Int. J. Morphol.,
42(5):1278-1287, 2024.

Analysis of Body Composition in Men and Women with Diverse Training Profiles: A Cross-Sectional Study

Análisis de la Composición Corporal en Hombres y Mujeres con Diversos Perfiles de Entrenamiento: Un Estudio Transversal

Lazar Toskic[1,2]; Milan Markovic[1]; Jozef Simenko[3,4]; Vladimir Vidic[5]; Nikola Cikiriz[2] & Milivoj Dopsaj[5]

TOSKIC, L.; MARKOVIC, M.; SIMENKO, J.; VIDIC, V.; CIKIRIZ, N. & DOPSAJ, M. Analysis of body composition in men and women with diverse training profiles: a cross-sectional study. *Int. J. Morphol., 42(5)*:1278-1287, 2024.

SUMMARY: The aim of the study is to investigate the differences in body composition between differently trained men and women. This research included 159 participants (84 male and 75 female) divided into 5 groups according to activity level: PI - physically inactive, PA – physically active, SP – strength and power athletes, EA – endurance athletes, TS – team sports athletes. The testing procedure of measuring body composition was carried out by the use of bioelectrical impedance analysis (BIA, InBody 720). Of the statistical analysis, ANOVA and MANOVA were used. The results showed that there is a significant difference in body composition parameters between differently trained men and women ($p = 0.000$; $F = 2.470$; $\eta^2 = 0.356$, on average). Both in groups of men and women the biggest differences were observed between PI, EA and other groups (F = from 9.656 to -1.673, p = from 0.000 to 0.043; F = from 10.966 to 1.073, p = from 0.000 to 0.050, respectively). The results showed that every physical activity is beneficial from the aspect of body composition status and that the most crucial factor in improving body composition status is the regularity of physical activity. It has been shown that regular physical activity leads to a decrease in muscle fat and an increase in muscle mass and protein. Also, it has been shown that practicing a physical activity typical for endurance sports has the most significant positive impact on body composition status and leads to a significant decrease in body fat mass.

KEY WORDS: Muscle mass; Body fat; Protein; Bioimpedance; Physical activity.

INTRODUCTION

Body composition is a term that describes the relative proportions of all major body components, including fat, bone, muscle, and water (Thibault *et al*., 2012). Its proportions play an essential role in health status (Woo *et al*., 2007; Lohman *et al*., 2008; Zaccagni *et al*., 2014), and have a significant influence on physical activity and movement (Okely *et al*., 2004; Nicolozakes *et al*., 2018; Campa *et al*., 2019), thus, has a significant influence on achieving top-level sports results (Loucks, 2004; Fields, *et al*., 2018a; Lukaski *et al*., 2021).

It is well known that endogenous (internal-genetic) and exogenous (external-environmental) factors influence morphological characteristics and body composition parameters (Vrieze *et al*., 2010; Ashtary-Larky *et al*., 2022). Accordingly, the greatest scope for the influence of external factors is from the aspect of physical activity (Jiménez-Zazo *et al*., 2022; Karchynskaya *et al*., 2022). In this regard, correctly implementing recreational and sports training is extremely important. The desirable effects of systematic, planned and regular physical activity on body composition is an increase in muscle mass and its contractility with a simultaneous reduction in the fat component, which leads to a positive effect on the manifestation of competitive performance, but also on the quality of life (Ryan, 2010; Westerterp, 2018; Aars *et al*., 2019; Kim *et al*., 2019). Training modulation with its components, such as type, intensity and volume, triggers the adaptation of the morphological characteristics of the body to achieve the desired body structure (Norton & Olds, 2001; Ackland *et al*., 2012). It is necessary to understand these laws in selecting and monitoring the achieved effects of the long-term training process.

[1] Faculty of Sport and Physical Education, University of Pristina - Kosovska Mitrovica, Leposavic, Serbia.
[2] Faculty of Sport, University ''Union-Nikola Tesla'', Belgrade, Serbia.
[3] School of Life and Medical Sciences, University of Hertfordshire, Hertfordshire, UK.
[4] Faculty of Sport, University of Ljubljana, Ljubljana, Slovenia.
[5] Faculty of Sport and Physical Education, University of Belgrade, Belgrade, Serbia.

Received: 2023-12-05 Accepted: 2024-01-01

Numerous studies have investigated the relationship between body composition and physical activity. Investigation of body composition parameters of physically inactive and physically active (recreational) individuals and athletes is important from the aspect of the sport selection and the influence of different sports and physical activities on body composition parameters (Santos *et al*., 2014; Fields *et al*., 2018a,b). Regarding the aforementioned, previous studies investigated differences between physically active and inactive individuals (Leskinen *et al*., 2009; Copic *et al*., 2014; Meleleo *et al*., 2017; Mateo-Orcajada *et al*., 2022), as well as between athletes from different sports (Carbuhn *et al*., 2010; Högström *et al*., 2012; Popovic *et al*., 2013, 2014; Mala *et al*., 2015; Dopsaj *et al*., 2017; Fields *et al*., 2018a,b). However, none of these studies considered all levels and types of physical activity (physically inactive, moderately physically active, athletes from different sports groups), so it is very hard to compare the influence of different physical activities on body composition parameters.

Accordingly, this study aims to investigate the differences in body composition between differently trained men and women, that is, individuals involved in different levels and types of physical activity. It is hypothesized that there will be significant differences in measured body composition parameters between groups of differently trained men and women. The results of this study could lead to important information about the influence of different types and levels of physical activity (and inactivity) on the body composition status of adults, which could further contribute to the development of the training process, sport selection, and health status in general.

MATERIAL AND METHOD

Participants. This research included 159 participants, male (84) and female (75). Participants were divided into 5 groups according to activity level. The first group included individuals who do not participate in any regular and systematic physical activity (control group): PI - physically inactive (15 men, age: 25.8±3.76 yrs.; 15 women, age: 22.9±2.25 yrs.). The other four groups were formed from individuals who participate in regular physical activity but at different levels. The second group included individuals who participate in regular and systematic physical activity but are not professional athletes (3 to 5 times per week, 45 to 90 minutes of moderate to intensive physical activity): PA – physically active (17 men, age: 24.8±3.68 yrs.; 15 women, age: 22.1±2.39 yrs.). This group was formed by the students of the Faculty of Sport and Physical Education and Criminalistic – Police Academy. The last three groups were formed from top-level athletes from three different sports groups. Athletes were participants in national and international competitions (European Championships, World Championships, Olympic Games) and had at least five years of competition experience at the high competition level. The first group of athletes were composed by the individuals from strength and power sports (judo, wrestling, karate, boxing, and short course runners, swimmers and cyclists): SP – strength and power athletes (18 men, age: 23±4.23 yrs.; 15 women, age: 22.8±3.14 yrs.). The second group of athletes included athletes from endurance sports (long-distance runners, swimmers and cyclists): EA – endurance athletes (17 men, age: 24.9±4.53 yrs.; 15 women, age: 27.5±3.85 yrs.). The last group was formed from athletes from team sports (football, basketball, volleyball, handball, water polo): TS – team sports athletes (17 men, age: 19.8±2.77 yrs.; 15 women, age: 21.7±1.76 yrs.).

