East African Scholars Journal of Medical Sciences
Abbreviated Key Title: East African Scholars J Med Sci
ISSN: 2617-4421 (Print) & ISSN: 2617-7188 (Online)
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-7 | Issue-5 | May-2024 | DOI: 10.36349/easms.2024.v07i05.006

Original Research Article

Chronic Lead Exposure Impairment of Hypothalamic-Pituitary-Gonadal Axis in Adult Male Wistar Rats: Biochemical and Histomorphological Evidence

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Article History
Received: 03.04.2024
Accepted: 07.05.2024
Published: 10.05.2024

Journal homepage:
https://www.easpublisher.com

Quick Response Code

Abstract: ***Introduction***: The upsurge in male infertility has been associated with impaired hypothalamic-pituitary-gonadal (HPG) axis. There is a dearth of conclusive empirical data as to the deleterious impacts of heavy metal intoxication on male reproductive functioning through the HPG axis. ***Objective:*** This study seeks to elucidate the possible effects of chronic lead exposure on HPG signalling activities via biochemical and histopathological assessment. ***Experimental Section/Material and Methods*:** Forty adult male Wistar rats were randomised into four experimental groups (n=10). Group A, the control group received standard feed and water ad libitume. In Groups B, C and D, animals were orally administered lead acetate at concentrations of 2.5% 3.0% and 3.5%, respectively, using a stock solution of 150mg/kg once daily for 35 days. After the treatment period, all animals were fasted overnight and euthanized by cervical dislocation. Blood levels of anterior pituitary hormones (FSH and LH) were analysed using standard methods. Statistical analyses was done on graph pad prism. Testicular tissue was processed routinely for histopathological analyses using different stains. ***Results***: Hormonal assays showed no significant changes in follicle-stimulating hormone (FSH) and luteinizing hormone (LH) ($p>0.05$) levels across groups. However, histological examination revealed alterations in testicular architecture, including disrupted spermatogonia cell arrangement and reduced Sertoli cell numbers, indicative of adverse effects on spermatogenesis. ***Conclusion***: Chronic lead exposure adversely affects testicular histomorphology in adult male Wistar rats, potentially impacting reproductive function. While hormonal levels remain relatively unaffected, alterations in testicular structure suggest a direct impact on gonadal functions at a cellular level.

Keywords: Lead acetate, HPG axis, Luteinizing hormone, Follicle stimulating hormone, testicular histomorphology, male infertility.

INTRODUCTION

The hypothalamic-pituitary-gonadal (HPG) axis involves the testes, the anterior and posterior sections of the pituitary gland, and the hypothalamus (Abel *et al.*, 2014). Gonadotropin-releasing hormone (GnRH) is released in a pulsatile manner from the hypothalamus and travels to the anterior pituitary gland through the hypophyseal portal system. Consequently, the gonadotrophic cells of the anterior pituitary gland biosynthesizes luteinizing hormone (LH) and follicle-stimulating hormones (FSH) (Oduwole *et al.*, 2021). Gonadotrophins LH and FSH play a vital role in the development, maturation, and reproductive function of mammals. Particularly in the male species, LH and FSH play a crucial role in controlling gene expression and cell communication during spermatogenesis. FSH and LH

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work together or function separately to control germ cell development and maturation (Das and Kumar, 2018).

Meanwhile, Lead acetate stands out as a significant toxic heavy element permeating the environment, posing various environmental health risks due to its physiochemical properties and historical usage (Mudipalli, 2007; Smith *et al.*, 2023). Its presence in paints, dust, air, and even potable water underscores the pervasive concern regarding lead acetate exposure (Garu *et al*., 2011). Over time, the release of numerous metals and chemicals into the environment has raised alarms regarding oral exposure and its detrimental effects on neurological male reproductive functions, with lead acetate being a prominent contributor (Garu *et al*., 2011; Adetunji and Obasi, 2019; Khan *et al*., 2022). Regrettably, lead acetate exhibits high toxicity, impacting nearly every organ in both children and adults (Wani *et al*., 2015). Chronic exposure to lead acetate can induce adverse effects on the nervous, excretory, cardiovascular, and reproductive systems in humans and animals alike (Leidens *et al*., 2017; Rodriguez-Sosa *et al*., 2020).

Notably, the testicular toxicity induced by lead acetate is a subject of extensive research, with investigations focusing on its mechanisms, including interference with testicular histological structure, and disruption of the blood-testis barrier (Smith *et al*., 2023; Rodriguez-Sosa *et al*., 2020). Understanding the repercussions of lead acetate exposure on male fertility is paramount, considering its widespread prevalence and potential for adverse health outcomes. While the exact mechanisms underlying acute lead acetate-induced testicular toxicity remain under scrutiny, it is not very clear if chronic exposure will implicate the downregulation of the HPG axis.

In particular, the current study is aimed at elucidating the possible effects of chronic lead acetate exposure on the pituitary hormones (LH and FSH) and testicular histomorphology in male Wistar rats. Through this investigation, we seek to provide insights into the involvement of the HPG axis underlying the gonadotoxic mechanisms of chronic lead exposure.

