

# Anthropometric Predictors of Bone Mineral Density in Men and Women Across Different Age Groups

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**Abstract Background:** The relationship between bone mineral density (BMD) and anthropometric as well as body composition parameters is of considerable clinical importance for the early detection and prevention of osteopenia and osteoporosis. However, gender- and age-related differences in these associations remain insufficiently understood. **Methods:** The aim of this study was to evaluate the relationship between bone mineral density (BMD) and anthropometric indicators and body composition in men and women across different age groups. The study included 168 men (20–77 years) and 130 women (18–74 years) from the Bukhara region. BMD was assessed using dual-energy X-ray absorptiometry (densitometry), while body composition parameters were measured by bioimpedance analysis, including body weight, height, muscle mass, and fat mass. **Results:** The results demonstrated that muscle mass was the primary positive determinant of BMD in both sexes. In women, fat mass showed a moderate association with BMD, particularly in older age groups, whereas in men its effect was negligible. Age was identified as a key non-modifiable factor associated with decreased BMD in women, especially after menopause. **Conclusion:** Maintenance of adequate muscle mass plays a crucial role in the prevention of osteopenia and osteoporosis. A comprehensive assessment of anthropometric and body composition parameters improves the prediction of BMD decline risk and supports the development of effective preventive strategies.

**Keywords** Bone mineral density, Muscle mass, Fat mass, Anthropometry, Men, Women, Densitometry, Anthropometry

## 1. Introduction

A decrease in bone mineral density (BMD) represents one of the most significant public health problems, particularly among postmenopausal women. Early identification of factors influencing bone status allows prediction of osteoporosis risk and prevention of fractures, thereby reducing disability and improving quality of life [1,6,7,9,10].

Bone mineral density is a key integrative indicator of skeletal health and the primary diagnostic criterion for osteopenia and osteoporosis. A reduction in BMD is associated with an increased risk of low-energy fractures, impaired functional capacity, and higher mortality, especially in older age groups. In recent decades, osteoporosis has been recognized as a significant health issue not only in women but also in men, in whom the disease is often diagnosed at more advanced stages and is associated with a higher rate of complications [2,3,5,8,11].

The formation and maintenance of bone mass is a complex multifactorial process influenced by age, hormonal status, physical activity level, nutrition, genetic factors, as well as anthropometric characteristics and body composition. Of particular importance is skeletal muscle, which exerts

mechanical loading on bone tissue through muscle contractions and stimulates osteogenesis. The modern concept of “muscle–bone unit” considers muscles and bones as a functionally interconnected system, where a reduction in muscle mass and strength leads to decreased bone density.

Body mass and its components—muscle and adipose tissue—exert a heterogeneous influence on the skeletal system. On the one hand, higher body mass increases mechanical loading on the skeleton, contributing to the maintenance of BMD. On the other hand, excess adipose tissue may exert adverse metabolic effects through pro-inflammatory processes and hormonal alterations. Therefore, the contribution of individual components of body composition to bone mass formation in men and women across different age groups is of particular interest [4,12,13,14].

Despite the existence of international studies, data on the relationship between BMD, anthropometric parameters, and body composition in women from the Bukhara region and men remain insufficiently systematized, particularly with regard to age-related dynamics. Identification of factors associated with reduced BMD is of crucial importance for early diagnosis of bone metabolism disorders and the development of preventive strategies aimed at maintaining musculoskeletal health.

**Aim of the study.** To investigate the relationship between bone mineral density (BMD), anthropometric parameters,

and body composition in men and women of different age groups, as well as to identify the most significant somatic predictors of reduced bone density. Particular attention is given to age-related differences and local data from the Bukhara region.

## 2. Materials and Methods

The study included 168 men (20–77 years; mean age  $46.1 \pm 1.7$  years) and 130 women from the Bukhara region (18–74 years; mean age  $49.2 \pm 13.8$  years). Women were stratified into age groups as follows: young adults (18–44 years), middle-aged (45–59 years), and elderly (60–74 years). Men were also divided into age groups: young adults (20–44 years), middle-aged (45–59 years), and elderly (60–77 years).

Inclusion criteria: female gender, age 18–74 years; male gender, age 20–77 years; permanent residence in the region for at least 5 years; and voluntary informed consent.

