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PROTEIN, BODY FAT AND PROTEIN FAT INDEX (PFI): MODEL CHARACTERISTICS AND DIFFERENCES BETWEEN ATHLETES AND NON-ATHLETES OF BOTH GENDERS ESTIMATED USING MULTICHANNEL BIOELECTRIC IMPEDANCE

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The main objective of this research was to define the quantitative indicators for model characteristics and differences pertaining to body protein (Protein) structure as the basic component of contractile tissue, body fat mass (BFM) as the ballast tissue relevant to the basic motor skills and movement in humans, and protein fat index (PFI), a new index developed to define the relationship between ballast and contractile body tissues. The sample included 1,055 subjects (729 men and 326 women). The subjects were divided into subsamples according to types of sport, while the control groups were divided according to age and exercise levels. Body composition was estimated using InBody720, a segmental multichannel bioelectrical impedance analyzer.

The results revealed highly significant statistical differences between the variables relative to gender, men subsamples, and women subsamples (Wilks' Lambda = 0.403, p= 0.000; WL = 0.602, p = 0.000; WL = 0.427, p = 0.000, respectively). The difference between genders was most influenced by the Protein variable with 56.7%, followed by PFI with 21.9%, and least by BFM with 6.7%. In other words, the difference between men and women was 8.5 times higher in body protein mass, i.e. in basic contractile tissue, than in body fat mass, i.e. in ballast tissue. In men, the between-groups difference was most influenced by the BFM variable with 26.4%, followed by PFI with 18.8%, and least by Protein with 10.2%. In women, Protein and PFI accounted for 33.7% and 33.1% of the between-groups difference, respectively, while the effect of BFM was 25.1%.

Based on the results of this research, it can be argued that multichannel bioelectrical impedance, as a new method for body composition analysis, is discriminative and sensitive in measuring body protein and fat mass, and that PFI can be used as an integral indicator of the ratio between body protein and body fat components in scientific research and in practice, both in sports and in medicine.

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Key words: *bioimpedance, body composition, athletes, protein fat index*

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Introduction

Body composition is the term that defines the phenomenon of body composition, i.e. the set of substances that constitute the materially manifest structure of the human body (1). The macro-level composition of the human body is represented by four biologically measurable segments of matter:

- water, as liquid;
- the fat component, as the basic reserve of energy;
- the mineral component, as the solid body component; and,
- the protein component, as the basis for the contractile component responsible for locomotion, i.e. movement (2).

Quantitative characteristics and proportions of body composition are the subject of research in anthropological, medical and sports sciences, focusing on the methodological, metrological or healthcare aspects of the problem (3-7).

However, in addition to the key elements of body composition determined by the basic morphological variables, the growing area of research takes into account the index variables, in which two or more data on body composition are integrated. Such integrated information enables the determination of not only the ratio or proportion of individual components but also of the segmented relationship between homogeneous components of body composition. This is equally important for research and clinical theory and practice (6-8).

Sport is an element of human social need to compete; as such, it represents a meaningful, long-term physical training and exercise system aimed at achieving an adequate level of general and specific competitive fitness, as well as an optimal level of efficiency in sports performance (9). Since athletes are systematically subjected to various physical efforts, the need for a specially tailored lifestyle, diet, work and rest regime has given rise to the special technology for continuous monitoring of their fitness level, health and morphological status (10-12). In monitoring the effects of training, a very important specific segment of the general technology considers the control and continuous monitoring of the level of adaptation with respect to body composition. This includes the adaptation of the tissue aimed at improving the contractile capacity, i.e. force or power, the increase in the resistance of bone tissue, or the improvement in a specific type of endurance (11-14).

Both in science and in sport, the use of multichannel bioelectrical impedance to estimate body composition is increasingly becoming the method of choice and a desirable standard in practice (7, 15-19). On the other hand, this method has offered an addition to the body of index variables already established in science and practice that define a particular aspect of body composition, such as BMI, FFMI, or FMI. Thus, the index space has been enriched by creating a provision for the definition of new indices of body composition bearing a greater innovative informational and scientific potential than the existing ones. One of such innovative indices is protein fat index, which provides a two-dimensional definition of the relationship between protein, as a purely contractile component of body composition, and total body fat mass, which is an energy reserve component from the biological aspect but is also seen as a non-contractile ballast mass in sports (12, 20).

The main objective of this research was to determine the general and the specific model characteristics of protein fat index (PFI), the new index developed to define the relationship between contractile and ballast body tissues, which can be regarded as an important conveyor of information on body composition in the system of sport and medical sciences. The secondary objective of the study was to contribute to the sports science by providing quantitative information and model values for the original PFI variables, namely, the data on protein mass and total body fat in the subsamples of athletes and non-athletes examined using the bioimpedance method.

