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Original research article

INITIAL MODEL OF MEN'S MUSCLE STRUCTURE INDICATORS DEFINED BY THE METHOD OF MULTICHANNEL BIOELECTRICAL IMPEDANCE *

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Abstract. *The current generic model of body composition is defined by four primary dimensions: water, proteins, minerals and fat mass. The most contemporary method of body composition analysis is the method of bioelectrical impedance (BIA) which registers a large number of body structure indicators quickly and noninvasively. One of the elements of body structure and the one most responsible for man's quality demonstration of motor abilities is muscle mass structure. In previous technological attempts at the examination of man's morphological structure, muscle mass was estimated indirectly and in that way its quantitative characteristics were defined. The goal of this research is to define the initial model of men's muscle structure indicators measured by means of the direct method and to do that via the multichannel bioelectrical impedance of the latest generation – InBody 720. The basic participant characteristics were: age 30.81±9.73 years, mass 86.17±14.95 kg, height 182.35±7.09 cm, BMI 25.88±3.99. This research comprises six variables for defining muscle components of body structure: two primary (proteins and skeletal muscle mass) and four derived (ratios between: skeletal and muscle mass, proteins and muscle mass, proteins and body mass, BMI and proteins) variables. The results showed the following descriptive values of the measured variables: proteins 14.11±1.64 kg, muscle mass 40.59±4.99 kg, the percentage of muscle mass in the body 47.59±4.34 %, the index of muscle thickness 0.348±0.002 kg, percentage of proteins in the body 0.165±0.015 kg, the ratio between BMI and proteins 1.842±0.246. The*

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dispersion of the data results indicates that all the variables can be used as representative and scientifically valid for further studies.

Key words: *proteins, body composition, muscles, men.*

INTRODUCTION

The fast-paced development of science, methodology and new technologies allows for registering and systematically following an ever-increasing number of parameters of the reactions of certain systems of organs and the entire body to exercising (American Alliance for Health, Physical Education, Recreation and Dance-AAHPERD, 1989). Different anthropometric, motor, functional, kinesiological and other indicators in the system of sport, recreation and physical education can be registered today by applying different methods and measurement technologies (Morrow, Jackson, Disch & Mood, 2005). Depending on whether it was measured by a direct method or estimated by an indirect method every registered and measured indicator gives information that is more or less objective and reliable. This information, taken on its own, is relevant to a certain point and it has different correlation degrees regarding the precision in observing the effects that are the goal of applying a certain exercise program (school curriculum, recreational exercise, training exercise, health exercise).

In the contemporary system of physical exercise there is an increasing need for the systematic observation of the indicators of practitioners' body composition, health condition, motor and functional abilities and psychological characteristics, regardless of gender, age and the level of physical fitness (Jorgić, Pantelić, Milanović & Kostić, 2011). One of the most important effects of physical exercise is its influence on body composition. The current model of body composition is defined with regard to four primary dimensions: water, proteins, minerals and fat mass (Heyward, 2010; InBody 720, 2008). From the point of view of sport and physical education the most interesting body composition elements are protein structure, which are biologically responsible for the quality of exhibiting man's motor (physical) attributes and fat mass as an energy reserve but at the same time as an indicator of nourishment status (Mazić et al., 2009).

Hydrodensitometry, the golden standard method in determining body structure, was replaced by technologically more modern and precise methods (Ostojić, 2005). One of the most contemporary body composition analysis methods is the method of bioelectrical impedance that quickly and noninvasively registers a large number of body composition indicators, which could not be registered by previously used methods (InBody 720, 2008; Kasum & Dopsaj, 2012).

In practice one of the most important pieces of information when it comes to body composition is the percentage of muscle and fatty tissue. Body composition adjustment is frequently identified with a reduction in body mass, which is erroneous. What has been overlooked is that the reduction of body mass does not simultaneously mean a reduction of fatty tissue percentage because a reduction can occur based on the reduction of muscle tissue as well, which does not represent the desired effect (Moon, 2013). The essence of programs in which body composition is adjusted refers to the reduction of fatty tissue with the preservation or enlargement of muscle tissue.

In terms of muscle tissue there is not much data on the average, i.e. desirable values for the general population measured with the direct method of multichannel bioelectrical impedance. Previous studies have showed that the average man has around 40% muscle tissue, whereas athletes and advanced recreational athletes have over 50% (Ostojić, Mazić, & Dikić, 2003). In a recently published research students of the Belgrade Faculty of Sport and Physical Education had about 51% of muscle and 14.5% of fat tissue (Stojiljković, 2005). Competitive bodybuilders can have over 60% of muscle tissue (Slater & Phillips, 2011).

