



# Biological Monitoring of Body Natural Metal Elements in Radiologists

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## Abstract

Radiologists are exposed to occupational radiation. Exposure to radiation increases the likelihood of changes in the body's essential metal elements and the occurrence of radical chain reactions and lipid peroxidation in the membrane, decreased enzymatic activity, ionic currents, and activation of ion channels. Biological monitoring of these elements is essential to prevent more serious side effects on the body. Therefore, this study aimed to determine the amount of copper, iron, zinc, and magnesium in the blood serum of radiologists. This case-control study was conducted in 2020 on 50 radiologists and 50 controls in Shiraz hospitals. Serum 5 cc of blood was extracted using a centrifuge. Then, the concentrations of copper, zinc, iron, and magnesium in serum were measured with an AA-7050 atomic absorption spectrometer. Finally, the data were analyzed by analysis of variance. The mean serum concentrations of iron and zinc in radiologists and the control group were significant ( $P < 0.05$ ). While the mean concentrations of iron and zinc in the radiologist's blood serum increase and decrease, respectively. But the mean concentrations of copper and magnesium in the blood serum of radiologists and the control group were not significant ( $P > 0.05$ ). The mean of iron concentration was higher in male radiologists than in female radiologists ( $P < 0.05$ ). The results of this study showed that radiation in radiologists can have positive or negative changes on the concentration of iron and zinc in the body. It is suggested that biological monitoring of these elements in the blood serum of radiologists be used as an indicator of exposure to this adverse physical agent to prevent more serious symptoms.

**Keywords:** Biological monitoring, Metal elements, Radiologists

## 1 Introduction

Radiologists are exposed to occupational radiation in imaging departments of hospitals and clinics. Although the dose of exposure to this beam is low, frequent contact during working hours can have detrimental effects (1). DNA sensitivity to radiation is one of the main effects in this regard (2). While some of the effects of radiation, such as radical chain reactions and lipid peroxidation in the membrane, cause a decrease in enzyme activity, ionic currents, activation of ion channels, and changes in the concentration of trace elements. The biological effects of low doses are small but significant changes in living systems. Therefore, a small amount of elements has been considered in this regard (6-3). The concentration of elements such as copper, zinc, iron, and magnesium in the body is controlled by the homeostasis system and their acceptable range is very limited to preserve the structural properties of the cell and the function of body tissues. Slight changes in the amount of these elements can cause significant changes in the body's physiological activities (8, 7). These elements play an essential role in all vital processes and recently their importance is increasing with the development of measurement methods. Studies have shown that the effect of low doses of X-rays on the concentration of trace metals in the blood and structural changes in the scalp and nails in radiologists has been reported (10, 9). Chronic effects of X-ray and gamma rays on animal specimens have been reported as

changes in the low concentration of these metallic elements in blood and irradiated tissues (11, 12). The effects of a high dose of X-ray and gamma rays on the amount of these elements in different tissues of mice were also statistically significant (1). But there are still many ambiguities about the effects of these rays on humans. Therefore, this study was performed to determine the effects of occupational radiation and its role on the concentration of copper, iron, zinc, and magnesium in the body of radiologists.

## 2 Materials and methods

This case-control study was carried out on 100 employees of hospitals in Shiraz in 2020. 50 of them were radiologists and 50 were controls and in each group, there were 25 females and 25 males. Radiologists with 10 to 15 years of experience were selected from imaging departments of hospitals including radiology, radiotherapy, and nuclear medicine. According to the Atomic Energy Organization, in the evaluation of the staff badge film, the above-mentioned individuals receive embroidery between zero and 1 millisievert in two months. The control group (non-radiologists) was selected from the staff of other wards of the hospital who were compatible with the radiologists in terms of age and socioeconomic status. To prevent adverse effects on the results, the subjects are free of the liver, blood, kidney, drug use, pregnancy, smoking, and special nutrition. Sampling was limited to certain hours of the

