Segmental Body Composition in Male and Female Ice-Hockey Players

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Abstract: The aim of the study was to determine relationships between the build indicators of the body segments (the upper and the lower extremity) in female and male ice-hockey players using an indirect method with the Zaciorski's equations (Zaciorski, 1979) utilising the body mass and the bioimpedance method (BIA). The study covered three groups of ice-hockey players. Males: Poland's I national team, n=25 (PZHL-M), Polish national team U-18, n=28 (U18). Females: Poland's I national team, n=29 (PZHL-W). All subjects were applied the bioimpedance method (BIA) to determine their body components: ECW (extra-cellular water), FFM (fat-free body mass), FM (body fat mass), ICW (intra-cellular body water), TBW (total body water), MM (muscular mass). The PZHL-M and PZHL U18 groups only slightly differ in the active mass indicators; in the case of FFM and MM the differences ranges between 8 and 9%. In the case of fat mass (FM) the range is 21-22%, which points to a greater absolute mass of fat tissue in subjects in the PZHL-M group. The female group is considerably different in the body components from the male groups. The absolute values show that the amount of their muscle mass accounts for 60-65% of that in both age groups of the male players, whereas the fat mass in the PZHL-M group is 74.63%, and 95,31% in the U18 group. The results of the study allowed, by analysing regression in the groups of Polish male ice-hockey players, calculating regression equations between the muscle mass of the extremities and their mass.

[Szmatlan-Gabryś U, Stanula A, Gabryś T, Ozimek M. **Segmental Body Composition in Male and Female Ice-Hockey Players**. *Life Sci J* 2014;11(5):389-395] (ISSN:1097-8135). http://www.lifesciencesite.com. 53

Keywords: body segments, ice-hockey

Introduction

Physical exercise undertaken on a regular basis in the form of sports training is a factor that has major effect on the human morphological composition. The most distinct changes can be observed in the physical and functional fitness of the body and in its tissue composition (DeLorenzo et al., 2000; Knechtle et al., 2008; Sánchez-Muñoz et al., 2007). Studies focusing on physical fitness and the morphological composition in relation to performance in sport have been conducted by many researchers (Musaiger et al., 1994; Stogll et al., 2010; Potteiger et al., 2010; Stanula et all., 2013). The preparation of precise somatic descriptions taking account of the body proportions and its tissue composition is a basis for comparative analyses of the body morphology in athletes within the same discipline, different disciplines and of different sex athletes in the same discipline. This is a road to developing selection criteria in the area of somatic build (Carling et al., 2012; Reilly et al., 2000; Hoare, 2000; Keogh, 2003; Douda et al., 2008). Acquiring the knowledge of relationships between the tissue components of the body and the determination of the tissue composition depends on the methods applied to study the components the body build. The occurrence of statistically significant correlation between simple somatic measurements and the laboratory-determined components of the body has become a basis for constructing generalizing formula, predictive equations and nomograms for the anthropometric methods of estimating somatic components (Brodie, 1998; Segal, 1985; Durnin, 1974). Body density is a point of departure for a general evaluation of body mass, i.e. the active tissue mass (composed of the skeleton and the muscles) and the fat mass. These components can be calculated as absolute values (i.e. in kilograms) or as percentages of total body mass. Density, the lean body mass, water and fat content are determined with formulas developed by various authors (Heymsfield et al., 2005; Heyward & Wagner, 2004).

Equations used to determine the human body components generate approximations, so it is important to remember in making comparisons that the results were made comparable with the body build data obtained in this way. Research results indicate that each sports discipline has athletes with specific anthropomotor and biomotor profiles (Gil et al., 2007; Mikkola et al., 2012; Orvanová 1990; Stogll et al., 2010). In many sports disciplines the body build has a strong effect on the athlete's performance. In team games such as volleyball (Malousaris et al., 2008; Gabbett & Georgieff, 2007; Gualdi-Russo & Zaccagni, 2001), basketball (Bale, 1991; Duncan, 2006; Angyán, 2003) or water ball

(Debanne & Laffaye, 2011; Platanou & Varamenti, 2011; Tsekouras et al., 2005; Lozovina & Pavicić, 2004; Alcaraz et al., 2012; Alcaraz et al., 2011) this effect is particularly distinct because of the course of competition (the height of the net or of the basket, the aquatic environment). In sports disciplines involving contact with opponents such as ice hockey or handball the athlete's physical conditions frequently predetermined their ability to demonstrate during the fight of their physical or tactical preparedness (Chaouachi et al., 2009; Vila et al., 2012; Srhoj, 2002; Vescovi et al., 2006; Geithner et al., 2006).

