

Full Length Research Paper

Effects of 950 MHz mobile phone electromagnetic fields on the peripheral blood cells of male rabbits

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Today, mobile phones are used frequently and held close to the body. It is believed that microwaves may interfere with the cellular signaling systems, affecting the mechanisms by which the cells balance their functions. The objective of this work is the evaluation of the influence of different intensities of 950 MHz cell phone electromagnetic field (EMF) on the hematological parameters of male rabbits. This study was conducted on 54 male rabbits of average mass of 1400 to 1700 g. The exposure period of simulated mobile phone radiations (950 MHz, 3 and 6 W) was 2 h/day for 2 weeks. The blood from the heart was collected on ethylenediaminetetraacetic acid (EDTA) and was analyzed for hematological parameters, and was then compared with the control group. The results showed an increase ($P < 0.05$) in the white blood cells (WBC) counts in 6 W group when compared with both 3 W and control groups. Platelets (PLT) counts decreased in 3 W group but increased in 6 W group. Lymphocyte counts decreased in 3 and 6 W groups when compared with each other and control group. There were no differences in red blood cells (RBC) counts and related indices of any groups. In conclusions, mobile phone EMF disturb the constant number of some hematological parameters which may reflects from thermal or non-thermal effects of such radiations, but the exact reason for such discrepancies is not easy to identify.

Key words: Mobile phone 950 MHz radiations, hematological parameters, rabbits.

INTRODUCTION

Over the past century, a vast and growing spectrum of man-made electromagnetic fields (EMF) was introduced and the most popular kind of these is mobile phone. These devices are potentially the most dangerous sources of EMF radiation relative to other sources, because mobile phones are held close to the body and are used frequently. In effect, the whole body can act as an efficient antenna to pick up electromagnetic radiation. Signals transmitted by a mobile phone will reach all parts of the body and penetrates living tissue easily. So, the effects of EMF occur at the cellular level (Goldworthy, 2007). In postnatal life in humans, blood cells are normally produced only in the bone marrow. Lymphocytes are produced in the secondary lymphoid

organs, as well as in the bone marrow and thymus gland. The constant cell number of bone marrow and hence peripheral blood are controlled by hematopoietic growth factors which regulate the proliferation and differentiation of hematopoietic precursor cells and facilitate the function of mature cells. These growth factors tend to enhance membrane integrity by binding to their receptors on cell surface and change cell functions and populations via modulation of proliferation or apoptosis. It is believed that microwaves may interfere with the cellular bio-electrochemical signaling system either by the development of temporary pores or leak in the membrane of the cells by letting small amounts of calcium into the cytosole. Many metabolic processes may be altered by such processes. What happens then depends on what the cells are currently programmed to do. If they are growing, the rate of growth may be increased. If they are repairing themselves, the rate of apoptosis may be increased

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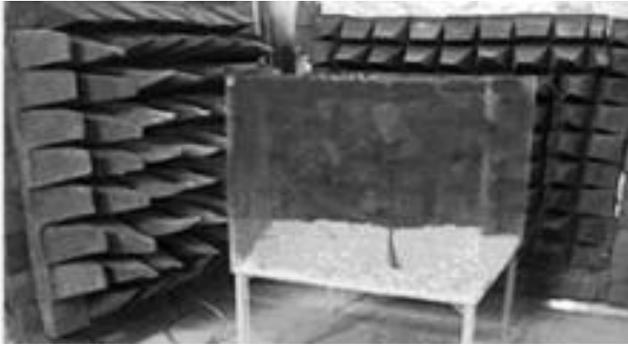


Figure 1. Schema of the facility (cage) for exposure of rabbits to 950 MHz magnetic field.

(Alasdair, 2009). In our past research, the influence of 950 MHz magnetic field (mobile phone radiation) on sex organ and adrenal functions of male rabbits was valued (Sarookhani et al., 2011). This study was an attempt to introduce the effects of non-ionizing 950 MHz microwave mobile phone exposure to hematological biomarkers in an animal (rabbit) model and expanding these findings to human model. To our knowledge, there are few authors dealing with the issue of 950 MHz EMF exposure with two power intensities (3 and 6 W or speaking and non-speaking conditions) in laboratory conditions.