Material and methods

This research was conducted using non-experimental scientific methods. The main testing technique involved taking quantitative measurements in the laboratory using multichannel segmental bioelectrical impedance. The chosen method type required parallel group testing (21), while the analytical method and mathematical modeling were used to gain new knowledge on the characteristics of the phenomenon under study (22).

Subject sample

The total effective sample was 1,055 subjects: 729 men (age 25.48 ± 8.33 years, body height 184.11 ± 8.52 cm, body mass 85.08 ± 14.16 kg, BMI 25.04 ± 3.39 kg m^2, length of training 12.12 ± 4.81 years), and 326 women (age 24.01 ± 5.26 years, body height 171.00 ±8 .86 cm, body mass 66.38 ± 11.75 kg, BMI 22.73 ± 3.61 kg m^2, length of training 12.12 ± 4.81 years) from the Republic of Serbia and the Republic of Slovenia. The subjects were divided into subsamples defined with respect to two criteria, as follows:

1. In athletes, with respect to the type of sport

- For men:
  - individual sports (athletics, swimming, cycling, tennis, rowing, kayaking),
  - combat sports (judo, karate, wrestling, kickboxing, fencing), and
  - team sports (water polo, basketball, volleyball, handball, football, rugby);
- For women:
  - individual sports (athletics, swimming, cycling, tennis, triathlon),
  - combat sports (judo, karate, wrestling), and
  - team sports (basketball, volleyball, handball, football).

2. In the control group of non-athletes, with respect to the level of physical exercise

- For men: adult working population not physically active, students of colleges with programmed physical exercise (Faculty of Sport and Physical Education-FSPE, Academy of Criminalistic and Police Studies-ACPS), students of colleges without programmed physical exercise (Faculty for Special Education and Rehabilitation-FASPER, Faculties of Medicine, Forestry, Pharmacy, Law, and Economics);
- For women: adult working population not physically active, students of colleges with programmed physical exercise (FSPE, ACPS), students of colleges without programmed physical exercise (FASPER, Faculties of Medicine, Forestry, Pharmacy and Law).

The research was conducted in accordance with the terms of the “Declaration of Helsinki: Recommendations guiding physicians in biomedical research involving human subjects” (23), with the approval and consent of the Ethics Committee of University of Belgrade Faculty of Sport and Physical Education. All participants were randomly selected and voluntarily participated in the study.

Measurement method

The method of measuring body composition using segmental multichannel bioelectrical impedance belongs to the latest, easily applicable non-invaive technology that provides valid data on body composition (18, 24). For the purposes of this study, measurements were carried out using InBody720 analyzer (Biospace Co. Ltd., http://inbody.rs/) with an integrated Tetrapolar 8-Point Tactile Electrode System, which uses DSM-BIA (Direct Segmental Multi-frequency Bioelectrical Impedance Analysis).

All measurements were conducted in the period 2013-2015 in the Methodical and Research Laboratory (MRL) of University of Belgrade Faculty of Sport and Physical Education and in the Laboratory for Physiology of University of Ljubljana Faculty of Sport, in accordance with the standard manufacturer's recommendations, and the recommendations found in previous studies (7, 16, 18), as follows:

- Measurement sessions were conducted between 08:00 and 11:00 in the morning;
- Subjects were instructed to fast after 22:00 h on the night before measurement, and not to consume food or beverages on the morning of the measurement session;
- Subjects were requested to avoid highly intensive or extensive training for 24 h before measurement, and to avoid any strenuous physical exercise for 12 h before measurement;
- Subjects were requested not to consume alcohol for 48 h before measurement;
- Subjects were instructed to void at least 30 minutes before measurement;
- Subjects were asked to remain in the stan-ding position for at least 5 min before measurement;
- Room temperature during measurement was between 20°C and 25°C;
- Menstruating women were excluded from the study.

Variables

Three variables were used for the purposes of this study: two primary variables and one derived index variable.

The primary variables were:

1. Protein – total body protein mass, expressed in kg; and,
2. Fat (BFM) – total body fat mass, expressed in kg.

The derived index variable was:

1. Protein Fat Index (PFI) – the index of total body protein and fat mass ratio, expressed in kg.

Statistical analysis

All raw data were subjected to descriptive statistical analysis to calculate the central tendency and dispersion (Mean, SD, cV%, Std. Error, Skewness, Kurtosis, Min and Max, and 95% confidence interval). In order to establish the normative classification for the given variables, the following percentile distribution values were quantified: 2.5, 5.0, 10.0, 20.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, 95.0 and 97.5‰. Multivariate and univariate analyses of variance (MANOVA and ANOVA) were used to determine the differences between the variables with respect to subsamples and gender, while the independent-samples t-test with the Bonferroni correction was used to establish the difference between paired variables. The SPSS Statistics 17.0 was used for all statistical analyses. The criterion for the statistical significance of the differences between groups was set at 95% probability level, or $p > 0.05$ (25).

