Rocz Panstw Zakl Hig 2015;66(1):61-67

EVALUATION OF MINERAL STATUS IN HYPERTENSIVE PATIENTS UNDERGOING PHARMACOTHERAPY

Katarzyna Marcinek[1], Joanna Suliburska[1], Zbigniew Krejpcio[1], Paweł Bogdański[2]*

[1]Department of Human Nutrition and Hygiene, Poznan University of Life Sciences, Poznan, Poland
[2] Department of Internal Medicine, Metabolic Disorders and Hypertension, University of Medical Science, Poznan, Poland

ABSTRACT

Background. The widespread and increasing occurrence of obesity, hypertension and associated disease has necessitated serial testing in order that risks of contracting such conditions become minimised through appropriate therapy and prevention. Many studies report that nutritional factors significantly affect the aetiology of hypertension and obesity that include mineral uptake. There are only a few studies however which are focused on the body's changing mineral content during pharmaco-therapeutic treatment.
Objectives. To determine concentrations of minerals in the hair and urine of hypertensive patients in conjunction with assessing their nutrition.
Material and Methods. Subjects were 17 patients presenting with essential hypertension and 18 healthy controls. Atomic absorption spectrometry (AAS) was used to measure Mg, Ca, Fe, Zn and Cu in the hair and urine on a Zeiss AAS-3 instrument. Dietary mineral intakes were assessed by interview over 24 hours prior to the analysis.
Results. The hypertensive group had significantly lower urine concentrations of Ca and Mg as well as Mg and Zn in hair. Urinary zinc excretion was significantly increased in this group compared to controls, but dietary intakes of Cu were reduced. The dietary mineral intakes were found to be unrelated to the concentrations of such minerals in the hair and urine.
Conclusions. Compared to controls, excretion of Ca and Mg were reduced in hypertensive subjects, whereas Zn excretion was higher, and Mg and Zn were relatively low in the hair. Daily dietary intakes of Cu were also reduced in the hypertensive.

Key words: *hypertension, minerals, nutritional status, atomic absorption spectrometry method*

STRESZCZENIE

Wprowadzenie. Ze względu na szeroko rozpowszechnione występowanie otyłości i nadciśnienia tętniczego oraz wzrost częstości zachorowań konieczne jest prowadzenie szeregu badań, które pozwoliłyby na minimalizację ryzyka wystąpienia tych chorób, dzięki właściwej terapii i prewencji. Liczne badania donoszą o istotnym wpływie czynników żywieniowych, w tym podaży składników mineralnych, na etiologię nadciśnienia tętniczego i otyłości. Natomiast niewiele jest badań dotyczących zmian zawartości składników mineralnych w organizmie zachodzących pod wpływem farmakoterapii.
Cel. Celem badań była ocena stężenia składników mineralnych we włosach i moczu pacjentów z nadciśnieniem tętniczym oraz ocena sposobu ich żywienia.
Materiał i metody. W badaniu uczestniczyło 17 pacjentów z pierwotnym nadciśnieniem tętniczym i 18 pacjentów zdrowych. Zawartość Mg, Ca, Fe, Zn, Cu we włosach i moczu oznaczono metodą spektrofotometrii atomowo-absorpcyjnej (AAS), przy użyciu spektrofotometru Zeiss AAS-3. Oceny spożycia poszczególnych składników mineralnych dokonano przy pomocy 24-godzinnego wywiadu żywieniowego przeprowadzonego w dniu poprzedzającym badanie.
Wyniki. Stwierdzono istotnie niższe stężenia Ca i Mg w moczu grupy badanej. Zaobserwowano istotne obniżenie zawartości Mg i Zn we włosach osób chorych na nadciśnienie tętnicze. Wydalanie Zn z moczem było istotnie zwiększone w stosunku do grupy kontrolnej. Ponadto wykazano niższe spożycie Cu wśród badanych osób. Nie wykazano istotnych statystycznie zależności między spożyciem poszczególnych składników mineralnych a ich zawartością we włosach i moczu.
Wnioski. U osób z nadciśnieniem tętniczym obserwowano zmniejszone wydalanie Ca i Mg, a zwiększone Zn w moczu oraz względnie niskie stężenie Mg i Zn we włosach. W całodziennych racjach pokarmowych osób z pierwotnym nadciśnieniem tętniczym występowała zbyt niska podaż Cu.

