POSITIONAL DIFFERENCES IN ANTHROPOMETRIC CHARACTERISTICS OF THE CROATIAN U18 FEMALE FIELD HANDBALL PLAYERS

Dinko Vuleta[1], Lidija Bojić-Ćaćić[2], Dragan Milanović[1], Marjeta Mišigoj Duraković[1], and Dražan Dizdar[1]

[1]Faculty of Kinesiology, University of Zagreb, Zagreb, Croatia
[2]Croatian Handball Federation, Zagreb, Croatia

Original scientific article
DOI: 10.26582/k.52.1.10

Abstract:

The aim of the study was to analyze the position-related differences in anthropometric characteristics of 32 Croatian selected female handball juniors (average age 18.43 years) who played in three positions: backs (B; n=19), wings (W; n=7) and pivots (P; n=6). Twenty-four anthropometric measures, defining the four latent morphological dimensions, were used. Globally, significant differences were revealed by means of ANOVA in 11 morphological measures (seven at $p \leq .01$ and four at $p \leq .05$) between the three groups of female juniors with no significant differences in longitudinal dimensions. Only one significant positional difference was found between pivots and backs (in the lower leg skinfold in favour of pivots suggesting a higher body fat percentage). Between wings and pivots no significant differences were found in longitudinal body dimensions; however, the measures of skeletal transversality, voluminosity and partially of fatty tissue (two variables) corroborated the fundamental difference between these two positions: pivots' body built was more robust. No significant differences were found in longitudinal and almost all transversal measures between backs and wings; the differences in body voluminosity (all in favour of backs) were probably due to the selection process. In the juniors' somatotype (3.72–3.49–2.32), endomorph and mesomorph components were predominant over the ectomorph component, in which the lowest values were obtained from the players in all the three positions. It is of outmost importance that handball practitioners focus on the reduction of players' percentage of subcutaneous fatty tissue and on the enhancement of the portion of active muscle mass in their body composition by the implementation of quality sports training programmes and changes in dietary habits if better game performance and sports achievements of the Croatian junior female handball players are expected.

Key words: *team handball, female players, juniors, body composition, body anthropometry, playing positions, pivots, backs, wings*

Introduction

Competition performance and sports achievements in handball, like in other invasion team sports, depend on a myriad of factors, some of which are hardly predictable, and all are intertwined influencing each other (Gréhaigne, Godbout, & Bouthier, 2001; Hughes & Bartlett, 2002; Lamas, Barrera, Otranto, & Ugrinowitsch, 2014). Therefore, sport practitioners and scholars have been striving for decades to reduce as many unknowns as possible. Players' constitution, or anthropometry, belongs to the so-called internal factors of playing performance, together with sex, age, genetics, maturity, and characteristics of players' physiological functioning (Michalsik, 2018). "From a physical point of view, the success of a team depends on selecting the right players for the various playing positions and developing a tactical approach that fits the strengths of the available players." (Michalsik, 2018: 18) Although there are many compensatory mechanisms, both the handball practitioners and scholars are seeking to get an insight into what is an appropriate anthropometry, being a prerequisite for good performance, especially with regard to handball position-specific requirements (Bon, Pori, & Šibila, 2015; Karcher & Buchheit, 2014; Michalsik, Aagard, & Madsen, 2015; Urban & Kandrač, 2013; Vuleta, Milanović, & Sertić, 1999; Vuleta, Milanović, et al., 2009; Wagner, Finkenzeller, Würth, & von Duvillard, 2014; Weber & Wegner, 2016; Zapartidis, et al., 2009). The position-specific requirements for players' anthropom-

etry have their origin in the match-play position-specific technical-tactical activities players execute while playing in the positions of either goalkeepers or field players: backcourt (B), wing (W), or line (P for pivot) players (Lidor & Ziv, 2011; Manchado, Hoffmann, Valdivielso, & Platen, 2007; Manchado, Tortosa, Vila, Ferragut, & Platen, 2013; Michalsik, Madsen, & Aagaard, 2014¸ Weber & Wegner, 2016). Pronounced longitudinal dimensions, especially body height and large hands, may be more important for backs than for wings, whereas a higher speed of movement and reaction is apparently more important for wings (Rogulj, Srhoj, Nazor, Srhoj, Lj., & Čavala, 2005; Srhoj, 2002; Šibila & Pori, 2009) since they perform more fast-breaks and engage in fewer physical confrontations (Michalsik, et al., 2015). Due to their higher speed and specific playing jobs and tasks, wings do not frequently establish direct body contacts with the opposition while attacking, thus their body built need not be especially robust (they may have lower values of body height, body mass and body voluminosity; Weber & Wegner, 2016) like the body constitution of pivots, who constantly establish body contacts with the opponents while struggling for the front position, trying to open free for ball reception, setting screens, or taking a shot (Bojić-Ćaćić, Vuleta, Milanović, Barišić, & Jerak, 2018; Čavala & Katić, 2010; Karcher & Buchheit, 2014; Karpan, Škof, Bon, & Šibila, 2015; Moss, McWhannell, Michalsik, & Twist, 2015;).

