A comparison of body composition in the adult population including persons aged 60+ who participate in a swimming training program

Skład ciała osób w różnym wieku z uwzględnieniem 60+ rekreacyjnie uprawiających pływanie

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Key words
body composition, the elderly, swimming, Masters, physical activity

Abstract
Introduction: The article presents the results of a study analyzing body composition in different age groups, including 60+ seniors who regularly participate in swimming training. **Study aim: The aim** of this study was to compare the body composition of adults divided into different age groups. The research hypothesis postulating that Masters swimmers are characterized by age-dependent differences in body composition was tested.
Materials and Methods: A total of 86 adults, including 32 women and 54 men, participated in the study. Body composition was determined by bioelectrical impedance with the *InBody* 270 analyzer. Eight body composition parameters were evaluated in Masters swimmers.
Results: The results revealed minor age-related changes in the body composition of female participants. The analyzed parameters were similar in the compared groups of females. In contrast, significant differences in percent body fat (PBF) values, right-arm fat free mass% (FFM%) values, left-arm FFM% values, left-arm body fat mass% (BFM%) values, left-arm BFM values and visceral fat level were observed among the surveyed males.
Conclusions: In men, the differences in Percent Body Fat and the anatomic distribution of adipose tissue measured with the relevant indicators increased with age. In male participants, considerable disproportions were observed in the content of inactive adipose tissue, and the accumulation of adipose tissue was higher in men older than 60.

Słowa kluczowe
skład ciała, starzenie się, pływanie, Masters, aktywność fizyczna

Streszczenie
Wstęp: Artykuł prezentuje wyniki analiz dotyczących składu masy ciała ludzi w różnym wieku z uwzględnieniem osób 60+ uprawiających regularny trening pływacki.
Cel: Celem pracy była analiza porównawcza składu ciała pomiędzy badanymi podzielonymi na grupy w różnym wieku. W związku z tak określonym celem sformułowano następującą hipotezę badawczą: osoby uprawiające pływanie w grupie Masters różnią się pod względem komponentów składu ciała w zależności od grupy wiekowej.

The individual division of this paper was as follows: a – research work project; B – data collection; C – statistical analysis; D – data interpretation; E – manuscript compilation; F – publication search

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Materiał: Badaniami objęto n=86 osób dorosłych, w tym 32 kobiet i 54 mężczyzn. Badania zostały przeprowadzone z zastosowaniem metody impedancji w oparciu o narzędzie jakim jest analizator składu ciała *InBody 270*. Dokonano analizy ośmiu wskaźników dotyczących komponentów ciała osób uprawiających pływanie w grupie *Masters*.
Wyniki: Uzyskane wyniki wykazały, iż u kobiet parametry składu ciała wraz z wiekiem nieznacznie się zmieniają. W porównywanych grupach prezentują się na zbliżonym poziomie. Odmiennie jest w grupie badanych mężczyzn, w której, wskaźniki PBF (Procent tkanki tłuszczowej), FFM (Masa beztłuszczowa) prawego ramienia FFM (Masa beztłuszczowa) lewego ramienia, BFM (Masa tkanki tłuszczowej) lewego ramienia, BFM% (Masa tkanki tłuszczowej) lewego ramienia, poziom tłuszczu wisceralnego, jak również wynik InBody wykazały różnice istotne statystycznie.
Wnioski: Wśród osobników płci męskiej, wraz z wiekiem, narasta zróżnicowanie pod względem ogólnej zawartości tkanki tłuszczowej, jak również pogłębiają się różnice w jej anatomicznym rozmieszczeniu mierzone za pomocą wskaźników dystrybucji. U badanych mężczyzn, dysproporcja wartości analizowanych parametrów była znaczna i określała zawartość tkanki nieaktywnej, stawiając grupę mężczyzn po sześćdziesiątym roku życia jako tę o zwiększonej zawartości tkanki tłuszczowej.

INTRODUCTION

The highest prevalence of overweight and obesity and excessive accumulation of adipose tissue in various anatomical locations is noted in the elderly population. A detailed analysis of changes in the total percentage of adipose tissue and its distribution in elderly women revealed a significant increase in the indicators of total body fat, but only minor differences in the indicators of adipose tissue distribution. A bioelectrical impedance analysis demonstrated that in males, body fat levels increase by around 35% on average with age, leading to an increase in the indicators of total body fat and adipose tissue distribution[1]. According to the literature, overweight and obesity are more prevalent in the 54-60 age group than in the population of 29- to 49-year-olds. The Body Mass Index (BMI) of 60+ seniors decreases with age[2].