The study was approved by the ethical board of the Faculty of Sport and Physical Education (IRB: 484-2) and participants were thoroughly briefed about the tests that would be conducted and informed about the aim of the study. Only participants who voluntarily agreed to be part of the study and signed a written informed consent form were included in the study. The research was carried out in accordance with the conditions of the Declaration of Helsinki, recommendations guiding physicians in biomedical research involving human subjects.

Procedures. 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., Seoul, Korea). Inbody 720 device uses the latest technology for measuring body composition using BIA (Direct Segmental Multi-frequency Bioelectrical Impedance Analysis) (Rauter & Simenko, 2021). The high test-retest, reliability, and accuracy of bioelectrical impedance were assessed, with high interclass correlation (ICC) (Gibson *et al*., 2008) and correlations with the reference measure (dual-energy X-ray absorptiometry-DXA) were shown to be significant (Esco *et al*., 2015). Body height was measured with a stadiometer (Seca 213, Seca, Hamburg, Germany).

This equipment is intensively used in sports health clinics and other healthcare improvement institutions. All participants were measured according to the manufacturer's suggestions and previous studies (Dopsaj *et al*., 2017). All measurements were performed by a qualified member with extensive experience. And prior to testing, they got these instructions:

- measuring was taken in the morning between 8:00 and 10:00 am,

- participants were asked to abstain from large meals after 9 pm the day before testing,
- participants were asked to abstain from eating and drinking prior to testing on the measuring day,
- participants were asked to refrain from extreme physical exertions 24 hours prior to measuring, and the last training should have been performed at least 12 hours prior to measuring,
- participants were asked to abstain from consuming any alcoholic drinks 48 hours before measuring,
- participants were asked to urinate and defecate at least 30 minutes prior to measuring,
- participants were in the standing position at least 5 minutes prior to measuring due to normal fluid distribution in the body,
- measuring was taken in the standing position, as it was suggested by the manufacturer (hands aside, placed 15 cm laterally from the body).

This study comprised 14 variables, 4 of which were primary and 10 were derived variables. The variables used in the further analysis were:

1. BH – body height, expressed in cm;
2. BM – body mass, expressed in kg;
3. BMI – body mass index, calculated as: BM / BH^2, expressed in kg/m^{-2};

4. BFM – body fat mass, expressed in kg;
5. PBFM – percent of body fat mass, calculated as: BFM / BM, expressed in %;
6. BFMI – body fat mass index, calculated as: BFM / BH^2, expressed in kg/m^{-2};

7. SMM – skeletal muscle mass, expressed in kg;
8. PSMM – percent of skeletal muscle mass, calculated as: SMM / BM, expressed in %;
9. SMMI – skeletal muscle mass index, calculated as: SMM / BH^2, expressed in kg/m^{-2};

10. PM – protein mass, expressed in kg;
11. PMI – protein mass index, calculated as: PM / BH^2, expressed in kg/m^{-2};
12. PFI – protein fat index, calculated as PM / BFM, expressed in kg.

13. FFM – free fat mass, calculated as: BM - BFM, expressed in kg;
14. FFMI – free fat mass index, calculated as: FFM / BH^2, expressed in kg/m^{-2};

Statistics. All analyses were carried out using the statistical package for social sciences (IBM, SPSS 20.0, Chicago, IL, USA). The presented results included mean and standard deviation (SD). The normality of data distribution was tested by the Kolmogorov-Smirnov test. To determine differences between the participant's subsamples, MANOVA was used in general meaning, while ANOVA was used in partial meaning. The differences between the pairs of individual variables of examined subsamples were tested by the Bonferroni criterion. Effect sizes were calculated using partial eta squared (η^2) and interpreted as small (0.01), moderate (0.06), or large (0.14) (Cohen, 1988). The discriminative analysis was used to define the most important factor of body composition variables' difference in the subsamples' function. The level of statistical significance is defined by 95 % and the probability values of $p < 0.05$ (Hair, 1998).

RESULTS

The MANOVA results showed that there is a significant difference in body composition parameters between differently trained men (Wilks' Lambda Value = 0.180; p = 0.000; F = 2.354; $\eta^2 = 0.329$) and women (Wilks' Lambda Value = 0.144; p = 0.000; F = 2.586; $\eta^2 = 0.384$).

Table I shows the descriptive statistics and ANOVA results. It can be noticed that men differ in 12 out of 14 parameters of body composition (F= from 13.769 to 2.88; p = from 0.000 to 0.028) while in the group of women subjects, there is a difference between differently trained individuals in 8 out of 14 measured and applied body composition parameters (F= from 7.527 to 5.273; p = from 0.000 to 0.001). In men, significant differences were obtained in all measured and derived parameters of fat mass, muscle mass, and protein parameters, while in women, differences exist in all parameters of the fat mass component.

Table II represents the results of the Bonferroni post hoc test, that is, differences between groups (differently trained individuals) of men in those parameters that showed significant differences. The biggest differences were observed between PI and other groups (F = from 10.966 to -1.299, p = from 0.000 to 0.005) and EA and other groups (F = from 10.966 to 1.073, p = from 0.000 to 0.050).

Based on the results presented in Table III, which shows the differences between groups of differently trained women in measured parameters of body composition, it can be noticed that, similar to the group of men subjects, the biggest differences were observed between PI and other groups (F = from 8.347 to -2.047, p = from 0.000 to 0.043) and EA and other groups (F = from 8.347 to -3.053, p = from 0.000 to 0.050).

Table I. Descriptive values of body composition parameters and ANOVA results.

