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Assessment of Reproductive and Renal Profiles in Photocopier Operators: Implications of Occupational Exposure to Emitted Pollutants

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ABSTRACT: *Photocopy machines emit several harmful pollutants that include ozone, VOCs, Ultraviolet, particulate matter and fumes of heavy metals. The operators are exposed to all these toxic toner components. The objective of the current investigation was to assess the effects of these emitted pollutants on reproductive and renal profile of photocopiers. For this study, photocopy operators (n=40) being occupationally exposed to photocopier emissions and non-exposed healthy controls (n=25) were recruited fulfilling the inclusion criteria. Serum level of testosterone and renal biomarkers of all the participants were evaluated. Independent sample "t"-test was applied at significance level P<0.05 by using GraphPad Prism. Significant decrease in testosterone levels in the photocopier group (5.19 ± 0.19) compared to the control group (8.04 ± 0.22, P < 0.001) was observed. The renal profile revealed notable increases in serum uric acid and creatinine levels in the photocopier group, with uric acid at 4.76 ± 0.18 versus 3.91 ± 0.10 in the control group (P < 0.001) and creatinine at 0.93 ± 0.04 compared to 0.78 ± 0.03 in the control group (P < 0.02). Additionally, serum albumin levels were significantly lower in the exposed group (3.63 ± 0.10) compared to the control group (4.47 ± 0.11, P < 0.001). The potential acute or chronic kidney disorders and reproductive damage associated with exposure in the photocopier workers.*

Keywords: Testosterone, Renal Profile, Photocopiers, Hypogonadism, Occupational exposure

INTRODUCTION

Photocopy machines effortlessly and affordably generate paper duplicates of documents and various visual images (Pakpahan et al., 2019). In advanced nations, the rapid progress in home and office automation has elevated the utilization of photocopiers (Gminski et al., 2011). Numerous individuals worldwide are employing photocopiers, irrespective of the economic advantages (Elango et al., 2013a).

In nations undergoing development, like Pakistan, a significant number of photocopy shops operate without constraints or safety control steps (Nandan et al., 2020). In photocopiers, dry toner is used, which include polycyclic aromatic hydrocarbons and styrene (Saritha et al., 2016) which are potential human carcinogens (Lee et al., 2006). The operators are exposed to all these toxic toner components (Saritha et al., 2016). This situation can potentially pose serious risks to the health of the workers (Lyu et al., 2021). The substances within photocopiers that pose health risks encompass VOCs, ozone, formaldehyde, particulates, heavy metals, nitrogen oxides, carbon monoxide, UV light (Hunashal, 2011) carbon black (CB), PAHs and heavy metals including zinc, Fe, Cr, and Ni (Gminski et al., 2011; Henschel et al., 2001).

Subjection to these chemicals can cause many damages, including irritation of lung tissues, eye irritation, headaches, and itching of the skin (Bai et al., 2010). VOCs especially can cause discomfort (Sarkhosh et al., 2012) even at very low concentration in photocopy workers. While prolonged Exposure may result in symptoms such as headaches, shortness of breath, allergies, fatigue, nausea, mental confusion, and the potential development of cancer (El-Hashemy and Ali, 2018).

The reproductive health of adults is of growing concern of this age (Gubhaju, 2002). In males, reproductive hormone, testosterone production is essential for the maintenance of sexual characteristics and the development of sex organs (Aydogdu and Swerdloff, 2016). In man, low levels of sex hormones associated with infertility are referred to as hypogonadism (Basaria, 2014). Extended exposure to photocopier toner powder may pose a risk of anemia due to potential renal damage (Osadolor and Ezegbogu, 2015). Furthermore, the nephrons exhibit sensitivity to exposure to lead, cadmium and mercury leading to persistent renal failure (Kum et al., 2014). In abnormal condition of

kidney, amount of creatinine released via urine reduced and accumulated in blood. Elevated urea concentration in comparison to creatinine levels may indicate the presence of certain kidney issues. When there is an elevation of urea levels in serum as compared to creatinine, some kidney malfunctioning may arise (Levey et al., 1999) and these renal impairments resulted in uremia (Hawkins and Dugaiczyk, 1982).

