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Position-Related Differences in Selected Morphological Body Characteristics of Top-Level Female Handball Players

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ABSTRACT

The study aimed to establish the main morphological characteristics of Slovenian junior and senior female national handball team players. Morphological characteristics of various player subgroups (goalkeepers, wings, back players and pivots) were also determined so as to establish whether they had distinct profiles. The subjects were 87 handball players who were members of the Slovenian junior and senior female national teams in the period from 2003 to 2009. A standardised anthropometric protocol was used to assess the subjects' morphological characteristics. The measurements included 23 different anthropometric measures. First, basic statistical characteristics of anthropometric measures were obtained for all subjects together and then for each group separately. Somatotypes were determined using Heath-Carter's method. Endomorphic, mesomorphic and ectomorphic components were calculated by computer on the basis of formulas. In order to determine differences in the body composition and anthropometric data of the subjects playing in different positions, a one-way analysis of variance was employed. The results show that, on average, the wings differed the most from the other player groups in terms of their morphological body characteristics. The wings differed most prominently from the other player groups in terms of their morphological body parameters as they were significantly smaller and had a statistically significantly lower body mass than the other groups. In terms of transversal measures of the skeleton and the circumferences, the wings significantly differed mainly from the pivots and goalkeepers and less from the backs. The goalkeepers were the tallest, with high values of body mass and low values of transversal measures compared to P. Their skin folds were the most pronounced among all the groups on average and their share of subcutaneous fat in total body mass was the highest. Consequently, their endomorphic component of the somatotype was pronounced. Players in the Pivot position were significantly taller than the W players but were not significantly different from G and B. They had high values of body mass which were significantly higher than that of W but did not differ significantly from the body mass values of B and G. The average values of their circumferences were the highest among all the player groups and the same is true for transversal measures of the skeleton. It is very interesting that, compared to the players in other playing positions, they achieved low values of subcutaneous fat. Their values of the somatotype revealed an endo-mesomorphic somatotype, with a pronounced mesomorphic component. Back players were tall and had the lowest share of subcutaneous fat of all the player groups. Significant differences were established mainly in terms of the structure of the lower extremities. The values of the somatotype characteristics were very balanced between all three components. The results of our study confirm that groups of handball players occupying different positions differed amongst themselves in terms of many measurements. This is a result of the specific requirements of handball play which are to be met by particular players. The tallest players should thus be oriented to back player positions. As regards pivots, the coaches must, besides body height, consider robustness. For goalkeepers, body height is very important; however, the robustness criteria are slightly lower. For wings, body height is not a decisive factor and smaller players can also occupy this position. Both of the above (also taking other criteria into account) facilitate coaches' decisions when orienting players into their playing positions.

Key words: *anthropometry, body composition, somatotype, female handball*

Introduction

Morphological characteristics of the body certainly have a great influence on an outstanding performance in handball[1-4]. This is particularly typical of top-level handball where the advantages of players with an appropriate morphological structure are evident with both men[5] and women[6]. Recent research studies dealing with the morphological profiles of male and female elite handball players highlighted that they are characterised by a prevailing

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mesomorphic somatotype with a touch of ectomorphy, that is, with a pronounced longitudinal dimensionality of the skeleton[7]. In general, more successful teams are taller and have lower body fat than less successful teams[8]. Previous research also indicates that groups of players who occupy different playing positions significantly differ from each other in terms of many morphological parameters[9,10]. This is particularly true of the values denoting body height and the quantity of subcutaneous fat[11,12]. A correlation between some morphological body characteristics of handball players and their playing position is therefore evident. This is attributed to the different technical and tactical tasks which players occupying different playing positions must execute. There are some exceptions to the rule. Authors who studied differences between Asian male and female handball players in terms of their morphological body dimensions established no statistically significant differences between the playing positions[8,13]. Also related to the above is the process of orienting players into the most appropriate playing positions[7,11]. In this respect, researchers have observed that selected young handball players aged between 10 and 14 were taller and had a higher body mass than their peers practicing some other sport[14]. In the case of 14-year-old girls, on average, significant differences in terms of some morphological body parameters start appearing between different playing positions[15]. Authors who have delved into morphological body characteristics in sport games with some similarity to handball have also reported similar findings – male and female players in different playing positions and of different quality categories significantly differ in terms of many morphological body parameters[16-19]. Researchers have also established a significantly positive correlation between the throwing velocity of the handball shot and body mass, lean body mass, arm span, hand length and width of the hand with the fingers abducted[20]. While some studies investigate the morphological body characteristics of male handball players, there is a paucity of such studies involving female players. A review of the literature on other team games reveals a similar situation[21]. For these reasons, the main morphological characteristics of Slovenian junior and senior female national handball team players were established. Morphological characteristics of various subgroups of players (goalkeepers, wings, back players and pivots) were also determined so as to establish whether they had distinct profiles.