Słowa kluczowe: *nadciśnienie tętnicze, składniki mineralne, stan odżywienia, metoda AAS*

***Corresponding author:** Katarzyna Marcinek, Department of Human Nutrition and Hygiene, Poznan University of Life Sciences, Wojska Polskiego Street 31, 60-637 Poznan, Poland, phone + 48 61 848-7334, e-mail: kmarcin@up.poznan.pl

INTRODUCTION

Hypertension is a chronic disease of the circulation. It is the most commonly occurring modern day disease belonging to the poly-metabolic syndrome group. If untreated, it may lead to cardiovascular complications and disorders of metabolism, haemodynamics and neuroendocrinology. For such reasons it is necessary to tailor treatment to the individual. Such treatments depend on the magnitude of the hypertension, its duration and any complications arising, with an increased BMI being a risk factor. Adopting pharmacotherapy does not however preclude non-pharmacotherapy treatments (e.g. reducing body mass, increasing physical activity) when used, above all, systematically in order to ensure effectiveness. As well being genetically predisposed, the pathogenesis of hypertension includes a major role for high salt and high fat diets, obesity, low levels of physical activity, smoking and excess alcohol consumption. Changing dietary habits is important in preventing and treating hypertension. In preventing circulatory disorders, anti-oxidant vitamins and minerals are key; the latter including Potassium (K), Sodium (Na), Calcium (Ca), Magnesium (Mg), Iron (Fe), Copper (Cu) and Zinc (Zn), with particularly Mg affecting hypertension. An appropriate intake of this element facilitates blood vessel relaxation leading to blood reducing pressure [15, 22]. Keeping to a diet balanced with Ca (≈900 mg intake) and Mg (≈350 mg intake) allows blood pressure to normalise [19]. For Ca alone, its hypotensive action results from dietary supplementation when intakes are low [1, 12]. According to *Hatton* and *McCarron*, increasing blood pressure arises from a defect in Ca metabolism that leads to hypercalciuria and increased secretion of parathyroid hormone. Increasing Ca intakes normalises the hypercalciuria and restores the hormonal balance [14]. Many studies have indicated the beneficial effects of Ca supplementation with an increased dietary salt intake [33]. The role of Fe and Cu in hypertension pathogenesis is still not fully known. However, mildly decreased Fe levels are recognised to be significant in preventing cardiovascular disease, but excessive levels cause atherosclerotic lesions through participating in lipid peroxidation, generating active oxygen species and thereby damaging the endothelium [8, 26].

Studies by *Goch* et al. reported lowered Zn but increased Cu plasma concentrations in hypertensive patients. Furthermore, the serum Zn/Cu molar ratio was decreased in those with hypertension when coupled with a prolonged duration of the illness [9, 34]. The anti-oxidant elements selenium and Zn are considered to play a large role in the pathogenesis of hypertension. Zn possesses antioxidant properties that stabilise the cell membrane and significantly affects the activities of zinc-dependent enzymes [20]. *Goch* et al. [11] demonstrated a positive correlation between low Zn levels and increased blood pressure, suggesting that mineral supplementation could thus be beneficial in dealing with hypertension.

The study aim was to therefore assess the body's mineral nutritional status based on determining the mineral content in hair and urine along with the dietary habits of subjects suffering from hypertension.

MATERIAL AND METHODS

Permission for undertaking the study was obtained from the Bioethical Commission (No. 86/09) at the Medical University of Poznan. Subjects were Poznan residents living in the Swarzedz district consisting of 19 women and 16 men, aged 57.72 ±10.53 years. Two groups were formed; test and controls. The latter were healthy individuals that were not taking any pharmacotherapy nor vitamin-mineral supplements. The former were patients diagnosed with hypertension according to the criteria set by the Polish Hypertension Society and who had been undergoing treatment for the last 2 years. The controls were made up of 18 subjects (8 women and 10 men) aged 45.8 ±13.5 years, who underwent an anthropometric and dietary survey and from whom hair and urine samples were obtained for the measurement of Ca, Mg, Fe, Zn and Cu.

Subjects were interviewed on their diet according to the method of 'current reporting' by using a 'Photograph Album of Foodstuffs and Dishes' (provided by the National Institute of Food and Nutrition, Poland) [28]. Dietary data was recorded from the 24 hours preceding the study, from which calorific values and the dietary composition of specified nutrients were obtained. Calculations also took into account the culinary/technological losses set at 10%.

Levels of Ca, Mg, Fe, Zn and Cu were then measured in samples of hair and urine. A cut 1 cm length of hair growing from the skin at 6 locations of the occipital part of the head was used as samples. Hair that had been dyed or permed was not used so as to avoid any artifactual environment effects. Hair samples were then washed in acetone and deionised water, followed by drying at 105-110ºC, which were then dried, weighed and then mineralised with HNO_3 in a Mars CEM apparatus. A fasting urine sample was obtained after nigh time. The mineral elements were measured by atomic absorption spectroscopy (AAS) on the Zeiss AAS-3 instrument.

