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Reference Values and Sensitivity for Different Body Fat Variables Measured by Bioimpedance Method in Female Athletes in Individual Sports: Discriminative and Comparative Study

Valores de Referencia y Sensibilidad para Diferentes Variables de Grasa Corporal Medidas por el Método de Bioimpedancia Eléctrica en Deportistas Femeninas en Deportes Individuales: Estudio Discriminativo y Comparativo

Dopsaj Milivoj[1]; Siljeg Klara[2] & Milic Radoje[3]

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SUMMARY: Athletes differ among themselves and one of the main differences is observed in relation to body shape and composition. Achieving top sports performance requires more standardization in the processes of training and development of a unique methodology for individualizing the control specific adaptation of athletes. The aim of this study is to establish reference data for the most sensitive variables to define the amount and structure of body fat in female athletes in individual sports. The sample included 895 females, divided in: a control group (Cont) of young females (N = 688); International (N = 113), and National level female athletes (N = 94) in 13 individual sports. Four variables described the structureof of body fat: Percentage of body fat (PBF), Body Fat Mass Index (BFMI), Protein Fat Index (PFI) and Index of Body Composition (IBC). Results showed that considering the control group, female athletes have all examined Body Fat variables statistically significantly different (BFMI and PBF are lower, p = 0.011 and p = 0.000, while PFI and IBC are higher, p = 0.000, respectively). Female athletes are also statistically significantly different in relation to the level of competition (p = 0.000), and the investigated variables are responsible for 17.7 % of the variability of the difference between the groups. Competitively more successful female athletes have higher IBC (lower percentage of fat per overall body volume, p = 0.013), as well as, a statistically significantly higher protein mass in relation to body fat mass (PFI, p = 0.018). The most sensitive variables for defining body fat differences between the examined individual sports were IBC, with an influence of 37.9 %, then PFI (32.4 %), then PBF (22.8 %), and finally BFMI, with an influence of 11.4 % on the differences. Based on the results of this study, IBC and PFI are variables that have shown useful scientific-methodological potential for research in the future.

KEY WORDS: Bioimpedance; Female athletes; Body fat status; Index of Body Composition; Protein Fat Index.

INTRODUCTION

During a sports career, the athlete's organism adapts in relation to general and specific loads in relation to physical, morphological, cognitive and sports skill areas. One of the most important adaptations in sports efforts in elite athletes is closely related to morphological adaptation (Ackland *et al*., 2012; Saraykin *et al*., 2018; Surina-Maryasheva *et al*., 2022). Each sport has its own specifics, which, among other things, relate to the morphological profile of the athlete, as in relation to the discipline, but also in relation to the position in the game or competitive level (Bankovic *et al*., 2018; Gardasevic & Bjelica, 2020; Dopsaj *et al*., 2021a; Cerqueira *et al*., 2022). This means that the process of individualizing the required standards in relation to the applied technology needed to control the level of adaptation, even in relation to morphological characteristics, is necessary for more precise and efficient management of the sports training process in relation to all its aspects.

The technology of assessing body composition using the multichannel bioimpedance method is a relatively new method that is increasingly being applied in the general population, but also in a system of sports science (Sillanpää

[1] University of Belgrade, Faculty of Sport and Physical Education, Belgrade, Serbia.
[2] University of Zagreb, Faculty of Kinesiology, Zagreb, Croatia.
[3] University of Ljubljana, Faculty of Sport, Ljubljana, Slovenia.

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et al., 2014; Bankovic *et al*., 2018; Kukic *et al*., 2018; Dopsaj *et al*., 2020).

There was more and more evidence that athletes with lower body fat (%BF) and high muscle mass may have better athletic performance (Silva *et al*., 2010; Andreato *et al*., 2017; Saraykin *et al*., 2018). It was explained that excessive body fat could negatively impact physical and sports performance independently in the type of sports (Franchini *et al*., 2011; Dopsaj *et al*., 2021a). Also, different sports, as well as sports disciplines, require a different anthropomophrological profile, as well as a different profile of body composition, that is, an optimal body profile, in order to achieve an appropriate body for appropriate competitive success (Saraykin *et al*., 2018; Alarcón-Jimenez *et al*., 2020; Dopsaj *et al*., 2021a; Akdogan *et al*., 2022; Cerqueira *et al*., 2022).

