Coll. Antropol. **32** (2008) 1: 231–239
Original scientific paper

Biomotor Structures in Elite Female Handball Players According to Performance

Marijana Čavala, Nenad Rogulj, Vatromir Srhoj, Ljerka Srhoj and Ratko Katić

Faculty of Natural Sciences, Mathematics and Kinesiology, University of Split, Split, Croatia

ABSTRACT

In order to identify biomotor structures in elite female handball players, factor structures of morphological characteristics and basic motor abilities, and of variables evaluating situation motor abilities of elite female handball players (n=53) were determined first, followed by determination of differences and relations of the morphological, motor and specific motor space according to handball performance. Factor analysis of 16 morphological measures produced three morphological factors, i.e. factor of absolute voluminosity, i.e. mesoendomorphy, factor of longitudinal skeleton dimensionality, and factor of transverse hand dimensionality. Factor analysis of 15 motor variables yielded five basic motor dimensions, i.e. factor of agility, factor of throwing explosive strength, factor of running explosive strength (sprint), factor of jumping explosive strength and factor of movement frequency rate. Factor analysis of 5 situation motor variables produced two dimensions: factor of specific agility with explosiveness and factor of specific precision with ball manipulation. Analysis of variance yielded greatest differences relative to handball performance in the factor of specific agility and throwing strength, and the factor of basic motoricity that integrates the ability of coordination (agility) with upper extremity throwing explosiveness and lower extremity sprint (30-m sprint) and jumping (standing triple jump). Considering morphological factors, the factor of voluminosity, i.e. mesoendomorphy, which is defined by muscle mass rather than adipose tissue, was found to contribute significantly to the players' performance. 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.

***Key words**: female handball players, morphological-motor status, 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]. 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)[1–5]. The prognostic value of explosive strength tests to predict situation efficiency has been confirmed in many studies[1,3–7]. 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[1,3,6,7]. Results of the studies performed in elementary school fifth- to eighth-grade female students included in handball training[4,5], and in elite female handball players[1,3,6,7], as well as those obtained in the studies of motor development in general[8–13] are consistent with these statements.

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

Received for publication January 31, 2008

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.

Four significant canonic correlations, i.e. linear combinations, explained the correlation between the set of eight latent variables of the morphological and basic motor space and five variables of situation motoricity. First canonic linear combination is based on the positive effect of the factors of agility/coordination on the ability of fast movement without ball. Second linear combination is based on the effect of jumping explosive strength and transverse hand dimensionality on ball manipulation, throw precision, and speed of movement with ball. Third linear combination is based on the running explosive strength determination by the speed of movement with ball, whereas fourth combination is determined by throwing and jumping explosive strength and agility on ball pass. The first canonic dimension in the space of specific motor abilities of female handball players was found to completely fit the model of selection and formation of the performance quality proposed (Srhoj et al., 2006)[2]. Accordingly, the speed of movement without ball has a crucial role, followed by the strength of throw and ball manipulation. Then, integration of these abilities into the ability of movement with ball occurs. The development of throw precision probably requires further integration of all the previously mentioned specific abilities, along with appropriate development of other anthropologic features. Thus defined general specific ability is determined by agility (factor of coordination), running speed (explosive strength of running type) and rate of movement frequency.

The above mentioned study 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. Therefore, the aim of the present study was to identify – on the basis of differences in latent variables-factors of the morphological, basic motor and specific motor spaces as a uniform set of variables between above-average and average players – the structure of these factors that determines performance quality in female handball.

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 53 subjects characterized as Croatian elite female handball players according to the level of handball technique training and experience.

Variable sample

The set of predictor variables were so chosen as to assess anthropometric dimensions, basic motor abilities, and specific motor abilities for handball.

