Evaluation of mineral and vitamin intake in the diet of a sample of Polish population – baseline assessment from the prospective cohort ‘PONS’ study

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Abstract
Objective: The aim of this cohort study was to evaluate selected mineral and vitamin intake of the Polish-Norwegian Study (PONS) participants.

Methods: Daily mineral and vitamin intake of PONS study participants was estimated using Food Frequency Questionnaire (FFQ). Overall, 3,862 inhabitants of Świętokrzyskie Province aged 45-64 (2,572 females and 1,290 males) enrolled in the study.

Results: Mean calcium, iron, magnesium, phosphorus, potassium, and sodium intake were, in males: 660.6 mg/day, 15.4 mg/day, 218.5 mg/day, 889.3 mg/day, 2,453.4 mg/day and 2,571.5 mg/day, and in females: 703.6 mg/day, 13.9 mg/day, 220.8 mg/day, 916.3 mg/day, 2,497.3 mg/day and 2,301.8 mg/day, respectively. Iron and sodium intake was significantly higher in males compared to females. Calcium intake was lower in males than in females and in participants aged 55-64 than those aged 45-54. Estimated daily sodium intake was similar among individuals with and without hypertension. Mean vitamin C, thiamin, riboflavin, vitamin B₆, A and E were, in males: 80.1 mg/day, 1.3 mg/day, 1.5 mg/day, 1.6 mg/day, 8,454.0 IU/day and 5.4 mg/day and in females: 83.7 mg/day, 1.1 mg/day, 1.6 mg/day, 1.6 mg/day, 9,494.6 IU/day and 4.9 mg/day, respectively. Females had a higher intake of vitamin C and A, while males had higher thiamin and vitamin E intakes. Higher daily vitamin C intake was observed in the younger than in the older group, and in participants with higher education than those with a lower level of education.

Conclusion: Significant differences were observed in daily intake of some vitamins and minerals by gender, age, level of education, and place of residence. Some participants had a lower intake of some minerals and vitamins than Polish recommendations.

Keywords
prospective study, mineral intake, vitamin intake, Food Frequency Questionnaire

INTRODUCTION

An important characteristic of a healthy balance diet is an adequate intake of minerals and vitamins. Some minerals participate in body structure (such as calcium, phosphorus, magnesium), some minerals are vital for fluid and electrolyte management and acid-alkaline balance (e.g. sodium and potassium), and others take part in metabolic and regulation processes. Vitamins are also necessary components to ensure human health. They participate in metabolic processes, proper functioning of the nervous and cardiovascular system, are involved in anti-oxidant processes. The metabolism of carbohydrates, proteins, fats, and synthesis of hormones are also dependent on vitamins [1,2].

To ensure an adequate supply of minerals and vitamins, diet should include whole grain cereals, vegetables and fruits rich in vitamin C and beta-carotene, low-fat milk and dairy products and vegetable oils as sources of unsaturated fatty acids. A healthy diet has a significant impact on the prevention of chronic diseases. Several studies have indicated that saturated fatty acid intake, fibre intake or antioxidant vitamins, sodium and potassium intake are associated with cardiovascular and cancer risk factors [3]. Between 1991-2002,
dissolving factors, such as decreasing saturated fatty acid intake, 
increasing vegetable oils consumption (rapeseed and soybean 
as a source of unsaturated fatty acids), and increasing fruit 
and vegetable consumption were associated with decreasing 
cardiovascular disease mortality in Poland [4].

The aim of present study was to assess the daily intake 
of minerals and vitamins by PONS study (The Polish-
Norwegian Study) participants, and to compare participants’ 
intake with dietary guidelines recommended for the Polish 
population.

MATERIALS AND METHODS

The presented results are preliminary analysis data from 
the first wave of participants of Polish-Norwegian Study 
(PONS) of chronic diseases in the Świętokrzyskie Province 
of Poland, a large open-ended prospective study with very 
broad research aims. The aim of this study is to understand 
the causes of premature morbidity and mortality in Poland, 
et al., to establish a solid base of knowledge for prevention and 
intervention actions.

Sample and data collection. Recruitment units were 
established in urban and rural areas of Świętokrzyskie 
Province. Eligibility criteria for the project population were 
place of residence (city of Kielce and Świętokrzyskie Province 
and age (45-64 years old). The results presented in this paper 
are based on data from the first 3,862 participants – 2,572 
females and 1,290 males within the above-mentioned age 
group, of whom 1,182 were rural and 2,680 urban inhabitants. 
The participants were recruited between 2010-2011.