Therefore, this study has multidimensional goals. The first is to establish reference data for the general classification of the examined variables and the applied measurement method that defines the amount and structure of fat in the body of female athletes in the examined individual sports. As a secondary goal, it is necessary to define the most representative and sensitive variable in relation to diagnostic and metrological procedures for the actual subject sample. The tertiary objective is to determine the importance of the examined variables in relation to competitive success for each examined sport individually.

MATERIAL AND METHOD

The research is organized as applied non-experimental scientific research. It was carried out as a laboratory measurement and using a random sample.

Subjects Sample: The sample included 895 randomly selected females, where the sample of individual sport athletes was (N = 207; Age = 23.9 ± 4.4 yrs.; BH = 169.5 ± 7.2 cm; 61.9 ± 8.4 kg; BMI = 21.51 ± 2.19 kg/m^2), and control group (Cont) of young non-sport females (N = 688; Age = 23.0 ± 2.5 yrs.; BH = 168.0 ± 6.7 cm; 62.8 ± 11.6 kg; BMI = 22.22 ± 3.83 kg/m^2). In the next step of the analysis sample that was taken from the athletes was generally divided in two sub-groups considering the competitive levels: National (NAT) and International (INT) level athletes. In the third step, the athlete sample was divided into thirteen individual sports, and as a final, fourth stage all sports were divided according to the competitive level at: NAT and INT rank athlete as: Judo (N = 12, 4 vs 8), Swimming (N = 29, 9 vs 20), Track and Field (N = 38, 21 vs 17), Triathlon (N = 9, 3 vs 6), Karate (N = 20, 10 vs 9), Archery (N = 7, 7 vs 0), Road Cycling (N = 8, 4 vs 4), Synchro Swimming (N = 5, 2 vs 3), Tenis (N = 9, 5 vs 4), Rowing (N = 8, 4 vs 4), Kayak (N = 12, 6 vs 4), Diving (N = 12, 6 vs 3), and Dance Sport (N = 43, 12 vs 31).

All subjects that conducted measurements were informed about the aim of the study and subjects were measured only if they agreed to be part of the study. The study was organized according to a multicentric study procedure, and measurement was realized in Belgrade (Faculty of Sport and Physical Education, University of Belgrade, Serbia) and Ljubljana (Faculty of Sport, University of Ljubljana, Slovenia), while the measured female athletes were representatives of sports associations from Serbia, Slovenia and Croatia. The research was carried out according to the Declaration of Helsinki (Christie, 2000), and it was approved by the Ethics Commission University of Belgrade (484–2).

Testing. The testing procedure of measuring body composition was carried out by the usage of bioelectrical impedance analysis (BIA), precisely InBody 720 Tetapolar 8 points by tactical electrodes system (Biospace Co, Ltd) according to previously explained procedures (Sillanpää *et al*., 2014; Kukic *et al*., 2018; Dopsaj *et al*., 2021b).

Variables. This study includes 7 variables where 3 are basic anthropometrical, and 4 are calculated as derived body fat variables i.e. index values. Index-values approach was applied so the body structure can be explained on the tissue level, independently of body height and volume. Following variables were used (Kukic *et al*., 2018; Dopsaj *et al*., 2021a):

Basic anthropo-morphological body variables:

1) Body height (BH) presented in cm; 2) Body weight (BW) presented in kg; 3) Body mass index (BMI), presented in kg/m^2;

Derived body fat variables (experimental):

3) Percentage of body fat (PBF) presented as body fat mass (BFM) relative to BM, calculated as: (BFM/BM) * 100 = PBF (%)

4) Body Fat Mass Index (BFMI) presented as body fat relative to body high (BH) ie. longitudinality size, calculated as: BFM/BH^2 = BFMI (kg/m^2)

5) Protein Fat Index (PFI) presented as protein mass (PM) relative to BFM, calculated as: PF/BFM = PFI (index unit)

6) Index of Body Composition (IBC), presented as BMI relative to PBF, calculated as: BMI/PBF = IBC (index unit).

