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Original Research

Protective effects of a locally manufactured device on electromagnetic radiation-induced cellular alterations in rats exposed to mobile phone radiation

Hussein Oyelola Bukoye Oloyede[1], Zakariyyau Atiq[2], Rilwan Adebayo Adigun[1], Musa Oyewole Salawu[1]

[1]Department of Biochemistry, University of Ilorin, PMB 1515, Ilorin, Nigeria, [2]ZOA Industries Nigeria Limited, Ilorin, Kwara State, Nigeria

Address for correspondence:
Musa Oyewole Salawu, Department of Biochemistry, University of Ilorin, Ilorin, Kwara State, Nigeria.
Phone: +2348056168553.
E-mail: musasalawu@yahoo.com

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ABSTRACT

Aim/Background: There is a worldwide concern on the possible health hazards induced by electromagnetic fields (EMFs) emitted by handheld devices and laptops. The present study, therefore, investigated the effect of a locally manufactured anti-electromagnetic radiation (EMR) device in rats exposed to mobile phone radiation. **Methods:** Thirty-two rats were acclimatized for 2 weeks and randomized into four groups; Group I was the control (not exposed to radiation or device) and Groups II-IV were exposed to phone only, device only, and phone and device, respectively. The rats were exposed to continuous EMFs for 1 h daily (totaling 50/missed calls) for 28 days. **Results:** EMF exposure caused a significant decrease ($P < 0.05$) in the activity of superoxide dismutase (SOD) and catalase (CAT) and also reduced glutathione (GSH) concentration, but a significant increase ($P < 0.05$) in alanine aminotransferase (ALT), aspartate transaminase, and malondialdehyde (MDA) concentrations, indicating lipid peroxidation. There was no significant difference ($P > 0.05$) between the rats exposed to the device only and those exposed to the mobile phone and the anti-EMR device when compared to the control. The histo-architecture assessment for the brain and liver also showed significant differences ($P < 0.05$) in organs of rats exposed to the mobile phone only when compared to the normal, the device only group, and the rats exposed to the anti-EMR device plus the mobile phone. From the study, the anti-EMR device was able to reverse the effect of mobile phone radiation on the SOD, CAT, ALT and aspartate aminotransferase activities, and reduced GSH and MDA concentrations. **Conclusion:** The locally manufactured anti-EMR device has anti-radiation capacity and reduced the threat posed by these EMRs in the rats.

KEY WORDS: Electromagnetic radiation, mobile phones, oxidative stress, protective device

INTRODUCTION

Mobile phone is currently one of the fastest evolving technologies today and it has become a major necessity in everyday life as it serves as one of the fastest media of communication. Wireless technologies are ubiquitous today, and the mobile phones are one of the prodigious outputs of this technology emitting electromagnetic radiations (EMRs). The widespread use of mobile phones in recent years has raised the research questions on the effect of the emitted EMR from it. In physics, radiation is the emission or transmission of energy in the form of waves or particles through space or through a material medium [1]. A report by the committee on the environment for the Council of Europe (2011) [2] recommended that member states should take all reasonable measures and devise means to reduce exposure to electromagnetic fields (EMFs), especially radiofrequencies emitted from mobile phones [2]. EMRs from a mobile phone may be absorbed by various body organs according to the places where they are carried [3,4]. The effects of EMRs emitted by mobile phones on the central nervous system have become a particular focus of concern owing to the fact that mostly mobile phones are kept near head during talking mode and are in close proximity to the brain [5]. Mobile phones transmit and receive microwave (MW) radiations at frequencies mainly ranged between 800 and 2000 MHz, which excites rotation of water molecules and some organic molecules, causing thermal and non-thermal effects on humans [6]. The reported thermal effects from mobile phones include headache, sensation of burning or warmth of the ear, burning sensation in the facial skin, and alteration in the blood–brain barrier [7]. Modification of sleep patterns, an increase in blood pressure, and effects on cognitive function are the non-thermal effects

described in literature [8]. The potential carcinogenic effects of EMFs from mobile phones are controversial. Given the large number of mobile phone users, investigating, understanding, and providing a possible means of suppressing or putting to stop any potential public health impact of mobile phone use are important.

