

## ANALYSIS OF THE DIETARY FACTORS CONTRIBUTING TO THE FUTURE OSTEOPOROSIS RISK IN YOUNG POLISH WOMEN

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### ABSTRACT

**Background.** The osteoporosis is becoming serious problem for the preventive healthcare, that is stated for Poland and western countries. The loss of bone mass in women may be even five times higher than in men, so in the osteoporosis preventive strategies, young women are indicated as best potential target group.

**Objective.** The aim of the study was to analyze the osteoporosis risk, on the basis of diet assessment in young Polish women, while satisfying nutritional needs for bone health-related nutrients was taken into account.

**Material and Methods.** The study was conducted in the group of 75 women, aged 20-30, who prepared three-day dietary record (14% of underweight, 15% of excessive body mass individuals). The intakes of nutrients being associated directly with risk of osteoporosis (protein, potassium, calcium, magnesium, vitamin D, vitamin B6, folates, vitamin B12, vitamin C) were analysed.

**Results.** The vast majority (89%) of individuals was characterized by lower declared energy intake than calculated requirement. The majority was characterized by inadequate intake of potassium, calcium, magnesium, vitamin D and folates. Only 25% was characterized by an adequate intake of calcium and, while supplementation was taken into account, 10% was characterized by an adequate intake of vitamin D.

**Conclusions.** Following diets declared by the analysed young women may be the factor increasing seriously the risk of osteoporosis, as well as the risk of other diet-related diseases. The low intake of majority of analysed nutrients in the analysed group may result mainly from low energy value of declared diets. Taking into account the proper BMI of the majority of analysed group of young women and low energy value of their declared diets, the common underreporting may be supposed, and it may contribute to osteoporosis risk overestimation.

**Key words:** *osteoporosis, young women, calcium, vitamin D, nutrients, underreporting*

### STRESZCZENIE

**Wprowadzenie.** Osteoporoza staje się obecnie, zarówno w Polsce, jak i innych krajach rozwiniętych, coraz poważniejszym problemem, który należy rozwiązywać, podejmując odpowiednie działania profilaktyczne. Utrata masy kostnej u kobiet może być nawet pięciokrotnie większa, niż u mężczyzn, stąd dla strategii w dietoprofilaktyce osteoporozy wskazuje się młode kobiety jako najlepszą potencjalną grupę docelową.

**Cel badań.** Celem badania była analiza ryzyka osteoporozy, w oparciu o ocenę diety młodych kobiet z Polski, w której uwzględniono ocenę pokrycia zapotrzebowania na składniki odżywcze niezbędne dla prawidłowego funkcjonowania kości.

**Materiał i metody.** Badanie przeprowadzono w grupie 75 kobiet w wieku 20-30 lat, które wykonały 3-dniowe bieżące notowanie spożycia (14% kobiet niedożywionych, 15% – z nadmierną masą ciała). Analizowano spożycie składników odżywczych bezpośrednio związanych z ryzykiem osteoporozy (białko, potas, wapń, magnez, witamina D, witamina B6, foliany, witamina B12, witamina C).

**Wyniki.** W przypadku zdecydowanej większości badanych kobiet (89%) stwierdzono niższą wartość energetyczną deklarowanej diety niż ich wyliczone zapotrzebowanie energetyczne. Większość z nich charakteryzowała się niedostatecznym spożyciem potasu, wapnia, magnezu, witaminy D i folianów. Zaledwie 25% miało zalecaną podaż wapnia i, po uwzględnieniu stosowanej suplementacji, 10% – witaminy D.

**Wnioski.** Stosowanie diet deklarowanych przez badane młode kobiety może być czynnikiem istotnie zwiększającym ryzyko osteoporozy, jak również ryzyko innych chorób dietozależnych. Niskie spożycie większości ocenianych składników odżywczych mogło w badanej grupie wynikać głównie z niskiej wartości energetycznej deklarowanych diet. Uwzględniając prawidłowe BMI większości młodych kobiet z badanej grupy i niską wartość energetyczną deklarowanych przez nie diet, można podejrzewać w tej grupie powszechne niedoszacowanie spożycia, co przyczyniać się może do przeszacowania faktycznego ryzyka rozwoju osteoporozy.