Statistics. Mean and standard deviation was calculated by the statistical software package SPSS (IBM, SPSS Statistics, version 23). Differences between groups of sub-samples and individual sports were defined by MANOVA and ANOVA, while pairwise comparison was made by T-test withBonferroni post-hoc test adjustment for multiple comparisons. To define the most sensitive body fat variable which makes the most important difference between the groups of analyzed individual sports we used Discriminant analysis. The level of statistical significance was defined by 95 % and the probability values of p <0.05 (Hair *et al*., 1998).

RESULTS

In Table I athletes' sample sub-groups (General, International and National) and the control group descriptive data are shown, with MANOVA (Multivariate statistics) and ANOVA (Univariate statistics) results of general and partial differences between groups. In Table II individual sport sample sub-groups of body fat variables descriptive data are shown.

The discriminant analysis defined two factors, the first of which is responsible for explaining 96.8 % of the total variance, while the second explained only 3.2 %. The Structure Matrix (Table III) showed that only one statistically significant factor (Factor 1, Wilks' Lambda = 0.692, p = 0.000) was singled out by which the examined groups (Table III) differ and that the most sensitive variables as carriers of the determined differences between the groups - IBC (-0.924) and PFI (-0.806).

Figures 1, 2, 3 and 4 show the results of the examined variables in relation to the investigated individual sports as a function of competitive level (Nat and Int) with the results of statistically significant differences.

In relation to BFMI (the amount of fat in the body standardized in relation to the body longitudinality), the results showed that statistically significant differences in relation to the competitive level (Nat vs Int) between female athletes were determined only in 4 sports, as: Swimming, p = 0.024; Road Cycling, p = 0.007; Diving, p = 0.014; Dance, p = 0.012 (Fig. 1).

Table I. Descriptive data for athlete sample sub-groups and control group with differences (MEAN±SD, MANOVA & ANOVA).

Sample Variables	Athlete General, (N=207)	Control (N=688)	Athlete Internat. (N=113)	Athlete National (N=94)	ANOVA	
					AG & C	AI & AN
BH (cm)	168.5±7.2	168.0±6.7	170.2±7.3	168.6±7.0	p=0.006	p=0.091
BM (kg)	61.9±8.4	62.8±11.6	63.2±8.0	60.4±8.7	p=0.333	p=0.015
BMI (kg/m^2)	21.51±2.19	22.22±3.83	21.76±1.93	21.22±2.45	p=0.023	p=0.079
BFMI (kg/m2)	4.31±1.49	6.35±2.94	4.23±1.54	4.40±1.43	p=0.011	p=0.428
PBF (%)	19.78±5.43	27.60±7.26	19.25±5.93	20.42±4.70	p=0.000	p=0.124
IBC (I.U.)	1.168±0.351	0.838±0.193	1.240±0.415	1.082±0.226	p=0.000	p=0.013
PFI (I.U.)	0.889±0.347	0.567±0.229	0.941±0.400	0.826±0.259	p=0.000	p=0.018
MANOVA	Wilks' Lambda F=91.20, p=0.000, part. Eta^2=0.291		Wilks' Lambda F=47.78, p=0.000, part. Eta^2=0.177			

Table II. Descriptive data for individual sport sample sub-groups with differences (MEAN±SD; MANOVA & ANOVA).

