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Sex Hormones Levels in Male Welders in Nnewi, South-Eastern Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Welding processes produce toxic fumes consisting of gaseous and aerosol by-products which pose a risk to the male reproductive systems. The rate of infertility has increased globally. This study therefore sought to assess the effects of welding fume inhalation on the sex hormones of welders in Nnewi. A site-by-site cross-sectional study of 45 welders (aged between 18 and 50 years) who were exposed to welding fumes (Test group) and 45 age-matched non-welders (Control group) was carried out. The ages of the Test and Control subjects, as well as the years of exposure of the Test subjects were obtained via questionnaire. A single non-fasting venous blood (about 5 mls) was collected from the ante-cubital space from the subjects via venipuncture between 8:00 AM and 11:00 AM. Serum was separated following clotting, and used for the investigation of the levels of male sex hormones: Testosterone (T), Progesterone (P), Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH) among welders. Sex hormones were

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assayed by Enzyme Linked Immunosorbent Assay. The results showed that Testosterone (2.45±0.34 ng/ml) was significantly lower ($p<0.05$) in welders when compared to controls (4.94±0.81 ng/ml) and significantly increased ($p<0.05$) levels of Progesterone (0.54±0.09 ng/ml) and LH (7.47±1.56 mIU/L) were found in welders compared with controls Progesterone (0.45±0.08 ng/ml) and LH (5.53±1.05 mIU/L). There was no significant difference in the levels of FSH of the test when compared with the controls. This finding of altered hormone levels indicates a likelihood of reduced reproductive outcome. Exposure to welding fume may therefore interfere with testicular functions leading to disordered reproductive performance, delayed conception, and reduced fertility.

Keywords: Sex hormones; manual electric arc welding; testosterone; progesterone.

1. INTRODUCTION

Welding is the most widely used technology for joining metals and alloys. Welding processes produce fumes consisting of gaseous and aerosol by-products composed of metals, metal oxides and volatilized chemical species from the base metals, welding electrode, or flux material [1]. Despite some welders' use of respiratory protective equipment, workers are still exposed to fumes produced by co-workers, when they themselves perform tasks other than welding [2]. However, it is observed that welders in private settings, in developing countries like Nigeria, seldom use the respiratory protective equipment.

Information on the toxicological effects of welding fumes on human reproductive organs in Nigeria is relatively scanty, and studies by Caucasian researchers are still controversial; while some researchers found no association between welding fumes and fertility abnormalities [3], other researchers reported a strong relationship existing between welding fume inhalation and reproductive abnormalities [4-7]. Serum levels of testosterone and progesterone in addition to LH and FSH in circulation, are used in the assessment of reproductive integrity in males [8].

This study therefore is designed to evaluate the possible effects of exposure to welding fumes and airborne particles in metal workers in welding halls and shops on the reproductive system.

2. MATERIALS AND METHODS

Study Design: The present study was conducted at Nnewi metropolis, South-Eastern Nigeria. A total of 90 adult male volunteers aged between 18–50 years were recruited for this study by convenient sampling technique, comprising of 45 individuals as test group, and 45 as control. The control population were age-matched volunteers who were not exposed to welding fumes (office workers, traders and students) and who were not also given to excessive smoking/alcohol use [9,10].

2.1 Inclusion Criteria

Subjects with no history of infertility prior to employment as a welder, who are not drug addicts or excessive smokers/alcohol users during the previous one year and with no history of prostate surgery.

2.2 Exclusion Criteria

Subjects with job duration less than one year, above the age of 50 years, with hypertension and diabetes and with history of infertility, prostate surgery prior to employment.

2.3 Specimen Collection

A single non-fasting venous blood (about 5 mls) was collected from the ante-cubital space from the subjects via venipuncture between 8:00 AM and 11:00 AM, to control for diurnal variations [11] and dispensed into plain containers. Blood was delivered to the laboratory where it was centrifuged, following clotting [12]. Centrifugation was performed at 1500 rpm for 5 minutes using bench centrifuge, and serum separated and stored frozen, until the time of assay.

2.4 Analytical Methods

The serum testosterone, progesterone, follicle stimulating hormone and luteinizing hormone assays were done using standard Enzyme Linked Immuno-Sorbent Assay technique.

2.5 Statistical Analysis

The data from this study were subjected to statistical analysis using SPSS package, version 23 and presented as mean ± standard deviation.

Student's t-test (independent t-test) was used to test difference in mean values. The tests of significance of variation within and among groups were compared using ANOVA at 95% level of confidence and post-hoc (Tukey) analysis was used to compare multiple variables. The results obtained were presented in tables for clarity. The p- value ≤ 0.05 was considered statistically significant. Correlation was performed using the Pearson's correlation.