RESULTS

The profiles of the test (n=17) and control (n=18) groups are shown in Table 1 with the former aged

Table 1. Profiles of studied groups

Parameter	Test group			Control group		
	Mean	W	M	Mean	W	M
Numbers subjects	17	11	6	18	8	10
AGE						
AM±SD	59.8 ± 6.3	61.5 ± 6.3	56.8 ± 5.6	45,8 ± 13,5	46.9 ± 15.2	44.4 ± 11.8
Median	60.0	62.0	56.0	42.0	46.0	38.5

W- Women, M- Men, AM - arithmetic mean, SD- standard deviation

Table 2. Daily dietary intakes of nutrients and calories for studied subjects

Parameter		Test group			Control group		
		Mean	W	M	Mean	W	M
Calories[kcal]	AM±SD	1559.1±547.7	1213.4±572.7	1892.8±312.0	1934.1±610,5	1468.1±526.2	2185.2±575.3
	Median	1533.4	1511.3	1883.5	1859.7	1818.9	2299.2
Protein [g]	AM±SD	55.5±15.5[a]	40.5±14.1	65.0±14.2	70.3±19.2[a]	52.8±14.3	76.6±21.0
	Median	50.4	45.9	67.0	69.0	61.1	72.5
Fats [g]	AM±SD	68.2±37.0	58.8±35.4	95.8±21.8	82.8±37.5	67.0±29.2	99.9±35.5
	Median	71.1	49.3	103.5	80.6	60.0	96.4
Carbohydrates [g]	AM±SD	195.0±69.4	150.5±76.6	210.2±56.9	247.6±75.7	187.3±79.3	268.7±69.4
	Median	187.2	165.9	206.2	238.6	214.4	306.6
Saturated fatty acids [g]	AM±SD	25.2±17.1[b]	22.4±16.4	35.5±14.3	33.6±12.5[b]	26.7±11.4	40.3±9.1
	Median	24.8	15.2	31.9	33.9	27.3	37.0
Monounsaturated fatty acids [g]	AM±SD	27.9±15.1	23.1±13.9	39.5±9.7	30.3±16.0	24.5±12.2	37.1±15.9
	Median	26.4	21.0	39.4	27.1	18.6	38.9
Polyunsaturated fatty acids [g]	AM±SD	9.8±5.4[c]	8.2±4.2	13.7±5.3	12.8±9.4[c]	10.5±6.9	15.0±10.8
	Median	9.3	7.1	13.6	9.5	8.1	12.4
Cholesterol [mg]	AM±SD	271.3±255.1	230.4±276.1	273.3±236.1	240.0±131.4	189.8±48.1	307.4±139.5
	Median	164.7	160.2	181.0	198.1	138.0	294.3
Sucrose [g]	AM±SD	33.5±21.4	29.3±22.8	30.2±20.4	40.7±25.4	33.0±36.2	37.6±13.1
	Median	32.9	31.5	38.9	32.9	32.3	37.1
Dietary fibre [g]	AM±SD	15.2±4.9	11.6±4.6	17.9±4.6	21.7±10.1	17.4±7.6	24.6±11.2
	Median	14.7	12.2	17.7	20.5	15.7	22.9

[a, b, c] – Statistically significant at $p<0,05$, DDI – Daily dietary intake, AM- Arithmetic mean, SD- Standard deviation, W- Women, M- Men

59.8 ±6.3 years and the latter 45.8 ±13.5 years. In all there were 19 women and 16 men taking part. Dietary intakes of macro and micro-nutrients are shown in Table 2. The average calorific intake in the controls was 23-39% lower than recommended values. Daily dietary intakes of protein in the hypertensive were also significantly lower than controls (55.5 g vs. 70.3 g). It is noteworthy that the dietary calories derived from fat exceeded recommended values for both groups. Dietary carbohydrates were lower in the test group compared to controls, where healthy men had 20% higher intakes than the hypertensive. The test group consumed significantly lower amounts of saturated fatty acids than controls (25.2 g vs. 33.6 g).

