27.77	23.97	33.03	1.97	0.11
Upper arm circumference in flexion	29.36	25.73	35.27	2.26	0.10
Lower leg circumference	38.34	34.53	42.83	2.00	0.14
Midarm skinfold	6.68	3.50	12.47	2.19	0.13
Back skinfold	10.10	6.53	16.33	2.24	0.14
Abdominal skinfold	11.54	5.87	23.00	4.17	0.12
Lower leg skinfold	5.07	3.00	8.67	1.62	0.15
Sidesteps#	8.00	6.95	9.77	0.82	0.22
8 with bow#	16.71	14.98	19.46	1.07	0.18
Shuttle-run test#	7.58	7.02	8.73	0.42	0.24
Hand tapping	36.03	26.33	40.33	3.11	0.20
Foot tapping	43.36	38.00	50.00	3.50	0.13
Wall foot tapping	26.60	22.67	29.67	1.73	0.16
Standing long jump	205.56	184.33	217.67	8.86	0.18
Standing high jump	30.26	20.17	38.67	4.09	0.14
Standing triple jump	604.90	513.00	700.00	45.38	0.12
Supine medicine ball throw	73.90	48.00	89.00	8.83	0.15
Standing medicine ball throw	90.37	68.67	111.67	11.79	0.15
Medicine ball bow throw	114.58	76.67	136.00	14.24	0.14
High start sprint 20 m#	3.61	3.26	3.82	0.16	0.15
High start sprint 30 m#	4.90	4.46	5.33	0.22	0.12
High start sprint 40 m#	6.46	6.10	6.93	0.23	0.15
Throw precision	2.85	0.33	5.33	1.32	0.09
Ball manipulation	3.96	3.44	4.74	0.29	0.15
Speed of movement with ball#	13.74	12.69	15.14	0.72	0.13
Speed of movement without ball#	25.87	22.00	29.67	1.77	0.14
Strength of throw	324.06	244.67	403.33	46.13	0.07
				Test=0.22	

#variable with opposite metric orientation

tion were superior to those playing at other positions in the speed of movement frequency, sprint and speed of movement with ball. In goalkeeper, however, the endomorphic component was more pronounced as compared with other playing positions. Although these differences did not reach statistical significance, the endomorphic component was found to be more pronounced in goalkeepers and pivots, mesomorphic component in wings, and ectomorphic component in back players. Endomorphic component prevailed in goalkeepers, whereas all three components were uniformly distributed in wings; ectomorphic component predominated in back players, while endomorphic and ectomorphic components were uniformly distributed in pivots.

Discriminative function demonstrated the discrimination of different playing positions to be possible, mostly according to psychomotor speed and explosive strength of running type (40 m sprint) as a basis for the speed of movement speed with ball, i.e. differentiation of the wing position relative to other positions.

Discussion

The aim of the study was to define, using the least possible number of variables, the biomotor factors that predominantly determine the overall performance and efficiency at particular playing positions in female hand-

TABLE 3
STRUCTURE OF PRINCIPAL COMPONENTS (H1) OF BASIC MOTOR SPACE

Variable	H1	H1	H1	H1	H1
Sidesteps#	–0.95				
8 with bow#	–0.94				
Shuttle–run test#	–0.96				
Hand tapping		–0.57			
Foot tapping		–0.78			
Wall foot tapping		–0.90			
Standing long jump			–0.85		
Standing high jump			–0.61		
Standing triple jump			–0.83		
Supine medicine ball throw				–0.79	
Standing medicine ball throw				–0.81	
Medicine ball bow throw				–0.92	
High start sprint 20 m#					–0.67
High start sprint 30 m#					–0.91
High start sprint 40 m#					–0.98
Expl.Var	2.72	1.74	1.78	2.13	2.24
Prp.Totl	0.91	0.58	0.59	0.71	0.75