3. RESULTS

Table 1 shows that there was no significant difference between the mean age of the test and control subjects (p= 0.703). Testosterone levels (2.45±0.34 ng/mL) of the test subjects was significantly lower (p= 0.000) when compared with the control subjects. Also, Progesterone (0.54±0.09 ng/mL) and Luteinizing hormone (7.47±1.56 mIU/mL) of the test subjects were significantly higher (p= 0.000) when compared with Progesterone (0.45±0.08 ng/mL) and Luteinizing hormone (5.53±1.05 mIU/mL) of the control subjects. There was no statistically significant difference (p= 0.071) when follicle stimulating hormone of the test subjects were compared with the control subjects.

Table 2 shows the correlation between duration of exposure and testosterone, progesterone, luteinizing hormone and follicle stimulating hormone of the test subjects in the study. There was a weak, positive relationship between duration of exposure and testosterone level of the subjects in the study, which was not significant (p= 0.824). Also, there was a weak, positive relationship between duration of exposure and progesterone level of the subjects in the study, which was not statistically significant (p= 0.621). Furthermore, there was a weak, negative relationship between duration of exposure and luteinizing hormone level of the subjects in the study, which was not statistically significant (p= 0.732) while there was a weak, positive relationship between duration of exposure and follicle stimulating hormone level of the subjects, which was not statistically significant (p= 0.089).

Table 3 shows the correlation between age and testosterone, progesterone, luteinizing hormone and follicle stimulating hormone of the test subjects in the study. From the table, there was a weak, negative relationship between age and testosterone level of the subjects in the study, which was statistically significant (p= 0.824). Also, there was a weak, negative relationship between age and progesterone level of the subjects in the study, which was not statistically significant (p= 0.271). Furthermore, there was a weak, negative relationship between age and luteinizing hormone level of the subjects in the study, which was statistically significant (p= 0.025), while there was a weak, positive relationship between age and follicle stimulating hormone level of the subjects, which was not statistically significant (p= 0.226).

Table 4 shows the correlation between age and testosterone, progesterone, luteinizing hormone, follicle stimulating hormone of the control subjects in the study. There was a weak, negative relationship between age and testosterone level of the subjects in the study, which was not statistically significant (p= 0.733). Also, there was a weak, negative relationship between age and progesterone level of the subjects in the study, which was not statistically significant (p= 0.852). Furthermore, there was a weak, positive relationship between age and luteinizing hormone level of the subjects in the study, which was not statistically significant (p= 0.668) while there was a weak, negative relationship between age and follicle stimulating hormone level of the subjects, which was not significant (p= 0.449).

Table 1. The levels of testosterone, progesterone, luteinizing hormone, follicle stimulating hormone of the subjects in the study (Mean±SD)

Parameters	Test subjects (N= 45)	Control subjects (N= 45)	t- value	P- value
Age (Years)	31.93±9.56	31.13±10.00	-0.383	0.703
Testosterone (ng/ml)	2.45±0.34	4.94±0.81	-18.950	0.000*
Progesterone (ng/ml)	0.54±0.09	0.45±0.08	4.564	0.000*
LH (mIU/ml)	7.47±1.56	5.53±1.05	6.918	0.000*
FSH (mIU/ml)	11.61±2.36	10.76±2.07	1.827	0.071

*Key: N: Number of subjects; p≤0.05: *Statistically significant; LH: Luteinizing hormone; FSH: Follicle stimulating hormone; Degree of freedom (df): 88*

Table 2. The correlation between duration of exposure and sex hormone of the test subjects in the study

Parameters	r (Pearson correlation coefficient)	P- value
Duration of exposure vs Testosterone	0.034	0.824
Duration of exposure vs Progesterone	0.076	0.621
Duration of exposure vs LH	-0.052	0.732
Duration of exposure vs FSH	0.257	0.089

*Key: N: Number of subjects (45); p≤0.05: *Statistically significant; LH: Luteinizing hormone; FSH: Follicle stimulating hormone*

Table 3. The correlation between age and sex hormone of the test subjects in the study

Parameters	r (Pearson correlation coefficient)	P- value
Age vs Testosterone	-0.034	0.824
Age vs Progesterone	0.168	0.271
Age vs LH	-0.334	0.025*
Age vs FSH	0.184	0.226

*Key: N: Number of subjects (45); p≤0.05: *Statistically significant; LH: Luteinizing hormone; FSH: Follicle stimulating hormone*

