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# ОСОБЕННОСТИ КОМПОЗИЦИОННОГО СОСТАВА ТЕЛА У ДОЛГОЖИТЕЛЕЙ С ИБС

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# Features of Body Composition in Centenarians with Coronary Artery Disease

**Резюме**

**Цель исследования:** изучение композиционного состава тела у больных ишемической болезнью сердца (ИБС) старше 90 лет (долгожителей) и анализ взаимосвязей между содержанием жировой, тощей ткани и минеральной плотностью костной ткани (МПКТ). **Материал и методы.** Данная работа — одномоментное («поперечное») исследование, в которое было включено 200 пациентов старше 90 лет (140 женщин и 60 мужчин, средний возраст 92,4 ±2,3 года), госпитализированных с диагнозом ИБС. Композиционный состав тела анализировали посредством двухэнергетической рентгеновской абсорбциометрии. **Результаты.** Избыточная масса тела или ожирение диагностированы у 139 (69,5%) больных. Скелетно-мышечный индекс оставался в пределах нормальных значений у 145 (72,5%) больных и был ниже нормы у 55 (27,5%). Снижение минеральной плотности костной ткани (Т-критерий) менее -2,5 SD выявлено у 81 (40,5%) больных, нормальные значения МПКТ — у 60 (30,0%) пациентов. Наименьшие значения МПКТ обнаружены в ребрах, наибольшие — в позвоночнике и нижних конечностях. Найдена положительная корреляция между индексом массы тела (ИМТ) и минеральной плотностью костной ткани во всех участках скелета (p <0,0001 для всех областей). Выявлена существенная прямая корреляция между содержанием жировой ткани во всех участках тела и МПКТ, особенно значимая между МПКТ ребер и содержанием жировой ткани в туловище (r=0,85; p <0,0001). Установлена прямая корреляция между содержанием тощей ткани и МПКТ; наиболее достоверная –между МПКТ верхних конечностей и содержанием тощей ткани в верхних конечностях (r=0,69; p <0,0001). Между содержанием жировой и тощей ткани найдена отрицательная корреляция, наиболее значимая между тощей и жировой тканью в нижних конечностях (r=-0,46; p <0,0001). **Заключение.** Полученные результаты свидетельствуют об особенностях композиционного состава тела у долгожителей. Отмечена достаточно высокая доля больных с избыточной массой тела, но с нормальными показателями МПКТ и содержания тощей ткани. Подтверждены значимые взаимосвязи между костной, жировой и тощей тканью.

***Ключевые слова:*** *состав тела, мышечная масса, минеральная плотность костной ткани, жировая ткань, двухэнергетическая абсорбциометрия, долгожители*

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**Конфликт интересов**

Авторы заявляют, что данная работа, её тема, предмет и содержание не затрагивают конкурирующих интересов

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**Abstract**

**Purpose.** To investigate the body composition in patients over 90 years old (long-livers) with coronary artery disease (CAD), and analyzed the relationships between the fat and lean tissues, as well as bone mineral density. **Material and Methods**. A cross-sectional study of 200 patients over 90 years old (140 men and 160 women, mean age 92,4±2,3 года) who were hospitalized with a diagnosis of CAD was conducted. The body composition was analyzed by dual-energy X-ray absorptiometry (DXA). **Results**. Overweight or obesity were diagnosed in 139 (69.5%) patients. The musculoskeletal index remained within normal values in 145 (72.5%) patients and was below normal in 55 (27.5%) patients. Decrease of total BMD (T-score) below -2.5SD was detected in 81 (40,5%), and normal total T-score — in 60 (30.0%) patients. The smallest values of BMD were found in the ribs, the largest — in the spine and in lower extremities. A positive correlation was registered between body mass index and bone mineral density in all areas of the skeleton ($p < 0.0001$). A significant positive correlation was found between BMD and the fat mass in all parts of the body, especially significant between BMD of the ribs and the trunk adipose tissue ($r = 0.85$; $p < 0.0001$). A positive correlation has been established between the lean mass and BMD; the most significant between the BMD and the lean mass in the upper extremities ($r = 0.69$; $p < 0.0001$). A negative correlation was found between the fat and lean mass; the most significant between lean and adipose tissue in the lower extremities ($r = -0.46$; $p < 0.0001$). **Conclusion**. The study results indicate some features of body composition in long-livers. The proportion of overweight patients with normal indices of BMD and lean mass was relatively high. Significant relationships between the bone, adipose and lean tissues were confirmed.

