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Effects of mobile phone radiation on certain hematological parameters

Bindhu Christopher[a], Y. Sheena Mary[a], Mayeen Uddin Khandaker[b,*], D.A. Bradley[b], M.T. Chew[b], P.J. Jojo[a,c,**]

[a] Centre for Advanced Research in Physical Science, Department of Physics, Fatima Mata National College (Autonomous), Kollam, 691001, India
[b] Centre for Biomedical Physics, School of Healthcare and Medical Sciences, Sunway University, 47500, Bandar Sunway, Selangor, Malaysia
[c] Department of Applied Physics, The Papua New Guinea University of Technology, Lae, Papua New Guinea

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ABSTRACT

Elevated chronic exposure to any sort of radiation is hazardous to human health. Besides ionizing radiation, exposures to electromagnetic radiation mainly from the use of mobile phones have become a matter of great health concern, especially its extended duration use even by children. At the same time there are several unknowns related to the ill effects including carcinogenicity of prolonged exposure. The objective of this investigation was to find the effect on certain vital hematological parameters namely hemoglobin level, white blood cell (WBC) count, platelet count and erythrocytes sedimentation rate (ESR) due to the prolonged exposure to mobile radiations through in vitro examination of human blood samples. Matched case control methodology was adopted for the study. Blood samples were collected by clinicians from 27 voluntary subjects for investigation. From each, one sample was kept un-exposed while the other three samples were exposed to mobile microwave radiations for 60 min continuously in identical and controlled conditions. A 4G hand phone of a very popular brand having transmission frequency range from 2.3 to 2.4 GHz including uplink and downlink was used. Hematological analyses were carried out on fresh samples immediately after collection. For comparison of the levels of hematological parameters, blood exposed to 1 h of phone radiation and control were analysed. Experimental results show that there is a significant change on the hematological components. The exposed blood samples were found to display decrease in platelet count only. Hemoglobin level, ESR rate and the WBC counts were found to be increased. While these observations are performed under controlled laboratory conditions, given the tremendous growth in number of mobile phone users, the effects could be a real concern especially in work places and cities even through passive exposure.

1. Introduction

Technological inventions have made human life much easier. Mobile phones, for instance, have communication related to many walks of life. It has become an indispensible gadget for all, irrespective of their profession or class. Nevertheless, with the escalation in use of mobile phones all over the world, exposure to electromagnetic fields (EMF) in the biosphere is mounting posing a question of potential health hazard. Prolonged and high rate of exposure to electromagnetic fields can affect human body tissues adversely since the neural network employs electric charges for transmitting signals between brain and tissues. Usually, mobile phones are held very close to the human head and are linked with a large number of base station antennas (Atasoy et al., 2009). In 2005, the Australian radiation protection and nuclear safety authority (ARPENSA) confirmed that 70% of radiation emitted from mobile phones are absorbed by the human head which may lead to imbalance in nerve system and circulatory systems (ARPENSA, 2005–2006). A recent report, points to degeneration of blood quality even after short-term cell phone radiation exposure, both in a passive condition in the pocket as well as in active use. The blood cells were found to have Rouleaux formation (groups of red blood cells (RBC) stacked together in a long chain) which would result in lowering oxygen transport and in reducing waste removal mechanism. This might lead to electromagnetic hypersensitivity resulting in headache, fatigue, lack of concentration, dizziness, nausea and weakness (Weston Price Foundation, 2015). In regard to base stations, cellular networks operate on different frequency bands including the 450 MHz band, 700 MHz band, 800 MHz band, 900 MHz band, 1800 MHz band, 2100 MHz band, and 2600 MHz band (https://www.

* Corresponding author.
** Corresponding author. Centre for Biomedical Physics, School of Healthcare and Medical Sciences, Sunway University, 47500, Bandar Sunway, Selangor, Malaysia.
E-mail addresses: mayeenk@sunway.edu.my (M.U. Khandaker), jojopanakal@gmail.com (P.J. Jojo).