The aim of the study was to determine relationships between the build indicators of the body segments (the upper and the lower extremity) in female and male ice-hockey players using an indirect method with the Zaciorski's equations (Zaciorski, 1979) utilising the body mass and the bioimpedance method (BIA). Regression analysis was used to find the answer to the question about the relationship between the muscular mass determined with the BIA method and the total mass of the upper and lower extremities derived indirectly from the body mass.

Research material and methods

The study covered three groups of ice-hockey players. Males: Poland's I national team, n=25 (PZHL-M), Polish national team U-18, n=28 (U18). Females: Poland's I national team, n=29 (PZHL-W). Subjects' characteristics are presented in table 1.

Table 1. The somatic characteristics of the investigated groups

Parame -ter	Group	n	Mean	Min	Max	SD
Body mass [kg]	U18	28	76,59	60,06	95,43	8,62
	PZHL-M	25	87,29	79,14	102,16	5,68
	PZHL-K	29	61,21	49,35	73,02	5,53
Body height [cm]	U18	28	179,68	170,00	190,00	5,31
	PZHL-M	25	183,96	174,00	192,00	4,62
	PZHL-K	29	164,35	153,30	174,00	5,05
BMI [kg·m^{-2}]	U18	28	23,65	20,30	27,00	1,64
	PZHL-M	25	25,81	23,00	28,90	1,72
	PZHL-K	29	22,66	19,40	26,50	1,74

All subjects were applied the bioimpedance method (BIA) utilising the BIA 101 Anniversary Sport Edition device (Akren Srl., Italia) to determine their body components: **ECW** *extra-cellular water*, **FFM** *fat-free body mass* (practically equivalent with the mass of the muscles and internal organs), **FM** *body fat mass*, **ICW** *intra-cellular body water* (mainly contained in the muscles and internal organs, to a very low degree in the fat tissue), **TBW** *total body water* (mainly indicating the fat-free body mass), MM – muscular mass. The mass of the body segments was determined with two methods. One was the Zaciorski's method (1979) using equations to establish the mass of particular body segments, where „x" stands for body mass (tab. 2).

Table 2. Regression equations for determining the mass of body segments (Zaciorski, 1979).

Foot	y=0.259 +0.01x
Leg	y=0.141 + 0.041x
Thigh	y= -0.799 + 0.153x
Hand	y=0.109+0.0046x
Forearm	y=0.165 +0.139x
Arm	y=-0.142+0.029x

As an alternative to seeking the muscle mass of the upper and lower extremity with the indirect method the BIA method was also used. The BIA 101 Anniversary Sport Edition (Akren Srl., Italia) device was used to make measurements in the lying subject with 8 electrodes placed on their lower and upper extremities. The BIA method determines the mass of the body segments by measuring their impedance of tissue (i.e. electrical resistance consisting of resistance and reactance) through which low-amperage electrical current (≈ 1 mA) is passed. The phenomenon of resistance is caused by resistance specific to particular types of tissue, whereas reactance is mainly related to the electrical capacity of cell membranes that because of their structure act as capacitors. The analysis of impedance (BIA) builds on the following assumptions:

- the human body consists of conductors and non-conductors,
- water representing 50-70% of the human body acts as a conductor,
- fat tissue is non-conductive,
- the classical BIA method measures impedance based on the assumption that the human body can be treated as a cylinder for the model.

Only subjects that were found not to be dehydrated or overhydrated were taken for analysis. The results obtained in the course of research were processed with statistical methods to calculate means, variance, skewness and concentration measures. Moreover, the linear regression analysis was applied to determine the models of equations describing the relationship between the mass of the extremities and muscular mass determined from different methods.

All calculations were performed with the Statistica 10.0 PL software package by StatSoft (*www.statsoft.com*).

