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CHARLES UNIVERSITY IN PRAGUE,
FACULTY OF PHYSICAL EDUCATION AND SPORT,
SPORT RESEARCH CENTRE,[1]
DEPARTMENT OF SPORT GAMES[2]

BODY COMPOSITION OF ELITE FEMALE HANDBALL PLAYERS

LUCIA MALÁ[1], TOMÁŠ MALÝ[1,2], FRANTIŠEK ZAHÁLKA[1], MARTIN TŮMA[2] , VÁCLAV BUNC[1]

SUMMARY

Body composition is considered a very important factor for athletes. Excessive adipose tissue acts as a dead weight in activities where the body mass must be repeatedly lifted against gravity during locomotion and jumping.

The aim of the study was to determine body composition of a national team of female handball players (n = 16, age 24.0 ± 3.5 years, height 176.0 ± 6.5 cm, weight 72.5 ± 8.3 kg). Research data were obtained by means of a bioimpedance method (BIA 2000 M, Germany).

We observed: absolute and relative amount of Fat Free Mass (FFM), percentage of Fat Mass (% FM), Body Cell Mass (BCM), Extra Cellular Mass (ECM) and their mutual ratio (ECM/BCM), Phase Angle (α), Total Body Water (TBW) distinguishing Extracellular Fluid (ECW) and Intracellular Fluid (ICW).

The mean value of TBW is 54.98% of a female player's body weight. TBW distribution was 67.88% in ICW and 42.12% in ECW. The mean value of FFM = 60.74 ± 1.48 kg. BCM was 50.40 ± 0.78 % of FFM (CQ), which in absolute value means 30.59 ± 0.83 kg. The ratio of ECM/BCM = 0.79 ± 0.03, α = 6.96 ± 0.19° and FM = 16.06 ± 0.65 %.

Individual body composition parameters provide the values characteristic for elite female athletes. Inter-individual comparison also revealed differences in terms of player's function. The presented data can serve as a certain top standard for comparisons of body composition quality in female players of the lower level with the aim to optimize and compensate the found differences.

Key words: body cell mass, body constitution, elite sport, fat mass, handball

INTRODUCTION

Handball is a sport that is gaining higher popularity. Team handball, combining aspects of basketball, soccer and baseball, is one of the most popular sports in the world (Sporiš et al., 2010). Interaction between individual components participating on the performance increasingly attracts the attention of scientists and is linked to the training practice. Results from individual tournaments are attributed to a high fitness level of the players who take part in long-term regular organized sport training. Raising the level of physical fitness presents one of the key factors for successfulness (Sporiš et al., 2010).

Handball is a game with a large number of explosive movements, therefore the emphasis is on the anaerobic capacity of the players, however the significance of the aerobic capacity should not be disregarded (Sporiš et al., 2010). Body composition is very important factor for athletes. Excessive adipose tissue acts as a dead weight in activities where the body mass must be repeatedly lifted against gravity during locomotion and jumping (Reilly, 1996). The measurement of physical (anthropometry, somatotypes, body composition) and physiological characteristics gives a great insight into the current status of handball players and allows coaches to evaluate such players (selection) and implicate the right training volume and intensity to raise their capabilities (preparation cycles programming).

From the point of view of somatotypes and body composition as predispositions for the performance, not only tall types with long extremities are suitable, but also the types with high proportion of Fat Free Mass and low proportion of inactive Fat Mass. Anthropometrical measures of handball players were researched in several studies which point out specific positional differences in some measures (Srhoj et al., 2002, 2006; Katić, Čavala & Srhoj, 2007; Visnapuu & Jürimäe, 2008). The results of study by Sporiš et al. (2010) have shown that there is a strong correlation between body composition, aerobic fitness and positional roles in elite handball players.

A significant proportion of research studies have been carried out in the male population (Musaiger et al., 1994; Jaric, Ugarkovic & Kukolj, 2001; Srhoj, Marinovic & Rogulj, 2002; Hasan et al., 2007a; Chaouachi et al., 2009; Mohamed et al., 2009; Sibila & Pori, 2009; Sporiš et al., 2010) compared to the female population (Bayios et al., 2006; Hasan et al., 2007b).