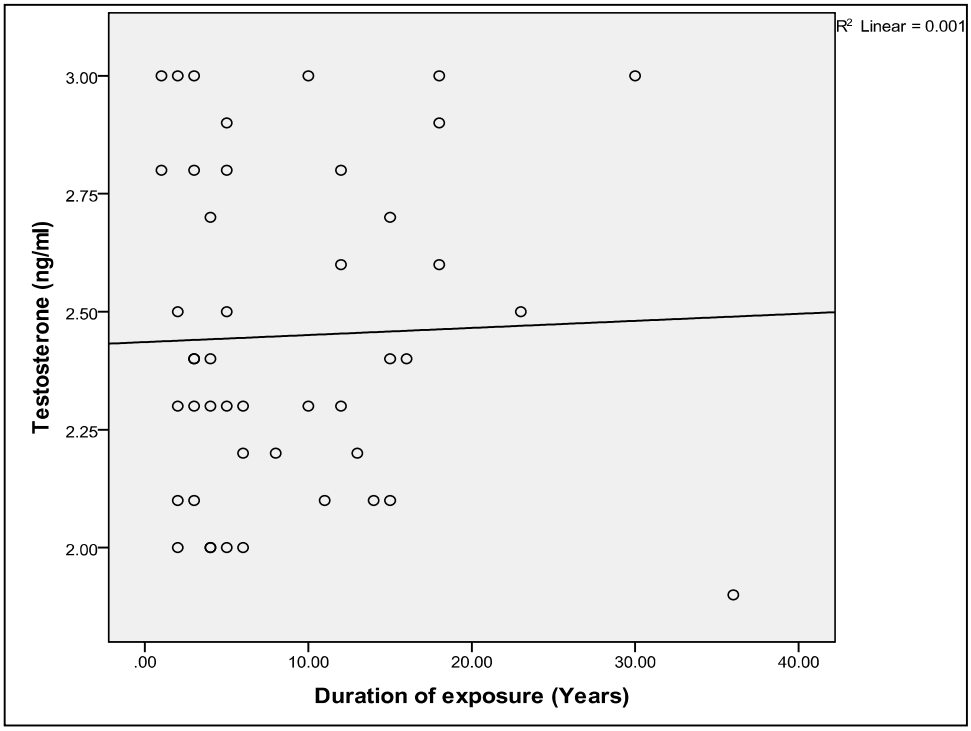

Fig. 1. Scatter plot showing the correlation between duration of exposure and testosterone level of the test subjects in the study

Table 5 shows the values of testosterone, progesterone, luteinizing hormone (LH), follicle stimulating hormone (FSH) based on different age groups of the test subjects in the study. Testosterone was not significant (p= 0.839) in age group 18-28 (years) when compared with age group 29-39 (years) and 40-50 (years) in the study. Progesterone and luteinizing hormone shows no statistical significant difference (p= 0.798, p= 0.077, respectively) when age group 18-28 (years) was compared with 29-39 (years) and 40-50 (years). Also, follicle stimulating hormone was not statistically significant (p= 0.293) when age group 18-28 (years) was compared with 29-39 (years) and 40-50 (years).

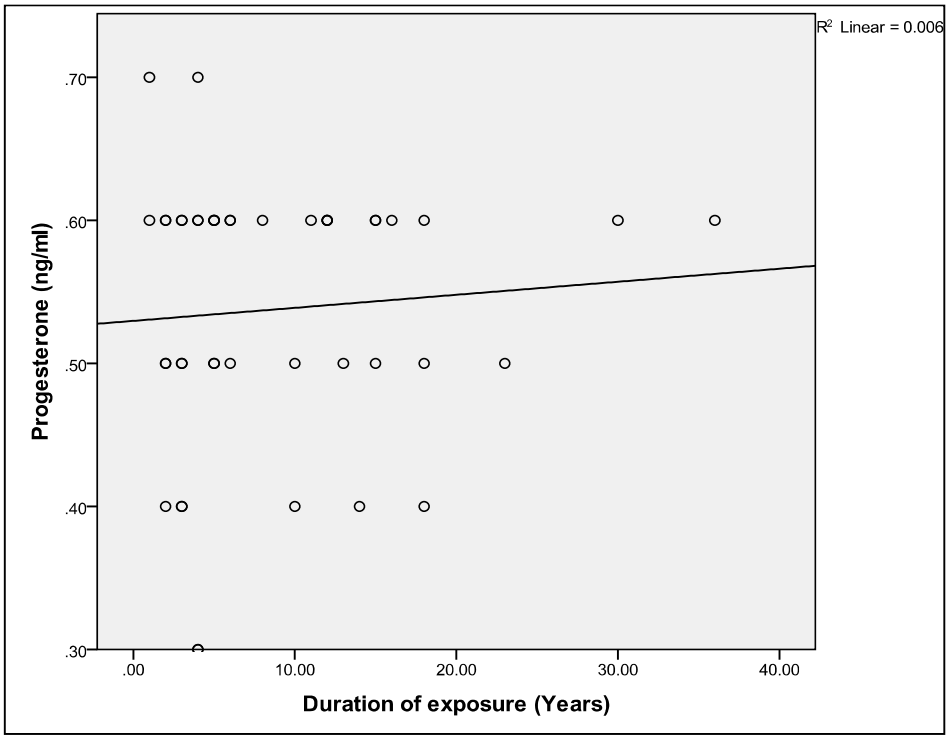

Fig. 2. Scatter plot showing the correlation between duration of exposure and progesterone level of the test subjects in the study

