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Detection of Zinc in Nail Samples of Iron Welders

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Abstract

The current study was conducted to quantify zinc in nail samples of iron welders from different areas of Lahore, Pakistan. This study intended to assess nutritional deficiencies of zinc in welders. As nails serve a beneficial biomarker of concentrations of trace elements, hence in the present study the nails of welders were used for monitoring. The total number of nail samples collected from workers of iron welding shops, were 40. In a standardized washing procedure the nail samples were scrapped and cleaned of dust particles with nonionic detergent (Triton X-100) and then nail samples were digested afterwards in acid mixture. The concentration of zinc was evaluated by atomic absorption spectrophotometer. The results revealed that concentration of zinc in nail samples ranged 0.297 – 1.718 mg/kg and averaged at 0.88±0.39 mg/kg which is below the ideal zinc levels in nail samples. Correlation of zinc (mg/kg) was significant with age (0.214< 0.5), weight (0.320< 0.5) and Body Mass Index (0.268< 0.5) of the welders, while a weak correlation of zinc (mg/kg) was found with height (0.042< 0.5) of the welders.

Keywords: Zinc, Nail samples, Iron welders, Atomic absorption spectrophotometer, Pearson's correlation.

Introduction

Zinc significantly contributes in constancy of human metabolism. Participation of this trace metal in all major biochemical pathways and formulation of genetic material such as DNA transcription, RNA translation and cell division is well documented [1]. Zinc content ranges from 1.5 to 2.5 grams in normal adult humans. Average content is higher in males and lesser in females comparatively. Human organs, fluids, tissues and major secretions contain zinc in them [2].

Zinc is found in a wide array of foods. Highest zinc per serving is offered by oysters while huge quantities are provided by poultry and red meat too. Dairy products, nuts, cereals, beans, whole grains and different types of sea foods as in lobsters and crabs are rich in zinc content. Institute of Medicine of the National Academies (formerly National Academy of Sciences) supports Food and Nutrition Board (FNB) for the formulation of Dietary Reference Intakes (DRIs) for zinc [3].

Impairment of immune function, retardation in the growth and loss of appetite are some of the serious aftermath of zinc deficiency in human body. Severity of zinc deficiency is characterized by skin and eye lesions, hair loss, male hypogonadism, impotence and delayed sexual maturation (Prasad, 2004). Reduced intake of zinc leads to lowered absorption of zinc in the body which is not compensated by reduced zinc excretion. Ultimately, zinc is lowered in the body as reserved mobile zinc is depleted [1]. Both acute and chronic types of zinc toxicities are common. When zinc is administered in high quantities it can lead to acute effects such as headaches, nausea, and diarrhea, loss of appetite, vomiting and cramps in abdomen [4]. As galvanized materials are welded, zinc oxide is formed which leads to metal fume fever on inhalation [5].

Trace elements found in human nails have been thoroughly studied using variety of techniques. Elemental analysis of trace metals is achieved through atomic fluorescence spectrometry, atomic absorption spectrometry, inductively coupled plasma atomic emission spectrometry (ICP-ALS) [6]. Fibrous proteins that make up tissue of nail are richly loaded with keratins appearing as residues of cysteine. Healthy cells influence their roots and transient concentrations are offered by fluids and blood therefore nails serve as a beneficial biomarker of concentrations of trace elements [7]. The present study focuses on the importance of zinc in human body. Zinc concentration in the body directly impacts immune system; development and growth of human body thereby influence the body directly.

Materials and Methods

Sampling area and Sample collection: For quantifying zinc in nail samples iron welders were selected from different welding shops found in Lahore, Pakistan. Male subjects from welding shops were chosen for nail sample collection. Hand of the respondents were washed using distilled water and metal free medicated soap. Drying was done by clean towel or tissue papers in order to get rid of external contamination. Clean scissors were used for collection of fingernails of male subjects between age ranges of 14-66 years. Nail samples were stored in air tight plastic jars at room temperatures. Analysis was carried out at Environmental Science Research Laboratory of Lahore College for Women University, Lahore, Pakistan. The general health status of the welders was assessed by means of a questionnaire related to their personal profile, general health, dietary habits, life style, age and gender, source of drinking water, smoking habits, health condition and medication.

Instrumentation: Atomic Absorption Spectrophotometer (AAS Thermo scientific M series GF95Z Zeeman Furnace) was used.

Washing of nail samples: Nonionic detergent Triton X-100 was used to wash nail samples in a standardized procedure [8]. Nail samples were cleaned off any dust particles and then soaked in acetone which cleared off contamination. Afterwards the nail samples were washed with deionized water five times. Oven was used for drying and then samples were stored in desiccator.

Wet-acid digestion and preparation of water-clear solution: Wet acid digestion was employed, whereby 10 mL of mixture of concentrated nitric acid and perchloric in ratio of 6:1 was used to digest dried nail samples. It was kept overnight at room temperature and excessive foaming was prevented. Then it was heated at 160-180°C to get water clear mixture. Heating reduced the volume of solution to 1 mL. Wet acid digestion destroys the organic matter and in this way solution is obtained that contains metal in its elemental form. Then each sample was diluted using 0.1 M nitric acid [9].