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spectrummonitoring.com/frequencies/). Dealing with such a frequency via the use of mobile phone could lead to various forms of reversible or irreversible structural and functional changes at the cellular level or in organs systems of exposed population (Diechmann et al., 1964). Although it is true that the degree of adverse effect largely depends on several key factors such as the frequency of the electromagnetic fields, intensity of the power, duration of exposure etc. (Alghamdi and El-Ghazaly, 2012; Challis, 2005), nevertheless, except the one controllable parameter namely 'duration of exposure', the other parameters play a vital role for mobile communications and their use can not be restricted. In this context, we initiated an investigation on the effect of important and primary hematological parameters namely hemoglobin (Hb) level, white blood cell (WBC) count, platelet count and erythrocytes sedimentation rate (ESR) level due to the prolonged exposure to mobile radiations through in vitro examination of human blood samples.

2. Materials and methods

2.1. Participants socio-demographic characteristics

An *in-vitro* matched case-control experiment was adopted for this study. Twenty-seven healthy subjects with the age ranging from 22 to 30 years old were recruited for the investigation. The participants selected were free from any systemic diseases, did not have smoking habits, nor chew tobacco or consume alcohol. None of them were employed by any telecommunication or electromagnetic wave based services. Neither do they have any permanent mobile base station near their locality (within a radius of 1 km) of residence nor have any sort of electronic implantations inside their bodies. All the subjects were abstained from using mobile phones for more than 3 h prior to the sample collection.

2.2. Collection of samples

A total of 27 blood samples were collected for the hematological studies. Blood sample collection and hematological analyses were carried out in the accredited pathological laboratory attached to the multispecialty Bishop Benzigor Hospital in Kollam, Kerala, India. Samples were collected by the medical staff of the pathological laboratory in the hospital following the standard protocols and procedures. They were collected following the cubital vein withdrawal procedure.

2.3. Pretreatment of samples and exposure to radiation

Freshly collected blood samples were transferred into a set of '1 ml shell vials' with appropriate identifications such as test and control. For each participant's blood sample, three vials were kept for test and one vial was kept as control. The three test samples were exposed to a mobile microwave radiation for 60 min continuously in identical and controlled conditions. The test vials were kept in close proximity (touching each other) of the mobile phone with specific absorption rate of about 1.42 W/kg on calling mode with an active Wi-Fi. A 4G hand phone of a very popular brand having transmission frequency range 2.3–2.4 GHz including uplink and downlink was used for microwave exposure to the blood samples. The specific absorption rates were determined using a sensitive handheld microwave leakage detector HTC ML-2.

2.4. Control samples

From each subject, one set of samples were kept as control without exposure to mobile radiation, in an enclosure with metallic body during the period while the other three samples were being exposed to radiation. After 60 min, the control samples were also analysed in the same manner as that of the exposed blood samples to determine the hematological parameters.

2.5. Analyses of samples

After exposure to the mobile radiation continuously for 60 min, the blood samples were immediately analysed using Mindray bc5000 hematology analyzer in the hematology department of the hospital to determine the levels of the specified parameters in the three experimental blood samples in the vials. Blood samples kept as controls in identical condition without radiation exposure were also analysed simultaneously. Similar procedure was followed for the analyses of blood samples collected from all the subjects. Power densities of electric and magnetic fields at the location of the samples measured by the microwave leakage detector were used for determining the specific absorption rate (SAR) values. The SAR is a measure of the rate of the energy absorbed by the human body when exposed to a radio frequency electromagnetic field; defined as the power absorbed per mass of tissue (W/kg). The platelet counts were determined by optical impedance method, Colorimetric method was used for Hb counts, flow cytometry was the method employed for WBC determination and Westergren method was adopted for assessing ESR. The mean values for the three experimental samples were calculated. In the case of control sample, average of the results before and after the exposure time was also determined in each case. Triplicate measurements were taken for all samples, both tests and controls.