***Key words:*** *body composition, muscle mass, bone mineral density, adipose tissue, dual-energy X-ray absorptiometry, centenarians*

**Conflict of interests**

The authors declare no conflict of interests

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BMD — bone mineral density, BMI — body mass index, IHD — ischemic heart disease, M — mean, SD — standard deviation

## Introduction

The process of aging is associated with numerous changes in body composition. Aging inevitably leads to a decrease in muscle mass and strength, along with an increase in body fat and a decrease in bone mineral density, which often contributes to the so-called osteosarcopenic obesity [1, 2]. To a certain extent, these changes are associated with the imbalance between energy intake and expenditure due to an increasingly sedentary lifestyle. Some disorders also depend on the age-related rearrangement of the endocrine system and metabolic processes.

Increasing fat mass and its redistribution by central type in the senile population are associated with risk factors for diabetes mellitus and cardiovascular diseases [3]. Decreasing bone density is a key risk factor for fractures that lead to significant disability and increased mortality in the senile population. In turn, sarcopenia also leads to different functional disorders and disability in elderly individuals [1].

Age-associated changes in bone, adipose and muscle tissues are usually not isolated — they are combined with each other. Therefore, the same pathogenetic factors can underlie the decrease in bone and muscle tissue with aging: subclinical inflammation, deficiency of hormones and nutrients, as well as a decrease in physical activity [2]. The relationship between bone and muscle tissue can be also explained by other factors. A decrease in muscle mass leads to a decrease in bone loading, which contributes to a decrease in bone density [4]. Muscles

also perform an endocrine function by synthesizing biologically active molecules (myokines) that can have an effect on bone tissue regulation [2].

There are also certain correlations between adipose and bone tissue. This primarily includes the positive effect of mechanical stress that stimulates the formation of bone tissue by reducing apoptosis and increasing proliferation and differentiation of osteoblasts and osteocytes [4]. Also, the relationship between adipose and bone tissue can be mediated by various biologically active substances, particularly leptin and estrogens synthesized by adipocytes, as well as by sclerostin and osteocalcin produced by osteoblasts and stimulating the secretion of adipokines and insulin [2, 4].

Although the specific features of body composition in different groups of patients only recently attracted closer attention, there are now plenty of studies concerning this problem in elderly and senile patients and patients with several chronic diseases. However, only a few have studied body composition in long-living persons [5–6]. Among the available literature sources, we did not find any studies with dual-energy X-ray absorptiometry as a method to study the characteristics of body composition in long-livers; the above studies were carried out using a less sensitive technique called bioelectrical impedance analysis. Considering the above, it seems interesting (both from a scientific and a practical point of view) to analyze body composition in individuals over 90 years old.

The **objective of this study** was to assess body composition in patients over 90 years old (long-livers) with IHD and analyze possible relationships between the amount of fat mass and lean tissue and bone mineral density.

## Materials and Methods

This was a one-stage (cross-sectional) study performed on the clinical base of the State Budgetary Healthcare Institution "Hospital for War Veterans (HWV) No. 3" (Moscow). Two hundred patients over 90 years old were involved in this study (140 women and 60 men, mean age 92.4 ± 2.3 years); they were hospitalized for a diagnosis of "ischemic heart disease" (IHD). This study included patients with confirmed IHD. Diagnosis of IHD was carried out in accordance with the European Society of Cardiology Guidelines for the diagnosis and management of chronic coronary syndromes (2019) [7].

Exclusion criteria: any diseases that can definitely cause changes in body composition (active malignant neoplasms, chronic obstructive pulmonary diseases, malabsorption syndrome, rheumatoid arthritis and other chronic inflammatory diseases, chronic kidney disease stage IV–V).

Standard methods of examination of patients with IHD were used to assess the condition of the patients. Also, the body weight and height of patients were determined and body mass index (BMI) was calculated. Normal parameters included body weight with BMI from 18.5 to 24.9; body weight with BMI from 25 to 29.9 was considered as overweight; obesity was diagnosed with BMI of more than 30 kg/m$^2$ [8].

Body composition was analyzed with dual-energy X-ray absorptiometry using the Lunar Prodigy Advance device (General Electric, USA). Analysis of body composition included the assessment of fat mass (in grams and as a percentage), lean tissue mass (in grams), bone mineral component (in grams), and total body weight (in kilograms). This analysis was performed in the left upper limb, left lower limb, left half of the trunk and in total in the left half of the body, right upper limb, right lower limb, right half of the trunk, and in total, in the right half of the body, in both upper limbs, both lower limbs, trunk, and in total, the whole body. Based on the results of body composition analysis, we further calculated the so-called appendicular skeletal muscle mass (ASMM) and musculoskeletal index. Appendicular skeletal muscle mass is the sum of lean tissue in the two upper and two lower limbs, and musculoskeletal index is the ratio of ASMM to body height squared. Sarcopenia was diagnosed in participants with musculoskeletal index less than 6.0 kg/m$^2$ in women and less than 7.0 kg/m$^2$ in men [9].