Findings have reported mobile phone-induced free radical formation in tissues of rats exposed to EMRs. Reactive oxygen species (ROS) have been implicated in tissue injury. ROS are scavenged by superoxide dismutase (SOD), glutathione (GSH) peroxidase (GSH-Px), and catalase (CAT) [4].

Due to the worldwide concern on the possible health hazards induced by EMFs, the current research is extended using a variety of approaches: Histological, biochemical, and experimental exposure on laboratory animals. These parameters which are used to evaluate the possible health hazards induced by EMRs were used in this study to evaluate the efficacy of the anti-EMR device locally manufactured in Nigeria.

MATERIALS AND METHODS

Anti-EMR Device

The locally manufactured anti-EMR device was manufactured by ZOA Nigeria Limited, Ilorin, Nigeria, and patented with the Assistance of Professor H.O.B. Oloyede of Department of Biochemistry, University of Ilorin, Ilorin, Kwara State.

The anti-radiation cell phone device is polystyrene laminated, weighing 14.10-14.50 g, and of the following dimensions: Length (8.60 cm) × width (5.40 cm) × thickness (0.2 cm). The device is said to be capable of reducing radiations by handheld communication devices and other household electronics significantly.

Experimental Animals

Thirty-two healthy male Wistar albino rats (*Rattus norvegicus*), weighing 110-120 g ± 12.13, were obtained from Animal House of the Department of Biochemistry, University of Ilorin, Ilorin, Nigeria. They were well kept in clean plastic cages contained in well-ventilated house conditions with free access to feeds (vita feeds). The animals were used in accordance to the Guidelines of National Research Council Guide for the Care and Use of Laboratory Animals (National Research Council, 2011) and according to the principles of Good Laboratory Procedure (WHO, 1998).

Methods

Experimental design/animal grouping

Thirty-two male rats were acclimatized for 2 weeks and randomized into four groups; Group I was the control (not exposed to radiation or device) and Groups II-IV were exposed to phone only, device only, and phone and device, respectively.

Animal exposure

Male Wistar albino rats aged 42-45 days were exposed continuously to 900 MHz frequency at a specific absorption rate of approximately 0.9 W/kg for 28 days at 1 h/day. Rats were exposed to mobile phone calls (continuous EMFs) for 1 h daily (totaling 50/missed calls) for 28 days. Experimental groups were continually exposed to EMR from mobile phone. The MW radiation was produced by a mobile test phone (Model Nokia 105, Nokia Mobile Phones Ltd.).

Blood Sample Collection and Preparation of Tissue Supernatant

Collection of serum

Animals were sacrificed under diethylether anesthesia. Blood samples were collected by jugular incision into separate bottles with no anticoagulants and allowed to stand for 20 min at room temperature (25°C) for coagulation to take place. The clear serum was thereafter collected using a Pasteur pipette and kept frozen until required.

Preparation of tissue homogenate

The rats were dissected and the livers and brains were removed. The livers were washed clean of blood. The organs were then quickly placed in ice-cold 0.25 M sucrose solution. Each organ was dried using a tissue paper and weighed. Each organ was cut into pieces using scalpels and then homogenized in ice-cold 0.25 M sucrose solution (1:5 w/v) using pre-refrigerated mortar and pestle. The homogenates were turned into specimen bottles and kept frozen until required [9].

Biochemical parameters

Activities of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were assayed by the method of Schmidt and Schmidt [10]. Malondialdehyde (MDA) was determined by Nelson and Cox [11], SOD was determined by Misra and Fridovich [12], CAT was determined by Beer and Sizer [13], and reduced GSH was determined by Ellman [14].

Statistical Analysis

Experimental data are presented as mean ± standard error of mean. Statistical analysis was implemented using computer software SPSS 17.0 version statistical package program (SPSS, Chicago, IL, USA). One-way analysis of variance was used to compare variables among the different groups. Level of significance (*post-hoc* comparisons) among the various treatments was determined by Duncan's multiple range test. The values were considered statistically significant at $P < 0.05$.

