

MINERAL SUPPLEMENTS' EFFECT ON TOTAL NUTRIENT INTAKE IN WARSAW ADULT POPULATION; CROSS-SECTIONAL ASSESSMENT

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ABSTRACT

Background. Mineral supplementation is important whenever any dietary deficiencies of these nutrients occur. However, an excessive consumption of such products can lead to the negative health consequences.

Objectives. To estimate the mineral supplements contribution to total dietary intake for adults living in Warsaw.

Materials and Methods. Within the frame of the EHES JA Poland and WAW-KARD Projects a representative sample of Warsaw population aged 20 years and above was screened in years 2011/2012. Nutrient intake and supplements use were available for 573 men and 497 women. The minerals levels were analyzed in reference to the Recommended Dietary Allowance (RDA) and the Tolerable Upper Intake Level (UL).

Results. In Warsaw population the intake of calcium, magnesium and potassium were lower than RDA, and supplementation didn't eliminate deficiency of these nutrients (except for magnesium in a group of women). Phosphorus intakes were somewhat higher than those recommended. Enriching the diet with zinc and copper supplements in both sexes were unnecessary, as was iron in men, as their daily dietary intakes closely met the recommended standards. Iron supplementation in women however proved effective, as their daily dietary intakes were rather low.

Conclusions. The effectiveness of supplementing the diets of adults living in Warsaw with minerals depends on their type.

Key words: *dietary supplements, minerals, adults, recommended dietary allowance, tolerable upper intake level*

STRESZCZENIE

Wprowadzenie. Suplementy składników mineralnych odgrywają ważną rolę w zmniejszaniu ryzyka niedoborów tych składników odżywczych. Jednocześnie nadmierne spożycie tych produktów może prowadzić do negatywnych konsekwencji zdrowotnych.

Cel badań. Ocena zasadności przyjmowania suplementów składników mineralnych wśród dorosłych mieszkańców Warszawy.

Material i metody. W roku 2011/12, w ramach projektów EHES JA- Polska oraz WAW-KARD, przebadano reprezentatywną próbę populacji Warszawy w wieku 20 lat i powyżej. Ocenę sposobu żywienia oraz przyjmowania suplementów przeprowadzono u 573 mężczyzn i 497 kobiet. Poziomy pobranych składników mineralnych analizowano w odniesieniu do wartości zalecanego spożycia (RDA) oraz najwyższego tolerowanego poziomu spożycia (UL).

Wyniki. Wśród mieszkańców Warszawy średnie spożycie wapnia, magnezu i potasu było niższe niż RDA i niedoborów tych nie uzupełniła zastosowana suplementacja (z wyjątkiem magnezu w grupie kobiet). Pobranie fosforu było zbyt wysokie w stosunku do zaleceń. Wzbogacanie diety suplementami cynku i miedzi u obu płci oraz żelaza u mężczyzn nie miało uzasadnienia, ponieważ średnia zawartość w dziennej racji pokarmowej tych składników mineralnych była zbliżona do zalecanych norm. Suplementacja żelazem w grupie kobiet była efektywna, ponieważ podaż żelaza z dzienną racją pokarmową była zbyt niska.

Wnioski. W dorosłej populacji Warszawy skuteczność stosowanej suplementacji diety składnikami mineralnymi zależała od ich rodzaju.

Słowa kluczowe: *suplementy diety, składniki mineralne, osoby dorosłe, zalecane spożycie, najwyższy tolerowany poziom spożycia*

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INTRODUCTION

Abnormal mineral intake impacts on the aetiology and development of some diseases such as cardiovascular disease, osteoporosis, anaemia, diabetes and certain types of cancer. Deficient and excess intakes or an inappropriate ratio of minerals may also lead to health disorders, reduced immunity and/or heightened susceptibility to various environmental factors [2, 24, 25].

