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ANALYSIS OF CHOSEN MACRONUTRIENTS AND VITAMIN D IN DAILY FOOD RATIONS OF ELDERLY MEN AND WOMEN IN THE CONTEXT OF CALCIUM-PHOSPHORUS HOMEOSTASIS

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Abstract

The loss of bone mineral components is an obvious and progressing process in elderly men and women. The rate of the bone metabolic turnover is associated with the nutrition and environmental conditions. Vitamins and minerals in a diet are indispensable for both prevention and treatment of diseases. The aim of the present study was to evaluate vitamin D, calcium (Ca) and phosphorus (P) content and to compare Ca-P homeostasis in daily dietary intake among the elderly members of a population-based study in Kołobrzeg.

The examined population comprised a group of 479 randomly chosen people aged > 51 years, including 316 women and 163 men. The eating habits of the respondents were evaluated in 2009. The information on individual food consumption was obtained by dietary history interviews (3 x 24-hour dietary recall).

The research proved that the vitamin D and Ca supply with a daily diet was extremely low, in contrast to the P content, which significantly exceeded the recommended daily intake for this age group. Daily food rations of both women and men were not properly balanced in terms of Ca and P and vitamin D. It was revealed that the vitamin D supply in the daily dietary intake of the elderly persons was very low, covering from 22 to 40% of the Adequate Intake (AI). Vitamin D is necessary for maintaining an appropriate calcium and phosphorus homeostasis in the body and ensuring that many tissues, organs and cells function properly. A diet rich in vitamin D and Ca has been identified as playing a potential role in the prevention of bone diseases.

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A change in dietary habits can be an important factor in reducing the incidence of chronic diseases, particularly an elevated fracture risk in osteoporosis.

Key words: calcium-phosphorus homeostasis, vitamin D, daily food rations.

ANALIZA WYBRANYCH SKŁADNIKÓW MINERALNYCH I WITAMINY D W CAŁODZIENNYCH RACJACH POKARMOWYCH OSÓB STARSZYCH W ASPEKCIE GOSPODARKI WAPNIOWO-FOSFORANOWEJ

Abstrakt

Utrata masy kostnej u ludzi starszych jest zjawiskiem naturalnym i postępującym zarówno u kobiet, jak i mężczyzn. Tempo obrotu metabolicznego tkanki kostnej zależne jest od sposobu odżywiania i uwarunkowań środowiskowych. Odpowiednia zawartość witamin i składników mineralnych w racjach pokarmowych oraz proporcje między nimi są istotne w prewencji i terapii żywieniowej. Celem pracy była analiza podaży witaminy D, wapnia i fosforu w całodziennych racjach pokarmowych osób starszych oraz ocena homeostazy wapniowo-fosforanowej.

Badania przeprowadzono w 2009 r., w Kołobrzegu, metodą sondażu diagnostycznego, stosując kwestionariusz wywiadu (na podstawie trzech wywiadów 24-godzinnych) wśród losowo wybranych 479 osób (316 kobiet i 163 mężczyzn) powyżej 51. roku życia.

W analizie ilościowej badanych racji pokarmowych stwierdzeno, iż posiłki badanych kobiet i mężczyzn były nieprawidłowo skomponowane; wykazano niedobory witaminy D i wapnia, a jednocześnie nadmierną zawartość fosforu w stosunku do rekomendacji żywieniowych oraz niewłaściwe proporcje między analizowanymi składnikami diety. Zawartość witaminy D w analizowanych racjach pokarmowych kobiet i mężczyzn była bardzo niska, pokrywała zapotrzebowanie badanych od 22 do 40% określonego zapotrzebowania na poziomie wystarczającego spożycia (AI). Witamina D jest niezbędnym elementem do utrzymania homeostazy wapniowo-fosforanowej w organizmie i zapewnia właściwe funkcjonowanie tkanek, narządów i komórek.

Zmiana zwyczajów żywieniowych badanych osób starszych może obniżyć ryzyko rozwoju przewlekłych chorób niezakaźnych, w tym złamań kości w osteoporozie.

Słowa kluczowe: homeostaza wapniowo-fosforanowa, witamina D, dzienne racje pokarmowe.