A study analyzing changes in body mass and BMI revealed a high prevalence of overweight and obesity in the evaluated groups, and only 5% of the studied population (1 female and 2 males) had a healthy body weight[3].

Body mass was evaluated based on the participants' BMI scores, where a score of 18.5-24.9 denotes a healthy weight, 25.0-29.9 denotes overweight, 30.0-34.9 denotes class I obesity, and ≤ 35.0 denotes class II obesity. In women, excessive accumulation of adipose tissue, in particular in the pelvic area, begins between 40 and 60 years of age, mainly due to unhealthy eating habits, hormonal treatment and low levels of physical activity. Men are most likely to gain weight in middle age, after which their body weight decreases, and 26% of the male population aged 65-84 tend to put on weight. Ageing is also accompanied by a decrease in mineral bone density, changes in cardiovascular physiology, transient hypotonia and persistent hypertonia, decrease in the activity of enzymes involved in aerobic and anaerobic processes, respiratory deterioration, decrease in vital capacity, decrease in basal metabolic rate, connective tissue stiffness and joint pain[4].

In the surveys carried out by the Central Statistical Office (GUS) and PolSenior, cycling was the preferred type of physical activity among the elderly (54.7% and 22.0%, respectively). The respondents surveyed by GUS also opted for other types of physical exercise promoting general fitness (22.7%), Nordic walking (20.1%) and swimming (12.2%). The percentage of respondents with swimming ability increased with age and peaked in the 15-19 age group (75.1%), and it decreased gradually with age to reach 32% in the 60+ group[5].

Swimming is a popular sporting activity among adults and seniors[6]. Masters swimming is a special class of competitive swimming for adults and seniors. Masters swimming clubs have been developing rapidly, and they bring together adults who have a passion for competitive swimming. The Masters program promotes physical fitness, friendship, participation and achievement. In Poland, the program features local events, Polish Cup and Masters Swimming Championships. The contestants have to master specific swimming techniques and observe FINA Masters rules. The participants follow swimming workout routines to prepare for competitive events. A well-planned training program promotes the development of different swimming styles and techniques, motor skills and improves swimming efficiency[7]. According to Goździejewska et al., Masters swimmers usually train 3-4 times a week, and each training session lasts 60-90 minutes. During each session, 68% of the participants swim 1000-3000 m. Approximately 60% of the participants train individually based on the trainer's professional knowledge or own athletic experience (45%). Regular Masters swimming training provides measurable benefits for the 60+ age group, including a considerable improvement in general health[8].

AIM

The aim of this study was to compare the body composition of adults divided into different age groups.

MATERIALS AND METHODS

A total of 86 adults, including 32 women and 54 men, participated in the study. The participants were divided into two age groups of 40-59 and 60+. The mean age was 47 in the first group and 64-65 in the second group. Female participants were characterized by highly similar basic somatic parameters (Table 1). Their average body height was 165 cm, and the average body mass was 66.1 kg in the younger group and 64.6 kg in the 60+ group. In men, the average body height was 180 cm in the younger group and 178 cm in the older group, whereas the average body mass was

85 kg and 83 kg, respectively. All participants had been declared fit to participate in competitive swimming based on the results of medical examinations. The study was approved by the Research Ethics Committee of the University of Warmia and Mazury in Olsztyn (decision No. 9/2018).

Research Design

The measurements were performed during Poland Masters Cup championships, in a specially prepared room by the swimming pool. The measurements were conducted at a temperature of 24°C.

All participants wore bathing suits only and stepped barefoot on the *InBody* 270 body composition analyzer (Figure 1). The InBody index is calculated on the basis of skeletal muscle mass, subcutaneous fat, visceral fat and body water content. The device measures impedance at a frequency of 20 and 100 kHz by passing an electric current of 200uA through an 8-point tactile electrode system (2 electrodes on the left foot, 2 electrodes on the right foot, 2 electrodes on the left hand, and 2 electrodes on the right hand). The participants placed their hands and feet on the device according to instructions. Measurement acquisition time was 15 seconds.

The obtained results were subject to statistical analysis based on the STATISTICA 13 program. The Mann-Whitney-Wilcoxon test was used. Due to the lack of normal distribution of the measurement results in the studied population, the non-parametric test function was used.

