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ORIGINAL ARTICLE

Effect of environmental parameters on the concentration of nickel (Ni) in bones of the hip joint from patients with osteoarthritis

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Abstract

Introduction. Bone trace elements levels including nickel (Ni) depend on biological and environmental factors: age, gender, remodeling state, exposure to occupational and environmental pollution, smoking, diet, and surgical implants.

Objective. The aim of this study was to determine Ni concentrations in bones of femur heads obtained from patients with osteoarthritis.

Materials and method. A total of 111 samples of hip joint bones (cartilage, cancellous bone and compact bone) collected from patients from north-western Poland were examined. Ni concentration was determined by ICP-AES (atomic absorption spectrophotometry).

Results. It was found that differences in Ni concentrations were statistically significant between cartilage and compact bone. Cartilage Ni concentrations were higher in patients with fractured femur neck than patients with osteoarthritis. Furthermore, higher Ni levels were also found in samples obtained from smokers compared to nonsmokers. In cancellous bone, higher Ni concentrations were found in samples from patients who had received implants than those without them. Moreover, higher Ni concentrations in cancellous bone were found in patients occupationally exposed to heavy metals than in those not exposed.

Conclusions. The bone tissue reflects long-term exposure to Ni and may be used as a bioindicator to study the process of Ni accumulation in the human body.

Key words

bone, nickel, environmental exposure, implants

INTRODUCTION

Osteoarthritis (OA) is a disease of an entire joint involving the cartilage, joint lining, ligaments, and underlying bone. The breakdown of these tissues eventually leads to pain and joint stiffness. The joints most commonly affected are the knees and hips. The specific causes of OA are unknown, but are believed to be a result of both mechanical, molecular events in the affected joint. Many trace elements, including nickel (Ni), have a major effect on bone condition and metabolism and may cause debilitating bone diseases. Their concentrations in bone are strongly associated with environmental conditions, including: diet, geography, occupational exposure and overall health status of the population. Nickel, an essential element commonly found in the environment, is also widely used in industry. Waste from the industrial processing of this element and the combustion of fossil fuels results in considerable Ni pollution in some areas [1]. It then reaches the human body through contaminated food and drinking water. The maximum concentration of total Ni allowed by law in Poland in drinking water is 20 μg/dm^{-3}.

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The minimum requirement for Ni in humans is estimated at 50 μg/day. An appropriate dose of this element is ensured by a balanced diet, particularly in fruits and vegetables and Ni supplementation is usually not necessary [2]. Absorption of Ni compounds from food and water occurs predominantly in the gastrointestinal tract, while Ni from the air is absorbed through the lungs and skin. It is removed from the body with stool and urine, as well as in sweat, saliva, bile and milk [3]. Nickel activates some enzymes, increases hormonal activity, stabilizes the structure of nucleic acids and plays an important role in the metabolism of lipids and sugars. It interacts with iron contained in haemoglobin, thus supporting oxygen transport. In addition, it stimulates metabolism and is considered a key metal in enzymatic systems. Nickel binds to keratin and insulin, and also activates arginase, trypsin, acetyl coenzyme A, carboxylase and synthetase [4]. Nickel deficiency leads to excessive oxygen consumption in the liver and fat accumulation. On the basis of experimental studies, it has been found that Ni deficiency leads to post-term pregnancy, reduced number of offspring, growth retardation, dwarfism, anaemia, rashes, brittle hair, a decrease in the amount of serum proteins, increase in the urinal excretion of nitrogen, and a decrease in haemoglobin and haematocrit [5]. The body burden of Ni in adult humans averages about 0.5 mg per 70 kg. Nickel does not normally accumulate in tissues due to the usually efficient Ni excretion from the body. However, when exposed to high doses of Ni, its highest concentrations are observed in the adrenal gland, lung and thyroid, and less in the kidney, heart, liver, brain, spleen and pancreas [6]. Relatively high amounts of Ni can also be found in cartilage and other tissues [7]. However, the average Ni content in human soft tissues is estimated at 0.088 mg kg^{-1} [8].

Chronic Ni poisoning is much more common than acute poisoning. It is usually accompanied by irritation of the conjunctiva, mucosa in the upper respiratory tract, ulceration of the nasal septum and so-called nickel pruritus. Skin lesions, including eczema, may be observed in about 5–13% of people who come into contact with Ni and its compounds. Excessive Ni concentrations may affect the absorption of trace elements, such as copper, iron and zinc. Experimental studies show that deficiency of these essential trace elements can be heightened by excessive concentrations of sulfate ($NiSO_4$) and nickel chloride ($NiCl_2$). All Ni compounds are classified as group 1 carcinogenic compounds, and metallic Ni as a probable group 2B carcinogen [9]. The main determinant of Ni toxicity and carcinogenicity is its ability to penetrate into the cells and release ions.