Senile asthenia syndrome was diagnosed according to Senile Asthenia Clinical Guidelines [10]. Screening diagnosis of senile asthenia syndrome was carried out using the "Age is no disqualification" questionnaire [10].

This study was conducted in accordance with international and Russian ethical standards, as well as the provisions of the Helsinki Declaration. All study participants signed an informed consent form. As part of a large research project, this study was approved on 14 JUN 2017 by the Independent Ethical Committee of Sechenov First Moscow State Medical University of the Ministry of Health of Russia (Resolution No. 05-2017).

The results obtained were analyzed using Statistica software (version 13.0, StatSoft Inc., USA). The sample was checked for normal distribution using Kolmogorov — Smirnov and Shapiro — Wilk tests. Descriptive statistics methods (mean values, standard deviation, minimum, maximum for quantitative variables; number and proportion for qualitative variables) were used to describe the obtained information. When the distribution of variational series did not meet the "normality" criteria, nonparametric statistics were used; the median (Me), quartiles (Q1–Q4) and interquartile range (from 25% to 75%) were determined. Groups were compared using parametric and nonparametric methods (Mann — Whitney or Kruskal — Wallis test, chi-square test or Fisher's exact test); correlation analysis was conducted using Spearman's rank correlation coefficient.

## Results

In the group of patients, multiple comorbidity was registered in addition to IHD, which was quite typical for individuals of this age (in particular, arterial hypertension, atrial fibrillation, etc.) (Table 1).

In the group of long-livers, overweight or obesity was diagnosed in 139 (69.5%) individuals. Obesity was observed in 58 (29.0%) participants; most of them (45; 77.6%) had class 1 obesity, while class 2 obesity was registered only in 13 (22.4%) patients. Only one patient (0.49%) was diagnosed with body mass deficiency. Mean body mass index was 27.6 ± 4.5 kg/m$^2$ (with fluctuations from 18.2 to 38.8 kg/m$^2$) (Table 2).

Women demonstrated a higher proportion of adipose tissue in all parts of the body compared to men. The most obvious differences between women and men were related to adipose tissue of upper and lower limbs (Table 3).

***Table 1.*** *Comorbid pathology in patients included in the study*

| Diseases | Number of patients | |
|---|---|---|
| | n | % |
| History of myocardial infarction | 48 | 23,8 |
| Chronic heart failure | 41 | 20,3 |
| Atrial fibrillation | 67 | 33,7 |
| History of acute cerebrovascular accident | 30 | 14,9 |
| Arterial hypertension | 200 | 100 |
| Diabetes mellitus / impaired glucose tolerance | 31 | 15,3 |

***Table 2.*** *General characteristics of patients*

| Parameters | Men n=60 (M±SD) | Women n=140 (M±SD) | p |
|---|---|---|---|
| Age, years | 92,6±2,8 | 92,3±2,1 | 0,5 |
| Body mass index, kg/m$^2$ | 27,3±3,8 | 27,6±4,8 | 0,6 |
| Weight, kg | 73,0±10,6 | 64,0±11,8 | **0,000001** |
| Height, cm | 165,3±14,6 | 152,1±6,8 | **<0,000001** |
| Bone mineral density (total), mg/cm$^3$ | 1130,6±136,2 | 957,6±107,6 | **<0,000001** |
| T-score, SD | -0,8 (-2,2; 0,5) * | -2,4 (-3,1; -1,3) * | **0,000004** |
| Z- score, SD | 0,65 (-0,9; 1,9) * | -0,2 (-1,1; 0,65) * | **0,008** |
| Fat mass (total): | | | |
| g | 21493±7690 | 23725±8451 | 0,08 |
| % | 29,9±8,0 | 37,1±8,3 | **<0,000001** |
| Lean mass (total), g | 48845±6326 | 38454±4653 | **<0,000001** |
| Frail, % | 44,4 | 74 | **<0,000001** |
| Pre-frail, % | 44,4 | 25,2 | **0,0002** |
| Robust, % | 11,1 | 0,8 | **0,0003** |