Mean age, BMI and waist circumference among the rural 
habitants was, in males: 55.0±5.5 years old, 29.1±3.9 kg/m², and 
100.7±9.8 cm, and in females: 53.9±5.1 years old, 29.1±5.2 kg/m² 
and 90.7±11.8 cm. Among urban inhabitants, these parameters 
were, respectively, in males: 56.1±5.3 years old, 28.3±3.8 
kg/m², and 99.0±10.4 cm and in females: 56.2±5.2 years old, 
27.8±4.8 kg/m² and 87.3±11.5 cm.

All participants were examined in accordance with the 
PONS project protocol. The questionnaire information 
was collected as a systematic interview, and the responses 
were entered on an electronic form; after completion of the 
interview, the data were sent directly to a data server for 
processing and further management.

Measurement. Long term dietary intake of the participants 
was assessed by a food frequency questionnaire (FFQ). PONS 
FFQ was constructed based on a previously developed and 
validated FFQ for the Polish branch of the PURE study [5]. 
Development and validation methods for FFQ were based on 
previous studies conducted in the United Arab Emirates and 
Kuwait [6], and in Colombia [7]. The PONS questionnaire 
included questions concerning 55 food items. Portions sizes 
were described as typical portions used at home (e.g. a glass, 
a slice, a teaspoon, a plateful). Each question was divided into 
2 parts. In the first part, participants were asked if they were 
eating/drinking each item at least once a month, for example, 
a slice of cheese or a glass of semi-skimmed/low fat milk). The 
possible answers were: ‘Yes’, ‘No’, ‘Don’t know’ and ‘Refusal’. 
In the second part of the question, participants were asked 
about consumption frequency of each item in the last year 
(e.g. ‘How often in the past 12 months did you eat a slice of 
cheese?’). The possible frequencies of consumption ranging 
from 1-3 times a month to 6 times per day. The question 
about sugar consumption was formulated differently and 
participants were asked how many teaspoons they normally 
added to drinks and meals every day. In the response, they 
had to indicate the number of teaspoons sugar.

The questionnaire included additional questions concerning 
oils consumption: canola oil, soybean oil, sunflower oil, olive 
oil, and other oils (e.g. grape seed oil), and the frequencies 
of consumption was formatted similar to the other part of 
FFQ.

The FFQ did not include question about alcohol intake, 
however, PONS study recorded individuals’ alcohol intake 
by another questionnaire. We incorporated the recorded 
alcohol intake in the energy estimation.

It was assumed that dietary intake of minerals and vitamins 
was in accordance with recommendations when the intake 
was at 90-110% of Estimated Average Requirement (EAR) 
or Adequate Intake (AI). It was assumed that insufficient 
intake was below 90% of EAR or AI, and excessive intake 
was above 110% of EAR or AI.

The recorded frequencies of consumption were converted 
into daily intake, and daily foods and nutrients intake were 
calculated. To compute the daily nutrient intake, the reported 
frequency of consumption for each food item was multiplied by 
the portion size, and then the total food intake was converted to 
nutrient intake based on the food’s nutrient profile. Daily intake 
of foods and nutrients was computed at the Population Health 
Research Institute (PHRI) at McMaster University, Hamilton, 
Canada. Based on the US Department and Agricultural 
(USDA) [8] and Poland’s Food Composition Table [9], a special 
nutrient food database, which included food products and 
dishes commonly eaten in Poland, was constructed. Merchant 
and Dehghan [10] described previously the procedure for 
compiling food composition database from USDA and local 
food composition tables. The intake of 10 minerals and 22 
vitamins in the PONS study group was evaluated.

Statistical analysis. Mean (SD) and median were calculated 
to summarize continuous variables. For all analysis, the 
criterion for statistical significance was set at alpha=0.05. 
Statistical analysis were carried out using computer 
programme STATISTICA v 9.1 PL StatSoft Inc., USA.

Ethics. The study was approved by the Ethics Committee of 
the Cancer Centre and the Institute of Oncology in Warsaw, 
Poland.