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morning to minimize possible fluctuations in the amount of elements. To eliminate errors caused by environmental pollution, pipettes, glass containers, and test tubes were placed in a 20-liter container containing 10% hydrochloric acid before work, and then rinsed three times with deionized water and drained. 5 cc of blood was collected from the elbow vein of the subjects with a plastic syringe and poured into a plastic test tube and the lid was closed with paraffin. To separate the serum from the rest of the blood contents, the tubes were centrifuged at 10,500 rpm for 10 minutes. The serum was then separated by a sampler and poured into another test tube. The lids of the serum tubes were closed with paraffin and placed in the freezer at a temperature of minus 20 degrees Celsius. To measure the concentrations of copper, zinc, iron, and magnesium in serum, an Atomic Absorption Spectrophotometer or Atomic Absorption Spectrometer (AAS) model AA-7050 made in China's EWAL company was used. In these measurements, acetylene flame was used and the device was calibrated for each element. The main standard solution of the desired element was poured into a hot flask using very precise pipettes and diluted by standard dilution with deionized water to concentrations of 0.25, 0.5, 0.75, 1, 1.25 mg per liter of the original solution. The same diluents and the same control solution were selected by successive measurements and trial and error methods (13).

To eliminate spectral interference and easier suction of the sample by an atomizer, the samples were diluted 1 to 5 for copper, zinc, and iron, and magnesium was diluted 1 to 50. After selecting the lamp for the desired element in the atomic absorption device, the absorption spectrum of each solution was measured and their calibration curve was drawn. In all stages of measurement and quality control of the system, the method of adding a standard to the sample was used to check the reproducibility of the system. Also, the absorption spectra of standard solutions were compared to the values given in the

device manual for a concentration of 1 ppm of the above elements. The concentrations of the elements in the irradiated and control groups were measured three times. Finally, the data were analyzed by analysis of variance and regression.

### 3 Results and Discussion

The mean age of the radiologist group was  $37 \pm 5$  and the control group was  $37 \pm 6$  years and both groups were not significantly different in terms of age and sex distribution ( $P > 0.05$ ). The mean and standard deviation of daily working hours in both radiologists and control group ( $0.5 \pm$ ) was 8 hours. The mean and standard deviation of daily work experience in both radiologists and control group were  $12 (\pm 0.5)$  and  $11.2 (\pm 0.65)$  years, respectively, and there was no significant difference ( $P > 0.05$ ). The changes in the mean concentrations of some of the elements tested in the group of radiologists and the control group are shown in Figure 1.

As shown in Figure 1, the mean concentrations of iron and zinc in the blood serum of radiologists and the control group were statistically significant ( $P < 0.05$ ). While the mean concentration of iron in the serum sample of radiologists is higher and the mean concentration of zinc in the serum sample of the control group is higher. Other results showed that the mean concentrations of copper and magnesium in the blood serum of radiologists and the control group were not statistically significant ( $P > 0.05$ ). The average concentrations of copper, iron, zinc, and magnesium in both radiologists and control groups by sex are shown in Table 1.

According to the results of Table 1, among the metallic elements studied in blood serum, only the mean concentration of iron was significantly related to sex, so that the average concentration was higher in men than women ( $P < 0.05$ ). A significant reduction of copper in female radiologists was obtained in comparison with the control group ( $P < 0.05$ ).