**Note:** * Me — median, Q25 and Q75 — 25% and 75% quartiles, respectively

***Table 3.*** *The amount of fat mass in different body parts in men and women*

| Parameters | Women n=140 (M±SD) | Men n=60 (M±SD) | p |
|---|---|---|---|
| Total fat mass, g | 21493±7690 | 23725±8451 | 0,08 |
| Total fat mass, % | 37,1±8,3 | 29,9±8,0 | **<0,0001** |
| Trunk fat mass, g | 12949±5316 | 13561±5270 | 0,4 |
| Trunk fat mass, % | 37,5±9,5 | 33,6±9,1 | **0,006** |
| Arms fat mass, g | 2149±952 | 1577±751 | **<0,0001** |
| Arms fat mass, % | 35,5±8,9 | 23,3±8,3 | **<0,0001** |
| Legs fat mass, g | 7857±2748 | 5803±2021 | **<0,0001** |
| Legs fat mass, % | 39,4±8,1 | 27,3±7,3 | **<0,0001** |

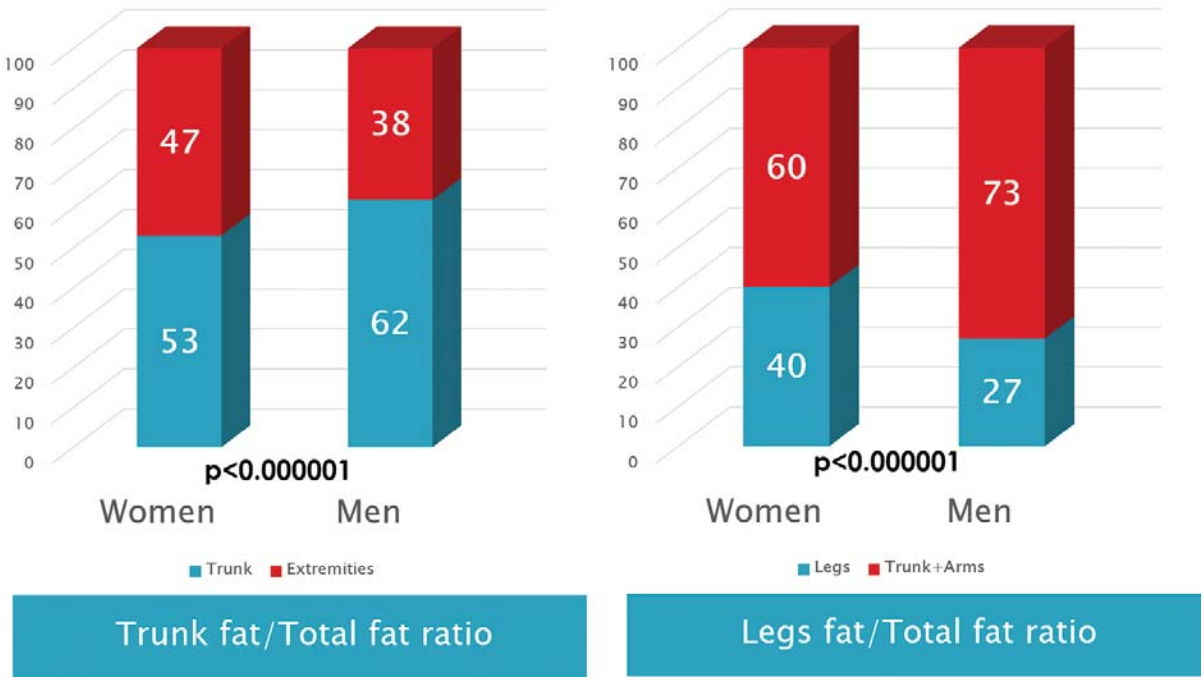


***Figure 1.*** *Fat mass distribution in men and women*

Figure 1 shows the differences in the distribution of adipose tissue in men and women. The average ratio of fat mass in the trunk to the total fat mass was 0.53 ± 0.06 in women and 0.62 ± 0.05 in men (**p < 0.0001**). The average ratio of fat mass in lower limbs to the total fat mass reached 0.40 ± 0.77 in women and 0.27 ± 0.05 in men (**p < 0.0001**). The average ratio of fat mass in limbs to the fat mass in the trunk was 0.83 ± 0.23 in women and 0.56 ± 0.14 in men (**p < 0.0001**).

Average bone mineral density reached 1,008 ± 140 mg/cm$^3$, and T-test showed −1.7 SD. BMD reduced by no more than 1 SD is considered normal; BMD reduced by more than 1 SD but not reaching −2.5 SD corresponds to osteopenia; values below −2.5 SD reveal osteoporosis. The lowest BMD values were registered in ribs (626 ± 85 mg/cm$^3$), the highest — in the spine and lower limbs (Figure 2).

All bone mineral density parameters were significantly lower in women than in men; the greatest differences were observed in lower and upper limbs (Table 4).

The amount of lean tissue in women and men is presented in Table 5. The musculoskeletal index stayed within normal (more than 6.0 kg/m$^2$ in women and 7.0 kg/m$^2$ in men) in 145 (72.1%) patients. A decrease in this index was observed in 35 (25%) women and 20 (33%) men.