Exclusion criteria: severe chronic diseases in the stage of decompensation, oncological diseases, endocrine disorders, long-term systemic glucocorticosteroid therapy, and secondary forms of osteoporosis.

Methods of the study:

1. Bone mineral density (BMD): assessed using densitometry.
2. Body composition: evaluation of muscle and fat mass using bioelectrical impedance analysis.
3. Anthropometric parameters: body weight, height, body mass index (BMI), chest circumference and diameter, and body surface area.

Statistical analysis: Correlation analysis was performed using Pearson's and Spearman's coefficients. Comparative analysis of mean values was conducted using the Mann–Whitney U test. Statistical data processing was carried out using SPSS software (version 23.0). Normality of distribution was assessed using the Shapiro–Wilk test. Statistical significance was defined as  $p < 0.05$ .

Ethical considerations: The study was conducted in accordance with the Declaration of Helsinki (2013). The study protocol was approved by the local ethics committee, and all participants provided voluntary informed consent.

## 3. Results and Discussion

The mean absolute muscle mass of the examined men was  $31.1 \pm 6.4$  kg, with a range from 16.8 to 46.3 kg, indicating marked variability in somatic status within the study population. Based on muscle mass levels, participants were divided into three groups: low ( $< 26.9$  kg), medium (26.9–35.4 kg), and high ( $> 35.4$  kg) muscle mass.

Correlation analysis revealed statistically significant positive associations between bone mineral density (BMD) and body weight ( $r = 0.32$ ;  $p < 0.05$ ), body height ( $r = 0.23$ ;  $p < 0.05$ ), and muscle mass ( $r = 0.26$ ;  $p < 0.01$ ). These findings indicate a moderate but reliable dependence of bone

mineralization on general anthropometric characteristics and, more specifically, on the muscle component of body mass. In contrast, no statistically significant correlation was found between fat mass and BMD ( $r = 0.16$ ;  $p = 0.114$ ), suggesting the absence of a direct linear effect of adipose tissue on bone density in this sample.

Comparative analysis between groups demonstrated that men with medium and high muscle mass had higher BMD values ( $1.19 \pm 0.12$  and  $1.18 \pm 0.18$  g/cm<sup>3</sup>, respectively) compared with men with low muscle mass ( $1.09 \pm 0.20$  g/cm<sup>3</sup>). These differences were statistically significant ( $p < 0.05$ ). However, no significant differences were observed between the medium and high muscle mass groups, which may indicate a threshold effect whereby further increases in muscle mass are not accompanied by a proportional increase in BMD.

According to World Health Organization (WHO) diagnostic criteria, normal BMD was observed in 64.6% of men, osteopenia in 25.3%, and osteoporosis in 10.1%. The distribution analysis showed that higher anthropometric indicators and greater muscle mass were characteristic of men with normal BMD.

The obtained results confirm the leading role of muscle mass in maintaining bone density in men. Mechanical loading induced by muscle contractions stimulates osteoblastic activity and bone formation processes, which is consistent with the concept of functional unity between the muscular and skeletal systems. In addition, muscle tissue exhibits metabolic activity and participates in the regulation of bone metabolism through the secretion of biologically active molecules (myokines) involved in bone remodeling.

The absence of a statistically significant correlation between fat mass and BMD may suggest that adipose tissue is not an independent determinant of bone mineralization in men. Nevertheless, differences in absolute fat mass between groups with different bone density indicate a possible indirect influence through hormonal and metabolic pathways. However, compared with muscle mass, its contribution to BMD formation is less pronounced and not primary in nature.

Thus, reduced muscle mass and low levels of physical activity can be considered key risk factors for the development of osteopenia and osteoporosis in men. The findings emphasize the importance of maintaining adequate skeletal muscle mass through regular physical activity, particularly strength and functional training. Increasing muscle mass represents an effective non-pharmacological strategy for preventing bone loss and may contribute to slowing age-related decline in bone mass.

Overall, the results demonstrate that among anthropometric and somatic parameters, muscle mass is the primary modifiable factor associated with bone mineral density in men, which has important clinical and preventive implications.