RESULTS

Assessment of the respondents' body mass based on the Body Mass Index (BMI) scores is presented in Figure 2.

The results of the analysis revealed similar values of body composition parameters in both groups of female participants, where no significant differences were found in the values of TBW (Total Body Water), protein, minerals, BFM (Body Fat Mass), FFM (Fat Free Mass) or SSM (Skeletal Muscle Mass) (Table 1). The values of the above parameters did not differ significantly in either group of male participants (Table 2).

Figure 1
***InBody*270 analyzer used in the study**

Minor differences in obesity indicators were observed in the group of female participants (Table 1). No significant differences were noted in BMI scores, percent body fat (PBF), waist-to-hip ratio (WHR), obesity class or the *InBody* score. The above values did not differ significantly among males, excluding PBF and the *InBody* score (Table 2). In the group of 60+ males, the average PBF was 21,02%, and it was 3,1% higher than in the group of younger males (Figure 3). Significant differences were also observed in *InBody* scores which were determined at 84,15 in younger participants and 79,23 in older males (Figure 4).

A segmental analysis of body composition revealed significant differences between males aged 40-59 and 60+ (Table 3). In those groups, right-leg FFM% 107,43 and 102.37, left-leg FFM% 106,71 and 101,65, left-arm BFM% 130,92 and 157, left-arm BFM 0,81 and 0,98 and visceral fat level 6,56 and 7,69 (Table 4, Figure 5, Figure 6).

DISCUSSION

The results of this study revealed elevated body fat parameters (BFM and PBF) in both female and male groups. A comparative analysis demonstrated higher levels of body fat in 60+ males. The percentage of females from both age groups (40-59 and 60+) with elevated body fat parameters (BFM – 48% and 43%; PBF – 56% and 43%, respectively) was not statistically significant.

Among males, the analyzed parameters differed significantly between 40-59 and 60+ groups (BFM – 24% and 61%; PBF – 27% and 61%, respectively). A significant difference in PBF values was determined at $p \leq 0.03$. Significant differences were also noted in the values of *InBody* score, right-arm FFM% and left-arm FFM%, left-arm BFM, left-arm BFM% and visceral fat level (Table 4).

Significant differences in the analyzed parameters between male groups are presented in Table 3 (a negative value indicates that the value of the parameter is higher in the 60+ group).

In males, total body fat increases and the anatomical distribution

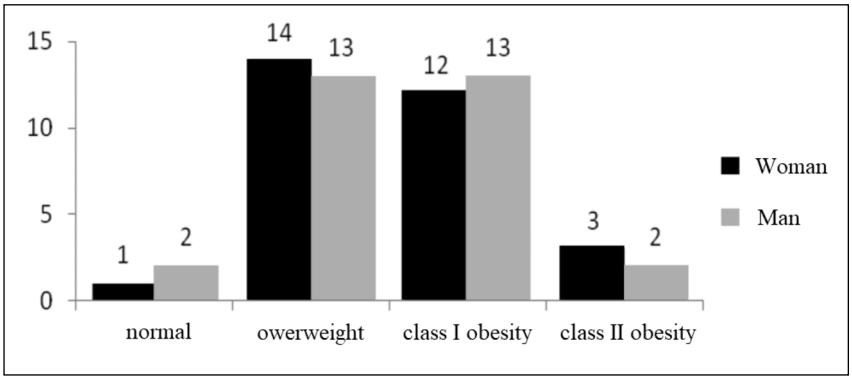

Figure 2
Assessment of the respondents' body mass based on the Body Mass Index (BMI) scores[3]

Table 1

Basic somatic parameters and body composition in the surveyed women

	Body height [cm]	Body mass [kg]	Total body water (TBW) l	PROTEIN [kg]	MINERALS [kg]	Body fat mass (BFM) [kg]	Fat-free mass (FFM [kg]	Skeletal muscle mass (SSM) [kg]
WOMEN AGED 40-59								
M	166.46	67.90	34.96	9.36	3.36	20.21	47.69	26.27
SD	5.81	10.51	4.14	1.12	0.42	7.26	5.68	3.38
Min	154.00	52.00	24.70	6.50	2.50	8.00	33.70	17.70
Max	175.00	89.20	42.90	11.60	4.10	37.20	58.60	33.00
V%	3.49	15.48	11.85	11.99	12.52	35.91	11.91	12.88
WOMEN AGED 60+								
M	166.71	64.90	35.39	9.41	3.37	16.74	48.16	26.43
SD	6.02	2.74	3.08	0.82	0.24	3.86	4.12	2.52
Min	160.00	61.80	32.00	8.50	3.04	12.40	43.80	23.70
Max	178.00	68.80	40.70	10.80	3.77	21.80	55.30	30.80
V%	3.61	4.22	8.70	8.66	7.14	23.03	8.56	9.54