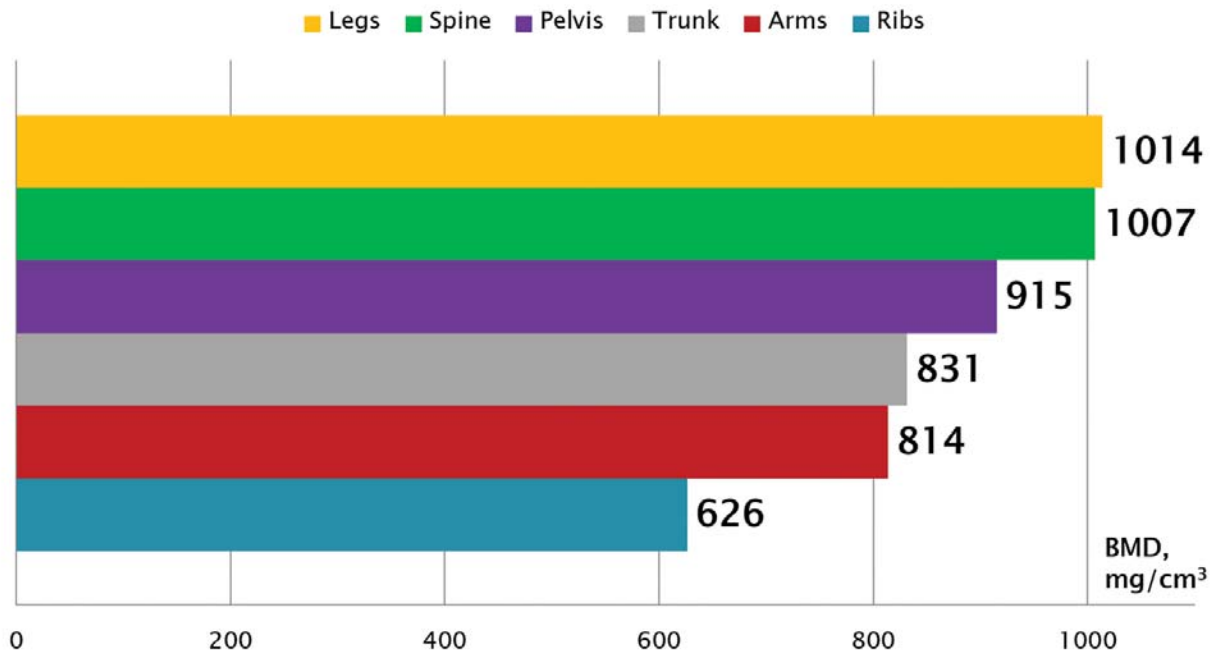


***Figure 2.*** *Bone mineral density in different skeleton parts*

***Table 4.*** *Bone mineral density in women and men*

| Bone mineral density | Women n=140 (M±SD) | Men n=60 (M±SD) | p |
|---|---|---|---|
| Total BMD (mg/cm³) | **957**±107 | **1130**±136 | **<0,0001** |
| Arms BMD (mg/cm³) | **730** (673; 791) * | **981** (896; 1090) * | **<0,0001** |
| Legs BMD (mg/cm³) | **929**±147 | **1212**±176 | **<0,0001** |
| Trunk BMD (mg/cm³) | **803**±95 | **897**±123 | **<0,0001** |
| Ribs BMD (mg/cm³) | **603**±75 | **682**±83 | **<0,0001** |
| Pelvis BMD (mg/cm³) | **879**±133 | **1000**±149 | **<0,0001** |
| Spine BMD (mg/cm³) | **962**±163 | **1114**±214 | **<0,0001** |

**Note:** * Me — median, Q25 and Q75 — 25% and 75% quartiles, respectively

***Table 5.*** *Lean mass in women and men*

| Parameters | Women n=140 (M±SD) | Men n=60 (M±SD) | p |
|---|---|---|---|
| Total lean mass, g | 38453±4653 | 48845±6326 | <0,0001 |
| Trunk lean mass, g | 20302±2729 | 25592±3379 | <0,0001 |
| Legs lean mass, g | 11634±1780 | 14785±2588 | <0,0001 |
| Arms lean mass, g | 3668±630 | 4965±697 | <0,0001 |
| Skeletal-muscle index, kg/m² | 6,6±0,8 | 7,3±0,9 | <0,0001 |

Correlation analysis revealed a significant direct correlation between the body mass index of patients and their fat mass (Fig. 3).

There was also a significant direct correlation between BMI and bone mineral density in all parts of the skeleton ($p < 0.0001$ for all areas); the strongest correlation was observed for the bones of the trunk ($r = 0.5$; $p < 0.0001$) and ribs ($r = 0.5$; $p < 0.0001$).

