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ORIGINAL ARTICLE

ASSESSMENT OF DIFFERENCES IN NUTRIENTS CONSUMPTION IN WOMEN DIAGNOSED WITH OSTEOPOROSIS AS COMPARED TO A HEALTHY CONTROL GROUP

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ABSTRACT

Background. Osteoporosis is a condition that has been much more frequent for women, which is related to menopause and to their lower bone mineral density (BMD). Inappropriate diet is among the development factors of the disease.

Objective. To assess differences in consumption of particular nutrients among women with and without osteoporosis diagnosed.

Material and Methods. The study was conducted in 2013 in a group of 100 women aged 51-70, using a questionnaire, including a 24-hour recall related to a participant's nutrients consumptions.

Results. Women suffering from osteoporosis were found to consume significantly lower amounts of fat (by 16%) and energy (by 13%), as well as vitamins: A (by 16%), E (by 20%), B_6 (by 20%), niacin (by 16%) and C (by 19%). Differences in the consumption of minerals have been observed in the cases of calcium, phosphorus, sodium and potassium. The women with osteoporosis were fund to consume lower amounts of those elements, by 14%, 13%, 21% and 19% respectively. On the average, participants of the study in both groups consumed amounts of calcium at a half of the recommended level, and substantially exceeded the recommended values of phosphorus, as well as displaying an inappropriate calcium to phosphorus ratio (0.5:1). As little as 8% of the participants with osteoporosis declared a considerable change in their diet, with increased consumption of dairy products.

Conclusion. The observed nutrition deficiencies in osteoporosis patients may be conducive to a worsened condition, and may lead to an onset of the disease in participants from the control group.

Key words: *consumption, nutrients, osteoporosis, women*

STRESZCZENIE

Wprowadzenie. Osteoporoza to choroba znacznie częściej występująca wśród kobiet, co związane jest z menopauzą i mniejszą szczytową masą kostną. Nieprawidłowy sposób żywienia jest jednym z czynników warunkujących powstawanie choroby.

Cel badań. Oszacowanie różnic w spożyciu składników pokarmowych wśród kobiet z osteoporozą i bez jej zdiagnozowania.

Materiał i metody. Badanie zostało przeprowadzone w 2013 roku, wśród 100 kobiet, w wieku 51-70 lat metodą ankietową, w tym metodą 24-godzinnego wywiadu żywieniowego.

Wyniki. Kobiety z osteoporozą spożywały istotnie mniejsze ilości tłuszczu (o 16%) oraz energii (o 13%), a także witamin: A (o 16%), E (o 20%), B_6 (o 20%), PP (o 16%), C (o 19%). Różnice w spożyciu składników mineralnych zaobserwowano w przypadku wapnia, fosforu, sodu oraz potasu. Kobiety z osteoporozą spożywały mniejsze ilości tych związków odpowiednio o 14%, 13%, 21% i 19%. Osoby badane z obu grup spożywały średnio 2-krotnie zbyt małe ilości wapnia, a znacząco zbyt duże ilości fosforu oraz charakteryzowały się nieprawidłowym stosunkiem wapnia do fosforu (0,5:1). Zaledwie 8% badanych z osteoporozą deklarowało zmianę sposobu żywienia po zdiagnozowaniu schorzenia zwiększając w diecie ilość produktów mlecznych.

Wniosek. Odnotowane nieprawidłowości spożycia mogą w przypadku osób z osteoporozą sprzyjać pogłębianiu schorzenia, a u osób z grupy kontrolnej stać się jego przyczyną.

Słowa kluczowe: *spożycie, składniki pokarmowe, osteoporoza, kobiety*

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INTRODUCTION

The World Health Organisation has defined osteoporosis as a systematic disease of the skeleton, characterised by low bone density levels, and by deficient micro-structure of the bone tissue, leading to increased bone fragility and to occurrence fractures [9].

While osteoporosis is found in both men and women, the latter display a considerably higher risk of osteoporosis-related fractures [7, 29]. The probability of injury with women of Caucasian race aged 50+ amounts to 32% for spinal fractures, 16–17.5% for proximal femoral fractures and 15% for fractures of the forearm. In contrast, the likelihood of proximal femoral fracture in male patients of similar age only amounts to 6% [3]. Other studies indicate that in the 50+ age group a fracture is reported in 30% of women and 8% of men. With a 50-year old woman a life risk of a fracture is 40%, while the corresponding ratio for a man is only 13% [26].

