



Assessment of Blood Iron and Manganese on Artesant Welders Exposed to Welding Fumes

Authors

Torka N. Sordum¹, Ndokiari Boisa²

¹Chemical Pathology, Department of Medical Laboratory Science, Rivers State University of Science and Technology Port Harcourt.

²Department of Chemistry, Rivers State University of Science and Technology Port Harcourt

Corresponding Author

Torka N. Sordum

+2348063480511, Email: torka@yahoo.com

ABSTRACT

Whole blood iron and manganese levels in artesant welders control subjects were investigated. Five (5ml) blood samples were collected via venepuncture from thirty (35) welders and twenty five (25) control subjects after their voluntary consent. Samples were digested using standard method. Aliquots of digested samples were assessed for Mn and Fe content with Atomic Absorption Spectrophotometer. The data obtained were expressed as the mean \pm Standard Deviation. Independent sample t- test was conducted with the means with SPSS Version 22.0. It was observed that both welders and controls subjects the mean \pm S.D were $3.37 \pm 1.34 \mu\text{g/l}$ and $3.34 \pm 1.43 \mu\text{g/l}$ respectively. Means and standard deviations of blood manganese (Mn-B) levels in welders and controls subjects were $3.37 \pm 1.34 \mu\text{g/l}$ and $3.34 \pm 1.43 \mu\text{g/l}$ respectively. Means and standard deviations blood iron (Fe-B) levels for welders and control subjects were $410 \pm 104 \mu\text{g/dl}$ and $166 \pm 37 \mu\text{g/dl}$ respectively. Significant difference at $p < 0.001$ was observed when means for test and control subjects were compared. There were no correlations between Mn-B and Fe-B levels of welders with duration of exposure and age. This study has revealed that welders in Elekahia Estate, Community and railway off Trans –Amadi Layout of Port Harcourt have normal Mn-B level with non welders while there Fe-B level is exceptionally high than non welders. Exposure to iron, may cause iron overload (siderosis) and iron accumulation in liver, heart, and kidney leading to hepatomegaly, myocardial siderosis and metabolic acidosis.

Keywords: Iron; Manganese; Welder; Duration of exposure; Welding fume; Welding electrode.

INTRODUCTION

Iron (Fe) is a mineral substance that is abundant in the hemoglobin of red blood cells and in the myoglobin of muscle cells. Iron catalyses the formation of vitamin A and is incorporated in some enzymes ^[1]. The human body contains approximately 20 mg of manganese (Mn), they are found in the bones, kidney and liver

^[2]. Though manganese is an essential trace element for human survival, it is also toxic when in high concentration in human body. Manganese is a mineral element that is both nutritionally essential and potentially toxic. Manganese is important in protein, carbohydrate, lipid and cholesterol metabolism. Manganese is essential for the development of

bone^[3]. Manganese is applied in the production of carbon steel, high temperature steel, cast iron and super alloy. Manganese oxide is used in the production of dry cell battery, fertilizers, pesticides, livestock nutritional supplement, glass, matches, ceramics and welding rod^[4]. Welding rods used for different classes of welding have been suggested to consist of Iron and traces of Manganese. Manganese and iron dust is generated during welding process can be inhaled by artesants involved the welding process. During welding these chemicals can also settle on surfaces be resuspended at later dates. And the amount of manganese produced depends on the welding wire, welding current/voltage, electrode type and base metal. Welding significantly increases exposure to manganese fume^{[5], [6]}. Prolonged inhalation of dust and fume containing manganese is of a major concern, and high body burden may cause manganism, low libido and impotency in male welders^[7]. Environmental and occupational exposure to manganese also causes cognitive, neuropsychological and neuro-behaviour,^{[8], [9]}. Exposure to low manganese levels may cause fatigue, glucose intolerance, blood clotting and skin problems, skeleton disorder, birth defect, changes of hair colour and neurological symptom^[10]. The normal blood manganese (Mn-B) level is 0.6 – 2.4µg/l. While that of blood iron (Fe-B) level is (55-160 µg/dl). Excess blood iron (iron toxicity or siderosis), called iron overload, usually leads to Iron accumulation in the liver, heart, and kidney causing hepatomegaly, myocardial siderosis and metabolic acidosis^[11].

Published data on human exposure to Iron and Manganese and associated health effects is presently scarce. Welding artesants in developing countries are not aware of their possible exposure to Iron and Manganese fume while carrying out their work. Therefore, this research was conducted to assess Iron and Manganese level in the blood of welding artesants.

MATERIALS AND METHODS

Study Area/ Materials

The study was carried out on welders within Elekahia Housing Estate, Elekahia community and Elekahia Railway in Port Harcourt, Rivers State, Nigeria. The welders selected for this study operated outside confined spaces and used the gauge 10 – 12 electrode.