Nickel is a ubiquitous metal frequently responsible for allergic skin reactions and has been reported to be one of the most common causes of allergic contact dermatitis, as reflected by positive dermal patch tests [10, 11]. Implants comprise various metals, particulary nickel, chromium (Cr), cobalt (Co), titanium (Ti), vanadium (V) and other metals. Previously acquired allergy to metals and plastics used in the biomaterials may case rejection of the implants, bone junctions or prosthesis (such as surgical plates and screws, nails, or implants of large and small joints) [12]. The prevalence of metal sensitivity among the general population is approximately 10% – 15%, with Ni sensitivity having the highest prevalence [13].

Numerous studies are available which suggest that occupationally-exposed workers display higher serum and urine Ni levels than those exposed non-occupationally. Urine and serum Ni concentrations may be used as biological indicators of occupational, environmental and iatrogenic exposures to Ni compounds [11]. Bones, however, are subject to long-term exposure to heavy metals, revealing the ability to accumulate and to be used as bioindicators of environmental pollution with metals. Even a small exposure to heavy metals may be detected in bone if it has persisted over a long period [10]. The biological half life of heavy metals in bones may be up to 30 years and reflect up to 90% of the whole body content, possibly because of the solid structure of the bone tissue along with optimal blood perfusion [14].

OBJECTIVE

Available scientific literature shows little data on Ni concentration in the bones of patients with various musculoskeletal system diseases. Therefore, the aim of this study was to determine and compare Ni concentrations in cartilage, compact and cancellous bone from the femoral heads of patients following hip replacement surgery. Another aim was to compare Ni concentrations in the corresponding tissues of the femoral head (between the types of samples) with regard to biological parameters (age, gender, and type of diseases of the bone), and environmental parameters (dental amalgams, place of residence, implants, smoking and occupational exposure).

MATERIAL AND METHODS

Material for the study was collected from patients who had undergone hip replacement at the Department of Orthopaedics and Traumatology of the Pomeranian Medical University in Szczecin, Poland, from November 2007 – December 2009. The indication for surgery was osteoarthritis and/or hip fracture. The study group comprised of men aged between 53–78 years (mean 62.6 years), and women aged between 32–82 years (mean 69.9 years).

The patients were divided into groups: NONS – non-smokers (n=15) and S – smokers (n = 22); occupationally-exposed (n=7) and unexposed (n=30) to heavy metals.

The exact characteristics of the study group are shown in previous works on the same population [15, 16]. From each patient, three types of materials were obtained from the femoral head: cartilage, compact bone and spongy bone. In some samples, articular cartilage was pathologically altered. There was also a significant loss of articular surfaces, and due to the advanced coxarthrosis, cartilage was scarce or even completely non-existent. As a result of hyperaemia, the subcartilaginous layer (compact bone) was subject to softening, disintegration and focal destruction. There was a strong variation of compact bone thickness – from a few millimeters to a complete absence. The remainder of the femoral head consisted of spongy bone. Because of the problems with separation of individual layers, in further analysis samples of articular cartilage and compact bone were combined.

This study was approved by the Bioethics Committee of the Pomeranian Medical University in Szczecin (BN/001/111/08). The patients filled in a questionnaire which focused on any biological or environmental exposure to metallic elements.

Material for study was removed from the femoral heads with a glass tool. Three types of material were obtained: cartilage, compact bone and cancellous bone. This material was dried at 105 °C to a constant weight, in order to determine the water content (gravimetric method). The material was crushed and divided into samples of 0.5–1.0 g. The bone and cartilage samples were ashed in glass vessels (Velp Scientifica), mineralised in a 4:1 mixture of 65% nitric acid (HNO_3) and 70% perchloric acid ($HClO_4$) (Suprapur Merck®). Following mineralisation, the samples were diluted and brought to 10 ml with bidistilled water. Mineralization was carried out in four step heating regime, with an upper temperature of 200 °C.

Nickel concentration was determined by ICP-AES (atomic absorption spectrophotometry) in inductively coupled argon plasma using a Perkin-Elmer Optima 2000 DV. The limit of quantification of Ni in the instrument was 0.5 µg L^{-1}. The concentrations of Ni were expressed in mg/kg dry weight.