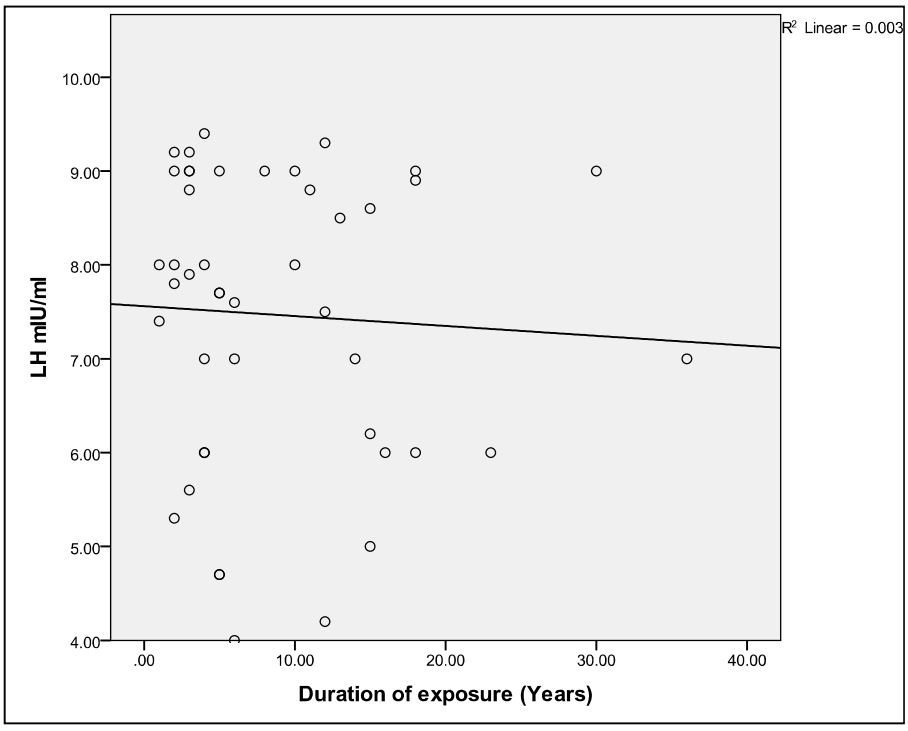

Fig. 3. Scatter plot showing the correlation between duration of exposure and luteinizing hormone level of the test subjects in the study

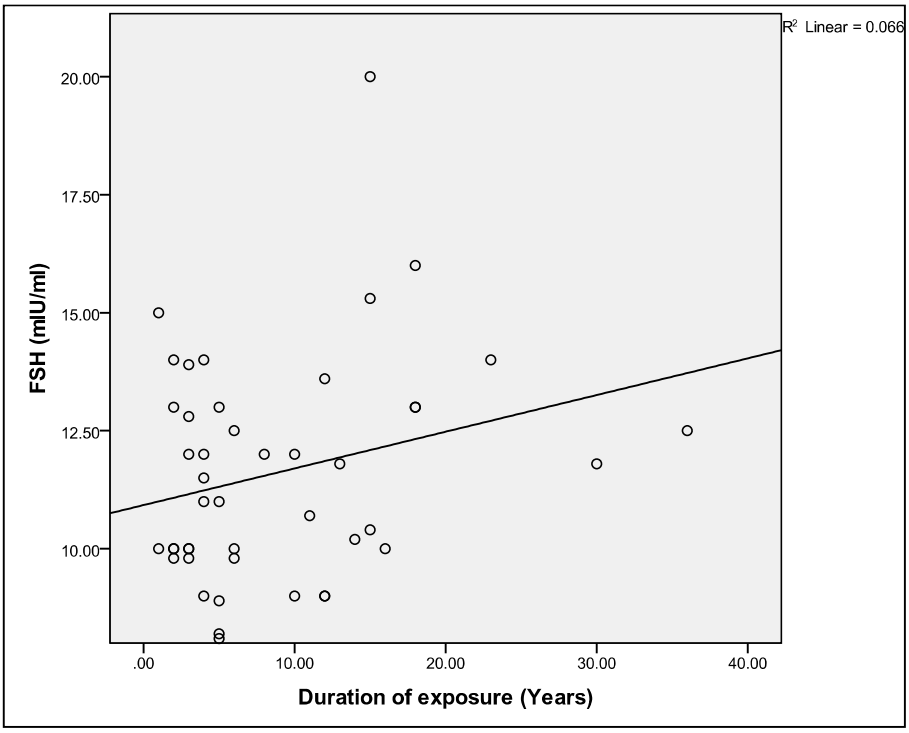

Fig. 4. Scatter plot showing the correlation between duration of exposure and follicle stimulating hormone level of the test subjects in the study