Experimental Section/Material and Methods

Animal procurement, housing, and handling:

Forty adult Wistar rats weighing between 93g-180g were obtained from Babcock University Animal House and housed in plastic cages with net covers for ventilation. The rats were divided into four groups to prevent overcrowding. They were provided with distilled water and feed daily and kept on wood shavings as bedding, changed every two days to maintain hygiene and prevent toxic ammonia build-up.

Materials/apparatus and uses:

A variety of materials and apparatus were utilized in the study, including syringes, feeding plates, distilled water, heparinized bottles, rat feed, methylated spirit, water bottles, measuring cylinders, specimen bottles, dissecting kits, drinkers, slide boxes, slides, weighing balances, centrifuge, haematoxylin and eosin, EDTA bottles, lead acetate, among others.

Procurement and administration of agent:

Lead acetate was obtained from Sigma Aldrich and prepared by dissolving 150mg/kg in 100ml of distilled water. Group A, the control group (n=10), received standard feed and water ad libitum until the day of sacrifice. In Group B (n=10) Group C (n=10), and Group D (n=10), animals were orally administered lead acetate at concentrations of 2.5% 3.0% and 3.5% of the stock solution respectively once daily for 35 days.

Method of administration:

The rats were orally administered the lead acetate solution using a cannula.

Measurement of body weight:

Daily body weight measurements were taken using a weighing balance, and the mean body weight was calculated as the difference between the final and initial body weights.

Animal sacrifice and organ harvest:

After 35 days of administration, animals were sacrificed, and blood and testicular tissue samples were collected. Blood samples were obtained from the heart and centrifuged to collect plasma. Testes were harvested, preserved in 10% formal saline, and processed for further analysis.

Tissue processing:

Tissue processing involved dehydration, clearing, impregnation, blocking, sectioning, mounting, dewaxing, and rehydration to prepare testicular tissue for microscopic examination.

Staining method:

Two staining methods were employed: Hematoxylin and Eosin staining for general tissue structure and Periodic Acid Schiff's staining for specific tissue components.

Hormonal assay:

Hormonal assays for Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH) were conducted using specific reagents and procedures.

Statistical analysis:

Data analysis was performed using one-way ANOVA and two-way ANOVA followed by Dunnett's Multiple Comparison Test, with significance set at $P<0.05$. GraphPad Prism software was utilized for statistical analysis.

RESULTS

BODY WEIGHT

As shown in the graph below at the end of the experiment, there was no significant ($P < 0.005$) increase in the body weight in control group (117.7 ± 16.74) and Group 2 (134.2 ± 10.84), Group 3 (119.4 ± 11.28) and Group 4 (135.9 ± 9.0). This could be recognized that higher doses of Lead acetate caused an increase in the body weight across test groups.

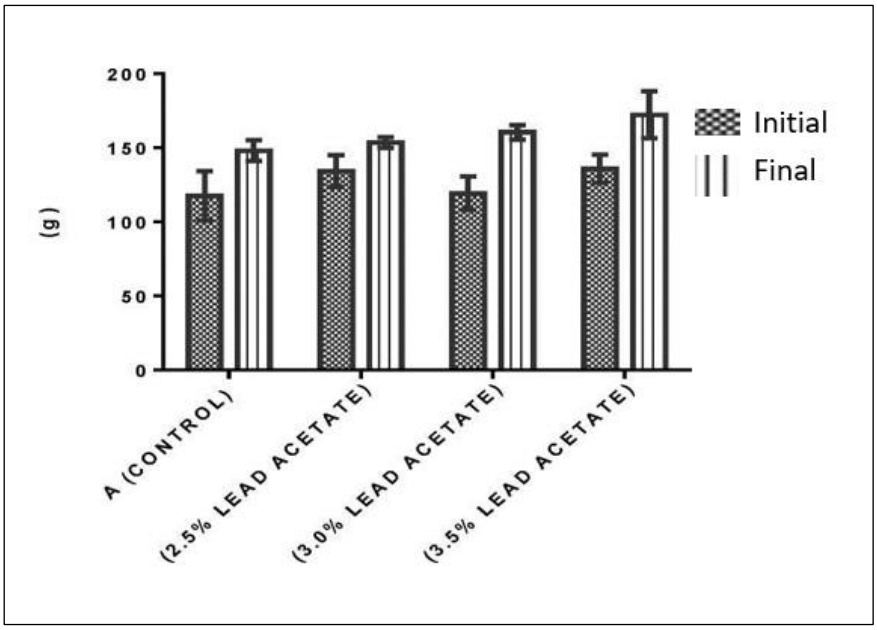

Figure 1: Bar chart showing the body weight of the rats, initial weights were taken during the 1 week adaptation period which helped the rate to be used to the environment and the final weight was taken a day before the rats were sacrificed. Increase in body weight was observed in all groups