3. Results of hematological analyses

After completing blood sampling from subjects, exposure of blood samples to mobile radiation and subsequent analyses of all the blood samples, the results were tabulated and were analysed statistically. The results of the four hematological parameters namely Hb level, WBC count, platelet counts and ESR are presented in Table 1 together with standard deviation (SD). Experimental results show that there is a noteworthy change in hematological components.

Post mobile radiation exposure, the exposed blood samples were found to have decreased platelet count as compared with the samples which were not exposed to radiation. Haemoglobin, ESR rate and WBC counts were found to be increased marginally. The numerical

Table 1
Summary of the variations of haemoglobin, WBC count, platelet counts and ESR in blood samples.

Parameters (unit)	Status	Mean ± SD	Extent of change (mean)	Percentage change (%)
Haemoglobin (g/dL)	Un exposed	14.4 ± 1.70	0.1 (g/dL)	+1
	Exposed	14.5 ± 1.73		
WBC count (cells/mm^3)	Un exposed	6800 ± 369.0	185 (cells/mm^3)	+3
	Exposed	6985 ± 390.0		
Platelets count (10^5/mm^3)	Un exposed	3.06 ± 0.6	−0.6 (10^5/mm^3)	−20
	Exposed	2.46 ± 0.4		
ESR (mm/hr)	Un exposed	14 ± 1.1	−2 (mm/hr)	−14
	Exposed	12 ± 1.1		

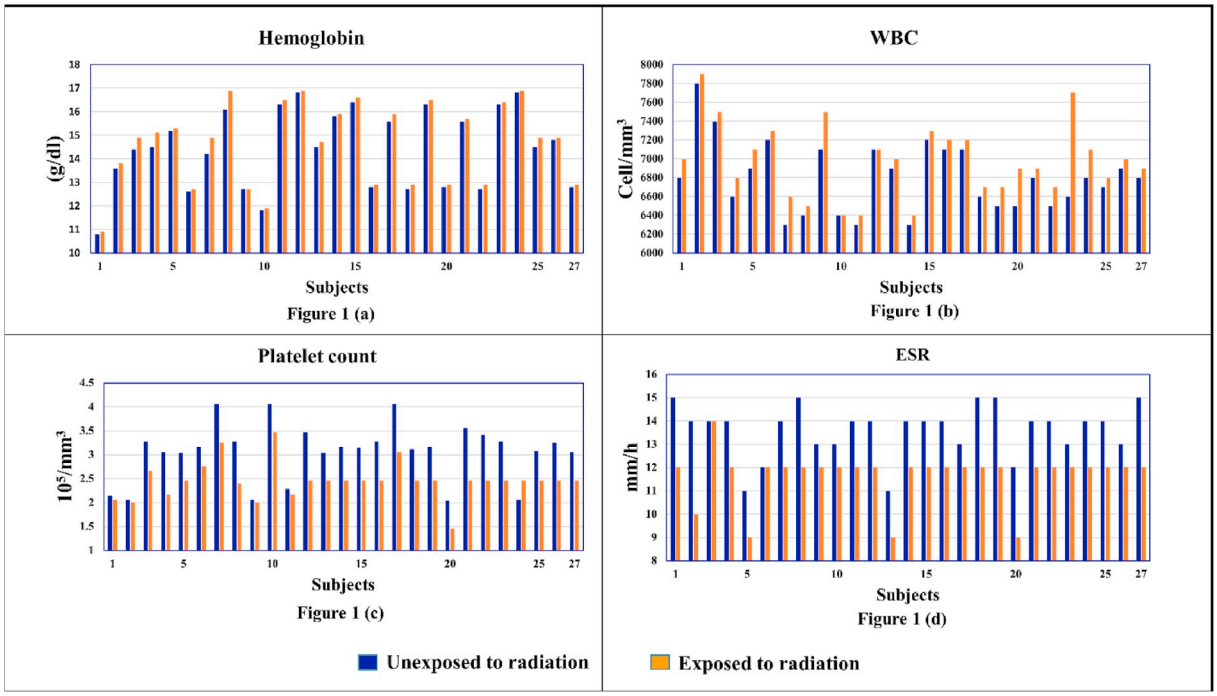

Fig. 1. Variations of the four hematological parameters among the subjects.