Results

Table 3 presents the main body composition indicators for the studied groups. Noteworthy are considerable differences between values recorded for males and females. In table 4 there are provided the percentage differences between the indicators of the morphological structure connected with physical activity. The PZHL-M and PZHL U18 groups only slightly differ in the active mass indicators; in the case of FFM and MM the differences ranges between 8 and 9%. In the case of fat mass (FM) the range is 21-22%, which points to a greater absolute mass of fat tissue in subjects in the PZHL-M group. As regards the value representing fat mass as a percentage of the total body mass the difference goes down to 10-11%.

Table 3. The body composition indicators in the studied groups of male and female ice-hockey players obtained from the BIA method.

Parame -ter	Group	Mean	Min	Max	SD
TBW-lt	U18	44.34	36.5	58.3	4.53
	PZHL-M	48.33	42.8	58.5	3.47
	PZHL-W	31.43	28	35.7	1.97
ECW-lt	U18	17.6	14.2	24.9	2.12
	PZHL-M	19.07	16.4	24.5	1.8
	PZHL-W	13.98	12.1	15.8	1
ICW-lt	U18	26.75	21.3	33.4	2.66
	PZHL-M	29.26	24.6	34	2.05
	PZHL-W	17.45	14.5	20.1	1.41
FFM-kg	U18	60.58	49.8	79.6	6.19
	PZHL-M	66.01	58.4	79.9	4.75
	PZHL-W	42.93	38.3	48.7	2.7
MM-kg	U18	44.27	35.3	55.3	4.39
	PZHL-M	48.48	40.7	58.2	3.59
	PZHL-W	28.97	24.3	33.3	2.3
FM 1-kg	U18	19.63	9.8	104.4	17.14
	PZHL-M	25.07	14.2	110.1	18.05
	PZHL-W	18.71	9.9	28.3	4.34
%FM	U18	11.38	5.8	17.3	2,87
	PZHL-M	13.23	9.4	18.1	3,56
	PZHL-W	24.33	5.3	10.7	34.2

The female group is considerably different in the body components from the male groups. The absolute values show that the amount of their muscle mass accounts for 60-65% of that in both age groups of the male players, whereas the fat mass in the PZHL-M group is 74.63%, and 95,31% in the U18 group. A considerably greater proportion of fat tissue in the body mass in the female group in relations to body mass is confirmed by a comparison of the %FM indicator. The fat tissue in the female group in relations to PZHL-M and U18 accounts respectively for 183.9% and 213.8% of the values recorded in the male groups. That considerable differences in the tissue composition of the body may considerably determine the possibility of arriving at the mass of the body segments using an indirect method.

Table 4. Percentage differences between selected body mass components in male and female ice hockey players

Parameter	PZHL-W / PZHL-M	PZHL-W / U18	U18 / PZHL-M
FFM-kg	65.04	70.86	91.8
MM-kg	59.76	65.44	91.32
FM 1-kg	74.63	95.31	78.3
%FM	183.9	213.8	89.42

The correlation between the two methods for identifying the mass of the body segments was investigated with regression analysis. It was used to characterize the relationships between the body segment values calculated with both methods in the group of male and female ice-hockey players. Figures 1a, b, c present the regression of the upper extremities' mass in three groups of ice hockey players derived from two methods. Figures 2 a, b, c that follow show regression between the amounts of the lower extremities' mass in the three groups of subjects.

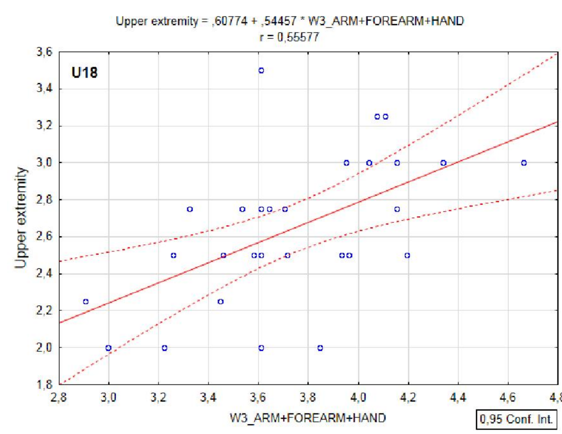

Figure 1a. An analysis of regression between two methods of analysing the mass of the upper extremity in the U18 groups of ice-hockey players Polish national teams.