HORMONAL ASSAY

LUTEINIZING HORMONE

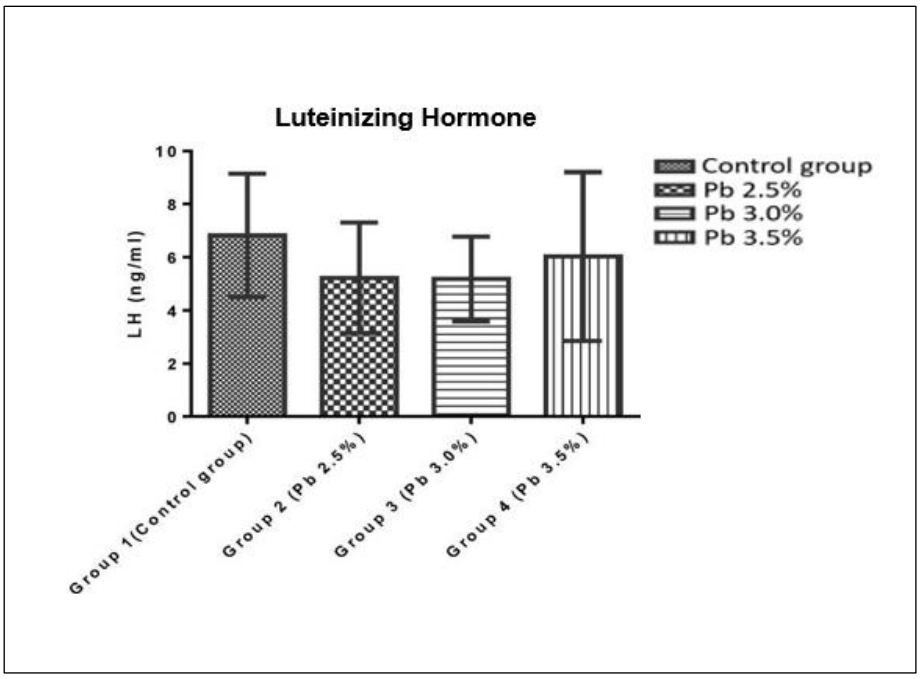

Figure 2: Bar chart showing the LH level of the group 2, group 3 and group 4 shows no significance when compared with the control group

The mean of the LH in control group after the experiment was (6.8±1.2). The mean of LH in group 2 was slightly lower (5.2±1.0) when compared to control group. The mean of LH in group 3 was slightly lower

(5.2±0.8) when compared to the control group. The mean of LH in group 4 was slightly lower (6.0±1.6) when compared with the control group. This also shows normal levels of LH in all groups. When analyzed using one-way ANOVA, there was no significant difference (P<0.05).

FOLLICLE STIMULATING HORMONE

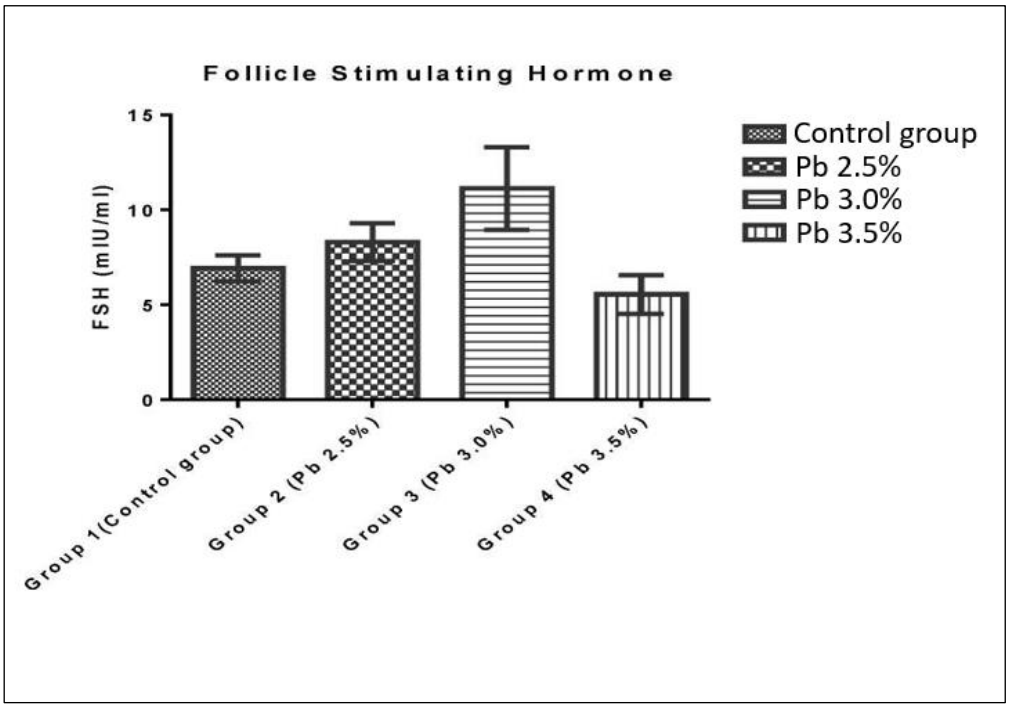

Figure 3: Bar chart showing the FSH level of Group 3 has a significant difference when compared with the control group

The mean of the LH in control group after the experiment was (6.9±0.68). The mean of LH in group 2 was slightly higher (8.3±1.0) when compared to control group. The mean of LH in group 3 was significantly higher (11±2.2) when compared to the control group. The mean of LH was slightly lower (5.6±1.0) when compared with the control group. This also shows normal levels of FSH in all groups. When analyzed using one-way ANOVA, there was no significant difference (P<0.05).

