

Distribution of the Severity of Osteoporosis by Bone Molecular Density among Age Groups of Patients after Dual-Energy Absorptiometry in 2017-2022 in the Belgorod Region

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Abstract: This article is a study of the prevalence and severity of osteoporosis diagnosed using dual-energy x-ray absorptiometry. The study period is 6 years, involving patients aged 18-74 years, living in the Belgorod region and having lesions in the lumbar spine and/or hip joints. The data obtained do not contradict the global trends in the prevalence of osteoporosis. In addition, men of the younger age group and women of the older age group were more prone to osteopenia.

Keywords: osteoporosis, osteopenia, dual-energy x-ray absorptiometry, bone mineral density, Belgorod region.

Introduction. Osteoporosis is one of the most common diseases worldwide, affecting all segments and age groups of the population. There are about 200 million people in the world suffering from osteoporosis. [12] According to the Russian clinical guidelines 2021, "Osteoporosis is a metabolic disease of the skeleton, characterized by a decrease in bone mass, a violation of the microarchitectonics of bone tissue and, as a result, fractures with minimal trauma." [1]

Osteoporosis depends on many factors and is a polyetiological disease, which onset is due to such factors as genetic predisposition, hormonal drugs, human endocrine status, lifestyle, physical activity, concomitant diseases and conditions, etc. [1]

During their life cycle, bones are constantly renewed to adapt the skeleton to mechanical stress, as well as to heal fractures. Bone resorption without proper reposition by specialized cells reduces mass and causes degradation of tissue microstructure. When a clinically significant imbalance occurs, a person is diagnosed with osteoporosis, i.e., a systemic skeletal disease that causes brittle bones and a tendency to fracture.

Osteopenia is also associated with a decrease in bone mineral content but is less severe than osteoporosis. In men over 20, bone resorption predominates, and the mineral content in it decreases by about 4% per decade. In women, peak mineral content usually persists until menopause; after that, there is a decline of about 15% per decade; in this case, the trabecular bone is first affected. Osteoporosis affects all people in the 60-74 age group to varying degrees. More than a third of older women and a quarter of older men have fractures associated with brittle bones. Some people develop osteoporosis earlier due to illness, medication, or a hormone deficiency. Frequent use of glucocorticoids (recommended for inflammatory rheumatic diseases and lung diseases) doubles the risk of fractures in both sexes.

There are differences in fracture risk between men and women due not only to different areal bone molecular density (BMD), but also to different bone size, bone geometry, and bone strength. [14]

Other risk factors are age, female gender, low body mass index, previous fracture, hip fracture, smoking, recent systemic glucocorticoid use, rheumatoid arthritis, diabetes mellitus, premature menopause, alcoholism, physical inactivity, and poor diet. Fracture risk can be assessed using tools such as FRAX, a fracture risk

assessment tool that determines the likelihood that a person will experience a fracture in the next 10 years by integrating the effects of multiple risk factors. [9]

Over the past quarter century, several effective pharmacological treatments for osteoporosis have been introduced. However, only a minority of people with osteoporosis are treated and therefore resources should be directed towards identifying and treating those who are most at risk of fracture.

By origin, osteoporosis is divided into primary (due to genetic diseases and aging) and secondary (caused, for example, by taking immunosuppressants). [2]

There are two main types of osteoporosis: primary and secondary, as well as the stage of osteopenia. Primary osteoporosis is an independent disease that has no other apparent reason for the decrease in BMD. It is 95% in the structure of osteoporosis in postmenopausal women (postmenopausal osteoporosis) and 80% in the structure of osteoporosis in men over 50 years of age. In addition, primary osteoporosis includes idiopathic osteoporosis, which develops in women before menopause, in men under 50 years of age, and juvenile osteoporosis, diagnosed in children under 18 years old. Secondary osteoporosis is the result of various diseases or conditions, as well as medications, so a decrease in BMD can be caused by various reasons. Secondary osteoporosis is diagnosed in 5% of women and 20% of men.

There is a pre-osteoporotic stage, i.e., the stage of osteopenia, the so-called intermediate state of bone density between healthy bone and osteoporosis. [3]

Quite often, the very first symptom of osteoporosis is pain in the thoracic, lumbosacral or sacral spine. In addition, patients usually complain of fatigue and the need for constant rest during the day.