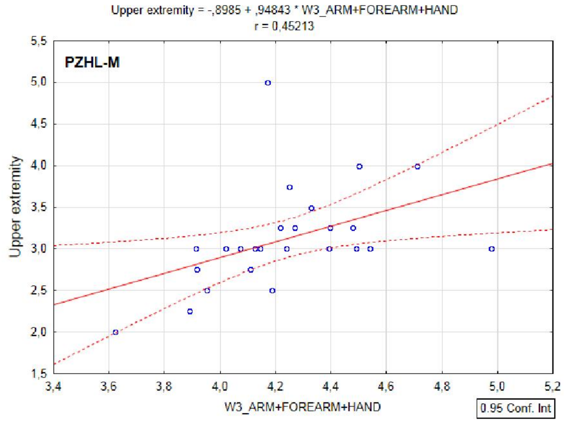

Fig. 1b. An analysis of regression between two methods of analysing the mass of the upper extremity in the I PZHL-male groups of ice-hockey players Polish national teams.

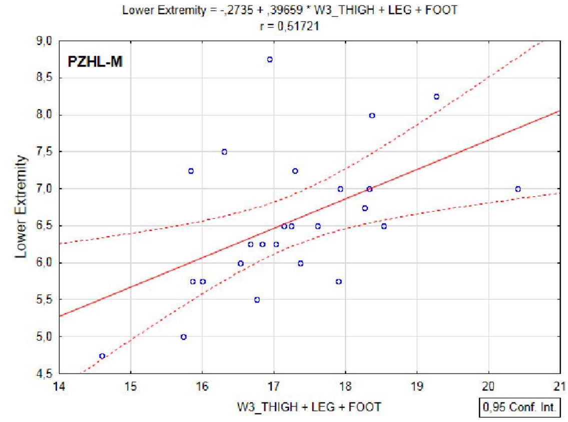

Fig. 2b. An analysis of regression between two methods of analysing the mass of the lower extremity in the PZHL-male groups of ice-hockey players Polish national teams.

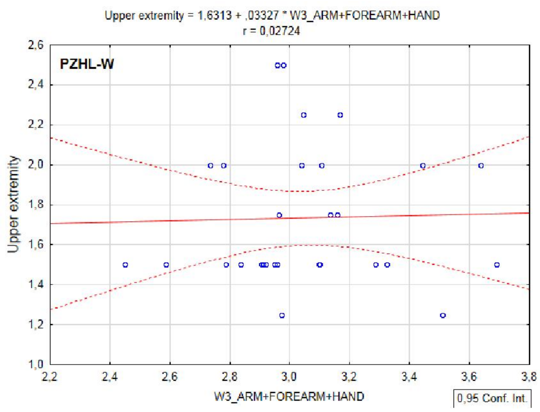

Fig. 1c. An analysis of regression between two methods of analysing the mass of the upper extremity in the PZHL- female groups of ice-hockey players Polish national teams.

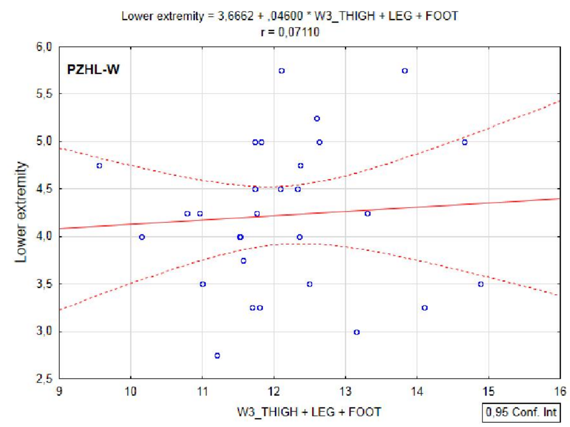

Fig. 2c. An analysis of regression between two methods of analysing the mass of the lower extremity in the PZHL-female groups of ice-hockey players Polish national teams.

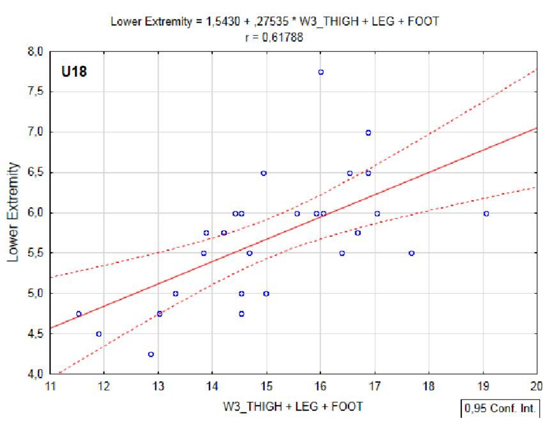

Fig. 2a. An analysis of regression between two methods of analysing the mass of the lower extremity in the U18 groups of ice-hockey players Polish national teams.