Results

Tables 1, 2 and 3 provide the basic results of descriptive statistical analysis and percentile distribution for the observed variables across the men and women subsamples.

Figures 1, 2 and 3 show comparative results for PFI, Protein, and BFM distributions with respect to gender.

Discussion

MANOVA and ANOVA results (Table 4) indicated that there was a highly statistically significant difference in the observed variables with respect to gender (Wilks' Lambda Value = 0.403, $F = 519.74$, $p = 0.000$), with respect to male subsamples (Wilks' Lambda Value = 0.602, $F = 26.79$, $p = 0.000$), and with respect to female subsamples (Wilks' Lambda Value = 0.427, $F = 21.14$, $p = 0.000$). The difference between genders accounted for 59.7% (Partial $Eta^2 = 0.597$), the between-groups difference for men accounted for 15.6% (Partial $Eta^2=0.156$), while the between-groups difference for women accounted for 24.7% of the explained variance (Partial $Eta^2 = 0.247$). In all analyses, the observed power was at the level of 100% (Observed Power = 1.000), indicating that the results can be accepted as a valid scientific truth. It can be argued that, on a general level, the observed variable that defines the ratio of protein and total body fat (PFI) as a function of gender was significantly discriminatory, and that it was nearly twice as discriminative across female subsamples as in men. Overall, the results showed that the differences in PFI were almost 2.5 to 4 times higher between the genders than across the same-gender subsamples.

Considering the effect of individual variables on the observed general difference, it can be maintained that the difference between genders was most influenced by Protein, the variable defining the protein body mass, which accounted for 56.7%, followed by PFI with 21.9%, and least by BFM with 6.7% (Table 4). In other words, the difference between men and women was 8.5 higher in body protein mass, i.e. in pure contractile tissue, than in body fat mass, i.e. in ballast tissue.

If the average PFI values are compared across gender and group specifics, it can be argued that gender dimorphism index for PFI was at the level of

132.07% for men in individual sports, 156.15% for men in combat sports, 92.95% for men in team sports, 92.81% for adult working men, as well as 43.81 and 81.62% for students with and without programmed exercise, respectively. Generally, dimorphism index value for PFI was at 136.33% for the total men sample (Tables 1 and 2, Men All PFI = 1.711, Women All = 0.724, which means that on average men had 136.33% more protein relative to total body mass than women in the total female sample).

Table 1. Descriptive statistics for the observed variables across the subject sample

Sample	Variable	Mean	Std. Dev.	cV%	Min	Max	Std. Error. Measur.		95% Confidence Interval	
							Aps.	Rel.	Lower Bound	Upper Bound
Men All (N = 729)	PFI	1.711	1.02	59.61	0.21	6.65	0.038	2.22	1.649	1.774
	Protein	14.63	2.08	14.22	8.60	23.50	0.077	0.53	14.49	14.77
	BFM	11.55	7.96	68.92	2.30	89.60	0.295	2.55	10.96	12.13
Individual Sports (N = 79)	PFI	2.453	1.66	67.67	0.98	6.46	0.128	5.22	2.28	2.63
	Protein	14.23	1.66	11.67	10.40	18.60	0.187	1.31	13.84	14.63
	BFM	6.75	2.49	36.89	2.30	14.80	0.280	4.15	5.22	8.29
Combat Sports (N = 148)	PFI	1.998	1.08	54.05	0.42	6.65	0.088	4.40	2.87	2.12
	Protein	14.81	2.24	15.12	10.70	22.80	0.184	1.24	14.52	15.10
	BFM	8.99	4.54	50.50	2.30	37.30	0.373	4.15	7.87	10.11
Team Sports (N = 213)	PFI	1.725	0.89	51.59	0.42	6.48	0.061	3.54	1.62	1.83
	Protein	15.55	2.08	13.38	10.10	23.50	0.142	0.91	15.31	15.79
	BFM	10.90	4.98	45.69	2.70	38.90	0.341	3.13	9.97	11.84
Adult Working (N = 111)	PFI	0.912	0.59	64.69	0.21	4.17	0.056	6.14	0.77	1.06
	Protein	13.93	1.86	13.35	8.90	19.90	0.177	1.27	13.60	14.26
	BFM	20.12	11.8	58.70	4.10	89.60	1.121	5.57	18.83	21.42
Students with programmed exercise (N = 110)	PFI	1.837	0.94	51.17	0.71	6.35	0.090	4.90	1.69	1.98
	Protein	14.07	1.57	11.18	11.20	18.20	0.150	1.07	13.74	14.41
	BFM	9.26	3.89	42.01	2.50	19.20	0.371	4.01	7.96	10.56
Students w/o programmed exercise (N = 68)	PFI	1.284	0.71	55.30	0.23	4.42	0.027	2.06	1.01	1.47
	Protein	13.91	2.19	15.74	8.60	21.60	0.265	1.91	13.49	14.34
	BFM	14.43	11.0	76.37	3.50	82.30	1.336	9.26	12.78	16.08