INTRODUCTION

Nutritional deficiencies of the ageing population are attributed to chronic diseases, inadequate nutrition, reduced absorbability as well as inefficient use of nutrients. The loss of bone mineral constituents is an obvious and progressing process in elderly men and women. It is understood that the bone mass accumulates in the first two decades of human life, afterwards remaining stable until approximately 40 years of age. The rate of the bone metabolic turnover is associated with the nutrition and environmental conditions. Nutrition should be among bone disease prevention strategies, especially as the human population is ageing and a diet produces an important

effect on bone health. Bone is the major store of both phosphorus and calcium (Andersen et al. 2005, Bonjour et al. 2009, Peacock 2010). There are some nutrients that are essential for attaining good bone tissue formation and maintaining its optimal metabolism, e.g. Ca, P, Mg, Zn, F as well as vitamins D, A, K, C and protein (Tang et al. 2007, Zhu, Prince 2012).

Calcium is an essential element that is available to the body only through dietary sources. An adequate Ca supply in a diet appears to be the main condition for keeping the right level of bone mass and slowing down its decrease (Zhu, Prince 2012). Possible reasons for Ca deficiency in an organism may be its insufficient supply, reduced absorption from the alimentary tract and excessive excretion with urine. Calcium is deposited in bones in the form of calcium-phosphate salt. Phosphorus is essential for the normal bone formation and therefore plays a very important role during the skeletal development. However, there are much larger stores of phosphorus than calcium in soft tissues, reflecting the central role of phosphorus in energy metabolism, intracellular signaling and cell structure (Peacock 2010). Phosphorus is ubiquitous in almost all foods. Although P deficiency was never a real problem in human nutrition, a surplus of phosphorus in the diet was more of the concern.

Vitamin D, parathormone (PTH), calcitonin and sex hormones play a principal role in maintaining calcium and phosphorus homeostasis and the balance between bone creation and bone resorption. Vitamin D is necessary to keep the right calcium and phosphorus homeostasis in the body and also to ensure that many tissues, organs and cells, unrelated to mineral economy, function properly (Holik 2006, 2007, Hines et al. 2010, Christakos et al. 2011).

The aim of the study was to evaluate the content of vitamin D as well as Ca and P and to compare the status and calcium-phosphorus homeostasis in daily dietary intake for the elderly by a population-based study in Kołobrzeg.

MATERIALS AND METHODS

The study was conducted in 2009, in the Rehabilitation and Recreation Center in Kołobrzeg, Poland. The participants were healthy adults aged >51 year. The examined group comprised 479 persons (316 women and 163 men) who were selected randomly from 1200 people. Three different age groups were distinguished for men and women: age 51-65; 66-75 and > 75 years. Each of the participants was individually inquired about the diet from 3 days, according to recommendation by the Food and Nutrition Institute in Warsaw.

The serving size was established based on products and portions reported by the respondents. The energy value and contents of nutrients in daily food intake were appraised with the aid of a computer program based on the current tables of values of nutritional products worked out at the Food and Nutrition Institute in Warsaw. The computer program takes into account the loss of nutritional value during food processing technological processes versus raw products. The assessment of the participants' eating habits was carried out using Polish recommendations (BUŁHAK-JACHYMCZYK 2008, WOJTASIK, BUŁHAK-JACHYMCZYK 2008).

An Excel 2010 calculation sheet was used to process the results, while the Polish version of Statistica 10.0 for Windows (StastSoft® Krakow, Polska) was applied to submit them to statistical evaluation. Statistical significance was determined by the Mann-Whitney U test for comparison of quantitative data between two groups. The Kruskal-Wallis test was applied to comparative analysis of more than two groups. The level of statistical significance was set at $p < 0.05$ and the Spearman's correlation coefficient for nonparametric variables distribution was used.

RESULTS AND DISCUSSION

The examined population of elderly subjects, who did not take any dietary supplements, was divided into different age groups. It was revealed that the levels of the basic nutrients in the tested cohort's rations had been not well-balanced (Table 1). Differences in the energy delivered with food within the tested groups were noticed. The results indicate that the group of men <75 y received less energy with daily dietary intake than required, while seniors >75 y were provided with more energy with food than needed. Irrespectively of the age range, energy values found for elderly women always exceeded the required levels. The protein content exceeded the recommended quantity limits for all the age groups of both men and women. Statistically significant ($p = 0.0004$) differences appeared in the consumed proteins within the examined age groups.

It was established that the energy intake from eaten fat was too high, exceeding 35% among all the respondents, while the percentage contribution of carbohydrates to energy intake was on the lowest recommended level. Actually, the average level of carbohydrates consumed in g d^{-1} was found to be on an acceptable level among the participants of the survey. However, the ratio between digestible carbohydrates and fats was inappropriate compared to the energy supply.