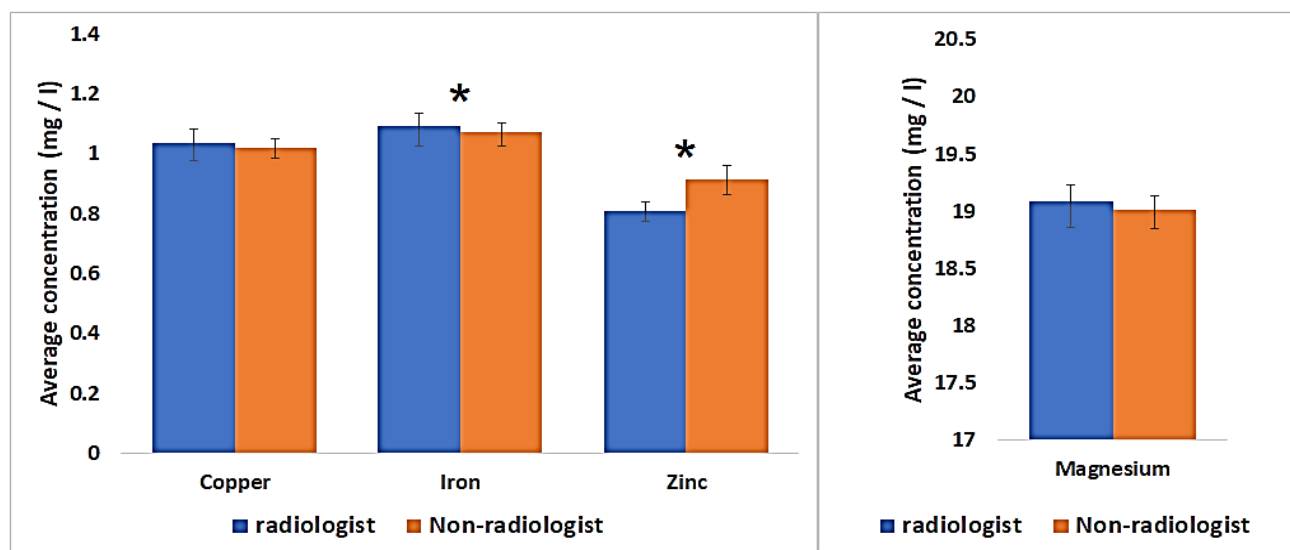


Figure 1: Mean concentrations of copper, iron, zinc and magnesium in radiologists and control group

Table 1. Mean and standard deviation of concentrations of studied metal elements in both radiologists and control group by sex

| Body natural metal elements | Control group         |                       | Radiologists         |                       |
|-----------------------------|-----------------------|-----------------------|----------------------|-----------------------|
|                             | Male                  | Female                | Male                 | Female                |
| Copper                      | 0.932 ( $\pm 0.021$ ) | 0.994 ( $\pm 0.036$ ) | 1.13 ( $\pm 0.018$ ) | 0.927 ( $\pm 0.023$ ) |
| Iron                        | 1.06 ( $\pm 0.038$ )  | 0.91 ( $\pm 0.01$ )   | 1.17 ( $\pm 0.029$ ) | 1.087 ( $\pm 0.031$ ) |
| Zinc                        | 0.823 ( $\pm 0.016$ ) | 0.776 ( $\pm 0.01$ )  | 0.73 ( $\pm 0.01$ )  | 0.74 ( $\pm 0.009$ )  |
| Magnesium                   | 19.42 ( $\pm 0.25$ )  | 19.35 ( $\pm 0.24$ )  | 19.89 ( $\pm 0.15$ ) | 19.75 ( $\pm 0.33$ )  |

In this study, an increase in the mean concentration of iron and a decrease in the concentration of zinc in the serum of radiologists were observed in comparison with the control group. Because the average concentration of the above elements corresponds to the natural range reported in the reference texts (15-13). It can be concluded that there was no systemic error. Zinc was less reported in female radiologists compared to control women. The mean iron concentration in the radiologist was higher than in the control group. In the study of Katraji et al., The reduction of copper and zinc elements and the increase of iron concentration were reported in the radiologist in comparison with the control group (16). Also, in the studies performed on the blood serum of the employees of the Chernobyl power plant, an increase in the concentration of copper element was observed (17). In a study conducted in Iran, a significant reduction in copper in female radiologists was compared with the control group (18). The results obtained in some cases are different from previous studies that these differences may be due to the type of blood sample in these studies. Whole blood was used in the catheter study and the study performed in Iran, while serum was used in the present study. Genetic diversity, nutritional factors, individual sensitivity to radiation, and environmental pollution can also explain these differences. Any factor that causes cell membrane integrity to fail will initiate oxidative damage and cause metals to leak small amounts of cellular components. The findings of this study confirm the possible effect of chronic radiation on the concentration of some blood metals.

#### 4 Conclusion

The results of this study showed that radiation in radiologist personnel can have positive or negative changes on the concentration of some natural metal elements in the body, such as iron. It is suggested that biological monitoring of changes in the concentration of these elements in the blood serum of irradiators be used as an indicator of exposure to this physically harmful factor to prevent more serious symptoms.

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#### Ethical issue

Authors are aware of and comply with, best practices in publication ethics specifically about authorship (avoidance of guest authorship), dual submission, manipulation of the figure, competing interests, and compliance with policies on research ethics. Authors adhere to publication requirements that submitted work is original and has not been published elsewhere in any language.

#### Competing interests

The authors declare that no conflict of interest would prejudice the impartiality of this scientific work.