Subjects and Methods

The subjects were 87 female handball players who were members of the Slovenian junior and senior female national teams in the period from 2003 to 2009 (average height (mean ± s) = 175.43 ± 6.68 cm, average body mass (mean ± s) = 69.85 ± 8.81 kg, average age (mean ± s) = 22.52 ± 4.7 years). The sample of subjects consisted of players occupying different positions. The measurement included 15 goalkeepers (G), 39 back players (B), 23 wings (W), and 10 pivots (P). Data were collected during the training camps of the national teams. A standardised anthropometric protocol was used to assess the subjects' morphological characteristics. The measurements included 23 different anthropometric measures covering all (four) morphological dimensions: longitudinal measures, diameters, circumferences and skin folds (Table 1).

TABLE 1
SAMPLE OF VARIABLES DEFINING ALL MORPHOLOGICAL DIMENSIONS

Morphological dimension	Description of variable	unit
Parameters of longitudinal dimension:	Body height	cm
Parameters of transversal dimension:	Biacromial diameter	cm
	Biliocristal diameter	cm
	Humerus diameter	cm
	Wrist diameter	cm
	Femur diameter	cm
	Ankle diameter	cm
Parameters of body volume and body mass:	Circumference of upper arm (relaxed)	cm
	Circumference of upper arm (contracted)	cm
	Circumference of forearm	cm
	Circumference of thigh (subgluteal)	cm
	Circumference of thigh (medial)	cm
	Circumference of calf	cm
	Body mass	kg
Parameters of body fat:	Subscapular skin fold	mm
	Abdominal skin fold	mm
	Suprailiacal skin fold	mm
	Chest skin fold	mm
	Triceps skin fold	mm
	Biceps skin fold	mm
	Forearm (volar) skin fold	mm
	Thigh (subgluteal) skin fold	mm
	Calf skin fold (medial)	mm

The data were processed by the »statistical package« SPSS 16.0. First, basic statistical characteristics of anthropometric measures were obtained for all subjects together and then for each group separately. Somatotypes were determined using Heath-Carter's method[22]. Endomorphic, mesomorphic and ectomorphic components were calculated with a computer on the basis of formulas[23].

ENDO = – 0.7182 + 0.1451 * ((Triceps skin fold + Subscapular skin fold + Suprailiacal skin fold) / 10) – 0.00068 * ((Triceps skin fold + Subscapular skin fold + Suprailiacal skin fold) / 10) * ((Triceps skin fold + Subscapular skin fold + Suprailiacal skin fold) / 10)

MESO = (0.858 * (Humerus diameter / 10) + 0.601 * (Femur diameter / 10) + 0.188 * (Circumference of upper arm (contracted) / 10 – Triceps skin fold / 100) + 0.161 * Circumference of calf / 10 – Calf skin fold / 10) – (body height / 10 * 0.131) + 4.5

ECTO = Body height / 10 (EXP (1/3 * LN (body mass) / 10) * 0.732) – 28.58

Body density (BD) was calculated using the Jackson and Pollock[24] formula and the quantity of body fat (BF) using the Siri[25] formula:

BD = 1.109380 – ((0.0008267 * (Chest skin fold + Thigh skin fold + Abdominal skin fold)) + (0.0000016 * (Chest skin fold + Thigh skin fold + Abdominal skin fold)^2) – (0.0002574 * age),

BF = ((4.950 / BD) – 4.500)) * 100.

Bone (BM) and muscle (MM) mass were calculated using the formulae of Drinkwater, Martin, Ross and Clarys[26]:

BM = (Humerus diameter + Femur diameter + Wrist diameter + Ankle diameter/4)^2 * body height * 0.92,

MM = (0.0546 * Circumference of thigh^2 + 0.119 * Circumference of forearm^2 + 0.0256 * Circumference of calf^2) * Body height

Body surface (BS) was calculated using following formula[27]:

BS = 71.84 * mass$^{0.425}$ * height$^{0.725}$.