**Słowa kluczowe:** *osteoporoza, młode kobiety, wapń, witamina D, składniki odżywcze, niedoszacowanie spożycia*

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## INTRODUCTION

Due to increasing life expectancy, the osteoporosis is becoming and will still be more and more serious problem for the preventive healthcare, that is stated both for Poland [11] and western countries [20]. According to the World Health Organization (WHO), the frequency of osteoporosis contribute to indicating it as a one of the most alarming health-related conditions [45]. According to *Czerwinski et al.* [13], the hip fracture osteoporosis frequency in Poland, in case of female inhabitants aged over 50 years, is 165 incidents per 100 000 individuals a year, while in case of inhabitants aged over 85 years – 1138 incidents per 100 000 women a year and 666 incidents per 100 000 men a year.

Moreover, the consequences of osteoporosis, including increased fractures incidence, health care use, disability and mortality, are also severe [12]. It was estimated, that in Europe each 30 seconds one osteoporotic fracture takes place [34] and the number of them will increase at least until 2050 year, when number of osteoporotic fractures will double [24]. As a consequence, it is stated, that osteoporosis prevention is essential [5].

In spite of the fact, that consequences of osteoporosis in men and women are similar, the incidence of osteoporosis in female is higher than in case of male individuals, due to estrogen-deficient bone loss [7]. As a result, the loss of bone mass in women may be even five times higher than in case of men [38]. To overcome the problem, in the osteoporosis preventive strategies, young women are indicated as the best potential target group [21, 37].

The aim of the study was to analyze the osteoporosis risk, on the basis of diet assessment in young Polish women, while satisfying nutritional needs for bone health-related nutrients was taken into account.

## MATERIAL AND METHODS

The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Ethic Committee of the Regional Medical Chamber in Warsaw, Poland (No 4/08; 7.02.2008).

The invitation to participate in the study, as well as information about inclusion criteria were distributed via social media. Inclusion criteria were: women, aged 20-30, not being on any special diet and not being during body mass reduction, not being pregnant and during lactation, without any chronic diseases diagnosed, living in Warsaw. The number of 75 individuals meeting the inclusion criteria volunteered to participate in the study.

The study was conducted during the period of 3 months – since September to November 2014. During mentioned period, participants were asked to conduct three-day dietary record based on the self-reported data. The basis of the analysis was record conducted in three typical random not following days (2 weekdays and 1 weekend day). The dietary record was conducted on the basis of widely accepted and applied rules [18]. To provide the reliable estimates of food intake, participants were instructed about the principles of doing dietary record, as well as about the necessity of accurate and scrupulous recording of all food products consumed and beverages drunk, while the serving sizes were verified using the Polish “Atlas of food products and dishes portion sizes” [41]. The energy and nutritional value of diets were assessed using the Polish dietician software “Dietetyk 2” and the Polish base of the nutritional value of the products [23]. The participants were asked also additional question about applied supplementation.

The nutrients that are especially important in preventing osteoporosis were chosen to be analyzed. The nutrients associated directly with risk of osteoporosis (protein, potassium, calcium, magnesium, vitamin D, vitamin B<sub>6</sub>, folates, vitamin B<sub>12</sub>, vitamin C) were chosen on the basis of the review of literature associated with osteoporosis prevention [43]. The total contents of mentioned nutrients in diets were compared with the recommendations for healthy women on the Estimated Average Requirement (EAR) / Adequate Intake (AI) level (Table 1) [19].

Table 1. Recommendations for nutrients intake for analysed group of young women [19]

	Recommended intake
Total protein [g/kg of ideal body mass]	0,73 <sup>1</sup>
Potassium [mg]	4700 <sup>2</sup>
Calcium [mg]	800 <sup>1</sup>
Magnesium [mg]	255 <sup>1</sup>
Vitamin D [µg]	10 <sup>1</sup>
Vitamin B <sub>6</sub> [mg]	1,1 <sup>1</sup>
Folate [µg]	320 <sup>1</sup>
Vitamin B <sub>12</sub> [µg]	2,0 <sup>1</sup>
Vitamin C [mg]	60 <sup>1</sup>

<sup>1</sup> EAR level, <sup>2</sup> AI level

The obtained data are presented as means ± standard deviations (SD) with minimum, maximum and median values. The normality of distribution was verified using the Shapiro-Wilk test. The Spearman's rank correlation was applied in the analysis of correlation between energy value of diet and intake of minerals and vitamins. The level of significance  $p \leq 0.05$  was accepted. The statistical analysis was carried out using the Statistica software version 8.0 (StatSoft Inc).