RESULTS

Mean daily minerals intake of participants is shown in 
Tables 1 and 2. It was found that iron, sodium, zinc, copper, 
and manganese intake were significantly higher in males than 
females, while calcium intake was significantly lower in males 
than in females (Tab. 1). It was observed that more than 90% 
of participants had calcium and potassium intakes below 
recommendations. More than 90% of males and almost 70% of 
females had magnesium intakes below the recommendations. 
Insufficient zinc intake was observed in about 80% of males 
and more than 40% of females (Tab. 2).

It was also found that younger participants had a higher 
intake of some minerals than others (Tab. 3).
Table 4 shows the intake of minerals of participants based on level of education. Overall, the intake of minerals was lower among people with a lower level of education than the others.

The estimated daily sodium intake was similar among males with and without hypertension, and among females with and without hypertension.

Mean daily intake of vitamins in the study group is presented in Table 5 and 6. Females had a higher intake of vitamins C, B5 and A than males (p<0.05), and it was also observed that males, compared to females, consumed significantly more thiamin (1.3 vs 1.1 mg/day), niacin (18.5 vs 17.4 mg/day), folate (279.3 vs 269.3 μg/day) and vitamin E (5.4 vs 4.9 mg/day). Intake of vitamin B6 was also higher in males than in females.

Almost 50% of the studied males and about 35% of studied females had a vitamin C intake below recommendations. Mean daily folate intake in more than 60% of the participants was too low compared with recommendations. Among vitamins B, the lowest intake compared with recommendations was observed for vitamin B12 (about 80% of the participants the...
intake was below recommendations). Almost 30% of males and 20% of females had insufficient vitamin B₁ intake, and, respectively, 27% and 23% had vitamin B₆ intake below recommendations. Vitamin E intake assessed in the PONS study group was very low compared with recommendations. Insufficient intake of this vitamin was observed in about 90% of the study group (Tab. 6).

Significant differences between participants aged 45-54 and 55-64 were observed only with regard to vitamin C, thiamin and niacin (Tab. 7). A higher daily vitamin intake was observed in the younger than in the older group (vitamin C, respectively, 85.6 vs 80.4 mg/day; niacin 18.0 vs 17.5 mg/day). Intake of vitamin B₁ was also higher in the younger than in the older age group.

Participants with primary education had lower vitamin C, niacin, riboflavin, vitamin B₁ and folate intake than those with secondary and university education (Tab. 8).

**DISCUSSION**

In this study, the daily intake of minerals and vitamins was assessed among participants of PONS study. It was observed that mineral intake was higher among males than females, but females consumed more vitamins than males. Participants with a lower level of education had less mineral and vitamin intake than those with a higher level of education.

The results presented indicate that the participants in this study had lower intakes of calcium, magnesium, potassium...
Table 8. Mean (SD) daily vitamin intake in the PONS study group by education level