In order to determine differences in the body composition and anthropometric data of the subjects playing in different positions, a one-way analysis of variance (one-way ANOVA) was employed. A probability level of 0.05 or less was taken to indicate significance.

Results

In Table 2 the basic statistical characteristics of the selected anthropometric variables are presented. The table shows the average values, standard deviations, minimum and maximum values and significance of the Kolmogorov-Smirnov test (Table 2).

The following tables show the results of the one-way analysis of variance based on which it was established whether there were any statistically significant differences between the handball players – with respect to their playing position in attack – in terms of an individual manifest variable. The analysis was carried out by individual morphological sub-spaces (longitudinal measures, diameters, circumferences and skin folds) (Table 3).

The tallest players in our sample are those playing in the G position and they are significantly taller than those in the W position (Table 3). The goalkeepers and pivots are also significantly taller on average than the wings. Therefore, in our sample the wing players are the shortest players on average. On average, players in the G, B and P positions do not significantly differ in terms of body height. The data show that in terms of body height, the playing position of a wing is somewhat distinctive from other playing positions. Obviously, the height of the player on this position is slightly less relevant for the playing performance of female players. In the activities performed by the wings, such as running start, dribble and shots in the area along the border of the court and defence of the zone at the border of the court, body height is not an important factor. Similar findings were also reported for male handball players[10] (Table 4).

On average, in the morphological sub-space of transversal dimensions the least robust players in our sample are those playing in wing positions, while more prominent transversal dimensions are those of the Bs and Ps (Table 4). Average values for the Ps are significantly higher than those of the Ws in terms of biacromial, biliocristal, humerus, femur and ankle diameter. On average, when compared to other players, the Ps have a significantly higher value of their femur diameter compared to the Bs. In other variables, the Ps do not significantly differ from the Bs, which is somewhat surprising. They do not differ from the Gs in any of the variables. The average values for the Gs are significantly higher than those of the Ws in terms of biliocristal and femur diameter. The femur diameters of the Bs are significantly longer than those of the Ws. There were no significant differences among the player groups in wrist diameter values. The results show that in terms of transversal dimensionality the wings significantly differ from other groups of players in many variables. The largest differences were seen between P and W. Other groups of players mostly do not differ to a significant extent (Table 5).

In all parameters of body circumferences and body mass, except for both upper-arm circumferences, significant differences between the player groups were identified (Table 5). In the basic parameter – body mass – the Ws' values are significantly lower than those of the other player groups. This is quite logical since the value of body mass is distinctively related to the value of body height, where the wings achieved significantly lower values on average. Players from the other groups did not significantly differ in terms of this parameter. As mentioned, there are no significant differences between the groups of players in terms of the circumference of relaxed and contracted upper arm. The wings have significantly lower values of the forearm circumference compared to the Ps and Bs. Many more significant differences are established in terms of the circumferences of the lower extremities than the upper extremities. The wings have significantly lower subgluteal values of the thigh circumference compared to the Ps and Gs. In terms of the medial thigh circumference, the Ws achieve significantly lower values than the Gs. In terms of calf circumference, the Ws also recorded significantly lower values compared to the Ps and Gs. The Ps had a