Similarly presented parameters are limited mostly to Fat Mass and Fat Free Mass in relation to specific actions in handball. The aim of this contribution was to present the body composition profile in elite female handball team, a participant in World Championship qualification 2011, by extended amount of body composition parameters.

METHODS

The screened sample consisted of a representative team of female handball players (n = 16), participants of World Championship qualification 2011. All participants have played handball for at least 8 years; therefore it is a specific group with high proportion of controlled physical activity. Basic somatometric characteristics of the sample are listed in Table 1.

Table 1. Basic somatometric characteristics of the screened sample

	Minimum	Maximum	Mean	Std. Error of mean	Std. Deviation	Variance
Age (years)	19	31	24	0.88	3.5	12.27
Body Height (cm)	163	190	175.97	1.62	6.48	41.95
Body Mass (kg)	57.5	87.6	72.54	2.08	8.32	69.3
BMI (kg × cm^{-2})	19.2	28.3	23.41	0.59	2.34	5.48

BMI – Body Mass Index

Data identifying body composition of the players were recorded under the same conditions in the morning; participants did not use any medicaments. In terms of periodization of the annual training plan, we were at the end of a competition period. Before the measurement, we measured the participants' current body weight by means of an electronic scale with accuracy of 0.1 kg (Soehnle ©, Germany) and body height in standing position to the nearest 1mm by anthropometer (SECA220 ©, Hamburg, Germany). To determine the whole body bioimpedance, we used BIA 2000 M device (Data Input GmbH, Frankfurt/Main, Germany), which operates on four frequencies (1, 5, 50 and 100 kHz) and is compatible with NUTRI 4 software. The measurement lasted approximately 45 s. Contact resistance between the surface electrodes arranged tetrapolarly and skin was not higher than 250 Ω.

On the basis of the obtained values we found out the current body composition of all participants. We observed absolute and relative amount of Fat Free Mass (FFM), percentage of Fat Mass in participants (% FM), Body Cell Mass (BCM) and Extra Cellular Mass (ECM) and their mutual ratio (ECM/BCM), Phase Angle (α), Total Body Water (TBW) distinguishing between Extracellular Fluid (ECW) and Intracellular Fluid (ICW). Conversion of individual indirectly measurable parameters identifying body composition quality was based on the particular prediction equations for this age group (Datainput, 2004).

The results were expressed in absolute values (mean ± standard error of mean) and percentages, and the evaluation was made with the use of basic statistical characteristics (Arithmetic Mean, Standard Error of Mean, Minimum Value, Maximum Value and percentage). For monitoring of the relationships between variables, we used Pearson correlation coefficient (r). The significance of the correlation coefficient was assessed with the risk of $p < 0.05$.

To determine the critical value we used the sum (difference) of the mean and double of the standard deviation in the monitored parameter.

$$x_{crit} = (\text{mean} + (2 \times \text{S.D})$$

Statistics was processed by means of statistical software SPSS (*Statistical Package for Social Science*) 18.0 in Laboratory of Sport Research Centre, Faculty of P. E. and Sports, Charles University.

RESULTS

TBW mean value is 39.88 ± 0.86 l (54.98% of a player's body weight), of which 23.08 ± 0.25 l (57.88% of TBW) includes ICW. ECW had a lower proportion; the mean value was 16.79 ± 0.62 l (42.12% of TBW). In the team, we recorded the mean absolute value FFM 60.74 ± 1.48 kg (83.73% of BM), what in relative conversion to kg BM amounted to 0.84 ± 0.01. Similarly, the mean of FFM, BCM component was 50.40 ± 0.78% of FFM (CQ), what in absolute value means 30.59 ± 0.83 kg and in relative terms per kg of body weight it is 0.42 ± 0.01. ECM had a lower proportion than BCM (23.89 ± 0.63 kg); the ratio of ECM/BCM thus indicated the value characteristic for elite sport (0.79 ± 0.03). The mean value of α parameter, related to ECM/BCM ratio, was 6.96 ± 0.19° for the whole team.

The mean value of Fat Mass in the team amounted to 16.06 ± 0.65%.