	Variables	Mean ± SD					ANOVA	
		PI	PA	SP	EA	TS	F	p
MEN	BH (cm)	180.5±7.02	181.3±6.49	180.4±7.77	181.6±5.96	186.9±8.37	2.382	0.058
	BM (kg)	83.3±12.98	81.5±7.98	78.9±9.77	73.5±8.78	81±11.1	2.266	0.069
	BMI (kg/m^{-2})	25.5±3.44	24.8±2.53	24.2±2.32	22.2±2.1	23.1±2.27	4.337	0.003
	BFM (kg)	17.3±7.98	11±5.05	7.8±1.72	8.1±2.91	7.4±2.85	13.03	0.000
	PBFM (%)	20.1±7.07	13.2±5.19	10±2.4	11±3.77	9.1±2.87	15.085	0.000
	BFMI (kg/m^{-2})	5.3±2.39	3.4±1.63	2.4±0.65	2.5±0.95	2.1±0.78	13.479	0.000
	SMM (kg)	37.7±4.48	40.5±3.29	40.6±5.73	37.2±4.98	42±5.65	2.942	0.025
	PSMM (%)	45.6±3.95	49.8±3.1	51.4±1.8	50.6±2.33	52±1.83	13.769	0.000
	SMMI (kg/m^{-2})	11.6±0.93	12.3±0.92	12.5±1.25	11.2±1.09	12±1.16	3.766	0.007
	PM (kg)	13.2±1.49	14.1±1.1	14.2±1.89	13±1.64	14.6±1.9	2.919	0.026
	PMI (kg/m^{-2})	4±0.31	4.3±0.31	4.3±0.41	3.9±0.35	4.2±0.39	3.847	0.007
	PFI (kg)	1±0.67	1.7±1.35	1.9±0.6	1.8±0.67	2.3±1.18	3.938	0.006
	FFM (kg)	66±7.67	70.5±5.65	71.1±9.69	65.4±8.34	73.5±9.57	2.88	0.028
	FFMI (kg/m^{-2})	20.2±1.55	21.5±1.47	21.8±2.07	19.8±1.8	21±1.91	3.725	0.008
WOMEN	BH (cm)	169.9±6.89	168.9±5.25	167.5±9.09	168.7±5.53	167.5±8.42	0.301	0.877
	BM (kg)	59.3±8.1	62.2±6.16	63.8±11.65	56.2±6.89	60.2±8	1.794	0.140
	BMI (kg/m^{-2})	20.5±1.92	21.8±1.68	22.5±2.22	19.7±1.5	21.5±2.1	5.273	0.001
	BFM (kg)	14.2±4.57	13.8±3.21	14.1±5.9	8.6±1.81	11±3.81	5.524	0.001
	PBFM (%)	23.6±4.58	22±3.75	21.6±6.74	15.2±2.45	18.2±5.1	7.527	0.000
	BFMI (kg/m^{-2})	4.9±1.37	4.8±1.15	5±1.77	3±0.58	4±1.45	6.05	0.000
	SMM (kg)	24.6±2.8	26.8±2.54	27.8±4.67	26.4±3.44	27.4±3.93	1.766	0.145
	PSMM (%)	41.7±2.6	43.1±2.14	43.8±4.51	46.9±1.59	45.5±2.96	7.22	0.000
	SMMI (kg/m^{-2})	8.5±0.65	9.4±0.66	9.8±0.93	9.2±0.79	9.7±0.81	6.776	0.000
	PM (kg)	8.8±0.94	9.5±0.84	9.9±1.54	9.4±1.14	9.7±1.3	1.771	0.144
	PMI (kg/m^{-2})	3.1±0.22	3.3±0.22	3.5±0.3	3.3±0.25	3.5±0.26	7.267	0.000
	PFI (kg)	0.7±0.15	0.7±0.15	1.1±1.58	1.1±0.24	1±0.35	1.312	0.274
	FFM (kg)	45.1±4.72	48.4±4.26	49.7±7.79	47.6±5.77	49.2±6.7	1.338	0.264
	FFMI (kg/m^{-2})	15.6±1.01	17±1.05	17.6±1.43	16.7±1.26	17.5±1.3	6.422	0.000

Legend: PI – physically inactive, PA – physically active, SP – strength and power athletes, EA – endurance athletes, TS – team sport athletes, BH – body height, BM – body mass, BMI – body mass index, BFM – body fat mass, PBFM – percent of body fat mass, BFMI – body fat mass index, SMM – skeletal muscle mass, PSMM – percent of skeletal muscle mass, SMMI – skeletal muscle mass index, PM – protein mass, PMI – protein mass index, PFI – protein fat index, FFM – free fat mass, FFMI – free fat mass index

Table II. Bonferroni post hoc test results – men.

Variables ↓	Groups →	PI				PA			SP		EA
		PA	SP	EA	TS	SP	EA	TS	EA	TS	TS
BMI	Mean Diffe.	0.691	1.314	**3.279**	2.402	0.624	**2.588**	1.712	1.964	1.088	-0.876
(kg/m^{2})	p	1.000	1.000	**0.005**	0.094	1.000	**0.041**	0.538	0.254	1.000	1.000
BFM	Mean Diffe.	**6.262**	**9.451**	**9.162**	**9.826**	3.190	2.900	3.565	-0.290	0.375	0.665
(kg)	p	**0.002**	**0.000**	**0.000**	**0.000**	0.403	0.653	0.242	1.000	1.000	1.000
PBFM	Mean Diffe.	**6.819**	**10.038**	**9.036**	**10.966**	3.219	2.218	4.147	-1.001	0.928	1.929
(%)	p	**0.000**	**0.000**	**0.000**	**0.000**	0.368	1.000	0.085	1.000	1.000	1.000
BFMI	Mean Diffe.	**1.936**	**2.875**	**2.830**	**3.184**	0.939	0.894	1.249	-0.045	0.310	0.354
(kg/m^{-2})	p	**0.002**	**0.000**	**0.000**	**0.000**	0.502	0.656	0.109	1.000	1.000	1.000
SMM	Mean Diffe.	-2.782	-2.944	0.500	-4.347	-0.162	3.282	-1.565	3.444	-1.403	**-4.847**
(kg)	p	1.000	0.916	1.000	0.149	1.000	0.559	1.000	0.422	1.000	**0.049**
PSMM	Mean Diffe.	**-4.184**	**-5.793**	**-4.948**	**-6.342**	-1.610	-0.765	-2.159	0.845	-0.549	-1.394
(%)	p	**0.000**	**0.000**	**0.000**	**0.000**	0.795	1.000	0.213	1.000	1.000	1.000
SMMI	Mean Diffe.	-0.771	-0.900	0.302	-0.462	-0.129	**1.073**	0.309	**1.202**	0.438	-0.764
(kg/m^{-2})	p	0.478	0.199	1.000	1.000	1.000	**0.050**	1.000	**0.015**	1.000	0.429
PM	Mean Diffe.	-0.902	-0.992	0.174	-1.426	-0.090	1.076	-0.524	1.166	-0.434	**-1.600**
(kg)	p	1.000	0.869	1.000	0.161	1.000	0.589	1.000	0.384	1.000	**0.048**
PMI	Mean Diffe.	-0.247	-0.304	0.106	-0.134	-0.056	**0.353**	0.113	**0.409**	0.169	-0.240
(kg/m^{-2})	p	0.544	0.174	1.000	1.000	1.000	**0.050**	1.000	**0.011**	1.000	0.538
PFI	Mean Diffe.	-0.698	-0.914	-0.812	**-1.299**	-0.217	-0.114	-0.602	0.103	-0.385	-0.488
(kg)	p	0.410	0.072	0.179	**0.002**	1.000	1.000	0.679	1.000	1.000	1.000
FFM	Mean Diffe.	-4.461	-5.056	0.651	-7.478	-0.595	5.112	-3.018	5.707	-2.423	**-8.129**
(kg)	p	1.000	0.873	1.000	0.135	1.000	0.782	1.000	0.468	1.000	**0.047**
FFMI	Mean Diffe.	-1.225	-1.552	0.450	-0.773	-0.328	1.674	0.452	**2.002**	0.779	-1.223
(kg/m^{-2})	p	0.562	0.149	1.000	1.000	1.000	0.077	1.000	**0.014**	1.000	0.491

Legend: PI – physically inactive, PA – physically active, SP – strength and power athletes, EA – endurance athletes, TS – team sport athletes, BH – body height, BM – body mass, BMI – body mass index, BFM – body fat mass, PBFM – percentgroupbody fat mass, BFMI – body fat mass index, SMM – skeletal muscle mass, PSMM – percent of skeletal muscle mass, SMMI – skeletal muscle mass index, PM – protein mass, PMI – protein mass index, PFI – protein fat index, FFM – free fat mass, FFMI – free fat mass index

Table III. Bonferroni post hoc test results – women.