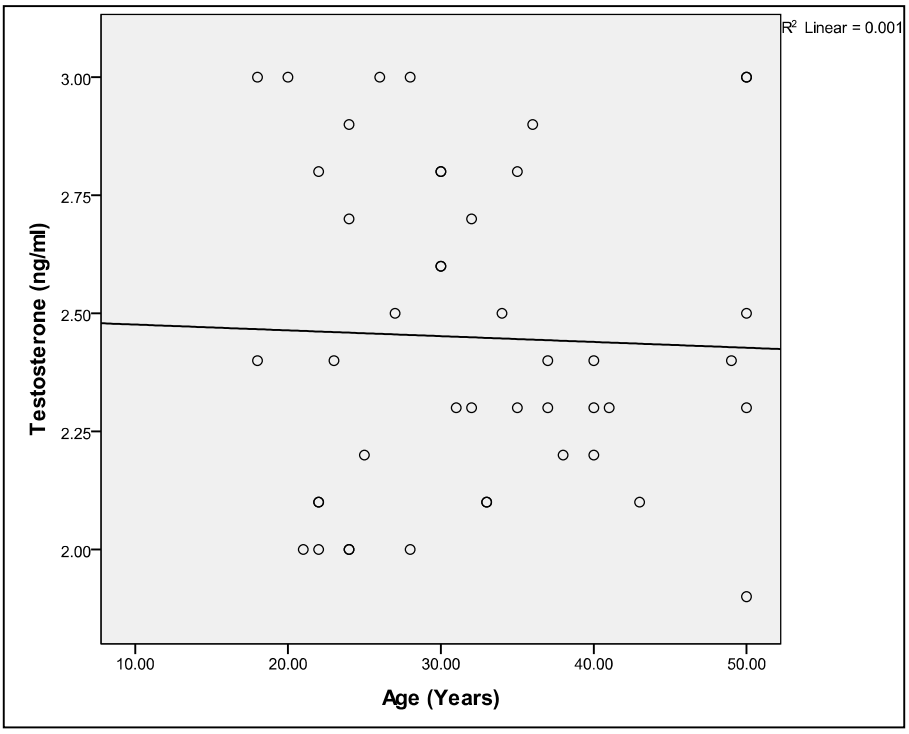

Fig. 5. Scatter plot showing the correlation between age and testosterone level of the test subjects in the study

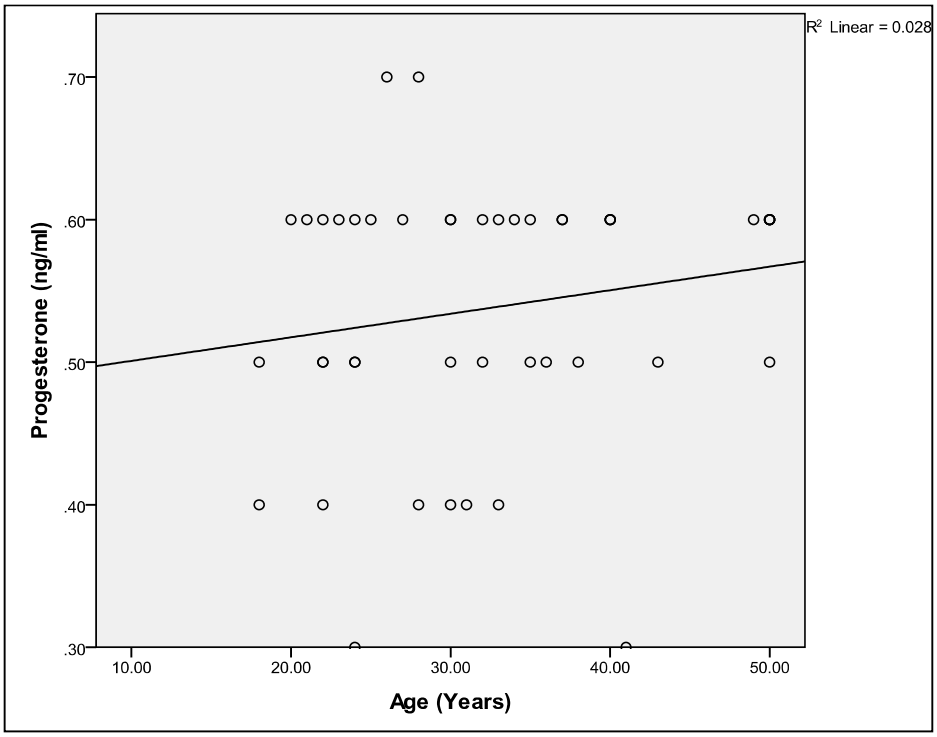

Fig. 6. Scatter plot showing the correlation between age and progesterone level of the test subjects in the study