A highly reliable direct correlation was found between the fat mass in all parts of the body (both in grams and percentage) and BMD (both in total and in each separate part of the skeleton); the most reliable values were established for the correlation between BMD of ribs and fat mass of the trunk ($r = 0.85$; $p < 0.0001$) (Table 6).

There was a significant direct correlation between the mass of lean tissue and BMD (both in total and in

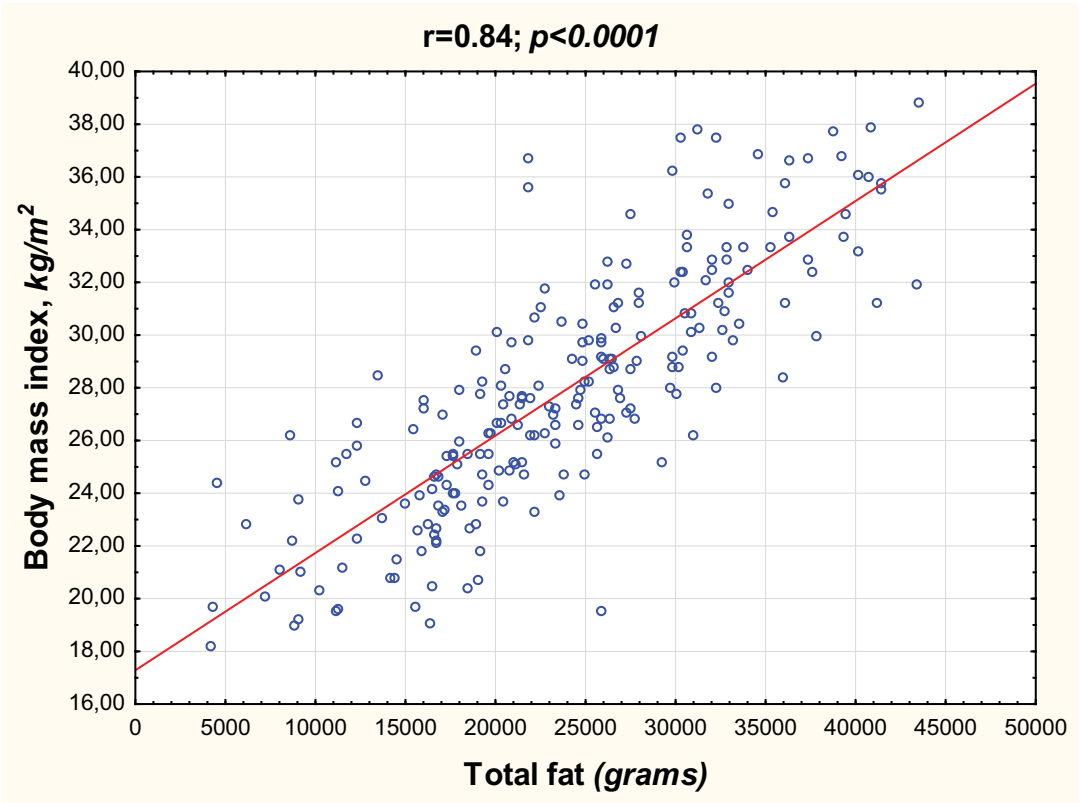


***Figure 3.*** *Correlations between body mass index and fat mass*

***Table 6.*** *Correlations between bone mineral density and trunk fat mass*

| Bone mineral density | Trunk fat mass (g) r; p | Trunk fat mass (%) r; p |
|---|---|---|
| Total BMD (mg/cm³) | 0,43; <0,000001 | 0,25; 0,0004 |
| Total BMD (T-score) | 0,46; <0,000001 | 0,33; 0,000003 |
| Total BMD (Z-score) | 0,2; 0,007 | 0,13; 0,06 |
| Arms BMD (mg/cm³) | 0,33; 0,000003 | 0,1; 0,08 |
| Legs BMD (mg/cm³) | 0,37; <0,000001 | 0,18; 0,01 |
| Trunk BMD (mg/cm³) | 0,59; <0,000001 | 0,4; <0,000001 |
| Ribs BMD (mg/cm³) | 0,85; <0,000001 | 0,4; <0,000001 |
| Pelvis BMD (mg/cm³) | 0,56; <0,000001 | 0,38; <0,000001 |
| Spine BMD (mg/cm³) | 0,51; <0,000001 | 0,36; <0,000001 |