Materials used were, 5 mls syringe and needle, Pasteur pipette, automated micropipette, lithium heparin container, plain containers, sterile urine container, cotton wool, methylated spirit, tourniquet, hand gloves, beaker, volumetric flasks, sample rack, test-tubes, cover glasses, funnel, wash bottle.

Equipment used were Atomic Absorption Spectrophotometer (AAS), centrifuge, refrigerator, hot air oven, hot plate. Solutions used were deionized water, perchloric acid, nitric acid, sulphuric acid, manganese and iron standard.

Collection of Blood Sample

Five (5) ml blood samples were collected via venepuncture from thirty-five (35) welders and twenty-five (25) non welders who gave their consent. The blood samples were stored in the fridge.⁷

Subject Selection

Test subjects were included on the basis that they have been involved in welding activity for at least five years. Only male subjects were selected because the profession is dominated by them. The thirty-five (35) welders willingly gave their blood samples. Control subjects (25) were selected on the basis that they have not been involved in any form of welding activity before. The welders average working experience is 14.4 years. Mean age for welders was 33.8 years, while that of non welder was 30.6 years. Subjects were grouped as Stick (SMAW), Structural (SAW), Argon (GMAW), scumcural (SCUW) welders and control (CTRL).

Treatment of Sample

Sample digestion

Prior to sample digestion time, all the test tubes, 100ml flasks, funnels and measuring cylinders were acid washed and dried in the hot air oven. To ensure they were free of contaminant of any kind. Digestion of sample was done using oxidizing acid mixture of nitric, perchloric and sulfuric acid in 3:1:1 v/v/v ratio ^[12]. About 9ml of the mixture was added to 1ml of whole blood, mixed, placed on hotplate and digested for 60 – 90 minute at 200⁰C. At the end of digestion process the solution was allowed to cool and the resulting mixture filtered into 100ml volumetric flask. The residue was washed with deionized into the 100 mL flask and the volume of the flask made to mark with deionized water.

Analysis

AAS calibration curves were established using absorbance from five freshly prepared manganese and iron standard solutions (1.0 mL to 5.0 mL). 10ug/L Aliquot of the digested samples were analysed with AAS using the manganese and iron lamps. The molar absorptivity obtained from slope of graph plotted was used to determine the concentration manganese and iron in the unknown samples based on Beer-Lambert law.

Statistical Analysis

The data obtained during interview sessions with study subjects and results were reviewed, and expressed as the mean, mean \pm standard deviation. Differences between two means were analysed using independent sample t-test with the Statistical Package for Social Sciences (SPSS) version 22.0.

RESULTS

Means and standard deviations of blood Manganese (Mn-B) levels in welders and controls subjects were $3.37 \pm 1.34 \mu\text{g/l}$ and $3.34 \pm 1.43 \mu\text{g/l}$ respectively (Table 3.1). The mean values for welders and control were not significantly different when compared ($t = -0.088$, $p = 0.930$) (Table 3.1). Means and standard deviations blood iron (Fe-B) levels for welders and control subjects were $410 \pm 104 \mu\text{g/dl}$ and $166 \pm 37 \mu\text{g/dl}$ respectively (Table 3.2). A significant difference ($t = -11.283$, $p = 0.000$) was observed when mean values for both subjects were compared.

Means and standard deviations of Mn-B levels for Stick, Structural, Argon, scumcural welders and control were $3.34 \pm 1.6 \mu\text{g/L}$, $3.40 \pm 1.35 \mu\text{g/L}$, $3.07 \pm 1.33 \mu\text{g/L}$, $4.1 \pm 0.14 \mu\text{g/L}$, and $3.34 \pm 0.27 \mu\text{g/L}$, respectively (Table 3.3). Means and standard deviations of Fe-B levels for Stick, Structural, Argon, scumcural welders and control were $418 \pm 104 \mu\text{g/dl}$, $415 \pm 104 \mu\text{g/dl}$, $415 \pm 132 \mu\text{g/dl}$, $345 \pm 28 \mu\text{g/dl}$, $401 \pm 107 \mu\text{g/dl}$ and $166 \pm 37 \mu\text{g/dl}$, respectively (Table 3.4). Using pearson correlation, the correlation and p values between Mn-B level of welders, duration of exposure and age are ($r = -0.04$, $p = 0.980$) and ($r = -0.174$, $p = 0.311$), respectively (Table 3.5). Similarly there was a negative correlation and no significant differences between welders Fe-B levels and duration of exposure ($r = -0.204$, $p = 0.246$) and between age and Fe-B levels ($r = -0.233$, $p = 0.172$).