decrement in ESR indicates an increment in the sedimentation rate. It should be noted that the effects were only due to a single mobile phone radiation in laboratory conditions. The variation of the four parameters are graphically presented in the Fig. 1.

4. Discussion

The observed borderline increase of 1% in the haemoglobin level may be attributed to the occurrences of deoxygenation due to the non-thermal electromagnetic field. Similar results have also been reported in the earlier study conducted by Muehsam et al. (2013) and Sani et al. (2018). There could also be the effects of free radicals on the RBC membrane and cytoskeleton that may contribute to the leak of Hb out of the cells (Jbireal et al., 2018).

Though there is only a marginal increase of 3% seen in WBC count post mobile radiation exposure, the effect can cause conditions like anaemia. The results concur by Alghamdi and El-Ghazaly (2012) show an increase in WBC count due to the electromagnetic exposure, even for a short period of time (Alghamdi and El-Ghazaly, 2012).

Platelet counts, which is a very significant hematological parameter, showed a substantial 20% drop after the radiation exposure. This effect of radiation exposure is important as such a drop in platelets can lead to serious health conditions like leukemia in the long run (Patruno et al., 2015). Interaction of electromagnetic radiation with blood cells could intervene with chemical reactions involving free radical generation and the reactive oxygen species (ROS), and this may lead to the destruction of platelets, thus lowering the count rate. There are similar reports of reduction of platelets in blood cells due to even short period of exposure (Vagdatli et al., 2014). Chronic oxidative stress has been found in several hematopoietic malignancies such as myeloid leukemia (Patruno et al., 2015).

Exposure to EMF may cause deformation of RBC and this could cause deterioration of its functions as its mechanical shape is changed. The decrease in superficial charge density may also increase their aggregation and density leading to Rouleaux formation. The ESR measures the rate of sedimentation of RBC in a sample of blood that has been placed in to a 100–200 mm tall, thin vertical tube, leaving a clear plasma at the top portion of the tube in 1 h (mm/hr). It has been used to indirectly measure the degree of inflammation present in the body. The ESR rates were found to drop by 2 mm/h, which is about 14% of the actual sedimentation rate. A decrease in ESR indicative of hypo fibrinogen, where the fibrinogen amount is less than normal level in the blood. On the other hand, an increase of ESR indicated an increase in blood viscosity which could impairs blood flow in the body. High blood viscosity is due to the Rouleaux formation of blood cells. This increment in blood viscosity known as hyper viscosity syndrome could lead to coronary and neurological disorders. The outcome of this investigation and associated analysis confirmed that all the four parameters of the whole blood count were largely effected by the radiation of mobile phone.

For all the four blood parameter variation, we conducted the Student's T-test to establish significance and repeatability of the results. For the changes in Hb and WBC count, the significance level was found as $p < 0.05$, and for platelet counts and ESR the changes were more significant with $p < 0.001$.

5. Conclusions

The radio frequency EMF created by mobile phones affected the Hb level, WBC count, platelets count and ESR. The effects of these EMF devices may be underestimated as these observations are measured in a controlled laboratory condition, but with the tremendous growth in number of mobile phone users, the effects could be many more folds especially in work places and cities, and even through passive exposure. Even if the changes are marginal, growing use of mobile phones and at longer exposure periods, even a small alteration may risk human health resulting in cumulative effects. Limited exposure time, in vitro experiment and possibly different physiological conditions of the subjects are the major limitations of the present study.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.radphyschem.2019.108443.

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