Table 2. Body composition of the monitored team of elite female handball players

Parameter	Mean	Std. Error	Std. Deviation	Range	Minimum	Maximum
TBW (l)	39.88	0.86	3.44	11.3	34	45.3
FFM (kg)	60.74	1.48	5.91	18.1	50.1	68.2
FM (%)	16.06	0.65	2.62	9.2	12.9	22.1
α (°)	6.96	0.19	0.76	2.5	5.8	8.3
ECM (kg)	23.89	0.63	2.52	7.7	20	27.7
BCM (kg)	30.59	0.83	3.33	11.1	24.3	35.4
ECM/BCM	0.79	0.03	0.10	0.34	0.63	0.97
CQ (%)	50.4	0.78	3.10	10.13	45.34	55.46
ECW (l)	16.79	0.62	2.49	7.8	12.8	20.6
ICW (l)	23.08	0.25	1.00	3.5	21.2	24.7
FFM/BM	0.84	0.01	0.03	0.09	0.78	0.87
BCM/BM	0.42	0.01	0.03	0.1	0.37	0.47

Legend: TBW –Total Body Water (l)
FFM – Fat Free Mass (kg)
FM – Fat Mass (%)
α – Phase Angle (°)
ECM – Extra Cellular Mass (kg)
BCM – Body Cell Mass (kg)
ECM/BCM – Ratio of Extra Cellular Mass and Intra Cellular Mass
CQ – Proportion of Body Cell Mass in Fat Free Mass (%)
ECW – Extra Cellular Fluid (l)
ICW – Intra Cellular Fluid (l)
FFM/BM – Fat Free Mass/Body Mass
BCM/BM – Body Cell Mass/Body Mass

Correlation analysis showed a significant relationship between BMI and Fat Mass proportion FM ($r = 0.499$, $p = 0.049$, Figure 1). The critical value for assessing the amount of inactive mass (FM) was calculated as 21.3% ($x_{crit} = (16.06 + (2 \times 2.62))$).

DISCUSSION

The recorded mean values of Body Height (BH), Body Mass (BM), i.e. BMI value (Table 1) show values commonly found in elite athletes. In terms of representation of individual playing positions, our basic somatometric data are in accordance with available literature (Van Den Tillar & Ettema, 2003; Chaouachi et al., 2009; Sporiš et al., 2010), where players who reached the highest BH were a backcourt player and goalkeeper (190 i.e. 183 cm) and players with the lowest BH were wing players (163 i.e. 165cm). Sporiš et al. (2010) recorded a significant difference in BH between wing players and other measured playing positions (goalkeepers, backcourt players, circle runner) in elite Croatian handball players (n = 167, men, Age 26.4 ± 3.8 year, BH 192.1 ± 8.2 cm, BM 96.0 ± 8.3 kg). However, the very BH, BM i.e. BMI do not show anything concrete about body composition of the

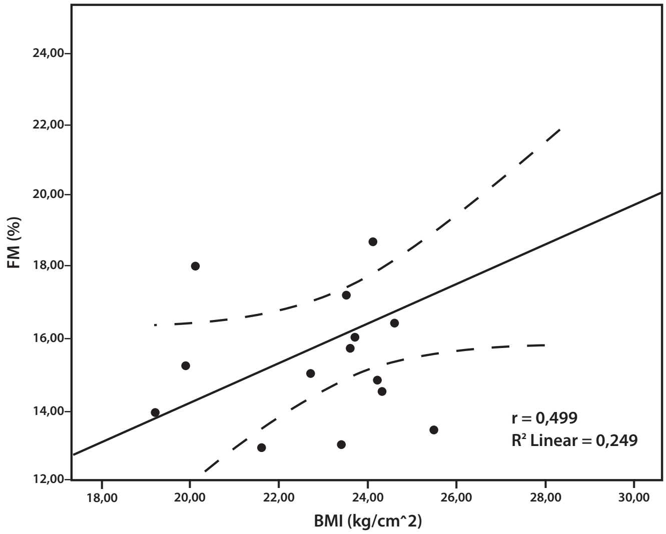

Figure 1. Correlation relationship between BMI and FM in the research group

observed team, although indices based on one-component model of the body are commonly used in practice and science and show a high correlation between the percentage of FM proportion and the BMI value (Bandyopadhyay, 2007).

