Bone Quality, Biochemical and Blood Markers in High Power Electrical Workersf

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Abstract

In this study, we investigated bone mineral density, body fat rates, products of bone formation and deformation and some blood parameters of the high power electrical line workers and compared to those control group.

Bone mineral density and body fat rates were measured by wholebody bone densitometer. For the other parameters, blood was taken from experiment and control groups at 8:30 of morning as hunger and bone formation and deformation products (calcitonin, PTH, osteocalsin c-telopeptide, creatin) and other biochemical markers (Glucose, urea, totalprotein, AST, ALT, ALP, uric acid, Globulin, Bilirubin I) were measured by autoanalyser in the laboratory and other blood parameters (RBC, WBC, Hgb, Hct, pH) were measured by hemogram apparatus.

In the bone mineral density values of the experimental group did not observed statistically significant changes compared to the control group. In the experimental group, body fat rate was observed to decrease ($p>0.05$). Glucose, urea, total protein, globulin, osteocalcine and ALP values were increased (respectively, $p<0,05$; $p<0,005$; $p<0,05$; $p<0,05$; $p<0,05$; $p<0,001$). In the other parameters (WBC, Hgb, Hct, pH, AST, ALT, uric acide, Bilirubin I, calcitonin, PTH, c-telopeptide, creatin ve Ca) did not observed any significant change ($p>0.05$).

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Introduction

Bone is a complex tissue that has several functions dependent on both its composition and structure. Bone is a dynamic and complex organ that complex tissue reside specialized bone cells; including osteoblasts, osteocytes and osteoclasts and remodels itself throughout life. Specific actions, bone resorption and formation, are performed by the specialized bone cells [1].

The potential health benefits of electric and magnetic fields have intrigued humans for thousands of year[2]. Firstly Yasuda I et al [3] reawoke this interest in 1953, when he demonstrated new bone formation in the vicinity of the cathode in a rabbit femur during current stimulation. Later, Basset et al[4], investigated the effect of electrical stimulation on bone growth. Their experiments were based on the principle that bone tissue has electrical properties under formation, as shown by Fukada E and Yasuda I[5]. Mc Leod et al. was published one report, who described acceleration in bone fracture repair on application of an external magnetic field (EMF)[6]. Recent report continue to confirm the positive effects of Capacitively-coupled fields on bone density[7]. Several researchers have investigated the therapeutic efficacy of electromagnetic field on bone tissue[8-11]. However, Yamada et al.[12] did not observe any effects on bone tissue. Futhermore an extremely low frequency magnetic field (ELF-MF) can induce the differentiation of cartilage cells and alter alkaline phosphatase activity in rat osteoblastic cells [13].

A variety of non-invasive bone fracture treatment techniques have been used for biophysical stimulation to accelerate and finalize bone healing. One of these methods is electromagnetic field (EMF) stimulation, a method which has been used in cases of bone fracture healing for over three decades. Despite a long history of clinical use of EMFs and research, there is still poor understanding of the underlying action mechanisms of EMFs and the optimal parameters for usage. A specific EMF as

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a biophysical stimulator had a positive effect on bone fracture healing[14]

Otherwise the presence of extremely low frequency electric and magnetic fields in the environment is becoming more and more pervasive. They are produced by transmission power lines and all equipment using alternating current, including household appliances with the development of power transmission lines, the consequences for public health of chronic exposure to such fields has come into sharper focus[15]. Occupational electromagnetic field exposures suggested a possible increase in deaths among electrical workers[16,17]. To our knowledge, did not reveal any study that investigated the bone mineral density and bone formation and resorption markers of high voltage electrical workers. There is not enough literature on this subject.

The aim of this study was to investigate the cumulative effect of electromagnetic field in a long time on the bone tissue of high voltage electrical workers with bone mineral density, bone formation and resorption markers.

Materials and methods

A total of 21 generally healthy males, who work approximately two hundred workdays per year at least ten years in the high power electric lines and 20 healthy controls, who work not in the high power lines in the same business, were enrolled in the study. The age range of subjects was between 35-40 and body mass index were between 20-25 all the subjects. History of the males and their parental had not metabolic bone disease, previous fracture and taking any medication known to affect bone metabolism. The subjects with malign disease, thyroid and parathyroid disorders, renal disease, drug or alcohol or smoke addiction were excluded from the study. They had not sexuel dysfunction. There were no significant abnormalities in urinary calcium excretion, no history of hypercalcuria or urolithiasis in either groups. They were not exposured magnetic field except in the their working area. Their nutrition status were estimated from self-administered foot frequency questionnaires that contain approximately 1500-1800 mg calcium per day. All subjects were informed about the study protocol and written consents were obtained from all participants. This project was approved by the Human Subjects Research Committee of Harran University.