<table>
<thead>
<tr>
<th>Vitamin Unit</th>
<th>Primary education</th>
<th>Trade education</th>
<th>Secondary education</th>
<th>University education</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=230</td>
<td>n=667</td>
<td>n=1710</td>
<td>n=1235</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Vit. C mg</td>
<td>71.2 (41.3) a</td>
<td>77.1 (44.0) a</td>
<td>81.8 (53.6) a</td>
<td>88.7 (51.6) a</td>
</tr>
<tr>
<td>Vit. B1 mg</td>
<td>1.1 (0.4) a,c</td>
<td>1.2 (0.4)</td>
<td>1.2 (0.5)</td>
<td>1.2 (0.4)</td>
</tr>
<tr>
<td>Vit. B2 mg</td>
<td>1.5 (0.5) a</td>
<td>1.5 (0.5)</td>
<td>1.6 (0.6)</td>
<td>1.6 (0.6)</td>
</tr>
<tr>
<td>Vit. B3 mg</td>
<td>16.7 (5.0) a</td>
<td>17.8 (5.2)</td>
<td>17.7 (6.5)</td>
<td>17.9 (5.9)</td>
</tr>
<tr>
<td>Vit. B6 mg</td>
<td>3.5 (1.2) a,c</td>
<td>3.6 (1.2)</td>
<td>3.7 (1.5)</td>
<td>3.8 (1.3)</td>
</tr>
<tr>
<td>Vit. B12 μg</td>
<td>1.5 (0.5)</td>
<td>1.6 (0.6)</td>
<td>1.6 (0.6)</td>
<td>1.6 (0.6)</td>
</tr>
<tr>
<td>Folate total μg</td>
<td>254.6 (83.3) a,c</td>
<td>269.6 (80.9)</td>
<td>272.1 (99.0)</td>
<td>278.4 (97.9)</td>
</tr>
<tr>
<td>Vit. B6 μg</td>
<td>5.7 (4.6) c</td>
<td>5.8 (4.1)</td>
<td>5.8 (6.0)</td>
<td>5.6 (4.2)</td>
</tr>
<tr>
<td>Vit. A IU</td>
<td>8892.4 (4052.6)</td>
<td>9043.6 (4975.5)</td>
<td>9304.6 (6535.0)</td>
<td>9033.7 (5354.7)</td>
</tr>
<tr>
<td>Vit. A μg RAE</td>
<td>890.0 (488.7)</td>
<td>903.0 (477.8)</td>
<td>914.7 (692.2)</td>
<td>880.0 (489.5)</td>
</tr>
<tr>
<td>Retinol μg</td>
<td>448.0 (423.9)</td>
<td>446.2 (366.1)</td>
<td>449.2 (550.2)</td>
<td>430.2 (375.7)</td>
</tr>
<tr>
<td>α-carotene μg</td>
<td>1413.7 (744.0)</td>
<td>1435.1 (947.9)</td>
<td>1476.3 (1199.2)</td>
<td>1426.5 (1027.2)</td>
</tr>
<tr>
<td>β-carotene μg</td>
<td>3657.4 (1790.5)</td>
<td>3737.1 (2307.9)</td>
<td>3861.1 (2599.3)</td>
<td>3751.0 (2494.5)</td>
</tr>
<tr>
<td>Vit. E mg</td>
<td>4.8 (1.9)</td>
<td>5.2 (2.1)</td>
<td>5.1 (2.4)</td>
<td>5.1 (2.3)</td>
</tr>
</tbody>
</table>

SD - standard deviation
- 1 v.2       - 1 v.3       - 1 v.4       - 2 v.3       - 2 v.4       - 3 v.4       - statistically significant differences, p<0.05

and zinc than the Polish recommendation [1]. Similar to our finding, previous studies also showed insufficient calcium intake in the Polish population [11-14]. Mean daily intake of calcium in 40-50-year-old inhabitants of Wroclaw was 801.6 and 701.4 mg in males, and 632.4 mg and 603.5 mg in females, respectively [15, 16]. Calcium intake in the American population (40-59-years-old) reported by in the National Health and Nutrition Examination Survey (NHANES) was 969 mg/day in males, and 744 mg/day in females [17].

Magnesium intake assessed in our study among males was lower than in the WOBASZ study, while among females it was similar [11, 12]. Among males from the POL-MONICA BIS study in Warsaw [14] and Tarnobrzeg [13], the magnesium intake was 310.2 mg/day and 278.7 mg/day, which was higher than in our study. The intake of magnesium among females from POL-MONICA BIS study in Warsaw was 225.5 mg/day, and in Tarnobrzeg, 204.5 mg/day [13, 14]. Mean daily intake of magnesium in the population of Wroclaw was higher than in our study [15, 16]. Daily magnesium intake among a 40-59-year-old American population was 349 mg in males, and 258 mg in females [17].

Yang et al. suggest [18] that a higher sodium-potassium ratio is associated with a significantly increased risk of CVD and all-cause mortality. It was also found that in the US population a higher sodium intake increases total mortality. In the PONS study, it was observed that almost all of the participants had a potassium intake below recommendations, while about 90% of the study group had a sodium intake above recommendations. These adverse proportions may have an important influence on prevalence of hypertension and CVD in the study group. Potassium intake observed in the POL-MONICA BIS study in Warsaw [14] and Tarnobrzeg [13] among males was higher than in our study. The mean daily potassium intake among 40-year-old Wroclaw inhabitants was 4,013.3 mg in males, and 3,187.3 mg in females, while among 50-year-old inhabitants it was 3,745.7 mg and 3,051.6 mg, respectively [15, 16]. Among the US population aged 40-59, the daily potassium intake was 3,332 mg in males, and 2,523 mg in females [17]. The daily intake of sodium assessed in the POL-MONICA BIS study, compared with our results, was similar among males but lower among females [13, 14]. Sodium intake assessed in NHANES was very high and amounted to 4,132 mg/day in males, and 2,978 mg/day in females [17].

