The evaluation of bone mineral density based on nutritional status, age, and anthropometric parameters in elderly women

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***Key words**: Mini Nutritional Assessment questionnaire; assessment of nutritional status; osteoporosis; osteodensitometry; anthropometrics; bone mineral density.*

***Summary.** Objective. To examine the relationship between bone mineral density and nutritional status, age, and anthropometrical data in elderly women.*

Materials and methods. A validated international nutrition-risk-screening questionnaire, the Mini Nutritional Assessment, was used for evaluation of nutrition. The Mini Nutritional Assessment is a clinical tool consisting of four items: anthropometric assessment, global evaluation, dietetic assessment, and subjective assessment. Height and body weight were measured while the participants wore indoor clothes and no shoes; mid-arm and calf circumferences were measured with tape measure. The measurements of skinfold thickness on triceps, waist, and thigh were taken with a caliper. Bone mineral density was measured at distal radius of the nondominant forearm by dual x-ray absorptiometry.

Results. Our results indicate that anthropometric parameters (height, weight, body mass index, skinfold thickness) in elderly women with osteoporosis were the smallest. It was determined that more fats and proteins are reserved in the body, the greater the bone mineral density is. The nutritional status and age had a significant influence on bone mineral density. It was determined that women with osteoporosis had a tendency for greater malnutrition risk according to Mini Nutritional Assessment. Women with osteoporosis had worse appetites and suffered from cardiovascular diseases more often.

Conclusions. It was determined that the nutritional status of elderly women, assessed by the Mini Nutritional Assessment questionnaire, reflects bone mineral density. It was found that women's age and anthropometric data, reflecting fat reserves in the body (body mass index, skinfold thickness), are significantly related to low bone mineral density.

Introduction

Osteoporosis is a systemic skeletal disease characterized by low bone mass and deterioration of bone structure with a consequential increase in bone fragility (WHO, 1993). This disease is a very common disorder in elderly people and is reaching an epidemic proportion, because the elderly population is the most rapidly growing segment of the population. Women more than men are at risk for osteoporosis-related fractures, especially in the wrist, lumbar spine, and hips. One of five of 7.8 million elderly women with osteoporosis at age of 50 years experiences a fracture in USA. The National Osteoporosis Foundation in USA estimated that in the country, about 22 million women older than 50 years have low bone mineral density. It is predicted that in the USA this number will increase to about 26 million by the year 2010 (1).

It is determined that physiological changes, insufficient physical activity, poor health, malnutrition, addictions induce fragility of bones and bone fractures in the elderly. Numerous diet and lifestyle factors, including body weight, influence bone mineral density (BMD) and, in turn, fracture risk. Researching the causes of osteoporosis, as a multifactor disease, scientists have been working on the determination of factors that have the greatest influence on bone density. It is determined that excess body weight had a preventive effect and ability to modify the bone resorption process. It is known that when body mass index that indicates body fat and fat-free mass decreases, the risk for osteoporosis-related fracture increases. National research study on evaluating the risk of osteoporosis in the USA indicates that the possibility of developing osteoporosis is lower when

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the body mass index is higher. Obesity and being overweight in postmenopausal women can protect them from osteoporosis. It was reported that higher body mass index and bone mineral density were preventive factors (2–4).

Poor nutrition is an important risk factor that causes osteoporosis in the elderly (5–8). Nutritional status assessment and individual nutrition correction could help to reduce bone fragility and improve the quality of life (5). Methods are still being researched to assess more effectively the nutritional status of patients. Not only nutrition peculiarities, but also many different factors (socioeconomic, physiologic, acute and chronic diseases, medication use) may affect food consumption, digestion, and absorption function (9–11).

The Mini Nutritional Assessment (MNA) is a noninvasive and validated questionnaire to evaluate nutritional status in elderly people (12). The questionnaire is only validated for patients aged more than 55 years (12–16). In general, the Mini Nutritional Assessment is not frequently used for evaluation of nutritional status in people with osteoporosis (5, 6). In Lithuania, different nutrition-risk assessment tools are typically used (8, 11).

The aim of this study is to examine the relationship between bone mineral density and nutritional status, age, and anthropometrical data in elderly women.

Material and methods

The study was performed between October 2004 and April 2005. The bone mineral density of 60–80-year-old women from different regions of Lithuania was measured**.** Women could not participate if they had acute diseases (heart failure, uncontrolled hypertension, angina pectoris or myocardial infarct, renal insufficiency, psychical, hematological, oncological diseases) or if they had previously undergone transplantation.