Meeting dietary mineral requirements by various population groups in Poland is fraught with many nutritional anomalies [8, 10, 11, 16, 19, 20, 22, 25]. For this reason some people remedy this situation by taking pharmaceutical products containing vitamins and minerals whose promotion is reinforced by intensive advertising, universal availability and a dynamically developing food supplements market. Enriching the diet with supplements can have two effects; beneficial, whenever deficiencies are compensated for, or adverse, if intakes of certain components are excessive.

The presented study is thus designed to estimate the prevalence and mineral supplements contribution to total dietary intake for the adult population of Warsaw. Previous like studies have, however focused on vitamin supplements [23].

MATERIALS AND METHODS

The material for the analysis comprised the data from the European Health Examination Survey - Joint Action (Polish part) - EHES-JA and from the Warsaw Health Survey - WAW-KARD, which was a continuation of the EHES project [5, 13]. The study included a representative randomized sample of the whole of Warsaw's population aged 20 years and above. The operator of randomization was the PESEL system (*PESEL - Universal Electronic System for Registration of the Population*). The sample randomization scheme was a one-step scheme - a simple sample stratified in terms of sex and place of residence (department of Warsaw). Profiles of classic risk factors for lifestyle diseases were obtained from questionnaires, laboratory findings, anthropometry, blood pressure and dietary assessment.

Dietary patterns and supplement intake were assessed using the 24-hour recall method, in which respondent provides all the products, food and beverages consumed within 24-h before recall. Food portion sizes were established with the aid of a 200 photograph album of foodstuffs designed by the Warsaw National Food and Nutrition Institute (IZZ). Subjects were also asked the names of taken supplements and their doses.

The minerals intake in the diet was calculated based on the amount of food consumed, with the use of Polish "Food Composition Tables" [12]. The amount of mine-

erals derived from supplementation was estimated using the NFNI 4D Diet (*IZZ Dieta 4D*) software, that includes a database nutrient pharmaceutical formulations in 1231 supplements, available on the Polish market.

The analyses included the data on 573 men and 497 women aged 20 years and above from the EHES and WAW-KARD studies and whose dietary data were reliable.

The levels of minerals were analyzed in reference to the Recommended Dietary Allowance (RDA) [25] and the Tolerable Upper Intake Level (UL) [4].

Statistical methods

The statistical analyses were performed with the Statistical Analysis System (SAS) 9.2 program. The methods of descriptive statistics were employed, the percentage of subjects taking supplements and the mean minerals intake from food and from supplements were calculated.

RESULTS

Warsaw residents most often took supplements containing magnesium (around 20% in both genders) followed by potassium (about 11% in both genders), calcium and zinc (approximately 12-13% women) but more rarely phosphorus and copper (4-7% of the population); Table 1.

Mineral intake doses derived from supplements (among supplement users of a selected nutrient)

Those taking supplements, were found to consume minerals from this source excessively above recommendations concerning iron and copper in both genders and zinc for only women. Depending on the minerals, the intake ranged from 118% to 187% of the RDA. At least fivefold higher intakes of iron than those recommended were observed in 2.6% men and 17.2% women taking iron supplements. Zinc intakes exceeded the UL in 2% men and magnesium in both genders by 1%; Table 1.

Minerals intake in daily food ration

Subjects from both genders, taking or not taking supplements, showed significant deficiencies in their diets of calcium, magnesium and potassium along with some in zinc, with also inadequate dietary intakes of iron for women. The mean copper and iron intakes from food were within recommendations. Daily dietary intakes of phosphorus exceeded those recommended for both men and women; Table 2.

