

CHROMOSOMAL ABERRATION OF WORKERS OCCUPATIONALLY EXPOSED TO PHOTOCOPYING MACHINES IN SULUR, SOUTH INDIA**MYTHILI BALAKRISHNAN* AND AYYAPPA DAS**

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Corresponding Author* biotechmythili@gmail.comABSTRACT**

The frequency of chromosomal aberrations (CA) in peripheral blood lymphocytes was performed in a group of workers occupationally exposed to photocopying machines. Samples of peripheral blood were collected from 66 workers out of which 34 were smokers and 32 were nonsmokers and 40 controls. Toxic components of the photocopiers are from their emissions, toners and extremely low frequency electromagnetic fields that cause DNA damage. Our results suggest that there was a significant increase in the chromosomal aberrations in the workers when compared to the controls. DNA frequency of the workers increased with length of the chemical exposure period. The results allowed us to conclude that the individuals studied belong to a risk group and should periodically undergo biological monitoring and appropriate care.

KEY WORDS

Chromosomal aberrations, photocopying machines, smokers, non smokers.

INTRODUCTION

Photocopiers, laser printers and facsimile machines are essential pieces of equipment in the modern office. These hazards of photocopying machines can come from breathing in the vapors, gases, and particles emitted by these machines. In addition, some of the chemicals used in photoduplication equipment (such as acrylates, styrene, and other off-gassing thermal degradation products) can cause an allergic contact dermatitis, which is a type of skin rash. Some of the volatile organic compounds (VOCs) that can be emitted by these machines include isodecane, xylene, 2,2,4 trimethyl octane, alkanes, nitropyrene,

phthalates, and isocyanates. That creates different health effects. Emissions of VOCs range from 0.5 to 16.4 µg/sheet of paper¹.

Photocopiers create ozone through their "corona wires" that apply a charge to the paper so the ink will cling to it. However, newer models use a different system to reduce the amount of ozone produced by the machine. The average ozone emitted is 40 µg/copy. At peak production, it is 131 µg/copy¹. Ozone levels can reach dangerous levels in small, poorly ventilated copying rooms since it can cause headaches, and irritate the eyes, nose, throat and lungs. Toner is used in the

photocopiers to produce an image on paper or transparency. Two essential components of dry toners are colorants (most common being carbon black) and binder resins. Toners dust may irritate the respiratory tract, resulting in coughing and sneezing. Some toners contain compounds such as nitropyrenes and trinitrofluorene. Iravathy Goud² has reported parallel genotoxic effect in the workers occupationally exposed to print copying machine.

Chromosomal aberrations (CA) in peripheral blood lymphocytes is a reliable biomarker of genotoxic exposure to both physical and chemical agents³, and an increase in CA frequency indicates the risk of exposure to clastogenic and/or aneugenic agents. In addition, cytogenetic end points in peripheral blood lymphocytes have been used as biomarkers which allow a reasonable epidemiological evaluation of cancer predictability⁴. Our study was to investigate the chromosomal aberration in individuals working with photocopying machines.

MATERIALS AND METHODS

The subjects were selected by random sampling. The study subjects comprised 106 healthy age matched individuals, which include 34 individuals working with photocopying machines with smoking habit, 32 individuals working with photocopying machines without smoking habit and 40 controls (non-workers/non-smokers). At the time of sample collection the subjects signed a term of informed consent. All subjects were selected based on questionnaire which included age, occupational exposure, smoking habit, use of drugs, such as alcohol, virus illnesses, recent vaccinations, and radiological exams. All the individuals who agreed to participate in the study were healthy, and they answered a detailed questionnaire according to the protocol published by the International Commission for Protection Against Environmental Mutagens and Carcinogens.

Blood samples were used to establish leukocyte cultures by following standard procedures. 0.5 mL blood was added to 4.5 mL RPMI 1640 medium supplemented with 10% calf fetal serum, 2 mM l-glutamine, 1% streptomycin-penicillin, 0.2 mL reagent grade phytohemagglutinin, and was incubated at 37 °C. After 50 h, cultures were treated with 0.1 g/mL colcemid to arrest the cells at metaphase in mitosis. Lymphocytes were harvested after 52 h by centrifuging cell suspension to remove culture medium (800-1000 rpm), addition of hypotonic solution (KCl 0.075 M) at 37 °C for 20 min to swell the cells, and treated twice with Carnoy's fixative (3:1 ratio of methanol: acetic acid). Slides were carefully dried on a hot plate (56°C, 2 min). Later, the slides were stained using the Giemsa staining technique. For the CA analysis, 100 well spread complete metaphase cells in first cell cycle were evaluated per subject under a microscope at ×100 magnification to identify numerical and structural CA. Chromatid-type CAs: (chromatid gaps; chromatid breaks) Chromosome-type CAs: (break; gap; exchange) were observed.