Table 3.1: Blood Manganese Level in $\mu\text{g/l}$ in Subjects and controls

Variables	Numbers	Mean \pm S.D	p-Value
Subjects	35	3.37 ± 1.34	p< .001
Controls	25	3.34 ± 1.47	

Table 3.2: Blood Iron concentration in $\mu\text{g}/\text{dl}$ in subjects and controls.

Variables	Numbers	Mean \pm S.D	p-Value
Subjects	35	410 \pm 104	p<.001
Controls	25	166 \pm 38,	

Table 3.3: Group presentation of various Mn-B Level($\mu\text{g}/\text{l}$) in subjects.

Classes	N	Min	Max	Mean \pm S.D
SMAW	24	1.40	9.10	3.34 \pm 1.61
SAW	6	2.10	5.90	3.40 \pm 1.35
GMAW	3	1.60	4.20	3.07 \pm 1.33
SCU W	2	4.00	4.20	4.1 \pm 0.14
CTRL	25	1.2	7.00	3.34 \pm 0.27

Table 3.4: Group presentation of various Fe-B Level($\mu\text{g}/\text{dl}$) in subjects and control.

Classes	N	Min	Max	Mean \pm S.D
SMAW	24	272	662	418 \pm 104
SAW	6	273	616	415 \pm 132
GMAW	3	324	366	345 \pm 28
SCU W	2	324	478	401 \pm 109
CTRL	25	108	256	166 \pm 37

Key:

SMAW: Stick Metal Arc Welding.

SCU-W : Scumcural Welding.

SAW : Structural Arc Welding

CTRL: Control

GMAW: Gas (Argon) Metal Arc Welding

Table 3.5: Pearson correlation

Variables	Duration of Exposure(r)	Welders's Age(r)
Mn-B level in $\mu\text{g}/\text{l}$	-004	-174
	-980	-311
N	34	35
Fe-B level in $\mu\text{g}/\text{dl}$	-204	-233
	-246	-172
N	34	35

DISCUSSION

The results obtained from this study showed no significant difference in mean Mn-B levels of both welders and controls in Table 3.1. This may be due to the absence of recent exposure to welding fume by welders recruited for this study. This suggestion is in agreement with the work of [13] that revealed that Mn-B level above normal reference value (0.6- 2.3 $\mu\text{g}/\text{l}$) suggest recent exposure. In a study [8, 14] that indicated high levels of Mn-B in welders the elevated levels were

suggested to be due very recent exposures to welding fume. A few studies [e.g.14, 15] have concluded that higher levels of Mn-B could be a maker for recent exposure to manganese in welders.

The low Mn-B levels observed for the exposed group in this study may be due the fact that all the welders involved in this studies were conducting their welding out-door (not in confined space). In such borderless environment the generated metallic fumes diffuses off spontaneneously. Our

suggestion relating to diffusion of generated fumes is consistent with the work of [16] on dose-effect relationship between Manganese exposure and neurological, neurophysiological and pulmonary function in confined space welders. At the end of study Mn-B level was greater than ten (10) µg/l.

Some other reasons for low Mn-B may be due to welding process, flux and based metal, electrode diameter and unsteady power/current supply. Also, this study demography shows that majority of welders (about 68.6%) used were engaged in stick welding process, the coating on the welding rod materials helps to minimize impurities. The study of [17] revealed that level of Manganese generated depended on the welding process.

The low Mn-B observed in this study may also depend availability of electric power to welders, since most of welders depended public power supply which is presently not regular in Port Harcourt. So there is no steady current during welding process, therefore fewer fumes are generated.

The significant difference between blood Iron of welders and control, (410 ± 104 and 166 ± 37 at $p < 0.001$). This is consistent with the work of [18], using the data obtained by Korean National Health and Nutrition Exam Survey (KNHANES) of 2008. They revealed that manganese level decreased steadily with higher blood levels and reached a plateau around Iron concentration of 75 µg/L.

The study of [16] on confined space bridge welders revealed that blood Iron level was 469 – 2016 µg/L. The work of [19] which revealed that blood manganese level may be lowered because both shared the up-regulation mechanism of gastrointestinal absorption [16]. The study of [20] also revealed that there is difference between blood half-life and tissue half-life of manganese which is two (2) hours and half-life of manganese from inorganic source which is fifty (50) to seventy (70) days.

CONCLUSION

The results obtained from this study on welders in Elekahia Estate, and railway (off Trans-Amadi Layout) revealed no significant difference in blood Manganese level of both welders and controls whilst the mean Fe-B level was significantly higher in welders than controls. This result indicates that iron is the major contaminant generated during welding. Since Iron compete with manganese during gastro-intestinal absorption, increased Fe-B may be responsible for low Mn-B. If welders are exposed to high levels of iron fumes, they may be prone to iron overload (siderosis) which may lead to its accumulation in liver, heart, and kidney causing hepatomegaly, myocardial siderosis and metabolic acidosis respectively.

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