#variable with opposite metric orientation

TABLE 4
RESULTS OF ANALYSIS OF VARIANCE AND CANONIC DISCRIMINATION ANALYSIS

Variable	Average (n=27) $\overline{X}$	Above-average (n=25) $\overline{X}$	F	F^p	DF
Endomorphic component	2.70	3.06	2.72	0.11	–0.18
Mesomorphic component	1.57	2.53	9.42	0.00	–0.34
Ectomorphic component	3.57	2.64	12.42	0.00	0.39
haCoordination/agility#	8.36	7.62	13.05	0.00	0.40
Speed of movement	26.26	26.96	2.17	0.15	–0.16
Explosive strength jump type	203.83	207.43	2.19	0.15	–0.16
Explosive strength throw type	88.62	92.27	1.25	0.27	–0.12
Explosive strength running type#	6.58	6.34	18.80	0.00	0.48
Throw precision	2.81	2.88	0.03	0.86	–0.02
Ball manipulation	25.26	26.53	7.56	0.01	–0.31
Speed of movement with ball#	4.09	3.82	14.39	0.00	0.42
Speed of movement without ball#	14.09	13.37	17.08	0.00	0.46
Strength of throw	300.94	349.03	19.12	0.00	-0.49
CanR					0.79*

F – univariate test of differences, F^p – significance of univariate test of differences, DF – structure of discriminative function, CanR – coefficient of canonic discrimination, #variable with opposite metric orientation, *$p<0.001$

ball. So, the somatotype components (3 variables) were calculated for assessment of the morphological state, one variable was defined for assessment of each individual factor of basic motoricity (5 variables in total) and one variable for assessment of each individual factor of specific motoricity (5 variables in total).

Study results clearly indicated the development of playing quality to be associated with integration of the basic and specific motor abilities, underlain by integration of the mechanisms regulating the intensity of energy mobilization, i.e. explosive strength, and mechanisms of movement structure, i.e. coordination/agility.

TABLE 5
RESULTS OF ANALYSIS OF VARIANCE AND CANONIC DISCRIMINATION ANALYSIS

Variable	G n=9 $\bar{X}$	W n=17 $\bar{X}$	B n=20 $\bar{X}$	P n=6 $\bar{X}$	F	F^p	DF
Endomorphic component	3.50	2.68	2.68	3.17	3.33	0.03	0.18
Mesomorphic component	1.99	2.52	1.70	1.81	1.48	0.23	–0.19
Ectomorphic component	2.72	3.00	3.45	3.00	1.19	0.32	0.03
Coordination/agility#	8.03	7.67	8.30	7.93	1.95	0.13	0.19
Speed of movement	26.33	27.84	26.03	25.33	6.24	0.00	–0.40
Explosive strength jump type	206.50	208.20	202.90	205.4	1.16	0.33	–0.13
Explosive strength throw type	89.81	89.27	90.23	94.78	0.32	0.81	0.05
Explosive strength running type#	6.55	6.30	6.54	6.53	4.92	0.00	0.37
Throw precision	2.07	3.29	2.93	2.44	1.99	0.13	–0.20
Ball manipulation	25.67	25.94	26.13	25.11	0.55	0.65	–0.04
Speed of movement with ball#	4.02	3.78	4.04	4.08	3.76	0.02	0.32
Speed of movement without ball#	14.01	13.45	13.78	14.06	1.83	0.15	0.22
Strength of throw	308.20	334.50	327.00	308.30	0.90	0.45	–0.13
CanR						0.83*	

G – goalkeepers, W – wings, B – back players, P – pivots, F – univariate test of differences, F^p – significance of univariate test of differences, DF – correlations of variables with discriminative function, CanR – coefficient of canonic discrimination, #variable with opposite metric orientation, *p<0.001

The motor system described, which is optimal for achievement of top playing quality, reflects upon the morphological system, i.e. on the formation of a morphological somatotype characterized by a significant proportion of the mesomorphic component[1,2].