In the last two decades, a number of research papers have focused on anthropometric characteristics of adult women handball players (for example: Bon, et al., 2015; Čavala & Katić, 2010; Granados, Izquierdo, Ibanez, Bonnabau, & Gorostiaga, 2007; Manchado, Tortosa, Vila, Ferragut, & Platen, 2013; Michalsik, et al., 2015; Vila, et al., 2012), but only a few dealt with female juniors (for example: Belka, Hulka, Safar, Weisseer, & Samcova, 2014; Moss, et al., 2015; Noutsos, Meletakos, & Bayios, 2019; Srhoj, 2002). Milanese, Piscitelli, Lampis, and Zancanaro (2011) investigated BMI of younger junior handball players and established the average BMI value of 23.35, indicating the pronounced ectomorph body constitution. Bon et al. (2015) established an average of 20.03% of body fat in Slovenian junior handballers, whereas Milanese et al. (2011) found body fat values of even 28.5% in the Italian female handballers (aged 17-19 years). In several research studies (Bon, et al., 2015; Čavala, Trninić, Jakšić, & Tomljanović, 2013; Villa, et al., 2011), it has been established that circle runners or pivots are more robust, havier, with larger transversal body dimensions than the wing players. Further, the backcourt players are taller than their teammates in other playing positions, whereas the wings are smaller and lighter than their teammates (Bon, et al., 2015; Granados, et al., 2007; Manchado, et al., 2013; Michalsik, et al., 2015; Weber & Wegner, 2016).

A favourable or desirable body constitution of female handballers generally refers to the mesomorph component being predominant over the relatively balanced endomorph and ectomorph component, although values of all the three somatotype components do not exceed average values of the general Caucasain female population (Bayios, Bergeles, Apostolidis, Noutsos, & Koskolou, 2006; Bon, et al., 2015; Čavala, et al., 2013; Exposito, et al., 2011; Nogueira, Cunha Junior, Dantas, & Fernandes Filho, 2005; Noutsos, et al., 2019; Urban, et al., 2013). Anthropometric measurements are indispensable in talent identification and selection for professional sport, as well as in training programme design and nutritional regime prescription and control (Mišigoj-Duraković, 2008).

In the last two decades, the situation with the Croatian women's handball is such that many juniors are expected to join their senior teammates in teams competing even in the Croatian Premier Handball League, due to which their formative sporting years, as a rule, are shortened considerably, thus making appropriateness of their anthropometric characteristics even more important. In the age category of juniors, after a decade of handball training and competition, players' position specialization has almost been finished.

The research aim was to establish both the extent and structure of position-specific differences in anthropometric characteristics among the Croatian selected female handball juniors (U18) who played in the positions of wings (W), backs (B) and pivots (P). We hypothesized that global, general differences existed between the three groups (B, W, P) of the Croatian U18 female handball players in their anthropometric characteristics, somatotypes included. Furthemore, we sought to see which differences between U18 pivots and backs, pivots and wings, and backs and wings contributed in partricular to the general positional differences.

Methods

Sample of subjects

The sample of participants consisted of 32 female junior hanball players (age 18.43±0.80 years), the members of the Croatian handball clubs who had been evaluated beforehand by their coaches and the Croatian Handball Federation's selectors as promising elite players according to their handball skills and experience, thus being representative for the Croatian women's handball of the respective age category. They participated in the preparation camp of the expanded U18 national team. Out of the total sample (N=32), seven were wingers (W; n=7), 19 backcourt players (B; n=19), and six were circle runners or pivots (P; n=6). The participants,

or their parents or guardians, provided the signed informed consent forms agreeing on the participation in the national team preparation camp and corresponding anthropometric measurements and physical fitness testing.

Sample of variables

Twenty-four anthropometric variables were chosen presenting the four well-defined latent morphological dimensions: longitudinal dimensionality of skeleton (body height, leg length, arm length, and arm span), transversal dimensionality of skeleton (shoulder width, knee diameter, elbow diameter, wrist diameter, ankle diameter, and hip width), body voluminosity and body mass (body mass, upperarm circumferences – extended and flexed, forearm circumference, thigh circumference, and calf circumference), and subcutaneous fatty tissue (assessed by eight skinfold measures: subscapular, abdominal, triceps, thigh, lowerleg, suprailiac, axillary, and chest) (Katić, Zagorac, Živičnjak, & Hraski, 1994; Kurelić, et al., 1975; Mišigoj-Duraković, 2008). The measurement procedures by which the variables were obtained respected procedures explained in Mišigoj-Duraković (2008), based on the International Biological Program, and were executed in conformity with the Helsinki Declaration. All but one anthropometric measure was taken once; thickness of skinfolds was obtained by three sequential measurements (Bojić-Ćaćić, 2018). Out of the obtained measures, players' somatotype was established, using the Heath-Carter anthropometric somatotype method (Carter, 2002). Body mass index (BMI) was computed as the ratio of weight in kilograms (kg) divided by height in metres-squared (m^2). The assessment of body density was based on Jackson-Pollock generalized prediction skinfold equation (Jackson, Pollocket, & Ward, 1980) and then converted to body fat percentage (%FM) using the Siri's equation (Siri, 1961).

Statistical analysis

Basic statistical methods were utilised to compute the descriptive indicators of variables – arithmetic mean (Mean) and standard deviations (SD) for the entire sample and for the positions in particular. The goodness of fit was verified with the Kolmogorov-Smirnov test.

Table 1. Basic descriptive parameters of body height and body weight, BMI and body fat percentage of the total sample of U18 female handball players (N=32)

Variables	*Mean*	*SD*
Body height (cm)	172.02	6.74
Body weight (kg)	68.18	8.40
BMI (kg/m²)	24.13	1.82
% body fat	18.37	3.87

Univariate analysis of variance (ANOVA) was used to test the set hypotheses, i.e. to establish the global and particular differences among the three groups of U18 female handballers playing in the positions of backs, wings and pivots in their morphological characteristics.

Data were processed by the Statistica for Windows, ver. 7.0.

Results

Basic descriptive statistics of body height, body weight, BMI and body fat percentage of the total sample of participants is presented in Table 1.

The Croatian female handball juniors are 172.02±6.74 cm high on average. Since Croatian girls on average reach almost 98% of their adult body height (BH) at the age of 16.5 years (Mišigoj-Duraković, 2008) and their noticeable growth usually stops around the age of 18 years, no considerable changes in their body height is expected in the future.