In order to assess the accuracy of the analytical procedures, Ni was determined in reference material IAEA-407–Trace Elements and Methylmercury in Fish Tissue (International Atomic Energy Agency). Nickel concentration for the certified material and our own determinations were as follows: RV – the reference value specified by the manufacturer of IAEA-407: 0.60 mg kg^{-1} dw, OD – own determinations: 0.48 mg kg^{-1} dw. Recovery (RV/ OD) of the determined element was 80% and proved to be satisfactory for biological samples because its error did not exceed ± 20%.

The Mann–Whitney nonparametric *U*-test was used for statistical analysis. The results were processed using the statistical programme Statistica for Windows ver. 10.0. pl.

RESULTS

The Kolmogorov-Smirnov test with Lilliefors correction showed that the distribution of the data was not consistent with an expected normal distribution ($p<0.01$); therefore, in further statistical analysis non-parametric tests were used to compare mean Ni concentrations. Table 1 shows Ni concentrations in the tested samples from the femoral head of patients following hip replacement surgery. The largest Ni concentration was found in compact bone and the smallest in articular cartilage (0.220 and 0.141 mg kg^{-1} dw). There were statistically significant differences between the Ni concentrations in the compared bone samples ($p=0.03$) as well as between cartilage and compact bone ($p=0.02$).

Table 1. Nickel concentration (mg kg^{-1} dry weight) in tested samples obtained from the femoral head of patients living in the province of West Pomerania

Material	Ni concentration (mg kg^{-1} dw)				
	n	Med	AM	SD	CV (%)
Without division into bone layers	111	0.177	0.301	0.492	163.5
Cartilage	37	0.141	0.206	0.214	103.7
Compact bone	37	0.220	0.325	0.456	140.4
Cancellous bone	37	0.170	0.372	0.687	184.5

Med – median; AM – arithmetic mean; SD – standard deviation; CV – coefficient of variation in percent

For comparisons of Ni concentration between the two age groups of patients (<60 years and >60 years) and gender, Mann-Whitney tests were used, but they did not show significant differences between any groups of samples. The Kruskal-Wallis (KW) test showed no statistically significant differences in Ni concentrations in the different layers of bone in those patients with or without amalgam dental fillings. This test also showed no statistically significant differences depending on the place of residence (rural areas, town with a population of 10,000–100,000, and >100,000). The nickel concentration in articular cartilage of patients hospitalized because of hip fracture was more than four times higher than in patients with degeneration of the hip, at 0.641 and 0.134 mg kg^{-1} dw, respectively (Tab. 2). The difference was statistically significant ($p<0.03$). There were no statistically significant differences between the Ni concentrations in other types of bone (compact and cancellous bone).

Table 2. The nickel concentrations (mg kg^{-1} dry weight) in the examined patients with fractures and osteoarthritis (Med – median; AM – arithmetic mean; SD – standard deviation; CV – coefficient of variation in percent; MW – Mann-Whitney test; p – level of significance; NS – difference non-significant)

Patients		cartilage	compact bone	cancellous bone
with fractures (F) (n=3)	Med	0.641	0.322	0.775
	AM	0.503	0.300	1.613
	SD	0.265	0.092	2.033
	CV (%)	52.56	30.85	126.08
	range	0.198-0.671	0.198-0.379	0.132-3.930
with osteoarthritis (O) (n=34)	Med	0.134	0.217	0.162
	AM	0.180	0.327	0.263
	SD	0.192	0.476	0.334
	CV (%)	106.70	145.40	127.24
	range	0.035-1.151	0.024-2.901	0.036-1.914
F vs O (n=37)	MW	p<0.03	NS	NS

Differences in Ni concentrations within each group of samples between patients with and without implants proved to be statistically significant only in the cancellous bone ($p<0.02$) (Tab. 3). The nickel concentrations in patients with surgical implants were more than twice as high compared to patients without implants (0.330 vs. 0.146 mg kg^{-1} dw).