There were was no significant differences in dietary monounsaturated fatty acids between both groups, however significant differences were observed for dietary polyunsaturated fatty acids between test and controls; respectively 9.8 ±5.4 g vs. 12.8 ±9.4 g. Both groups showed mean dietary intakes of cholesterol to be lower than the recommended value for maximum consumption (330 g). In addition, it was observed in both groups that the dietary fibre intake was 35% higher in women than men. The dietary analyses also included daily intakes of chosen minerals (Table 3) and the proportion of recommended standard intakes that this represents. A significantly lower intake of Cu in the test group was found compared to controls; respectively 0.9 ±0.3 mg vs 1.1 ±0.4 mg. Dietary Mg intakes constituted 72.7% of the Recommended Daily Allowance (RDA) in the hypertensive and 94.1% RDA for healthy controls. In men, recommended dietary Mg intakes were 105.2% RDA in the controls. Fe levels in the diet of the test group were lower than controls (72% RDA). Hypertensive women consumed less Fe than healthy women control (67.9% RDA vs. 72% RDA), whereas for men this position was reversed (67.9% RDA vs. 58.1% RDA). The dietary requirement targets for Zn in the test group were attained by 58% and 67% for controls.

The mean concentrations of mineral elements (Ca, Mg, Fe, Cu, Zn) in hair and urine are presented in Tables 4 and 5. Urinary Mg and Ca in the test group were lower than for controls. Healthy women had 30% higher urinary levels of Ca than the hypertensive, whereas this

Table 3. Daily dietary intakes of mineral elements measured in studied subjects

Parameters		Test group			Control group		
		Mean	W	M	Mean	W	M
Ca [mg]	AM±SD	426.0±256.2	356.3±284.0	471.6±212.0	655.3±409.6	563.4±473.5	618.2±373.0
	Median	386.6	340.3	527.6	625.3	625.3	590.8
Mg [mg]	AM±SD	218.0±77.5	169.7±72.6	245.6±85.3	282.2±131.4	218.0±90.0	315.7±153.3
	Median	213.7	183.5	232.7	240.3	223.7	282.1
Fe [mg]	AM±SD	9.5±5.2	7.6±6.4	9.4±2.5	10.1±4.1	7.8±1.8	11.6±4.8
	Median	8.0	7.3	9.3	9.3	7.6	10.4
Zn [mg]	AM±SD	8.7±3.1	7.0±3.6	10.9±3.0	10.1±4.3	8.0±1.7	12.0±5.0
	Median	9.0	6.9	11.5	9.5	7.4	10.8
Cu [mg]	AM±SD	0.9±0.3[a]	0.7±0.3	0.9±0.2	1.1±0.4[a]	0.9±0.2	1.3±0.5
	median	0.9	0.8	1.0	1.0	0.9	1.2

[a] – statistically significant at $p<0.05$, DDI – daily dietary intake, AM- arithmetic mean SD- Standard deviation, W- Women, M- Men

Table 4. Mineral content of hair in studied subjects

Parameters		Test group			Control group		
		Mean	W	M	Mean	W	M
Ca [µg/g]	AM±SD	1742.0±1580.7	1505.2±1589.6	2073.5±1687.0	1356.2±1217.6	1905.3±1567.1	875.7±543.1
	Median	1153.1	400.0	1553.8	887.5	1517.9	847.9
Mg [µg/g]	AM±SD	58.8±48.2	32.1±181.6	94.4±54.1	60.4±36.1	59.5±41.1	60.9±35.1
	Median	40.8	33.0	83.0	50.4	54.9	50.5
Fe [µg/g]	AM±SD	67.3±96.4	60.0±111.0	80.6±68.9	35.2±31.9	28.0±22.2	41.5±38.9
	Median	30.9	25.6	68.9	30.2	22,.	31.6
Cu [µg/g]	AM±SD	13.8±7.7	13.8±7.5	13.8±9.1	13.0±10.0	12.4±7.6	13.6±12.2
	Median	11.2	12.4	8.6	9.2	9.4	9.2
Zn [µg/g]	AM±SD	212.4±136.3	192.1±127.5	249.5±156.1	220.9±63.5	207.0±59.3	232.1±67.7
	Median	163.5	163.5	173.5	219.6	219.6	218.1

$p> 0.05$, W-women, M- men, AM- arithmetic mean, SD- standard deviation

increase was higher in men at 55%. Despite generally low Zn consumption, this element was significantly raised in the urine of hypertensive. There were no other significant differences in mineral elements between the test group and healthy controls. Molar ratios of the mineral analytes were also calculated, which in the following cases proved significant; Fe/Zn in hair (with the test group being higher at 0.36 ±0.36 vs. controls at 0.018 ±0.16), Zn/Cu in urine (with the test group being higher at 9.46 ±6.36 vs. controls at 8.36 ±7.71) and Zn/Cu in hair (with the healthy controls being higher at 20.48 ±9.21 vs. hypertensive at 16.07 ±7.47.