Basic descriptive parameters and analysis of positional differences, global and particular alike, in the variables of anthropometric characteristics of the Croatian female handball juniors are presented in Table 2.

At the global level, the significant differences were established among the juniors in 11 anthropometric variables: knee diameter (p=.02), elbow diameter (p=.01), hip width (p=.02), body mass (p=.00), extended upperarm circumference (p=.01), flexed upperarm circumference (p=.03), forearm circumference (p=.02), thigh circumference (p=.01), calf circumference (p=.01), lowerleg skinfold (p=.00), and midaxillary skinfold (p=.01). The differences were obtained in the spaces of body transversality, body mass and body voluminosity. No global difference was found for the longitudinal body dimensions.

These global differences were obtained mainly due to the particular differences between the wings, on the one hand, and the pivots, primarily, and backs, on the other. Namely, between the backs and pivots only one significant difference was found (lowerleg skinfold; p<.05). Pivots and wings differed significantly in the following variables: knee diameter (p<.05), elbow diameter (p<.01), body mass (p<.05), extended upperarm circumference (p<.01), forearm circumference (p<.05), thigh circumference (p<.05), calf circumference (p<.01), lowerleg skinfold (p<.00), and midaxillary skinfold (p<.05). Backs and wings differed in the following: hip width (p<.05), body mass (p<.01), extended upperarm circumference (p<.05), flexed upperarm circumference (p<.05), thigh circumference (p<.05), calf circumference (p<.05), and midaxillary skinfold (p<.01).

Antropometric somatotype components of the participants are displayed in Table 3.

Table 2. Basic descriptive parameters of anthropometric characteristics and analysis of positional differences among female junior handball players

U18 female handball players' anthropometric measurements	Mean±SD			Total		PIVOTS vs. BACKS	PIVOTS vs. WINGS	WINGS vs. BACKS
	PIVOTS (6)	BACKS (19)	WINGS (7)	F	p	p	p	P
ALVT (cm)	171.28±7.72	173.68±6.51	168.16±5.59	1.86	0.17	0.74	0.70	0.18
ALDN (cm)	96.23±5.57	98.02±4.66	94.99±4.31	1.14	0.33	0.73	0.90	0.37
ALDR (cm)	73.03±2.97	74.76±3.56	72.40±3.10	1.51	0.24	0.56	0.94	0.30
ALRR (cm)	168.02±6.84	172.59±7.65	167.29±5.37	1.91	0.17	0.40	0.98	0.26
ATSR (cm)	38.37±2.48	38.10±1.56	37.30±2.45	0.58	0.57	0.96	0.62	0.66
ATDK (cm)	9.32±0.60	9.07±0.44	8.57±0.33	4.80	**0.02**	0.53	**0.02**	0.06
ATDL (cm)	6.53±0.37	6.26±0.27	6.00±0.19	6.08	**0.01**	0.13	**0.01**	0.11
ATDRZ (cm)	5.13±0.33	5.24±0.42	4.81±0.36	2.99	0.07	0.85	0.35	0.07
ATDSZ (cm)	7.28±0.42	7.05±0.37	6.84±0.22	2.53	0.10	0.37	0.10	0.43
ATSZ (cm)	27.90±2.27	29.24±1.65	26.86±1.76	4.85	**0.02**	0.30	0.59	**0.02**
BW (kg)	71.78±4.19	70.20±8.11	59.60±6.35	6.42	**0.00**	0.90	**0.02**	**0.01**
AVONADE (cm)	29.03±2.32	28.21±1.38	26.03±1.88	5.97	**0.01**	0.58	**0.01**	**0.02**
AVONADF (cm)	30.18±1.92	30.04±1.45	27.99±2.09	4.20	**0.03**	0.98	0.08	**0.03**
AVOPOD (cm)	25.67±1.49	25.10±1.06	23.77±1.38	4.48	**0.02**	0.61	**0.03**	0.06
AVONAT (cm)	61.37±2.20	59.76±3.88	55.20±3.81	5.52	**0.01**	0.64	**0.02**	**0.03**
AVOPOT (cm)	38.70±1.67	37.70±2.22	35.13±1.35	6.11	**0.01**	0.56	**0.01**	**0.02**
ANL (mm)	10.97±2.88	11.20±3.05	8.80±2.04	1.87	0.17	0.99	0.40	0.18
ANT (mm)	21.51±7.40	18.64±5.25	15.06±3.45	2.36	0.11	0.53	0.12	0.34
ANNAD (mm)	15.53±5.16	15.95±2.67	13.14±3.00	1.88	0.17	0.96	0.44	0.17
ANNAT (mm)	24.94±10.59	23.93±5.49	20.61±4.34	0.88	0.43	0.95	0.49	0.52
ANPOT (mm)	18.16±3.93	13.82±3.27	11.29±2.41	7.42	**0.00**	**0.03**	**0.00**	0.23
ANSIL (mm)	15.89±5.64	13.20±6.49	8.55±1.92	2.88	0.07	0.60	0.08	0.20
ANAKS (mm)	12.98±4.83	12.90±3.50	7.77±1.47	6.00	**0.01**	1.00	**0.04**	**0.01**
ANP (mm)	13.40±2.70	11.89±3.59	10.30±3.91	1.26	0.30	0.66	0.30	0.60

Note. F – results of F test; p – level of significance; ALVT – body height; ALDN – leg length; ALDR – arm length; ALVT – body height; ALDN – leg length; ALRR – arm span; ATSR – shoulder width; ATDK – knee diameter; ATDL – elbow diameter; ATDRZ – wrist diameter; ATDSZ – ankle diameter; ATSZ – hip width; BW – body weight; AVONADE – extended, relaxed upperarm circumference; AVONADF – flexed, contracted upperarm circumference; AVOPOD – forearm circumference; AVONAT – thigh circumference; AVOPOT – calf circumference; ANL – subscapular skinfold; ANT – abdominal skinfold; ANNAD – triceps skinfold; ANNAT – thigh skinfold; ANPOT – lowerleg skinfold; ANSIL – suprailiac skinfold; ANAKS – midaxillary skinfold; ANP – chest skinfold.