Based on the previously mentioned analyses it can be concluded that there is a need for data on body structure status, among which specific data on muscle mass indicators would be exceptionally significant for the area of sport and physical education. The aim of this paper is to define the initial model of men's muscle structure indicators defined by the method of multichannel bioelectrical impedance. This way qualitative indicators of grown men's given biological component would be defined which will provide a foundation for the needs of further studies in the area of sport and physical education.

THE METHOD

Sample of participants

By random selection a group of 157 male participants was chosen, with an average age of 30.81±9.73 years, weight 86.17±14.95 kg, height 182.35±7.09 cm and BMI 25.88±3.99. The structure of participants regarding their age and physical activity percentage is shown in tables 1 and 2.

Table 1. The structure of the participants in terms of age.

Year range	Number of participants per year range	Percent of participants per year range
19-29	81	51.27
30-39	50	31.65
40-49	14	8.86
50-59	12	7.59

Table 2. The participants' physical activity percentage in the course of one week.

Weekly number of trainings	Number of participants	Percent out of total sample
none	25	15.92
from 1 to 2	47	29.94
from 3 to 4	46	29.30
5 times and more	39	24.84

The participants represent a part of the student and the employed population from the territory of the city of Belgrade. Regarding the student population, the participants came from the following faculties: the Faculty of Sport and Physical Education, Faculty of Law, Faculty of Economics and Faculty of Organizational Sciences. Regarding the employed population the participants belonged to the following professions: police, army, administrative sector, service industry and education. All of the participants were engaged in different degrees of physical activities but were not professional athletes so the measured sample can be treated as the reference population of averagely physically active men. All of the participants agreed to be measured voluntarily before testing. The research was conducted in accordance with the "Declaration of Helsinki for recommendations guiding physicians in biomedical research involving human subjects" (World Medical Organization, 1996), and also with the permission of the Ethics Committee of the Belgrade University Faculty of Sport and Physical Education.

Methods of measurement

The measurements of the participants' morphological characteristics were conducted at the Belgrade University Faculty of Sport and Physical Education in the Methodology-Research Laboratory (MRL) in January and February 2012 via a method of multichannel bioelectrical impedance (Bioelectrical Impedance Analysis – BIA), on a professional new-generation device - InBody 720 Tetrapolar 8-Point Tactile Electrode System (Biospace, Co., Ltd), that uses the DSM-BIA method (Direct Segmental Multi-frequency Bioelectrical Impedance Analysis) (Picture 1).

Following the manufacturer's recommendation (InBody 720 multichannel bioelectrical impedance, 2008) all of the measurements were conducted in the morning (from 8:30 to 10:00 AM), and the participants did not have breakfast before the measurement and they also did not have abundant meals or long-lasting and demanding physical activities the night before.

Variables

This research comprises six (6) variables: two (2) primary and four (4) derived or index variables with which indicators of men's muscle structure are defined.

Primary variables are the following:

- Proteins – expressed in kilograms,
- Skeletal muscle mass (SMM), expressed in kilograms.
- Derived (index) variables are:
- Skeletal muscle mass and body mass ratio (SMM/BM), used to calculate the percentage of skeletal muscles to body mass;
- Proteins and skeletal muscle mass ratio (Proteins/SMM), as the indicator of skeletal muscle thickness;
- Proteins and body mass ratio (Proteins/BM), used to calculate the percentage of proteins to body mass;
- The body mass index and proteins ratio (BMI/Proteins), as a ratio between indicators of body mass (i.e. nourishment) and protein structure.

Statistical analyses

The results were analyzed by applying the descriptive statistical procedure to define the basic measures of central tendency and dispersion data (Mean, SD and cV%). After that separate measures of dispersion data were calculated – the absolute and the relative value of the method's measurement error (sX and sX%) and the value of the range for the measurement results (min and max); upper and lower reliability intervals of measurement were determined to be at 95%.

The normality of the data distribution was found by applying the non-parametric test of the normality of distribution – the Kolmogorov-Smirnov test. All the statistical analyses were realized with the help of the software program SPSS Statistics 19.0.

THE RESULTS

In Table 3, all of the calculated descriptive statistics of the studied variables and indicators of muscle structure models are shown.

Table 3. The descriptive indicators of primary and derived variables.