#### Authors' contribution

All authors of this study have a complete contribution to data collection, data analyses, and manuscript writing.

#### References

1. Parikh JR, Geise RA, Bluth EI, Bender CE, Sze G, Jones AK, et al. Potential radiation-related effects on radiologists. *American Journal of Roentgenology*. 2017;208(3):595-602.
2. Kuefner M, Brand M, Engert C, Schwab S, Uder M, editors. *Radiation induced DNA double-strand breaks in radiology. RöFo-Fortschritte auf dem Gebiet der Röntgenstrahlen und der bildgebenden Verfahren*; 2015: © Georg Thieme Verlag KG.
3. Zeraatpishe A, Oryan S, Bagheri MH, Pilevarian AA, Malekiran AA, Baeeri M, et al. Effects of *Melissa officinalis* L. on oxidative status and DNA damage in subjects exposed to long-term low-dose ionizing radiation. *Toxicology and industrial health*. 2011;27(3):205-12.
4. Rothkamm K, Balroop S, Shekhdar J, Fernie P, Goh V. Leukocyte DNA damage after multi-detector row CT: A quantitative biomarker of low-level radiation exposure. *Radiology*. 2007;242(1):244-51.
5. Tolunay HE, Şükür YE, Ozkavukcu S, Seval MM, Ateş C, Türksoy VA, et al. Heavy metal and trace element concentrations in blood and follicular fluid affect ART outcome. *European Journal of Obstetrics & Gynecology and Reproductive Biology*. 2016;198:73-7.
6. Derakhshanjafari M, Jangjou A, Bagherzadeh R, Reza M, Monazzam ZZ. Prevalence of Heat-Related Illnesses among Outdoor Workplaces Workers in Hot and Dry Areas of Iran. *Journal of Environmental Treatment Techniques*. 2021;9(1):253-8.
7. Ulri H, Yoldas T, Doluy K. Magnesium, zinc and copper content in hair and their serum concentration in patient with epilepsy. 2003.
8. Chie S, Hiroshi K, Yutaka A, Ryoji O. Concentration of copper and zinc in liver and serum samples in biliary artesia patients. *J Exp Med*. 2005;27(1):271-7.
9. Majumdar S, Chatterjee J, Chaudhuri K. Ultrastructural and trace metal studies on radiographers' hair and nails. *Biological trace element research*. 1999;67(2):127-38.
10. Man AC, Zheng Y-H, Mak P-K. Structural and trace element changes in scalp hair of radiographers. *Biological trace element research*. 1998;63(1):11-8.
11. Paunesku T, Wanzer M, Kirillova E, Muksinova K, Revina V, Romanov S, et al. X-ray fluorescence microscopy for investigation of archival tissues. *Health physics*. 2012;103(2):181.
12. Shimura N, Kojima S. The lowest radiation dose having molecular changes in the living body. *Dose-Response*. 2018;16(2):1559325818777326.
13. Butt E, Nusbaum R, Gilmour T, Didio S, Mariano S. Trace metal levels in human serum and blood. *Archives of Environmental Health: An International Journal*. 1964;8(1):52-7.
14. Goullé J-P, Mahieu L, Castermant J, Neveu N, Bonneau L, Lainé G, et al. Metal and metalloid multi-elementary ICP-MS validation in whole blood, plasma, urine and hair: Reference values. *Forensic science international*. 2005;153(1):39-44.
15. Tulić L, Vidaković S, Tulić I, Čurčić M, Bulat Z. Toxic metal and trace element concentrations in blood and outcome of in vitro fertilization in women. *Biological trace element research*. 2019;188(2):284-94.
16. Chatterjee J, Mukherjee B, De K, Das A, Basu S. Trace metal levels of X-ray technicians' blood and hair. *Biological trace element research*. 1994;46(3):211-27.
17. Protasova O, Maksimov I, Nikiforov A. Altered balance of trace element in blood serum after exposure to low doses of ionization radiation. *Bio Bull*. 2001;2:344-9.
18. Haidar Barghi M, Bolouri B, Osati Ashtiani F, Goorabi H. Investigation of the possible effect of chronic occupational exposure to x-rays on the amount of trace elements zinc and copper in the blood of x-ray technicians. *Razi Journal of Medical Sciences*. 2003;9(32):681-6.