Table 2. Percentile distribution across the men and women subsamples

Percentiles M	***2.5***	***5.0***	***10.0***	***20.0***	***30.0***	***40.0***	***50.0***	***60.0***	***70.0***	***80.0***	***90.0***	***95.0***	***97.5***
Men All	0.44	0.57	0.73	0.97	1.17	1.33	1.50	1.67	1.90	2.24	2.92	3.63	4.71
Individual Sports	1.05	1.09	1.34	1.65	1.78	1.96	2.09	2.34	2.62	3.16	4.26	5.00	6.39
Combat Sports	0.83	1.04	1.18	1.27	1.45	1.55	1.67	1.89	2.13	2.41	3.15	4.71	5.37
Team Sports	0.73	0.80	0.90	1.12	1.26	1.40	1.50	1.61	1.78	2.25	2.89	3.52	4.04
Adult Working	0.33	0.34	0.40	0.50	0.60	0.68	0.78	0.90	1.03	1.18	1.42	1.93	2.83
Student w Prog. Ex.	0.75	0.78	0.83	1.14	1.28	1.49	1.67	1.82	1.99	2.25	3.28	3.45	4.82
Student w/o Prog. Ex.	0.35	0.48	0.59	0.77	0.83	0.99	1.09	1.31	1.46	1.75	2.19	2.69	3.44
Percentiles F	***2.5***	***5.0***	***10.0***	***20.0***	***30.0***	***40.0***	***50.0***	***60.0***	***70.0***	***80.0***	***90.0***	***95.0***	***97.5***
Women All	0.25	0.31	0.36	0.47	0.55	0.62	0.69	0.76	0.82	0.93	1.11	1.21	1.53
Individual Sports	0.46	0.47	0.57	0.71	0.74	0.80	0.90	1.06	1.14	1.64	1.84	1.99	2.07
Combat Sports	0.50	0.51	0.52	0.56	0.76	0.78	0.79	0.80	0.83	0.93	1.06	1.10	1.11
Team Sports	0.47	0.49	0.56	0.66	0.75	0.78	0.85	0.92	1.03	1.12	1.21	1.36	1.54
Adult Working	0.17	0.20	0.24	0.33	0.36	0.41	0.44	0.49	0.55	0.66	0.73	0.78	0.87
Student w Prog. Ex.	0.37	0.46	0.49	0.54	0.61	0.65	0.72	0.79	0.86	0.89	1.00	1.07	1.24
Student w/o Prog. Ex.	0.27	0.30	0.31	0.36	0.43	0.52	0.57	0.62	0.68	0.74	0.85	1.06	1.24

Table 3. Descriptive statistics for the observed variables across the female subsamples