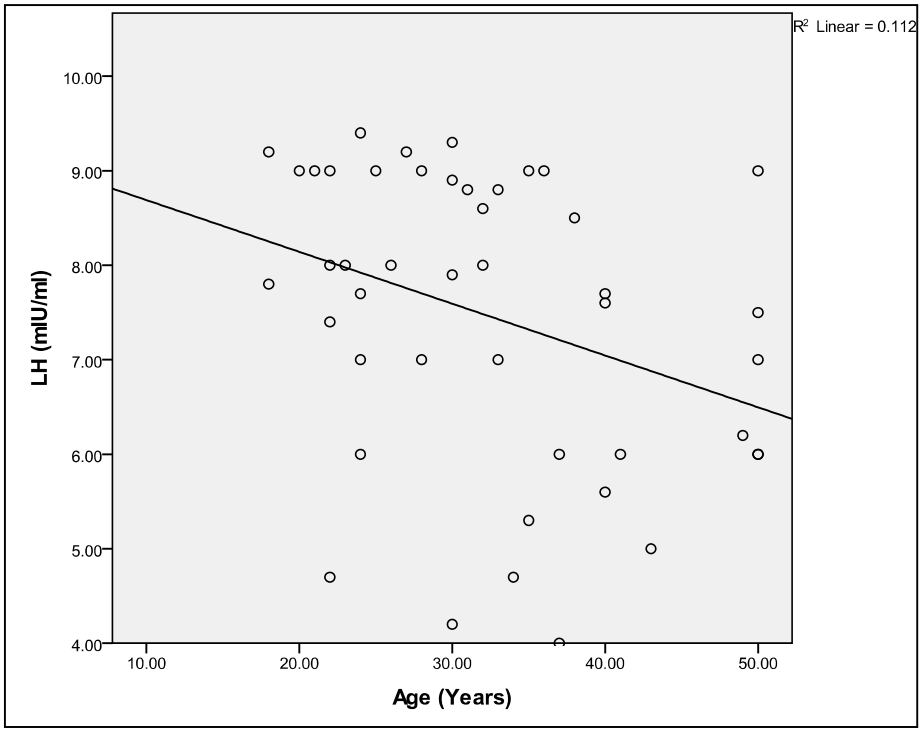

Fig. 7. Scatter plot showing the correlation between age and luteinizing hormone level of the test subjects in the study

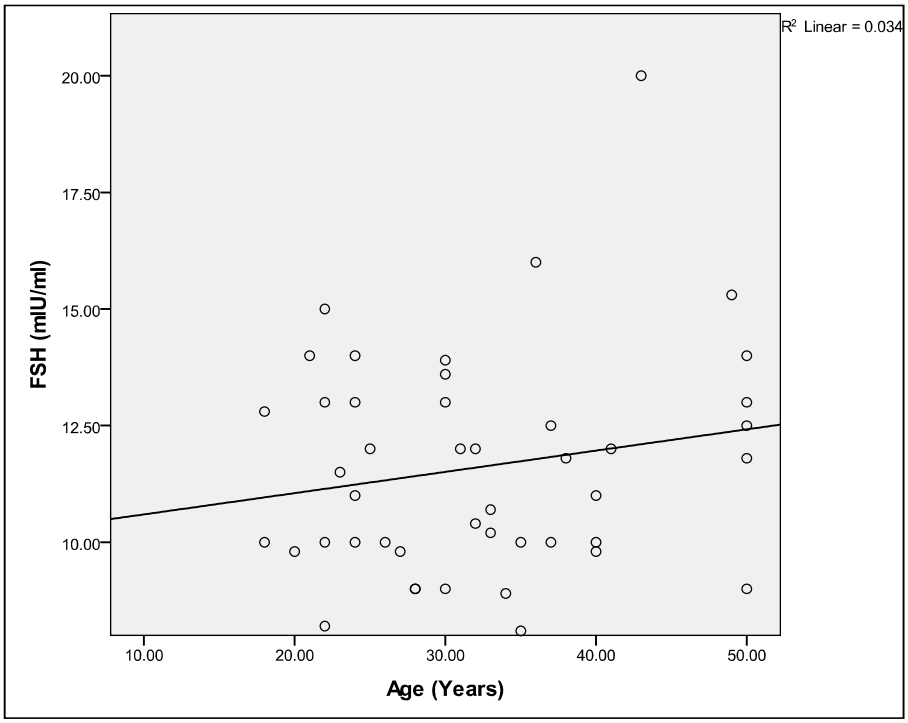

Fig. 8. Scatter plot showing the correlation between age and follicle stimulating hormone level of the test subjects in the study