The choice of 16 morphological variables was based on the presumed existence of four dimensions, i.e. longitudinal skeleton dimensionality, transverse skeleton dimensionality, body volume and body mass, and subcutaneous fatty tissue[1,8,10]. The following variables were chosen:

- measures for assessment of longitudinal skeleton dimensionality: body height, arm span, leg length, arm length and hand length;
- measures for assessment of transverse skeleton dimensionality: knee diameter, wrist diameter, and hand diameter;
- measures for assessment of body mass and volume: body weight, upper arm circumference in relaxation, upper arm circumference in flexion, thorax circumference, and lower leg circumference; and
- measures for assessment of subcutaneous adipose tissue: midarm skinfold, back skinfold, and abdominal skinfold.

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

- for assessment of agility (coordination factor): side-steps, 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; and
- 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)[14]. 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, and
- 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:

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

- 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.

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[15,16].

Statistical analysis

Latent variables of the morphological space, basic motor space and specific motor space were obtained by factor analysis on the model of main components, with direct oblimin rotations. The number of significant factors was determined by use of Guttman-Kaiser criterion, according to which a component with a variance exceeding 1.00 is considered significant.

According to team ranking, the players were divided into two quality groups: those scored 1, 2 and 3 in average group (n=28) and those scored 4 and 5 in above-average group (n=25). Differences in isolated factors of the sets of variables between the groups (formed on the basis of handball performance) were assessed by the analysis of variance (ANOVA and MANOVA).

Correlation between the set of predictor latent variables (factors of the anthropometric and basic motor space and factors of the situation motor space) and the criterion variable (situation efficiency, i.e. playing quality in handball) was determined by regression correlation analysis. Partial coefficients of regression (β), coefficient of partial correlation (P/C), coefficient of multiple correlation between the set of predictors and the criterion (ρ), coefficient of determination (δ), and level of significance of regression coefficients and multiple correlation were calculated.

Results

Factorization of the manifest variables of the morphological space produced characteristics roots (Expl.Var.) explaining the common variance of each individual factor. According to Guttman-Kaiser criterion, three morphological factors explaining 73% of the common variance in total were isolated from the overall space of variables (Table 2).

First factor (Expl.Var.=5.06) showed significant correlation with all circumference measures and the body weight variable, while the subcutaneous adipose tissue variables showed lower yet relatively high projections upon the first latent dimension.

It should be noted that knee diameter as a measure hypothetically pertaining to transverse skeleton dimensionality showed a relatively high projection upon this factor. It is quite understandable for knee size or knee width, considering that female handball players have to possess a high level of stability while also being capable of quick and explosive change of movement direction.

TABLE 2
STRUCTURE OF LATENT VARIABLES OF MORPHOLOGICAL SPACE (F)

Variable	F1	F2	F3
Body height	0.00	0.93	0.06
Arm span	0.23	0.78	0.29
Leg length	–0.06	0.92	0.02
Arm length	0.23	0.88	0.17
Hand length	0.03	0.68	0.19
Hand diameter	0.20	0.36	0.77
Wrist diameter	0.08	0.35	0.86
Knee diameter	0.70	–0.07	0.28
Body weight	0.78	0.52	0.13
Upper arm circumference	0.90	–0.04	0.16
Upper arm circumference in flexion	0.89	–0.19	0.22
Thorax circumference	0.70	0.39	0.06
Lower leg circumference	0.67	0.36	0.01
Midarm skinfold	0.58	0.32	–0.52
Back skinfold	0.73	–0.10	–0.16
Abdominal skinfold	0.62	0.35	–0.19
Expl.Var	5.06	4.65	1.98
Prp.Totl	0.32	0.29	0.12

Expl.Var. – particular component variance,
Prp.Totl. – total amount of the explained system variance

Such a combination of abilities is only found in players with very strong knees. Considering its correlation with the mentioned variables, this factor can be interpreted as a factor of mesoendomorphy and/or factor of overall voluminosity. Generally, this factor described 32% of total variance in the system of morphological set of variables applied.

Second factor (Expl.Var.=4.65) correlated significantly with all the variables evaluating longitudinal skeleton dimensionality (body height, arm span, leg length, arm length and hand length). This factor represented longitudinal skeleton dimensionality and explained 29% of total system variance.