TABLE 2
BASIC STATISTICAL CHARACTERISTICS OF ALL PARAMETERS

Parameter	$\bar{x}$	s	min	max	pK-S
Longitudinal dimension (lengths)					
Body height	175.43	6.68	156.6	186.6	0.749
Transversal dimension (diameters)					
Biacromial diameter	38.69	1.61	35.3	43.3	0.802
Biliocristal diameter	28.63	1.84	24.4	33.2	0.741
Humerus diameter	6.44	0.36	5.7	7.5	0.382
Wrist diameter	5.25	0.27	4.6	5.8	0.263
Femur diameter	9.17	0.50	8.0	10.8	0.428
Ankle diameter	7.06	0.45	5.8	8.1	0.507
Body volume (circumferences)					
Circumference of upper arm (relaxed)	28.63	2.32	23.1	36.3	0.569
Circumference of upper arm (contracted)	30.09	2.39	24.6	38.5	0.604
Circumference of forearm	25.26	1.35	22.1	29.5	0.759
Circumference of thigh (subgluteal)	59.91	4.07	52.0	72.8	0.325
Circumference of thigh (medial)	56.00	4.32	45.8	70.0	0.547
Circumference of calf	38.51	2.47	33.0	45.2	0.694
Body mass	69.85	8.81	53.5	99.4	0.842
Body fat (skin folds)					
Subscapular skin fold	11.09	4.05	6.4	29.0	0.046
Triceps skin fold	12.1	4.58	4.4	30.0	0.337
Biceps skin fold	6.65	2.57	3.4	16.2	0.024
Forearm (volar) skin fold	7.60	2.23	4.0	15.2	0.353
Abdominal skin fold	16.68	7.20	3.2	40.0	0.417
Chest skin fold	7.95	2.29	4.8	15.8	0.083
Suprailiacal skin fold	14.38	6.53	6.6	40.0	0.068
Thigh (subgluteal) skin fold	22.73	6.58	8.4	40.0	0.252
Calf skin fold (medial)	13.66	5.35	4.6	35.0	0.130
Body indexes					
Relative body mass	0.40	0.04	0.3	0.6	0.000
% of body fat	20.03	4.44	9.6	35.3	0.678
Body surface	1.85	0.14	1.6	2.2	0.811
Muscle mass	33.78	4.24	24.9	44.7	0.999
% of muscle mass	45.36	3.35	35.7	54.4	0.590
Bone mass	11.01	2.12	6.9	16.3	0.010
% bone mass	15.82	2.68	11.4	23.2	0.008
Somatotype					
Ectomorphic components	2.67	1.00	–0.1	4.8	0.375
Mesomorphic component	3.70	0.99	1.6	6.1	0.868
Endomorphic component	3.65	1.08	1.7	6.9	0.551

$\bar{x}$ – average values, s – standard deviations, min – minimum values, max – maximum values, pK-S – significance of the Kolmogorov-Smirnov test

significantly higher circumference of the calf than the Bs (Table 6).

It is slightly surprising that the players from the different groups do not significantly differ in terms of skin fold (Table 6). Obviously, all playing positions are occupied by players with similar measured values of skin folds (Table 7).

In the parameter of relative body mass, there was a significant difference only between the wings and pivots, with the wings achieving lower values (Table 7). The share

TABLE 3
DIFFERENCES IN BODY HEIGHT (LONGITUDINAL MORPHOLOGICAL DIMENSION) AMONG THE VARIOUS PLAYER SUBGROUPS

Parameter	G	B	W	P
Body height	178.33*	177.68*	168.73*	177.73*

*p<0.05, G – goalkeepers, B – back players, W – wings, P – pivots, W<P, G and B; P>W; G>W; B>W

TABLE 4
DIFFERENCES IN DIAMETER MORPHOLOGICAL DIMENSION PARAMETERS AMONG THE VARIOUS PLAYER SUBGROUPS

Parameter	G	B	W	P
Biacromial diameter[a]	39.23	38.62	37.98*	39.78*
Biliocristal diameter[b]	29.57*	28.61	27.70*	29.49*
Humerus diameter[c]	6.40	6.47	6.31*	6.72*
Wrist diameter[d]	5.34	5.25	5.14	5.33
Femur diameter[e]	9.32*	9.20*	8.80*	9.64*
Ankle diameter[f]	7.10	7.11	6.84*	7.29*

*p<0.05, G – goalkeepers, B – back players, W – wings, P – pivots, [a] W<P, P>W; [b] W<P and G, P>W, G>W; [c] W<P, P>W; [d] no statistically significant differences; [e] W<P, B and G, P>W and B, G>W, B>W, B<P; [f] W<P, P>W

TABLE 5
DIFFERENCES IN CIRCUMFERENCE AND BODY MASS PARAMETERS AMONG THE VARIOUS PLAYER SUBGROUPS

Parameter	G	B	W	P
Circumference of upper arm (relaxed)[a]	28.86	28.65	27.87	29.95
Circumference of upper arm (contracted)[b]	30.24	30.30	29.27	30.93
Circumference of forearm[c]	25.28	25.42*	24.52*	26.27*
Circumference of thigh (subgluteal)[d]	62.60*	59.44*	57.94*	62.22*
Circumference of thigh (medial)[e]	58.33*	55.75	53.99*	58.10
Circumference of calf[f]	39.31*	38.47*	37.07*	40.79*
Body mass[g]	74.60*	69.92*	63.55*	76.93*

*p<0.05, G – goalkeepers, B – back players, W – wings, P – pivots, [a] no statistically significant differences; [b] no statistically significant differences; [c] W<P and B, P>W, B>W; [d] W<P and G, P>W, G>W and B, B<G; [e] W<G, G>W; [f] W<P and G, P>W and B, G>W, [g] W<P, G and B, P>W, G>W, B>W

of fat tissue in total body mass shows no significant differences in terms of this variable. The wings have a significantly smaller body surface than the other three groups of players, who do not significantly differ amongst