Osteoporosis can be asymptomatic for a long time and cause no anxiety, while it is found with fractures that appear in people with minor injuries and stress on the musculoskeletal system. Such fractures pose a serious danger due to the high likelihood of disability and death. The clinical manifestations of such fractures are always accompanied by pain, possible development of hematomas, reduced growth, and also lead to chronic health problems. Due to the aging of the population, the global impact of osteoporosis is greatly increasing, which requires serious decisions and efforts for its early diagnosis and prevention of fractures. Diagnosing osteoporosis is an urgent problem, since the prevention of low-energy fractures today is not a priority of the national health policy of our country [10] but is only aimed at identifying pathological fractures, assessing their risk, and determining bone mineral density in various population groups. [4]

The objective of the research is to analyze the results of a survey of patients of all age groups who underwent dual-energy absorptiometry at the St. Joseph Belgorod Regional Hospital over the past 6 years, determining the severity and prevalence of osteoporosis in these patients and considering their gender and age groups according to WHO classification.

Relevance. The problem of the prevalence of osteoporosis has existed for a long time and is gradually increasing. According to RKO, in Russia, among people aged 50 years and older, osteoporosis is diagnosed in 34% of women and 27% of men, and the incidence of osteopenia is 43% and 44%, respectively. The incidence of osteoporosis increases with age. Overall, about 14 million people suffer from osteoporosis, and another 20 million people have a decrease in BMD consistent with osteopenia. [1]

The social significance of osteoporosis is determined by its consequences, i.e. fractures of the vertebral bodies and bones of the peripheral skeleton, leading to large material burden for the healthcare sector and causing a high incapacity for work, including disability and mortality. The most common osteoporosis-related fractures are fractures of the proximal femur, radius, and vertebral body fractures, as well as fractures of other large bones of the skeleton (pelvis, ribs, sternum, tibia, humerus, etc.).

The average cost of 1 year of treatment of osteoporosis complicated by a fracture is 61,151 rubles, while the most expensive is the treatment of patients with a fracture of the proximal femur, and the least expensive is the treatment of patients with a fracture of the distal forearm.

Given the projected increase in life expectancy in Russia, there will be an increase in the incidence of pathological fractures in the coming years. For example, by 2035, the number of cases of fracture of the proximal femur will increase by 36% and 43% in men and women respectively. [1]

Over the past quarter century, many risk factors for bone loss (and hence fracture) have been identified and several effective pharmacological treatments for osteoporosis have been introduced. However, only a minority of people with osteoporosis are treated and therefore resources should be directed towards identifying and treating those who are most at risk of fracture. [13]

Osteoporosis affects all social strata, including families with people with osteoporosis, government agencies, and medical schools in various fields. Providing a comprehensive picture of the prevalence of osteoporosis worldwide is important for health policy makers to make appropriate decisions. [5]

Especially due to the high social and economic costs of osteoporosis, the significant treatment gap and the projected increase in the economic burden associated with population aging, the use of pharmacological interventions to prevent fractures has declined in recent years.

Patients with osteoporosis should undergo regular monitoring of the expected BMD gains using serial dual-energy x-ray absorptiometry. [6]

Thus, the high and constantly growing prevalence of osteoporosis, the significant cost of treating both the disease itself and its direct complications, i.e. fractures, pain, deformities, and loss of ability to work and self-care, determine the importance of this problem for the healthcare of the Russian Federation.

Materials and Methods. The study used the results of densitometry of patients examined in 2017-2022. Bone mineral density analysis was performed using dual-energy x-ray absorptiometry with 2005 LUNAR DXP (USA).

All densitometric results were recorded in a special study report. The analysis of the data obtained consisted in the distribution of patients by sex, followed by percentage calculation. Identification of the prevalence of the severity of osteoporosis was carried out first among all age groups in quantitative and percentage terms, and then separately for each age group to create a general information diagram. The same analysis was carried out with patients of the opposite sex.

MS Office Excel 2016 was used as the main analytical program; STATISTICA 6.0 was also used.