Third factor (Expl.Var.=1.98) was defined by hand and wrist diameters, and could be characterized as transverse hand dimensionality. This factor is of special interest, knowing the major role of hand size on ball manipulation. This factor described 12% of total variance in the system of morphological set of variables applied.

Accordingly, factor analysis defined three morphological factors: factor of absolute voluminosity, i.e. mesoendomorphy; factor of longitudinal skeleton dimensionality; and factor of transverse hand dimensionality.

Factorization of the manifest basic motor variables produced characteristic roots (Expl.Var.) that explained common variance of each individual factor. Five factors that taken together explained 84% of the common variance were isolated by use of Guttman-Kaiser criterion from the overall space of variables (Table 3).

Survey of the system matrix (Table 3) reveals the variables evaluating agility coordination to exert highest projections (0.87–0.94) upon the first factor (Expl.Var.= 4.69). Some variables evaluating throwing explosive strength (standing med-ball throw), sprint (30-m run) and jumping (standing triple jump) also elicited relatively high projections upon this factor, suggesting a strong association and high correlation between the dimensions of explosiveness and agility. This factor explained 31% of total variance of the system of the basic motor variables applied, and could thus be termed factor of agility.

Second factor (Expl.Var.=2.20) was defined by the variables hypothetically pertaining to the factor of throwing explosive strength and could thus be termed accordingly. The variables of throwing explosive strength were juxtaposed by the variables of lower extremity movement frequency. This factor explained 15% of total variance of the system of the basic motor variables applied.

Third factor (Expl.Var.=2.14) correlated significantly with the variables evaluating speed of sprint type, with the high start sprint 30 m variable showing a lower projection upon this factor. Based on the results obtained, the dimension thus produced could be presented as a running explosive strength, explaining 14% of total variance of the system of the variables applied.

Fourth oblimin factor (Expl.Var.=2.06) was defined by jumping explosive strength tests, with highest projection exerted by the variable of vertical jump, followed by projection of the long jump variable and lowest projection of the standing triple jump variable. Based on these results, this factor could be termed factor of jumping ex-

TABLE 3
STRUCTURE OF LATENT VARIABLES OF BASIC MOTOR SPACE (F)

Variable	F1	F2	F3	F4	F5
Sidesteps#	–0.94	–0.01	0.08	–0.09	0.15
8 with bow#	–0.90	–0.10	0.06	0.11	–0.16
Shuttle-run test#	–0.87	–0.08	0.23	–0.19	0.08
Hand tapping	–0.18	0.09	0.04	0.13	0.91
Foot tapping	–0.21	–0.66	–0.18	0.60	0.11
Wall foot tapping	0.20	–0.61	–0.25	0.11	0.59
Standing long jump	0.26	–0.10	–0.25	0.68	0.11
Standing high jump	–0.03	0.15	–0.09	0.84	0.10
Standing triple jump	0.63	0.15	0.02	0.46	–0.27
Supine medicine ballthrow	0.21	0.72	–0.40	0.25	0.17
Standing medicine ballthrow	0.71	0.51	0.18	–0.16	–0.24
Medicine ball bow throw	0.58	0.64	–0.05	0.22	0.14
High start sprint 20 m#	0.13	0.15	0.88	–0.27	0.04
High start sprint 30 m#	–0.67	–0.27	0.61	0.03	–0.13
High start sprint 40 m#	–0.55	–0.17	0.76	–0.14	–0.07
Expl.Var	4.69	2.20	2.14	2.06	1.47
Prp.Totl	0.31	0.15	0.14	0.14	0.10

#variable with opposite metric orientation, Expl. Var. – particular component variance, Prp. Totl. – total amount of explained system variance plosive strength, explaining 14% of total variance of the system of the variables applied.