TABLE 6
DIFFERENCES IN BODY FAT PARAMETERS AMONG THE VARIOUS PLAYER SUBGROUPS

Parameter	G	B	W	P
Subscapular skin fold[a]	12.23	10.40	11.30	11.56
Triceps skin fold[b]	12.69	11.60	12.34	12.64
Biceps skin fold[c]	7.23	6.25	6.75	7.10
Forearm (volar) skin fold[d]	8.07	7.27	7.81	7.66
Abdominal skin fold[e]	19.27	14.83	17.92	16.98
Chest skin fold[f]	8.81	7.34	8.31	8.22
Suprailiacal skin fold[g]	17.59	12.62	15.61	13.64
Thigh (subgluteal) skin fold[h]	24.77	21.71	22.70	23.70
Calf skin fold (medial)[i]	15.12	13.06	13.45	14.32

*p<0.05, G – goalkeepers, B – back players, W – wings, P – pivots, [a] no statistically significant differences; [b] no statistically significant differences; [c] no statistically significant differences; [d] no statistically significant differences; [e] no statistically significant differences; [f] no statistically significant differences; [g] no statistically significant differences; [h] no statistically significant differences; [i] no statistically significant differences

TABLE 7
DIFFERENCES IN BODY INDEXES AMONG THE VARIOUS PLAYER SUBGROUPS

Parameter	G	B	W	P
Relative body mass[a]	0.410	0.397	0.381*	0.432*
% of body fat[b]	21.43	19.04	20.59	20.55
Body surface[c]	1.93*	1.86*	1.73*	1.95*
Muscle mass[d]	35.49*	34.35*	30.13*	37.34*
% of muscle mass[e]	45.29	45.87	44.16	46.30
Bone mass[f]	11.20	11.20*	9.73*	12.96*
% of bone mass[g]	15.21	16.05	15.36	16.90

*p<0.05, G – goalkeepers, B – back players, W – wings, P – pivots, [a] W<P, P>W; [b] no statistically significant differences; [c] W<P, G and B, P>W, G>W, B>W; [d] W<P, G and B, P>W, G>W, B>W; [e] no statistically significant differences; [f] W<P, and B, P>W, B>W; [g] no statistically significant differences

themselves. With the wings, the absolute quantity of muscle mass is significantly lower than with the pivots, back players and goalkeepers. The other player groups do not significantly differ in terms of the average values measured for this variable. Comparisons between the groups showed no significant differences in terms of the share of muscle mass in total body mass. As regards the absolute quantity of bone mass, the wings achieved significantly lower values than the Ps and Bs. The other player groups do not significantly differ in terms of this parameter. As regards the share of bone mass in total body mass, there were no significant differences between the groups. The results of body indexes also show that the largest differ-

TABLE 8
DIFFERENCES IN SOMATOTYPE PARAMETERS AMONG THE VARIOUS PLAYER SUBGROUPS

Parameter	G	B	W	P
Somatotype-endo[a]	3.96	3.43	3.80	3.69
Somatotype-meso[b]	3.52*	3.46*	3.87	4.52*
Somatotype-ecto[c]	2.56	3.03*	2.41	2.07*

*p<0.05, G – goalkeepers, B – back players, W – wings, P – pivots, [a] no statistically significant differences; [b] P>B, B<P; [c] B>P, P<B

ences occurred between the group of wings and other groups. The highest number of significant differences was observed between P and W. Other groups of players did not differ significantly in terms of these variables (Table 8).

The player groups do not significantly differ in terms of the endomorphic component of the somatotype (Table 8). In terms of mesomorphic and ectomorphic components only the P and B groups differ. Thus, on average, players in the P position achieve significantly higher values in terms of the mesomorphic component than the Bs. On the contrary, those playing in the B position achieve on average significantly higher values in terms of the ectomorphic component of the somatotype than the Ps (Figure 1).