Table 3. Somatotypes of the Croatian female junior handball players – basic descriptive parameters and differences among the three groups

U18 female handball players' somatotype components	MEAN±SD			Total		PIVOTS vs. BACKS	PIVOTS vs. WINGS	WINGS vs. BACKS
	PIVOTS (6)	BACKS (19)	WINGS (7)	F	p	p	p	p
ENDOMORPHY	4.122±0.947	3.846±0.919	3.025±0.574	3.113	0.060	0.795	0.091	0.117
MESOMORPHY	4.371±0.664	3.425±0.639	2.891±0.937	7.102	**0.003**	**0.029**	**0.003**	0.256
ECTOMORPHY	1.654±0.908	2.286±0.585	2.977±0.797	5.866	**0.007**	0.172	**0.008**	0.098

The entire sample of the Croatian female handball juniors demonstrated generally endomorph-mesomorph somatotype (3.72–3.49–2.32), where both components significantly predominated over the ectomorphic component, especially in the pivots. Only the wings demonstrated a rather balanced ratio among the three somatotype components.

Discussion and conclusions

Generally, the Croatian junior female handballers (BH 172.02±6.74 cm) are on average taller than their Czech (169.60±6.9 cm; Belka, et al., 2014), Greek (166.6±4.5 cm; Noutsos, et al., 2019), and Spanish (169.93±4.51 cm; Exposito, et al., 2011) peers; however, they are smaller than the Danish juniors, being the European champions (176.3±6.6 cm; Moss, et al., 2015). The Croatian senior female handballers (elite 178.23±3.55 cm, average 180.07±7.40 cm; Čavala, Rogulj, & Srhoj, 2008), Slovene juniors and seniors (175.43±6.68 cm; Bon, et al., 2015), Danish Premier League seniors (175.4±6.1 cm; Michalsik & Aagaard, 2015) as well as the members of the 12 junior national teams (173.98±5.89 cm; Urban, et al., 2011) are taller than the Croatian juniors. Since it has been established (for a review see Manchado, Tortosa, et al., 2013; Lidor & Ziv, 2011) that a pronounced body height of players is performance relevant in handball, especially for the goalkeepers, backs and pivots, body height may be one of the reasons why the Croatian junior female handballers are inferior to their higher ranked and more successful European peers.

As regards body mass, the Croatian juniors had 68.18±8.40 kg on average, which was similar to the Croatian senior players (70.86 kg; Čavala, 2012) and Danish Premier League seniors (69.5±6.5 kg; Michalsik & Aagaard, 2015); however, the Croatian juniors were on average havier than the Slovene both seniors and juniors (69.85±8.81 kg; Bon, et al., 2015) and Czech juniors (65.4±6.9 kg; Belka et al., 2014.). At the 2011 ECh for female junior handball players, Urban and associates (2011) established an average body mass of players in 12 national teams to be 71.26 kg. Information on body mass alone does not contribute significantly to the understanding of its performance relevance; its structure, i.e. the odd ratio between lean body mass, especially the muscular one, and body fat is more performance important.

Body mass index (BMI) of the entire sample of the Croatian juniors was 24.13 kg/m^2, which was similar to the values found in the Italian first league players, aged between 17-26 years (23.3±4.01 kg/m^2; Milanese et al., 2011), and Spanish cadet and junior members of the national teams (25.73±9.67 kg/m^2 and 23.95±2.88 kg/m^2, respectively; Exposito, et al., 2011). When compared to the BMI values of the Croatian senior players, high ranked first league players and national team members (22.70±1.99 kg/m^2; Čižmek, Ohnjec, Vučetić, & Gruić, 2010), or Greek peers (21.88±2.91 kg/m^2; Naisidou, Kepesidou, Kontostergiu, & Zapartidis, 2017; 21.49±2.35 kg/m^2; Zapartidis, Toganidis, et al., 2009; selected for the national team 20.79±2.38 kg/m^2; Zapartidis, Vareltzis, Gouvali, & Kororos, 2009), it becomes obvious that the BMI values of the Croatian junior handball players are far from the optimal level. Fortunately, BMI and body weight are training sensitive, that is, they can be transformed under the influence of sports training and proper diet intervention (Milanović, 2010; Mišigoj-Duraković, 2008).

Body fat percentage was in the Croatian juniors 18.37%, which was lower than in the Slovene seniors and juniors (20.03%; Bon et al., 2015). In Spanish elite professional players (aged 23.5 years) and amateur players (aged 21.4 years), a portion of body fat was 20.5% and 23.3%, respectively (Granados, et al., 2007). Urban and associates (2011) reported much lower body fat percentage (11.35±3.95%) in the European Championship participants, members of 12 national teams. The findings indicate that, when selecting young players for a team, preference should be given to the players whose anthropometric characteristics meet handball game requirements (in general and by playing positions), which means the players of the pronounced athletic body built with a small contribution of body fat (Čavala, et al., 2013).

The differences between pivots and backs

In the current study, no significant differences were revealed between backs and pivots in all variables but in one: lower leg skinfold in favour of pivots.