The analysis of regression between values characterising the muscle mass of lower and upper extremities obtained from the BIA method and the total body mass calculated using the Zaciorski's approach (1979) indicates that a close correlation is lacking only in the female group. Therefore, in this group the total mass of the extremities should not be connected with the muscle mass. In females, the mass of the lower extremities depends not only on the muscle mass. Hence, a hypothesis can be formulated that a high proportion of fat tissue in relation to body mass, also in relation to the mass of the extremities will cause a lack of correlation between values determined with the BIA approach and the indirect method.

Discussion

Players' body build in ice hockey is important for their being able to engage in sports fighting. In addition to having effect on motor capabilities, the body build determines muscle mass in relation to developed power and the effectiveness of fight in direct contact with the opponent. Potteiger et al. (2010) have demonstrated in their study that the ability to develop great power is closely related to the amount of fat tissue. During the speed and speed-endurance effort on ice the correlations were statistically significant (respectively ($r=0.53$; $p<0.01$ and $r=0.57$; $p<0.01$). The studied athletes in whom the above correlation was found to occur had the %FM value of 11.9 ± 4.6%, i.e. similar to that in both male groups of Polish ice-hockey players. The study by Gilenstam et al. (2011) have revealed a significant correlation ($p<0.05$) between subject's time in the speed test on ice and the absolute body mass – a positive correlation (the greater the body mass, the longer time of skating over the distance) and a negative relationship between the time of skating and the percentage of LBM (the lower amount of fat, the shorter the skating time). The amount of tissue in subjects from the group of the US Women's Ice Hockey team (Ransdell & Murray, 2011) was estimated at 15.8 ± 1.9%, i.e. at a level much lower than that in the Polish female ice hockey players.

Gilenstam (2009) have pointed to relationships between body mass and physical performance and to the differences between men and women in that respect. Women with low body mass and a high percentage of lean tissue generate high indicators of aerobic capacity, however the strength of their legs is relatively lower than in men with a similar content of fat tissue. In relation to body mass, women exercising on ice show a lower level of physical performance than men. In relation to LBM (the fat-free mass), the differences decrease or disappear (Gilenstam, 2009). The high proportion of fat tissue in Polish female ice-hockey players 24,33 ± 10.7 reveals that the development of physical performance and special physical fitness in this group of athletes faces major somatic limitations, particularly strongly affecting the strength of the lower extremities and their aerobic capacity. Gilenstam (2011) has observed that the special fitness of female ice-hockey players could be improved by increasing the muscular endurance of the extremities, aerobic capacity, and relative muscle mass.

Conclusion

1. The results of the study allowed, by analysing regression in the groups of Polish male ice-hockey players, calculating regression equations between the muscle mass of the extremities and their mass. With the equations, the muscle mass of the extremities can be determined based on their total mass obtained with an indirect method from Zaciorski's equations (1979). The equations can be applied to groups of ice-hockey players with fat tissue content ranging from 6 to 17% – group U18 – and from 9 to 18% – group PZHL-M

Group U18

Upper extremity

$y=0.607737+0.555773 \times$ mass (arm + forearm + hand)

Lower extremity

$y=1,543019+0,617875 \times$ mass (thigh + leg + foot)

Group PZHL-M

Upper extremity

$y=-0.898455+0.452134 \times$ mass (arm + forearm + hand)

Lower extremity

$y=-0.273515+0.517212 \times$ mass (thigh + leg + foot)

2. The analysis of the results has shown that the muscle mass cannot be estimated based on Zaciorski's equations (1979) when the fat tissue content is high (1979). Considerable differences in the body build, but particularly in the proportions of LBM, FM and FFM between the groups of males and females indicate that in the training process a special attention should be given to the tissue composition of female athletes deciding to specialise in ice-hockey.

Acknowledgements:
The scientific work funded from the budget centers on the science in years 2011-2014 grant N RSA1 002951.

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2/26/2014