MATERIALS AND METHODS

Present study plan was endorsed by This study was approved by the ethical review committee of the Institute of Zoology, University of the Punjab, Lahore. Informed consent was obtained from all participants. A questionnaire was designed and distributed before blood sampling to measure their BMI, age, medical record and other details related to occupational exposure of subjects.

The research involved 65 participants, consisting of 25 healthy male subjects of same age groups as controls and 40 male workers recruited from different photocopy shops present in Punjab University, Lahore. The subjects in both groups having any medical history were excluded from the study. All healthy and hygienic measures have opted as the investigation involved human sampling. Participants of the investigation were in good health condition. A registered technician was engaged for blood sampling. Blood samples (5cc) were collected after 12 hours of fasting in the morning. The blood was allowed to coagulate by placing it in a clot activator vial for almost 30 minutes at a temperature of 25°C. Afterwards, the blood underwent serum separation through centrifugation at 3000rpm. Using a micropipette, the serum was carefully transferred to a labeled plastic Eppendorf tube, taking approximately 10 minutes. Subsequently, the collected serum was stored at -80°C for further analysis.

The ELISA technique was employed for hormonal analysis. Specifically, the testosterone estimation assay was conducted on serum samples from the subjects using a PerkinElmer ELISA kit. The sample was allowed to thaw for 10 minutes at 25°C prior to utilization. Renal profile (Urea, Uric acid, Creatinine and Albumin) was measured by commercially available kits of Monlab, Spain using photometer (5010) *v5plius* ROBERT RIELE GmbH & Co KG, Germany.

Statistical Analysis

Data obtained from control and exposed group subjects have

been analyzed through a two-tailed independent sample t-test at a significance level of $P<0.05$ by using software GraphPad Prism-5 and presented as mean±SEM.

RESULTS

No significant difference was observed in the Body Mass Index (BMI) between the exposed and control groups (Fig. 1). While a highly prominent decrease ($P<0.001$) of 43% in serum testosterone level in photocopiers exposed group was observed when compared to the control group (Fig. 2). Among the renal profile, in the photocopiers exposed group, serum urea concentration was non-significantly high when compared to control group (Fig. 3). Serum uric acid concentration in the photocopier's exposed group was increased significantly ($P<0.001$) by 19% on comparing with control group (Fig. 4). While serum creatinine level in photocopiers exposed group was decreased significantly ($P<0.05$) by 11% while comparing with control group (Fig. 5) as well as serum albumin level was also significantly high ($P<0.001$) with an increase of 14% in exposed group (Fig. 6) (Table: 1).

Table 1: Overall Comparison of Body Mass Index (BMI), Testosterone and Renal parameters in Control and Exposed Group

Parameters	**Mean±SEM**		***P*-value**	**Percentage difference**
	Control (25)	**Exposed (n=40)**		
BMI (Kg/m^2)	23.21 ± 0.58	22.77 ± 0.35	0.49	2↓
Testosterone (ng/mL)	8.04 ± 0.22	5.19 ± 0.19	<0.001***	43↓
Urea (mg/dL)	22.80 ± 0.85	25.92 ± 1.43	0.10	8 ↑
Uric acid (mg/dL)	3.91 ± 0.10	4.76 ± 0.18	<0.001***	19↑
Creatinine (mg/dL)	0.78 ± 0.03	0.93 ± 0.04	0.02*	11 ↑
Albumin (mg/dL)	4.47 ± 0.11	3.63 ± 0.10	<0.001***	14 ↓

* and *** indicates significance at $P < 0.05$ and 0.001, respectively: ↑ Increase, ↓ Decrease.