Table 4. The correlation between age and sex hormone of the control subjects in the study

Parameters	r (Pearson correlation coefficient)	P- value
Age vs Testosterone	-0.052	0.733
Age vs Progesterone	-0.029	0.852
Age vs LH	0.066	0.668
Age vs FSH	-0.105	0.494

*Key: N: Number of subjects (45); p≤0.05: *Statistically significant; LH: Luteinizing hormone; FSH: Follicle stimulating hormone*

Table 5. The values of biochemical parameters based on duration of exposure of the subjects in the study Mean±SD

Groups (Years)	Testosterone (ng/ml)	progesterone (ng/ml)	LH (mIU/ml)	FSH (mIU/ml)
1-5 (A)	2.48±0.36	0.54±0.10	7.65±1.54	11.14±2.09
6-10 (B)	2.33±0.34	0.53±0.08	7.43±1.86	10.88±1.46
≥11 (C)	2.45±0.32	0.54±0.09	7.26±1.55	12.41±2.74
F- value	0.400	0.008	0.297	1.787
P- value	0.673	0.992	0.745	0.180
A vs B	0.651	0.994	0.952	0.968
A vs C	0.981	1.000	0.724	0.218
B vs C	0.738	0.992	0.971	0.352

*Key: P≤0.05: *Statistically significant; N: Number of subjects (A= 21, B= 6, C= 18); LH: Luteinizing hormone; FSH: Follicle stimulating hormone*

Table 5 shows the values of testosterone, progesterone, luteinizing hormone (LH) and follicle stimulating hormone (FSH) based duration of exposure of the subjects in the study. Testosterone was not statistically significant (p= 0.673) in group 1-5 (years) when compared with

group 6-10 (years) and group ≥11 (years) in the study. Progesterone and luteinizing hormone shows no statistical significant difference (p= 0.992, p= 0.745, respectively) when group 1-6 (years) was compared with 6-10 (years) and ≥11 (years). Also, follicle stimulating hormone was not statistically significant (p= 0.180) when group 1-6 (years) was compared with 6-10 (years) and ≥11 (years).

4. DISCUSSION

Exposure to welding fume toxicants has been associated with reduced semen quality and altered hormone levels [7].

This study reports significant alterations in the levels of the reproductive hormones of the study group. The mean testosterone concentrations of the test subjects was significantly suppressed as compared to the control group. This finding of low testosterone levels may carry long term fertility consequences. Normal testosterone levels in males is associated with normal sperm production [8]. The significantly lower testosterone levels as observed in this study could be due to the exposure to welding fumes.

Testosterone suppression was followed by significant elevations of LH and Progesterone respectively. Although FSH levels were higher in the study group, the difference was not statistically significant. This suppression of testosterone levels with concomitant elevations of LH and FSH in the study group is consistent with a compensatory response arising from increased positive feedback on the Hypothalamic-Pituitary-Gonadal axis by the lowered testosterone levels. Luteinizing hormone is known to stimulate testicular Leydig cells to secrete testosterone, enhancing sperma-togenesis; while FSH induces the sertoli cells to secrete androgen binding protein (ABP) and inhibin and plays an essential role in initiation and progression of spermatogenesis via germ cell proliferation and maturation [8]. This finding of testosterone suppression with concomitant elevations of LH and FSH in the study group suggests that the endocrine effect of the welding fume toxicants was at the level of the gonads. Owing to the fact that the intoxication was gonadal, there was no equivalent corresponding response. This finding of abnormal hormonal levels suggest a disruption of steroid-genesis function in humans exposed to welding fumes.

Although Haneke [3] found no association between welding and fertility abnormalities, Ernst and Bonde [4] reported that there was significant decrease in the number of motile sperm as well as serum testosterone levels. They also reported that the serum concentrations of both LH and FSH were significantly increased. This agrees with the findings of this study. Tas, et al. [5] as well as Wu, et al. [6] independently concluded that certain metals that are common in welding fumes may have toxic effect on reproductive function and sperm quality. Figa, et al. [7] also reported that exposure to welding fume toxicants is associated with reduced semen quality and altered hormone levels.

Also from this study, there was a weak positive correlation between duration of exposure and Testosterone and progesterone levels of the study group, which was not significant. Still, there was a weak negative correlation between exposure duration and LH levels in the study group, which was not statistically significant, while there was a weak positive correlation between exposure duration and FSH levels, which was also not significant. This is consistent with the findings of Bonde, [13] as well as Kumar, et al. [14] who observed higher levels of FSH in welders with higher exposure duration.