The risk factors for osteoporosis-related fractures include age, gender and ethnic group (osteoporosis is more frequent in people with a fair complexion), but also others, such as the hormonal status, genetic factors and family conditions, as well as specifically a thin body build (underweight), numerous earlier fractures and an insufficient level of physical activity [2, 4, 9, 16, 29, 31]. The risk of osteoporosis may also be heightened by tobacco smoking and by excessive alcohol consumption. Nutritional factors represent an important component in preventive treatment of osteoporosis. Appropriate intake of calcium, vitamin D, phosphorus, sodium and proteins may well decrease the risk of osteoporosis [2, 9, 11, 16, 31].

It has been observed that a certain number of women at perimenopausal age are afraid of a substantial body mass increase and try to reduce it spontaneously, to prevent themselves from becoming overweight or obese. The actions of these women are often in disagreement with rationalistic nutrition principles. Inappropriate dietary habits in the menopausal period may lead to deficits of many important nutrients in that period, may potentially accelerate the aging processes and raise the risk of many diseases, including osteoporosis [2, 19]. The study aimed to assess the differences in consumption of nutritional components in osteoporosis patients against a reference group without osteoporosis, based on purpose-built nutrition interviews.

MATERIAL AND METHODS

The study was conducted in winter/spring of 2013, using a purpose-built questionnaire, in 50 women patients of an osteoporosis treatment centre in Warsaw, diagnosed with osteoporosis, and a control group of 50 women from the Masovian district. All the participants were at age of 51-70 years. Participants in the study gave signed consent.

The questionnaire contained two parts. The first part (demographic summary) comprised the questions related to the participant's age, place of dwelling, level of education, body height and weight, physical activity, use of tobacco and to any changes that took place in the participant's nutrition after osteoporosis was diagnosed. Based on the data on body height and weight, the Body Mass Index (BMI) was calculated for each of the participants [20]. The second part of the questionnaire registered all the meals, dishes, products and drinks (in domestic or weight-based measures) that were consumed by the participant. Consumption was assessed using the method of a 24-hour recall. 24-hours interview was conducted to determine the nutrition irregularities and the diet during that day was typical for each of the subject To specify actual portions of food consumed, a photographic album of products and dishes was used [24]. Using a special 'Żywienie' (*Nutrition*) program, based on food composition tables [15], consumption of energy was assessed for the obtained data, as well as of main nutrients, selected vitamins and minerals. The values obtained were subsequently adjusted for technological and plate losses [27]. The results for intake of energy and major nutrients were presented in the context of current recommended values for age, level of physical activity and proper body mass of participants or in the case of vitamins and minerals were compared to EAR/AI values [10]. Intake of vitamin D from the diet was not estimated in the presented study. Skin synthesis is evolutionarily source of vitamin D and 90% of vitamin D in the body is the endogenous origin [10].

A *Chi*-square test was used for statistical development of the data in order to compare the sample distributions**.** Normality of the distribution was checked using the *Shapiro-Wilk* test. Parametric variables failing to meet the assumptions necessary for the ANOVA test were subject to the U *Mann-Whitney* test using the Statistica ver.10 software. The significance level of α=0,05 was assumed for all calculations.

RESULTS

The study participants in the osteoporosis group and the reference group did not display significant differences in terms of age, place of dwelling, physical activity levels and frequency of tobacco smoking (Table 1). The Body Mass Index (BMI) of participants was within the bracket of 20.4 – 30.9. Among the women with osteoporosis, appropriate body mass was represented by 68% of the group, corresponding to 35% in the control group (statistically significant difference). The remaining participants were overweight. None of the participants was underweight. Among the osteoporosis patients, 80% of participants declared secondary or higher education, corresponding to only 54% in the reference group (statistically significant difference). Education was not found to affect the levels of participants' physical activity.

The majority of the osteoporosis group (80%) declared that they did not change, or only slightly changed,

nutritional habits after being diagnosed with the disease. As little as 8% of the participants from that group hale significantly changed their diet, declaring increased share of dairy products. 12% of the group's respondents were unable to assess the change in their nutritional habits.