Variable	MEAN	SD	cV%	sX	sX%	Min	Max	95% lower	95% upper	KSZ	p value
Proteins (kg)	14.11	1.64	11.62	0.131	0.93	11.00	19.00	13.85	14.38	.640	.807
SMM (kg)	40.59	4.99	12.29	0.395	0.97	39.81	41.38	39.82	41.38	.597	.868
SMM/BM	47.59	4.34	9.12	0.346	0.73	30.58	55.27	46.90	48.27	.681	.743
Proteins/SMM	0.348	0.002	0.57	0.001	0.00	0.336	0.354	0.347	0.348	.834	.490
Proteins/BM	0.165	0.015	9.38	0.001	0.63	0.105	0.192	0.163	0.168	.677	.749
BMI/Proteins	1.842	0.246	13.37	0.019	1.03	1.302	2.895	1.803	1.881	.832	.494

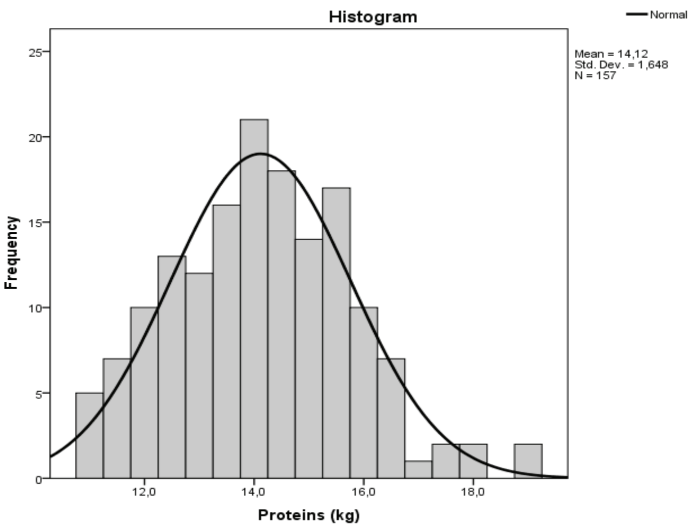
Legend: MEAN – arithmetic mean; SD – standard deviation; cV% - variation coefficient in percentages; sX% - standard arithmetic mean error in percentages; Min – minimum, Max – maximum; 95% low – lower bound of the confidence interval; 95% upper – upper bound of the confidence interval; KSZ – Kolmogorov-Smirnov; p value – significance of the Kolmogorov-Smirnov test; Proteins (kg) – Proteins expressed in kg, SMM (kg) skeletal muscle mass expressed in kg; SMM/BM skeletal muscle mass and body mass ratio; Proteins/SMM proteins and skeletal muscle mass ratio; Proteins/BM proteins and body mass ratio; BMI/Proteins body mass index and proteins ratio

Descriptive statistics results showed that the variation coefficient range is between 0.97% for the Proteins/SMM variable and 13.37% for the BMI/Proteins variable. This tells us that the values of all the tested sample's variables belong to exceptionally homogeneous groups of participants, so descriptive indicators can be accepted as being representative.

Also, the results of the standard arithmetic mean error (sX and sX%) showed that the measurement method error is extremely small, from 0.001 for the variable Proteins/SMM to 0.019 (1.03%) for BMI/Proteins, which shows that the measurement method applied is exceptionally precise.

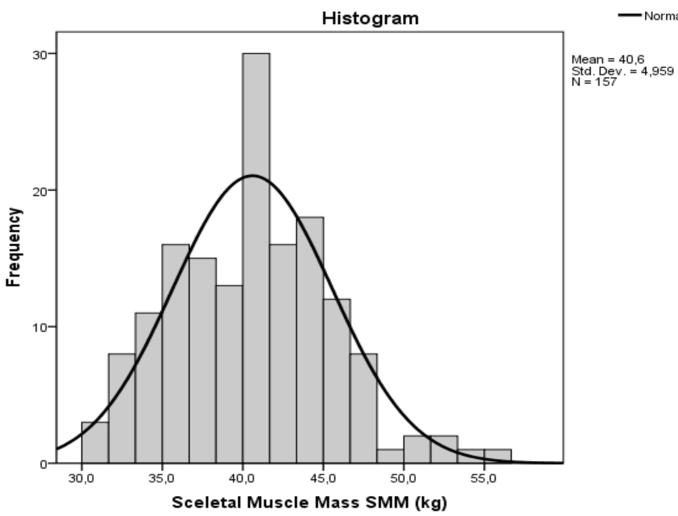
Based on the results of the tested variables' normality of distribution, it can be claimed that their distribution does not deviate in a statistically significant way from the hypothetically normal one (KSZ, p value, table 3).