Similarly observed somatometric characteristics still remain important parameters for selection of a talented player and playing function, or for choosing the right tactics in the match, etc. However, studies (Chaouachi et al., 2009) emphasize an insignificant difference between BH, i.e. BM and other parameters related to performance in handball (standing throw velocity) and, on the contrary, a negative correlation between performance parameters (maximal running speed) and FM in handball players (Zapartidis et al., 2009; Sporiš et al., 2010). Bayios et al. (2006) even state that BH is not a criterion for selection of athletes, since the mean value of this variable recorded in the present study is lower than the corresponding values in the other two sports (basketball, volleyball).

FFM, a parameter closely correlated to individual game performance in sport games (Melrose et al., 2007) was 83.73% of BM (Table 2) in the screened sample. For comparison, Granados et al. (2008) found approximately similar values – FFM 55.0 ± 4 kg – in elite female handball players (n = 16, age 23.1 ± 4 years, BM 69.4 ± 7.7 kg, BH 175 ± 6 cm). The authors also indicate significant changes in FFM during annual training period. However, in comparison it is important to take into account differences in methodology used (authors estimated FFM from FM detected by skinfold caliper method). Relative values (FFM/BM) indicate individual differences between players; in our case, it is, however, not possible to clearly determine the tendency because of FFM proportion in various playing positions. The highest, approximately comparable value of FFM/BM (0.87) was recorded in different playing positions (wing player, goalkeeper and back court players). The lowest value was measured in pivot position (0.78). Thanks to regular sport training, all players show FFM/BM values at the level of elite athletes.

BCM as a predictor of muscle efficiency for sport performance (Andreoli et al., 2003) was on average 30.59 ± 0.83 kg; in relative value per kg of BM it was 0.42 ± 0.01. In terms of the percentage of cells in FFM, as an indicator of individual state of nutrition and fitness, it amounted to 50.40 ± 0.78% (CQ). When we look individually at all participants, we may state values approaching the recommended 50% in almost all participants, except three players whose playing positions were goalkeeper and backcourt player (45.64 – 48.19 %). BCM can amount to 60% of FFM in elite athletes (Dörhöfer & Pirlich, 2007); however, common values in female are around 50% (Datainput, 2004; Malá et al., 2010). This smaller deficit in the percentage of BCM proportion in FFM may be caused by intraindividual differences of players, various types of trainings in different sport clubs, i.e. from the perspective of physiological demands on the playing position. It would be appropriate to verify these hypotheses by the selected general and specific motor tests and revision of players' training diaries.

Due to dynamic (intermittent) performance, we consider amount of BCM a very important element as it determines player's muscularity. Another important factors are its ratio with ECM and α parameter, which is directly related through intracellular liquid to the amount of cellular mass (BCM = Phase Angle × ICW × constant) (Malá et al., 2010). When comparing individual components of FFM in our sample, the mean proportion of BCM was higher than ECM proportion (Table 2). The ratio of the both components ECM/BCM considered as a criterion for assessment of predisposition was in the recommended range (Datainput, 2004) and indicated excellent predispositions for muscle work and thus for the sport performance of the national team of female players.

Individually, higher values (0.84 – 0.97) were found in some players. It may be caused by genetics (constitutive type) and age, or the actual training focus (especially in terms of energy demands). In accordance with available literature (Malá et al., 2010), our participants, who take part in regular and long-termed training process, have high value of BCM compared with the common population. Eventual decrease in ECM/BCM would indicate an improved level of body composition in most cases during the long-term monitoring; however, we would have to take into account the possibility that the decrease was caused by the loss of water in extracellular space, for instance because of insufficient drinking regime during the load or after it (Malá et al., 2010); in other words it would be essential to monitor changes of individual components of water, especially the intracellular component (23.08 ± 0.25 l). Total TBW (39.88 ± 0.861) affects body composition and fat free mass density and thus an estimate of the percentage of FM, ECM/BCM and other parameters of body composition.