Table 1. Characteristics of the study population

Factor	Total n=100	Osteoporotic group n=50	Control group n=50	p***
Age (years)	60±6.0* 51-70**	60±6.0 51-70	61±6.1 51-70	ns
Place of dwelling				
village	24%	8 (16%)	16 (32%)	ns
town	25%	9 (18%)	16 (32%)	
city	51%	33 (66%)	18 (36%)	
Level of education				
primary	7%	1 (2%)	6 (12%)	0.010****
vocational	26%	9 (18%)	17 (34%)	
collage	45%	27 (54%)	18 (36%)	
high	22%	13 (26%)	9 (18%)	
BMI (kg/m^2)	24.7±2.0* 20.4-30.9**	24.7±1.7 20.4-27.8	25.4±2.1 21.1-30.9	0.001****
18,5-24,9	52%	34 (68%)	18 (35%)	
>25	48%	16 (32%)	32 (65%)	
Physical activity				
sedentary	65%	32 (64%)	33 (66%)	ns
moderate	32%	15 (30%)	17 (34%)	
high	3%	3 (6%)	0 (0%)	
Smoking status				
never	46%	27 (54%)	19 (38%)	ns
ex-smoker	30%	13 (26%)	17 (34%)	
current	24%	10 (20%)	14 (28%)	

* - mean ± standard deviation, ** - range, *** - p-value for *Chi*-square test (for age and BMI p-value is the result of U-*Mann-Whitney* test), **** - differences statistically significant ($p \leq 0.05$); ns - values are not statistically different ($p > 0.05$).

Among the participants, important differences were found in terms of consumption of fat and overall energy (Table 2). The women from the control group consumed considerably more fat (by 19%), which influenced a higher overall energy intake (by 16%). No substantial differences were registered in the consumption of proteins, carbohydrates, cholesterol and fibre between the groups, although the patients suffering from osteoporosis tended to consume lower amounts of these components – by 10% (proteins, cholesterol) to 20% (fibre).

In the area of selected vitamins, considerable differences of consumption were displayed among the groups studied (Table 3). Participants in the reference group consumed substantially more of vitamin A (by 19%), vitamin E (by 26%), vitamin B_6 (by 25%), niacin (by 18%) and vitamin C (by 24%), compared to the participants with diagnosed osteoporosis. No differences were observed in the consumption of vitamins B_1 and B_2.

In terms of selected minerals, no difference was observed in the consumption of magnesium and iron. Calcium consumption was deficient in both groups, although it was significantly higher in the reference group (by 17%). Other minerals were also consumed in considerably higher amounts by the controls, including a higher intake of phosphorus (by 15%), sodium (by 27%) and potassium (by 24%).

DISCUSSION

The menopausal period, i.e. the age bracket of approximately 40-50, causes a range of changes in a woman's body. First of all, starting before the menopause, the oestrogens production decreases. The lowered concentration of oestrogens, hormone that stimulate ossification (bone building) and inhibit bone resorption, leads to weaker absorption of calcium in

the digestive tract which causes bone mass loss in perimenopausal and postmenopausal women [19, 31]. Calcium absorption after the 50th year of life remains stable for the following period of approximately 25 years. After the 75. year of life the absorption of calcium falls significantly, by an average of approx. 30% [17]. Moreover, with age, the cutaneous synthesis of vitamin D decreases, and the creation of its active metabolite in kidneys is retarded. The menopausal process leads to a reduced number of vitamin D receptors in target organs. This phenomenon additionally decreases the calcium absorption from the digestive tract. Therefore, the deficit of vitamin D increases the susceptibility to fractures and osteomalacia and affects the development of osteoporosis. In addition, it causes the weakening of the lower limb muscles, decreases the grip strength and leads to a generally lower functional capacity [4, 5, 19, 31]. As a result of these combined processes, just after the menopause one can observe the fastest decrease in the BMD, i.e. bone loss of between 3% and 5% per annum, even though the process slows down significantly in the 65+ age group [1].

The postmenopausal period is also the age of declining professional activity. That is an indirect factor contributing to the decreasing bone density as a result of lower physical activity levels. Physical fitness and general functional capacity of women decreases, while the risk of falls increases, leading to potential osteoporotic fractures [2, 4, 9].