Discussion and Conclusion

The players from our sample were quite similar to a comparable sample of players from Europe in terms of their basic morphological body indicators (height, body mass and body fat). Thus, players from various elite European national teams in the 1996-1999 period were on average 173.9 cm to 178.0 cm tall and their body mass ranged from 66.4 kg to 70.4 kg[28]. More recent are the results concerning the average body height (178.4 cm) and body mass (70.98 kg) of elite Croatian female handball players[9]. Considerable differences emerge in a comparison with top-level Asian players[13]. For the most part, these players have much lower body height values (average values of different national teams ranging between 168 cm and 175 cm) and a lower body mass (average values of different national teams ranging between 60.6 kg and 68.7 kg), whereas the share of subcutaneous fat is quite similar (average values ranging between 18.9% and 24.2%). As expected, the results of our study revealed some significant differences between female handball players in individual playing positions. The most pronounced differences in terms of morphological body parameters, compared to other player groups, were observed with the wings. They are significantly smaller and have a significantly lower body mass than players in all other groups. In terms of transversal measures of the skeleton and the circumferences, the wings significantly differ mainly from the Ps and Gs and slightly less from the Bs – only in terms of the transversal measure of the femur and upper arm circumference. Similar findings were reported by authors who studied differences in the morphological body characteristics of male handball players[10-12]. The situation with subcutaneous fat is interesting. The groups of players do not significantly differ in terms of any skin fold measurement. Thus also the wings with lower values of body height and total body mass do not differ on average from the other player groups in terms of the share of subcutaneous fat. Other authors have reported similar findings[9,13]. The situation is slightly different with male players as the wings have the lowest values of subcutaneous fat of all player positions[10]. In terms of the values of somatotype characteristics (3.80-3.87-2.41) the wings in our sample may be characterised as an endo-mesomorphic type, which is why they are to some extent comparable with male players (only the endomorphic component is more pronounced)[10]. The morphologic body structure of the B players is very interesting. These players are tall and have the lowest share of subcutaneous fat of all the player groups. Significant differences were established mainly in terms of the structure of the lower extremities. Thus the Bs achieved lower values of the diameter of the femur than the Ps, lower subgluteal values of the circumference of the thigh than the Gs and lower values of the circumference of the calf than the Ps. The values of the somatotype characteristics are very balanced between all three components (3.43-3.46-3.03). They achieved significantly lower values in the mesomorphic component compared to the Ps, while at the same time they had significantly higher values of the ectomorphic component than the Ps. The B players are therefore slightly leaner than the rest. This is to be expected considering the tasks they have to carry out during a game. During a game, players in this position are the most burdened with different activities of both cyclic and acyclic natures[29-31]. They have to be well prepared in terms of conditioning, which is related to their balanced

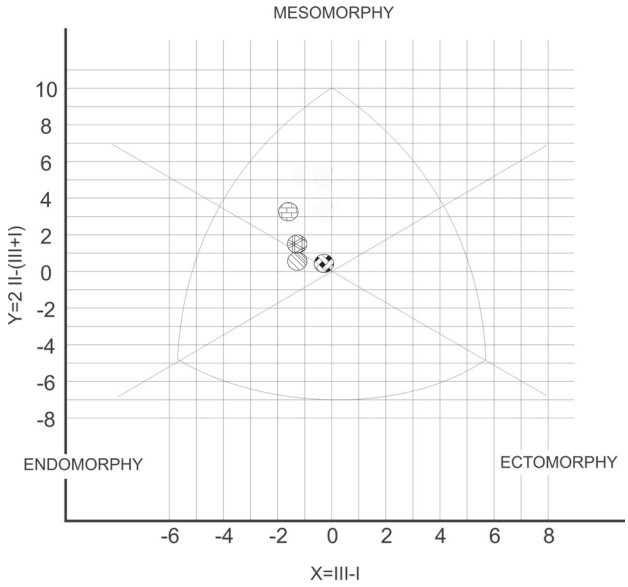

Fig. 1: Somatotype of players in individual playing positions. – Goalkeepers, – Backs players, – Wings, – Pivots.