HISTOLOGICAL STUDIES

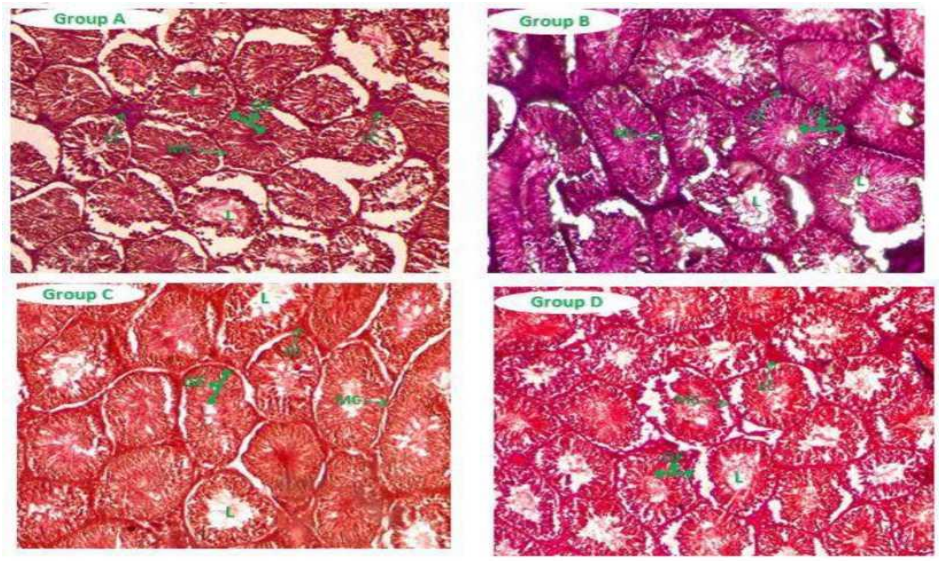

Plate 1: Photomicrographs showing view of testes general histomorphology in the Wistar rats of group A (Control group), group B (2.5% Pb), group C (3.0% Pb) and group D (3.5% Pb) at magnification of X100

Leydig Cell (LC). Spermatids (ST), Vacuole (V), Meyoid Cell (MC), Spermatozoa (MZ), Lumen (L), Sertoli Cell (SC), Primary Spermatocyte (PS), Germinal Epithelium (GE).