The proposed model of selection in female handball is confirmed by relations among the elements of the biomotor system identified[1–3]. This model leads to the formation of playing quality. The following data are substantial in this process:

- the level and development of explosive strength that predominantly determines efficient performance in handball imply an association between explosive strength of the running type, manifesting as the rate of space control, and specific explosive strength of throw type, manifesting mostly as attacking the opponent's goal. Thus, there is integration of both the basic and specific explosive strength, and of explosive strength of the upper and lower extremities;
- playing quality implies optimal correlation of the basic and specific explosive strength factors with specific abilities of the speed of movement with and without ball
- playing quality implies optimal correlation of the basic and specific motoricity, in particular with the abilities of ball manipulation and speed of movement with and without ball
- considering specific demands in female handball, the development of basic and specific motor abilities is paralleled by the formation of the morphological system with all the three somatotype components uniformly distributed. Unlike male handball players, in female handball players there is a predominance of mesomorphic component over the other two somatotype components[4,22,23,27].

The results of discriminative analysis (Table 5) revealed the female handball players at various playing positions to differ significantly in the set of biomotor variables applied, however, this differentiation was only demonstrated in the following: two variables of basic motoricity underlain by psychomotor speed, manifesting in the lower extremity movement frequency (wall foot tapping and 40 m run); speed of movement with ball (from the group of specific movement abilities); and endomorphic component (from the group of somatotype components). Relative to other playing positions, wings were found to be superior in the speed of movement frequency, sprint and speed of movement with ball; and along with the back player position, they had a less pronounced endomorphic component. In male handball, wings and back players have also been reported to have a less pronounced endomorphic component as compared with goalkeepers and pivots, where this component is more pronounced[8,22,23]. Such morphological-motor properties enable the wings to cross the ball more easily in defense and to perform fast counterattack.

Study results yielded no significant differences among particular playing positions according to other basic and specific motor abilities, suggesting that the players can perform properly at different playing positions, thus enabling exchange of the positions. Our results also showed the efficiency in female handball to depend on the function of the two primary regulators, i.e. force regulator and speed regulator, and function of the superimposed secondary regulator based on the movement structuring, which coordinates performance of the primary regulators and determines the proportion of force and speed on performing specific tasks in handball. It is consistent with the model of motor functioning presented in the study by Katić et al. (2004)[12] and the model of selection in female handball described by Srhoj et al. (2006)[3].

Studies in a larger sample and thus greater subgroups of female handball players are needed for a more precise biomotor differentiation of performance quality and particular playing positions in particular. In future studies, differentiation of performance quality and playing positions should be done following partialization of the effects of morphological characteristics on motor abilities, i.e. after the impact of morphological characteristics on basic and specific motoricity in female handball players has been annulled.

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MORFOLOŠKE, MOTORIČKE I SITUACIJSKO MOTORIČKE ZNAČAJKE VRHUNSKIH RUKOMETAŠICA U ODNOSU NA IGRAČKU KVALITETU I POZICIJU U IGRI

SAŽETAK

Cilj istraživanja je bio definirati bio-motoričke značajke koje determiniraju igračku kvalitetu i poziciju u igri u ženskom rukometu. U tu svrhu na uzorku od 52 vrhunske rukometašice primijenjen je skup od 13 varijabli sastavljen od komponenti somatotipa (3 varijable), bazičnih motoričkih sposobnosti (5 varijabli) i specifičnih motoričkih sposobnosti (5 varijabli). Zatim su primjenom analize varijance (ANOVA) i diskriminativne analize utvrđene razlike bio-motoričkih značajki u odnosu na igračku kvalitetu rukometašica i poziciju u igri. Rezultati su pokazali kako se vrhunske-kvalitetne rukometašice u odnosu na manje kvalitetne dominantno razlikuju u specifičnom faktoru snage šutiranja i bazičnom faktoru sprinta, zatim u specifičnim sposobnostima brzine kretanja bez lopte i sa loptom, u bazičnoj koordinaciji/agilnosti i specifičnoj sposobnosti manipulacije loptom, te više izraženom mezomorfnom komponentom. Rezultati su također pokazali kako su rukometašice na poziciji krila superiornije u brzini frekvencije pokreta (psihomotorna brzina), u sprintu (eksplozivna snaga), te u brzini kretanja sa loptom od rukometašica ostalih pozicija u igri. Kod igračica na poziciji krila i beka je ujedno manje zastupljena endomorfna komponenta u odnosu na pozicije golmana i pivota kod kojih je endomorfna komponenta znatno više izražena.