somatotype characteristics[32]. Similar findings were also reported with samples of elite male handball players[10]. Some authors report a similar situation in women's field hockey. Thus all field players in women's field hockey tend toward mesomorphy; however, the halves and backs tend toward greater mesomorphy and endomorphy and lower ectomorphy than the forwards[33]. Some researchers have suggested that body mass and body composition (% of fat) are associated with the amount of running players do relative to their position[33,34]. The players in the P position are very tall on average, too. They are also characterised by a high body mass value. The average values of circumferences are the highest among all player groups and the same is true for transversal measures of the skeleton. It is very interesting that, compared to the players in other playing positions, they have a low value of subcutaneous fat – lower than the Gs and Ws. All the above characteristics are reflected in the value of the somatotype (3.69-4.52-2.07) which can be described as an endo-mesomorphic somatotype with a pronounced mesomorphic component. During an attack, pivots must also catch lob passes and are hindered by the tall defence players – thus, high body height values can give them an advantage over defence players. Body robustness is particularly important for the Ps who have to carry out different actions in direct physical contact with guards from the opposite team. Most often, these players also take up the most exposed defending positions in defence. In this case, robustness and the previously mentioned body height are extremely important as they facilitate players in blocking the opponent with their body and arms. A pronounced body height is obviously very important for the Gs as the players of this group are on average the tallest of all. Goalkeepers must cover the maximum of the goal area so as to prevent shooters scoring a goal from different attacking positions. Their body height primarily helps them stop shots directed at the upper corners of the goal. The Gs have low values of transversal measures. The exceptions are average values of the biliocristal and femur diameter which are significantly higher than those of the Ws. In terms of circumference, the most pronounced are both circumferences of the thigh and the circumference of the calf where the goalkeepers achieved significantly higher values than the Ws (in terms of subgluteal circumference also significantly higher values than the Bs). The goalkeepers' skin folds are the most pronounced among all groups on average and their share of subcutaneous fat in total body mass is the highest. Something similar was found by some researchers who investigated the morphological body characteristics of both male[10,12] and female[9] handball players. Similar findings were also reported for football[35] and ice hockey[36]. The most pronounced average value of body mass of all player groups was that of the Gs. Specific activities of the handball goalkeeper mainly involve fast short acyclic actions, whereas cyclic activities are relatively scarce and involve running at different speeds. Thus aerobic endurance is of little importance for the goalkeeper's performance[29]. As regards the values of somatotype characteristics (3.96-3.52-2.56), on average, the Gs significantly differed in terms of the mesomorphic component value only from the Ps, with lower values being achieved. Their somatotype can be categorised as endo-mesomorphic, with a pronounced mesomorphic component.

Similarly to their male counterparts and in keeping with many other elite athletes, elite female handball players tend to be lean and muscular. If the players from our sample are compared with highly selected samples of players from sport games which have similar performance requirements – volleyball and basketball – data from different studies yield results which are to some extent similar to ours. Thus, female basketball players achieved the following results in terms of their average body height, body mass and percentage of subcutaneous fat: Greek first division players – body height 174.7 cm, body mass 71.5 kg and share of body fat 24.3%[21]; Bosnian first division players – body height 177.6 cm, body mass 69.8 kg[17]; Spanish first division players: body height 183.2 cm, body mass 74.3 kg and share of body fat 12%[19]. Volleyball players achieved the following values: Greek first division players – body height 177.1 cm, body mass 69.5 kg and share of body fat 23.4%[21]; Australian junior national team players – body height 179.2 cm, body mass 68.4 kg and sum of 7 skin folds 69.7 mm[37]; elite Italian players – body height 178.4 cm and body mass 71.2 kg[38]. Roughly the same also applies to water polo players – the only exception being body height, which in the Scottish national team was only 171.0 cm[39] on average and with elite Australian players whose body height was 173.7 cm[40]. A somewhat different situation was reported for Australian elite women rugby league players[41] and elite ice hockey players[36] from Alberta, Canada whose percentage of body fat and somatotype was slightly above that level, while their mesomorphic component was particularly pronounced. The authors of this study also established differences between players in different playing positions in many morphological parameters. Volleyball, basketball, water polo, ice hockey and rugby players occupying different positions differ in many morphological parameters. A basic law can be derived from all of the abovementioned studies, namely, the greater the quality level of female players, the greater their body height and mass and the lower their share of subcutaneous fat. Although these figures are useful for providing reasonable guidelines for the percentage of body fat in these sports, caution must be exercised when interpreting such data due to the methods used to assess body fat. All of the above studies (including ours) used skin fold thickness measures, but varied in the use of skin fold sites. Moreover, with women athletes the fact that the quantity of subcutaneous fat can change substantially between the preparatory and competitive seasons must be taken into consideration[39].

Our results show that in female handball the selection of players for individual playing positions must also be based on the players' morphological characteristics. Coaches should have good knowledge of the general and specific tasks that are to be executed by players in the game. At the same time, they have to be familiar with the morphological body characteristics players should possess to perform the tasks required by individual playing posi-

tions with the greatest efficiency. The tallest players should thus be oriented to back player positions. As regards pivots, the coaches must, besides body height, consider robustness. For goalkeepers, body height is very important; however, the robustness criteria are slightly lower. For wings, body height is not a decisive factor and smaller players can also occupy this position. Both of the above (also taking other criteria into account) facilitate coaches' decisions when orienting players into their playing positions.