Table 3. The nickel concentrations (mg kg^{-1} dry weight) in the examined patients with and without implants (Med – median; AM – arithmetic mean; SD – standard deviation; CV – coefficient of variation in percent; MW – Mann-Whitney test; p – level of significance; NS – difference non-significant)

Patients		cartilage	compact bone	cancellous bone
with implants (I) (n=7)	Med	0.198	0.222	0.330
	AM	0.337	0.262	0.422
	SD	0.377	0.140	0.278
	CV (%)	112.09	53.63	65.81
	range	0.082-1.151	0.089-0.512	0.130-0.847
without implants (NONI) (n=30)	Med	0.134	0.217	0.146
	AM	0.176	0.340	0.361
	SD	0.149	0.503	0.754
	CV (%)	84.74	148.05	209.10
	range	0.035-0.671	0.025-2.901	0.036-3.930
I vs NONI (n=37)	MW	NS	NS	p<0.02

The nickel concentration determined in articular cartilage in smokers was almost twice as high as than in non-smoking patients (Tab. 4) – 0.177 and 0.095 mg kg^{-1} dw, respectively. Statistical analysis showed that the difference between those values was statistically significant ($p<0.05$). In other types of bone (compact and cancellous bone) no such differences were found.

Table 4. The nickel concentrations (mg kg^{-1} dry weight) in smokers and non-smokers among examined patients (Med – median; AM – arithmetic mean; SD – standard deviation; CV – coefficient of variation in percent; MW – Mann-Whitney test; p – level of significance; NS– difference non-significant)

Group of patients		cartilage	compact bone	cancellous bone
Smokers (S) (n=22)	Med	0.177	0.221	0.162
	AM	0.220	0.267	0.407
	SD	0.167	0.128	0.814
	CV (%)	75.88	47.88	199.90
	range	0.035-0.671	0.058-0.512	0.036-3.930
non-smokers (NONS) (n=15)	Med	0.095	0.194	0.206
	AM	0.185	0.411	0.321
	SD	0.273	0.705	0.464
	CV (%)	147.60	171.7	144.4
	range	0.058-1.151	0.024-2.901	0.070-1.914
S vs NONS (N=37)	MW	p<0.05	NS	NS

There were significant differences in the Ni concentrations in cartilage between the patients occupationally exposed and unexposed. The nickel concentration in the cartilage of occupationally-exposed patients was higher than in unexposed individuals (Tab. 5) – 0.185 and 0.138 mg kg^{-1} dw, respectively.

Table 5. The nickel concentrations (mg kg^{-1} dry weight) depending on the occupational exposure of patients (Med – median; AM – arithmetic mean; SD – standard deviation; CV – coefficient of variation in percent; MW – Mann-Whitney test; p – level of significance; NS – difference non-significant)

		cartilage	compact bone	cancellous bone
occupational exposure of patients (OE) (n=7)	Med	0.185	0.186	0.330
	AM	0.173	0.203	0.409
	SD	0.136	0.063	0.243
	CV (%)	78.48	31.02	59.37
	range	0.035-0.432	0.157-0.336	0.141-0.847
unexposed patients (UOE) (n=30)	Med	0.138	0.243	0.146
	AM	0.214	0.354	0.364
	SD	0.229	0.503	0.757
	CV (%)	107.20	142.26	208.10
	range	0.054-1.151	0.025-2.901	0.036-3.930
OE vs UOE (n=37)	MW	$p<0.05$	NS	NS

DISCUSSION

Nickel concentrations in the human hip joint tissues are connected with biological and environmental factors: age, gender, remodelling state, genetic susceptibility, geographic location, exposure to occupational and environmental pollution, smoking, diet, and surgical implants [16, 17].

In the presented study, similar to the research by Brodziak-Dopierala et al. [18, 19] and Kwapulinski et al. [20], diverse values of Ni concentration were found in the analyzed bone material, probably influenced by the differences in morphology of the individual parts of the femoral head. The largest Ni concentration in the current study was observed in the compact bone of the patients (0.325 mg kg^{-1} dw). On the other hand, Brodziak-Dopierala et al. [19] found the highest concentration of this metal in the cancellous bone, both in men and women (7.90 vs. 9.68 mg kg^{-1} dw), which could probably probably be related to the high metabolic activity of the cancellous bone and the greater blood supply, compared to the cartilage and compact bone. In another study by Brodziak-Dopierala et al. [18], the highest Ni concentration was found in the articular cartilage, both in men and women (9.69 vs 9.43 mg kg^{-1} dw), while the smallest in the cancellous bone (4.80 vs 3.73 mg kg^{-1} dw). In view of the fact that Kwapulinski et al. [20] and Brodziak-Dopierala et al. [18, 19] had studied patients living in the Upper Silesian Industrial Region of Poland, the Ni concentrations they reported in the femur were many times higher than the concentrations of the element presented in the current study. The Upper Silesian Industrial Region is considered to be the largest industrial agglomeration in Poland, and it is also the most anthropogenically-transformed area in the country. The concentrations of highly toxic metals in water, air and soil in that area sometimes exceed the legal limits [18, 19].