M – arithmetic average; *SD* – standard deviation; min – minimum value from the sample; max – maximum value from the sample; V% – Coefficient of variation; TBW – Total Body Water; BFM – Body Fat Mass; FFM – Fat Free Mass; SSM – Skeletal Muscle Mass

Table 2

Basic somatic parameters and body composition in the surveyed men

	Body height [cm]	Body mass [kg]	Total body water (TBW) l	PROTEIN [kg]	MINERALS [kg]	Body fat mass (BFM) [kg]	Fat-free mass (FFM [kg]	Skeletal muscle mass (SSM) [kg]
MEN AGED 40-59								
M	180.22	84.80	50.71	13.70	4.64	15.74	69.06	39.35
SD	6.63	12.34	5.14	1.40	0.50	8.30	7.03	4.22
Min	165.00	67.80	41.20	11.20	3.57	7.90	56.00	31.80
Max	194.00	124.60	63.50	17.30	5.85	53.90	86.70	50.30
V%	3.68	14.55	10.15	10.22	10.83	52.76	10.18	10.71
MEN AGED 60+								
M	178.54	83.25	48.20	12.91	4.43	17.72	65.53	36.92
SD	4.74	6.01	3.44	0.88	0.29	6.20	4.58	2.66
Min	171.00	74.20	40.80	11.00	3.87	5.50	55.70	31.20
Max	188.00	93.20	53.80	14.30	4.83	30.10	72.80	41.40
V%	2.65	7.22	7.13	6.84	6.50	35.01	6.98	7.21

M – arithmetic average; *SD* – standard deviation, min – minimum value from the sample, max – maximum value from the sample, V% – Coefficient of variation; TBW – Total Body Water; BFM – Body Fat Mass; FFM – Fat Free Mass; SSM – Skeletal Muscle Mass

of adipose tissue changes with age, which implies that different factors are responsible for the percentage and distribution of adipose tissue in the body. According to many research studies, the ratio between fat mass and fat-free mass is conditioned genetically, but it is also highly influenced by environmental factors[1].

At least 300 minutes of moderate intensity exercise or 150 minutes of vigorous intensity exercise per week is recommended for overall health. Strength-building exercises that involve the major muscle groups should be performed twice weekly or more often. Elderly persons who are unable to exercise vigorously for health reasons should remain as physically active as permitted by their medical condition and impairment. Percent body fat increases with age, from around 16-20% at 25, to more than 36% at 70. The anatomical distribution of adipose tissue changes, and elderly persons are more likely to accumulate fat in the trunk. Fat-free mass and skeletal muscle mass also decrease with age[9].

Wysocki observed differences in body composition parameters between elderly women preforming regular exercise combined with water activities, elderly women performing various types of physical activity, and elderly women performing water activities only. Significant differences in the percentage of visceral fat were noted between the groups. The differences in body fat percentage were not statistically significant, which could be attributed to the fact that this parameter increases until the age