RESULTS

General Findings

At the end of the 28-day exposure, none of the animals died as a result of the exposure and there were no apparent sign of distress.

SOD

There was no significant difference ($P > 0.05$) in SOD activity in brain and liver of rats [Figures 1 and 2] in all the groups when compared to the control at the 1st and 2nd weeks. A significant decrease ($P < 0.05$) in the activity of SOD was observed in rats exposed to mobile phone only from the 3rd week till the 4th week when compared to the control. At the 3rd and 4th weeks, there was no significant difference ($P > 0.05$) in the activity of SOD in brain and liver of rats in the device only and phone plus device group when compared to the control unlike the phone only group which showed significant difference at $P < 0.05$.

CAT

There was no significant difference ($P > 0.05$) in CAT activity in brain and liver [Figures 3 and 4] of rats for all the groups in the 1st and 2nd weeks, respectively, when compared to the control. However, there was a significant increase in the activity of CAT in brain and liver of rats exposed to the mobile phone only at the 3rd and 4th weeks, respectively.

In the brain and liver, there was no significant difference ($P > 0.05$) in the activity of CAT in the device only and phone plus device groups at the end of the experiment when compared to the control.

Reduced GSH

In addition, reduced GSH concentration in the brain and liver of rats exposed to the device only and those exposed to the phone and device showed no significant difference ($P > 0.05$) when compared to the control from the 1st week to the 4th week. In contrary, there was a significant decrease ($P < 0.05$) in the concentration of reduced GSH in the rats exposed to the mobile phone only when compared to the control from the 1st week to the 4th week [Figures 5 and 6].

Lipid Peroxidation (LP) Product

MDA

There was no significant difference ($P > 0.05$) in concentration of MDA in the brain and liver of rats in all the groups when compared with the control in the 1st week of the experiment. As the week progresses, there was a significant increase ($P < 0.05$)

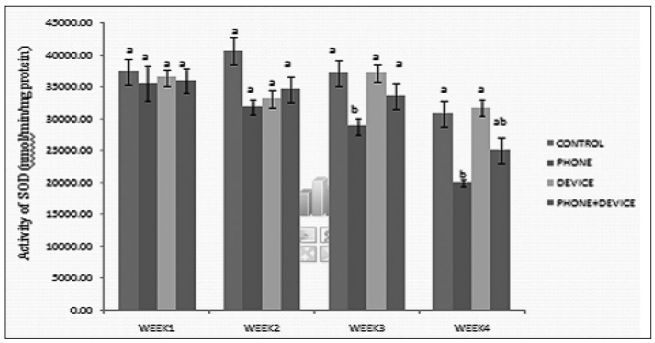

Figure 1: Activity of superoxide dismutase in brain of rats exposed to mobile phone radiation and anti-radiation device. Values are expressed as mean ± standard error of mean for $n = 4$. Bars not sharing common superscript (a, b, c,…) differ significantly at $P < 0.05$

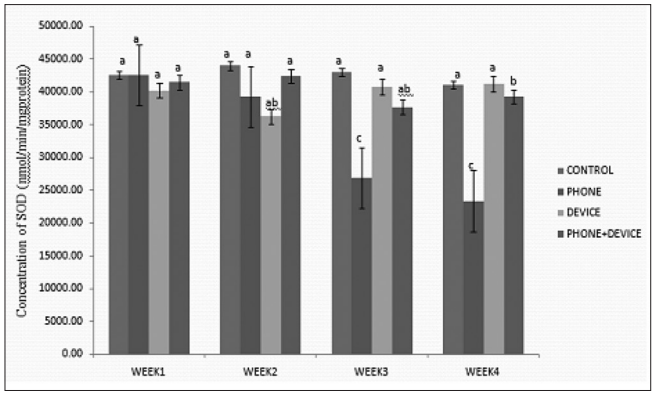

Figure 2: Activity of superoxide dismutase in liver of rats exposed to mobile phone radiation and anti-radiation device. Values are expressed as mean ± standard error of mean for $n = 4$. Bars not sharing common superscript (a, b, c,…) differ significantly at $P < 0.05$