Statistically significant differences in the calcium and phosphorus intake within all examined population divided by gender were established by the Man Whitney U test, $p = 0.002$ for Ca and $p = 0.02$ for P (Figure 1).

Table 1

Distributions of dietary energy and macronutrients intake per day (means ± SD and range) by different age and gender groups (women-W, men-M)

Macronutrient intake per day	W 51-65 y (n = 155)	M 51-65 y (n = 51)	W 66 -75 y (n = 133)	M 66 -75 y (n = 85)	W >75 y (n = 28(	M >75 y (n = 27)
Total energy (kcal)	2104 ± 449 (831-3150	2341 ± 394 (1505-2859)	2201 ± 562 (870-4174)	2033 ± 455 (1254-3006)	2252 ± 736 (928-3980)	2382 ± 410 (1666-2751)
Total protein (g)	92.1 ± 23.4 (37.5-172.4)	89.2 ± 21.9 (52.2-115.0)	86.6 ± 20.4 (42.2-136.1)	85.3 ± 16.4 (54.5-112.8)	91.3 ± 2 3.2 (42.0-132.3)	96.3 ± 20.5 (53.0-120.9)
Animal protein (g)	66.2 ± 22.8 (23.3-144.2)	59.0 ± 19.3 (21.7-81.9)	58.8 ± 16.8 (22.2-95.4)	58.9 ± 13.8 (34.3-87.3)	62.8 ± 19.1 (29.7-110.1)	67.3 ± 17.9 (35.5-89.3)
Fat (g)	88.4 ± 24.1 (35.5-158.1)	94.0 ± 19.0 (56.3-117.6)	87.2 ± 29.3 (27.3-177.4)	77.6 ± 15.8 (38.1-112.2)	87.9 ± 28.4 (41.5-139.9)	89.6 ± 16.5 (69.2-116.1)
Carbohydrates (g)	253.3 ± 75.1 (32.4-454.1)	305.1 ± 69.2 (164.4-411.7)	286.9 ± 77.2 (118.5-551.1)	270.5 ± 82.1 (152.6-469.4)	298.1 ± 121.3 (99.1-603.5)	314.2 ± 63.2 (168.8-372.2)
Energy from protein (%)	12.6 ± 3.5 (5.0-21.8)	10.1 ± 2.9 (3.9-12.7)	10.9 ± 2.8 (5.4-23.2)	11.9 ± 2.9 (7.2-19.0)	11.7 ± 3.0 (6.1-17.6)	11.3 ± 2.5 (6.9-14.5)
Energy from fat (%)	37.9 ± 6.0 (23.7-52.6)	36.2 ± 4.9 (30.7-47.1)	35.8 ± 6.1 (19.8-53.4)	34.8 ± 4.8 (26.5-45.1)	35.5 ± 5.7 (22.4-44.0)	34.3 ± 5.4 (26.2-44.5)
Energy from carbohydrates (%)	49.5 ± 8.1 (28.2-66.1)	53.7 ± 4.7 (45.9-62.1)	53.3 ± 7.0 (37.9-74.8)	53.3 ± 6.2 (42.6-63.9)	52.9 ± 7.8 (40.8-68.6)	54.3 ± 4.0 (45.8-60.8)

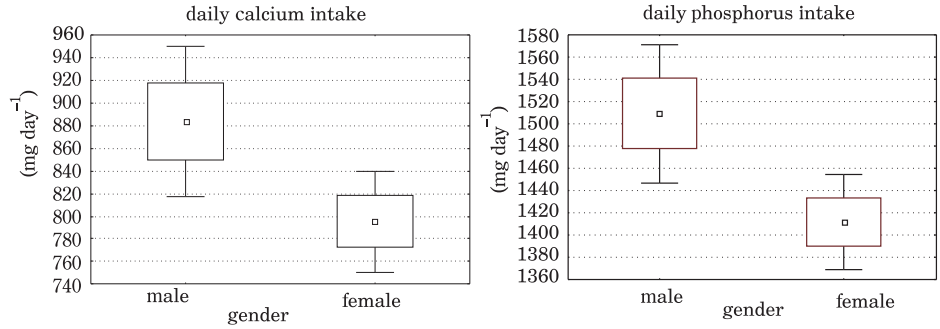

Fig. 1. Comparison of daily calcium and phosphorus intake by the examined males and females (Man-Whitney U test, p = 0.002 for Ca and p = 0.02 for P)

The average Ca, P and vitamin D concentrations in the daily food portions of the interviewees are presented in Tables 2 and 3. The RDIs for Ca, P and vitamin D are different in different countries and regions. There is no consensus in Europe, e.g. in Poland RDIs are different for adults, postmenopausal women and the elderly (WHO/FAO 2004). It is claimed that while quite a number of people between the age of 60 up to 75 are still active physically, socially and professionally, most of those over 75 years of age have worse present worse life quality indicators.