DISCUSSION

Healthy nutrition plays an important role in treating and preventing hypertension. Vital areas include consuming dietary fibre, polyunsaturated fatty acids and minerals, of which Ca, Mg, Zn, Cu and Fe are important. Also of import, is that these minerals are present in appropriate proportions. A deficient intake in one may disrupt the effects of the others leading to abnormalities in metabolism and humoral blood pressure control through effects on the synthesis of protein, hormones and other factors influencing epithelial function. Such inter-dependencies have been observed by *Steffen* et al. [25], who studied the effects of dairy product consumption on the development of hypertension. This study was performed on n=4304 subjects aged 18 -30 years, where a low dietary intake of Ca was observed in those with hypertension. A WOBASZ study aimed at determining Polish nutritional habits, found that Ca intake levels were 51% and 41% of those recommended in respectively men and women [27]. Similar findings were reported by *Mi-Hyun* et al. that estimated a daily dietary Ca intake of 360.5 mg for hypertensive and 429.9 mg in healthy subjects [23]. An increased consumption of Ca is linked with its increased urinary excretion. A positive association between Ca ions and blood pressure levels was observed by *Ram* et al in hyper- and normal – tensive patients [24], as likewise a study by *Hamet* et al. on 182 Canadian subjects [13]. However, a study by *Taylor* on subjects taking the DASH diet did not find any effect of dietary Ca intake on its urinary levels [32]. When measuring micro- and macro-components of hair Ca concentrations were insignificantly higher in a test group (463.3 µg/g) compared to controls (437.0 µg/g) [11]. Similar results were found in the presented study. Raised levels of Ca in hair have

Table 5. Urinary mineral content in studied subjects

Parameters		Test group			Control group		
		Mean	W	M	Mean	W	M
Ca [μg/ml]	AM±SD	125.4±84.4[a]	135.3±99.7	105.5±18.3	217.1±151.5[a]	195.0±152.3	233.7±173.5
	Median	105.0	118.8	87.8	170.7	170.7	176.6
Mg [μg/ml]	AM±SD	62.2±28.3[b]	59.0±25.3	68.8±35.7	97.1±40.6[b]	93.7±46.9	100.0±38.0
	Median	50.3	56.6	50.3	87.7	96.5	85.8
Fe [μg/ml]	AM±SD	0.34±0.18	0.31±0.19	0.43±0.14	0.32±0.21	0.31±0.17	0.32±0.24
	Median	0.29	0.26	0.45	0.24	0.26	0.22
Cu [μg/ml]	AM±SD	0.060±0.035	0.050±0.027	0.087±0.037	0.057±0.038	0.053±0.023	0.060±0.048
	Median	0.051	0.051	0.086	0.051	0.056	0.042
Zn [μg/ml]	AM±SD	0.54±0.55[c]	0.41±0.28	0.82±0.88	0.36±0.25[c]	0.26±0.09	0.44±0.31
	Median	0.38	0.32	0.42	0.28	0.28	0.37

[a, b, c]- statistically significant at $p<0.05$, W -women, M- men, AM- arithmetic mean, SD- standard deviation

been reported by *Durkalec-Michalski* et al. (1381±780 μg/g vs. 1102±869 μg/g) in 30 patients [4]. A 12% higher excretion of Ca compared to healthy controls was found by a retrospective study by *Eisner* et al. [6] on 462 patients. The current study showed reduced Ca excretion in the hypertensive patients compared to the healthy controls.

Many studies confirm the positive effect of Mg on the circulatory system. *Chiuve* et al. found, in a prospective cohort study, that dietary magnesium levels affect the development of coronary heart disease [3]. An assessment of dietary supplementation with magnesium and added vitamin B_6 was undertaken by *Kozielec* et al. which determined mean Mg levels in hair and found those lowest to be in patients treated with diuretics (at 11.4 μg/g) and those highest in patients on *beta*-blockers (at 32.87 μg/g). In all patient groupings, there was a significant increase in ionised Mg after supplementation which was linked to the proportional decrease in clinical symptoms as previously observed. Also following the supplementation, the systolic and diastolic blood pressures fell respectively by 20 mm Hg and 10 mm Hg [18].

