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Chromosomal Aberration after Exposure to 2.45 Ghz Microwave Radiation

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Abstract: The study investigated the effects of 2.45 GHz microwave radiation on rats' chromosomes. Thirty mature male and female Sprague Dawley rats of sixteen weeks old, weighing between 160-190 g were used. They were divided into five groups of six each; Control (group A) were not exposed to radiation (Group B-E) were exposed to various values of SAR from microwave generator model ER660E. Chromosomal aberration study was carried out by injecting the rats with colchicines 0.6 mg kg^{-1} 2 h prior to sacrifice in order to arrest the chromosome at the metaphase using conventional method. Structural chromosome aberrations such as gaps; acentric; breaks and centric rings were observed in the exposed rats. Group exposed to SAR 2.39 W/kg have the highest gaps (6.45 ± 0.24); highest breaks (7.28 ± 0.08); highest acentric (8.11 ± 0.15) and centric rings (1.24± 0.21) in males and similar trend was observed for female. The result is not sex-dependent as there was no significant difference between the measured values for both male and female rats, there is high correlation (C = 0.96) between the values obtained for both sexes. The study suggests that microwave radiation could induce chromosomal aberrations in rats.

Key words: Chromosomal aberrations, 2.45 GHz microwave radiation, SAR, bone-marrow, Nigeria

INTRODUCTION

There is increase of human exposure to Radio Frequency (RF) radiation due to technological advancement of non ionizing radiation. It has been the concern of regulatory and non-regulatory bodies as the use of these energy sources and large number of devices emitting microwaves and Radio Frequencies (RF), including mobile phones. There has been some controversy as whether the exposure to RF radiation might be responsible for the process of carcinogenesis. Given the high numbers of users of these devices, even a small increase in the risk of cancer could have major public health implications. The biological effects of microwaves on living organisms are highly controversial (Maes *et al*., 1997). Though, microwaves are not sufficiently energetic to be able to directly damage DNA, theoretically. There are both positive and negative findings about the carcinogenic effects of RF radiation. Findings with significant increase in chromosome aberrations reported by following researchers (Sagripanti and Swicord, 1986; Lai, 1996; Verschaeve and Maes, 1998; Vijayalaxmi *et al*., 1997; Phillips *et al*; 1998; Tice *et al*; 2002). However, some number of studies have failed to detect obvious genotoxicity effects such as DNA strand breaks, gene mutations, chromosomal aberrations and sister chromatid exchange (Verschaeve and Maes, 1998; Heynick *et al*., 2003; Vijayalaxmi, 2004; Usikalu *et al*., 2013). Ambrosio *et al*. (1995), Martelli *et al*. (2000) and Tice *et al*. (2002) reported increased frequency of micronuclei in eukaryotic cells and animals. Hence, the answer to whether exposure to microwaves can increase the frequency of chromosomal aberrations is still inconclusive. The aim of this present study is to investigate chromosomal aberrations in the bone marrow of Sprague Dawley rats after exposure to 2.45 GHz microwave radiation.

MATERIALS AND METHODS

Animals and Micro Wave (MW) radiation treatment Thirty mature male and female Sprague Dawley rats of sixteen weeks old, weighing between 160-190 g were used for this study. All rats were housed in standard plastic cage under 12 h light and 12 h darkness and were all provided with rat chow and water ad libitum from Pfizer Pharmaceutical Company, Nigeria. The laboratory animal house guidelines on animal handling and euthanasia, as approved by the ethical committee of College of Medicine, University of Lagos were duly observed. All the rats except the control rats were given whole body irradiation by exposure to various SAR delivered from a controlled

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radiation chamber for 10 min using MW generator model ER 6660 E from Toshiba UK Ltd at a power density of 6 $mWcm^{-2}$, available in the Department of Radiation Biology and Radiotherapy, College of Medicine, University of Lagos was used for irradiation. The full detail of exposure procedure has been discussed the author's previous work (Usikalu *et al*., 2010). The animals were divided into five groups of six each as follows; Control group A that were not exposed to radiation Group B - E were exposed to 0.95, 1.43, 1.91 and 2.39 W kg^{-1} SAR radiation, respectively.