Pivots were 171.28 cm tall and backs 173.68 cm. Their arm span was 168.02 cm and 172.59 cm, respectively. Due to the age of the investigated players, that is the age at which the stage of pronounced growth has usually been completed, no significant changes are expected in the future in the longitudinal dimensionality of their skeleton. Our participants were somewhat higher than their Czech peers (Tuma & Vozobulova, 2011), but considerably smaller than the peer members of 12 national teams participating in the European Championship (Urban, et al., 2011): European pivots were 175.56 cm tall, and left and right backs were 178.69 cm tall (centre backs were somewhat smaller: 173.63 cm). The tallest national team was the Polish team the players of which had an average body height of 177.75 cm (Urban, et al., 2011).

Although no difference in tranversal body measures reached either level of significance, we would like to highlight them because they may be beneficial for the design of selection criteria for a particular playing position. Pivots were somewhat heavier than backs (71.70 kg and 70.20 kg, respectively), which was in line with the positional requirements, as demonstrated in the study on the 12 national teams' members (77.16 kg and 68.20 kg for pivots and backs, respectively; Urban et al., 2011). European pivots were expectedly havier than the Croatian pivots because the former were taller than the latter. Pivots are supposed to have

a marked robust body built since they play under constant physical contact, fighting for the front position in attack by assuming and maintaining a diagonal semi-squat stance. An undesirable result of the comparison emerged for the Croatian backs: they were all heavier than the European centre backs.

The differences between pivots and wings

In the current study, no significant differences were found between pivots and wings in all variables depicting longitudinal body dimensionality: pivots were 171.28 cm tall which was by three non-significant centimetres more than body height of wings (168.16 cm). The results are comparable with the results of the Czech peers (Tuma & Vozobulova, 2011). The Croatian players were smaller than their European counterparts, but the similar difference in body height values was obtained between pivots and wings by Urban and associates (2011) with the national teams' members at the European Championship: pivots 175.56 cm and wings 170.08 cm. When the average results of European and Croatian pivots and wings are compared to those of Danish international elite senior players (Michalsik, Madsen, & Aagaard, 2011), then it is feasible to say that European juniors have completely satisfied anthropometric criteria for top-level performance. The Croatian junior wing players also met elite standard's anthropometric criteria related to the longitudinal body dimensionality, which cannot be said for the Croatian pivots who were considerably smaller than their Danish elite counterparts.

Two variables from the space of transversal body dimensionality significantly differed pivots from wings: knee and elbow diameters, both in favour of pivots. These differences corroborate fundamental differences in body built between pivots and wings. Body physique of pivots should be more robust and they need powerful musculature to be able to struggle for favourable position for ball reception and shooting or for screen setting; that is, they attempt to invade and control some space within the defensive wall, where there is almost no space for movements without the ball, while simultaneously sustaining and overcoming resistance coming from defenders who are attempting to deny the mentioned actions to pivots (Michalsik, et al., 2011; Michalsik, Madsen, & Aagard, 2014; Vuleta, et al., 1999; Vuleta, Milanović, et al., 2009). Pivots usually play the most demanding positions in defence (in the heart of defence executing tasks of centre-halves or halves). Conversely, wings usually play in side, end defensive positions (numbers 1 and 6) where they rarely establish physical contact with powerful, robust attackers; in attack, wings rarely execute one-on-one actions; more often, they run in fastbreaks or realize open shots, created by their teammates.

Out of six variables depicting body voluminosity, significant differences between pivots and wings were established in five: body mass, extended upperarm circumference, forearm circumference, thigh circumference, and calf circumference, all in favour of pivots. The selection of players for a particular position was obviously well executed since stronger, heavier, more robust and muscular players were pivots (body mass 71.78 kg), as demonstrated here and in the section on transversal body dimensionality, whereas wings were of a more delicate body built (body mass 59.60 kg, stature 168.16 cm). The Croatian wings are considerably lighter than their European counterparts, members of 12 national teams (64.45 kg; Urban, et al., 2011) and Danish elite senior wings (63.50 kg; Michalsik, et al., 2011). The Croatian wings should develop their muscle mass if they are to compete successfully with European elite handball wings.

The differences between wings and backs

Interestingly enough, no significant differences between wings and backs were obtained in variables of the longitudinal skeletal dimensionality. Wings and backs were 168.16 cm and 173,68 cm tall, respectively, indicating that both were taller than their Czech counterparts (Tuma & Vozobulova, 2011). We expected significant differences since numerous previous studies indicated wing players were considerably if not significantly smaller than their colleagues in other playing positions (e.g., Bon, et al., 2015). The absence of significance may be attributed to body height of the Croatian backs.

A significant difference between backs and wings was revealed in only one variable depicting body skeletal transversality: hip width, in favour of backs. Significant differences, also in favour of backs, were found in five, out of six, variables of body voluminosity: body mass, extended upperarm circumference, flexed upperarm circumference, thigh circumference, and calf circumference. These differences also reveal different selection criteria for the positions of backs and wings. Taller and heavier players, whose greater body weight is a consequence of their higher stature and well-developed musculature (expressed in circumferences) have been directed to the positions of backs. The former statement is corroborated by the absence of significant differences in all skinfold measures but one (midaxillary skinfold). Michalsik and associates (2011) have demonstrated that backs need athletic body build since they are, during a game, frequently exposed to intense physical contacts in both defence and attack; in attack, they are tackled by defenders when executing either jump shots or ground shots and, even more, when executing brekthroughs or feints.

Somatotype: characteristics and differences among the three groups of the Croatian female junior handball players in different positions

It is well known that somatotyping is a taxonomy method by which human physique, its present shape and composition is quantified and described through a contribution of three components: endomorphy, mesomorphy and ectomorphy (Carter, 2002).