Serum concentration of calcium (Ca), phosphorus (P), total alkalen phosphatase (ALP), serum type 1 collagen cross-linked C telopeptide (CTX) and osteocalcin (OC) were measured as bone turnover markers in all subjects. Blood samples were collected at $9^{:00}$ a.m. after an overnight fast. ALP was determined by spectrophotometric (using *p*-nitrophenyl phosphate) method (Abbott, Aeroset, USA). Both the intra and interassay coefficients of variation (CV) were less than 3.9 %. CTX was measured by chemiluminescent immunometric assay (ECLIA Elecsys 170, Roche, Germany). The intra and interassay CV were 2.5 and 4.5%. OC was assayed by chemiluminescent immunometric assay (Immulite 2000). The intraassay variation was 2.35% and interassay variation was 2.55%.

Bone mineral density (BMD) of whole body and body composition were measured by Hologic QDR 4500 W (Hologic Inc., Bedford, MA, USA) fan beam DXA scanner. The within subject coefficient of variations were 3.9 % for whole-body fat mass and 0.57, 1.2 % for whole-body BMD in our laboratory.

Electric current level in this power lines was 608-637 ampere. On the other hand, Magnetic field level was 38-40 mT in a point far 1 cm and 0,38-0,40 mT in a point far 1m from lines. Magnetic field level was measured by using a digital Hall effect Gauss meter (Bell 5170,SYPRIS, USA).

Data were analysed by using independent t-test in SPSS for Windows (version 11.5). study group and control group were compared with one another. P-values below 0.05 were considered to be statistically significant.

Results

As a result, in values of the BMD of study group compared to control group was not observed an important change as statistical ($p>0.05$) (Table 1).

The body fat rate decreased in study group compare to control group but, it wasn't statistically an important change ($p>0.05$) (Table 2). OC and ALP values were changed significantly in study group compared to control group (respectively, $p<0,05$ ve $p<0,001$) (Table 3,4). Furthermore, glucose, urea, total protein, globuline were changed significantly in experiment group compared to control group (respectively, p<0,05; p<0,005; p<0,05; p<0,001) (Table 4).

Other parameters (WBC, Hgb, Hct, pH, AST, ALT, uric acide, I Bilirubin, Calcitonin, PTH, C-telopeptide, creatin and ca)was not significantly changed compared to control group (p>0.05) (table 4,5).

	Group	Experimental and Control group numbers	BMD Mean	BMD Standard Deviation	p
Larm	E C	21 20	0.77 0.79	0.045 0.037	>0.05
RArm	E C	21 20	0.80 0.79	0.042 0.036	>0.05
L Ribs	E C	21 20	0.67 0.69	0.072 0.048	>0.05
R Libs	E C	21 20	0.66 0.66	0.061 0.061	>0.05
T Spine	E C	21 20	0.87 0.87	0.100 0.110	>0.05
L Spine	E C	21 20	1.01 0.99	0.120 0.130	>0.05
Pelvis	E C	21 20	1.11 1.10	0.092 0.130	>0.05
L Leg	E C	21 20	1.17 1.22	0.094 0.072	>0.05
R Leg	E C	21 20	1.18 1.22	0.086 0.067	>0.05
S Total	E C	21 20	0.97 0.99	0.067 0.048	>0.05
Head	E C	21 20	1.89 1.84	0.230 0.310	>0.05
Total	E C	21 20	1.08 1.10	0.075 0665	>0.05

Table 1. Bone mineral density in total body and in sections of body. There was no difference between control and experimental groups in both total body and body section.
E: Experimental group, C: Control group.