There is numerous data indicating an inverse association between dietary Ca and Mg intakes with blood pressure, however much less is known about Ca and Mg urinary excretion and its link to blood pressure. *Kesteloot* et al. [17] showed a positive relationship between 24 hour urinary Ca and Mg excretion and blood pressure in two cross sectional studies, where in the case of Mg excretion and blood pressure, the link was more pronounced in women than men [17]. A study by *Goch* et al. compared Mg concentrations in hair, serum and urine of 170 subjects divided into 3 groups; those clinically healthy, and hypertensive patients with or without complications. There were no significant differences in hair Mg levels between groups; as found in the presented study, whereas the urinary Mg daily excretion in the 3 groups were respectively 248 ±98 mg, 270 ±148 mg and 274 ±169 mg [10]. The current study showed mean urinary Mg levels from the morning in hypertensive to be significantly lower than the healthy controls. Of note is a Mg result obtained by *Durkalec-Michalski* in hair where levels were significantly higher in the test group than controls; 104±122 μg/g vs. 64±54 μg/g [4]. A reverse observation was reported in another study, *Goch* et al. [11], as was also seen in the presented study. Patients that suffered acute ischemic stroke were found to have higher Mg levels in hair than controls [16].

Iron, as a constituent of antioxidant enzymes also affects blood pressure levels. The current study observed no differences in daily dietary intakes of Fe between test and control groups [16], unlike the *Całyniuk* et al. study which did. They looked at adolescent nutrition in boys aged 16-18 years and found higher dietary Fe levels in hypertensive boys compared to their healthy peers [2]. The *Michalski* study reported mean Fe levels of 47.6 ±40.2 μg/g in hypertensive compared to healthy controls; 36.6 ±20.7 μg/g [21]. Hair levels of Fe were determined as being 17.25 ±13.19 μg/g in hypertensive and 21.43 ±15.49 μg/g in healthy subjects by *Goch* et al [11], however Zn levels in hair were significantly lower in hypertensive than healthy subjects. Lower Zn levels in hair were also demonstrated by *Tang* et al. [31] and *Michalski* [21]; 163±111 μg/g vs. 235±52 μg/g. In another study by *Goch* et al. [10], plasma levels of Zn and Cu were measured in those suffering from arterial hypertension (hypertension) dived into 3 groups depending on symptom duration and with or without complications. This found that decreased Zn concentrations and increased plasma Cu, along with a decreased Zn/Cu ratio occurred for the duration of hypertension, whilst an increase in Zn and Cu plasma concentrations coupled with a decreasing Zn/Cu ratio occurred in those hypertensives that suffered complications. It was also observed that the 24 hour urinary Zn and Cu excretion and the Zn/Cu ratio increased, while the hypertension lasted together with its complications [10]. A study by *Vivoli* et al. [29], conducted on 31 hypertensive patients and 31 healthy controls, found significant associations

of Zn and Cu levels between serum and urine in those suffering from hypertension. For the controls, the correlations in serum and urine were respectively r=0.577 and r=0.394 between Zn and Cu, in which a similar correlation in urine was observed in the presented study (r=0.58). The relationship between Cu and Zn concentrations with hypertension were confirmed by a study by *Dzięgielewska-Gęsiak* et al. [5]. This study showed higher serum Cu concentrations in the test subjects compared to healthy clinical controls, coupled also with higher Zn concentrations in the hypertensives than in the controls [5]. Such results suggest a link between hypertension and a lack of a Zn-Cu balance [29]. Furthermore, *Taneja* and *Mandal* [30] reported higher urinary Zn and Cu concentrations in hypertensive patients compared to healthy subjects. The current study also determined the daily dietary intakes of Cu. These intakes were significantly lower in hypertensive than the healthy controls. Levels of Cu found by *Goch* et al. in hair were higher in those with hypertension (10.75 ±12.03 μg/g) compared to healthy subjects (8.01 ±4.39 μg/g) [11]. In the presented study, together with that of *Michalski*, Cu levels were comparable for the controls; being respectively 36.0 ±25.9 μg/g and 38.1 ±18.9 μg/g. In the latter study [21], the molar ratios were determined for Ca/Mg, Fe/Zn, Cu/Fe and Zn/Cu, where significant differences were only observed for the Cu/Fe ratio between test subjects (3.15±6.37) and controls (1.31 ±0.71), which was not seen in the presented study. The Fe/Zn ratio was found [21] to be lower in the test group (0.73 ±1.01) than controls (0.19 ±0.11). Similar findings were seen in the current work where the Fe/Zn ratio was higher in the hypertensive than controls. The Ca/Mg ratio found by *Goch* et al. [11] was 22.04 ±17.55 in hypertensive and 23.92 ±27.47 in healthy subjects.