Sample	Variables	Mean	Std. Dev.	cV%	Min	Max	Std. Error. Measur.		95% Confidence Interval	
							Aps.	Rel.	Lower Bound	Upper Bound
Women All (N = 326)	PFI	0.724	0.31	42.82	0.16	2.47	0.017	2.35	0.63	0.82
	Protein	9.88	1.50	15.18	6.90	14.90	0.083	0.84	9.67	10.09
	BFM	16.20	8.23	50.80	4.50	78.10	0.456	2.81	15.33	17.08
Individual Sports (N = 27)	PFI	1.057	0.46	43.52	0.46	2.07	0.457	43.24	0.76	1.35
	Protein	10.55	1.07	10.14	8.10	12.30	1.072	10.16	9.88	11.23
	BFM	11.52	3.86	33.51	5.70	21.60	3.857	33.48	8.89	14.14
Combat Sports (N = 12)	PFI	0.780	0.17	21.79	0.51	1.11	0.050	6.41	0.34	1.22
	Protein	9.05	1.39	15.36	7.50	12.30	0.402	4.44	8.04	10.06
	BFM	12.43	4.04	32.50	7.50	18.30	1.166	9.38	8.49	16.37
Team Sports (N = 80)	PFI	0.894	0.30	33.56	0.27	2.47	0.034	3.80	0.72	1.07
	Protein	11.25	1.29	11.47	8.50	13.70	0.144	1.28	10.86	11.64
	BFM	13.89	5.04	36.29	4.50	38.60	0.564	4.06	12.36	15.41
Adult Working (N = 63)	PFI	0.473	0.18	38.05	0.16	1.00	0.022	4.65	0.28	0.67
	Protein	9.54	1.47	15.41	7.30	14.90	0.185	1.94	9.10	9.98
	BFM	23.78	12.20	51.30	9.10	78.10	1.537	6.46	22.06	25.50
Students with programmed exercise (N = 85)	PFI	0.735	0.20	27.21	0.28	1.29	0.022	2.99	0.57	0.90
	Protein	9.38	1.09	11.62	7.00	12.40	0.119	1.27	9.00	9.76
	BFM	13.66	3.97	29.06	6.20	29.00	0.431	3.16	12.18	15.14
Students w/o programmed exercise (N = 59)	PFI	0.582	0.224	38.49	0.25	1.33	0.029	4.98	0.38	0.78
	Protein	8.99	1.07	11.90	6.90	11.60	0.139	1.55	8.53	9.44
	BFM	17.83	7.63	42.79	6.60	44.30	0.993	5.57	16.06	19.61