Analytical procedure: Flame mode of Atomic Absorption Spectroscopy was used for analysis of nail samples. Instrument calibration was achieved by running three different standards at the start of the analytical procedure. Sample injection was done using a small capillary. For analyzing zinc in nail samples, Hollow cathode lamp with the atoms of zinc was used (Table 1).

Table 1. **Concentration of zinc in nail samples of iron welders.**

Sample ID	Zinc concentration mg/kg	Sample ID	Zinc Concentration mg/kg
1	0.821	21	0.469
2	1.350	22	0.395
3	0.869	23	1.395
4	0.572	24	1.199
5	0.746	25	1.083
6	0.735	26	1.602
7	0.464	27	1.319
8	0.483	28	1.178
9	0.541	29	1.014
10	0.420	30	1.180
11	0.297	31	1.388
12	1.219	32	1.118
13	0.470	33	0.448
14	0.457	34	1.239
15	0.454	35	1.108
16	0.515	36	1.192
17	0.661	37	1.718
18	0.583	38	1.333
19	0.482	39	1.115
20	0.553	40	1.145

***Data interpretation and analysis*:** After analysis, the concentration of zinc in nail samples was depicted using statistical methods of averages, ranges, standard errors and Pearson's correlation. SPSS-17 and Microsoft Excel 2010 were utilized for statistical calculations and data interpretations.

Results and Discussion

The present study revealed low concentrations of zinc in nails of iron welders (Table 2). As per reports of World Health Organization (WHO), concentration range of zinc in body must be between 2-3 g/kg. Study of Lawrence Wilson in 2012 showed that zinc levels in nails ranging between 0.8-2.8 mg/dl or 8-28 mg/kg is considered ideal. Comparison of average zinc concentration in the samples was made with allowable limits. The results revealed that the zinc concentration was well below the prescribed limit. According to the present study, in almost all of the workers deficiency of the zinc was observed. The zinc concentration studied in welders' nails increases significantly with age. The younger group showed least levels when compared with older group (Fig. 1).

Table 2. **Mean and Standard Deviation of the Variables.**

	N	Minimum	Maximum	Mean	Std. Deviation
Age (years)	40	14	66	28.95	13.27
Weight (kg)	40	40	106	64.57	12.68
Height (meters)	40	1.52	2.00	1.66	0.1016
Body Mass Index kg/m3	40	18.6	31.6	23.61	3.4
Concentration (ppm)	40	0.2970	1.7183	0.8836	0.3944

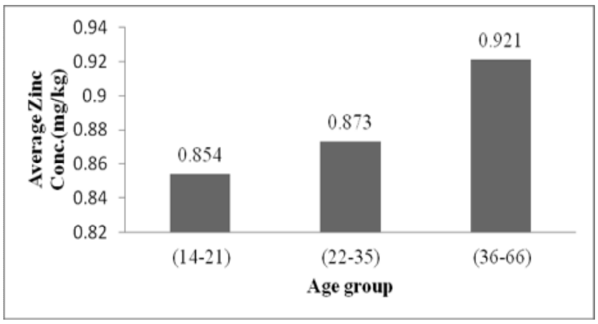

Figure 1. **Comparison of average value of zinc (mg/kg) in nails of welders from different age groups**

Data which was gathered during survey revealed that 57.5% of welders have largest proportion of vegetable in their daily diet (Fig. 2). Diets rich in zinc were missing from their meals. Zinc is critically important for healthy skin, men's reproductive health and for mood and brain health. Zinc deficiency may be associated with certain nutritional reasons. Deficiencies appear in the consumers, if zinc content in the consumed food is low or if the forms of zinc are unavailable. Other causes include deficiency associated with some ailments and genetic disorders which effect absorption of zinc in the intestine. In some severe cases, zinc levels fall due to loss of zinc from intestines [10]. It can be inferred from the studies that the lack of balanced diet and poor nutritional status of food are the most evident causes of zinc deficiency. Assessment of variety of food consumed by the workers showed that there was over dependence on food items such as vegetables and pulses while meat, fruits and rice were consumed comparatively less frequently by these workers. Such nutritional imbalances have led to a low mineral diet deficient in zinc.

Similar studies with use of nails as biomarkers for quantifying heavy metals in a wide variety of age groups of workers from iron welder workshops found in Maiduguri Metropolis, Borno State, Nigeria were depictive of strong links between nutritional deficiencies and low concentration of zinc in nails. Poor socioeconomic conditions, haphazard outdoor works, unhygienic food intake and rapid loss of zinc from body were the main reasons for lower levels of zinc in respondents [6].