Fifth factor (Expl.Var.=1.47) showed significant and predominant correlation (0.91) with the variable evaluating upper extremity movement frequency rate. The variable of wall foot tapping also showed high projection upon this factor (0.59), thus it could be termed factor of movement frequency rate. The third variable of foot tapping, hypothetically pertaining to the latent dimension of movement frequency rate, showed highest association with the factor of take-off explosive strength, indicating that lower extremity explosiveness is considerably saturated by the rate of lower extremity movements. Yet, the fifth factor that was predominantly defined by the test assessing the rate of upper extremity frequency (hand tapping), explained a significant proportion (10%) of total variance of the system of the motor variables applied.

Accordingly, factor analysis produced five basic motor dimensions: factor of agility, factor of throwing explosive strength, factor of running explosive strength (sprint), factor of jumping explosive strength, and factor of movement frequency rate.

TABLE 4
STRUCTURE OF LATENT VARIABLES OF SPECIFIC MOTOR SPACE (F)

Variable	F1	F2
Throw precision	–0.05	0.88
Ball manipulation	0.24	0.72
Speed of movement with ball#	–0.68	0.03
Speed of movement without ball#	–0.85	–0.09
Strength of throw	0.81	0.33
Expl.Var	1.90	1.42
Prp.Totl	0.38	0.28

#variable with opposite metric orientation, Expl. Var. – particular component variance, Prp. Totl. – total amount of explained system variance

Factorization of the manifest specific motor variables isolated two factors that taken together explained 66% of common variance (Table 4).

The variables evaluating specific abilities, i.e. speed of movement without ball, throw strength and speed of movement with ball, showed highest projections upon the first factor (Expl.Var.=1.90). This factor integrated specific agility – mobility with throw strength and speed of movement with ball into a general dimension, which provides the basis of specific motor efficiency of female handball players.

The variables evaluation specific abilities of throw precision and ball manipulation exerted highest projections upon the second factor (Expl.Var.=1.42). Thus, this factor integrated throw precision and ball manipulation into a single dimension that could only be fully manifested when a satisfactory level in the previous, basic dimension, i.e. the factor of specific agility and throw strength, has been achieved.

Results of the analysis of variance between the female handball players of above-average and average level of performance for isolated latent variables of the morphological, basic motor and specific motor spaces are presented in Table 5. The highest differences according to the level of performance were recorded in the factor of specific agility and throw strength, followed by the factor of basic motoricity integrating the ability of coordination (agility) with upper extremity throw explosiveness, lower extremity sprint explosiveness (30-m sprint) and lower extremity jump explosiveness (standing triple jump). Considering morphological factors, the factor of voluminosity, i.e. mesoendomorphy, predominantly defined by muscle mass rather than adipose tissue, contributed significantly to the level of performance.

TABLE 5
ANALYSIS OF VARIANCE BETWEEN PLAYER GROUPS OF DIFFERENT SITUATION EFFICIENCY (ANOVA/MANOVA)

Morphological-motor factors	Above-average (n=25) Mean±SD	Average (n=28) Mean±SD	F	F^p
Mesoendomorphy	0.41±1.13	–0.36±0.70	9.14	0.00
Longitudinality	–0.04±0.85	0.03±1.13	0.06	0.81
Transverse hand dimensionality	0.26±1.17	–0.23±0.77	3.33	0.07
Coordination/agility#	0.59±0.49	–0.53±1.05	23.46	0.00
Explosive strength throw type	–0.06±0.92	0.05±1.08	0.15	0.70
Explosive strength running type#	0.01±0.70	–0.01±1.22	0.00	0.95
Explosive strength jump type	–0.20±1.18	0.18±0.79	1.93	0.17
Speed of movement	0.24±0.88	–0.21±1.07	2.77	0.10
Specific agility and explosive strength	–0.66±0.85	0.59±0.71	33.87	0.00
Throw precision and ball manipulation	0.20±0.70	–0.18±1.19	1.87	0.18
Wilks λ = 0.35	F = 7.62		p = 0.000	

#variable with opposite metric orientation; Wilk's λ and F – multivariate tests of differences, p – level of significance of multivariate tests of differences, F^p – significance of univariate test of differences