CONCLUSIONS

1. Hypertensive patients consumed rather fewer foodstuffs rich in copper.
2. In the hypertensive, the amounts of calcium and magnesium excreted in urine were lower, but urinary Zn was higher compared to healthy controls.

Acknowledgements
The study was in-house funded by the University of Life Sciences in Poznan.

Conflict of interest
The authors declare no conflict of interest.

REFERENCES

1. *Bucher H.C., Cook R.J., Guyatt G.H., Lang J.D., Cook D.J., Hatala R., Hunt D.L.*: Effects of dietary calcium supplementation on blood pressure. JAMA 1996;275:1016–1022.
2. *Całyniuk B., Grochowska-Niedworok E., Zołoteńka-Synowiec M., Piątkowska A.*: Sposób żywienia i stan odżywienia chłopców w wieku 16–18 lat a występowanie nadciśnienia tętniczego. Piel Zdrowie Publ 2013;3(3):281–291.
3. *Chiuve S.E., Sun Q., Curhan G.C, Taylor E.N., Spiegelman D., Willett W.C., Manson J.E., Rexrode K.M., Albert C.M.*: Dietary and Plasma Magnesium and Risk of Coronary Heart Disease Among Women. J Am Heart Assoc: Cardiovascular and Cerebrovascular Disease 2013;2(2): e000114.
4. *Durkalec-Michalski K., Suliburska J., Krejpcio Z., Jeszka J., Bogdański P.*: Analiza zależności pomiędzy spożyciem wybranych składników mineralnych a ich zawartością we włosach w wybranej grupie pacjentów z pierwotnym nadciśnieniem tętniczym. Żywność. Nauka. Technologia. Jakość 2012;2(81):186-197
5. *Dzięgielewska-Gęsiak S., Maćkowiak K., Wysocka E., Torliński L.*: Stężenie miedzi i cynku w surowicy osób w podeszłym wieku z nadciśnieniem tętniczym. Now Lek 2013;82(1):9-18.
6. *Eisner D.A., Trafford A.W.*: Heart Failure and the Ryanodine Receptor: Does Occam's Razor Rule? Circ Res. 2002;91:979-981.
7. *Głuszek J., Pawlaczyk K.*: Działania niepożądane antagonistów wapnia; Chor Serc Nacz 2006;3(1):18–3.
8. *Goch A.*: Stężenie pierwiastków w osoczu u chorych na samoistne ciśnienie tętnicze. Pol Arch Med Wewn 2005;114(4):947-952.
9. *Goch A., Dąbrowska G., Strzelczyk M, Goch J.H.*: Zmiany zawartości cynku i miedzi w osoczu i ich wydalania z moczem u chorych na nadciśnienie tętnicze. Nadciśnienie Tętnicze 2002;4:34.
10. *Goch A., Wlazłowski R., Goch J.*: Magnez we włosach, osoczu i moczu dobowym u chorych na nadciśnienie tętnicze. Nadciśnienie Tętnicze 2005;9(5):344-349.
11. *Goch A., Goch J.H.*: Zawartość makro- i mikroelementów we włosach osób z nadciśnieniem tętniczym. Nadciśnienie Tętnicze 2004;8(3): 177–184.
12. *Griffith L.E., Guyatt G.H., Cook R.J., Bucher H.C., Cook D.J.*: The influence of dietary and nondietary calcium supplementation on blood pressure: an updated meta-analysis of ramdomized controlled trials. Am J Hypertens 1999;1:84-92.
13. *Hamet P., Daignault-Gélinas M., Lambert J.*: Epidemiological evidence of an interaction between calcium and sodium intake impacting on blood pressure. A Montréal study. Am J Hypertens 1992;5(6 Pt 1):378-85.
14. *Hatton D.C., McCarron D.A.*: Dietary calcium and blood pressure in experimental models of hypertension. Hypertens 1994;4:513–530.
15. *Jee S.H., Miller III E.R., Guallar E., Singh V.K., Singh V.K., Appel L.J., Klag M.J.*: The Effect of magnesium supplementation on blood pressure: A Meta-Analy-