Figures 1 to 6 show the primary and derived variables' data distribution.



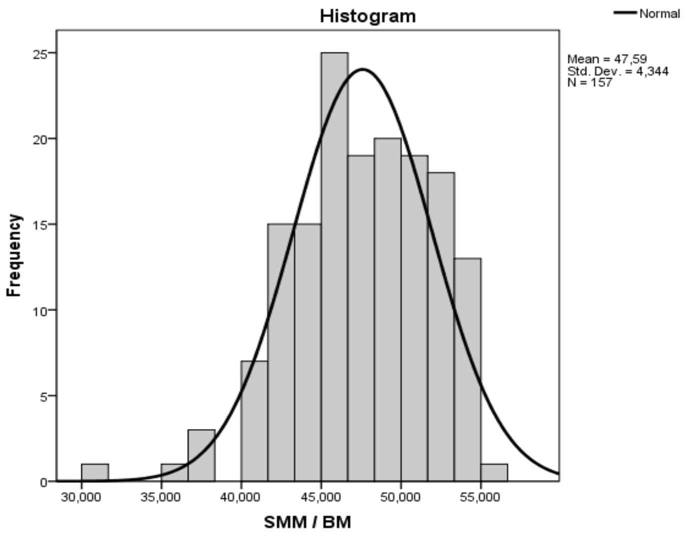
Percentiles	Proteins (kg)
2.5	11.20
5	11.40
25	12.90
50	14.10
75	15.30
95	16.63
97.5	18.11

Fig. 1. Illustration of the distribution for the primary variable – Proteins.



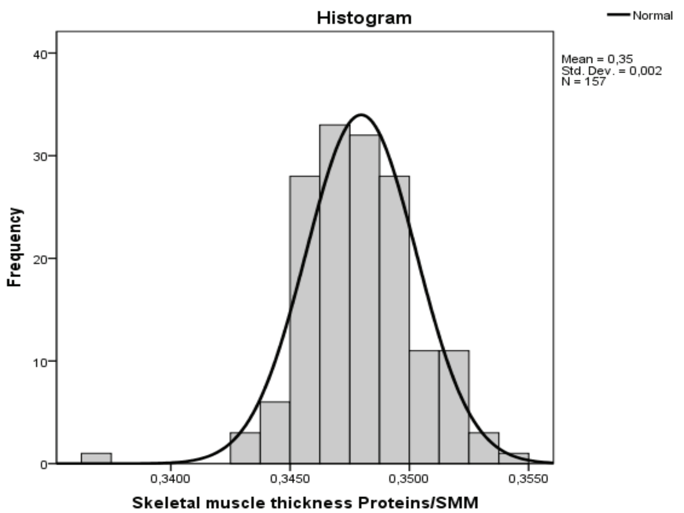
Percentiles	SMM (kg)
2.5	31.78
5	32.48
25	37.00
50	40.60
75	44.20
95	48.27
97.5	52.53

Fig. 2. Illustration of the distribution for the primary variable – SMM.



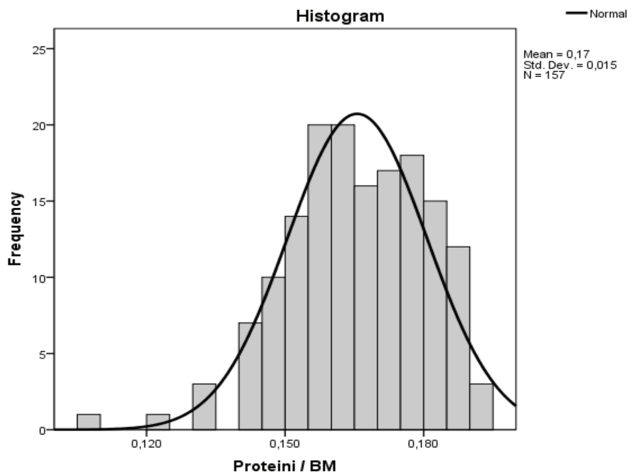
Percentiles	SMM / BM
2.5	37.58
5	40.98
25	44.82
50	47.82
75	51.13
95	54.02
97.5	54.84

Fig. 3. Illustration of the distribution for the derived variable - SMM/BM.