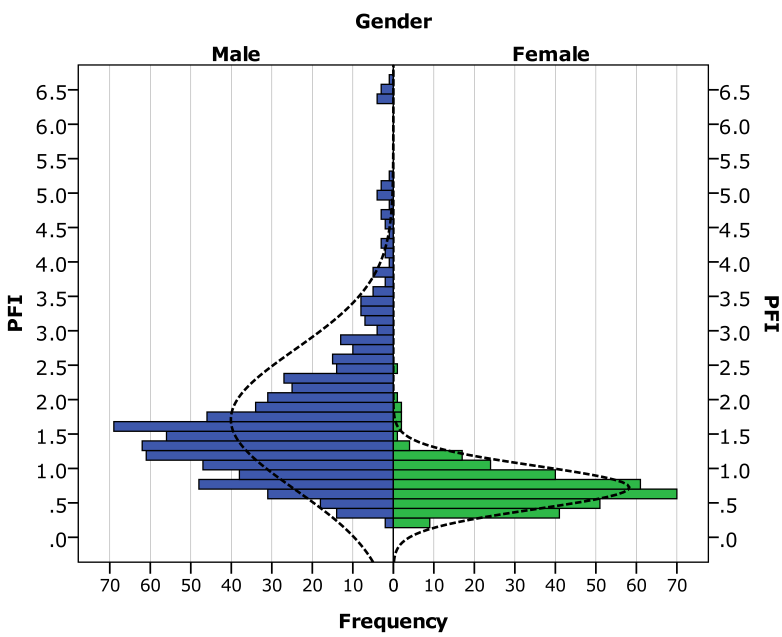

Figure 1. Comparative results for PFI distribution with respect to gender

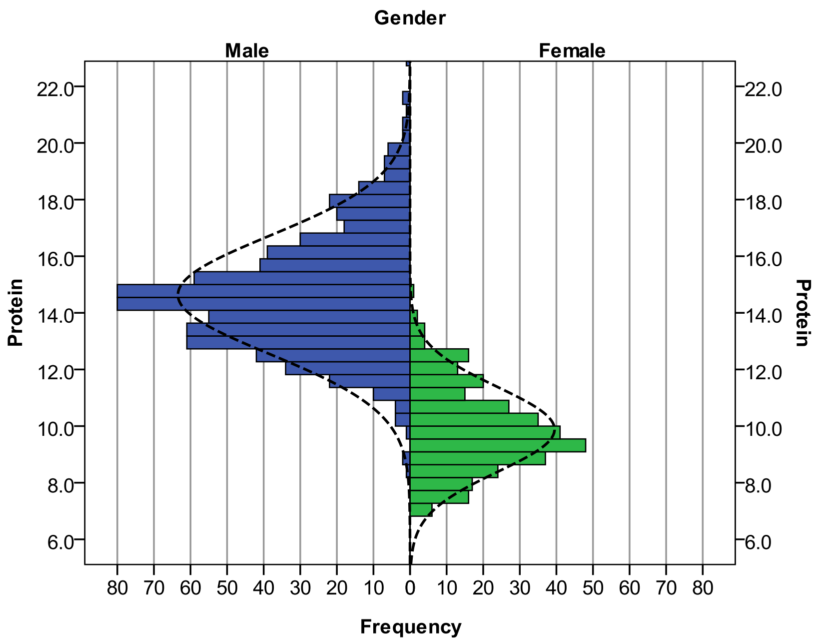

Figure 2. Comparative results for Protein distribution with respect to gender

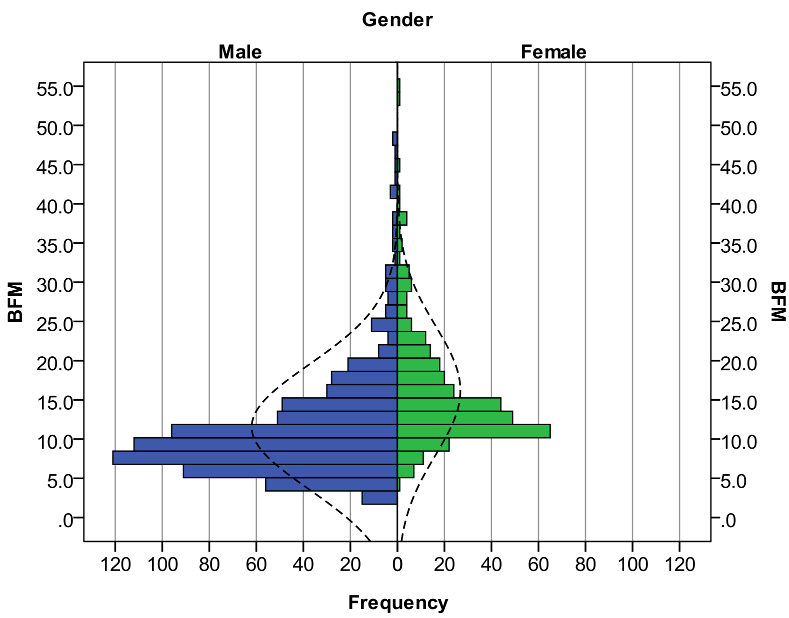

Figure 3. Comparative results for BFM distribution with respect to gender

Table 4. MANOVA and ANOVA results for the observed variables with respect to gender, male and female subsamples

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta^2	Observed Power
Gender	Wilks' Lambda	0.403	519.74	3.00	1051.00	0.000	0.597	1.000
Males	Wilks' Lambda	0.602	26.79	15.00	1990.77	0.000	0.156	1.000
Females	Wilks' Lambda	0.427	21.14	15.00	878.26	0.000	0.247	1.000

Tests of Between-Subjects Effects - Gender

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta^2	Observed Power
Gender	Protein	5086.02	1	5086.02	1377.09	0.000	0.567	1.000
	BFM	4878.80	1	4878.80	75.45	0.000	0.067	1.000
	PFI	219.63	1	219.63	295.74	0.000	0.219	1.000
Groups - Male	Protein	321.71	5	321.71	16.38	0.000	0.102	1.000
	BFM	12176.74	5	12176.74	51.95	0.000	0.264	1.000
	PFI	140.81	5	140.81	33.41	0.000	0.188	1.000
Groups - Female	Protein	245.53	5	245.53	32.57	0.000	0.337	1.000
	BFM	5516.39	5	5516.39	21.40	0.000	0.251	1.000
	PFI	10.51	5	10.51	31.66	0.000	0.331	1.000

Discussion

In men, the between-groups difference was mostly affected by BFM, accounting for 26.4%, followed by PFI with 18.8%, and least by Protein with 10.2%. These results showed that the difference across male subsamples was highest for the fat, i.e. ballast, component and lowest for the protein, i.e. contractile component. Namely, the difference for the body fat component was 2.6 times higher than for the body protein component.

In women, the between-groups difference was mostly affected by Protein and PFI, accounting for 33.7 and 33.1%, respectively, while the value for BFM accounted for 25.1%. The results across women subsamples showed that the difference for the pro-tein, or contractile, component was 1.5 times higher than for the fat, or ballast, component.

The average PFI value for the total women sample was 0.724, and for men it was 1.711. The observed index value for women was at the level of 42.31% compared to men; namely, on average, the ratio of protein to fat in men was 2.36 times higher than in women. The average Protein value was 14.63 kg for men and 9.88 kg for women; while men had 1.48 times more contractile tissue, protein mass in women was 67.53% of that in men. In contrast, the results were reverse for the total body mass component, with the average of 16.20 kg fat in women and 11.55 kg fat in men. This means that there was 1.40 times more fat mass in women than in men, while the fat mass component in men accounted for 71.30% of that in women.