*Table 7. Correlations between bone mineral density and lean mass*

| Bone mineral density | Total lean mass r; p | Trunk lean mass r; p | Arms lean mass r; p | Legs lean mass r; p |
|---|---|---|---|---|
| Total BMD (mg/cm³) | 0,57;<0,000001 | 0,52;<0,000001 | 0,64;<0,000001 | 0,49;<0,000001 |
| Total BMD (T-score) | 0,45;<0,000001 | 0,4;<0,000001 | 0,51;<0,000001 | 0,37;<0,000001 |
| Total BMD (Z-score) | 0,2; 0,003 | -0,17; 0,01 | 0,31; 0,00001 | 0,15; 0,04 |
| Arms BMD (mg/cm³) | 0,6; <0,000001 | 0,57; <0,000001 | 0,69;<0,000001 | 0,56;<0,000001 |
| Legs BMD (mg/cm³) | 0,6; <0,000001 | 0,54; <0,000001 | 0,66;<0,000001 | 0,51;<0,000001 |
| Trunk BMD (mg/cm³) | 0,56;<0,000001 | 0,51; <0,000001 | 0,56;<0,000001 | 0,48;<0,000001 |
| Ribs BMD (mg/cm³) | 0,55;<0,000001 | 0,52; <0,000001 | 0,53;<0,000001 | 0,49;<0,000001 |
| Pelvis BMD (mg/cm³) | 0,55;<0,000001 | 0,52; <0,000001 | 0,54;<0,000001 | 0,43;<0,000001 |
| Spine BMD (mg/cm³) | 0,52;<0,000001 | 0,47; <0,000001 | 0,54;<0,000001 | 0,45;<0,000001 |

all parts of the body); the most reliable relationship was between BMD of upper limbs and lean tissue mass in upper limbs ($r = 0.69$; $p < 0.0001$) (Table 7).

An inverse correlation was observed between fat mass and lean tissue; the most significant one was for lower limbs ($r = -0.46$; $p < 0.0001$).

In the studied group of long-livers, sarcopenic obesity was found in 3 (1.5%) patients, along with absolutely normal bone mineral density, and in 10 (5%) patients — along with osteopenia. Osteosarcopenic obesity (a combination of osteoporosis, sarcopenia and obesity in one patient) was found in 4 (2%) patients, and a combination of osteoporosis with obesity was found in 17 (8.7%) patients. Normal BMD values combined with the absence of sarcopenia and obesity were registered in 33 (16.5%) patients, and isolated osteoporosis (with normal fat and muscle tissue) — in 41 (20.5%) patients.

## Discussion

According to the available medical literature, our study is one of a few studies concerning body composition in long-livers [5, 6, 11]. Most other publications presented the results of studies of body composition in the elderly population and their comparison with younger individuals. It should be noted that we found no results of studying the body composition of long-livers using dual-energy X-ray absorptiometry in the available literature sources; a few studies of long-livers used a less sensitive technique of bioelectrical impedance analysis [5, 6, 11].

The results revealed a large number of overweight and obese 90-year-old patients (70%). As is known, fat mass increases with age; this fact is also obvious in the results of our work [2]. It should be emphasized that class 1 obesity was the most common, while there were no cases of class 3 obesity. Most of the examined patients had body mass index in the optimal range since, in senile age, the lowest mortality is observed in individuals with body mass index corresponding to overweight or class 1 obesity [12]. Adipose tissue is believed to have a protective effect in senile individuals, and the so-called "obesity paradox" means that the prognosis in overweight elderly patients is better than in individuals with normal or low body weight [13, 14]. Information obtained during this study supports this "obesity paradox," at least, in relation to long-livers.

In the studied group of patients, the ratio of fat mass in the trunk to the total fat mass was 0.53 in women and 0.62 in men. In other words, half of fat mass in women and more than half in men was distributed in the trunk (mainly in the abdominal area). These results confirm the well-known types of distribution of adipose tissue in men (more in the upper part, "apple-shaped") and in women (more in lower limbs, «pear-shaped»), although with aging, adipose tissue in women accumulates in the abdominal area too [15].

However, female long-livers demonstrated a higher proportion of adipose tissue; the most significant differences between women and men were in the adipose tissue of limbs. It is known that there are significant differences in women and men in the incidence of obesity, distribution of fat mass and fat metabolism [15]. Women generally have a higher proportion of adipose tissue than men, and they have more subcutaneous fat and fat in lower limbs; men are more prone to visceral fat deposition [15]. Sex hormones have a significant effect on adipose tissue. However, the level of estrogens in postmenopausal women decreases, leading to the excessive

accumulation of visceral fat in women. Postmenopausal women have a higher fat mass and its percentage than pre- and perimenopausal women. The more time passes after the start of menopause, the higher the increase in body weight, body mass index and the proportion of adipose tissue [15]. Menopause in all women in our study began at least 40 years ago.