## RESULTS

The recruited female individuals were aged 20-30 (24,1 ± 3,4 ages), while the mean height was 167,8 ± 6,1 cm (156 – 191 cm) and weight was 60,9 ± 11,2 kg (44,5 – 96,0 kg). The mean BMI was 21,5 ± 3,24 kg/m<sup>2</sup>, but 14% of individuals were characterized by BMI ≤ 18,5 kg/m<sup>2</sup> (underweight) and 15% were characterized by BMI ≥ 25,0 kg/m<sup>2</sup> (excessive body mass).

The mean energy requirement calculated individually for analyzed female participants, on the basis of the Harris-Benedict equation and adequate physical activity level coefficient, was 2020 ± 143 kcal, while mean energy intake, calculated on the basis of declared diet, was 1488 ± 583 kcal. The vast majority (89%) of individuals was characterized by lower declared energy intake than calculated energy requirement, while only for 11% energy value of declared diet was higher than calculated energy requirement.

The nutrients intake in analysed group of young women is presented in the Table 2, while comparison with recommendations is presented in Table 3. The analysis of the diets of analyzed female individuals revealed, that majority of them was characterized by inadequate intake of potassium, calcium, magnesium, vitamin D and folate. The highest share of individuals characterized by inadequate intake was stated for vitamin D, as for less than 3% the intake from diet was higher than 10 µg of cholecalciferol daily, while less than 7% of group declared additional supplementation. While supplementation was taken into account, it was stated, that 10% of individuals were characterized by an adequate intake of vitamin D.

Table 2. Nutrients intake in analysed group of young women

	Mean ± SD	Median (min – max)
Total protein [g]	67.75 ± 23.59	61.71 <sup>1</sup> (23.96 – 159.6)
Potassium [mg]	2753.08 ± 951.95	2542.15 (785.52 – 5039.4)
Calcium [mg]	605.57 ± 278.62	563.52 <sup>1</sup> (103.39 – 1456.0)
Magnesium [mg]	267.14 ± 123.04	239.88 <sup>1</sup> (89.84 – 780.3)
Vitamin D [µg]	2.57 ± 3.04	1.58 <sup>1</sup> (0.02 – 17.2)
Vitamin B <sub>6</sub> [mg]	1.82 ± 0.68	1.74 (0.46 – 3.5)
Folate [µg]	267.12 ± 115.61	249.65 <sup>1</sup> (89.56 – 708.6)
Vitamin B <sub>12</sub> [µg]	3.44 ± 2.59	2.86 <sup>1</sup> (0.39 – 17.5)
Vitamin C [mg]	117.21 ± 72.93	108.31 <sup>1</sup> (10.83 – 378.6)

<sup>1</sup> nonparametric distribution

Table 3. Nutrients intake in analysed group of young women in comparison with recommendations

	% of group characterised by intake	
	below recommended level	above recommended level
Total protein	0.0	100.0
Potassium	93.3	6.7
Calcium	74.7	25.3
Magnesium	53.3	46.7
Vitamin D	97.3	2.7
Vitamin B <sub>6</sub>	12.0	88.0
Folate	76.0	24.0
Vitamin B <sub>12</sub>	28.0	72.0
Vitamin C	22.7	77.3

The protein was stated to be the only of the assessed nutrients for which no women of inadequate intake was observed in the analyzed group. Simultaneously, for 73,3% of analyzed young women, inadequate intake of multiple nutrients was stated, as for at least 5 of 9 assessed nutrients, intake lower than recommended was observed.

Due to the fact, that energy value lower than recommended was observed in the analysed group, it was checked, if it may be the main reason of inadequate intake of mentioned minerals and vitamins. The analysis of correlation between energy value of diet and intake of analysed minerals and vitamins is presented in Table 4. It was observed, that for majority of assessed nutrients, the statistically significant correlation was stated, but not for vitamin C. The strongest correlation was observed for potassium, magnesium, vitamin B<sub>6</sub> and vitamin B<sub>12</sub>.