Chromosomal aberration study from rats bone marrow: After exposure of the specimens to MW radiation of five various SARs (0, 0.95, 1.43, 1.91 and 2.39 W kg^{-1}) and left for 2 days, the chromosomal aberration study was carried out. Each rat was injected with colchicines 0.6 mg/kg (anti-mitotics inhibitor) 2 h prior to sacrifice. This was done in order to arrest the chromosome at the metaphase. At 48 h post irradiation, the specimens were sacrificed by cervical dislocation and bone marrow cells were prepared from the femoral bone marrow by the conventional method. Briefly, bone marrow cells were flushed from the femurs in 2.2 % Sodium Citrate and the cells were centrifuged at 1500 rpm for 10 minutes. Pelleted bone marrow cells were then resuspended in 5 ml of a hypotonic solution of 0.075 M KCl for 20 min at 37 °C. The cells were centrifuged again and fixed with three changes of 5 ml each of ice cold carnoy's fixative (Methanol Acetic acid, 3:1 v/v) for 30 min at 25 °C. The cells were then dropped onto clean, grease free microscope slides which were air dried and stained with 5 % Giemsa for 15 minutes (Alimba *et al*., 2006). All slides were blindly evaluated in oil-immersed x 100 objectives for structural chromosomal aberrations. Fifty well spread complete metaphases were scored per slide and 6 slides were prepared per specimen at each SAR.

RESULTS

Microwave showed the ability to induce the following structural chromosome aberrations: gaps; acentric; breaks and centric rings. The number of structural aberration obtained is presented in Fig. 1 for male rats. Group exposed to SAR 2.39 W kg^{-1} have the highest gaps (6.45 ± 0.24); highest breaks (7.28 ± 0.08); highest acentric (8.11 ± 0.15) and centric rings (1.24± 0.21). The same trend was observed in female rats. Group exposed to SAR 2.5 W kg^{-1} have the highest gaps (6.45 ± 0.24); highest breaks (7.28 ± 0.08); highest acentric (8.11 ± 0.15) and centric rings (1.24± 0.21). The lowest chromosomal aberrations were consistently observed in the group exposed to SAR 0.95 W kg^{-1}. The effect of MW

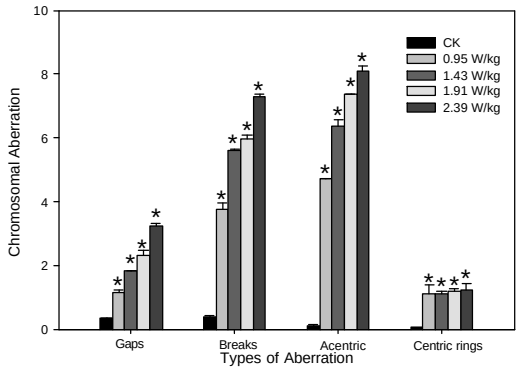

Fig. 1: Variations of the chromosomal aberrations in male rats

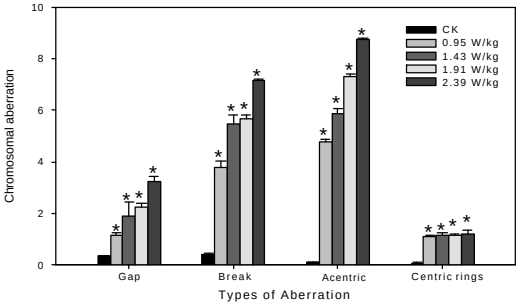

Fig. 2: Variations of the chromosomal aberrations in female rats;* indicates significantly different ($p< 0.05$) compared to control

radiation on the chromosomal aberrations as observed in this study was not sex-dependent as there was no significant difference between the measured values for both male and female rats, there is correlation between the values obtained for both sexes (C = 0.96). The number of chromosomal aberration in female rats is shown in Fig. 2 which displays the variations in the measured values for clear comparisons.

DISCUSSION

The exposure of the animals to various SARs produced significant difference in all the exposed groups compared with the control. The effects of the exposure on the chromosomal aberration is SAR-dependent as the all lowest structural aberrations were observed in group exposed to SAR 1.0 W/kg. This finding correlates with the result of (Mashevick *et al*., 2003) they reported a linear increase in chromosomes 17 aneuploidy as a function of SAR value in HPBLs exposed for 72 h to continuous 830 MHz in the SAR range of 1.6-8.8 W kg^{-1}. Data related to the genotoxic potential of MF is an important basis for the

assessment of MF-induced cancer risk. Although past investigations have suggested that ELF-MF induces genotoxicity such as strand breaks, clustered DNA damages and micronuclei formation, the identity of specific lesions responsible for these biological effects of ELF-MF remains elusive (Simko and Mattsson, 2004). However, it is thought that MW shows its effects by increased ROS, although there is no clear information on this issue. On the other hand, it is known that unrepaired oxidatively induced DNA base modifications can lead to genomic instability, chromosomal aberrations and abasic site (Yokus *et al*., 2008; Simko, 2004).

CONCLUSION

The results from this study suggest that exposure to low SAR MW radiation has harmful effects on the living systems. It induced structural chromosome aberrations such as gaps; acentric; breaks and centric rings to rats exposed to it compared to the control. It was observed in this study that MW effects are not sex dependent but SAR dependent, in the sense that the observed effects in both sexes follow the same trend, there is high correlation between the effects on both sexes (C = 0.98) but changes with increasing SAR.

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