Urban and associates (2001) investigated 207 junior handball players from 12 national teams at the European championship and determined their somatotype using anthropometric Heath-Carter method: 2.20–4.17–2.19, meaning that female handball juniors were mesomorphs with the equal contribution of endomorph and ectomorph components (balanced mesomorphs). Predominant mesomorphs played for the national teams of Croatia, Denmark, France, Germany, Hungary, the Netherlands, Poland, Romania, Russia and Slovenia. In 59 Spanish national team players, ranging in age from cadets to seniors, Exposito and associates (2011) found the following values of somatotype components: A national team (n=11; age 28.07±4.41 years) 3.35±0.71–4.31±1.14–2.62±0.8; B national team (n=16; age 22.09±3.33 years) 3.78±0.75–4.30±0.78–2.39±1.02; junior national team (n=14; age 18.42±0.62 years) 4.24±0.98–4.89 ±1.91–2.62±1.02; cadet national team (n=18; age 16.74±0.59 years) 4.50±1.53–4.80±2.40–2.14±1.09. An elevated contribution of endomorph component is obvious in the subsamples of cadet and junior players. Members of the Brazilian senior national team (Nogueira, et al., 2005), the world champions in 2013, demonstrated favourable somatotype in which mesomorph component prevailed over comparable endomorph and ectomorph components (2.65±0.88–3.03±1.18–2.73±1.18).

Such a favourable morphological built, determined in previous studies (Bayios, et al., 2006; Bon, et al., 2015; Čavala, et al., 2013; Exposito, et al., 2011; Nogueira, et al., 2005; Urban, et al., 2013) was not found in the Croatian female juniors. The Croatian junior female players' somatotype was generally characterized by the predominance of endomorph and mesomorph components, whereas ectomorph component had low values (3.72–3.49–2.32).

Croatian pivots differ significantly from their peers in the positions of backs and wings in the mesomorph component – they are distinctly athletic and predominant with their musculature and robust body built, which is in accordance with their positional tasks. The differences are in line with the results obtained with the Slovene junior and senior national team players (Bon, et al., 2015). However, mesomorph component barely prevailed over endomorph component, which is contrary to the findings published by Urban et al. (2013). That means that the Croatian pivots have a greater portion of fatty tissue than the European pivots in their body composition. In the Croatian backs, a slight prevalence of the endomorph over the mesomorph component was registered, whereas the ectomorph component had the least contribution to their somatotype. Conversely, the participants in the European championship had quite opposite ratios of somatotype components (Urban, et al., 2013): the mesomorph component was considerably predominant over the other two, where the endomorph component had the least contribution to their body composition. In Croatian junior wings, all the three somatotype components were in balance, meaning that the favourable mesomorph component was not predominant and that the endomorph component had a too large contribution to their somatotype when compared to the wings participating in the European championship.

In conclusion, the findings of the current study revealed anthropometric status of the Croatian junior female handball players was not at the level needed for higher game performance and sports achievements. The Croatian female handball juniors have not been at the topmost tier of the European national teams for a decade and more. One of the most relevant reasons for such a situation with the national team sports achievements may be found in morphological characteristics of the Croatian junior female players. Namely, an excessive portion of fatty tissue in athletes' body composition is a ballast mass that has a negative impact on players' performance due to an additional load imposed on their organisms, therefore on the organisms' functioning, thus reducing players' speed of running, jump efficiency, their endurance and agility (Mišigoj-Duraković, 2008). Therefore, it is of outmost importance to reduce players' body fat percentage and enhance the portion of active muscle mass in their body composition by the implementation of quality sports training programmes and changes in dietary habits. To achieve the wanted objective, it is necessary to plan and realize more training hours per week than is the current average of 12 training and competition hours a week. Namely, the insight into the unpublished results of the internal survey of the Croatian Handball Federation on the number of training sessions Croatian clubs realized for all age category players reveals that the Croatian female junior players have 20-30% fewer training sessions than their cadet colleagues with a negligible portion of individual training sessions, either with resistance or without it. Croatian handball practitioners should therefore enhance the number of training sessions, especially those aiming at developing aerobic and anaerobic endurance as well as dynamic and static strength. Also, qualitatively and quantitatively adequate, correctly dosed nutrition is essential for achieving sports success. Moreover, regular testing of players should be implemented in Croa-

tian clubs to allow for timely and adequate introduction of appropriate training operators. And last but by no means least, although handball is a team sport game, more individualized training programmes should be implemented across the Croatian handball clubs.

References

Bayios, I.A., Bergeles, N.K., Apostolidis, N.G., Noutsos, K.S., & Koskolou, M.D. (2006). Anthropometric, body composition and somatotype differences of Greek elite female basketball, volleyball and handball players. *Journal of Sports Medicine and Physical Fitness*, *46*, 271-280.

Belka, J., Hulka, K., Safar, M., Weisseer, R., & Samcova, A. (2014). Analyses of time-motion and heart rate in elite female players (U19) during competitive handball matches. *Kinesiology*, *46*, 33-43.

Bojić-Ćaćić, L. (2018). Antropološka obilježja odabranih rukometašica različite dobi. [Anthropological characteristics of selected handball players of different age categories. In Croatian.] (Doctoral dissertation, University of Zagreb) Zagreb: Faculty of Kinesiology.

Bojić-Ćaćić, L., Vuleta, D., Milanović, D., Barišić, V., & Jerak, T. (2018). Age differences among the Croatian female young pivots in the indicators of basic and handball-specific physical fitness. In M. Baić, W. Starosta, P. Drid, J.M. Konarski, T. Krističević & N. Maksimović (Eds.), *14th International Scientific Conference of Sport Kinetics 2018 "Movement in Human Life and Health": Proceedings* (pp. 160-165). Zagreb; Novi Sad: Faculty of Kinesiology, University of Zagreb; Faculty of Sport and Physical Education, University of Novi Sad.