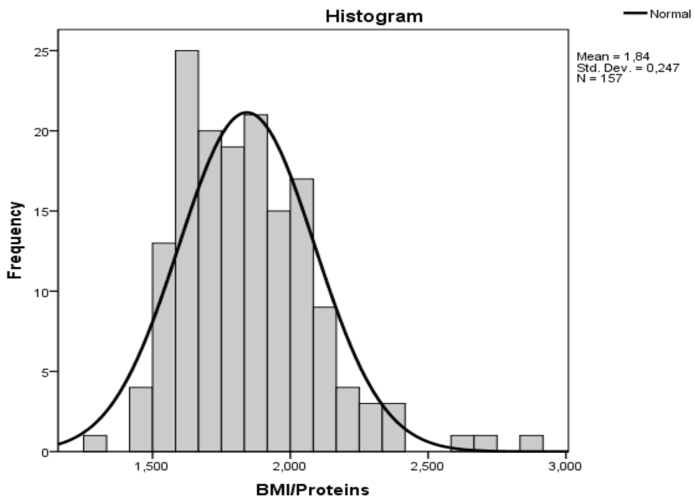
Percentiles	Proteins / SMM
2.5	.34
5	.34
25	.35
50	.35
75	.35
95	.35
97.5	.35

Fig. 4. Illustration of the distribution for the derived variable - Proteins/SMM.



Percentiles	Proteins/ BM
2.5	.13
5	.14
25	.16
50	.17
75	.18
95	.19
97.5	.19

Fig. 5. Illustration of the derived variable - Proteins/BM.



Percentiles	BMI / Proteins
2.5	1.49
5	1.52
25	1.65
50	1.82
75	2.00
95	2.28
97.5	2.41

Fig. 6. Illustration of the derived variable - BMI/Proteins.

DISCUSSION

The results showed that the average value of the protein mass in the bodies of healthy grown-up men is 14.11±1.64 kg (table 3). Since the participants' average body mass was 86.17±14.95 kg, the index used to determine the relation between the two mentioned variables was found, and is the indicator of the quantitative percentage of proteins in the body in relation to body mass, has a value of 0.165±0.015 kg Proteins/kg BM. With regard to the tested sample, i.e. healthy grown-up men who maintain an average level of physical activity, the reliability of the proteins variable interval ranged from 13.85 to 14.38 kg (table 3), whereas the standard arithmetic mean error value (sX) was 0.131 kg, that is, only 0.93% (sX%). These measurement error results point to the exceptional precision of the instrument used, i.e. the method and measurement procedure. Based on the distribution indicators (table 3, KSZ test) it can be concluded that there is no difference between the hypothetical and measured value, whereas based on the percentile distribution indicators it can be claimed that the extreme values of protein mass for healthy grown-up men who are averagely active are on 11.40 kg for the lower bound, and 16.63 kg for the upper bound (figure1).

In a previous study it was found that the protein mass of trained top athletes of the speed-strength type (wrestlers) is 15.00±2.62 kg, with a reliability interval range on 95% from 14.06 to 15.91 (Kasum, & Dopsaj, 2012). The percentage of protein mass in relation to the body mass of wrestlers is 0.183 kg proteins/kgBM. Compared to the training population, the averagely physically active population of participants from the sample has 0.89 kg of proteins less (5.94% less proteins), that is 9.84% fewer proteins per body mass kilogram.

From this data it can be concluded that the speed-strength type of sports leads to an increase of proteins in the body.

The results showed that the average value of skeletal muscle mass in the body of healthy grown-up men is 40.59±4.99 kg (table 3). As the participants' average body mass was 86.17±14.95 kg, the index used to determine the ratio between the two mentioned variables was found, and used to calculate the percentage of skeletal muscles in relation to the body mass, has a value of 47.59±43.4% SMM/ TM. With regard to the tested sample, i.e. healthy grown-up men who maintain an average level of physical activity, the SMM variable reliability interval ranged from 39.82 to 41.38% (table 3), whereas the standard arithmetic mean error value (sX) was 0.395 kg, that is, only 0.97% (sX%). Based on the percentile distribution indicators, it can be claimed that the tested sample's extreme values of skeletal muscle mass are 32.48 kg for the lower bound, and on 48.27 kg for the upper bound (figure 2).

In one of the previous studies it was found that top athletes' (wrestlers) skeletal muscle mass is 43.26±7.96 kg, with a reliability interval range of 95% from 40.50 to 46.02 (Kasum & Dopsaj, 2012). The percentage of skeletal muscle mass in relation to the body mass of wrestlers is 52.80%. Compared to the trained population the sample's average physically active population of participants has 5.21% less skeletal muscle mass.