Overall, there was an inverse relationship between protein and fat in men and women.

The results revealed that in men, the average value for body protein mass was 14.64 kg; the highest value of 15.55 kg was observed in the subjects in team sports subsample, while the lowest values of 13.91 and 13.93 kg were found in students without programmed exercise and adult working subjects, respectively (Table 1). At the same time, the average value for total body fat was 11.55 kg in the total men sample; the highest value of an average of 20.12 kg was found in adult working subjects; and, the lowest value of 6.75 kg was found in individual sports athletes (Table 1).

In contrast to men, the average value for body protein mass in the total women sample was 9.88 kg; the highest value of 11.25 kg was found in the subjects in team sports subsample, while the lowest value of 8.99 kg was found in students without programmed exercise (Table 3). At the same time, the average value for total body fat mass was 16.20 kg in the total women sample; the highest value of an average of 23.78 kg was found in adult working subjects; and, the lowest value of 11.52 kg was obser ved in individual sports athletes (Table 2).

In men, the highest PFI value was found in individual sports subsample at 2.453 (the subjects had 2.453 kg protein per 1 kg fat), while the lowest index value of 0.912 was found in adult working subjects (Table 3). The same relationship structure for PFI was established in women, with the subjects in individual sports subsample having an average PFI of 1.057, while the subjects in adult working subsample had the lowest value of 0.473 (Table 3).

Considering the results for between-groups differences in men, PFI value showed higher statistical significance in individual sports athletes than in all other subsamples, at p = 0.000 (PFI individual sports = 2.453 vs relative differences in combat sports 1.988 (22.77% lower), team sports 1.725 (42.20% lower), adult working 0.912 (168.97% lower), students with programmed exercise 1.837 (33.53% lower) and students without programmed exercise 1.284 (91.04% lower)). With regard to the differences observed between other subject pairs, it should be noted that the PFI value for combat sports did not differ from team sports or students with programmed exercise. Similarly, no difference was found between male subjects in adult working subsample and students without programmed exercise. Across all other subsamples, there were statistically significant differences higher than $p > 0.005$.

With respect to between-groups differences in women, PFI value showed higher significance in individual sports athletes than in all other subsamples except in team sports athletes, at p = 0.000 (PFI individual sports = 1.057 vs relative differences in combat sports 0.780 (35.51% lower), adult working 0.473 (123.47% lower), students with programmed exercise 0.735 (43.81% lower), and students without programmed exercise 0.582 (81.62% lower)).

Considering the differences observed between other subject pairs, it could be argued that in women as well as in men the PFI value for combat sports did not differ from team sports, students with programmed exercise, or students without programmed exercise. Similarly, no difference was found between female subjects in adult working subsample and students without programmed exercise. Across all other subsamples, there were statistically significant differences higher than p > 0.005.

One of the few studies that used the same va-riables in estimating body composition in elite wrest-lers found that their average body protein mass was 15.00 ± 2.62 kg, their average body fat mass was 6.99 ± 3.28 kg, and their average PFI was 2.69 ± 1.54 kg (12). In the present study, the same vari-able values observed with respect to combat sports subsample were slightly lower for PFI, quite similar for Protein, and slightly higher for body fat; this was to be expected, as elite wrestlers are typically mus-cular with low percentage of body fat (%BF≈8.5%; %SMM≈52.8%) (12) so that their PFI is high due to low fat levels and high muscle mass.

Previous research has shown that the values for total body fat mass obtained using the bioimpedance method were approximately 15.4 ± 5.5 kg in physically active women (26), and approximately 21.9 ± 7.4 kg and 18.9 ± 6.8 kg in general population of adult women and men, respectively (27). Thus, it can be argued that since the results from the present study demonstrated acceptable external validity they can be used in defining the initial standard for the observed variables.

Conclusion

Measurement and control of body composition with the use of multichannel bioelectrical impedance is increasingly becoming the method of choice and the standard of practice in science and sport. The main objective of this research was to define the qu-antitative indicators for model characteristics and the differences relative to body protein structure as the basic component of contractile tissue, body fat as the ballast tissue relevant to the basic motor skills and movement in humans, and protein fat index (PFI), a new index developed to define the relationship be-tween ballast and contractile body tissues.