RESULT

The chromosomal aberration was used to study the DNA damage. Table 1 shows the total number of subjects, age range, mean age and mean duration of exposure. The workers were categorized into two groups based on smoking habit. Table 2 shows frequencies of chromosome aberrations. The mean values ± SD of CA in workers with smoking habit was 9.37 ± 3.52 for more than 6 years exposure group and 7.51 ± 2.95 for less than 6 years exposure group respectively; in workers without smoking habit it was 6.92 ± 2.39 (> 6 years exposure) and 5.15 ± 2.66 (< 6 years exposure), respectively. Statistically significant results were obtained in experimental subjects compared to control groups ($p < 0.01$), confirmed by chi-square test. To determine the effect of exposure period on DNA damage showed slight difference with increasing the

duration of exposure. Low number of DNA damage was observed in experimental subjects

when compared to their respective controls.

Table 1
General Characteristics of Study Population

Groups	N=106	Mean Age	Mean Period of Exposure (yr)
Controls	40	36.67±0.58	-
Workers with smoking habit	34	38.12±0.52	9.73
Workers without smoking habit	32	32.24±0.84	10.59

Table 2
Chromosomal Aberrations in Workers and Control Subjects

Subjects	Year of Exposure	Chromosomal Aberration (CA)		
		Chromatid type Aberration	Chromosomal Aberration	Total
Controls	-	0.81±0.69	0.11±0.26	0.92±0.95
Workers with smoking habit	< 6 yrs (n=15)	4.21±1.72	3.30±1.23	7.51±2.95
	> 6 yrs (n=19)	5.05±2.01	4.32±1.51	9.37±3.52
Workers without smoking habit	< 6 yrs (n=12)	3.37±1.47	1.78±1.19	5.15±2.66
	> 6 yrs (n=20)	4.01±1.35	2.91±1.04	6.92±2.39

DISCUSSION

The toxicants that enter into human body cause disturbance to normal state and behavior of the chromosomes which in turn lead to reshuffling of hereditary material causing chromosomal aberrations and gene mutations in somatic and germ cells. Chromosomal aberrations represent damage to DNA that is visible in stained cells. Usually, lymphocytes are obtained from exposed populations and examined for various types of chromosomal damage. This methodology has been applied to numerous occupational and environmental exposures to chemicals and radiation in addition to extensive animal studies⁵.

Several earlier reports suggest harmful effects in subjects occupationally exposed to metals. Mylius and Gullvag⁶ reported significant increase in macrophages in sputum expectorates from 84 aluminium potroom workers. Deleterious effects on peripheral nervous system were reported by Araki et al.⁷ in the workers exposed to lead, zinc and copper. Vanderwaal et al.⁸ reported high incidence of lung and skin cancers in welders and cutters exposed to chromium, nickel, copper etc. Magnesium is a relatively nontoxic metal. However acute poisoning has been observed in cows fed on diet containing high content of magnesium⁹. As all these reports

suggest toxic effects of metals. The present study was designed to assess the DNA damage among photocopying machine workers who are occupationally exposed to toners chemicals and low frequency electromagnetic field. For comparison studies were carried out on smokers and nonsmokers who were exposed to photocopying machines. In exposed group there was a significant increase of chromosomal aberrations in the smokers when compared to nonsmokers and controls.

Our reports are in accordance with previous reports of Obe and Herha et al.¹⁰ (1978), Fatima et al.¹¹ (1995), Rupa et al.¹² (1989) who reported high incidence of chromosomal aberrations in smokers. Of the various confounding factors studied, duration of exposure showed significant effects and it has also shows a positive effect on DNA. Similarly for example, workers of phosphate fertilizer factory, paint manufacture industry, out-door painters, cement workers, aluminium sulphate worker, those exposed to sulphur dioxide and environmental factors and low dose ionizing radiation showed increased frequency of genetic damage with increase in duration of work

suggesting a cumulative genotoxic effect^{13,14,15,16,17,18,19,20}. The photocopy machine workers with smoking habits also shows more amount of DNA damage was observed in smokers which shows cigarette smoking has synergistic effect on inducing DNA damage. Some previous findings reported similar results on bidi, smokeless tobacco users^{18,19}. Furthermore the present study correlates with smoking and photocopiers. Smoking-related DNA adducts have been detected by a variety of analytical methods in the respiratory tract, urinary bladder, cervix and other tissues. On terms of biological activity, cigarette smokers and its conductors have been shown to form adducts with DNA protein and to induce chromosome aberrations. Our previous study reported smokers has a synergic effect on inducing DNA damage among cement industry workers. Our present study suggests that workers exposed to photocopy machines are prone to genetic damage. Appropriate precautionary measures should be taken by the workers to minimise exposure in their work environment.

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