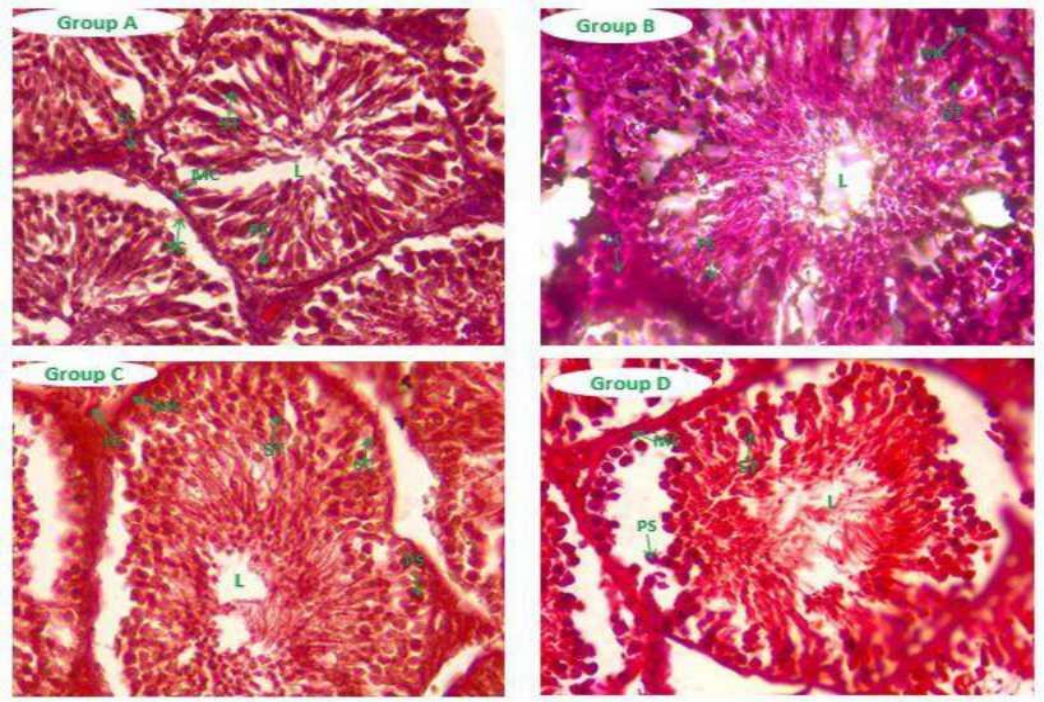

Plate 2: Photomicrographs showing view of testes general histomorphology in the Wistar rats of group A (Control group), group B (2.5% Pb), group C (3.0% Pb) and group D (3.5% Pb) at magnification of 400

Leydig Cell (LC). Spermatids (ST), Vacuole (V), Meyoid Cell (MC), Spermatozoa (MZ), Lumen (L), Sertoli Cell (SC), Primary Spermatocyte (PS), Germinal Epithelium (GE).

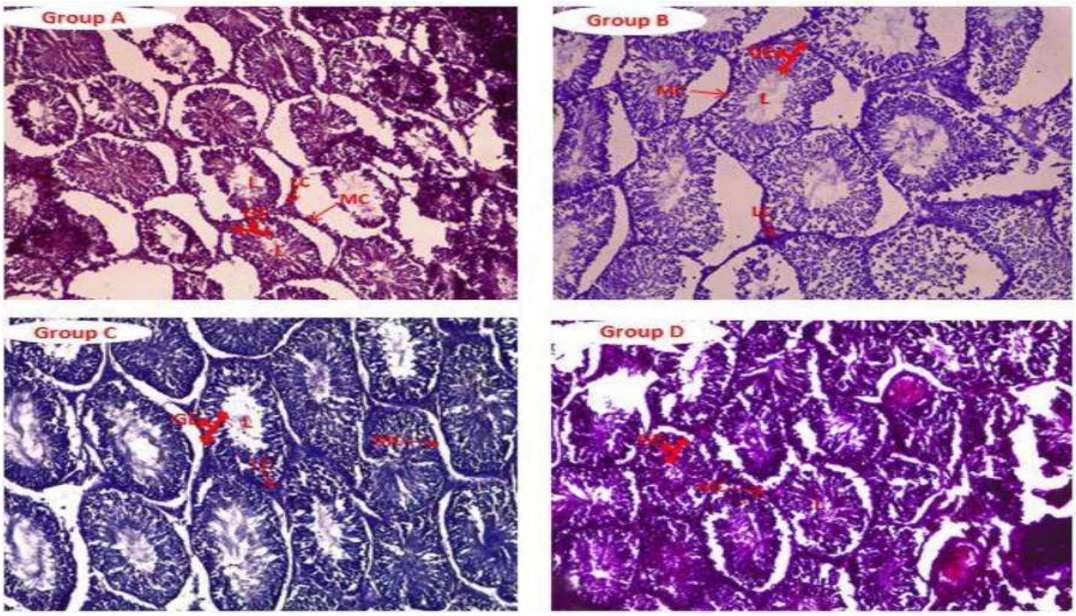

Plate 3: Photomicrographs showing Periodic acid-Schiff (PAS) staining of the Wistar rats of group A (Control group), group B (2.5% Pb), group C (3.0% Pb) and group D (3.5% Pb), spermatogonia (SG), primary spermatocyte (PS), spermatid (ST), spermatozoa (SZ), vacuoles (V), detached basement membrane (DBM), Germinal Epithelium (GE) and Vacuolation (V) (PAS X400). To visualize the glycoproteins/acrosomes (violet) and nuclei (blue)

The testis sections of Group A show normal spermatogenesis with well-organized stages of germ cell development, round spermatids with PAS-positive normal acrosomal caps (arrows), elongating and

elongated spermatids and chromatin condensation. While Group B, C & D show defective spermatogenesis with abnormal acrosomal caps, distorted elongated spermatids and chromatin condensation.