Variables ↓	Groups →	PI				PA			SP		EA
		PA	SP	EA	TS	SP	EA	TS	EA	TS	TS
BMI	Mean Diffe.	-1.313	**-2.047**	0.82	-1.007	-0.733	**2.133**	0.307	**2.867**	1.04	-1.827
(kg/m^2)	p	0.627	**0.043**	1.000	1.000	1.000	**0.030**	1.000	**0.001**	1.000	0.105
BFM	Mean Diffe.	0.44	0.073	**5.633**	3.193	-0.367	**5.193**	2.753	**5.56**	3.12	-2.44
(kg)	p	1.000	1.000	**0.003**	0.361	1.000	**0.009**	0.697	**0.004**	0.405	1.000
PBFM	Mean Diffe.	1.593	2.007	**8.347**	**5.373**	0.413	**6.753**	3.78	**6.34**	3.367	-2.973
(%)	p	1.000	1.000	**0.000**	**0.028**	1.000	**0.002**	0.323	**0.005**	0.558	0.903
BFMI	Mean Diffe.	0.063	-0.061	**1.885**	0.92	-0.124	**1.822**	0.857	**1.945**	0.981	-0.965
(kg/m^{-2})	p	1.000	1.000	**0.002**	0.612	1.000	**0.003**	0.807	**0.001**	0.464	0.500
PSMM	Mean Diffe.	-1.487	-2.167	**-5.22**	**-3.82**	-0.68	**-3.733**	-2.333	**-3.053**	-1.653	1.4
(%)	p	1.000	0.466	**0.000**	**0.006**	1.000	**0.008**	0.325	**0.050**	1.000	1.000
SMMI	Mean Diffe.	**-0.881**	**-1.319**	-0.72	**-1.208**	-0.437	0.161	-0.327	0.599	0.11	-0.488
(kg/m^{-2})	p	**0.027**	**0.000**	0.132	**0.001**	1.000	1.000	1.000	0.379	1.000	0.888
PMI	Mean Diffe.	**-0.294**	**-0.448**	-0.235	**-0.405**	-0.154	0.059	-0.111	0.212	0.042	-0.17
(kg/m^{-2})	p	**0.022**	**0.000**	0.132	**0.000**	1.000	1.000	1.000	0.246	1.000	0.700
FFMI	Mean Diffe.	**-1.368**	**-1.993**	-1.074	**-1.871**	-0.625	0.294	-0.503	0.919	0.122	-0.797
(kg/m^{-2})	p	**0.030**	**0.000**	0.184	**0.001**	1.000	1.000	1.000	0.427	1.000	0.778

Legend: PI – physically inactive, PA – physically active, SP – strength and power athletes, EA – endurance athletes, TS – team sport athletes, BH – body height, BM – body mass, BMI – body mass index, BFM – body fat mass, PBFM – percent of body fat mass, BFMI – body fat mass index, SMM – skeletal muscle mass, PSMM – percent of skeletal muscle mass, SMMI – skeletal muscle mass index, PM – protein mass, PMI – protein mass index, PFI – protein fat index, FFM – free fat mass, FFMI – free fat mass index

Tables IV to VI, and Figures 1 and 2 represent the results of discriminative analyses. There are four defined parameters, of which only the first is significant (p = 0.000), in both sexes respectively (Table IV). In men subjects, the first function explains 74.8 % of the variance (Table IV), and it is composed of PBFM (0.838), PSMM (0.804), BFMI (0.779), BFM (0.774) and PFI (0.401) (Table V). In women subjects, the first function explains 61.7 % of the variance (Table IV), and it is composed of PBFM (0.608), PSMM (0.595), BFMI (0.514) and BFM (0.502) (Table V). Table VI represents the quantitive values of defined functions, created based on the discriminability of included body composition parameters for each group and sex. Based on the defined values of the functions, centroid positions of differently trained men and women are presented (Figs. 1 and 2).

Table IV. Results of discriminative analysis with results of defined functions

Sex	Male				Female			
Test:	**Eigenvalues**							
Function	Eigenvalue	% of Variance	Cumul. %	Canon. Correl.	Eigenvalue	% of Variance	Cumul. %	Canon. Correl.
1	1.046	74.8	74.8	0.715	1.144	61.7	61.7	0.730
2	0.206	14.7	89.5	0.414	0.522	28.1	89.8	0.586
3	0.121	8.6	98.1	0.328	0.158	8.5	98.3	0.369
4	0.026	1.9	100.0	0.160	0.032	1.7	100.0	0.176
Test:	**Wilks' Lambda**							
Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.	Wilks' Lambda	Chi-square	df	Sig.
1 through 4	0.352	79.820	32	0.000	0.257	90.457	40	0.000
2 through 4	0.721	25.047	21	0.245	0.550	39.742	27	0.054
3 through 4	0.869	10.702	12	0.555	0.837	11.824	16	0.756
4	0.975	1.975	5	0.853	0.969	2.085	7	0.955

Table V. Structure matrix.

Male	Function				Female	Function			
	1	2	3	4		1	2	3	4
PBFM (%)	**0.838**	0.369	-0.108	-0.072	**PBFM (%)**	**-0.608**	0.079	0.136	0.215
PSMM (%)	**-0.804**	-0.261	0.227	0.170	**PSMM (%)**	**0.595**	0.085	-0.142	-0.160
BFMI (kg/m^{-2})	**0.779**	0.473	0.030	-0.130	**BFMI (kg/m^{-2})**	**-0.514**	0.273	0.130	0.240
BFM (kg)	**0.774**	0.385	0.134	-0.184	**BFM (kg)**	**-0.502**	0.219	0.059	0.271
PFI (kg)	**-0.401**	-0.271	0.365	0.003	**PMI (kg/m^{-2})**	0.239	**0.815**	0.140	0.163
BMI (kg/m^{-2})	0.279	**0.756**	0.376	-0.349	**SMMI (kg/m^{-2})**	0.240	**0.785**	0.142	0.182
PMI (kg/m^{-2})	-0.198	**0.752**	0.502	-0.359	**FFMI (kg/m^{-2})**	0.231	**0.758**	0.181	0.182
SMMI (kg/m^{-2})	-0.200	**0.727**	0.555	-0.316	**BMI (kg/m^{-2})**	-0.207	**0.680**	0.234	0.250
FFMI (kg/m^{-2})	-0.211	**0.709**	0.512	-0.401	**PM (kg)**	0.116	**0.404**	0.056	0.181
SMM (kg)	-0.222	0.215	**0.842**	-0.348	**SMM (kg)**	0.120	**0.403**	0.060	0.186
PM (kg)	-0.224	0.216	**0.823**	-0.381	**BM (kg)**	-0.172	**0.354**	0.083	0.266
FFM (kg)	-0.229	0.180	**0.815**	-0.403	**FFM (kg)**	0.103	**0.346**	0.075	0.187
BM (kg)	0.156	0.318	**0.727**	-0.412	**BH (cm)**	-0.054	**-0.158**	-0.021	0.155
BH (cm)	-0.121	-0.474	**0.696**	-0.130	**PFI (kg)**	0.185	0.169	**-0.345**	-0.257

Legend: BH – body height, BM – body mass, BMI – body mass index, BFM – body fat mass, PBFM – percent of body fat mass, BFMI – body fat mass index, SMM – skeletal muscle mass, PSMM – percent of skeletal muscle mass, SMMI – skeletal muscle mass index, PM – protein mass, PMI – protein mass index, PFI – protein fat index, FFM – free fat mass, FFMI – free fat mass index.