Values recorded in α angle indicate high quality cells in all participants, which is related to a higher proportion of intracellular volume and BCM compared to common population (Table 2). In individual assessment, the highest values of α were measured in wing players, pivot and backcourt players (8–8.3º). Relatively high values of TBW, FFM and ECM/BCM (0.63–0.65) in these players indicate their good fitness and belong to values characteristic for elite sport. The lowest α value was recorded in a backcourt player and goalkeeper (5.8–5.9º).

When determining the average percentage of FM, the lower proportion of the inactive component (Table 2) in sporting women is in accordance with available sources when Lohman (1992) recommends the values of body fat for sporting women in the range of

12–16% depending on the sport. Similarly Bayios et al. (2006) emphasize variability of body composition between different sport games teams depending on the concrete sport. The authors found significantly higher percentage of fat mass in female handball players than in female basketball or volleyball players (Women and Youth Greek national teams, n = 518). When we compared our results with available literature, we found out that the recorded percentage of FM (Table 2) is lower than in foreign sources (Van den Tillaar & Etema, 2004; Hasan et al., 2007; Bayios et al., 2008; Granados et al., 2008; Chaouachi et al., 2009). The highest value of FM was measured in the goalkeeper and pivot (20.2 –22.1%), the lowest value was found in the goalkeeper and backcourt players (13.4–13.9%). On the basis of the measured FM values, we can not clearly state the trend of FM proportion in individual playing positions.

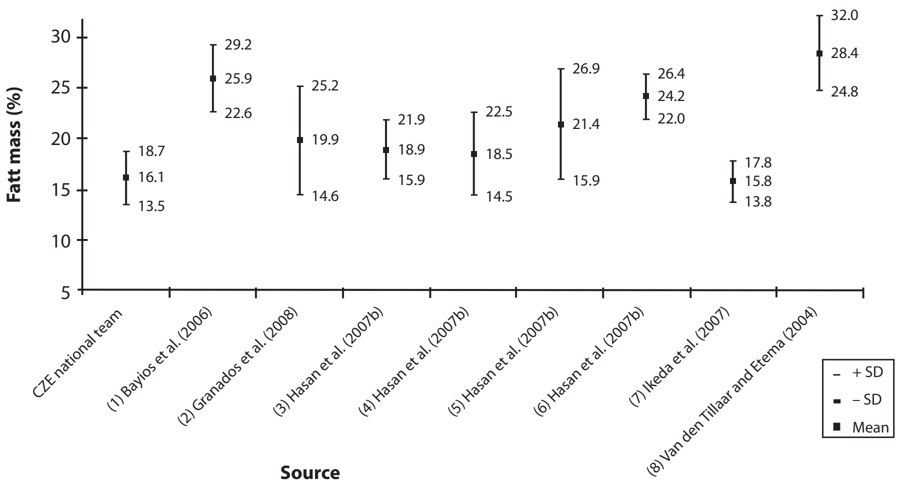

Figure 2. Comparison of fat mass percentage with available sources

Legend: (n, age, level, method)
(1) – 222, 21.5 ± 4.6 years, I and II. Greek national league, skinfolds, (2) – 16, 23 ± 4 years, Spanish National First Division, skinfolds, (3) – 14, 21 ± 3 years, China National Team, skinfolds, (4) – 16, 24 ± 2 years, Japan National Team, skinfolds, (5) – 14, 23 ± 4 years, Kazakhstan National Team, skinfolds, (6) – 16, 21 ± 2 years, South Korea National Team, skinfold, (7) – 6, 19–22 years, Japan college players, skinfolds, (8) – 20, 22.2 ± 2.6 years, II and III Norwegian National league, skinfold.

The reason for the need of FFM and absence of FM is that data from the available literature indicate better relationship of FFM to success in sport (maximal aerobic performance, running time, etc.) than percentage of FM. It appeared that amount and proportion of FFM has a close relationship to different functional variables, unlike total BM, BW and other morphological characteristics. According to Musaiger et al. (1994), low relative body fat is desirable owing to the high negative relationship between performance and percentage body fat.