TABLE 6
BASIC DESCRIPTIVE PARAMETERS OF MORPHOLOGICAL VARIABLES AND ANALYSIS OF VARIANCE BETWEEN PLAYER GROUPS OF DIFFERENT SITUATION EFFICIENCY (ANOVA/MANOVA)

Variable	Above-average (n=25) Mean±SD	Average (n=28) Mean±SD	F-test	F^p
Body height	178.23±3.55	180.07±7.40	1.29	0.26
Arm span	182.36±5.75	181.51±7.04	0.22	0.64
Leg length	99.93±3.48	102.17±4.38	4.17	0.04
Arm length	78.53±2.27	77.66±3.58	1.08	0.30
Hand length	18.34±0.90	18.21±1.25	0.20	0.66
Hand diameter	5.60±0.23	5.45±0.21	6.51	0.01
Wrist diameter	8.12±0.29	7.97±0.35	2.90	0.09
Knee diameter	10.04±0.72	9.70±0.30	5.38	0.02
Body weight	73.49±7.06	68.51±6.62	7.01	0.01
Upper arm circumference	28.47±2.27	27.23±1.51	5.53	0.02
Upper arm circumference in flexion	30.34±2.39	28.57±1.81	9.40	0.00
Thorax circumference	89.96±3.50	87.87±2.87	5.71	0.02
Lower leg circumference	38.82±1.75	38.02±2.19	2.10	0.15
Midarm skinfold	6.95±2.95	6.42±1.11	0.78	0.38
Back skinfold	10.33±2.48	9.80±2.04	0.72	0.40
Abdominal skinfold	13.05±4.51	10.05±3.31	7.69	0.01
Wilks λ = 0.31	F = 4.99		p = 0.00	

Wilk's λ and F – multivariate tests of differences, p – level of significance of multivariate tests of differences, F-test – univariate test of differences, F^p – significance of univariate test of differences

TABLE 7
BASIC DESCRIPTIVE PARAMETERS OF BASIC MOTOR VARIABLES AND ANALYSIS OF VARIANCE BETWEEN PLAYER GROUPS OF DIFFERENT SITUATION EFFICIENCY (ANOVA/MANOVA)

Variable	Above-average (n=25) Mean±SD	Average (n=28) Mean±SD	F-test	F^p
Sidesteps#	7.62±0.41	8.40±0.95	14.43	0.00
8 with bow#	16.07±0.61	17.41±1.21	25.10	0.00
Shuttle-run test#	7.32±0.15	7.82±0.45	28.23	0.00
Hand tapping	36.35±2.56	35.76±3.50	0.47	0.50
Foot tapping	43.19±3.22	43.68±3.83	0.25	0.62
Wall foot tapping	26.96±2.19	26.20±1.12	2.59	0.11
Standing long jump	207.4±7.97	204.37±9.7	1.55	0.22
Standing high jump	31.55±4.54	29.24±3.35	4.51	0.04
Standing triple jump	609.6±30.5	598.3±56.3	0.79	0.38
Supine medicine ball throw	77.68±6.30	70.48±9.31	10.61	0.00
Standing medicine ball throw	92.27±8.75	88.43±13.75	1.43	0.24
Medicine ball bow throw	121.0±11.2	107.90±14.6	13.29	0.00
High start sprint 20 m#	3.58±0.16	3.65±0.15	3.02	0.09
High start sprint 30 m#	4.78±0.18	5.02±0.22	18.08	0.00
High start sprint 40 m#	6.34±0.17	6.58±0.22	20.11	0.00
Wilks λ = 0.22	F = 8.45		p = 0.00	

#variable with opposite metric orientation; Wilk's λ and F – multivariate tests of differences, p – level of significance of multivariate tests of differences, F-test – univariate test of differences, F^p – significance of univariate test of differences

TABLE 8
BASIC DESCRIPTIVE PARAMETERS OF SPECIFIC MOTOR VARIABLES AND ANALYSIS OF VARIANCE BETWEEN PLAYER GROUPS OF DIFFERENT SITUATION EFFICIENCY (ANOVA/MANOVA)