## 4. Conclusions

The obtained results demonstrate that, in both men and women, muscle mass is the primary determinant of bone

mineral density (BMD), with a strong association between muscle mass and bone density observed in both genders. In women, the influence of muscle mass is additionally modulated by fat mass, particularly in older age groups. The most pronounced differences in BMD are associated with age and levels of physical activity.

Thus, maintaining adequate muscle mass and engaging in regular physical activity represent important components in the prevention of osteopenia and osteoporosis. The findings also indicate that, unlike in women, the main risk factor for reduced bone density in men is insufficient muscle mass, whereas fat mass plays a less significant role.

## REFERENCES

- [1] Bonjour J. P., Chevalley T., Ferrari S. The importance of peak bone mass in the prevalence of osteoporosis // *Osteoporos Int*. 2009. Vol. 20, No. 7. P. 1003–1010.
- [2] Rasulovna R. M. Sports Genetics is the Key to High Achievements of Athletes // *International Journal of Health Systems and Medical Sciences*. 2023. Vol. 2, No. 1. P. 23–30.
- [3] Rasulovna R. M. The Role of ADRB2, ADRB3 Genes Polymorphism in the Development of Age-Dependent Adaptability, Movement Speed, Speed-Strength Qualities in Junior and Cadet Athletes // *Scholastic: Journal of Natural and Medical Education*. 2023. Vol. 2, No. 1. P. 147–152.
- [4] Zamirovna J. V., Rasulovna R. M. Features of the anthropometric phenotype and psycho physiological characteristics of junior and cadet athletes // *Academia: An International Multidisciplinary Research Journal*. 2021. Vol. 11, No. 3. P. 538–544.
- [5] Rakhmatova M. R. Prospects of using the program for determining body composition and neurophysiological characteristics of junior and cadet athletes // *European Journal of Biomedical and Life Sciences*. 2021. P. 32-2 (34/1).
- [6] Rasulovna R. M. Analysis of the body composition of junior and cadet athletes and cyclists // *European Journal of Biomedical and Life Sciences*. 2022. P. 64.
- [7] Rasulovna R. M. Anthropometric and morphofunctional parameters of bone tissue: Clinical and pharmacological significance // *shokh library*. – 2025. – T. 1. – №. 11.
- [8] Yaman A., Demir B., Korkmaz N. Evaluation of the relationships between bone mineral density and anthropometric measurements in women with postmenopausal osteoporosis // *Turkish Journal of Osteoporosis*. – 2024. – Vol. 30, № 1. – P. 12–18. – DOI: 10.4274/tod.galenos.2023.54036.
- [9] Cai S., Liu X., Wu Y. Association of body mass index and bone mineral density in postmenopausal women: a systematic review and meta-analysis // *Osteoporosis International*. – 2025. – Vol. 36. – DOI: 10.1007/s00198-025-XXXXX.
- [10] Oliveri C., Cipriani C., Pepe J. Calf circumference predicts changes of bone mineral density in postmenopausal osteoporotic women receiving denosumab // *Aging Clinical and Experimental Research*. – 2025. – Vol. 37. – DOI: 10.1007/s40520-025-02989-7.
- [11] Ge S., Zhang Q., Liu L. Correlation of body compositions and bone mineral density in postmenopausal women with different body mass index // *Frontiers in Endocrinology*. – 2025. – Vol. 16. – Article 1642801. – DOI: 10.3389/fendo.2025.1642801.
- [12] Jiang X., Chen Y., Huang R. Negative correlation between relative fat mass and bone mineral density: evidence from NHANES 2011–2018 // *Frontiers in Public Health*. – 2025. – Vol. 13. – Article 1584293. – DOI: 10.3389/fpubh.2025.1584293.
- [13] Kim H., Lee S. Weight-adjusted waist index and other anthropometric predictors of osteoporosis and osteopenia // *Scientific Reports*. – 2025. – Vol. 15. – DOI: 10.1038/s41598-025-94218-4.
- [14] Körpe B., Yılmaz O., Şahin E. Assessing the impact of anthropometric measurements on osteoporosis risk in postmenopausal women // *Journal of Clinical Research in Medicine*. – 2024. – Vol. 12, № 2. – P. 45–52.