Table VI. Functions at Group Centroids

Sex	**Male**				**Female**			
Group:	**Function**				**Function**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
PI	2,000	0,022	0,004	-0,114	-1,378	-0,899	-0,068	-0,126
PA	0,048	0,456	0,197	0,249	-0,452	0,096	0,364	0,293
SP	-0,912	0,490	-0,202	-0,174	-0,482	1,056	-0,465	-0,027
EA	-0,213	-0,519	-0,483	0,105	1,561	-0,611	-0,345	0,065
TS	-0,635	-0,476	0,496	-0,070	0,751	0,358	0,513	-0,205

Legend: PI – physically inactive, PA – physically active, SP – strength and power athletes, EA – endurance athletes, TS – team sport athletes.

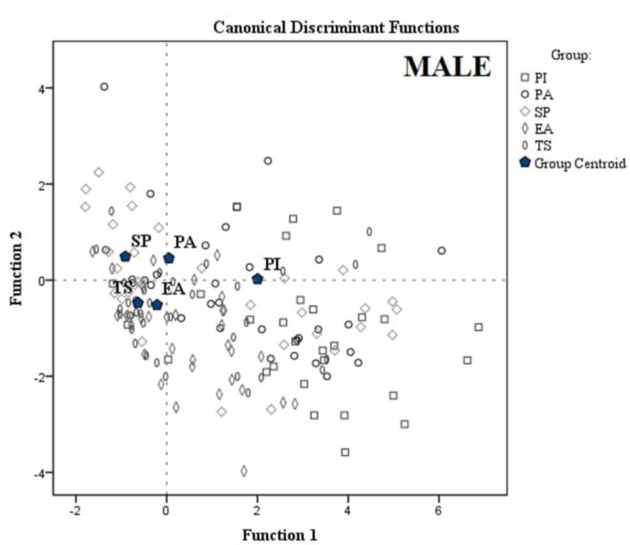

Fig. 1. Canonical Discriminant Functions (Female).

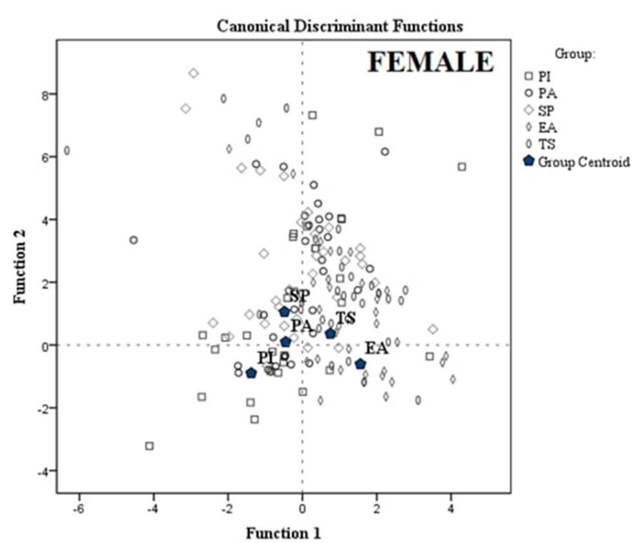

Fig. 2. Canonical Discriminant Functions (Male).

DISCUSSION

This study aimed to investigate the differences in body composition parameters between differently trained men and women, that is, men and women who practice different types and levels of physical activity. To the best of the author's knowledge, this is the first study that dealt with the body composition status of differently trained individuals on such minutely level; all important parameters for sport and exercise are included (muscle and fat mass, protein) as well as new derived parameters, and all types of physical activity are taken into consideration (physically inactive, physically active – recreational, three types of athletes – strength and power, endurance and team sport athletes).

The main finding of this study is that there are significant differences in body composition status between differently trained men and women (p = 0.000). It has shown that there is a difference between the groups in most of the measured and applied parameters (71.4 %, on average) (Table I). These results confirm previous studies which have found that there are significant differences in body composition parameters between physically inactive and active subjects (Leskinen *et al*., 2009; Copic *et al*., 2014; Meleleo *et al*., 2017; Mateo-Orcajada *et al*., 2022), as well as between athletes from different sports groups (Carbuhn *et al*., 2010; Högström *et al*., 2012; Popovic *et al*., 2013, 2014; Mala *et al*., 2015; Dopsaj *et al*., 2017; Fields *et al*., 2018a,b).

Post hoc results revealed that the differences between the groups of differently trained individuals in both sexes were observed only between PI, EA, and other groups (Tables II and III). In men, the PI group has a higher BMI index than the EA group (13.8 %), lower PFI (35.2 %) than the TS group, higher BFM (68.2 %, on average), PBFM (60.6 %, on average), BFMI (69.3 %, on average) and lower PSMM (13.1 %, on average) then all other groups. Similar to men, in women subjects, the PI group have lower BMI than the SP group (9.3 %), higher BFM (49.1 %), PBFM (43.2 %), and BFMI (48.1 %) than the EA group, higher PBFM than TS group (25.8 %), lower PSMM than EA (11.7 %) and TS (8.7 %) group, lower SMMI (12.4 %, on average), PMI (10.1 %, on average) and FFMI (10.7 %, on average) than PA, SP and TS group. Besides the aforementioned differences with the PI group, in men, the EA group had lower BMI (11.06 %), SMMI (9.3 %), and PMI (9.7 %) than the PA group, lower SMMI (10.2 %), PMI (9.7 %) and FFMI (9.6 %) than SP group, and lower SMM (12.1 %), PM (11.5 %), and FFM (11.6 %) than TS group. In women, the EA group has lower BMI (11.6 %, on average), BFM (47.4 %, on average), PBFM (35.6 %, on average), BFMI (48.07 %, on average), and higher PSMM (7.6 %, on average) than PA and SP group. There were no significant differences between the PA, SP, and TS groups in any measured and applied body composition parameters in men and women.

The first important finding of this study is the fact that every physical activity is beneficial from the aspect of body composition status. Thereby, the type (besides endurance activities) and level of physical activity (recreational level, athletes) are not essential factors in improving body composition. The most crucial factor is the regularity of physical activity. It has been shown that regular physical activity leads to a decrease in muscle fat and an increase in muscle mass and protein, and vice versa. Physical activity stimulates the body by inducing a broad range of metabolic changes that are beneficial for health and performance, making it a powerful non-pharmaceutical drug that alleviates symptoms of almost all types of physical and mental health issues (Kramer, 2020; Ramirez-Campillo *et al*., 2021) and effectively reduces all-cause and cause-specific mortality in adults (Kraus *et al*., 2019; Lee *et al*., 2022) and in the older population (Watts *et al*., 2022). Body composition changes are just one of the benefits that one can experience as a consequence of regular exercise, especially considering their impact on the reduction of body fat mass in the overweight population (Westerterp, 2018; Zeng *et al*., 2021). This study has confirmed these statements.