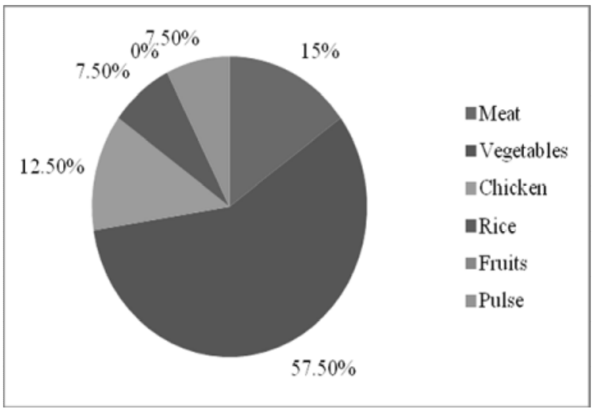

Figure 2. **Graph showing preference of food items by welders**

Descriptive statistic

Study variables were analyzed using descriptive statistics and averages and standard deviations were interpreted. Ranges were calculated. Table 3 of the study showed mean age (28.95 0±13.27yrs), mean weight (64.57±12.68kg), mean height (1.66±0.101m) and average Body Mass Index BMI (23.61±3.4). The mean concentration of zinc in nail samples of iron welding workers was 0.883±0.394. Ranges calculated in the present study are shown in the table.

Table 3. **Correlation of concentration of Zinc with age, weight, height and BMI.**

		Age	Weight	Height	BMI
Concentration Zinc	**Pearson's correlation**	0.214	0.093	0.042	0.454
	Sig.2 (tailed)	0.294	0.32	0.341	0.268
	N	40	40	40	40

Analysis of relationship

The present study also utilized Pearson's correlation (level of significance set at 0.05) for determining the relationship between variables. Correlation determined the strength of relationship between variables. 1 means the relationship is strong. 0.5 or above means relationship is positive strong. Less than 0.5 means there is weak relationship. Negative means inverse relationship. Table 3 showed strength of correlation (0.320 < 0.5) between weight and zinc concentration. Similar strength was depicted between zinc concentration and BMI (0.268 < 0.5). Rest of the variables determined in the study such as age (0.214 < 0.5) and height (0.042 < 0.5) showed a comparatively weaker correlation with concentration of zinc in mg/kg Table 4. Thus the data analysis indicated that there was a significant but weak relationship of zinc concentration with age, height, weight and BMI of the workers.

Table 4. **FAAS Specifications for Zinc Analysis.**

Lamp current (m Ao)	5
Wavelength (nm)	213.9
Linear range (mg/litre)	0.4–1.5
Slit width (nm)	0.5
Integration time (seconds)	2.0
Flame	Air acetylene

Body weight and metabolism of zinc have shown a strong interrelationship in a variety of clinical and experimental studies conducted on the subject. When a person becomes underweight either due to insufficient diets, regular attacks of illnesses and infections then it causes low intake of protein diet, vitamins and minerals particularly zinc. If the workers are obese or overweight, then deficiency of zinc is critically harmful, this was concluded in World Health Organization (WHO) studies. This is further complicated by prevalence of decreased resistance to infections and behavioral and learning issues. The respondents which fall in 1.52 m category of height showed least levels of zinc concentration when compared with the, 2.0 m categories. It was evident from the finding of this study that respondents with low BMI had low zinc concentration as compared to normal and high BMI. This result can be related to other study in which nail mineral analysis was performed on over three-hundred males with BMI ranging between low, normal and high. Significant differences were noted in zinc levels between men with a low compared to those with a high BMI [11]. Institute of Medicine (2001) supported the fact that zinc deficiency has become a leading risk factor for a number of diseases and disorders prevailing worldwide. Occupants involved in iron welding are at a higher risk of developing such zinc deficiencies due to risky operations they are involved in make them more vulnerable to such deficiencies. Developing countries depict higher zinc deficiencies which hampers the health as well as productivity [12]. The influence of certain factors (age, sex, health, occupation, etc.) causing the change in zinc levels is obvious, whereas the influence of other factors (structure of nail, height of the subject, etc.) is obscure. It is very important to consider all the factors at the time of investigation for effective interpretation, validity, and application of results of nail analysis [13].

Further organized feeding programs for industrial workers in public sector undertakings is gaining importance to promote better nutritional status, since well-fed Labor force and productivity are closely related.

Conclusion

Zinc deficiency is one of the leading risk factors for disability and death worldwide affecting an estimated billion people. Nutritional zinc deficiency arises when physiological requirements cannot meet by zinc absorption from diet. The high prevalence of zinc deficiency in the developing world has substantial health and economic costs including decreased productivity. Zinc is an important component of the human body and its level greatly influence the body by means of different ways as it plays an important role in immune system, growth and development of the human body. Present study utilized nails as a biomarker for quantifying zinc levels in welders. The prevailing situation of zinc that appeared in alarmingly low concentration (0.297 – 1.718 mg/kg) in all samples of nail of the welders is quite concerning. Main cause of the zinc deficiency in the body is the lack of balanced diet and poor nutrition. Zinc concentration showed positive correlation with age, weight, BMI and height. The poor health conditions of these workers have direct relationship with their socioeconomic status and nutritional deficiencies.

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