Variables Sample	BFMI (kg/m^2)	PBF (%)	IBC (I.U.)	PFI (I.U.)
Judo (N=12)	3.988±1.263	18.60±4.38	0.873±0.153	0.917±0.244
Swimming (N=29)	3.682±1.246	17.23±5.34	0.810±0.237	1.079±0.479
T & F (N=38)	3.226±1.154	15.14±4.20	0.720±0.189	1.206±0.370
Triatlon (N=9)	3.367±0.631	17.46±3.01	0.909±0.171	0.959±0.184
Karate (N=20)	5.207±1.481	23.03±4.60	1.027±0.137	0.693±0.178
Archery (N=7)	5.253±0.823	22.77±2.51	0.997±0.151	0.678±0.098
Road Cycling (N=8)	4.015±0.838	19.75±2.51	0.972±0.192	0.835±0.203
Synchro Swim (N=5)	4.854±1.232	22.17±4.81	0.992±0.186	0.746±0.195
Tenis (N=9)	4.322±1.568	19.25±4.69	0.869±0.129	0.884±0.295
Rowing (N=8)	5.350±1.901	22.18±5.23	0.926±0.164	0.740±0.209
Kayak (N=10)	5.147±0.882	21.66±3.10	0.921±0.176	0.738±0.150
Diving (N=9)	3.756±0.779	18.56±3.28	0.924±0.183	0.897±0.189
Dance Sport (N=43)	5.115±1.477	23.63±4.88	1.102±0.177	0.671±0.184
MANOVA	Wilks' lambda F = 11.30, p = 0.000, Partial Eta ^{2} = 0.143, Observed Power = 1.000			
ANOVA	F=8.71, p=0.000,	F=19.97, p=0.000,	F=41.33, p=0.000,	F=32.49, p=0.000,

Table III. Summary of Canonical Discriminant Functions for individual sport general sample sub-groups.

Structure Matrix		
	Function	
Variables	1	2
IBC	-0.924*	0.142
PFI	-0.806*	-0.094
PBF	0.720*	0.429
FMI	0.480*	0.365
Functions at Group Centroids		
Competitive Level	Function	
	1	2
National	-0.833	-0.423
International	-1.458	0.231
Control	0.353	0.020

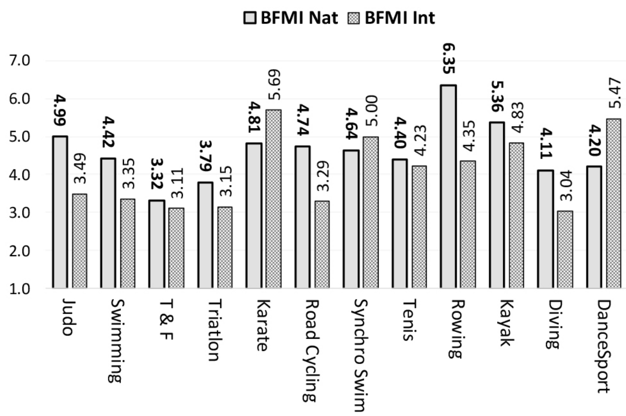

Fig. 1. Results and differences between BFMI according to sport and competitive level. Statistical significance: FMI - National vs International: Judo, p = 0.126; Swimming, p = 0.024; T & F, p = 0.566; Triathlon, p = 0.346; Karate, p = 0.196; Road Cycling, p = 0.007; Syncho Swimming, p = 0.749; Tenis, p = 0.873; Rowing, p = 0.174; Kayak, p = 0.408; Diving, p = 0.014; Dance, p = 0.012.

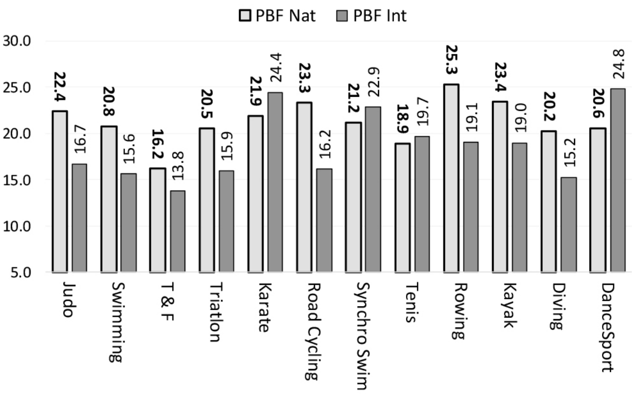

Fig. 2. Results and differences between PBF according to sport and competitive level. Statistical significance: PBF - National vs International: Judo, p = 0.055; Swimming, p = 0.007; T & F, p = 0.076; Triathlon, p = 0.085; Karate, p = 0.230; Road Cycling, p = 0.002; Syncho Swimming, p = 0.707; Tenis, p = 0.812; Rowing, p = 0.164; Kayak, p = 0.030; Diving, p = 0.005; Dance, p = 0.018.