sis of Randomized Clinical Trials. Am J Hypertens 2002;15:691–696.
16. *Karaszewski B., Kozera G., Dorosz A., Łukasiak J., Szczyrba S., Łysiak-Szydłowska W., Nyka W.M.*: High magnesium or potassium hair accumulation is not associated withischemic stroke risk reduction: a pilot study. Clin Neurol Neurosurg. 2007;109(8):676-679.
17. *Kesteloot H., Tzoulaki I., Elliott P.*: Relation of urinary calcium and magnesium excretion to blood pressure. Am J Epidem 2011;174(1):44-51.
18. *Kozielec T., Michoń P.*: Wpływ suplementacji preparatem Slow−Mag B6 na wybrane parametry laboratoryjne i kliniczne u pacjentów leczonych z powodu nadciśnienia tętniczego. Pol Med Rodz 2000;2(4):71-75.
19. *Kozłowska – Wojciechowska M.*: Czynniki żywieniowe w profilaktyce i leczeniu nadciśnienia tętniczego. Terapia 2005;13(7/8):17- 21.
20. *Mc Clain C., Morris P., Hennig B.*: Zinc and endothelial function. Nutrition 1995;11:117–120.
21. *Michalski K.*: Ocena sposobu żywienia, wyróżników stylu życia oraz wybranych wskaźników biochemicznych w krwi i włosach u pacjentów z pierwotnym nadciśnieniem tętniczym. Praca dyplomowa, Biblioteka Wydziału Nauk o Żywności i Żywieniu Człowieka. Uniwersytet Przyrodniczy w Poznaniu, 2007.
22. *Michon P.*: Poziom frakcji całkowitej i zjonizowanej magnezu na podstawie analizy biochemicznej krwi i włosów oraz wpływ suplementacji magnezu (Slow Mag B6) na wybrane parametry w chorobie nadciśnieniowej u pacjentów leczonych różnymi grupami leków. Ann Acad Med Stetin 2002;48:85–97.
23. *Mi-Hyun K., So Young B., Mi-Kyeong Ch.*: Daily calcium intake and its relation to blood pressure, blood lipids, and oxidative stress biomarkers in hypertensive and normotensive subjects. Nutr Res Pract 2012;6(5):421-428.
24. *Ram J.L., Standley P.R., Sowers J.R.*: Calcium function in vascular smooth muscle and its relationship to hypertension. Calcium antagonists and the kidney. St. Louis, Hanley & Belfus, 1993, 29–28.
25. *Steffen L.M., Kroenke C.H., Yu X., Pereira M.A., Slattery M.L., Van Horn L., Gross M.D., Jacobs DR Jr.*: Associations of plant food, dairy product, and meat intakes with 15-y incidence of elevated blood pressure in young black and white adults: the Coronary Artery Risk Development in Young Adults (CARDIA) Study. Am J Clin Nutr 2005;82(6):1169-77.
26. *Sullivan J.L., Mascitelli L.*: Current status of the iron hypothesis of cardiovascular disease. Recenti Prog Med 2007;98:373–377.
27. *Sygnowska E., Waśkiewicz A., Głuszek J., Głuszek J., Kwaśniewska M., Biela U., Kozakiewicz K., Zdrojewski T., Rywik S.*: Spożycie produktów spożywczych przez dorosłą populację. Wyniki programu WOBASZ. Kardiol Pol 2005;63(6/4): 670-676.
28. *Szponar L., Wolnicka K., Rychlik E.*: Photograph Album of Foodstuffs and Dishes. Ed. National Institute of Food and Nutrition, Warsaw, Poland, 2000.
29. *Vivoli G., Bergomi M., Rovesti S., Pinotti M., Caselgrandi E.*: Zinc, Copper and Zinc-or Copper-Dependent Enzymes in Human Hypertension. Biol Trace Elem.Res. 1995;49:97–106.
30. *Taneja S.K., Mandal R.*: Mineral factors controlling essential hypertension – a study in the Chandi-garh, India population. Biol Trace Elem Res 2007;120(1–3):61–73.
31. *Tang Y.R., Zhang S.Q., Xiong Y., Zhao Y., Fu H., Zhang K.M., Xiong K.M.*: Studies of five microelement contents in human serum, hair, and fingernails correlated with aged hypertension and coronary heart disease. Biol Trace Elem Res 2003;92(2):97-104.
32. *Taylor E.N., Stampfer M.J., Góra B.D., Curhan G.C.*: DASH-Style Diet and 24-Hour Urine Composition, CJASN 2010;5(12):2315- 2322.
33. *Wyss J.M., Chen Y.F., Meng Q.C., Jin H.K., Jirikulsomchok S., Oparil S.*: Dietary Ca2+ prevents NaCl induced exacerbation of hypertension and increases hypothalamic norepinephrine turn-over in spontaneously hypertensive rats. J Hypertens 1987;7:711–719.
34. *Zozaya J.L.*: Nutritional factors in high blood pressure. J Hum Hypertens 2000;14(1):100–104

Received: 20.06.2014
Accepted: 30.12.2014