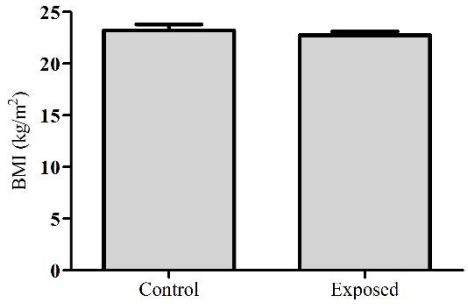

Fig. 1: Comparison of BMI (Kg/m^2) between Control and exposed groups. Values are Mean±SEM

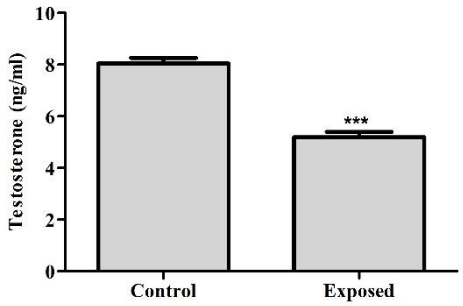

Fig. 2: Comparison of serum testosterone (ng/mL) in control and exposed group. Values are Mean±SEM. *** indicates significance at $P< 0.001$

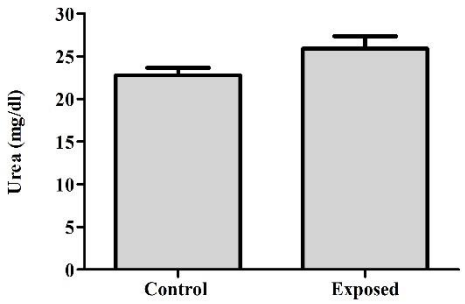

Fig. 3: Comparison of serum urea (mg/dL) in control and exposed group. Values are Mean±SEM

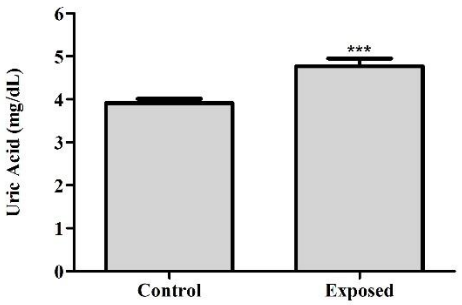

Fig. 4: Comparison of serum uric acid (mg/dL) in control and exposed group. Values are Mean±SEM*** indicates significance at $P<0.001$

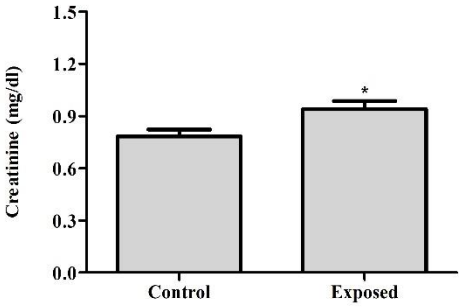

Fig. 5: Comparison of serum creatinine (mg/dL) in control and exposed group. Values are Mean±SEM. * indicates significance at $P<0.05$.

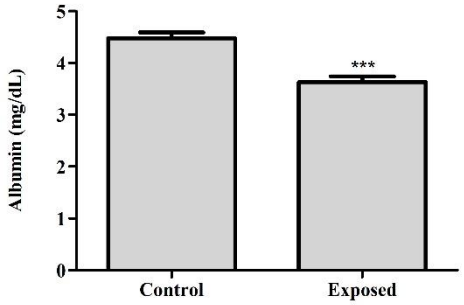

Fig. 6: Comparison of serum albumin (mg/dL) in control and exposed Group. Values are Mean±SEM*** indicates significance at $P<0.001$

DISCUSSION

DISCUSSION

Within workplaces and other business organizations, photocopiers are deemed crucial utilities (Elango et al., 2013b). Our current investigation of adult males, working in photocopier shops, indicated significant ($P<0.001$) decrease of 43% in serum testosterone concentration compared to the control group which is aligned by the findings of a previous study demonstrated a significant decrease in serum testosterone levels associated with exposure to heavy metals pollutants (Eisenegger et al., 2011). Our findings are consistent with previous research showing that exposure to heavy metals can disrupt endocrine functions (Aronson et al., 2000). In an in vitro setting, when cadmium was administered on Leydig cells of rats exhibited a diminished action of testosterone synthesis. In another experiment, rats were treated with manganese, resulting in lowering of blood testosterone concentration (Laskey and Phelps, 1991).