	Group	n	Mean	Standard Deviation	P
LArm	E C	21 20	23.22 27.26	7.18 7.34	>0.05
RArm	E C	21 20	22.43 25.47	7.21 7.13	>0.05
T Trunk	E C	21 20	24.74 28.93	7.21 6.78	>0.05
L Leg	E C	21 20	22.52 25.85	5.74 4.95	>0.05
R Leg	E C	21 20	23.09 26.12	6.29 4.79	>0.05
Subtotal	E C	21 20	23.84 27.65	6.58 5.87	>0.05
Head	E C	21 20	19.07 19.21	0.68 0.69	>0.05
Total	E C	21 20	23.52 27.01	6.10 5.49	>0.05

Table 2. Body fat rate in total body and in sections of body. There was no significant difference in fat rate between control and experimental groups.
E: Experimental group, C: Control group.

	Group	n	Mean	St Deviation	p
Calsitonin	E C	21 20	8.07 9.77	5.48 5.14	>0.05
PTH	E C	21 20	47.62 35.08	21.44 13.22	>0.05
Osteocalsin	E C	21 20	32.54 24.16	8.11 5.91	<0.05
C telopeptide	E C	21 20	0.45 0.46	0.208 0.154	>0.05
Creatin	E C	21 20	1.00 0.95	0.208 0.124	>0.05
Calcium	E C	21 20	9.92 9.45	0.840 0.660	>0.05

Table 3. Biochemical markers of bone. Osteocalcin was significantly increased in the experimental group.
E: Experimental group, C: Control group.

	Group	n	Mean	St.deviation	p
Glikoz	E C	21 20	126.625 96.583	22.213 18.158	<0.05
Ürea	E C	21 20	24.157 33.760	9.388 6.647	<0.005
Total protein	E C	21 20	7.760 7.430	0.404 0.342	<0.05
AST	E C	21 20	28.260 24.690	10.877 8.430	>0.05
ALT	E C	21 20	41.100 32.840	18.749 16.767	>0.05
ALP	E C	21 20	155.78 71.15	29.300 23.929	<0.001
Uric aside	E C	21 20	5.630 5.260	1.254 0.907	>0.05
Globulin	E C	21 20	3.000 2.590	0.337 0.287	<0.05
I Bilirubine	E C	21 20	0.740 0.550	0.409 0.215	>0.05

Table 4. Some biochemical parameters in serum. Glucose, urea, total protein, ALP and globulin were significantly changed in the experimental group.
E: Experimental group, C: Control group.

	Group	N	Mean	St. Deviation	p
Red blood cell (RBC)	E C	21 20	5.41 5.13	0.32 0.29	<0.05
White blood cell (WBC)	E C	21 20	8.23 7.43	1.18 1.58	>0.05
Hemoglobin	E C	21 20	15.51 15.38	0.97 1.04	>0.05
Hematocrit	E C	21 20	44.45 42.83	3.13 1.98	>0.05
pH	E C	21 20	5.13 5.57	0.51 0.70	>0.05

Table 5. Some blood parameters in serum. RBC significantly increased in experimental group.
E: Experimental group, C: Control group.

Discussion

Electricians and plant operators have exposed to magnetic field approximately in hour 1 μt level[18]. The guideliness of the international nonionizing radiation committee of international radiation protection association for maximum levels of magnetic field exposure for occupational situation are 0.5 mt for workday exposure and 5 mt for short term exposure, whereas for general public it is 0.1 mt for 24 h/ day exposure and 1 mt for exposure of a few hours per day[19]. In the most of investigation, it is referred brain cancer and leukemia risk among electrical workers[20]. About this subject, experimental studies are not enough but epidemiological studies shows that low level electromagnetic fields have such an effect[21]. This is the first report about the bone mıneral density and some bıochemıcal parameters of bone ın high power electrıcal workers. In the present study, the bone mıneral density was found to be increased in hıgh power electrıcal workers but it was not statistically different from other groups.

Electromagnetic fields (EMF) are also reported to have a beneficial effect on bone micro-architecture and might reduce the risk of fracture. EMF were developed based on the finding that electrical currents exist in mechanically-loaded bone and are important for physiological regulation of bone metabolism. There is some evidence for the effectiveness of EMF. However, due to the large variation in the characteristics of EMF signals of different generators, comparison of different in vitro and in vivo studies is difficult[22].