The second important conclusion of this study is that practicing a physical activity typical for endurance sports (aerobic activities; long-distance running, swimming, and cycling) has the most significant positive impact on body composition status compared to other types of physical activities. Participating in these types of physical activities leads to a significant decrease in body fat mass. The lower amount of body fat mass in endurance exercise could be explained by higher utilization of lipids (Mata *et al*., 2019; Muscella *et al*., 2020) and possible overall greater energy cost of endurance training that generally outweighs energy requirements needed for other activities (i.e. strength and power training) (Reis *et al*., 2011). Nevertheless, despite the results of this study, the nutritional caloric energy part of the equation also must be taken into account. With proper diet and exercise planning, we can also attain a very low body fat percentage in athletes of other specializations. However, it has been shown that these physical activities are related to decreasing muscle mass and protein, so it points to caution. Performing endurance exercise training only is not an adequate stimulus for achieving muscle mass potential. Since muscle mass is strongly associated with muscle strength (Jaric, 2003), and muscle strength is an important factor in health status (McLeod *et al*., 2016), it is important, from the aspect of general health, that aerobic activities are combined with strength exercises.

Interestingly, various physical activities influence body composition parameters more in men than in women. In the group of men subjects, there are differences in 12 out of 14 applied parameters (85.7 %), while women differ in 8 parameters (57.1 %) (Table I). These results can be explained by a more favorable hormonal milieu in the male body, primarily circulating testosterone levels. Effects of this hormone on body muscle and fat mass are very well established in the literature (Traish, 2014; Fink *et al*., 2018) and its impact on sex differences in athletes and the consequent effect on male and female body composition in athletes (Handelsman *et al*., 2018) and in untrained people (Deepika *et al*., 2022). The effect of this hormone is already apparent with the onset of puberty with the sex divergence in athletic performance and reaches the adult plateau in the late teenage years, where the timing and tempo of differences are in accordance with the rise in circulating testosterone in boys during puberty (Handelsman, 2017). Combining any type of training in such a hormonal environment with a higher level of circulating testosterone in the male body seems to elicit an even greater response and create greater differences regarding body composition changes between men and women.

Another interesting finding of this study is that there are no significant differences in muscle mass or protein components between PA, SP, and TS groups. Since previous studies revealed that SP athletes have a higher level of muscle power, muscle stiffness, and muscle contraction velocity than athletes from most other sports groups (Toskic´ *et al*., 2020, 2022), it would be expected that they have more muscle mass and protein level than these subjects. The explanation for the lack of differences in muscle mass and protein content between SP and other groups could be found in the physical activity that PA, and TS athletes group implement, which incorporates enough training stimuli to induce hypertrophy through their overall training program. Another possible reason could be that weight categories (judo, wrestling, karate and boxing) might present the essential limiting factor in the SP group. This would mean that they are deliberately not reaching the full potential of muscle mass accretion due to the aforementioned boundaries of that classification requirement. Therefore, this should be further researched.

The results of the discriminative analysis show that parameters PBFM, PSMM, BFMI, and BFM are measured and applied parameters of body composition that make the largest differences between groups of differently trained men and women, that is, have the highest discriminative value (Tables IV, V, and VI; Figs. 1 and 2). These results are very similar to previous studies (Dopsaj *et al*., 2017), and they conclude that physical activity mainly influences muscle and fat mass and their mutual relationship. Interestingly, the groups had no significant differences in parameters BH and BM (Table I). These results confirm the necessity of proper assessment in body composition analysis, that is, the usage of valid, precise and direct measurement devices. When it comes to the parameters applied in this study, it must be mentioned that derived parameters (indexes) have shown great validity and can be used in monitoring body composition status and scientific studies.

The study needs to acknowledge some limitations. The athletes were not all in the same part of the season as some were in the pre-season and some were already in the competition part of the season. Additionally, combat sports athletes might be in the weight loss period, slightly affecting their body composition measurements. However, this is the realistic nature of these sports.

CONCLUSION

The main finding of this study is that every physical activity is beneficial from the aspect of body composition status and that the type and level of physical activity are not essential factors in improving body composition. The most crucial factor in improving body composition status is the regularity of physical activity. It has been shown that regular physical activity leads to a decrease in muscle fat and an increase in muscle mass and protein, and vice versa. Also, it has been shown that practicing a physical activity typical for endurance sports has the most significant positive impact on body composition status compared to other types of physical activities and leads to a significant decrease in body fat mass. Finally, it can be concluded that derived parameters of body composition (indexes) applied in the study have shown great validity and can be used in monitoring body composition status and scientific studies.

ACKNOWLEDGMENTS. The paper is a part of the project of Ministry of education, science and technological development of the Republic of Serbia, number III47015, Research Projects Cycle 2011-2019.

TOSKIC, L.; MARKOVIC, M.; SIMENKO, J.; VIDIC, V.; CIKIRIZ, N. & DOPSAJ, M. Análisis de la composición corporal en hombres y mujeres con diversos perfiles de entrenamiento: un estudio transversal. I*nt. J. Morphol., 42(5)*:1278-1287, 2024.

RESUMEN: El objetivo del estudio fue investigar las diferencias en la composición corporal entre hombres y mujeres con entrenamiento diferente. Esta investigación incluyó a 159 participantes (84 hombres y 75 mujeres) divididos en 5 grupos según el nivel de actividad: FI - físicamente inactivos, FA - físicamente activos, FP - atletas de fuerza-potencia, AR - atletas de resistencia, DE - atletas de deportes de equipo. El procedimiento de prueba para medir la composición corporal se llevó a cabo mediante el análisis de impedancia bioeléctrica (BIA, InBody 720). Para el análisis estadístico se utilizaron ANOVA y MANOVA. Los resultados mostraron que existe una diferencia significativa en los parámetros de composición corporal entre hombres y mujeres con entrenamiento diferente ($p = 0,000$; $F = 2,470$; $\eta^2 = 0,356$, en promedio). Tanto en los grupos de hombres como en los de mujeres las mayores diferencias se observaron entre FI, AR y otros grupos (F = de 9,656 a -1,673, p = de 0,000 a 0,043; F = de 10,966 a 1,073, p = de 0,000 a 0,050, respectivamente). Los resultados mostraron que toda actividad física es beneficiosa desde el punto de vista del estado de la composición corporal y que el factor más crucial para mejorar el estado de la composición corporal es la regularidad de la actividad física. Se ha demostrado que la actividad física regular provoca una disminución de la grasa muscular y un aumento de la masa muscular y las proteínas. Además, se ha demostrado que la práctica de una actividad física típica de los deportes de resistencia tiene el impacto positivo más significativo en el estado de la composición corporal y conduce a una disminución significativa de la masa grasa corporal.

PALABRAS CLAVE: Masa muscular; Grasa corporal; Proteína; Bioimpedancia; Actividad física.