In the presented study it was observed that despite under-reporting in the study, the intake of minerals, such as iron, phosphorus and copper in almost all of the study group was higher than Polish recommendations [1]. A lower daily iron intake than in our study was observed in previous Polish studies [11,13,14]. The mean daily iron intake among males in Wroclaw was similar to the presented study, while among females it was lower [15, 16]. A higher iron intake than in the presented study among males, and similarly among females, was observed in the US population [17].

A high phosphorus intake was in the the PONS study. Moreover, taking into account the low calcium intake, this may increase the risk of osteoporosis in the study group. How et al. [15, 16] observed an even higher phosphorus intake among the Wroclaw population, especially among males, than in the PONS study group. The phosphorus intake observed in NHANES was also very high and amounted to 1,565 mg/day in males, and 1,111 mg/day in females [17].

Vitamins may play an important role in the prevention of CVD. It must be stressed that vitamin intake should be supplied by a healthy diet, and not by using supplements [19]. In a randomized trial conducted in the UK among people with high risk of death from coronary heart disease, an antioxidant supplementation was analyzed. Vitamin A, C and E supplementation did not have a beneficial impact on treatment [20]. The supplementation of vitamin E has not been supported in many studies [21-23]. It was found that a high antioxidant intake with diet has an influence on reducing the risk of CVD, while the effect of supplementation was not so evident [24]. Moreover, it was found that supplementation may have harmful effects, such as in the case of beta-carotene supplementation, which caused an increased incidence of lung cancer in smokers [25]. No influence on decreasing the risk of recurrent CVD after myocardial infarction were found for vitamin B supplementation [26]. In the presented study, a low vitamin intake was observed, which may result in an increased risk of CVD in the study group.

Mean daily vitamin C intake assessed in the WOBASZ study [11, 12] and in the POL-MONICA BIS study in Tarnobrzeg [13] was lower than in our results, while in the POL-MONICA BIS study in Warsaw [14] it was higher, whereas the daily intake of vitamin C observed in the Wroclaw population was higher than in the PONS study [15, 16]. In the USA, the daily vitamin C intake observed among 40-59-year-old Americans amounted to 107 mg in males, and 91 mg in females [27].

Compared with the presented study, vitamin B intake assessed in the WOBASZ [11,12] and POL-MONICA BIS studies [13,14] was higher in males, and lower in females. The intake of vitamin B1 among Wroclaw inhabitants was similar in females and higher in males than in the PONS study [15, 16]. In a group of 40-59-year-old American population, they consumed more vitamin B (males 1.9 mg/day; females 1.4 mg/day) compared with the presented study [27].

A better achievement of recommendations in the PONS population was found for the intake of vitamin B1, B2 and B12. Among the 40-50-year-old Wroclaw inhabitants, the vitamin B2 intake in females was 1.4 mg/day (in both age...
groups), and in males, 1.8 and 1.7 mg/day, respectively [15, 16]. The daily intake of niacin (vitamin B3) was higher among the 40-50-year-old males in Wrocław (22.5 mg and 20.8 mg, respectively) than in the presented study, while among the females it was lower (14.6 mg and 14.7 mg) [15, 16].

Regarding vitamin E, the results of the presented study were also very low compared with other Polish studies [11-16]. The dietary intake of the PONS participants was measured using a short FFQ, which may have underestimated the daily nutrient intake. Therefore, the results of the presented study may slightly differ from previous studies conducted in Poland, where 24-hours recall was used as a method of measurement.

CONCLUSIONS

Significant differences were observed in the daily intake of some vitamins and minerals by gender, age, level of education, and place of residence. Some participants had a lower intake of some minerals and vitamins than the Polish recommendations. It is important to pay attention to proper proportions between minerals, such as calcium and phosphorus, and between sodium and potassium, because this may play a significant role on the prevalence of such diseases as osteoporosis and hypertension. Insufficient intake of minerals and vitamins should be eliminated by an increase in the consumption of fruit, vegetables, whole grain cereals, and low-fat dairy products. A properly balanced and varied diet will supply a sufficient intake of all necessary nutrients. In Poland, there are institutions which could be involved in the promotion of such action [28].

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