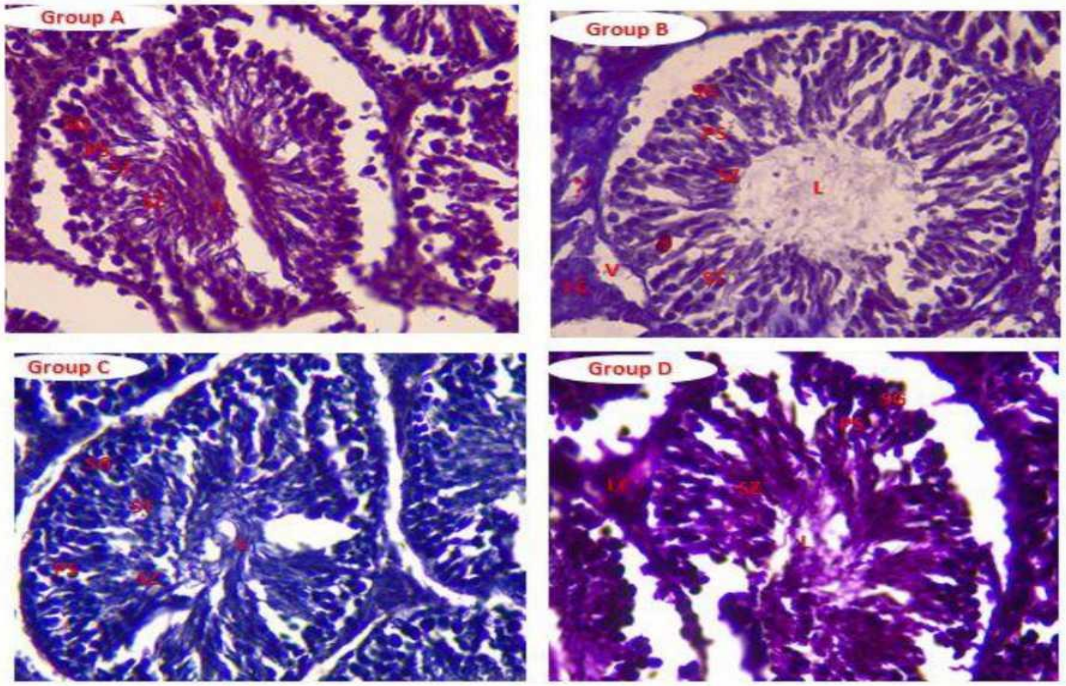

Plate 4: Photomicrographs showing Periodic acid-Schiff (PAS) staining of the Wistar rats of group A (Control group), group B (2.5% Pb), group C (3.0% Pb) and group D (3.5% Pb), spermatogonia (SG), primary spermatocyte (PS), spermatid (ST), spermatozoa (SZ), vacuoles (V), detached basement membrane (DBM), Germinal Epithelium (GE) and Vacuolation (V) (PAS X400). To visualize the glycoproteins/acrosomes (violet) and nuclei (blue)

The testis sections of Group A show normal spermatogenesis with well-organized stages of germ cell development, round spermatids with PAS-positive normal acrosomal caps, elongating and elongated spermatids and chromatin condensation. While Group B, C & D show defective spermatogenesis with abnormal acrosomal caps, distorted elongated spermatids and chromatin condensation.

DISCUSSION

The testis plays a crucial role in male reproductive function, encompassing both steroid hormone synthesis and sperm production. Throughout the study, there was a noticeable increase in body weight across all experimental groups (Fig 1). This observation aligns with previous research indicating that lead acetate exposure can influence body weight gain, food intake, and feed efficiency, which were consistently heightened throughout the experimental period across all groups (Ibrahim *et al*., 2012). These findings are further corroborated by the work of Wang *et al*., (2017), who also observed dose-specific weight gain in adult Wistar rats following lead acetate exposure.

The observed increase in body weight across all groups suggests a potential systemic effect of lead acetate on metabolic processes, which may impact overall health and physiological function. Lead acetate's influence on body weight gain could be attributed to various mechanisms, including alterations in hormonal regulation, metabolic pathways, and energy balance. Additionally, lead acetate exposure may disrupt endocrine function, leading to changes in appetite regulation and nutrient metabolism (Akinsomisoye *et al*., 2019).

Meanwhile, the progressive increase in body weight observed throughout the experimental period underscores the importance of considering the duration and dose of lead acetate exposure in understanding its effects on metabolic parameters. The dose-specific response to lead acetate exposure highlights the complex relationship between toxin exposure and physiological outcomes, emphasizing the need for careful evaluation of dosage levels in toxicity studies.

The observed significant decrease in luteinizing hormone (LH) levels across the groups compared to the control group suggests that lead acetate exposure may lead to disruptions in the hypothalamic-pituitary-gonadal (HPG) axis, which regulates reproductive hormone secretion (Fig 2). This finding is consistent with previous research indicating that lead acetate exposure can result in alterations in LH levels (Pillai, 2003). However, it is noteworthy that there was no significant difference in LH levels between groups 2 and 3 compared to the control,

indicating a potential dose-dependent effect of lead acetate on LH secretion (Adetunji and Obasi, 2019).

The lack of significant changes in follicle-stimulating hormone (FSH) levels suggests a differential response of the HPG axis to lead acetate exposure. While LH secretion appears to be suppressed, FSH levels remain relatively unaffected (Fig 3). This differential response may reflect the specific actions of lead acetate on the regulatory mechanisms governing LH and FSH secretion.

One possible mechanism underlying the observed decrease in LH levels is the direct toxic effects of lead acetate on the hypothalamus and pituitary gland. Lead acetate has been shown to disrupt neuroendocrine function by interfering with neurotransmitter signaling and receptor activation in the hypothalamus and pituitary (Sun, 2017). This disruption may lead to decreased secretion of gonadotropin-releasing hormone (GnRH) from the hypothalamus, consequently reducing LH release from the pituitary.