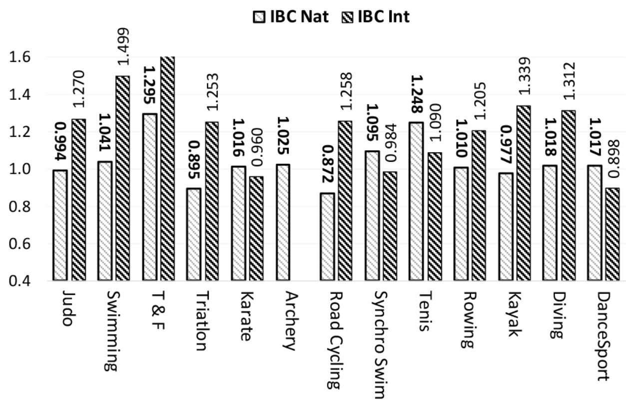

Fig. 3. Results and differences between IBC according to sport and competitive level. Statistical significance: IH - National vs International: Judo, p = 0.013; Swimming, p = 0.002; T & F, p = 0.002; Triathlon, p = 0.000; Karate, p = 0.419; Road Cycling, p = 0.001; Syncho Swimming, p = 0.411; Tenis, p = 0.292; Rowing, p = 0.154; Kayak, p = 0.001; Diving, p = 0.017; Dance, p = 0.095.

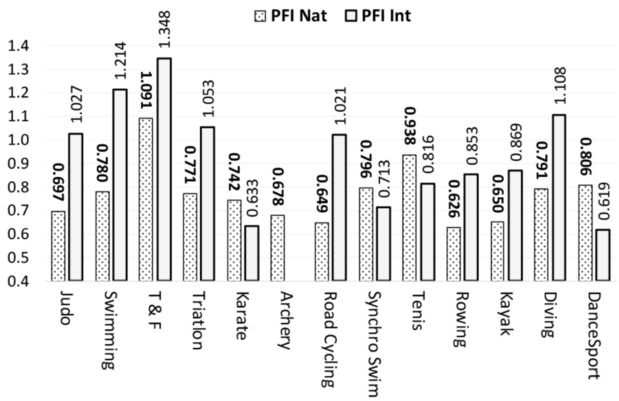

Fig. 4. Results and differences between PFI according to sport and competitive level. Statistical significance: PFI - National vs International: Judo, p = 0.015; Swimming, p = 0.002; T & F, p = 0.038; Triathlon, p = 0.035; Karate, p = 0.164; Road Cycling, p = 0.000; Syncho Swimming, p = 0.649; Tenis, p = 0.486; Rowing, p = 0.139; Kayak, p = 0.050; Diving, p = 0.002; Dance, p = 0.020.

PBF results showed that (the relation between the body mass and amounts of body fat), statistically significant differences in relation to the competitive level (NAT vs INT) between female athletes were determined in 5 sports, as: Swimming, p = 0.007; Road Cycling, p = 0.002; Kayak, p = 0.030; Diving, p = 0.005; Dance, p = 0.018 (Fig. 2). In relation to IBC (the relation between the level of overall body volume and relative amounts of body fat), the results showed that statistically significant differences in relation to the competitive level between female athletes were determined in 7 sports, as: Judo, p = 0.013; Swimming, p = 0.002; T & F, p = 0.002; Triathlon, p = 0.000; Road Cycling, p = 0.001; Kayak, p = 0.001; Diving, p = 0.017 (Fig. 3). For

PFI (as a quantitative relationship between protein, as a pure contractile component, and amounts of body fat, as a ballast component in the body) the results showed that statistically significant differences in relation to the competitive level between female athletes were determined in 8 sports, as: Judo, p = 0.015; Swimming, p = 0.002; T & F, p = 0.038; Triathlon, p = 0.035; Road Cycling, p = 0.000; Kayak, p = 0.050; Diving, p = 0.002; Dance, p = 0.020 (Fig. 4).

In Table IV general sample sub-groups (Control, Athletes National, and International) reference values for the most sensitive body fat variables are shown.

Table IV. Percentile referent data for control and athlete sub-ample groups for IBC and PFI variables.