The somewhat unexpected results of this study include a significant proportion of patients with normal bone mineral density, although a steady decrease in bone density with aging is usually observed [16]. For the clinical interpretation of these results, the following concept can be proposed: individuals with higher bone mass density are characterized by maximum life expectancy and, therefore, lower risk of fractures, while patients with severe osteoporosis die at an earlier age, primarily after femoral neck fractures. Other studies and our paper demonstrated that a decrease in bone mineral density was significantly more often observed in women [15]. It should be noted that gender differences in regard to osteoporosis persisted in patients over 95 years old. Despite their senile age, 5 out of 11 (45.5%) men over 95 had normal BMD values; this parameter in women amounted to 18.2%, which once again confirmed a greater predisposition to osteoporosis in women, even among super-long-livers.

Another unforeseen result of our study that allowed us to take a fresh look at the health status of long-livers is the relative preservation of muscle mass in the patients we observed. The musculoskeletal index stayed normal in almost three-quarters of patients, while a decrease in this index was found in 20 (33%) men and 35 (25%) women.

However, it should be noted that the total amount of lean tissue in the examined men was more than 10 kg higher than that in women (48 and 38 kg, respectively). As is known, muscle mass in men is initially higher due to the anabolic effect of testosterone, and its reduction with aging, in contrast to women, is less noticeable and more gradual [15].

In long-livers, significant relationships between bone, adipose, and lean tissues were established. There was a direct correlation between body mass index, fat mass in all parts of the body and BMD; the most reliable values were found for the correlation between BMD of ribs and fat mass in the trunk. Similar results were obtained in other studies that demonstrated a direct relationship between adipose tissue and BMD [4]. A meta-analysis with more than 20 thousand people enrolled in 44 studies revealed the most significant relationship between bone and adipose tissue in postmenopausal women of the Caucasian race (most of the patients in our study were of this type) [4].

It should be noted that all the effects of adipose tissue on the state of BMD are not fully understood; they can vary (from positive to negative) depending on fat mass and distribution — subcutaneous or visceral [2, 17]. According to some authors, an increase in body fat over 35–40% can have an adverse effect on BMD, while its smaller amount has a positive effect [18]. According to our data, no decrease in BMD, along with an increase in body fat to 40% or more, was detected, with the exception of BMD of upper limbs with an average value of 777.8 mg/cm$^3$ in obese individuals and 828.9 mg/cm$^3$ in patients with body fat less than 40% ($p = 0.03$).

In our study, as expected, a definite positive correlation was revealed between lean tissue mass and bone mineral density. This relationship between lean tissue in upper and lower limbs and BMD in the corresponding areas was more significant than the effect of fat on BMD in limbs. Similar results were obtained in other studies [4, 11]. According to a large meta-analysis by Ho-Pham L.T. et al. (2014), the effect of lean tissue on BMD is significantly greater than that of fat, especially in men as well as in pre-menopausal women [4].

This study established the expected inverse correlation between fat mass and lean tissue. With aging, fat mass increases and muscle tissue decreases, which is called sarcopenic obesity [2, 17]. However, it is not clear whether adipose tissue replaces the empty space remaining after the death of muscle fibers, or whether the number and size of muscle cells decrease due to fatty infiltration of muscle fibers [17]. Our data support the concept of substitution; it is no coincidence that the most significant negative correlation was found between the relative amount of adipose and lean tissue in lower limbs; body fat (in grams) and total fat mass (in grams), on the contrary, positively correlated with lean tissue amount. Other studies also describe the inverse relationship between fatty tissue and muscle mass; it is significant that the decrease in muscle mass was not accompanied by a corresponding change in body mass index since fat seemed to replace lost muscle tissue [19].

A typical decrease in muscle mass and bone density, along with an increase in fat mass with aging, is more often referred to as “osteosarcopenic obesity” [2, 17]. It should be noted that osteosarcopenic obesity was

found only in 4 (2%) patients enrolled in this study, and sarcopenic obesity was found in 10 (5%) participants. At the same time, 33 (16.5%) patients had normal BMD and muscle tissue with no obesity. The following could offer a possible explanation for this low incidence of osteosarcopenic obesity: our group of patients included a sufficient number (one-third) of men, and, as is known, men are less subject to a decrease in bone mineral density. Only a quarter of men had osteoporosis, and only one (1.7%) of them had both sarcopenia and obesity.

## Conclusion

- The results can help to describe the body composition in long-living persons.
- A relatively high proportion of overweight patients, but with normal BMD and lean tissue mass, was found.
- Significant correlations between bone, adipose and lean tissues were confirmed.

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All the authors contributed significantly to the study and the article, read and approved the final version of the article before publication

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