The patients were classified by severity of osteoporosis using one of the criteria for diagnosing M81 - "osteoporosis without a pathological fracture" in accordance with the Clinical Guidelines of the Ministry of Health of the Russian Federation for "Osteoporosis":

- Decrease in BMD by 2.5 or more standard deviations (SD) by T-score in the femoral neck and/or in the whole proximal femur and/or in the lumbar vertebrae (L1-L4, L2-L4) measured by dual-energy x-ray absorptiometry (DXA). [1]

In x-ray densitometry, two values are measured during scanning: projected body surface area (cm²) and the mineral content of the bone (g). [6]

Densitometry is considered the gold standard for measuring bone mineral density (BMD), has an extremely low radiation dose (1-10 μSv), comparable to the natural daily background radiation (7 μSv), and is intensively researched and validated around the world.

DXA systems generate X-rays at two different energy levels. Absorption of high (eg, 71 keV) and low (eg, 39 keV) energy beams by various tissues of the body allows the DMD to be quantified. Bone minerals (such as calcium) absorb more low-energy X-rays than soft tissues. Soft tissue attenuation of x-rays in boneless areas of the body is used as a baseline measurement. The bone mineral content is then estimated by subtracting the attenuation coefficient between low energy and high energy x-rays through tissue and bone from the original measurement. The system also performs an x-ray scan of the region of interest to obtain images.

BMD (g/cm²) is the ratio of the measured bone mineral content (g) and the measured bone area (cm²). For diagnostic purposes, bone density is usually reported as units of standard deviation associated with a normal probability density distribution of a homogeneous control group of Caucasian women.

Reference values for healthy people, low bone density (osteopenia) and osteoporosis, respectively:

T-index ≥ -1 , $-1 > T\text{-score} > -2.5$, T-point ≤ -2.5 . [7]

The study is performed by the staff of the department of diagnostic radiation: X-ray laboratory assistant; the analysis of the data obtained, as well as the final conclusion, is made by a radiologist. For the timely detection of a decrease in bone mineral density, the central parts of the skeleton are examined first. The most complete picture of the state of both the cortical and trabecular bone can be obtained from a simultaneous study of at least two parts of the skeleton: the spine and the proximal femur. These two areas are sufficient for the diagnosis of osteoporosis (according to the positions of ISCD 2015/2019)

It is recommended to diagnose osteoporosis and prescribe therapy if a decrease in bone mineral density is 2.5 or more standard deviations (SD) by T-score in the femoral neck, and/or in the proximal femur as a whole, and/or in the lumbar vertebrae (L1-L4, L2-L4) measured by DRA in postmenopausal women and men over 50 years). [8]

However, some patients, instead of a decrease in BMD, show an increase, especially in the spine (L1-L4), which is often associated with the development of degenerative diseases of the spine, spondylitis, scoliosis, vertebral compression fractures, aortic calcification, the consequences of surgery and other reasons. The presence of such changes in the spine reduces the sensitivity of the method in relation to this part of the skeleton, and in such cases it is necessary to focus on the measurement of BMD in the proximal femur. [11]

Results. The database for the study was the results of the review of 1765 reports of patients aged 18 to 74 years, living in the Belgorod region, who applied to the St. Joseph Regional Clinical Hospital for suspected osteoporosis of the lumbar spine and hip joint, their prevention and treatment over the past 6 years. The sample was made randomly. 73.82% of women and 26.18% of men applied for the study.

Based on the WHO age classification (Young age - 18-44; Middle age - 45-59; Old age - 60-74), gender groups were divided into younger, middle and old age groups. Thus, data on the age distribution of patients were obtained. In female patients, the highest representation was in the older age group, and the lowest – in the younger one. The shares of young, middle-aged and old women in the study were 10.9%, 32.5%, and 56.6% respectively. As mentioned above, the main period of development of osteoporosis is observed in the older age group due to menopause.