Sample	Control Group		Athletes National		Athletes International	
Variables	IBC	PFI	IBC	PFI	IBC	PFI
2.5	0.615	0.236	0.758	0.426	0.727	0.396
5.0	0.636	0.299	0.823	0.505	0.752	0.431
10.0	0.669	0.336	0.863	0.555	0.790	0.543
50.0	0.808	0.542	1.033	0.778	1.151	0.857
90.0	1.026	0.807	1.331	1.130	1.865	1.540
95.0	1.148	0.951	1.652	1.387	2.139	1.802
97.5	1.245	1.047	1.705	1.552	2.374	2.089

DISCUSSION

Different sports, as well as different sports disciplines, require athletes to be selected, trained and adapted - physically, technically, tactically, psychologically and anthropomorphologically in accordance with the performance requirements of the particular sport, discipline or playing position (Franchini *et al*., 2011; Bankovic *et al*., 2018; Saraykin *et al*., 2018; Alarcón-Jimenez *et al*., 2020; Gardasevic & Bjelica, 2020; Cerqueira *et al*., 2022; Semenov *et al*., 2022). Achieving top sports performance at today's level of development of sports results requires more and more standardization in all processes of training, but also the development of a unique methodology for individualizing the control of training and specific adaptation in athletes (Morin & Samozino, 2016; Dopsaj *et al*. 2021a; Surina-Maryasheva *et al*., 2022). Athletes, even from the same sport or discipline, differ among themselves in relation to various aspects, and one of the main differences is observed in relation to body shape, longitudinality, transversality and symmetry of the body and body composition (Santos *et al*., 2014; Bankovic *et al*., 2018; Dopsaj *et al*., 2021a).

The results showed that female athletes from the examined individual sports, on a general level, differ significantly from the control group of healthy young non-athlete women, and that the examined variables are responsible for 29.1 % of the variability of the difference between the groups (Table I, F = 91.20, p = 0.000, partial Eta^2 = 0.291). Female athletes are taller (p = 0.006) but have lower BMI (p = 0.023), and all examined body fat variables are statistically significantly different (BFMI and PBF are lower, p = 0.011 and p = 0.000, respectively), while PFI and IBC are higher (p = 0.000, Table I, ANOVA). In other words, in addition to the fact that female athletes are taller and with a lower BMI, they also have a body composition with statistically significantly less fat (standardized both in relation to longitudinality and in relation to body volume), but also with more protein in the body (female athletes have 0.889 kg of protein per kg of body fat, while subjects from the control group have only 0.567 kg of protein per kg of body fat).

Female athletes are also generally statistically significantly different in relation to the level of competition (Table I, F = 47.78, p = 0.000, partial Eta^2 = 0.177), and the investigated variables are responsible for 17.7 % of the variability of the difference between the groups. Competitively more successful female athletes (Int) have higher BM (p = 0.015), higher IBC (lower percentage of fat per overall body volume, i.e. BMI, p = 0.013), as well as a statistically significantly higher protein mass in relation to a unit of body fat mass (PFI, p = 0.018). Between the analyzed sports, a general statistically significant difference was also found between the examined variables of body fat (Table II, F = 11.30, p = 0.000, partial Eta^2 = 0.143), which are responsible for 14.3 % of the variability of the difference between the examined sports. Statistically significant differences were found between all individual variables of body fat and the largest for IBC, with an influence of 37.9 %, then for PFI, with an influence of 32.4 %, then for PBF, with an influence of 22.8, and finally for BFMI, with an influence of 11.4 % on the determined differences between the examined individual sports. In other words, female athletes from the analyzed individual sports differed the most in relation to the IBC variables as a measure of the ratio of overall body volume (BMI) and relative body fat (PBF), followed by PFI, as a measure of the ratio of the pure contractile component in the body (protein) and pure ballast masses in the body (body fat). These results were also confirmed by the Discriminant Analysis (Table III), which singled out only one significant function, as methodological evidence that the selected variables had the same generic origin, i.e. that they measured the same body attribute (body fat in relation to some dimension of body proportion). The analysis also showed that the variables IBC and PFI are the most sensitive (Table III, -0.924 and -0.806, respectively) in relation to the information they carry regarding the status of body fat in young women, regardless of whether they are athletes or not.