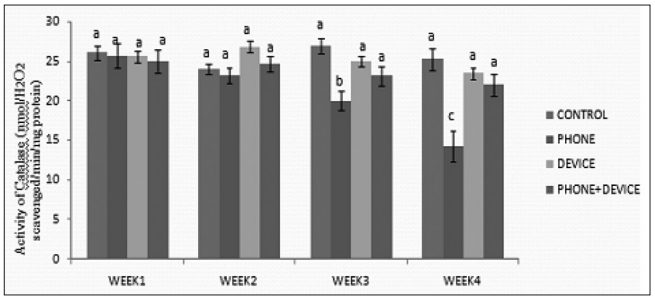

Figure 3: Catalase activity in brain of rats exposed to mobile phone radiation and anti-radiation device. Values are expressed as mean ± standard error of mean for $n = 4$. Bars not sharing common superscript (a, b, c,…) differ significantly at $P < 0.05$

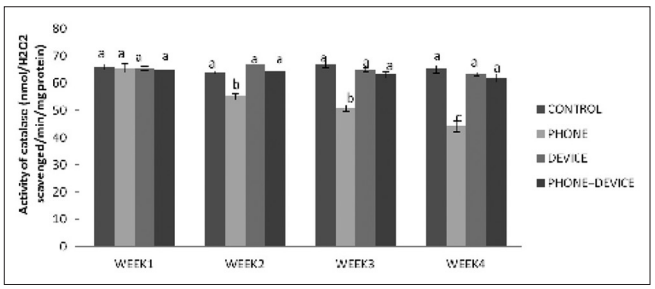

Figure 4: Activity of catalase in liver of rats exposed to mobile phone radiation and anti-radiation device. Values are expressed as mean ± standard error of mean for $n = 4$. Bars not sharing common superscript (a, b, c,…) differ significantly at $P < 0.05$

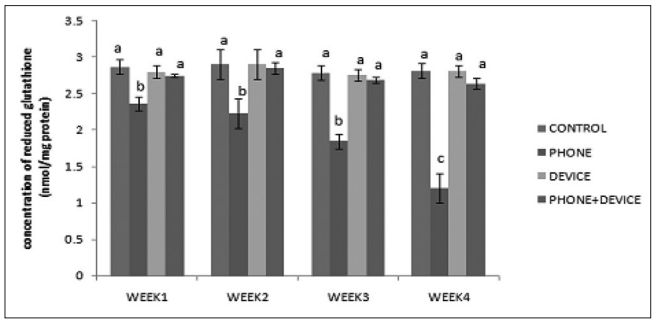

Figure 5: Reduced glutathione concentration in brain of rats exposed to mobile phone radiation and anti-radiation device. Values are expressed as mean ± standard error of mean for $n = 4$. Bars not sharing common superscript (a, b, c,…) differ significantly at $P < 0.05$

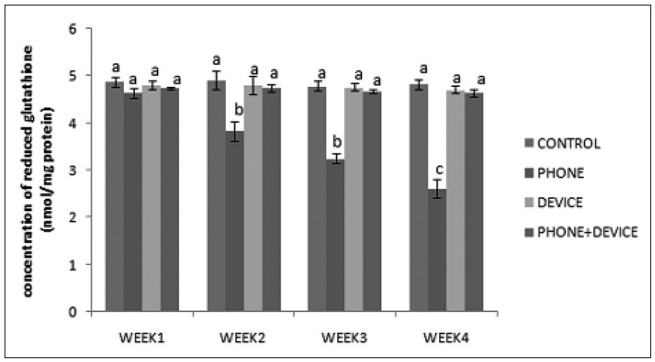

Figure 6: Reduced glutathione concentration in liver of rats exposed to mobile phone radiation and anti-radiation device. Values are expressed as mean ± standard error of mean for $n = 4$. Bars not sharing common superscript (a, b, c,…) differ significantly at $P < 0.05$

in the concentration of MDA in brain and liver of rats exposed to the mobile phone only unlike the device only group and phone plus device group which showed no significant difference ($P > 0.05$) to the control till the end of the study.