The Mini Nutritional Assessment (MNA) questionnaire, validated and used in the medical institutions in Lithuania currently (11, 17), was utilized to assess the nutritional status of interviewed women (12, 13). The Mini Nutritional Assessment is a clinical tool consisting of four items: anthropometric assessment, global evaluation, dietetic assessment, and subjective assessment.

The questions were administered by means of face-to-face interviews. The entire interview process took about 30 minutes to complete. Questions about nutrition took approximately 10 minutes. Four questions pertained to measuring the subject's height and weight (for calculating body mass index, BMI), mid-arm circumference (MAC), and calf circumference (CC). These measurements indicate total body fat and muscle mass and help to assess the protein and calorie reserves in the body (18).

In addition, measurements of skinfold thickness (triceps, waist, and thigh) were taken with a caliper (Fat Track Digital Body Fat Caliper), pressing skin fold for 3 seconds. These measurements indicate total body fat in the body (18). Measurements were repeated three times, recording the mean of measurements. The percentage of total body fat was provided by the caliper monitor. The caliper monitor provided the total body fat percentage.

Other components of the MNA include questions on physical activity, neuropsychological problems, and intake of major food groups including meat, poultry, fish, seafood, eggs, dairy, legumes, vegetables, fruits, cereal food, dark green and red colored vegetables, and water. In addition, it also included a record of the women subjective opinion of the respondent's body fatness, overall physical condition, information on smoking habits and chronic diseases. According to the obtained score using this MNA questionnaire, patients were stratified into well-nourished (24≤ MNA points <30), at risk of malnutrition (17≤ MNA points <23.5), and undernutrition (MNA points <17) groups (12, 13).

Bone mineral density was measured at the distal radius of the nondominant forearm by dual x-ray absorptiometry (DXA) using a Lunar DPX (Lunar Corp. Model Pixi). Dual-energy x-ray absorptiometry is a safe, painless, convenient, and noninvasive technique for assessing body composition. By applying this method, fat mass, bone mineral content, and fat-free mineral mass can be evaluated. Bone mineral density of a specific bone is measured in grams per square centimeter (g/cm^2). BMD tests are performed to determine whether a patient has osteoporosis or osteopenia, a low bone mass that puts one at risk for osteoporosis. To make this determination, it is calculated using the patient's T-score. The World Health Organization (WHO) established the criteria for determining the T-score. As outlined in the WHO diagnostic categories, individuals whose T-score is within one standard deviation of the "norm" are considered to have normal bone density. Scores below the "norm" are indicated as negative numbers. A score from –1 to –2.5 SD below the norm indicates low bone mass, or osteopenia, and a score of more than –2.5 SD below the norm indicates osteoporosis (19). Patients were divided into three study groups according to T-score. There were 40 women in each group.

Statistical analysis was performed using descriptive statistics with software SPSS for Windows, version 10.0. Pearson's coefficient was used to evaluate the correlation. The significance of differences between means was assessed by Student's t-test. The correlation or difference is statistically significant, when $p<0.05$. Drawing the conclusions, when there are no statistically significant differences between the means in the groups, the alteration tendencies of these data/ quantities should be taken into account.

Results

The mean age of the 120 women was 69 years. Table 1 shows that women with osteoporosis (Group I) were older and had lower height. Triceps and waist skinfold thickness, percent body fat, and MNA score of Group I statistically significantly differed from the same parameters of Groups II and III. The body weight is statistically significantly different between Groups I and III.

Correlation analysis (Table 2) showed that BMI, skinfold thickness, and percent body fat were significantly correlated with bone mineral density. The strongest correlation was found between MNA score and T-score. A significant inverse correlation was observed between age and T-score.

There was a significant correlation ($p<0.001$) between triceps, waist, and thigh skinfold thickness and BMI ($r=0.56$; 0.56; 0.69).

The study demonstrates that poor nutrition can affect body mass. People with a low percentage of body fat may be at greater risk of developing osteoporosis (Table 3). It was determined that cardiovascular diseases (in 6.6% of cases) and pain syndrome (in 12.5% of cases) could have the most impact on the reduction of food intake. A reduction in appetite was reported in 40% of women with osteoporosis, while only 25% of women with osteopenia had the same problem.