The study also revealed that there was a weak negative correlation between age and Testosterone levels, which was not statistically significant. There was, also, a weak negative correlation between age and progesterone levels of the study group, but it was not statistically significant. Further, there was a weak negative correlation between age and LH levels in the study group, which was statistically significant, while there was a weak positive correlation between age and FSH levels of the subjects, which was not statistically significant. These findings suggest that the Hypothalamic-Pituitary-Gonadal function actually diminishes with age, perhaps due to age-related changes in testicles including decrease in the number of Leydig cells which act on feedback mechanisms and cause increased secretion of gonadotropins due to gradual testicular atrophy. This agrees with Well, et al. [15] who reported that age-related structural and functional changes in testicles actually cause increased secretion of pituitary gonadotropins.

5. CONCLUSION

Chronic welding fume inhalation caused a significant reduction in Testosterone levels, as well as a significant increase in Progesterone

and pituitary gonadotropins of exposed individuals as compared to controls. Since the study and control groups were comparable, the differences in these hormone levels so obtained may have resulted from the exposure and could signify endocrine disruption. Since fertility has been correlated with Testosterone levels as well as the pituitary gonadotropin levels, it can be concluded, from this study, that welding fume inhalation by causing a significant reduction of Testosterone, may have a potential for causing infertility. Therefore, the findings from this study highlight that welders need to apply precautionary measures such as limiting exposure time as well as strict adherence to respiratory protective devices.

CONSENT

As per international standard written participant consent has been collected and preserved by the authors.

ETHICAL APPROVAL

The ethical approval for this research was obtained from the Human Research Ethics Committee of Nnamdi Azikiwe University Teaching Hospital, Nnewi, Anambra State. The procedures were explained to the subjects, and written informed consent obtained from each subject before specimen collection.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Zimmer AT, Biswas P. Characterization of the aerosols resulting from arc welding processes. Journal of Aerosol Science. 2001;32(8):993–1008.
2. Merja J, Paula K, Timo T, Ritva L, Harri L, Riina N, Eeva M, Timo H. Inflammatory response to acute exposure to welding fumes during the working day. International Journal of Occupational Medicine and Environmental Health. 2013;26(2):220–229.
3. Haneke E. Findings in the ejaculate of electro welders. Dermatologische monatsschrift. 1973;159(11):1036-1040.
4. Ernst E, Bonde JP. Sex hormones and epidymal sperm parameters in rats following subchronic treatment with hexavalent chromium. Human and Experimental Toxicology. 1992;11(4):255-258.
5. Tas S, Lauwerys R, Lison D. Occupational hazards for the male reproductive system. Critical Review in Toxicology. 1996; 26(23):261-307.
6. Wu W, Zhang Y, Zhang F. Studies on semen quality in workers exposed to manganese and electric welding. Chinese Journal of Preventive Medicine. 1996; 30(5):266-268.
7. Figa-Talamanca I, Traina ME, Urbani E. Occupational exposures to metals, solvents and pesticides: Recent evidence on male reproductive effects and biological markers. Occupational Medicne (London). 2001 ;51(3):174–188.
8. Teitz Teitz Fundamentals of clinical chemistry (6th edition). Elsevier Inc. 2008; 780–786. ISBN: 978-81-312-1374-2
9. Tim N, Mette R, Berit L, Hanne T. Gold standard program for heavy smokers in a real-life setting. International Journal of Environmental Research and Public Health. 2013;10(9):4186-4199.
10. National Institute of Alcohol Abuse and Alcoholism NIAAA council approves definition of binge drinking. NIAAA Newsletter. 2004;3:3.
11. Feldman Henry A, Christopher L, Carol AD, Catherine BJ, Andre BA, Andrea DC, William JB, John BM. Age trends in the level of serum testosterone and other hormones in middle-aged men: Longitudinal results from the massachusetts male aging study. The Journal of Clinical Endocrinology and Metabolism. 2002;87(2):589-598.
12. Goh VH, Tong TYY. Sleep, sex steroid hormones, sexual activities and aging in Asian men. Journal of Andrology. 2010; 31(2):131-137.

13. Bonde JP. Semen quality in welders exposed to radiant heat. British Journal of Industrial Medicine. 1992;49(1):5-10.
14. Kumar S, Zaidi S, Gautam A, Dave L, Saiyed H. Semen quality and reproductive hormones among welders-A preliminary study. Environmental Health and Preventive Medicine. 2003; 8(2):64–67.
15. Well D, Yang H, Houseni M, Iruvari S, Alzeair S, Sansovini M, Wintering N, Alavi A, Torigian DA. Age-related structural and metabolic changes in the pelvic reproductive end organs. Seminars in Nuclear Medicine. 2007;37(3):173-184.

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