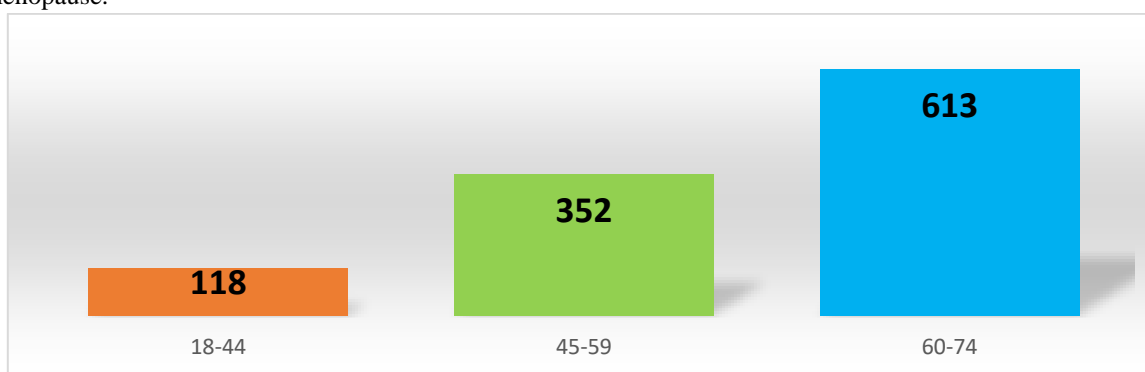


Fig. 1. Distribution by age groups of women who underwent densitometry

Among male patients, age differentiation is weakly expressed: young men - 37.2%, middle-aged men - 30.1%, old men - 32.7%. An analysis of the appeals of patients of the younger age group indicates a fairly high degree of traumatization of patients who are referred for densitometry during subsequent treatment.

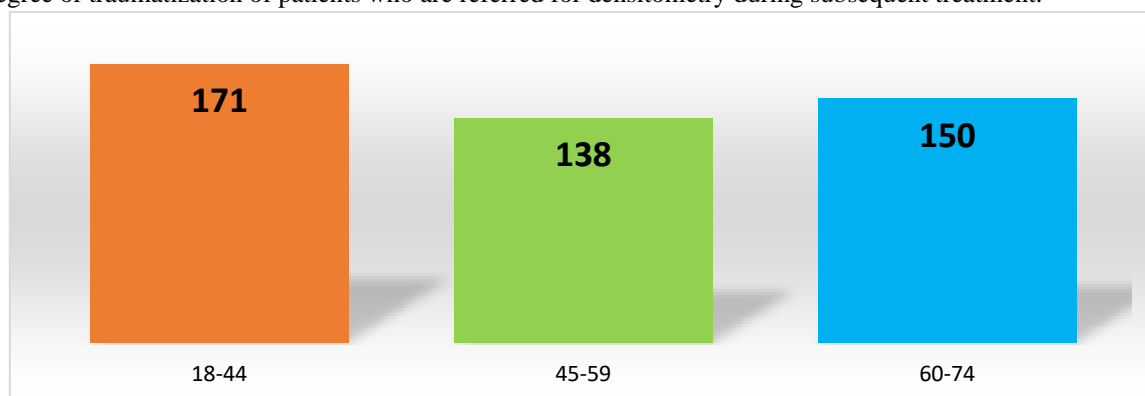


Fig. 2. Distribution by age groups of men who underwent densitometry

Further, the distribution of the results of the study by the "healthy", "osteopenia", "osteoporosis" groups was analyzed based on the criterion for determining the disease in accordance with the clinical guidelines of the Ministry of Health of the Russian Federation. During the study and analysis of the results of the densitometric study, the YA T-Score (BMD deviation degree) was considered with the distribution of values by age and sex. Based on the WHO recommendations, the norm is the T-Score greater than or equal to -1, a deviation from -1 to -2.5 is considered to be osteopenia (BMD). If the T-Score is less than or equal to -2.5, the patient is diagnosed with osteoporosis. Consistent with these data, there is generally a more severe BMD abnormality in women than

in men, with a strong bias towards osteoporosis, while in men, the T-Score indicates osteopenia in general in all age groups.

Further, the data were evaluated considering the study of the lumbar spine and hip joint. Thus, the study will show a fuller picture of the susceptibility to the disease of various parts of the skeleton of the residents of the Belgorod region.

Densitometry of the lumbar spine in age groups of male patients showed the distribution of deviations as follows: in the younger age group, there is a high degree of osteopenia, while the normal state and osteoporosis are poorly differentiated. Similarly, the distribution of T-Score occurs in the middle age group: a high degree of development of osteopenia compared to the normal state and osteoporosis. In this analytical group, an old group stands out: it has an increase in the normal state in relation to the still dominant osteopenia and mild osteoporosis.