Table 1. **Anthropometric parameters, age, and bone mineral density values distribution in three groups: osteoporosis, osteopenia, and normal bone mineral density**

Characteristic	Osteoporosis Group I. n=40	Osteopenia Group II. n=40	Normal BMD Group III. n=40
Age, years	70.45** (69.05–71.85)	68.83 (67.13–70.52)	66.68 (65.52–67.83)
Height, cm	157.83 (156.34–159.31)	161.23 (159.54–162.91)	160.30 (158.79–161.81)
Weight, kg	65.60** (61.37–69.83)	71.90 (67.88–75.92)	73.63 (69.83–77.42)
Body mass index, kg/m^2	26.25 (24.79–27.70)	27.61 (26.35–28.86)	28.69 (27.25–30.14)
Triceps skinfold thickness, mm	17.65* (16.10–19.19)	23.07 (20.42–25.72)	21.45 (19.51–23.38)
Waist skinfold thickness, mm	16.92* (14.16–19.68)	24.37 (21.68–27.07)	26.05 (23.36–28.73)
Thigh skinfold thickness, mm	22.25 (19.33–25.16)	26.50 (23.67–29.32)	27.20 (24.69–29.70)
Body fat, %	25.29* (23.29–27.29)	30.54 (28.33–32.74)	30.90 (28.96–32.84)
MNA. points	22.43* (21.42–23.44)	24.54 (23.68–25.38)	25.72 (25.01–26.43)
T-score	–3.49 (–3.76–(–3.23))	–1.87 (–2.02–(–1.71))	–0.25 (–0.5–(+1.7))
Bone mineral density, g/cm^2	0.278 (0.266–0.29)	0.384 (0.368–0.400)	0.474 (0.458–0.490)

Data are given as mean (95% confidence interval). BMD - bone mineral density; MNA - Mini Nutritional Assessment.

* - statistically significant differences between I and III groups ($p<0.05$); ** - statistically significant differences between I and II, III groups ($p<0.05$).

Table 2. **Pearson's correlation coefficients between T-score and anthropometric parameters, age, and nutritional status assessment**

Characteristic	T-score
Age	–0.40*
Body mass index	0.36*
Triceps skinfold thickness	0.29*
Waist skinfold thickness	0.44*
Thigh skinfold thickness	0.31*
Body fats	0.39*
Nutritional status assessment	0.45*

* - statistically significant correlation ($p<0.001$).

The risk of malnutrition was found in 4 (10%) women with osteoporosis. In the group with osteopenia, there was only one case. Malnutrition occurred in 23 (57.5%) women with osteoporosis, in 13 (32.5%) with osteopenia, and in 5 (12.5%) with normal bone mineral density. The number of women who were well nourished differed in the groups. Thirty-five patients in the well-nourished group had normal bone mineral density, and only 13 patients with osteoporosis had good nutritional status.

The total score was calculated by questionnaire. It showed the following results: women with osteoporosis had the mean total score of 22; these scores in the groups with osteopenia and normal BMD were 25 and 26, respectively, i.e., patients in these groups were well nourished (Table 4).

Results indicate that the evaluation scores of nutritional status significantly correlate with anthropometric parameters. Aging women are at higher risk for malnutrition (Table 5).

Study results showed that 78% of women with normal BMD and 65% with osteoporosis ate dairy foods. Women with normal BMD (65%) ate legumes and eggs more often than women with osteoporosis (12.5%). Meat, fish, poultry were eaten daily by only 25% of women with osteoporosis and even by 70% of women with normal BMD. A statistically significant correlation ($p<0.001$) was found between T-score of bone mineral density and the consumption of eggs ($r=0.47$) and meat ($r=0.29$) and fluid intake ($r=0.22$).

Discussion

Advanced aging is associated with an increased risk of under-nutrition, especially protein-energy malnutrition. There are many factors that can contribute

Table 3. **The reasons and frequencies of poor appetite**

Group	Good appetite	The reasons of poor appetite				Total
		digestion diseases	cardiovascular diseases	depression	pain syndrome	
Osteoporosis	60 (24)	7.5 (3)	10 (4)	7.5 (3)	15 (6)	40
Osteopenia	75 (30)	2.5 (1)	5 (2)	5 (2)	12.5 (5)	40
Normal BMD	80 (32)	5 (2)	5 (2)	–	10 (4)	40
Total	71.6 (86)	5 (6)	6.6 (8)	4.2 (5)	12.5 (15)	120

Table 4. **Patients' nutritional status assessment using MNA questionnaire**

Patients groups according to BMD	Well-nourished patients n (%)	Patients at risk for malnutrition n (%)	Under-nourished patients n (%)	MNA score mean (95 % CI)
Osteoporosis n=40	13 (32.5)	4 (10.0)	23 (57.5)	22 (13–28.5)
Osteopenia n=40	26 (65.0)	1 (2.5)	13 (32.5)	25 (17–29)
Normal BMD n=40	35 (87.5)	–	5 (12.5)	26 (18.5–29.5)
Total	74 (61.7)	5 (4.1)	41 (34.2)	

BMD - bone mass density; MNA - Mini Nutritional Assessment; CI - confidence interval.