Variable	Above-average (n=25) Mean±SD	Average (n=28) Mean±SD	F-test	F^p
Throw precision	2.88±1.01	2.75±1.59	0.12	0.73
Ball manipulation	26.53±1.85	25.17±1.54	8.62	0.00
Speed of movement with ball#	3.82±0.23	4.09±0.28	15.14	0.00
Speed of movement without ball#	13.37±0.59	14.15±0.71	18.44	0.00
Strength of throw	349.0±37.2	299.7±41.5	20.57	0.00
Wilks λ = 0.53	F = 8.29		p = 0.00	

#variable with opposite metric orientation; Wilk's λ and F – multivariate tests of differences, p – level of significance of multivariate tests of differences, F-test – univariate test of differences, F^p – significance of univariate test of differences

TABLE 9
REGRESSION ANALYSIS BETWEEN LATENT VARIABLES OF THE MORPHOLOGICAL AND BASIC MOTOR SPACE AND SPECIFIC MOTOR SPACE AND THE CRITERION VARIABLE
(situation efficiency: score 1–5)

Morphological-motor factors	β	P/C	p
Mesoendomorphy	0.29	0.42	0.00
Longitudinality	–0.10	–0.12	0.43
Transverse hand dimensionality	0.05	0.07	0.64
Coordination/agility#	0.17	0.16	0.29
Explosive strength throw type	0.05	0.06	0.70
Explosive strength running type#	–0.07	–0.11	0.47
Explosive strength jump type	0.17	0.23	0.14
Speed of movement	0.24	0.39	0.01
Specific agility and explosive strength	–0.62	–0.49	0.00
Throw precision and ball manipulation	0.14	0.19	0.22
ρ		0.87	0.00
δ		0.75	0.00

β – partial coefficients of regression, P/C – coefficient of partial correlation, ρ – coefficient of multiple correlation, δ – coefficient of determination, p – level of significance

Results of the analysis of variance between the female handball players of above-average and average level of performance for manifest variables of the morphological, basic motor and specific motor spaces are shown in Tables 6, 7 and 8, respectively. These results additionally specified the particular space variables that contributed most to differentiation between the above-average and average handball players. In the morphological space, the two groups were discriminated by the variables evaluating body mass and volume, i.e. muscle mass, favorably followed by the variables of knee diameter and abdominal skinfold and unfavorably by the length of lower extremities. In the basic motor space, discrimination between the groups was based on the variables evaluating coordination/agility and variables evaluating explosive strength, i.e. running explosive strength of the running type (sprint), throwing type and jumping type, in this descending order. In the space of specific motor abilities in handball, the two groups were differentiated by the variables evaluating the abilities of throw strength, speed of movement without ball and speed of movement with ball, and of ball manipulation.

Regression correlation analysis was performed to more precisely identify the latent variables of the morphological, basic motor and specific motor spaces as predictor variables determining performance quality, which is directly related to the efficiency of handball performance, i.e. criterion variable (Table 9). Results of regression analysis showed the quality of handball performance to be predominantly determined by the general specific motor factor underlain by specific agility and explosiveness, and by the morphological factor underlain by body mass and volume, i.e. muscle mass. Concerning basic motor abilities, the factor of movement frequency rate showed significant prediction of the quality of performance in handball, associated with the ability of ball manipulation.

Discussion

Out of the ten latent variables of the morphological, basic motor and specific motor spaces obtained, highest differences according to the performance of handball players were recorded in the factor of specific agility and throw strength, and in the factor of basic coordination/agility (Table 5).

The first factors isolated in the set of variables evaluating specific abilities, termed factor of specific agility and explosiveness, was a general factor of specific motor efficiency of the female handball players, because it integrated the following:

- specific agility – mobility through the test of the speed of slalom (shuttle-run) movement without ball;
- throw strength through the test of jump handball throw; and
- speed of movement with ball through the test of the speed of straight-line handball manipulation.