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RAZLIKE U ODABRANIM MORFOLOŠKIM TJELESNIM KARAKTERISTIKAMA KOD RAZLIČITIH IGRAČKIH POZICIJA KOD VRHUNSKIH RUKOMETAŠICA

SAŽETAK

Cilj studije je bio utvrditi glavne morfološke karakteristike ženskih juniora i vrhunskih igračica u reprezentaciji Slovenije. Morfološke karakteristike različitih igrača u podskupinama (vratari, krila, leđa igrača i osovina) također su određena kako bi utvrdilo da li su imali različita profile. Ispitano je 87 rukometašica koji su bili pripadnici slovenske juniorske i seniorske ženske reprezentacija u razdoblju od 2003. do 2009. godine. Standardizirani antropometrijski protokol je korišten za procjenu morfoloških karakteristika subjekata. Mjerenja uključuju 23 različite antropometrijske mjere. Prvo, osnovne statističke značajke antropometrijskih mjera dobiveni su za sve ispitanike zajedno te se za svaku skupinu posebno. Somatotipi su određeni koristeći Heatha-Carter metodu. Endomorfne, mezomorfne i ektomorfne komponente je izračunato pomoću računala na temelju formula. Kako bi se utvrdilo razlike u sastavu tijela i antropometrijskih podataka subjekata koji igraju na različitim pozicijama, upotrebljena je jednosmjerna analiza varijance. Rezultati

pokazuju da se, u prosjeku, krila najviše razlikuju od ostalih igračkih grupa u pogledu njihovih morfoloških karakteristika tijela. Krila se razlikuju od drugih igračkih skupina u pogledu njihovih morfoloških parametara jer su prosječno niži i imaju statistički značajno nižu tjelesnu masu od ostalih skupina. U smislu transverzalnih mjera kostura i ospega, krila se značajno razlikuju uglavnom od pivota i vratara, a manje od vanjskih igrača. Vratari su bili najviši, s visokim vrijednostima tjelesne mase i niskim vrijednostima poprečnih mjera u odnosu na pivote. Njihovi kožni nabori su najizraženiji među svim skupinama i njihov udio potkožnog masnog tkiva u ukupnoj tjelesnoj masi je najviši. Prema tome, njihova endomorfna komponenta somatotipa je izražena. Pivot su bili značajno viši od krilnih igrača, ali nisu bili značajno različiti od vratara i vanjskih igrača. Oni su imali visoke vrijednosti tjelesne mase koje su bile znatno veće nego kod krila, ali se nije bitno razlikovala od tjelesne mase vrijednosti vanjskih igrača i vratara. Prosječne vrijednosti njihovih opsega je bila najviša među svim skupinama igrača, a isto vrijedi i za transverzalne mjere kostura. Vrlo je zanimljivo da su, u usporedbi s igračima na drugim igračkim pozicijama, oni postigli niske vrijednosti potkožnog masnog tkiva. Njihove vrijednosti somatotipa su otkrile endo-mezomorfno somatotip, s izrazitim mezomorfnim komponentama. Vanjski igrači su bili visoki i imali su najmanji udio potkožnog masnog tkiva od svih igračih skupina. Značajne razlike su ustvrđene uglavnom u smislu strukture donjih ekstremiteta. Vrijednosti svojstava somatotipa su vrlo uravnotežene između svih triju komponenti. Rezultati našeg istraživanja potvrđuju da skupine rukometaša koji zauzimaju različite pozicije se razlikuju među sobom u pogledu mnogih mjerenja. To je rezultat specifičnih zahtjeva rukometne igre koje trebaju ispunjavati pojedini igrači. Najviši igrači stoga treba biti usmjerena na vanjske pozicije. Treneri moraju, u pogledu pivota, osim tjelesne visine misliti i na robusnost. Za vratare, tjelesna visina je vrlo važna; Međutim, kriteriji za robusnost su nešto niži. Tjelesna visina nije odlučujući faktor krilima pa i manji igrači mogu zauzeti tu poziciju. Ove karakteristike (uzimajući u obzir i druge kriterije) mogu uvelike olakšati odluke trenera prilikom usmjeravanja igrača u svoje igračke pozicijama.