Bon, M., Pori, P., & Šibila, M. (2015). Position-related differences in selected morphological body characteristics of top-level female handball players. *Collegium Antropologicum*, *39*(3), 631-639.

Carter, J.E.L. (2002). *The Heath-Carter anthropometric somatotype. Instruction manual*. Retrieved from: http://www.somatotype.org/Heath-CarterManual.pdf on April 14. 2018.

Čavala, M., & Katić, R. (2010). Morphological, motor and situation-motor characteristics of elite female handball players according to playing performance and position. *Collegium Antropologicum*, *34*(4), 1355-1361.

Čavala, M., Rogulj, N., Srhoj, V., Srhoj, Lj., & Katić, R. (2008). Biomotor structures in elite female handball players according to performance. *Collegium Antropologicum*, *32*(1), 231-239.

Čavala, M., Trnininć, V., Jakšić, D., & Tomljanović, M. (2013). The influence of somatotype components and personality traits on the playing position and the quality of top Croatian female cadet handball players. *Collegium Antropologicum*, *37*(Suppl. 2), 93-100.

Čižmek, A., Ohnjec, K., Vučetić, V., & Gruić I. (2010). Morphological differences of elite Croatian female handball players according to their game position. *Hrvatski Športsko-medicinski Vjesnik*, *25*, 122-127.

Exposito, M.G., Alcaraz Ramón, P.E., Ferragut Fiol, C., Manchado López, C., Abraldes Valeiras, J.A., Rodríguez Suárez, N., & Vila Suárez, H. (2011). Body composition and throwing velocity in elite women's team handball. [In Spanish.] *Cultura, Ciencia y Deporte* (Murcia), *7*(6), 129-135.

Granados, C., Izquierdo, M., Ibanez, J., Bonnabau, H., & Gorostiaga, E.M. (2007). Differences in physical fitness and throwing velocity among elite and amateur female handball players. *International Journal of Sports Medicine*, *28*(10), 860-867.

Gréhaigne, J.-F., & Godbout, P. (1995). Tactical knowledge in team sports from a constructivist and cognitivist perspective. *Quest*, 47(4), 490-505.

Gréhaigne, J.-F., Godbout, P., & Bouthier, D. (2001). The teaching and learning of decision making in team sports. *Quest*, *53*(1), 59-76.

Grujić, S. (2016). *Modelne karakteristike mladih rukometaša u odnosu na morfološka i motorička obeležja*. [Model characteristics of younger age handball players in relation to morphological and motor characteristics. In Serbian.] (Doctoral dissertation, University of Novi Sad) Sremska Kamenica: Fakultet za sport i turizam Novi Sad

Hughes, M.D., & Bartlett, R.M. (2002). The use of performance indicators in performance analysis. *Journal of Sports Sciences*, *20*, 739-754.

Jackson, A.S., Pollock, M.L., & Ward, A. (1980). Generalized equations for predicting body density of women. *Medicine and Science in Sports and Exercise*, *12,* 175-182.

Karcher, C., & Buchheit, M. (2014). On-court demands of elite handball, with special reference to playing positions. *Sports Medicine*, *44*(6), 797-814.

Karpan, G., Škof, B., Bon, M., & Šibila, M. (2015). Analysis of female handball players' effort in different playing positions during official matches. *Kinesiology*, *47*, 100-107.

Katić, R., Zagorac, N., Živičnjak, M., & Hraski, Ž. (1994). Taxonomic analysis of morphological/motor characteristics in seven-year old girls. *Collegium Antropologicum*, *18*(1), 141-154.

Kurelić, N., Momirović, K., Stojanović, M., Šturm, J., Radojević, Đ., & Viskić-Štalec, N. (1975). *Struktura i razvoj morfoloških i motoričkih dimenzija omladine*. [The structure and development of the morphological and motor dimensions of the young. In Croatian.] Beograd: Institut za naučna istraživanja Fakulteta za fizičko vaspitanje.

Lamas, L., Barrera, J., Otranto, G., & Ugrinowitsch, C. (2014). Invasion team sports: Strategy and match modeling. International Journal of Performance Analysis in Sport, *14*, 307-329.

Lidor, R., & Ziv, G. (2011). Physical and physiological attributes of female team handball players – A review. *Women in Sport and Physical Activity Journal*, *20*(1), 23-38.

Manchado, C., Hoffmann, E., Valdivielso, F.N., & Platen, P. (2007). Beanspruchungsprofil im Frauenhandball – Belastungdauer und Herzfrequenzverhalten bei Spielen der Nationalmannschaft. [Physiological demands in female handball-demands and heart rate during matches of the German National Team. In German.] *Deutsche Zeitschrift für Sportmedizin*, *58*(10), 368-373.

Manchado, C., Tortosa, J., Vila, H., Ferragut, C., & Platen, P. (2013). Performance factors in women's team handball. Physical and physiological aspects – A review. *Journal of Strength and Conditioning Research*, *27*(6), 1708-1719

Michalsik, L.B. (2018). On-court physical demands and physiological aspects in elite team handball. In L. Laver et al. (Eds.), *Handball sports medicine* (pp. 15-33). ESSKA; EHF; Springer. Dostupno na http://bukufreedownloadmurah.club/download/3662558912

Michalsik, L.B., & Aagaard, P. (2015). Physical demands in elite team handball: Comparisons between male and female players. *Journal of Sports Medicine and Physical Fitrness*, *55*, 878-891.

Michalsik, L.B., Aagaard, P., & Madsen, K. (2015). Technical activity profile and influence of body anthropometry on playing performance in female elite team handball. *Journal of Strength and Conditioning Research*, *29*(4), 1126-1138.