The results indicated that there was a highly statistically significant difference in the observed variables with respect to gender (Wilks' Lambda Value = 0.403, F = 519.74, p = 0.000), with respect to male subsamples (Wilks' Lambda Value = 0.602, F = 26.79, p = 0.000), and with respect to female subsamples (Wilks' Lambda Value = 0.427, F = 21.14, p = 0.000). It can be argued that, on the general level, the PFI as a function of gender was significantly discriminatory, and that it was nearly twice as discriminative across female subsamples compared to men. Considering the effect of individual variables on the observed general difference, it can be maintained that the difference between genders was most influenced by Protein, the variable defining the protein body mass, which accounted for 56.7%, followed by PFI with 21.9%, and least by BFM with 6.7%. In other words, the difference between men and women was 8.5 higher in body protein mass, i.e. in pure contractile tissue, than in body fat mass, i.e. in ballast tissue.

In men, the between-groups difference was mostly affected by BFM, accounting for 26.4%, followed by PFI with 18.8%, and least by Protein with 10.2%. These results showed that the difference across men subsamples was highest for the fat, i.e. ballast, component, and lowest for the protein, i.e. contractile component. Namely, the difference for the body fat component was 2.6 times higher than for the body protein component.

In women, the between-groups difference was mostly affected by Protein and PFI, accounting for 33.7 and 33.1%, respectively, while the value for BFM accounted for 25.1%. The results across female subsamples showed that the difference for the protein, or contractile, component was 1.5 times higher than for the fat, or ballast, component.

The results showed that the average values in men and women were 14.63 ± 2.08 and 9.88 ± 1.50 kg for body protein mass, 11.55 ± 2.08 and 16.20 ± 8.23 kg for total body fat mass, and 1.711 ± 1.02 and 0.724 ± 0.31 kg for PFI, respectively. With respect to PFI, the highest values in men and female subsamples were found in individual sports (2.453 ± 1.66 and 1.057 ± 0.46 kg, respectively), while the lowest values were found in adult working subjects (0.912 ± 0.59 and 0.473 ± 0.18 kg, respec-tively).

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PROTEIN, TELESNA MAST I PROTEINSKO-MASNI INDEKS (PROTEIN FAT INDEX– PFI): MODELSKE KARAKTERISTIKE I RAZLIKE IZMEĐU SPORTISTA I NESPORTISTA OBA POLA, MERENE METODOM MULTIKANALNE BIOELEKTRIČNE IMPEDANSE

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Osnovni cilj ovog istraživanja bio je definisanje kvantitativnih pokazatelja modelskih karakteristika i razlika u odnosu na proteinsku strukturu u telu (proteini), kao osnove kontraktilnog tkiva, telesnih masti (BFM), kao balastnog tkiva u kontekstu osnovne motorike i kretanja kod čoveka, kao i karakteristike novog indeksa, kojim se definiše odnos kontraktilnog i balastnog tkiva u organizmu tj. proteinsko masnog indeksa (PFI). Uzorak je bio sastavljen od 1055 ispitanika (729 muškaraca i 326 žena). Ispitanici su bili podeljeni na subuzorke, definisane u odnosu na kriterijum tipa sporta, a kontrolne grupe su bile podeljene u odnosu na kriterijum uzrasta i vežbanja. Merenja telesnog sastava realizovana su primenom segmentalne električne multikanalne bioimpedanse pomoću instrumenta InBody720.

Rezultati su pokazali da postoje visoko statistički značajne razlike između ispitivanih varijabli u odnosu na pol, ispitivanih subuzoraka muškaraca i ispitivanih subuzoraka žena (Wilks' Lambda = 0,403, p = 0,000; WL = 0,602, p = 0,000; WL = 0,427, p = 0,000, respektivno). Na razliku između polova najviše je uticala varijabla Proteini i to sa 56,7%, zatim PFI sa 21,9%, a najmanje BFM sa 6,7%. Drugim rečima, muškarci i žene se 8,5 puta više razlikuju u odnosu na masu proteina u telu, tj. osnovno kontraktilno tkivo, nego u odnosu na masno, tj. balastno tkivo. Kod muškaraca, na razliku između grupa najviše je uticala vrednost varijable BFM i to sa 26,4%, zatim vrednost PFI sa 18,8%, a najmanje vrednost variable Proteini sa 10,2%. Kod žena, na razliku između grupa najviše je uticala varijabla Proteini PFI i to sa 33,7 i 33,1%, respektivno, dok je varijabla BFM uticala sa 25,1%.

Na osnovu dobijenih rezultata ovog istraživanja može se tvrditi da je multikanalna bioelektrična impedansa, kao nova metoda merenja telesne strukture, diskriminativna i senzitivna u odnosu na merenje mase proteina i masti u telu, a da se PFI može koristiti kao integralni pokazatelj odnosa proteinske i masne komponente tela i u nauci i u praksi, kako u sportu tako i u medicini.

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Ključne reči: *bioimpedansa, telesna struktura, sportisti, proteinsko-masni indeks*