Prolonged exposure to lead acetate may induce direct testicular toxicity, leading to impairment of Leydig cell function and testosterone production. Reduced testosterone levels can feedback negatively on the HPG axis, resulting in decreased LH secretion (Rodamilans *et al*., 1988). Furthermore, lead acetate exposure may also induce oxidative stress and inflammation in the testes, further contributing to disruptions in gonadal function and hormone secretion.

The findings from the study suggest that exposure to lead acetate (Groups B, C, and D) resulted in significant histopathological changes in the testes compared to the control group (Group A). Specifically, there was evidence of epithelial cutting, reduction in the number of Leydig cells and primary spermatocytes, and vacuolation in the lumen of the seminiferous tubules in Groups B, C, and D. These observations indicate that lead acetate exposure induces damage to the germinal epithelium and disrupts germ cell development within the testes.

The cutting in the epithelium and reduction in Leydig cells and primary spermatocytes suggest that lead acetate exerts cytotoxic effects on the testicular tissue, leading to structural alterations and impaired spermatogenesis (Plates 1 and 2). Previous studies have also reported similar findings, indicating that lead acetate exposure can cause damage to germinal cells and loss of the germinal cell layer (Isabel *et al*., 2001; Batra *et al*., 2004; Adhikari *et al*., 2001). These histopathological changes may result from the direct toxic effects of lead acetate on testicular cells, including oxidative stress, inflammation, and apoptosis (Benoff *et al*., 2000; Türk *et al*., 2012).

The presence of vacuolation in the lumen of the seminiferous tubules suggests disruption of the normal architecture and function of the testicular microenvironment. Vacuolation is often associated with cellular damage and dysfunction, indicating that lead acetate exposure may compromise the integrity of the seminiferous epithelium and impair sperm production and maturation (Isabel *et al.*, 2001).

The Periodic acid-Schiff (PAS) staining of testes sections further supports the histopathological findings, revealing defective spermatogenesis characterized by abnormal acrosomal caps, distorted elongated spermatids, and chromatin condensation in Groups B, C, and D compared to the control group (Group A) (Plates 3 and 4). These abnormalities suggest disruptions in the normal process of sperm development and maturation, which could adversely affect male fertility (Isabel *et al*., 2001).

The histopathological changes observed in the testes of lead acetate-exposed rats highlight the detrimental effects of lead acetate on testicular morphology and function. These findings underscore the importance of minimizing environmental exposure to lead acetate to protect male reproductive health and fertility. Further research is needed to elucidate the underlying mechanisms of lead acetate-induced testicular toxicity and explore potential therapeutic interventions to mitigate its adverse effects.

CONCLUSION

Empirical findings from this study highlights the detrimental effects of lead acetate exposure on both body weight, anterior pituitary hormones and testicular histoarchitectural parameters in the male reproductive system of Wistar rats. We observed a dose-dependent increase in body weight following lead acetate administration, suggesting potential disruptions in metabolic processes or alterations in feeding behavior induced by lead toxicity.

Moreover, histological analysis revealed significant alterations in the reproductive organs of rats exposed to lead acetate, including epithelial cutting, reduction in Leydig cells and primary spermatocytes, and vacuolation in the seminiferous tubules' lumen. These changes indicate structural damage and impaired function of testicular tissue, potentially affecting sperm production and fertility.

These findings carry important implications for individuals regularly or occupationally exposed to lead acetate in their workplaces. Chronic exposure to lead acetate, even at low levels, may lead to metabolic disturbances, reproductive dysfunction, and adverse health effects. Thus, measures should be implemented to minimize lead acetate exposure in occupational settings, such as enforcing safety protocols, providing personal protective equipment, and monitoring exposed

individuals' blood lead levels. Moreover, our study underscores the necessity for further research to elucidate the underlying mechanisms of lead acetate toxicity in the male reproductive system and develop targeted interventions to mitigate its adverse effects. By gaining a better understanding of lead acetate-induced reproductive toxicity's pathophysiology, we can identify potential therapeutic strategies and preventive measures to safeguard reproductive health in individuals exposed to this hazardous substance.