The results of the differences between sub-groups of female athletes in relation to the competitive level (NAT or INT) showed that for certain groups of sports, a certain level of specificity of the importance of the investigated variables was determined as a function of the influence on international competitive performances. It is interesting that based on the results, it can be concluded that the total sample of sports can be classified into three groups.

The first group consists of three sports: swimming, cycling and diving, where a statistically significant difference between national and international athletes was found in all four variables of body fat. In other words, in those sports, the adaptation in female athletes towards a body profile with a lower amount of fat, both in relation to height, in relation to mass, in relation to volume and in relation to the pure contractile component, significantly positively affects the potential of achieving elite sports results (Figs. 1 to 4). It is obvious that, regardless of the level of success and in addition to specific sports skills, the physical adaptation in female athletes in the mentioned sports is directed towards a body composition with a markedly low percentage of fat. In this way, the body balance between body lean mass (mostly protein i.e. muscle mass) and fat mass is optimized, which is likely to be beneficial and of particular importance for maximizing competitive performance in, for example swimming (Dopsaj *et al*. 2021a).

However, it seems that there are also sports where none of the examined variables have a statistically significant effect on achieving a high competitive level, which was found in Synchro Swimming, Tennis and Rowing (Figs. 1 4). It is obvious that in those sports some other factors are much more important in terms of achieving international results (technical efficiency, psychological profile, energy systems, physical characteristics, particular specific sports skills, etc.) than the adaptation of body composition in terms of body fat components.

And the third group consists of sports where certain variables have a statistically significant connection with the potential for achieving a top result. Thus, for Judo, T & F and Triathlon, it was determined that the variables where body fat is partialized in relation to the longitudinality (FMI) and mass (PBF) of the body do not have a statistically significant relationship with the competitive level, but they do if the fat is partialized in relation to the general body voluminousness (BMI) and contractile component (Protein) (Figs. 1 to 4).

Judo and T & F belong to the category of sports in which the highly developed component of maximal strength and anaerobic power dominates in the relation to training and competition loads, while Triathlon belongs to the category of sports in which aerobic endurance dominates, but also the component of strength and anaerobic power is very important. Especially in races on hilly terrains, as well as in situations of powerful acceleration, or in finishing at the end of the race (Silva *et al*., 2010; Franchini *et al*., 2011; Morin & Samozino, 2016; Kukic *et al*., 2018). This is the most likely reason why the differences between groups within the given sports were determined precisely in the variables that carry information about protein as a pure contractile component (PFI), or a total body volume (IBC) (Tables III and IV).

On the other hand, the relativized values of body fat (BFMI, PBF) in all three sports are below average, i.e. at the level of excellent values (PBF = 10.1 to 17.4 %, Rakic *et al*., 2019), or significantly below the average for an untrained healthy female person of the general population (Table II, BFMI Judo – 3.988 till T & F 3.226 vs general health non-athlete female population – 5.84±2.89) (Dopsaj *et al*., 2021b) in relation to the standard for women aged 20 to 29. This practically means that female athletes from the given three sports generally have a low percentage of fat in their bodies, but competitively those who had more protein components in their bodies were more successful.

Based on the obtained reference values for the two most sensitive variables (Tabel 4, IBC and PFI), it can be concluded that they can serve as initial criterion values of the mentioned variables, but the final scientifically valid criteria must be defined on a more multinational selected and larger sample of female athletes.

CONCLUSION

Achieving top sports performance requires more standardization in all processes of training, but also the development of a unique methodology for individualizing the control of training and specific adaptation in athletes.

Therefore, the aim of this study is to establish reference data for the most sensitive variables that define the amount and structure of fat in the body of female athletes in the examined individual sports. The sample included 895 randomly selected females, divided in the following sub-groups: control group (Cont) of young non-sport females (N = 688); International level (N=113), and National level female athletes (N = 94) from 13 individual sports. Four variables described the structure of body fat as well as: Percentage of Body Fat (PBF), Body Fat Mass Index (BFMI), Protein Fat Index (PFI) and Index of Body Composition (IBC).