Advisability of taking supplements

The efficacy of dietary supplementation depended on the type of mineral. The low dietary intakes of cal-

Table 1. Minerals intake from supplements (among supplement users of a selected nutrient) in relation to Recommended Dietary Allowance (RDA) and the tolerable upper intake level (UL) in Warsaw population in years 2011/12

Mineral	Supplement users; numbers (percentage)	RDA	Mean intake % RDA	UL	% subjects with intakes exceeding	
					>5 RDA	>UL
Men						
Calcium (mg)	39 (6.8)	1100	16.5	2500	0	0
Phosphorus (mg)	25 (4.4)	700	13.7	-	0	-
Magnesium (mg)	113 (19.7)	420	18.6	250 ¹	0	0.88
Potassium (mg)	61 (10.7)	4700	3.5	-	0	-
Iron (mg)	39 (6.8)	10	176.4	-	2.6	-
Zinc (mg)	51 (8.9)	11	94.7	25	0	1.96
Copper (mg)	39 (6.8)	0.9	186.9	5	0	0
Women						
Calcium (mg)	67 (13.5)	1100	33.7	2500	0	0
Phosphorus (mg)	17 (3.4)	700	13.7	-	0	-
Magnesium (mg)	109 (21.9)	315	22.9	250 ¹	0	0.92
Potassium (mg)	54 (10.9)	4700	5.0	-	0	-
Iron (mg)	35 (7.0)	13	247.0	-	17.2	-
Zinc (mg)	60 (12.1)	8	118.0	25	0	0
Copper (mg)	26 (5.2)	0.9	180.9	5	0	0

¹ - UL refers only to the magnesium derived from supplements but not from the regular diet

Table 2. Daily mineral intakes derived from food and supplementation in Warsaw population in years 2011/2012 either taking or not taking supplements

Minerals	Supplement nonusers		Supplement users				
	Average intake from food	% RDA	Average intake			% RDA	>UL
			from food	from supple- ments	total		
Men							
Calcium (mg)	592± 433	53.8	687±508	182±113	869±510	80.0	2.6
Phosphorus (mg)	1220±495	174.3	1237±482	96±37	1332±488	190.4	-
Magnesium (mg)	293±127	69.7	297±115	78±60	375±130	89.4	-
Potassium (mg)	3126±1263	66.5	3050±1161	167±193	3217±1151	68.4	-
Iron (mg)	11.6±5.0	115.5	11.6±5.3	17.7±30.6	29.3±30.0	292.8	-
Zinc (mg)	10.5±4.4	95.5	10.9±4.0	10.4±6.1	21.3±7.5	193.6	35.3
Copper (mg)	1.14±0.48	126.7	1.25±0.47	1.68±0.71	2.93±0.79	325.5	0
Women							
Calcium (mg)	514±308	46.8	586±338	370±246	956±456	86.9	1.5
Phosphorus (mg)	957±360	136.4	1028±447	96±42	1124±472	160.6	-
Magnesium (mg)	238±92	75.4	252±92	72±55	324±105	103.1	-
Potassium (mg)	2579±958	54.8	2454±844	235±223	2689±847	57.2	-
Iron (mg)	8.9±3.6	68.7	9.3±3.4	32.1±32.9	41.4±33.9	318.4	-
Zinc (mg)	7.7±2.8	95.8	8.1±2.6	9.4±6.5	17.5±7.5	219.3	18.3
Copper (mg)	0.96±0.38	106.7	1.05±0.36	1.62±0.71	2.67±0.84	296.7	0

cium and potassium in both genders, and magnesium in men, were found not to be sufficiently compensated for by supplementing with pharmaceutical products to remove any deficiencies.

Supplementing the diet with magnesium and iron was however sufficient to cover their recommended nutritional requirements. Nonetheless, taking supplements of phosphorus, copper and zinc for both genders as well as iron in men was unnecessary, because the diet was a sufficient source of these minerals, being close to the recommended levels; in some subjects, zinc intakes exceeded the tolerable upper intake level (UL); Table 2.