REFERENCES

Aars, N. A.; Jacobsen, B. K.; Morseth, B.; Emaus, N. & Grimsgaard, S. Longitudinal changes in body composition and waist circumference by self-reported levels of physical activity in leisure among adolescents: the Tromsø study, Fit Futures. *BMC Sports Sci. Med. Rehabil., 11(1)*:1-11, 2019.

Ackland, T. R.; Lohman, T. G.; Sungot-Borgen, J.; Maughan, R. J.; Meyer, N. L.; Stewart, A. D. & Müller, W. Current status of body composition assessment in sport. *Sports Med., 42(3)*:227-49, 2012.

Ashtary-Larky, D.; Bagheri, R.; Asbaghi, O.; Tinsley, M.G.; Kooti, W. & Abbasnezhad, A. Effects of resistance training combined with a ketogenic diet on body composition: a systematic review and meta-analysis. *Crit. Rev. Food Sci. Nutr., 62(21)*:5717-32, 2022.

Campa, F.; Piras, A.; Raffi, M. & Toselli, S. Functional movement patterns and body composition of high-level volleyball, soccer, and rugby players. *J. Sport Rehabil., 28(7)*:740-745, 2019.

Carbuhn, A. F.; Fernandez, T. E.; Bragg, A. F.; Green, J. S. & Crouse, S. F. Sport and training influence bone and body composition in women collegiate athletes. *J. Strength Cond. Res., 24(7)*:1710-7, 2010.

Cohen, J. *Statistical Power Analysis for the Behavioural Sciences*. 2nd ed. Hillsdale (NJ), Lawrence Erlbaum Associates, 1988.

Copic, N.; Dopsaj, M.; Ivanovic, J.; Nesic, G. & Jaric, S. Body composition and muscle strength predictors of jumping performance: Differences between elite female volleyball competitors and nontrained individuals. *J. Strength Cond. Res., 28*:2709-16, 2014.

Deepika, F. N. U.; Ballato, E.; Colleluori, G.; Aguirre, L.; Chen, R.; Qualls, C.; Villareal, D.T. & Armamento-Villareal, R. Baseline testosterone predicts body composition and metabolic response to testosterone therapy. *Front. Endocrinol., 13*:915309, 2022.

Dopsaj, M.; Markovic, M.; Kasum, G.; Jovanovic, S.; Koropanovski, N.; Vukovic, M. & Mudric, M. Discrimination of different body structure indexes of elite athletes in combat sports measured by multi frequency bioimpedance method. *Int. J. Morphol., 35(1)*:199-207, 2017.

Esco, M. R.; Snarr, R. L.; Leatherwood, M. D.; Chamberlain, N. A.; Redding, M. L.; Flatt, A. A.; Moon, J. R. & Williford, H. N. Comparison of total and segmental body composition using DXA and multifrequency bioimpedance in collegiate female athletes. *J. Strength Cond. Res., 29(4)*:918-25, 2015.

Fields, J. B.; Merrigan, J. J.; White, J. B. & Jones, M. T. Body composition variables by sport and sport-position in elite collegiate athletes. *J. Strength Cond. Res., 32(11)*:3153-9, 2018a.

Fields, J. B.; Metoyer, C. J.; Casey, J. C.; Esco, M. R.; Jagim, A. R. & Jones, M. T. Comparison of body composition variables across a large sample of national collegiate athletic association women athletes from 6 competitive sports. *J. Strength Cond. Res., 32(9)*:2452-7, 2018b.

Fink, J.; Schoenfeld, B. J. & Nakazato, K. The role of hormones in muscle hypertrophy. *Phys. Sportsmed., 46(1)*:129-34, 2018.

Gibson, A. L.; Holmes, J. C.; Desautels, R. L.; Edmonds, L. B. & Nuudi, L. Ability of new octapolar bioimpedance spectroscopy analyzers to predict 4-component–model percentage body fat in Hispanic, black, and white adults. *Am. J. Clin. Nutr., 87(2)*:332-8, 2008.

Hair, J.; Anderson, R. E.; Tatham, R. L. & Black, W. C. *Multivariate Data Analysis.* 5th ed. Hoboken, Prentice Hall, 1998.

Handelsman, D. J. Sex differences in athletic performance emerge coinciding with the onset of male puberty. *Clin. Endocrinol., 87(1)*:68-72, 2017.

Handelsman, D. J.; Hirschberg, A. L. & Bermon, S. Circulating testosterone as the hormonal basis of sex differences in athletic performance. *Endocr. Rev., 39(5)*:803-29, 2018.

Högström, G. M.; Pietilä, T.; Nordström, P. & Nordström, A. Body composition and performance: influence of sport and gender among adolescents. *J. Strength Cond. Res., 26(7)*:1799-804, 2012.

Jaric, S. Role of body size in the relation between muscle strength and movement performance. *Exerc. Sport Sci. Rev., 31(1)*:8-12, 2003.

Jiménez-Zazo, F.; Hernández-Martínez, A.; Romero-Blanco, C.; Cabanillas, E.; Pérez-Gómez, J.; Ara, I.; Casajús, J. A.; Vicente-Rodríguez, G.; Gesteiro, E.; González-Gross, M.; *et al*. Physical Activity Adherence Related to Body Composition and Physical Fitness in Spanish Older Adults: 8 Years-Longitudinal EXERNET-Study. *Front. Psychol., 13*:858312, 2022.

Karchynskaya, V.; Kopcakova, J.; Madarasova-Geckova, A.; Klein, D.; de Winter, A. F. & Reijneveld, S. A. Body image, body composition and environment: do they affect adolescents' physical activity?. *Eur. J. Public Health, 32(3)*:341-6, 2022.

Kim, K. B.; Kim, K.; Kim, C.; Kang, S. J.; Kim, H. J.; Yoon, S. & Shin, Y. A. Effects of exercise on the body composition and lipid profile of individuals with obesity: a systematic review and meta-analysis. *J. Obes. Metab. Syndr., 28(4)*:278, 2019.

Kramer, A. An overview of the beneficial effects of exercise on health and performance. *Adv. Exp. Med. Biol., 1228*:3-22, 2020.

Kraus, W. E.; Powell, K. E.; Haskell, W. L.; Janz, K. F.; Campbell, W. W.; Jakicic, J. M.; Troiano, R. P.; Sprow, K.; Torres, A.; Piercy, K. L.; *et al*. Physical activity, all-cause and cardiovascular mortality, and cardiovascular disease. *Med. Sci. Sports Exerc., 51(6)*:1270-81, 2019.

Lee, D. H.; Rezende, L. F.; Joh, H. K.; Keum, N. N.; Ferrari, G.; Rey-Lopez, J. P.; Rimm, E. B.; Tabung, F. K. & Giovannucci, E. L. Long-term leisure-time physical activity intensity and all-cause and cause-specific mortality: a prospective cohort of US adults. *Circulation, 146(7)*:523-34, 2022.

Leskinen, T.; Sipilä, S.; Alen, M.; Cheng, S.; Pietilainen, K. H.; Usenius, J. P.; Suominen, H.; Kovanen, V.; Kainulainen, H.; Kaprio, J.; *et al*. Leisure-time physical activity and high-risk fat: a longitudinal population-based twin study. *Int. J. Obes., 33(11)*:1211-8, 2009.