The updated standards for calcium intake have been agreed on a level of sufficient consumption; for adults over 50 years old, 1300 mg of calcium per day is recommended (WOJTASIK, BUŁHAK-JACHYMCZYK 2008). The average content of calcium has been determined from 786±350 to 809±488 mg in women's daily dietary intake, irrespective of their age, which enables them to achieve a sufficient calcium intake level from 60 to 62% of the standard (Table 2). MARKIEWICZ and co-workers have obtained similar outcome when analyzing the calcium content in daily food rations of elderly people from Podlasie, revealing calcium deficiency of the diets (MARKIEWICZ et al. 2009). It appears that men's daily food rations contained from 853±225 to 883±213 mg of calcium, which corresponds to 66- 68% of the level considered as a sufficient calcium level intake. The insufficient calcium intake in daily food rations among the examined elderly population is a disturbing finding (ANDERSEN et al. 2005, TANG et al. 2007, BRONKOWSKA et al. 2010). A much lower calcium intake among women than men has been ascertained in our study; moreover, the most severe calcium deficiency (786±350 mg d^{-1}) has been found within the 66-75 y age group. We have shown that calcium deficiency in a daily food ration of the subjects does not depend on the gender. Ca deficiency is a common problem, especially among elderly women. There has been an ongoing process of decreasing the estrogen level among the tested women. This causes a growing risk of a bone mass decrease within aging and the risk of osteoporosis can only be reduced by sufficient Ca (TANG

Table 2

Intake of the analyzed nutrients per day (means ± SD and range) and percent of the RDI and AI realization in women's age groups

Women (years)	Ca (mg)	AI (%)	P (mg)	RDI (%)	Ca:P	Vitamin D (µg)	AI (%)	*r* Ca - P	*r* Ca - Vit. D
51 -65	809 ± 488 (977-4559) *M*- 733	1300 mg 62%	1421 ± 488 (761-3128) *M*- 1467	700 mg 245%	1.8	4.0 ± 2.8 (1.1-11.3) *M*- 2.9	10 µg 40%	0.823	-0.045
66 -75	786 ± 350 (172-2105) *M*- 764	1300 mg 60%	1419 ± 343 (732-2263) *M*- 1365	700 mg 245%	1.8	4.4 ± 4.0 (1.1- 22.1) *M*- 2.5	15 µg 29%	0.775	0.278
>75	804 ± 357 (236-1747) *M*-802	1300 mg 62%	1617 ± 445 (954-2680) *M*- 1564	700 mg 279%	2.0	4.0 ± 3.1 (1.7 - 11.0) *M*- 2.5	15 µg 27%	0.909	0.490

r – Spearman correlation coefficient for nonparametric variables distribution, *M* – median

Table 3

Intake of the analyzed nutrients per day (means ± SD and range) and percent of the RDI and AI realization in men's age groups

Men (years)	Ca (mg)	AI (%)	P (mg)	RDI (%)	Ca:P	Vitamin D (µg)	AI (%)	*r* Ca - P	*r* Ca - Vit. D
51 -65	859 ± 269 (481-1206) *M*- 756	1300 mg 66%	1426 ± 328 (817-1877) *M*- 1643	700 mg 245%	1.7	2.7 ± 1.2 (1.0 - 4.8) *M*- 2.8	10 µg 27%	0.705	0.199
66 -75	883 ± 213 (579-1504) *M*- 867	1300 mg 68%	1354 ± 237 (929-1815) *M*- 1470	700 mg 234%	1.5	3.6 ± 3.0 (1.0 - 11.2) *M*- 2.4	15 µg 24%	0.731	0.259
>75	853 ± 225 (401-1223) *M*- 822	1300 mg 66%	1363 ± 206 (909-1536) *M*- 1491	700 mg 235%	1.6	3.3 ± 2.3 (1.7 - 9.0) *M*- 2.5	15 µg 22%	-0.024	-0.190

r – Spearman correlation coefficient for nonparametric variables distribution, M – median

et al. 2007, Stransky, Rysava 2009, Peacoc 2010). There are several vital roles that Ca plays in the human body apart from building the skeletal system. For example, calcium is essential in sustaining proper cardiac functions. It also participates in metabolic processes, nerve impulse conduction, muscle contraction, etc. (Velicer 2008, Peacoc 2010). Despite positive changes in the eating habits that have recently been occurring in Poland, Poles often eat diets which do not satisfy the nutritional recommendations. Apparently, the level of calcium intake in Poland is low, reaching 598 mg d^{-1} (Wojtasik, Bułhak-Jachymczyk 2008).