DISCUSSION

The use of mobile phones is currently one of the fastest growing technological developments and it has become a major necessity in everyday life as it serves as one of the fastest media of communication. MW from mobile phones may affect biological systems by increasing free radicals, which may enhance LP and by changing the antioxidative activities of the brain and liver cells. The proximity of the antenna of such a device to the abdominal organs has raised concerns about the biological interactions between EMR and the liver and testis [15]. The reason for selection of the brain is because during talk mode, the brain is in closest proximity to the mobile phone kept near the head and most susceptible to radiation. The brain is the most complex organ in a vertebrate's body. Physiologically, the function of the brain is to exert centralized control over the other organs of the body and thus serves as the center of the nervous system in all vertebrates. EMR emitted from a mobile phone may be absorbed by various body organs according to the places where they are carried [3]. Liver is an important metabolic tissue and it is also the main and most responsible organ for detoxification. Another reason for selection of the liver is its sensitivity to waste products.

The enzymic antioxidant system, which includes SOD, CAT, GSH-Px, GSH-Red, as well as glucose-6-phosphate dehydrogenase, plays a coordinated role in the prevention of oxidative damage by ROS [16]. The ability of radiation to induce oxidative stress and thus oxidative damage is indicated with the increase in MDA concentration of the brain and liver organs in the phone only group. The primary antioxidant enzymes (SOD and CAT) are mostly preventive; these enzymes can decompose ROS and prevent the damage to cellular constituents [17]. The alteration in these marker enzymes can be ameliorated by antioxidant capability of the anti-EMR device to mop up or break the chain of free radical reactions. They are inducible enzymes, whose synthesis is therefore initiated by an increase in the level of free radicals in the body [18], leading to an elevation in their activities. However, in the case of chronic exposure, depletion in their activities has been reported. This was also observed in this study. Depletion in antioxidant activity of the phone only group could be attributed to the assault of mobile phone radiation on the antioxidant enzymes.

The long-term exposure to infectious agent (such as radiation) increases LP and causes inhibition of SOD activity in the organs [19]. GSH-red is a cytosolic enzyme involved in the replenishment of GSH stores by reduction of oxidized GSH, which is an end product of GSH-Px activity [20]. Elevation in the concentration of end products of LP in the brain and liver of mobile phone-exposed rats was observed. Preservation or increase in the activity of these antioxidant enzymes in the phone plus device group further confirmed the anti-radiation potency of the locally manufactured anti-EMR device when compared with the phone only group where the antioxidant enzymes have significantly depleted due to the effect of radiation causing free radicals. The increase in MDA concentrations in the liver and the brain of the mobile phone only exposed rats suggests enhanced peroxidation leading to tissue damage and failure of the antioxidant defense mechanisms to prevent the formation of excessive free radicals. The locally manufactured anti-EMR device was able to prevent the activity of each of the antioxidant enzymes studied from being significantly changed as a result of the assault by the mobile phone radiation.

There are many enzymes such as ALT and AST that are found in the serum which did not originate from the extracellular fluid. During tissue damage, some of these enzymes find their ways into the serum probably by leakage through disrupted cell membranes [21-23]. Serum enzymes provide a marker in toxicity studies as well as in clinical diagnosis. The aminotransferases are two closely related enzymes of clinical significance, particularly in the assessment of liver function. Both enzymes increase in many disorders related to liver damage, and hence they have been proven to be sensitive indicators of liver cell injury [24]. The device only group also showed no significant increase or decrease when compared to normal control implying that the anti-EMR device had no negative effect on the rats exposed to it.

CONCLUSION

From the results obtained from this study, the following conclusions can be made: The locally manufactured anti-EMR device was able to reduce the risk posed by ROS by maintaining the antioxidant levels and liver function indices of rats exposed to mobile phone radiation. The anti-EMR device, therefore, protects the body from EMRs capable of producing alterations in the biochemical parameters investigated. There were no alterations pronounced in the brain and liver of rats exposed to the locally manufactured anti-EMR device.

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