Players who have more body fat than appropriate will become tired much faster during a game than those players with optimal amount of body fat, also these players will run slower during the second period of the game (Sporiš et al., 2010). The authors also confirmed a strong negative correlation between body fat and maximal running speed ($r = -0.68$, $p < 0.01$) in elite Croatian handball players ($n = 167$, male, mean age 26.4 ± 3.8 years, mean body height 192.1 ± 8.2 cm, mean body weight 96.0 ± 8.3 kg). Granados et al. (2008) confirmed a positive correlation between changes in percentage of FM and BM ($p < 0.01$) and changes in maximal strength and muscle power. Van den Tillaar & Etema (2004) reports, that FFM, as an approximation for skeletal muscle mass, is the best measure to express body size when related to physical performance.

Therefore, the optimal solution for our participants appears to be increasing of FFM while maintaining the current proportion of FM, what can be achieved by proper fitness training (Lim, 2003). However, the problem is the limit of FFM increase from the perspective of individual limits, i.e. predispositions and individual playing positions in handball in terms of speed and coordination abilities, i.e. agility.

CONCLUSION

Body composition parameters indicate values related to female athletes of the elite level. Body composition monitoring based on targeted choice of the population (national team) showed that fat mass values (FM) should not exceed 21.3% in elite female players when measured by the bioimpedance method. Our data are capable of being compared to studies, in which body composition parameters were monitored using the bioimpedance analysis. In interindividual comparisons we found also differences in terms of playing positions. Worse body composition parameters were measured in a goalkeeper, what may be associated with different content and intensity of the training process. The presented data can serve as a certain top standard for comparisons of body composition quality in female players of the lower level with the aim to optimize and compensate the found differences.

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TĚLESNÉ SLOŽENÍ ELITNÍCH HÁZENKÁŘEK

LUCIA MALÁ, TOMÁŠ MALÝ, FRANTIŠEK ZAHÁLKA, MARTIN TŮMA, VÁCLAV BUNC

SOUHRN

Tělesnému složení musí sportovci věnovat velmi velkou pozornost. Nadměrné procento tuku představuje neaktívni hmotnost obzvláště v situacích, kdy tělesná hmota musí být během lokomoce a při výskocích opakovaně zdvíhána proti zemské přitažlivosti. Cílem studie bylo zjistit tělesné složení u reprezentačního družstva žen v házené (n = 16, věk 24.0 ± 3.5 roku, výška 176.0 ± 6.5 cm, hmotnost ±72.5 ± 8.3 kg). Tělesné složení bylo měřeno pomocí bioimpedanční metody (BIA 2000 M, Germany).
Sledovanými parametry bylo absolutní a relativní množství beztukové hmoty Fat Free Mass (FFM), procentuální zastoupení tuku Fat Mass (% FM), tělesné buněčné hmoty Body Cell Mass (BCM), mimobuněčné hmoty Extra Cellular Mass (ECM) a jejich vzájemný poměr (ECM/BCM), fázový úhel Phase Angle (α), celková tělesná voda Total Body Water (TBW) s rozlišením extracelulární (mimobuněčné) tekutiny Extracellular Fluid (ECW) a intracelulární (buněčné) tekutiny Intracellular Fluid (ICW).
TBW tvoří průměrně 54,98% tělesné hmotnosti hráčky. Distribuce TBW byla 57,88% v ICW a 42,12% v ECW. Průměrná hodnota FFM = 60,74 ± 1,48 kg. BCM představovala 50,40 ± 0,78 % z FFM (CQ), což je v absolutní hodnotě 30,59 ± 0,83 kg. Poměr ECM/BCM = 0,79 ± 0,03, α = 6,96 ± 0,19° a FM = 16,06 ± 0,65%.
Jednotlivé parametry tělesného složení vypovídají o hodnotách odpovídajících sportovkyním elitní úrovně. Při inter-individuálním hodnocení byly také zjištěny rozdíly z hlediska hráčské funkce. Námi prezentované výsledky mohou pomoci jako jistý vrcholový standard pro porovnávání kvality tělesného složení hráček nižší výkonnostní úrovně s cílem optimalizace a kompenzace zjištěných rozdílů.

Klíčová slova: vnitrobuněčná hmota, tělesná konstituce, elitní sport, házená

Dr. Lucia Malá, Ph.D.
mala@ftvs.cuni.cz