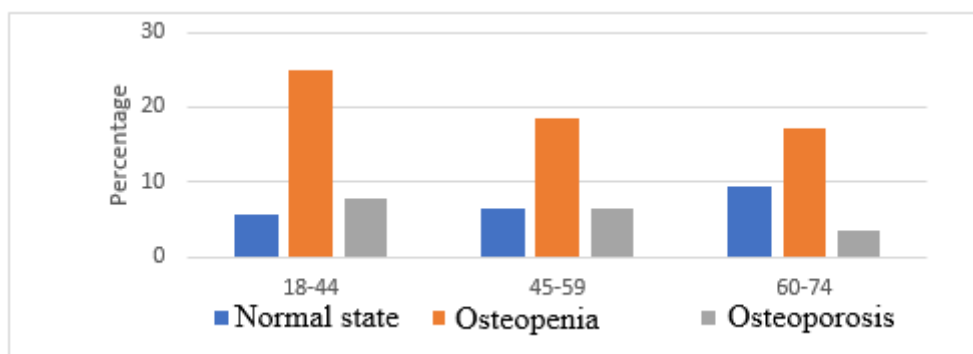


Fig. 3. Percentage of the severity of osteoporosis of the lumbar spine in men of all age groups

The results of hip densitometry in men showed that the middle-aged group is most often subjected to this type of study, however, the distribution of diagnoses from normal state to osteoporosis is poorly differentiated. In general, there are few injuries of the hip joint in men (Fig. 4). It is important that hip joint injuries were most recorded in a study of male patients of the middle age group.

Next, let us consider the results of densitometry in women.

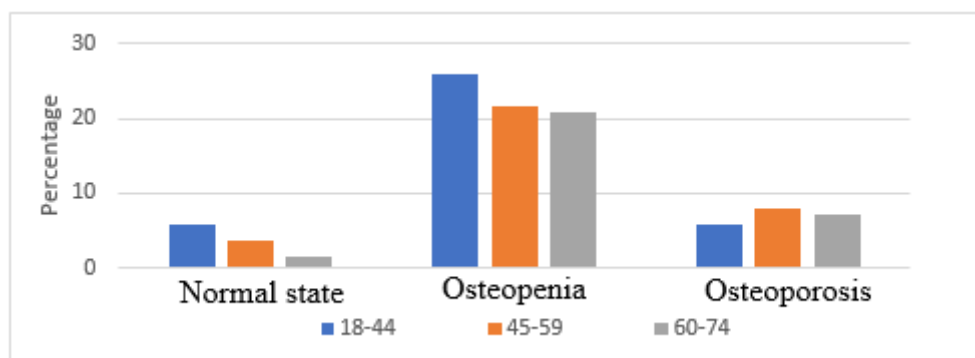


Fig. 4. Percentage of the severity of osteoporosis of the hip joint in men of all age groups

The analysis and distribution of the results of the assessment of the BMD in women proceeded in a similar way: both by age groups and by type of study - the lumbar spine or the hip joint.

The data obtained demonstrate a low prevalence of abnormalities in the younger age group, while there is a sharp increase in diagnosed osteoporosis in middle age, and a decrease in changes in the older age group. With lower values, however, with similar changes, osteopenia is also recorded in women.

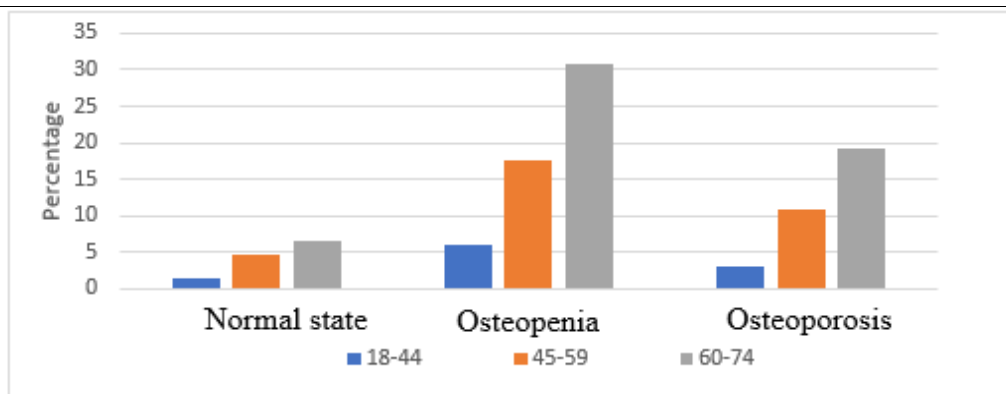


Fig. 5. Percentage of the severity of osteoporosis of the hip joint in women of all age groups