Although experimental evidence of the effectiveness of EMF on bone formation seems quite extensive, clinical evidence is lacking. For example, EMF are widely used for the treatment of nonunion. However, their activities are limited to observational studies[14-18] and few experimental studies[19-21]. Therefore, the use of EMF in nonunions bone studies is still under debate[22-24]. Clinical studies have shown that bone markers are correlated to bone remodeling. In the present study, we investigated two markers of bone formation with OC and ALP. Osteocalcin (OC) is the major noncollagenous bone protein, which is synthesized in osteoblasts.

EMF was induced differentiation of cartilage cells[25] and increased ALP activity in rat osteoblastic cells[6]. In our former study, we observed that 1mT magnetic field stopped osteoporosis, was occured with experimental method[11].

Leod et al. showed that variation increased in rat osteoblastic cells was exposed to EMF[7]. According to this study, mT level of magnetic field increase collagen type I mRNA and ALP expression and occurs good organized extracellular matrix[7]. In our study, ALP increased but variation in BMD wasn't seen. We didn't study collagen type I mRNA expression and not look extracellular matrix in electron microscopy in this workers. It was very difficult to study this, because workers didn't give permission surgery attempt. It can be also difficult in experimental study. Because, in laboratory was impossible to produce 140 kV and 360 kV high voltage. In kind of this studies, taking bone from workers with microinjection, extracellular matrix should be investigated with electron microscope and mineral density should be determined with atomic absorbtion spectroscopy to explain relation between osteocalcin and ALP level change and extracellular matrix and BMD. Furthermore, collagen type I mRNA expression should be determined. There is concrete example to compare BMD results, because BMD wasn't measured in workers that have worked in this field.

In our study, decrease of body fat rate compare to control is very interesting result. But, there is no sample study to compare this too. We observed in our former study that EMF lead to decrease in phospholipids fatty acid composition of rat testis cell membrane[26]. Some interaction mechanism have been suggested. For example, this interaction mechanisms are effect by electrophoretic and electroosmotic ways[27], effect by free radicals and hydration in cell[28], effect in membrane receptors and/ion transport[29,30]. It is claimed that EMF in this levels affects hypothalamo-pituitary-thyroid (HPT) and Hypothalamo-pituitary-adrenal axis, so changes as thyroid and melatonin hormone levels[31,32].

The electromagnetic fields are shown to reduce the calcium ion uptake by the cells[33]. The role of calcium in cellular damage, with its role in activating the nucleases and proteases of the cell was shown earlier[34].

Takamo-Yamamoto et al. observed that ALP levels significantly increased after seven days in rats exposed to EMF[9]. Nicola Giordano et al. didn't observed any change in the level of BMD, serum ALP and serum Ca in patients with osteoporozis that exposed to EMF, significant increase in serum osteocalcin levels was observed in these patients [35]. But osteocalcin level became normal after a month from the end of application. The reason of the result can be low level magnetic field and short time application. Although magnetic field level is more high in our study, results is compatible with this study.

Gürgül S et al. showed that energy absorbtion capacity, maximum load, dicplacement and stiffness values, ultimate stres and elastic modulus parameters were significantly decreased in rat bone exposed to magnetic field in comparison that of controls[36]. But, these physical parameters is not possible to determeine in man bone.

In this such kind of application, bone density is evaluated after 6-12 month. Osteocalcin is an early marker of growth of bone. Thus, increase of osteocalcin can be the result of this. The increase of serum ALP can be possibly synthesis from both and liver. BMD hasn't changed, but some biochemical values as glucose, urea, total protein, globuline have changed. In male and famale rats that exposed to 60 Hz, 240kV/m electromagnetic field wasn't observed any changes in growth, blood and biochemical parameters[37]. In the most of experimental studies, the change of BMD with the exposed to EMF can depend on different application. In result of exposed to long time EMF, bone tissue can adapt to electromagnetic fields.

Conclusions

Bone mineral density, body fat percentage and other biochemical parameters were measured in workers working in high voltage lines.

In the bone mineral density values of the experimental group did not observed statistically significant changes compared to the control group. In the experimental group, body fat rate was observed to decrease. Glucose, urea, total protein, globulin, osteocalcine and ALP values were increased. In the other parameters (WBC, Hgb, Hct, pH, AST, ALT, uric acide, Bilirubin I, calcitonin, PTH, c-telopeptide, creatin ve Ca) did not observed any significant change.

We think that these changes can create significant health problems in these workers for a long time.

Declaration of Interest

The authors report no conflict of interest and the article is not funded or supported by any research grant.

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