Table 2. Intake of energy and major nutrients by the test group of women

Ingredient	Recommended intake for the group	Total n=100	Osteoporotic group n=50	Control group n=50	p****
Energy (kcal/day)	1890	1743 ± 271* 920 – 2574** 1707***	1617 ± 241 920 – 2303 1585	1869 ± 250 1274 – 2574 1906	0.001*****
Protein (g/day)	33-58	60.5 ± 14.0 30.2 – 107.4 61.5	57.2 ± 15.0 30.2 – 107.4 56.7	63.8 ± 12.6 34.8 – 85.0 63.1	ns
Fat (g/day)	70	68.9 ± 19.9 21.4 – 120.0 68.6	62.9 ± 19.2 21.4 – 103.5 63.6	74.8 ± 19.8 31.5 – 120.0 72.3	0.003*****
Cholesterol (mg/day)	300	303.5 ± 146.3 72.4 – 862.8 266.9	287.9 ± 151.2 81.3 – 862.8 264.8	319.0 ± 140.8 72.4 – 662.1 285.3	ns
Carbohydrates (g/day)	>130	234.9 ± 43.4 124.0 – 327.6 234.6	218.4 ± 41.1 124.0 – 327.6 222.4	251.3 ± 39.4 176.3 – 326.4 251.1	ns
Dietary fibre (g/day)	23	16.0 ± 4.8 5.5 – 28.1 15.4	14.2 ± 4.5 5.5 – 25.8 13.8	17.7 ± 4.3 8.0 – 28.0 16.6	ns

* - mean ± standard deviation, ** - range, *** - median, **** - p-value for the U-*Mann-Whitney* test,

***** - differences statistically significant ($p<0.05$), ns - values are not statistically different ($p>0.05$).

A person's diet plays an important role in osteoporosis prevention, and calcium consumption is among the most important factors. Appropriate consumption of calcium may decrease the risk of osteoporosis significantly [2, 12, 28]. Calcium is found in almost all food products, but its bioavailability from particular products varies considerably, depending on the consumption levels of proteins, minerals (i.e. phosphorus, magnesium, iron, zinc and nutritional fibre), as well as on the presence of the oxalic acid and phytates, as the latter substances, if consumed excessively, disturb the absorption of calcium, while vitamin D and lactose increase the calcium absorption from food products. The ratio of calcium to phosphorus intake is an important part of a nutritional assessment, as excessive supply of phosphorus with a simultaneous deficit of lactose or of vitamin D may inhibit the calcium absorption in the digestive tract. The Ca:P ratio in the diet of postmenopausal women should be as high as 1.3:1 [5]. Maintaining the equimolar Ca:P proportion, favourable for the body, is difficult due to the very common presence of phosphorus in food products. The phosphorus content tends to be increasing, mainly due to the use of additives that are introduced to food products in the technological process [14].

The reduction of bone density is also facilitated by excessive supply of proteins in the early period of life. With consumption of 1 g of protein, the body

releases 1 mg of calcium in urine [5]. Proteins lead to acidification of human urine, whereas calcium plays an indispensable role as a buffering substance. Additionally, a diet high in sodium is also conducive to the loss of calcium in urine. Consuming 1 g of sodium causes the body to release 26 mg of calcium with urine [18]. Animal origin products include low amounts of calcium (except for milk and dairy products), and it is usually in the form that is not easily available in digestion. Additionally, these products often are rich in phosphorus – processed meats are an example. An excessive intake of alcohol and caffeine is also likely to cause increased excretion of calcium in urine [22].

Some plants and related products, such as grain legumes (soya, broad beans), nuts (sunflower seeds, sesame seeds, hazelnuts) or curly kale, include relatively high content of calcium, both in absolute values (mg of calcium per 100 g of the product) and relative to energy content (per 100 kcal). However, the calcium absorption level from plant products is only between 5 and 15%. That is related to a high ratio of fibre, as well as of oxalates, in some plant products, which considerably limits their value as a source of calcium [23].