An analysis of the BMD study of the hip joint in women demonstrates even greater changes in the development of osteoporosis. The younger age group poorly represents the presence of deviations. In the middle group, there is a sharp increase in both diagnosed osteopenia and, even more significantly, osteoporosis. However, in the older age group, the severity of the disease again sharply decreases. Thus, it is obvious that women of the middle age group are most susceptible to changes in the hip joints of varying severity.

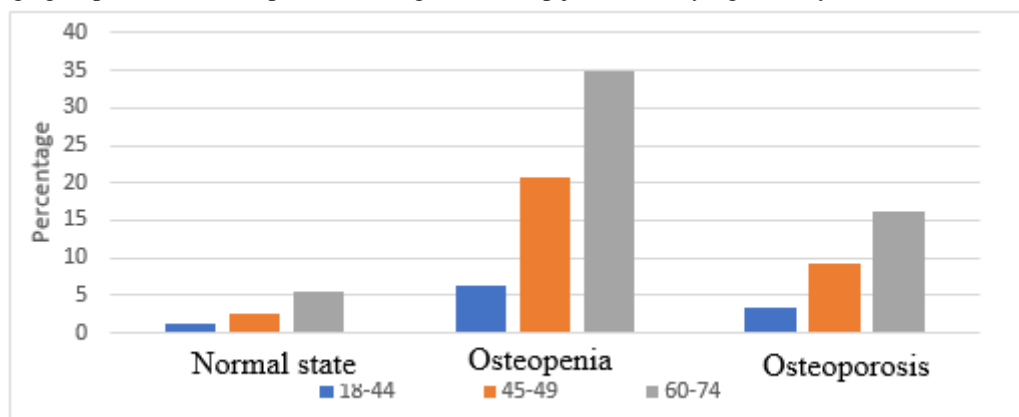


Fig. 6. Percentage of the severity of osteoporosis of the hip joint in women of all age groups

The following has been revealed as a result of the study.

In the Belgorod region, in 2017-2022, DXA were more often performed in women, mostly of older age groups, and, to a lesser extent, of middle age groups. In men, age differentiation is implicit, as well as the number of BMD studies is significantly lower than in the female group.

An analysis of data specific to male patients showed a high probability of osteopenia in all age groups when examining the lumbar region, and in the middle age group when examining the hip joint.

In female patients, there is a sharp increase in the detection of osteopenia and osteoporosis in the middle age group for both types of examination (both the lumbar spine and the hip joint). Strong changes are also found in the older age group, which, however, is compensated by a sharp increase in the number of studies.

Table 1. Summary table of the distribution of the severity of the disease (%)

	Age, years	Normal state, %	Osteopenia, %	Osteoporosis, %
men with lumbar spine lesions	18-44	14.81481	64.81481	20.37037
	45-59	20.45455	59.09091	20.45455
	60-74	30.95238	57.14286	11.90476
men with hip joint lesions	18-44	15.38462	69.23077	15.38462

	45-59	10.86957	65.21739	23.91304
	60-74	4.878049	70.73171	24.39024
women with lumbar spine lesions	age	normal state	osteopenia	osteoporosis
	18-44	13.58025	58.02469	28.39506
	45-59	13.84615	53.46154	32.69231
	60-74	11.51242	54.62754	33.86005
women with hip joint lesions	18-44	11.39241	58.22785	30.37975
	45-49	8.085106	63.82979	28.08511
	60-74	9.535452	61.85819	28.60636

Thus, the study demonstrates the urgent need for sex differentiation of guidelines for the diagnosis of osteoporosis. In addition, it should be noted that age-related differentiation of diagnostic studies is also required, since the peak values for detecting skeletal lesions are observed in the middle age group in women (which is explained by the menopause period) and in the younger age group in men. However, the reasons for this uncharacteristic distribution of diagnosis remain unknown and are subject to further research.

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