REFERENCES

- Abel, M. H., Widen, A., Wang, X., Huhtaniemi, I., Pakarinen, P., Kumar, T. R., & Christian, H. C. (2014). Pituitary gonadotrophic hormone synthesis, secretion, subunit gene expression and cell structure in normal and follicle-stimulating hormone β knockout, follicle-stimulating hormone receptor knockout, luteinising hormone receptor knockout, hypogonadal and ovariectomised female mice. *Journal of neuroendocrinology*, *26*(11), 785–795. https://doi.org/10.1111/jne.12178
- Adetunji, O. A. & Obasi, K. (2019). Histological toxicity and seminohormonal alterations on the testis of male wistar rats after oral lead induction (rattus novergicus). *era's journal of medical research, 6*(2). doi:10.24041/ejmr2019.125.
- Adetunji, O. A., & Obasi, K. (2019). Histopathological Degeneration of Spermatogenesis and Histomorphometric Alterations of the Testicular Microanatomy of Male Wistar Rats after Oral Lead Intoxication. *JKIMSU, 8*(2), 13-20.
- Adhikari, N., Sinha, N., & Narayan, R. (2001). Effects of lead on testicular function and its possible mechanism. *Journal of Environemental Biology*, *22*(2), 127-132.
- Akinsomisoye, O.S., Owolabi, A. R., Akano, O. P., Akintayo, C.O., Ariyo, O.M
- (2019). Effects of Ethanol Extract of Stachytarpheta angustifolia (Mill.) Vahl Leaf on Lead Acetateinduced Reproductive Toxicity in Male Wistar Rats. *European International Journal of Science and Technology*, 8(11), 30-40.
- Batra, N., Nehru, B., & Bansal, M. P. (2004). Influence of lead and zinc on rat male reproduction at 'biochemical and histopathological levels. *Journal of Applied Toxicology, 24*(1), 7-12.
- Benoff, S., Jacob, A., Hurley, I. R., & Cooper, G. W. (2000). Male infertility and environmental exposure to lead and cadmium. *Human Reproduction Update, 6*(2), 107-121.
- Das, N., & Kumar, T. R. (2018). Molecular regulation of follicle-stimulating hormone synthesis, secretion and action. *Journal of molecular endocrinology*, *60*(3), R131–R155. https://doi.org/10.1530/JME-17-0308
- Garu, S., Kim, Y., & Kim, D. (2011). Environmental heavy metals, human health and the environment. *International Journal of Environmental Science and Technology*, *8*(3), 471-479.
- Ibrahim, Z. S., El-Tarras, A. E., El-Sherbiny, E. M., & El-Sherbiny, M. (2012). Protective effect of soybean oil against lead acetate-induced hematological and biochemical alterations in male rats. *Experimental and Toxicologic Pathology*, *64*(7-8), 845-851.
- Isabel, V., Calvo, A., Suescun, M., & Ciganda, C. (2001). Histopathological changes in rats after lead intoxication. *Human & Experimental Toxicology*, *20*(12), 637-641.
- Leidens, N., Ha, E., & Cakmak, S. (2017). A review on environmental lead exposure and its health effects. *Journal of Environmental and Public Health*, 2017, 1-7.
- Mudipalli, A. (2007). Lead hepatotoxicity & potential health effects. *Indian Journal of Medical Research, 126*(6), 518-527.
- Oduwole, O. O., Huhtaniemi, I. T., & Misrahi, M. (2021). The Roles of Luteinizing Hormone, Follicle-Stimulating Hormone and Testosterone in Spermatogenesis and Folliculogenesis Revisited. *International journal of molecular sciences, 22*(23), 12735. https://doi.org/10.3390/ijms222312735
- Pillai, A. K. (2003). Luteinizing hormone response to lead toxicity in male rats. *Toxicology Letters, 144*(3), 265-271.
- Rodamilans, M., Gallardo, J. M., & Almaraz, R. (1988). Lead poisoning produces a decrease of plasma testosterone and hCG levels in men. *Toxicology Letters, 42*(1-2), 187-192.
- Smith, M. T., Guyton, K. Z., Gibson, J., & Ferreccio, C. (2023). Human health effects of lead exposure. In Franzblau, A. J., & Fillippelli, T. L. (Eds.), Lead in the Environment (pp. 183-211). Springer.
- Sun, H. (2017). Lead-induced disruption of the hypothalamic-pituitary-adrenal axis. *Endocrine Connections, 6*(4), R200-R209.
- Türk, G., Ateşşahin, A., Sönmez, M., Ceribaşı, A. O., Yüce, A., & Aksakal, M. (2012). Lycopene protects against lead acetate-induced testicular toxicity in rats. *Drug and Chemical Toxicology, 35*(2), 203-210.
- Wang, H., Xu, Y., & Yan, J. (2017). The toxicity, oxidative stress, and apoptosis effects of lead acetate exposure on the liver, intestine, and kidney in ducks. *Environmental Science and Pollution Research, 24*(4), 3929-3939.
- Wani, A. L., Ara, A., & Usmani, J. A. (2015). Lead toxicity: A review. *Interdisciplinary Toxicology, 8*(2), 55-64.

Cite This Article: Adetunji Opeyemi Adebola, Linus Chiamaka Marvellous, Adeoye Bayo Olufunso, Akano Oyedayo Phillips, Ogunsanya Sanmi Tunde, Oyewumi Samson Oluwole, Adeoye Ayodeji David, Olayinka Olugbenga Olawole, Adeogun Adetomiwa Ezekiel (2024). Chronic Lead Exposure Impairment of Hypothalamic-Pituitary-Gonadal Axis in Adult Male Wistar Rats: Biochemical

and Histomorphological Evidence. *East African Scholars J Med Sci*, *7*(5), 191-198.