Table 3**.** Intake of vitamins and minerals by the test group of women

Ingredient	Recommended intake	Total n=100	Osteoporotic group n=50	Control group n=50	p****
Vitamin A (µg retinol eq./day)	500	757.0 ± 467.0* 178.8– 2438** 610.1***	689.8 ± 407.4 192.9 – 2099.9 596.8	824.2 ± 542.0 178.8 – 2438.0 616.1	0.03*****
Vitamin E (mg α-tokopherol eq./ day)	8	10.6 ± 4.5 3.0 – 31.4 9.8	9.4 ± 4.3 3.0 – 25.9 8.6	11.8 ± 5.3 3.1 – 31.4 10.2	0.02*****
Vitamin B_1 (mg/day)	0.9	0.9 ± 0.3 0.4 – 1.7 0.9	0.9 ± 0.3 0.4– 1.7 0.8	1.0 ± 0.2 0.7 – 1.6 1.0	ns
Vitamin B_2 (mg/day)	0.9	1.3 ± 0.34 0.6 – 2.3 1.31	1.3 ± 0.3 0.6 – 2.2 1.24	1.4 ± 0.3 0.7 – 2.3 1.4	ns
VitaminB_6 (mg/day)	1.3	1.8 ± 0.6 0.7 – 3.4 1.7	1.6 ± 0.6 0.7 – 2.7 1.6	2.0 ± 0.6 1.0 – 3.4 1.9	0.03*****
Vitamin PP (mg/day)	11	14.2 ± 5.7 3.6 – 28.6 13.4	13.0 ± 5.8 3.6 – 25.5 12.8	15.4 ± 5.5 5.3 – 28.6 14.9	0.04*****
Vitamin C (mg/day)	60	45.7 ± 25.6 3.5 – 140.0 43.5	40.8 ± 26.0 3.5 – 98.8 40.3	50.6 ± 25.5 11.0 – 140.0 47.6	0.03*****
Calcium (mg/day)	1000	546.5 ± 198.3 177.0 – 1114.9 516.8	504.4 ± 175.3 177.0 – 1055.2 485.1	588.6 ± 196.6 228.3 – 1115.0 591.5	0.01*****
Phosphorus (mg/day)	580	1123 ± 264 555 – 1878 1120	1047 ± 257 555 – 1878 1055	1200 ± 241 730 – 1710 1190	0.003*****
Ca:P	1:1	0.5:1	0.5:1	0.5:1	ns
Magnesium (mg/day)	265	269.1 ± 70.6 122.2 – 439.2 259.8	244.4 ± 68.4 122.2 – 377.7 230.6	293.8 ± 63.1 189.9 – 439.2 285.9	ns
Sodium (mg/day)	1370	1891 ± 716 687 – 4182 1764	1665 ± 637 687 – 4103 1661	2117 ± 710 820.5 – 4182 2026	0.004*****
Potassium (mg/day)	4700	2899 ± 794 1203 – 4743 2766	2589 ± 723 1203 – 4225 2580	3209 ± 763 1564 – 4743 3069	0.003*****
Iron (mg/day)	6	9.4 ± 2.5 3.4 – 16.4 9.3	8.5 ± 2.2 3.4 – 13.4 8.3	10.2 ± 2.4 5.4 – 16.4 9.8	ns

* - mean ± standard deviation, ** - range, *** - median, **** - p-value for the U-*Mann-Whitney* test,

***** - differences statistically significant ($p<0.05$), ns - values are not statistically different ($p>0.05$).

The most valuable sources of calcium are milk and dairy products. Drinking milk contains an average of 120 mg of calcium in 100 g. A similar level of calcium is found in processed dairy products (yoghurts, kephir). Calcium-rich sources also include cheese spreads and rennet cheeses [15], however, while trying to achieve a calcium-rich diet one should choose products with a possibly high ratio of calcium to energy value. Women with lactose intolerance often limit their consumption of dairy products, thus making their diet calcium-deficient. Lack or a low level of lactose in their diet usually leads to a much poorer use of calcium, by as much as 50%. In case of restricted consumption of dairy products, alternative sources of calcium are recommended. These can for instance include processed foods based on soya, whey, buttermilk and products containing casein hydrolysates [21].

Metabolism of bone tissue also requires a diet with an adequate supply of vitamins, including vitamin A, C and K [30]. Along with a lower level of energy in diet, these vitamins were also restricted in the diet of the osteoporosis group. Participants from the group under study reported mainly – which can be grounds for concern – significantly deficient levels of calcium consumption (relevant difference against the control group), and excessive level of phosphorus consumption, with an erroneous ratio between the two. This, coupled with a diet high in sodium and low in potassium, may contribute to a further aggravation of osteoporosis. Similar erratic consumption patterns have also been reported in studies by other authors conducted in groups of female osteoporosis patients [6, 8, 12, 13, 18, 25, 28], as well as in the control group. The latter finding points to a possible future development of osteoporosis in some participants from the control group, particularly those with a lower or deficient body mass (in the adipose tissue adrenal androgens are converted to oestrogens) [9] and with lower bone density.

CONCLUSIONS

1. 8% of the study participants with diagnosed osteoporosis declared significant changes in their diet, with more dairy products introduced. Women with osteoporosis consumed lower levels of fat and energy, which affected a lower intake of vitamins (A, E, B_6, niacin, C) and minerals, including calcium and potassium.
2. Study participants in both groups (diagnosed with osteoporosis and a control) consumed insufficient amounts of calcium, while their diet was excessively rich in phosphorus. The erratic consumption patterns may lead to a worsened condition in osteoporosis group, and may cause the condition in the control group.

Conflict of interest

The authors declare no conflict of interest.

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