In this study, as in the study by Brodziak-Dopierala et al. [18], no significant differences in the concentrations of Ni were found between women and men. In the inhabitants of Upper Silesia, Brodziak-Dopierala et al. [18] found that Ni concentrations in articular cartilage, compact and cancellous bone in women were 4.05; 3.49 and 7.90 mg kg^{-1} dw, respectively, while in men – 5.15, 6.32 and 9.68 mg kg^{-1} dw. In the presented study, in patients from north-western Poland Ni concentrations in cartilage, compact and cancellous bone in women were several times lower than in the inhabitants of Upper Silesia, at 0.18; 0.35 and 0.28 mg kg^{-1} dw, similar to the men – 0.25, 0.28 and 0.54 and mg kg^{-1} dw. In a study by Kwapulinski et al. [20], Ni concentrations in articular cartilage, cortical and cancellous bone of the femoral head of women living in Upper Silesia were 2.08, 1.98, and 1.64 mg kg^{-1} dw, while in men these values were significantly lower in cartilage and cancellous bone – 0.39 and 0.61 mg kg^{-1} dw, but higher in compact bone – 30.85 mg kg^{-1} dw. Kubaszewski et al. [14] showed a bone Ni concentration that was lower than in Brodziak-Dopierala et al. [19] – 1.46–1.51 vs 4.82 mg kg^{-1} dw, respectively. Futhermore, it was found that Ni concentration in the femoral neck correlated with male gender, where osteoporotic changes are observed later than in females.

In the elderly, fractures may occur as a result of osteoporosis, injury, degeneration and bone tumours. Sameer et al. [21] have shown a mechanism for the exchange of calcium (Ca^{2+}), potassium (K^+) and hydrogen (H^+) for nickel (Ni^{2+}) between the bone tissue of animals and aqueous solutions. Therefore, it can be concluded that high Ni concentrations can reduce the content of Ca in the bone. In scientific literature there is little data on Ni in bones of the joint in patients with fractures and hip degeneration. Brodziak-Dopierala et al. [19] found that Ni concentration in material collected from patients with fractures was higher than in patients with degeneration, at 6.12 and 4.69 mg kg^{-1} dw, respectively. A similar regularity was observed in the presented study in which Ni concentrations in cartilage and cancellous bone were greater in patients with fractures of the femur (0.50 and 1.61 mg kg^{-1} dw) than in patients with degeneration of the hip (0.18 and 0.26 mg kg^{-1} dw). Similar to this research, Kubaszewski et al. [14] observed that the stage of osteoarthritis in bone samples was moderate or severe. The cartilage of femoral head showed partial or total damage in the area of 50%–90% of the cartilage, which may explain the lowest Ni concentration in this active part of bone. Usually, the levels of this trace element in hard tissues, including those with osteoarthrosis, can be arranged in the following descending order: cartilage>spongy bone> cortical bone [15, 19].

There is a known connection between smoking and bone fractures in both men and women. Smoking affects the distribution of elements in different parts of the femur and adversely affects bone density. Postmenopausal female smokers are exposed to a greater loss of bone mass than non-smokers. In smokers, bone density decreases by an additional 2% (over the next 10 years of age), and at the age of 80 years may be reduced by 6%, compared to non-smoking women. The risk of hip fracture in the group of smokers increases to 17% at the age of 60, 41% at 70, and even 100% at 90 [22]. In nonsmokers, about 99% of the estimated daily Ni absorption originates from food and water; for smokers the figure is about 75% [8]. Tobacco components can reduce bone density by inhibiting the formation of osteoblasts, as well as apoptosis in other cell types [23]. Smoking can have a significant impact on the amount of Ni absorbed by the body; therefore, smokers are more vulnerable to its adverse effects than non-smokers. Even passive smoking increases Ni accumulation in the tissues [24].