Table 5. **Pearson's correlation coefficients (r) between nutritional status assessment using MNA questionnaire and patients' age and anthropometric parameters**

Parameter	MNA score
Age	–0,34*
Weight	0,45*
Height	0,37*
Body mass index	0,38*
Triceps skinfold thickness	0,32*
Waist skinfold thickness	0,28*
Thigh skinfold thickness	0,31*
Body fat	0,34*

MNA - Mini Nutritional Assessment.
* - statistically significant correlation ($p<0.001$).

to malnutrition, such as physiological disorders, physical handicaps, poor dentition, digestive disorders, use of multiple medications, social factors (2, 8–10, 20). For this reason, it is important to assess not only anthropometric parameters, but also food intake. The Mini Nutritional Assessment questionnaire, which is not frequently used at this time, was administered to patients in this study for the complex assessment of factors.

It was determined that women with osteoporosis were older and overweight, had lower height and body weight. Their BMI, skinfold thickness, body fat percentage values were lowest. Our study showed that bone mineral density was related to body mass index and triceps, waist, and thigh skinfold thickness. Women's nutritional status and age had a great influence on bone mineral density.

The data of our study are similar to the results of other studies. A. C. Tsai *et al.* (21) examined 4440 women and men aged more than 53 years. They determined that approximately 65% of males and 60% of females aged more than 53 years were of normal weight (BMI=19.1–25 kg/m^2). The proportion of overweight (BMI=25.1–30 kg/m^2) and obese (BMI>30.1 kg/m^2) individuals decreased from a high of approximately 35% in 53–60-year-old subjects to less than 20% for those subjects aged >80 years. A. Saletti *et al.* (14) evaluated the nutritional status of all individuals in assisted accommodation, *i.e.*, service flats, old people's homes, group living homes for the demented, as well as in nursing homes of three Swedish municipalities. They determined that more than half of subjects' BMI was less than 25, and approximately 30% of those subjects had BMI less than 20.

Earlier studies showed that when body mass index decreased, which indirectly indicates body fat and fat-free mass, risk for osteoporosis-related fracture increased. In addition, bone mineral density of total body, hip, lumbar spine, and wrist directly correlated with body weight and fat mass. Those persons who have a low percentage of body fat (less than 15%) may be at greater risk of developing osteoporosis than persons with higher percentages. The lower the body fat, the less dense become the bones (2–4, 6).

A. C. Tsai *et al.* (21) observed that body mass index, mid-arm circumference and calf circumference values of the elderly decreased with advanced aging, supporting the observation of earlier studies that aging is associated with a loss of fat-free mass or body muscle protein (21–24).

The results of this study show that the lower body weight and fat mass are in the hypoderm, the less the bone mineral density is. Bone mineral density of women participating in the study significantly correlated with BMI, skinfold thickness, percent body fat, and age. It could be stated that the better nutritional status assessment is, the closer BMD measurements are to the norm.

Looking for the relationship between parameters reflecting patients' nutritional status, A. Saletti *et al.* (14) found strong correlation between BMI and triceps and thigh skinfold thicknesses (r=0.4 and r=0.7, respectively). In addition, a significant correlation between total MNA score and BMI was found (r=0.52).

A strong correlation between BMI and those skinfold thicknesses (coefficients were 0.6 and 0.7) was determined in this research study. It could be stated that the results describe both findings: skinfold thickness and BMI, both of which reflect patient's percentage of fats.

Using Mini Nutritional Assessment that summarizes anthropometric, nutritional, and social aspects, it was determined that total MNA score was significantly correlated with body weight (r=0.45), BMI (r=0.38), and percentage fat mass (r=0.34). A moderate correlation was found between aging and the risk of malnutrition (r=–0.34). Anthropometric parameters (height, weight, BMI) and in addition measured skinfold thickness reflect the best the nutritional status of women.