DISCUSSION

Our study has demonstrated significant defects in quality of diet for the studied inhabitants of Warsaw, where seriously low intakes of calcium, potassium and magnesium have been found. Furthermore, such deficiencies were not sufficiently compensated for, by the taking of supplements; excepting magnesium in women subjects. Daily calcium dietary intakes for instance, only covered the recommended standards by 47-60%. Those taking calcium supplements, however showed a rise in this aspect by respectively 17% and

34% in men and women, but not enough to make up the dietary deficiency. Nevertheless, around 2-3% of the subjects that took calcium supplements managed to exceed the UL.

Many studies draw attention to the general prevalence of dietary calcium intake deficiency. Indeed, household budget surveys [20] and the WOBASZ study [19] conducted on representative population samples in Poland have shown low daily intakes of dietary calcium at levels ranging 500-780 mg. Other studies on various population groups in Poland, irrespective of age, have also demonstrated such intake deficiencies of this mineral [1, 11, 18, 22]. Throughout Europe however, calcium intake is variable, with Poland being the lowest at around 500-600 mg but Germany and Scandinavia the highest (about ≥ 1100 mg), where no health risks had been identified associated with its excessive consumption [6].

Low calcium intakes, lasting for long periods, may adversely affect health advancing the development of diseases of affluence such as hypertension, coronary heart disease, certain cancers and osteoporosis. Intestinal absorption of calcium also becomes impaired when dietary intake of vitamin D is low, but phosphorus is high [2]. Such a situation is observed in the diet of Warsaw inhabitants, where the intake ratio, by weight, of calcium to phosphorus lies within 0.5:1.0 in those not taking any supplements, whilst it is 0.65-0.85:1.0 for those that did; the recommended ratio however being 1.3:1.0 [2]. It is also unfortunate that increasingly excessive phosphorus intakes have been noted in Poland; not just in Warsaw [1, 11, 18, 20, 22]. Phosphorus is a trace-element widespread in foodstuffs and soft, sparkling drinks. By manufacturers it is frequently added as a preservative. Such a high dietary phosphorus content may adversely affect the uptake of minerals other than calcium like iron, copper, magnesium and zinc [25]. The only favourable finding for phosphorus was that low numbers of Warsaw inhabitants took it as supplements (4%), which only marginally increased its total intake.

Average magnesium intakes derived from foodstuffs for Warsaw inhabitants, ranged 240-290 mg which was significantly far below optimal values. Even though this trace-element was supplemented in 20% subjects, it was only in women that adequate intakes were achieved relative to the recommendations. Most industrialised countries, including Poland, show deficiencies in magnesium intakes. Those having adequate intakes were only Germany, for both sexes and Spain for women only; the rest being below recommended standards [6]. In Poland, low magnesium intakes are particularly acute in women [1, 10, 15, 16, 19, 20, 22], nonetheless in some groups that take supplements, magnesium deficiencies were overcome [16, 15, 19]. The dietary intakes of

magnesium were found to adequately match recommendations only in students from Lower Silesia [11].

As with calcium, magnesium deficiency can lead to cardiovascular disease, that includes coronary artery disease, myocardial infarction, arrhythmia and sudden death as well as certain cancers, anaemia and neurological symptoms. This arises because magnesium participates in many metabolic reactions, where it is a cofactor in over 300 enzymatic reactions essential to energy transfer and the synthesis of protein and nucleic acids [2, 25].

Subjects also demonstrated low dietary intakes of potassium which, even when supplemented by those taking pharmaceutical products (by 6-7%), proved insufficient to overcome the deficiency. Such a finding of potassium intake deficiency, coupled to similar observations by other studies [10, 22], is highly disturbing especially when manifested in women [11, 18, 20]. Potassium is vital in water homeostasis and for maintaining the body's acid-base balance, together with regulating the activity of muscle and joints [2]. Past studies indicate a inverse relationship between dietary potassium and its blood concentration with incidence rates of stroke and cardiac arrhythmia [24]. It is also worth emphasising that significantly higher potassium intakes are important for the non-pharmacological treatment of hypertension and in preventing renal disease [7].