Lohman, T. G.; Ring, K.; Pfeiffer, K.; Camhi, S.; Arredondo, E.; Pratt, C.; Pate, R. & Webber, L. S. Relationships among fitness, body composition, and physical activity. *Med. Sci. Sports Exerc., 40(6)*:1163-70, 2008.

Loucks, A. B. Energy balance and body composition in sports and exercise. *J. Sports Sci., 22(1)*:1-14, 2004.

Lukaski, H. & Raymond-Pope, C. J. New frontiers of body composition in sport. *Int. J. Sports Med., 42(07)*:588-601, 2021.

Mala, L.; Maly, T.; Zahalka, F.; Bunc, V.; Kaplan, A.; Jebavy, R. & Tuma, M. Body composition of elite female players in five different sports games. *J. Hum. Kinet., 45(1)*:207-15, 2015.

Mata, F.; Valenzuela, P. L.; Gimenez, J.; Tur, C.; Ferreria, D.; Domínguez, R.; Sanchez-Oliver, A. J. & Martínez Sanz, J. M. Carbohydrate availability and physical performance: physiological overview and practical recommendations. *Nutrients, 11(5)*:1084, 2019.

Mateo-Orcajada, A.; Gonzalez-Galvez, N.; Abenza-Cano, L. & Vaquero-Cristobal, R. Differences in physical fitness and body composition between active and sedentary adolescents: a systematic review and meta-analysis. *J. Youth Adolesc., 51(2)*:177-92, 2022.

McLeod, M.; Breen, L.; Hamilton, D. L. & Philp, A. Live strong and prosper: the importance of skeletal muscle strength for healthy ageing. *Biogerontology, 17*:497-510, 2016.

Meleleo, D.; Bartolomeo, N.; Cassano, L.; Nitti, A.; Susca, G.; Mastrototaro, G.; Armenise, U.; Zito, A.; Devito, F.; Scicchitano, P.; *et al*. Evaluation of body composition with bioimpedence. A comparison between athletic and non-athletic children. *Eur. J. Sport Sci., 17(6)*:710-9, 2017.

Muscella, A.; Stefàno, E.; Lunetti, P.; Capobianco, L. & Marsigliante S. The regulation of fat metabolism during aerobic exercise. *Biomolecules, 10(12)*:1699, 2020.

Nicolozakes, C. P.; Schneider, D. K.; Roewer, B. D.; Borchers, J. R. & Hewett, T. E. Influence of body composition on functional movement Screen™ scores in college football players. *J. Sport Rehabil., 27(5)*:431-7, 2018.

Norton, K. & Olds, T. Morphological evolution of athletes over the 20th century: Causes and consequences. *Sports Med., 31*:763-83, 2001.

Okely, A. D.; Booth, M. L. & Chey, T. Relationships between body composition and fundamental movement skills among children and adolescents. *Res. Q. Exerc. Sport., 75(3)*:238-47, 2004.

Popovic, S.; Akpinar, S.; Jaksic, D.; Matic, R. & Bjelica, D. Comparative study of anthropometric measurement and body composition between elite soccer and basketball players. *Int. J. Morphol., 31(2)*:461-7, 2013.

Popovic, S.; Bjelica, D.; Jaksic, D. & Hadzic, R. Comparative Study of Anthropometric Measurement and Body Composition between Elite Soccer and Volleyball Players. *Int. J. Morphol., 32(1)*:267-74, 2014.

Ramirez-Campillo, R.; García-Pinillos, F.; Nikolaidis, P. T.; Clemente, F. M.; Gentil, P. & García-Hermoso, A. Body composition adaptations to lower-body plyometric training: a systematic review and meta-analysis. *Biol. Sport., 39(2)*:273-87, 2021.

Rauter, S. & Simenko, J. Morphological asymmetries profile and the difference between low-and high-performing road cyclists using 3D scanning. *Biology (Basel), 10(11)*:1199, 2021.

Reis, V. M.; Júnior, R. S.; Zajac, A. & Oliveira D. R. Energy cost of resistance exercises: An uptade. *J. Hum. Kinet., 29A*:33-9, 2011.

Ryan, A. S. Exercise in aging: its important role in mortality, obesity and insulin resistance. *Aging Health, 6(5)*:551-63, 2010.

Santos, D. A.; Dawson, J. A.; Matias, C. N.; Rocha, P. M.; Minderico, C. S.; Allison, D. S.; Sardihna, L. B. & Silva, A. M. Reference values for body composition and anthropometric measurements in athletes. *PLoS One, 9(5)*:e97846, 2014.

Thibault, R.; Genton, L. & Pichard, C. Body composition: why, when and for who? *Clin. Nutr., 31(4)*:435-47, 2012.

Toskic, L.; Dopsaj, M.; Markovic,M.; Toskic, D. & Ignjatovic, A. Mechanical and contractile properties knee joint muscles measured by the method of tensiomyography in differently trained men and women. *J. Strength Cond. Res., 36(6)*:1532-9, 2022.

Toskic, L.; Dopsaj, M.; Toskic, D. & Markovic, M. Isokinetic muscle power of the knee extensor and flexor muscles among differently trained people in relation to gender. *Hum. Mov., 21(3)*:81-9, 2020.

Traish, A. M. Testosterone and weight loss: the evidence. *Curr. Opin. Endocrinol. Diabetes Obes., 21(5)*:313322, 2014.

Vrieze, A.; Holleman, F.; Zoetendal, E. G.; De Vos, W. M.; Hoekstra, J. B. L. & Nieuwdorp, M. The environment within: how gut microbiota may influence metabolism and body composition. *Diabetologia, 53*:606-613, 2010.

Watts, E. L.; Matthews, C. E.; Freeman, J. R.; Gorzelitz, J. S.; Hong, H. G.; Liao, L. M.; McClain, K. M.; Saint-Maurice, P. F.; Shiroma, E. J. & Moore, S. C. Association of leisure time physical activity types and risks of all-cause, cardiovascular, and cancer mortality among older adults. *JAMA Netw. Open, 5(8)*:e2228510, 2022.

Westerterp, K. R. Exercise, energy balance and body composition. *Eur. J. Clin. Nutr., 72(9)*:1246-50, 2018.

Woo, J.; Leung, J. & Kwok, T. BMI, body composition, and physical functioning in older adults. *J. Obes., 15(7)*:1886-94, 2007.

Zaccagni, L.; Barbieri, D. & Gualdi-Russo, E. Body composition and physical activity in Italian university students. *J. Transl. Med., 12*:1-9, 2014.

Zeng, J.; Peng, L.; Zhao, Q. & Chenm, Q. G. Effects over 12 weeks of different types and durations of exercise intervention on body composition of young women with obesity. *Sci. Sports., 36(1)*:45-52, 2021.

Corresponding author:
Lazar D. Toskic
Faculty of Sport and Physical Education
University of Pristina in Kosovska Mitrovica
Dositeja Obradovica bb
38218 Leposavic
SERBIA

E-mail: lazar.toskic@pr.ac.rs