Table 4. Analysis of correlation between energy value of diet and intake of analysed minerals and vitamins (*Spearman* rang correlation)

	p-Value	R
Potassium	0.0000 ***	0.5494
Calcium	0.0001 **	0.4373
Magnesium	0.0000 ***	0.6328
Vitamin D	0.0001 **	0.4449
Vitamin B <sub>6</sub>	0.0000 ***	0.5654
Folate	0.0025 *	0.3434
Vitamin B <sub>12</sub>	0.0000 ***	0.5397
Vitamin C	0.0527	0.2246

\* p < 0,01, \*\* p < 0,001, \*\*\* p < 0,0001

## DISCUSSION

Taking into account the inadequate intake of multiple nutrients, associated with the risk of osteoporosis, that was stated in the case of majority of the analysed women, it may be concluded, that their declared diet was not properly balanced and may

result in the osteoporosis development. As the number of osteoporotic fractures, in comparison with observed now, in the 2050 will double [24], it may be supposed, that they will affect the analysed women, who will be 55-65 years old in 2050. The women being older than 50 years old, regardless of menopause status, are indicated by the National Osteoporosis Foundation [27] as a risk group of osteoporosis, if they have family history of osteoporosis, personal history of low trauma fracture at age of more than 45 years old, are currently smokers or have low body mass (<127 lb, i.e. <58 kg). Currently observed improperly balanced diet and low energy value of diet, in the analysed group, may contribute to low body mass in the future and, in consequence, increase the osteoporosis risk.

By the age of 30 years, peak bone mass, maximum bone strength and maximum bone density are reached, while afterwards the initiation of progressive loss of bone mass occurs [5]. Taking it into account, it must be indicated, that in young adults, osteoporosis prevention and related nutritional education are necessary [10].

However, the results of the study of *Bohaty et al.* [6] indicated, that nutritional education, associated with osteoporosis prevention, conducted in a group of female individuals aged 19-30 contributed to knowledge improvement, but simultaneously, did not contribute to change in dietary intake of calcium, vitamin D, or dairy products. Moreover, authors concluded, that calcium, vitamin D and dairy products intake were not adequate in comparison with recommended daily allowance for young adult women, both before and after education [6]. Nevertheless, in the study of *Chan et al.* [9], different results were observed – in a group of women aged more than 18 years old, nutritional education, associated with osteoporosis prevention, contributed not only to higher calcium intake, but also to higher sunlight exposure in order to obtain higher skin synthesis of vitamin D. In the mentioned study, authors stated, that they observed positive feedback, that suggests that women who participated in their education were motivated to make changes in their diet and their lifestyle [9].

It is stated, that for adults, the evidence of a link between intakes of nutrients, with the exception of calcium and vitamin D, and fracture risk is not sufficiently secure to make firm recommendations, but accumulated evidences suggest that following current healthy-eating advices may be beneficial [33]. However, it must be indicated, that for calcium and vitamin D, in analysed group of young women, high or very high frequency of inadequate intake was stated. Even, when applied supplementation of vitamin D, recommended for Central Europe [32], was taken into account, only 25% (for calcium) or 10% (for vitamin D) of individuals in the studied group were characterized by an adequate intake. In the recent meta-analysis of

studies analyzing the effect of combined calcium and vitamin D supplementation, it was concluded, that supply of mentioned nutrients may effectively cause fracture risk reduction in middle-aged to older adults [44]. Also for young women, the sufficient intake of calcium and vitamin D is indicated as an evidence-informed strategy to prevent osteoporosis [16].

Taking into account the group of young women, not only future osteoporosis risk may be emphasized to be as a serious issue for public health policy, but also a fact, that vitamin D and calcium insufficiencies are risk factors for multiple chronic diseases [39]. Both for vitamin D insufficiency and calcium deficit, the convincing evidences from multiple epidemiological large cohort studies, interventional trials and experimental studies are indicated not only for osteoporosis, but also for colorectal cancer and breast cancer risk [31]. The breast cancer accounts for more than 40% of all cancers in the group of women before the age of 40, while about 7% of breast cancers are diagnosed in this age group [4]. Simultaneously, colorectal cancer is now one of the most commonly diagnosed cancers among women before the age of 50 and its frequency is especially increasing in case of young individuals [17]. The increasing frequency of mentioned cancers and previously mentioned increasing frequency of osteoporosis is corresponding with, commonly stated in case of young women, low calcium and vitamin D intake. As it is indicated by the EUROpean micronutrient RECommendations Aligned (EURRECA) Network of Excellence Project, the frequency of inadequate vitamin D intake in adult female individuals is 77-100% and the frequency of inadequate calcium intake in adult female individuals is 26-61% in majority of analyzed European countries [35].