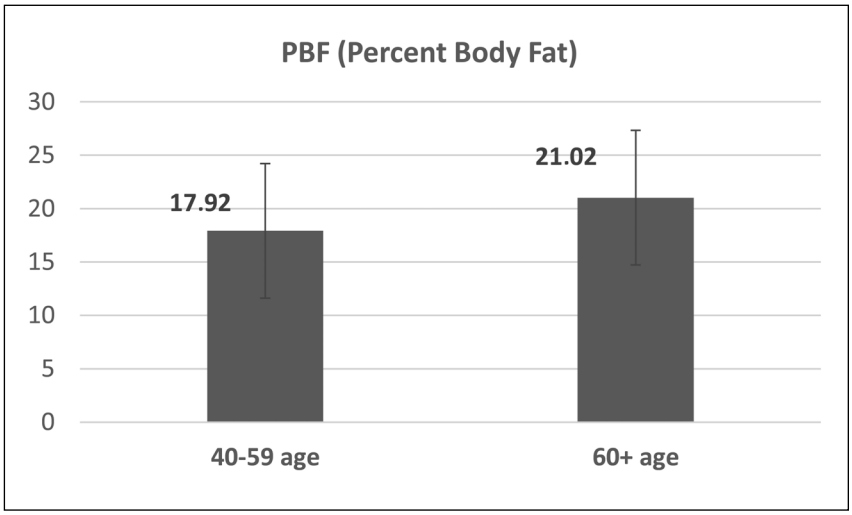

Figure 3
Percent body fat in male participants

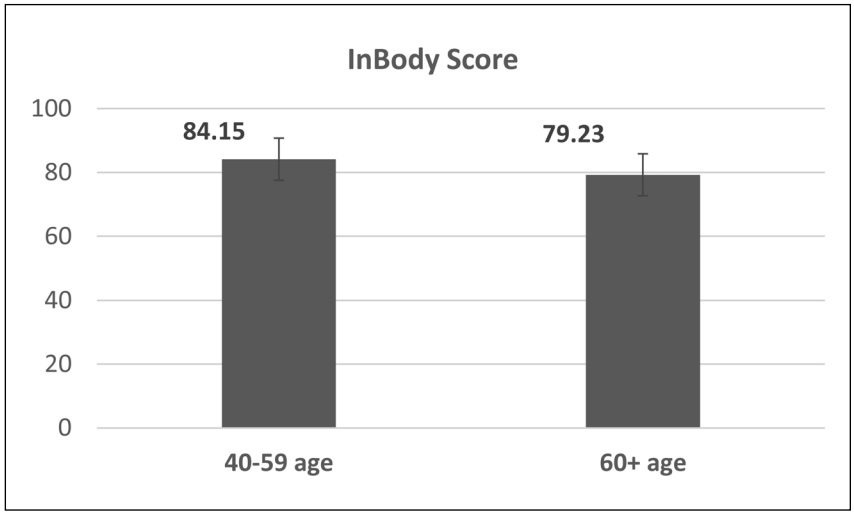

Figure 4
Average *InBody* score of male participants

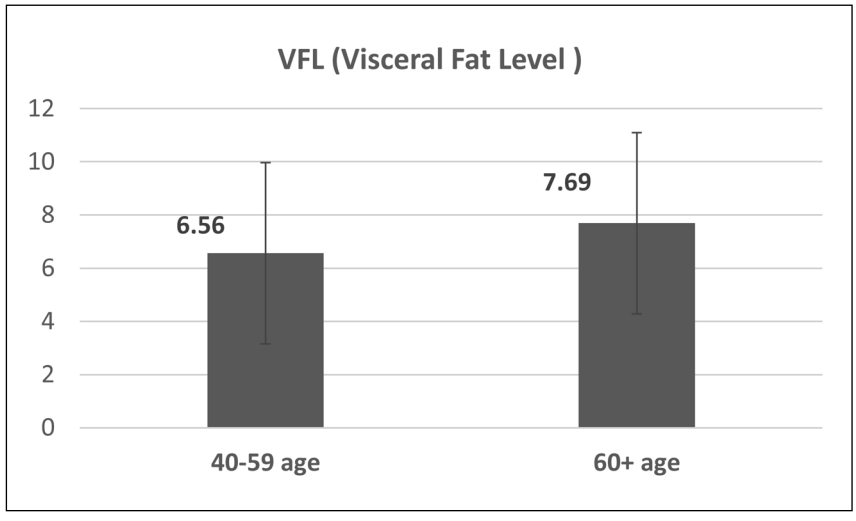

Figure 5
Visceral fat levels in male participants

of 60, and the study was performed on females older than 60. In the analyzed group of body composition parameters, significant differences were found only in the percentage of visceral fat. Women involved in various types of physical activity were characterized by significantly lower levels of visceral fat than women who performed water activities only[10]. In another study, males who regularly performed strength training were characterized by a lower percentage of body fat and higher muscle mass. Differences were also observed in the distribution of adipose tissue between groups, where one group accumulated less trunk fat and less visceral fat ($p<0.0001$). Therefore, regular strength training can contribute to the prevention and treatment abdominal obesity, and long-term weight maintenance[11]. However, no such correlations were found in our study.