Motor functioning of female handball players was predominantly defined by the first isolated factor of the basic motor space, thus representing general motor ability that is primarily defined by basic coordination in the form of agility, integrated with all the forms of explosive strength, i.e.:

- throwing explosiveness by the variable of standing med-ball throw, which is associated with throw strength in handball;
- running explosiveness by the variable of high-start 30-m run, including start speed with the speed of reaction and acceleration, i.e. maximal running speed; and
- jumping explosiveness by the variable of standing triple jump, which is associated with performance of the handball three-step technique.

The level of performance in female handball is mostly differentiated by the general motor factors of both specific and basic motor spaces described. Therefore, above-average female handball players are superior to average handball players both in specific motor functioning and in basic motor functioning. These two motor functioning systems are tightly connected, as demonstrated in a previous study[1]. The factor of agility/coordination was found to exert favorable effects on the ability of fast movement without ball, which is quite logical because handball is abundant in agile movements without ball as a prerequisite for successful performance of the tasks posed in handball. Thus, female players with properly developed ability of explosive strength of the running-sprint type are able to move faster with ball. The effects of throwing and jumping explosive strength and of agility on the strength of handball throw have also been demonstrated.

It is concluded that a player would throw the ball more strongly and to a greater distance if she has developed a higher level of explosiveness, agility and strength in arms and shoulder girdle, as it is known that all motor abilities are intertwined and that good performance in this criterion variable requires a spectrum of motor abilities. This implies coordinated and concerted activity of all parts of the body, i.e. muscle groups involved in the kinetic chain that ensures progressive transfer of the muscle strength over to the ball directed in the desired throw direction.

Motor functioning in handball implies an appropriate morphological structure, which means that integration of motor abilities into the morphological system occurs during the process of quality development in female handball. Therefore, considering motor efficiency, the factor of voluminosity, i.e. mesoendomorphy, which is mostly defined by muscle mass rather than adipose tissue, contributes significantly to the level of handball performance.

The difference in performance quality relative to the second specific motor factor defined as throw precision and ball manipulation was not statistically significant but was present; however, this factor will dictate performance in the sample of elite female handball players where the system of abilities described by the first factor has already achieved a certain level. Accordingly, it is only when the impact of the factor of general specific ability on the performance has been eliminated, the quality will be determined by the factor of throw precision and ball manipulation; the manifestation of the latter is considerably saturated by upper extremity coordination and transverse hand dimensionality.

Results of regression analysis indicated the handball performance to be predominantly determined by the general specific motor factor underlain by specific agility and explosiveness and integrating basic motor abilities of coordination/agility and all explosive strength types (throwing, running and jumping). Morphological structure of female handball players is formed in accordance with the specific motor system described, and is based on the body mass and volume, i.e. muscle mass. Considering basic motor abilities assessed, only the factor of movement frequency rate (upper extremities in particular) was found to significantly determine handball performance, exerting favorable impact on the ability of ball manipulation.

The results of the present study, along with those from two previous studies[1,2], provide comprehensive information on the identification of ideal biomotor structures that determine performance in female handball.

Acknowledgement

This study was supported by the grant No. 177-0000000-1811 from the Croatian Ministry of Science, Education and Sport.