Michalsik, L.B., Madsen, K., & Aagaard, P. (2011). Activity match profile and physiological demands in female elite team handball. U *European Handball Federation Scientific Conference 2011 – Science and Analytical Expertise in Handball*, Proceedings of the 1st International Conference on Science in Handball (str. 162-167). Vienna, Austria.

Michalsik, L.B., Madsen, K., & Aagaard, P. (2014). Match performance and physiological capacity of female elite team handball players. *International Journal of Sports Medicine*, *35*, 595-607

Milanese, C., Piscitelli, F., Lampis, C., & Zancanaro, C. (2011). Anthropometry and body composition of female handball players according to competitive level or the playing position. *Journal of Sports Sciences*, *29*(12), 1301-1309.

Milanović, D. (2010). *Teorija i metodika treninga: Primijenjena kineziologija u sportu* (2nd revised ed.). [The theory and methodology of training: The applied kinesiology in sports In Croatian.] Zagreb: Faculty of Kinesiology.

Mišigoj-Duraković, M. (2008). *Kinantropologija – Biološki aspekti tjelesnog vježbanja*. [Kinanthropology – Biological aspects of physical exercise. In Croatian.] Zagreb: Kineziološki fakultet Sveučilišta u Zagrebu.

Moss, S.L., McWhannell, N., Michalsik, L.B., & Twist, C. (2015). Anthropometric and physical performance characteristics of top-elite, elite and non-elite youth female team handball players. *Journal of Sports Sciences*, *33*(17), 1780-1789.

Naisidou, S., Kepesidou, M., Kontostergiou, M., & Zapartidis, I. (2017). Differences of [in] physical abilities between successful and less successful young female athletes. *Journal of Physical Education and Sport*, *17*(1), 294-299.

Nogueira, T.N., Cunha Junior, A.T., Dantas, P.M.S., & Fernandes Filho, J. (2005). Somatotype, dermatoglyphical and physical qualities profiles of the Brazilian adult feminine handball selection for game position. [In Portuguese.] *Fitness and Performance Journal*, *4*(4), 236-242.

Noutsos, S.K., Meletakos, G.P., & Bayios, A.I. (2019). Morphological characteristics of adolescent elite female handball and volleyball players. *Journal of Physical Education and Sport, 19*(Supp. 4), 1502-1507.

Rogulj, N., Srhoj, V., Nazor, M., Srhoj, Lj., & Čavala, M. (2005). Some anthropologic characteristics of elite female handball players at different playing positions. *Collegium Antropologicum*, *29*(2), 705-709.

Siri, W.E. (1961). Body composition from fluid space and density. In J. Brozek & A. Hanschel (Eds.), *Techniques for measuring body composition* (pp. 223-244). Washington, DC: National Academy of Science.

Srhoj, V. (2002). Situational efficacy of anthropomotor types of young female handball players. *Collegium Antropologicum*, *26*(1), 211-218.

Šibila, M., & Pori, P. (2009). Position-related differences in selected morphological body characteristics of top-level handball players. *Collegium Antropologicum*, *33*(4), 1079-1086.

Tuma, M., & Vozobulova, P. (2011). Somatic characteristics of selected youth female players by Czech training centres. U *European Handball Federation Scientific Conference 2011 – Science and Analytical Expertise in Handball*, Proceedings of the 1st International Conference on Science in Handball (str. 204-207). Vienna, Austria.

Urban, F., & Kandráč, R. (2013). The relationship between morphological profile and player performance in elite female handball players. In 2nd EHF Scientific Conference: *Woman and Handball: Scientific and Practical Approaches*, 22-23 November 2013, Vienna (pp. 163-168). Vienna: European Handball Federation.

Urban, F., Kandráč, R., Táborský, F. (2011a). Anthropometric profiles and somatotypes of national teams at the 2011 Women's 17 European Handball Championship. *EHF Web Periodical*. Retrieved from activities.eurohandball.com/web-periodicals on January 23, 2017.

Vila, H., Manchado, C., Abraldes, A., Alcatraz, P., Rodrigez, N., & Ferragut, C. (2011). Anthropometric profile in female elite handball players by playing position. In *EHF Scientific Conference 2011, Science and Analytical Expertise in Handbll* (pp. 219-222). Vienna.

Vuleta, D., Milanović, D. and associates (2009). *Science in Handball*. Zagreb: Faculty of Kinesiology.

Vuleta, D., Milanović, D., & Sertić, H. (1999). Latent structure of spatial, phasic, positional and movement characteristics of the handball game. *Kinesiology*, *31*, 37-53.

Wagner, H., Finkenzeller, T., Würth, S., & von Duvillard, S.P. (2014). Individual and team performance in team-handball: A review. *Journal of Sports Science and Medicine*, *13*(49), 808-816.

Weber, J., & Wegner, M. (2016). Konstitutionelle Anforderungen für verschiedene Spielpositionen beim Frauenhandball. [Constitutional demands for different playing positions in female team handball. In German.] *Sportwissenschaft*, *46*(4), 305-314.

Zapartidis, I., Toganidis, T., Vareltzis, I., Christodoulidis, T., Kororos, P., & Skoufas, D. (2009). Profile of young female handball players by playing position. *Serbian Journal of Sports Sciences*, *3*(1-4), 53-60.

Zapartidis, I., Vareltzis, I., Gouvali, M., & Kororos, P. (2009). Physical fitness and anthropometric characteristics in different levels of young team handball players. *The Open Sport Science Journal*, *2*, 22-28.

Submitted: March 14, 2020
Accepted: April 29, 2020
Published Online First: May 21, 2020

Correspondence to:
Dinko Vuleta, Ph.D.
Faculty of Kinesiology, University of Zagreb,
Zagreb, Croatia
E-mail: dvuleta@kif.hr