The results of this study show that women with osteoporosis had worse appetites. It was shown that cardiovascular diseases and pain syndrome had the most impact on the reduction in food intake. Similar to previous studies, there is evidence that not only aging, but also other diseases involve risk factors which con-

tribute to disorders of nutrition (9, 11, 23). It is known that the pain syndrome caused by vascular spasms and reduction in heart minute volume can significantly worsen blood perfusion, the secretion of the digestive tract, and therefore decrease the appetite (9).

These results show that women with osteoporosis ate less fruits and vegetables (complex carbohydrates), eggs, meat, poultry, dairy (animal proteins). These foods are known to have a lot of necessary building material for bones, as well as calcium, vitamins, and minerals. Especially important nutrients in fruits and vegetables are: vitamin C, beta-carotene, potassium, magnesium, and fibers. It is determined that these nutrients have an effect on the spine and peripheral bones (hip, wrist) BMD, because they maintain blood acid-base balance and protect from acidosis. Reduced concentration of bicarbonates in the blood induces bones resorption. The vitamin C provides "potent protection" against free radicals, which disorganize bones structure (8).

It could be stated that age-related physiological changes, as well as inappropriate selection of food, poor appetite and health, diseases, and inadequate physical activity together with other risk factors could cause malnutrition and increase the risk of osteoporosis.

Conclusions

1. The nutritional status of elderly women, assessed by the Mini Nutritional Assessment questionnaire, reflects bone mineral density.
2. It was found out that women's age and anthropometric data (body mass index, skin fold thickness), reflecting fat reserves in the body, are significantly related to low bone mineral density.

Pagyvenusių moterų kaulų mineralų tankio įvertinimas remiantis mitybos būkle, amžiumi bei antropometriniais duomenimis

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Raktažodžiai: mitybos mini anketa, mitybos būklės įvertinimas, osteoporozė, osteodensitometrija, antropometrija, kaulų mineralų tankis.

Santrauka. Tyrimo tikslas. Ištirti ryšį tarp pagyvenusių moterų kaulų mineralų tankio, mitybos būklės, amžiaus bei antropometrinių duomenų.

Metodai. Kaulų mineralų tankis vertintas atliekant osteodensitometriją dvisrautės rentgenoabsorbciometrijos metodu dilbio srityje. Mitybos būklei vertinti naudota tarptautinė standartizuota mitybos mini anketa, kurią sudarė keturios dalys: antropometrinis, bendrasis, mitybos ir subjektyvus mitybos vertinimai. Atliekant antropometrinius tyrimus, matuotas moterų ūgis, svoris, žasto ir blauzdos apimtys. Žasto ir blauzdos antropometrija tiriama centimetrine juostele matuojant žasto vidurinės dalies (nedominuojančios rankos) ir blauzdos storiausios dalies apimtis. Papildomai kaliperiu buvo matuojami odos raukšlių storiai žasto nugarinio paviršiaus trigalvio raumens, pilvo klubinėje ir šlaunies vidinio paviršiaus srityse.

Rezultatai. Remiantis antropometrinių tyrimų duomenimis, nustatyta, kad tirtų pagyvenusių moterų, sergančių osteoporoze, antropometriniai duomenys: svoris, odos raukšlių storis, kūno riebalų dydžiai (apskaičiuoti procentais) buvo mažiausi. Visų tiriamųjų kaulų mineralų tankis buvo susijęs su kūno masės indeksu ir odos raukšlės storiu trigalvio raumens, pilvo bei šlaunies vidinio paviršiaus srityse. Esant mažesniam poodžio riebaliniam sluoksniui, kaulų minerališkumas taip pat mažesnis. Stiprų poveikį kaulų mineralų tankiui turėjo moterų mitybos būklė ir amžius. Naudojant mitybos mini anketą, nustatyta, jog osteoporoze sergančioms pagyvenusioms moterims yra didesnė mitybos nepakankamumo rizika. Be to, osteoporoze sergančios pagyvenusios moterys turėjo blogesnį apetitą, dažniau sirgo širdies ir kraujagyslių ligomis.

Išvados. Pagyvenusių moterų mitybos būklė, įvertinta naudojant mitybos mini anketą, atspindi kaulų mineralų tankį. Šių moterų kaulų retėjimas stipriai susijęs su amžiumi ir antropometriniais duomenimis, rodančiais riebalų atsargas organizme (kūno masės indeksu, odos raukšlių storiu).

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