According to research by Stojanovic et al. [25], the Ni concentration in tobacco is 2.20–4.91 mg/kg dw, and in cigarettes 2.32–4.20 mg/kg dw. The researchers found that the Ni concentration in the urine of smokers was more than twice as high than in non-smokers, and ranged from 0.01–8.20 μg L^{-1} and from undetectable to 4.60 μg L^{-1}, respectively. Brodziak-Dopierala et al. [19] showed that the Ni concentration in the femoral head of smokers was higher than in non-smokers – 6.09 against 4.52 mg kg^{-1} dw. Furthermore, Brodziak-Dopierala et al. [18] showed that in the inhabitants of Upper Silesia, the average Ni concentration in the head of the femur in female smokers was higher than in non-smoking women – 8.85 compared with 6.46 mg kg^{-1} dw. A similar relationship was observed in smoking and non-smoking men (6.85 vs 4.04 mg kg^{-1} dw), although the Ni concentration was lower compared to women. A similar relationship was observed in the presented study, where patients form north-western Poland showed higher Ni concentrations in articular cartilage and cancellous bone in smokers (0.22 vs. 0.41 mg kg^{-1} dw) compared with non-smoking patients (0.19 vs. 0.32 mg kg^{-1} dw). In the compact bone of non-smokers, Ni concentration was higher than in smokers and was 0.41 and 0.27 mg kg^{-1} dw, respectively. It should be noted, however, that the significant differences in Ni concentrations were demonstrated only for cartilage ($p<0.05$). Different results are presented by Kwapulinski et al. [24] who showed that Ni concentration was higher in non-smokers (1.59 mg kg^{-1} dw) than smokers (0.62 mg kg^{-1} dw).

Nickel concentrations in the bone may also be influenced by metal implants which can increase the Ni concentration in an individual. Research on the release of metals from endoprostheses showed the presence of chromium and nickel in tissues surrounding the implant. These elements were also detected in the blood and urine in higher concentrations in people having endoprostheses for more than 10 years, compared to those without any implants [12]. In available scientific literature, no studies were found about the value of Ni concentration in patients with implants. Patients from north-western Poland who had implants had a higher Ni concentration in the articular cartilage and cancellous bone (0.34 and 0.42 mg kg^{-1} dw) compared with patients without implants (0.18 and 0.26 mg kg^{-1} dw), yet statistically significant differences in concentrations were recorded only for the cancellous bone ($p<0.02$). Moreover, in two patients with more than one implant, the highest Ni concentrations were observed in spongy bone and the concomitant skin reactions. *In vitro* studies suggest that endoprostheses may release Ni, the most important contact allergen.

Exposure to heavy metals is often associated with occupation and/or environmental status. It was found that people who worked in conditions of constant contact with Ni and other heavy metals may be exposed to disease and bone damage due to adverse changes occurring under the influence of heavy metals, including Ni [5, 11]. Brodziak-Dopierala et al. [18] found that the Ni concentrations in the femoral head of petrol station staff and coal miners were greater (7.74 and 5.60 mg kg^{-1} dw) than in unexposed individuals (5.44 mg kg^{-1} dw). A similar relationship was found in the presented study. The cancellous bone of occupationally-exposed patients from north-western Poland had a higher concentration of Ni (0.41 mg kg^{-1} dw) compared with non-exposed individuals (0.36 mg kg^{-1} dw). The difference between the means was statistically significant ($p<0.02$). However, Ni concentrations in the examined patients from the hospital in Szczecin were an order of magnitude smaller than those found by Brodziak-Dopierala et al. [18].

A comparison of the current results with corresponding data from different authors dealing with the inhabitants of other regions of Poland, shows that people living in Western Pomerania have an order of magnitude lower bone Ni concentrations than individuals living in the highly industrialized region of Upper Silesia.

CONCLUSIONS

The number of hip replacement surgeries continues to increase. The metal surfaces in implants may be subject to wear and corrosion; trace and or heavy metals may released from implants, which may be involved in the pathological processes in human organism. Despite many studies on the concentration of trace elements (including Ni) in the human body, knowledge of their concentration in bone and their effects on the osteoarticular system is still incomplete. It seems very likely that the concentrations of elements in bone are strongly associated with environmental conditions, diet, geographical range, occupational exposure and health status of populations. The same as in Europe, there is a lack of comparative data on the concentration of these elements in the bones of the hip against the place of residence and environmental exposure, it is t6herefore necessary to conduct wider and more numerous studies in this field, including Central Europe. Furthermore, 50–60 million Europeans are allergic to Ni, which was selected as the 'the allergen of the year' in 2008 to draw more attention to its adverse effects [26]. This is still a problem for health and the public, especially because of the elderly population. On the basis of the research and findings of other authors, it can be concluded that bones are a good bioindicative material for assessing the long-term exposure of the human body to Ni, especially for patients exposed to Ni released from endoprostheses.

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