According to experts, age-associated involution processes lead to a gradual decrease in muscle mass and physical activity levels. In a study of Polish seniors, 67.1% of the surveyed females were overweight or obese. A survey of the elderly population in the Polish city of Łódź (65-69 years of age) revealed a decrease in mobility with an increase in BMI values. Body fat mass (BFM) increases and lean body mass (LBM) decreases with age due to the loss of muscle proteins. Elderly subjects can lose up to 16% of muscle mass over a period of 10 years. The physiological cross-sectional area of muscles decreases, whereas the percentage of connective tissue and intramuscular fat increases with age. Significant changes in body mass are observed around the age of 50, whereas LBM values tend to decrease considerably in older age, which is partially consistent with our findings. In the 65+ age group, total body mass was negatively correlated with fat-free mass, which implies that the higher the body mass, the lower the percentage of non-fat body components[12]. The results of our study support this observation, which can be attributed to the fact that the basal metabolic rate decreases with age.

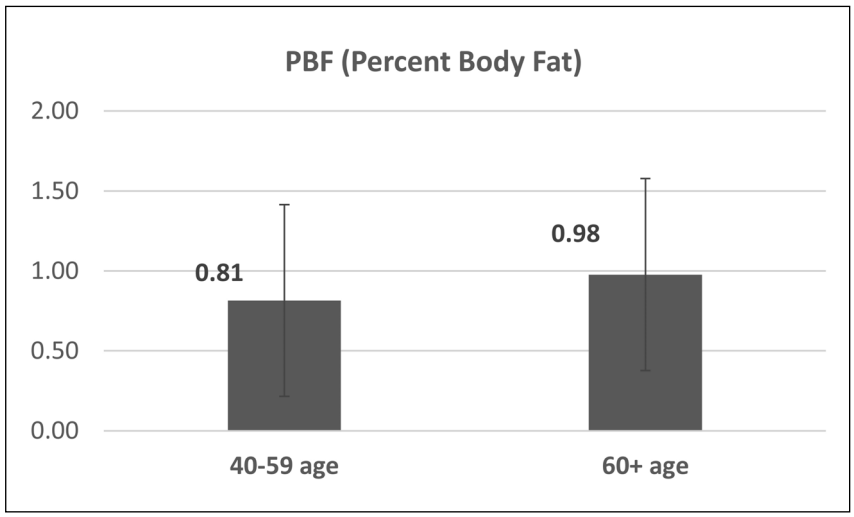

Figure 6
Average left-arm body fat mass in male participants

Table 3

Significant differences in the segmental body composition of the surveyed men		
Mann-Whitney U test	Z	*p*
PBF (percent body fat)	**-2.155**	0.031
InBody score	2.468	0.014
right-leg FFM %	2.236	0.025
left-leg FFM %	2.195	0.028
left-arm BFM	**-2.033**	0.042
left-arm BFM%	**-2.003**	0.045
VFL (Visceral Fat Level)	**-2.003**	0.045

PBF – Percent Body Fat; FFM – Fat Free Mass; BFM – Body Fat Mass; VFL – Visceral Fat Level

Some researchers have reported significant differences in the basal metabolic rate and, consequently, the percentage of body fat in females from different age groups. The anatomical distribution of adipose tissue changes with age. The percentage of trunk fat increases, and the percentage of limb fat decreases in seniors. These changes are more pronounced in elderly males, in particular in the lower limbs. In the present study, the segmental analysis of body composition revealed differences in the distribution of adipose tissue between female groups (Table 3). Similar results were reported in a study of seniors aged 60-75 who were characterized by lower levels of subcutaneous fat and relatively higher levels of visceral fat, in particular in comparison with younger subjects (26-44)[2].

According to the literature, ageing processes lead to changes in body composition, where muscle mass decreases and body fat mass increases until the age of 60-70. The percentage of body fat in 60+ seniors should be maintained at 25–35%. Men are characterized by higher average LBM than women. Lean body mass and soft lean mass (SLM) values differ between the sexes, which could be attributed to higher bone mass in men[13]. However, further research is needed to investigate other factors that contribute to differences in the body composition of men and women. According to many authors, the type and intensity of training influence the ratio of fat-free mass (FFM) to body fat mass (BFM). The percentage of FFM and BFM differs in people performing various types of physical activity. According to Meleski and Malina[14] the body composition of athletes involved in the same sports discipline can change in different training periods due to various levels of training intensity. In their study, a significant decrease in body mass (-1.3±1.8 kg), body fat mass (-2.4 ±1.2 kg) and body fat percentage (-3.8 ±1.9%) was noted in female swimmers (aged 19.1 ±1.3) in the first part of the season which involved highly vigorous training. The corresponding decrease was lower in the second part of the season which was characterized by less vigorous endurance and strength training (-0.8 ±1.2 kg, -0.8 ±1.5 kg, and -1.2 ±2.0%, respectively). In the cited study, body mass and fat-free mass differed between groups.