The results of our research are corroborated by another study which suggests that PM 2.5 can disrupt hormone concentrations and potentially pose a significant risk to the fertility of males by impacting the sperm production process (Qiu et al., 2018; Yang et al., 2019).

The result of our research that hypogonadism in males take place due to exposure to heavy metals is aligned by a previous study in which exposure to heavy metal such as nickel (Ni) in occupational settings may lead to a reduction in inhibin B by Sertoli cells or testosterone release by Leydig cells. Nickel was reported to interact with reproductive hypothalamic hormones LH and Follicle stimulating harmone along with testosterone (Sancini et al., 2014).

A deficiency in testosterone level, known as hypogonadism in males, gives rise to various health implications, including erectile dysfunction, diminished libido, reduced bone mass, dizziness, fatigue, mood swings, loss of body hair, diminished vitality, metabolic syndrome, insulin resistance, visceral obesity, and infertility resulting from hypogonadism (Basaria, 2014; Dohle et al., 2012).

According to the results, exposed group exhibited a notable rise in creatinine levels compared to the control group, supported by a previous study that elevations in creatinine levels in either blood serum samples or urine samples may have adverse effects on the kidney profile. The elevation of creatinine corresponded with a decrease in the levels of ascorbic acid and vitamin E in the body. These vitamins play a crucial role in protecting cells against such contaminants (Ilahi et al., 2012). In our study, there was a notable 19% increase in uric acid levels in the exposed group when compared to the control group. Our findings are corroborated by a previous study in Taiwan, which reported that elevated uric acid levels are predominantly observed in individuals exposed to heavy metals. This may be lead to chronic kidney disease, where the kidneys fail to eliminate uric acid efficiently because of the accumulation of heavy metals, leading to hyperuricemia (Lu et al., 2023).

There was a noteworthy 14% reduction in albumin levels in the exposed group. As in previous research has supported that the decreased quantity of albumin is a result of abnormal filtration by the kidney (Jude et al., 2002). These deviations in parameters were linked to disorders affecting both kidney and reproductive hormones. The potential accumulation of toner particles in the kidney was proposed to impact its filtration functions for blood and urine. As a result, heightened levels of urea, uric acid and creatinine were observed in the serum, but albumin and testosterone levels experienced a decline. These abnormal concentrations suggested kidney dysfunction, potentially leading to complete kidney failure. Additionally, the typical testosterone levels could be attributed to a diminished number of interstitial cells and impairment in the testosterone synthesis pathway, contributing to suboptimal sperm production and male infertility or hypogonadism.

This study with relatively small sample size limits generalizability, Further research with larger cohort is needed. However, this is the first-time study on photocopier workers from Pakistan. Further validations are required to reach a conclusive understanding.

CONCLUSION

In Pakistan, there is a notable absence of significant research on the reproductive health concerns of adult males employed in photocopy shops. The current study identifies hypogonadism and renal damage in workers, underscoring the necessity for further research to address reproductive and renal health issues among photocopy workers in Pakistan and other progressing nations.

It can be concluded from this study that photocopy operators are at risk of hypogonadism and renal destruction due to exposure to various harmful chemicals that jeopardize their reproductive sterility. Therefore, it is recommended that health officials should initiate collaboration between photocopier workers, administration, and health professionals to endorse technical precautionary measures. Undertake large-scale, detailed epidemiological studies to further investigate the prevalence and severity of hypogonadism and renal damage among photocopy workers. Data should be collected on the types and levels of chemical exposure in photocopy shops to establish a clear link between specific chemicals and health outcomes. Invest in research and development of environmentally friendly and health-safe photocopying alternatives.

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CONFLICT OF INTEREST

The authors declared no conflict of interest.

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