However, in the analysed group, not only inadequate intake of calcium and vitamin D, but inadequate intake of multiple minerals and vitamins was stated, while only protein intake was observed to be not inadequate. It may be associated not only to the increased osteoporosis risk, but also other diet-related diseases. Especially important may be deficiencies observed for majority of assessed group, that was stated, except from calcium and vitamin D, for potassium, folate and magnesium. Inadequate intake of potassium is indicated as the second, except from the excessive sodium intake, key to the pathogenesis of hypertension [1]. It should be indicated, that in spite of the fact that excessive body mass is the risk factor of hypertension in youth [22], the hypertension is diagnosed also in the case of young women with BMI lower than 25 kg/m<sup>2</sup> – it was stated to be diagnosed in 1,6% of healthy weight female individuals aged 20-39 years [8]. As in the group, majority of individuals was characterized by proper body mass, the inadequate potassium intake may be indicated

as a factor influencing possibility of hypertension. Especially, taking into account the National Health and Nutrition Examination Survey (NHANES) data, indicating, that individuals characterized by BMI lower than 25 kg/ m<sup>2</sup> were more likely to be not aware of their hypertension, than individuals with higher BMI [30], the education associated with hypertension risk factors seems also to be essential.

In the case of folate, its role in the diet of young women is obvious and this issue is indicated as an important aim in public health strategies [2]. The main possible consequence of the inadequate folate intake is associated with indicated by WHO influence of low maternal folate intake or low folate status and increased risk of neural tube defects in their offspring [14]. The problem of inadequate intake of folate is serious worldwide, as in the United States, in the NHANES study, the majority of non-pregnant women of childbearing age reported dietary folate intake lower than recommended [46]. The result of other studies, conducted in the United States, indicate also, that not only non-pregnant women, but also pregnant women are likely to develop folate deficiency, that is stated especially in the case of individuals characterized by short inter-pregnancy intervals [26].

The inadequate intake of magnesium is the factor influencing general body functioning, as it may impact heart rhythm, glucose tolerance, serum cholesterol [28], or neurological transition [3]. However, it must be stated, that in a Polish populations of women of various age, the inadequate intake of magnesium is common [40]. Simultaneously, in Polish study, in the case of women characterized by BMI lower than 18,5 kg/ m<sup>2</sup>, in comparison with proper body mass female individuals, lower body magnesium concentration was stated [15].

As it was described above, it may be suggested, that in the analysed group of women, not only osteoporosis risk, but also risk of other diet-related diseases is stated. However, the existing correlations between energy value of diet and the intake of potassium, calcium, magnesium, vitamin D, vitamin B<sub>6</sub>, folate, as well as vitamin B<sub>12</sub>, indicates, that not the improperly balanced diet, but too low intake may be the main reason of observed situation.

When too low reported energy intake is stated, real low energy intake and underreporting must be always considered. For women, underreporting is commonly stated, and is observed for various methods of dietary assessment [36]. Moreover, it is stated, that one of the factors leading to food intake underreporting may be dissatisfaction with body image [29]. In general, body image dissatisfaction is observed more commonly in women, than in men [25], while the importance of body shape and weight decreases for them with the age progression [42]. As a result, the analysed group

of young women, as other groups of young women may be perceived as a group of individuals prone to underreporting. Especially the fact, that for the vast majority of group (89%) energy value of diet being lower than calculated mean energy requirement was declared, while BMI ≤ 18,5 kg/ m<sup>2</sup> (underweight) was stated only for 14% of individuals, may confirm supposed underreporting. Taking it into account, it must be concluded, that possible underreporting may cause that the real level of inadequate intake in the analysed group may be lower than stated on the basis of the declared diets.

## CONCLUSIONS

1. The declared diets of analysed young women were characterized by low energy value, in comparison with their calculated energy requirements, as well as low intake of potassium, calcium, magnesium, vitamin D and folate, as the inadequate intake of mentioned nutrients was stated for majority of analysed individuals.
2. Following diets declared by the analysed group of young women may be the factor increasing seriously the risk of osteoporosis, as well as the risk of other diet-related diseases.
3. The low intake of majority of analysed nutrients (potassium, calcium, magnesium, vitamin D, vitamin B<sub>6</sub>, folate and vitamin B<sub>12</sub>) in the analysed group of young women may result mainly from low energy value of declared diets.
4. Taking into account the proper BMI of the majority of analysed group of young women and low energy value of their declared diets, the common underreporting may be supposed and it may contribute to osteoporosis risk overestimation.

## Conflict of interest

*The authors declare no conflict of interest.*

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