Results showed that female athletes are taller (p = 0.006), have lower BMI (p = 0.023), and all examined body fat variables are statistically significantly different, where BFMI and PBF are lower (p = 0.011 and p = 0.000, respectively), while PFI and IBC are higher (p = 0.000). In other words, considering differences between the control group and female athletes (examined variables are responsible for 29.1 % of the variability of the difference), the fact is that female athletes are taller and with a lower BMI, they also have a body composition with statistically significantly less fat (standardized both in relation to longitudinality or in relation to body volume), but also with more protein in the body.

Female athletes are also generally statistically significantly different in relation to the level of competition (p = 0.000), and the examined variables are responsible for 17.7 % of the variability of the difference between the groups. Competitively more successful female athletes (INT) have higher BM (p = 0.015), higher IBC (p = 0.013), as well as a statistically significantly higher protein mass in relation to a unit of body fat mass (PFI, p = 0.018). The most sensitive variables for defining body fat differences between the examined individual sports were IBC (37.9 % of influence), then for PFI (32.4 % of influence), then for PBF (22.8 % of influence), and finally for BFMI (11.4 % of influence). The Discriminant Analysis also showed that the variables IBC and PFI are the most sensitive (-0.924 and -0.806, respectively) in relation to the information they carry regarding the status of body fat in young women, regardless of whether they are athletes or not.

Based on the results of this study, IBC and PFI are variables that have shown useful scientific-methodological potential for research in the future.

DOPSAJ, M.; SILJEG, K. & MILIC, R. Valores de referencia y sensibilidad para diferentes variables de grasa corporal medidas por el método de bioimpedancia en mujeres atletas en deportes individuales: Estudio discriminativo y comparativo. *Int. J. Morphol., 41(3)*:717-724, 2023.

RESUMEN: Los deportistas difieren entre sí y una de las principales diferencias se observa en relación a la forma y composición corporal. Alcanzar el máximo rendimiento deportivo requiere una mayor estandarización en los procesos de entrenamiento y en el desarrollo de una metodología única para individualizar el control de adaptación específico de los atletas. El objetivo de este estudio fue establecer datos de referencia de las variables más sensibles para definir la cantidad y estructura de la grasa corporal en mujeres deportistas en deportes individuales. La muestra estuvo compuesta por 895 mujeres, divididas en: un grupo control (Cont) de mujeres jóvenes (N = 688); Atletas femeninas de nivel internacional (N = 113) y nacional (N = 94) en 13 deportes individuales. Cuatro variables describieron la estructura de la grasa corporal: Porcentaje de grasa corporal (PBF), Índice de Masa Grasa Corporal (BFMI), Índice de Proteína Grasa (PFI) e Índice de Composición Corporal (IBC). Los resultados mostraron que, considerando el grupo control, todas las atletas tuvieron diferecias estadísticamente significativas respecto a las variables de grasa corporal (BFMI y PBF son más bajos, p = 0,011 y p = 0,000, mientras que PFI e IBC son más altos, p = 0,000, respectivamente). En relación al nivel de competencia, las atletas femeninas presentan diferencias estadísticamente significativas (p = 0,000), y las variables investigadas son responsables por el 17,7 % de la variabilidad de la diferencia entre los grupos. Las atletas femeninas competitivamente más exitosas tienen un IBC más alto (menor porcentaje de grasa por volumen corporal total, p = 0,013), así como una masa proteica estadísticamente más alta en relación con la masa de grasa corporal (PFI, p = 0,018). Las variables más sensibles para definir las diferencias de grasa corporal entre los deportes individuales examinados fueron IBC, con una influencia del 37,9 %, luego PFI (32,4 %), a seguir PBF (22,8 %) y finalmente BFMI, con una influencia del 11,4 % en las diferencias. En base a los resultados de este estudio, IBC y PFI son las variables que han mostrado un potencial científico-metodológico útil para la investigación en el futuro.

PALABRAS CLAVE: Bioimpedancia; Atletas femeninas; Estado de la grasa corporal; Índice de Composición Corporal; Índice de proteínas y grasas.

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Corresponding author:
Klara Siljeg
University of Zagreb
Faculty of Kinesiology
Zagreb
CROATIA

E-mail: klara.siljeg@kif.unizg.hr