The results of the daily dietary intake analysis carried out among all the men's and women's age groups showed higher than required phosphorus content, i.e. 245-273% for women and 234-273% for men. The systemic phosphoric metabolism together with the calcium metabolism are the main factors responsible for the maintenance of calcium/phosphate homeostasis. An optimum Ca:P ratio in a daily dietary intake is 1:1, but after converting into the gravimetric unit index it equals 1.3 (Bonjour et al. 2009). The average Ca:P ratio (presented in grams) within the analyzed diets of different women's age groups was 1.8 within the age group of 51 to 65 y, 1.8 from 66 to 75 y of age and 2.0 among the most senior group. The respective results for men were: 1.7, 1.5 and 1.6. Comparing the content of phosphorus to calcium in the respondents' food rations, we obserevd simultaneous growth trends in all diets except the diets of men aged > 75 y.

Presence of phosphorus in such food products as cheese, poultry, fish and cereal is responsible for an unstable balance between calcium and phosphorus in a human organism. This is due to the fact that phosphates and polyphosphates are added to food products. Chronic hyperphosphatemia might lead to stimulation of bone tissue resorption (Bonjour et al 2009, Stransky, Rysava 2009, Zhu, Prince 2012). The reason for hyperparathyroidism, which is manifested by higher than normal PTH secretion. might be the calcium/phosphorus low ratio in a diet. Moreover, vitamin D plays an essential role in calcium and phosphorus metabolism. Without vitamin D, only 10-15% dietary calcium and about 60% of phosphorus are absorbed (Holik 2006). The relationship between Ca and vitamin D in daily intake rations was investigated. Within most of the examined groups, the correlation between Ca and vitamin D is very weak or nonexistent.

The standards proposed in Poland are adapted to the ones by FAO/WHO and expressed as an Adequate Intake (AI) of vitamin D. The organism's requirement for vitamin D can vary and a daily dose ranges from 10 to 15 µg of vitamin D per se according to the age (Bułhak-Jachymczyk). The vitamin D supply including daily dietary intake among the examined elderly persons was very low. The lowest and the highest levels in the women's daily dietary intake were 4.0±2.8 and 4.4±4.0 µg d^{-1}, respectively. Among the men, they ranged from 2.7±1.2 to 3.6±3.0 µg d^{-1}. In all of the men's and women's diets, the required supply of vitamin D was covered from 22 to

40% of the AI levels. Vitamin D deficiency in elderly population may be a cause of bone mineralization disorders and muscle tone decrease, which raise the risk of falls. The reduced dermal synthesis and insufficient quantity of vitamin D delivered in a diet are presumably the reason for a vitamin D shortage in elderly population (ANDERSEN et al. 2005, HOLIK 2007).

The results of studies have shown relatively low vitamin D intake levels in Poland and in other European countries, like Denmark and Ireland, reaching no more 3.8 μg day^{-1} (ANDERSEN et al. 2005, BONJOUR et al. 2009).

The research carried out among the elderly population proved that the vitamin D and calcium supply including daily dietary intake was extremely low. In contrast, the dietary phosphorus content exceeded the recommended daily intake for this age group by 234 to 279%. Results of studies across the world (ANDERSEN et al. 2005, HOLIK 2007, TANG et al. 2007, VELICER 2008, KAVIANI et al. 2012) show insufficient calcium and vitamin D levels among elderly people.

CONCLUSIONS

Particular attention must be drawn to educational programs for elderly people and the need of calcium and vitamin D supplementation in a diet in order to prevent negative effects of malnutrition. In conclusion to the above data, in order to restore the lost metabolic stability in senior people it will be necessary to correct their lifestyles, including changes in the nutritional habits, which should be accompanied by intensive educational efforts regarding nutrition. Low calcium and vitamin D levels along with an excessive phosphorus content in the analyzed diets might be the reason for developing health disorders related to the lack of calcium/phosphorus homeostasis.

Regular monitoring of the elderly people's nutrition seems to be a good starting point for improving their diets, which may help to slow down the biological ageing process and to deter physiological and pathological changes.

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