When considering the obtained intake results for calcium, magnesium and potassium it should be noted that their actual intakes may in fact be even lower. Such a view arises from a study by *Marzec et al* [17], which demonstrated that the mineral intakes obtained from dietary survey interviews were an overestimate compared to actual values determined by flame absorption atomic spectrometry on duplicate reconstructed diets.

The iron intakes found from the female subjects' diets were also incompatible with the body's requirements, especially taking into consideration the losses incurred due to menstruation, pregnancy and lactation [2]; men's intakes of this element however adequately fulfilled the recommended standards. However, upon iron supplementation those deficiencies were cancelled out in women and the high doses taken in around 3% men and 17% resulted in a five-fold exceedance of the RDA from iron derived from just the supplementation alone. It should be noted that the UL for iron has not yet been established.

Other studies report similar iron consumption; the WOBASZ study [19] and household budget surveys [20] showed deficient dietary intakes for women as also did other studies conducted in groups of variously aged women [1, 8, 9, 11, 14]. Many of these studies however found that men's iron consumption was close to recommended levels [1, 3, 19, 20]. In many cases, iron supplementation constituted a necessary component of the

intake in achieving adequate levels [14, 19]. Generally speaking it is considered that there is no risk in excessive iron consumption *via* the total diet in European countries (including iron supplementation/fortification), although some women taking supplements may suffer a short-term risk from excessive intakes of iron [6].

Iron is a cofactor for numerous enzymes and is vital component of haemoglobin and myoglobin on which cellular respiration depends upon. It also plays a key role in red blood cell formation and in aiding the immune system for combating bacteria and viruses [2].

On average, daily dietary intakes of zinc and copper were close to those recommended at respectively $\approx 95\%$ and $>100\%$ of the RDA for the subjects studied. In case of zinc, taking supplements on one hand made up for small dietary deficiencies but worryingly, 36% of men and 18% women exceeded the UL threshold when taking these supplements. A different study performed on Lublin University students, found that over half consumed somewhat high amounts of zinc, from the diet and supplements, with the RDA being greatly exceeded [15]. Likewise for copper, the UL levels were not exceeded from dietary intake, however in those taking supplements this level was surpassed by 300%. Other similar studies throughout Poland have shown analogous results for zinc [1, 10, 18, 21] and copper [1, 18, 20, 21, 22], however comparing these results to standards is difficult as in the past the standards themselves have changed making outcomes that were previously considered deficient now to be within recommendations.

In Europe mean daily dietary zinc intakes for men vary from 9.3 mg in Spain to 14.6 mg in Germany, whilst for women 7.2 mg in Ireland to 10.9 mg in Germany and copper from 1.4 mg for men and 1.0 mg for women in the UK to 2.1 mg in both genders in Germany [6]. EU data indicate that zinc and copper are dietary components for which there is a risk of excess consumption and exceedance of the UL [4, 6]. The beneficial role of zinc arises from it being a component of over 300 enzymes, its involvement in eliminating free radicals and participating in the metabolism of fatty acids and prostaglandins. Taking large and regular doses of zinc over the long-term may lead to decreased immune response, affect iron metabolism and detrimentally impact nutrient role of copper. Copper is a component of enzymes involved in oxygen metabolism, iron transport and hem synthesis [2, 25].

CONCLUSIONS

The following was found for the sample of surveyed Warsaw residents:

1. Dietary intakes of calcium, magnesium and potassium were very low and those deficiencies were not sufficiently made up by taking supplements (except: magnesium in women).
2. Phosphorus intakes were somewhat higher than the nutritional recommendations.
3. Daily dietary intakes of zinc and copper in both sexes as well as iron in men were close to those recommended. Supplementing the diet with these elements was unjustifiable, especially in the case of zinc with the UL being exceeded.
4. Dietary iron supplementation for women was advisable because the daily dietary intakes were rather low, nonetheless in some women taking such supplements can lead to too high dosing.

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Conflict of interest

The authors declare no conflict of interest.

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