The muscle mass and protein ratio was shown through the relation of these two variables that are the indicator of skeletal muscle thickness and the average value is 0.348±0.002 kg Proteins/kg SMM, whereas the reliability interval is from 0.347 to 0.348 kg. With top wrestlers this value is almost identical and amounts to 0.347 kg Proteins/kg SMM. Although trained athletes have regular training sessions this does not reflect on the values of the index variable Proteins/SMM, because a greater amounts of protein in the body is accompanied by greater skeletal muscle mass.

With regard to the body mass index (BMI), the tested sample's average measured value was 25.88±3.99 kg/m2, and this result can be taken as being representative of men who have an average level of physical activity. Values of the index variable BMI/Proteins, which represent the ratio between indicators of body mass (i.e. nourishment) and protein structure, is 1.842±0.246, with an interval of reliability from 1.803 to

1.881. Based on the percentile distribution indicators it can be claimed that the extreme values of the index variable BMI/Proteins are at 1.52 for the lower bound, and 2.28 for the upper bound (figure 6).

CONCLUSION

The results of this research showed that with healthy, grown-up and averagely active men, with an average age of 30.81±9.73 years – the mass amounts to 86.17±14.95 kg, height to 182.35±7.09 cm and BMI to 25.88±3.99. Bearing in mind that muscle mass structure is the most responsible for man's quality demonstration of motor abilities, the goal of this research was to define the initial model of men's muscle structure indicators measured by the direct method of the multichannel bioelectrical impedance of the latest generation – InBody 720.

Six variables for defining body structure muscle components were used in this paper: two primary variables (proteins and skeletal muscle mass) and four derived (index) variables (skeletal and muscle mass ratio, proteins and muscle mass ratio, proteins and body mass ratio and BMI and proteins ratio).

Based on the regularity of distribution of the found data measured via the method of multichannel bioelectrical impedance, a conclusion was reached about the homogeneity of the measured sample regardless of the year range and level of physical activity percentage.

The results showed the following measured variables' descriptive values: proteins 14.11±1.64 kg, muscle mass 40.59±4.99 kg, percentage of muscle mass in the body 47.59±4.34 %, muscle thickness index 0.348±0.002 kg, percentage of proteins in the body 0.165±0.015 kg, BMI and proteins ratio 1.842±0.246. The dispersion of the results indicate that all the variables can be used as referential and scientifically valid for further researches.

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INICIJALNI METOD ZA INDIKACIJU MIŠIĆNE STRUKTURE MUŠKARACA DEFINISAN MBI METODOM

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Aktuelni generički model telesne kompozicije definisan je sa četiri osnovne dimenzije: voda, proteini, minerali i masti. Najsavremenija metoda analize telesnog sastava je metoda bioelektrične impedance (BIA) koja brzo i neinvazivno registruje veliki broj pokazatelja telesne strukture. Jedan od činilaca telesne strukture, a najodgovorniji za kvalitativno ispoljavanje motorike kod čoveka je struktura mišićne mase. U dosadašnjim tehnološkim postupcima ispitivanja morfološke strukture kod ljudi, mišićna masa je procenjivana indirektno i tako su utvrđivane njene kvantitativne karakteristike. Cilj ovog istraživanja je da definiše inicijalni model indikatora mišićne strukture kod muškaraca merene direktnom metodom i to multikanalnom bioelektričnom impedancom najnovije genereacije – InBody 720. Osnovne karakteristike ispitanika su bile: uzrast 30.81±9.73 godina, masa 86.17±14.95 kg, visina 182.35±7.09 cm, BMI 25.88±3.99. Ovim istraživanjem obuhvaćeno je šest varijabli za definisanje mišićne komponente telesne strukture: dve osnovne (proteini i masa skeletnih mišića) i četiri izvedene (odnosi: skeletne i mišićne mase, proteina i mišićne mase, proteina i telesne mase, BMI i proteina) varijable. Rezultati su pokazali sledeće deskriptivne vrednosti ispitivanih varijabli: proteini 14.11±1.64 kg, mišićna masa 40.59±4.99 kg, procenat mišićne mase u telu je 47.59±4.34 %, indeks gustine mišića 0.348±0.002 kg, procenat proteina u telu 0.165±0.015 kg, odnos BMI i proteina je 1.842±0.246. Rezultati mera disperzije ukazuju da se sve varijable mogu koristiti kao reprezentativne i naučno validne za dalja istraživanja.

Ključne reči: *proteini, telesni sastav, mišići, muškarci.*