Men tend to lose more body mass than women with age. Men who weigh 6.5 kg more on average than their female peers at the age of 40-49 are more likely to be 1.2 kg lighter in old age. In women, body mass increases until the age of 60-69, and it decreases after 70 to reach values similar to those noted at the age of 40-49. In men, body mass begins to decrease between the ages of 40 and 59, which is related to the loss of muscle mass. This parameter increases between 60-69 years of age, and clearly decreases after 70. The loss of body mass is also associated with a decrease in the body water percentage (higher in males) which can reach up to 38% of total body water[4]. These findings indicate that proper hydration is essential for maintaining healthy TBW values during athletic performance.

CONCLUSIONS

Analysis of the results authorizes to formulate the following conclusions:

1. In males, with age, the diversity in terms of overall body fat increases, as well as the differences in its anatomical distribution.
2. In the examined men, the disproportion in the values of the analyzed parameters was significant and determined the content of inactive tissue, putting the group of men over sixty years of age as the one with increased fat content.
3. In the examined groups of women (40-59 and over sixty years of age)

Table 4

Segmental body composition of the surveyed women and men

	FFM % RA	FFM % LA	FFM % T	FFM % RL	FFM % LL	BFM % RA	BFM % LA	BFM % T	BFM % RL	BFM % LL
WOMEN AGED 40-59										
M	107.96	105.64	102.52	104.50	104.19	137.39	140.62	180.83	122.26	121.65
SD	11.56	11.60	6.73	8.87	8.97	63.22	63.64	66.43	42.22	42.06
min	75.40	72.40	83.60	81.00	79.40	44.50	49.30	55.40	56.60	56.30
max	128.70	128.60	113.30	127.00	126.80	284.00	286.90	287.20	225.60	224.60
V%	10.70	10.98	6.56	8.49	8.61	46.01	45.26	36.74	34.53	34.57
WOMEN AGED 60+										
M	110.16	110.84	103.13	103.84	102.74	107.39	107.19	153.37	100.83	100.20
sd	6.08	5.61	2.64	8.96	8.68	38.45	37.74	45.33	26.05	26.01
min	103.30	103.00	100.00	92.60	90.50	56.40	60.00	94.90	69.20	67.80
max	118.50	116.60	106.20	119.00	115.10	151.30	148.70	209.10	137.90	137.00
V%	5.52	5.06	2.56	8.63	8.45	35.80	35.21	29.56	25.84	25.95
MEN AGED 40-59										
M	113.80	113.11	107.07	108.34	107.71	112.25	113.86	179.99	116.93	115.51
SD	8.09	7.01	4.37	6.18	6.51	80.98	83.92	79.00	36.61	35.82
min	99.40	98.40	99.90	96.60	95.60	33.20	33.50	82.50	72.60	72.00
max	136.40	131.00	119.20	125.60	127.40	442.80	456.40	464.80	248.50	242.40
V%	7.11	6.20	4.09	5.70	6.05	72.14	73.70	43.89	31.31	31.01
MEN AGED 60+										
M	114.39	114.10	107.14	103.55	102.73	123.89	124.71	219.00	134.25	132.63
SD	9.42	9.02	5.60	6.57	6.09	80.69	80.59	137.48	67.20	66.06
min	102.50	100.90	99.60	89.30	90.50	15.10	15.10	47.50	48.70	50.70
max	139.10	134.30	120.00	116.90	114.10	375.90	378.80	750.10	385.20	378.80
V%	8.24	7.91	5.23	6.35	5.93	65.13	64.62	62.78	50.05	49.81

M – arithmetic average; *SD* – standard deviation; min – minimum value from the sample; max – maximum value from the sample; V% – Coefficient of variation; A – arm; L – leg; R – right; L – left; T – trunk; FFM - fat-free mass; BFM – body fat mass

there was no significant percentage of people in the above normal range (for BFM - 48% and 43%, respectively for PBF - 56% and 43%).

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Conflict of interest

The authors declare that there is no conflict of interest regarding this research.

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