REFERENCES

1. KATIĆ R, ČAVALA M, SRHOJ V, Coll Antropol, 31 (2007) 795. — 2. SRHOJ V, ROGULJ N, ZAGORAC N, KATIĆ R, Coll Antropol, 30 (2006) 601. — 3. SRHOJ V, ROGULJ N, PADOVAN N, KATIĆ R, Coll Antropol, 25 (2001) 611. — 4. SRHOJ V, Coll Antropol, 26 (2002) 201. — 5. KATIĆ R, Physical culture (Skopje), 26 (1995) 76. — 6. ROGULJ N, SRHOJ V, SRHOJ LJ, Coll Antropol, 28 (2004) 739. — 7. ROGULJ N, SRHOJ V, NAZOR M, SRHOJ LJ, ČAVALA M, Coll Antropol, 29 (2005) 705. — 8. KATIĆ R, ZAGORAC N, ŽIVIČNJAK M, HRASKI Ž, Coll Antropol, 18 (1994) 141. — 9. KATIĆ R, BONACIN D, BLAŽEVIĆ S, Coll Antropol, 25 (2001) 573. — 10. KATIĆ R, Coll Antropol, 27 (2003) 351. — 11. KATIĆ R, PEJČIĆ A, VISKIĆ-ŠTALEC N, Coll Antropol, 28 (2004) 261. — 12. KATIĆ R, PEJČIĆ A, BABIN J, Coll Antropol, 28 (2004) Suppl. 2; 357. — 13. KATIĆ R, SRHOJ LJ, PAŽANIN R, Coll Antropol, 29 (2005) 711. — 14. PAVLIN K, ŠIMENC Z, DELIJA K, Kineziologija, 14 (1982) 177. — 15. KATIĆ R, GRGANTOV Z, JURKO D, Coll Antropol, 30 (2006) 103. — 16. GRGANTOV Z, KATIĆ R, JANKOVIĆ V, Coll Antropol, 30 (2006) 87.

R. Katić

Faculty of Natural Sciences, Mathematics and Kinesiology, University of Split, Teslina 12, 21000 Split, Croatia
e-mail: katic@pmfst.hr

BIOMOTORIČKE STRUKTURE VRHUNSKIH RUKOMETAŠICA U ODNOSU NA IGRAČKU KVALITETU

S A Ž E T A K

U cilju identifikacije biomotoričkih sklopova u ženskom vrhunskom rukometu najprije su utvrđene faktorske strukture kako morfoloških karakteristika i baziĉnih motoričkih sposobnosti, tako i varijabla koje procjenjuju situacijske motoričke sposobnosti u rukometu kod vrhunskih rukometašica (n=53), a zatim su utvrđene razlike i relacije dobivenih faktora morfološkog, motoričkog i specifičnog motoričkog prostora u odnosu na igračku kvalitetu. Faktorskom analizom 16 morfoloških mjera dobivena su tri morfološka faktora: faktor apsolutne voluminoznosti, tj. mezoendomorfije, faktor longitudinalne dimenzionalnosti skeleta i faktor transverzalne dimenzionalnosti skeleta šake. Faktorskom analizom 15 motoričkih varijabla dobiveno je pet baziĉnih motoričkih dimenzija: faktor agilnosti, faktor eksplozivne snage tipa bacanja, faktor eksplozivne snage tipa trčanja (sprinta), faktor eksplozivne snage tipa skočnosti i faktor brzine frekvencije pokreta. Faktorskom analizom 5 situacijskih motoričkih varijabla dobivene su dvije dimenzije i to: faktor specifične agilnosti uz eksplozivnost i faktor specifične preciznosti uz manipulaciju loptom. Primjenom analize varijance najveće razlike u odnosu na igračku kvalitetu utvrđene su u faktoru specifične agilnosti i snazi šutiranja, zatim u faktoru bazične motorike koji integrira sposobnost koordinacije (agilnost) s eksplozivnosti ruku u vidu bacanja i eksplozivnosti nogu u vidu šprinta (šprint 30 m) i u vidu skoka (troskok iz mjesta). Od morfoloških faktora značajan doprinos igračkoj kvaliteti ima faktor voluminoznosti, tj. mezoendomorfije, koji je u znatno većoj mjeri definiran mišićnom masom nego masnim tkivom. Rezultati regresijske analize su pokazali da je igračka kvaliteta u rukometu dominantno određena generalnim specifičnim motoričkim faktorom u osnovi kojeg je specifična agilnost i eksplozivnost te morfološkim faktorom u osnovi kojeg je volumen i masa tijela, tj. mišićna masa. Od bazičnih motoričkih sposobnosti značajnu prognozu igračke kvalitete u rukometu ima faktor brzine frekvencije pokreta, što je povezano sa sposobnošću manipulacije loptom.