MATERIALS AND METHODS

This is a basic experimental study which was conducted on 54 white New Zealand male rabbits (18 animals for each group) of an average mass of 1400 to 1700 g. The rabbits were obtained from a known (Razi Institute, Tehran, Iran) breeding unit. The rabbits were housed per cage in a well ventilated room $25 \pm 2^\circ\text{C}$ and 12 h light and dark cycle at the animal house where they were regularly fed on a standard diet. The exposure system was a radiation chamber designed and calibrated in Khajeh Nasir Toosi University (Tehran, Iran) with a horn antenna producing magnetic field of 3 and 6 W (power intensity during speaking) sources which mimicked actual fields originating from mobile phones (Figure 1).

Each test group of rabbits was exposed to 950 MHz EMF of 3 W (18 animals) or 6 W (18 animals) intensities for 2 h per day for 2 weeks (Khavanin et al., 2007, 2008). The control group (18 animals) was not exposed to EMF. After exposure, the tests and control groups were anesthetized and blood samples were collected from the heart (equivalent to peripheral blood) and were mixed in individual tubes with ethylenediaminetetraacetic acid (EDTA) anticoagulant. Total blood cell counts were determined in a calibrated cell counter (Sysmex K-1000) using the standard laboratory method. In order for microscopical examination, blood smears were stained with Giemsa standard solution. The data were statistically analyzed using Statistical Package for Social Sciences (SPSS) statistical software (Qazvin, Iran), and finally, statistical significance was set at $P < 0.05$.

RESULTS

The average of measured parameters in 3 groups

Table 1. Average levels of blood cell counts in 3 study groups.

Group	Normal	3 W	6 W
	Mean \pm 1 SD	Mean \pm 1 SD	Mean \pm 1 SD
WBC $\times 10^3$	7.04 \pm 0.22	6.18 \pm 0.41	11.47 \pm 0.36
RBC $\times 10^6$	5.01 \pm 0.40	4.78 \pm 0.11	4.68 \pm 0.24
HGB	10.90 \pm 0.20	10.40 \pm 0.17	10.30 \pm 0.38
HCT	33.60 \pm 0.53	31.40 \pm 0.76	33.50 \pm 1.20
MCV	67.00 \pm 0.99	65.90 \pm 2.40	69.10 \pm 1.50
MCH	21.80 \pm 0.41	21.70 \pm 0.46	21.50 \pm 0.18
MCHC	32.60 \pm 0.23	33.20 \pm 0.62	31.20 \pm 0.61
PLT $\times 10^3$	432.00 \pm 44.70	280.00 \pm 49.50	415.00 \pm 21.70
LYM (%)	56.40 \pm 4.80	57.00 \pm 2.00	50.10 \pm 4.50
RDW	14.00 \pm 0.17	13.00 \pm 0.23	13.00 \pm 0.45

HGB: Hemoglobin, HCT: Hematocrit, Lym: Lymphocyte, RDW: Red Cell Distribution Width, MCV: Mean Corpuscular Volume.

(control, 3 and 6 W) is as shown in Table 1. As shown in this table, the results of statistical analyses are summarized. The results show that in comparison to control group, in 3 W exposed group, total white blood cells (WBC) and red blood cells (RBC) counts as well as lymphocytes have no differences, but platelets (PLT) counts decreased. In comparison between 3 and 6 W groups, there is a decrease in WBC and PLT counts, but an increase in lymphocyte counts in 3 W group. No differences were observed in all RBC counts and related indices, but mean corpuscular hemoglobin concentration (MCHC) which decreased in 6 W group ($P < 0.05$). Figures 2 and 3 show the average level of blood cell counts in 3 normal (control), 3 and 6 W groups.

DISCUSSION

Results of various studies of EMF radiation on other hematological parameters are often conflicting. A paper by Matause et al. (2000) revealed a permanent decrease in WBC count of irradiated rats from eight day of radio frequency exposure which was simultaneous with decline in relative count of lymphocytes, but the proportion of polymorphonuclear granulocytes was not changed. By contrast, in the current study, in 3 W exposed animals, the total number of leukocytes as well as lymphocytes was not altered, but in 6 W exposed group, the total WBC counts increased. Lymphocytes counts declined when compared with control group. It is speculated that 950 MHz EMF emitted from cell phones of 6 W power releases polymorphonuclear granulocytes (neutrophils), from marginal or bone marrow pools via thermal effects or signaling mechanisms of released cytokines. Decline

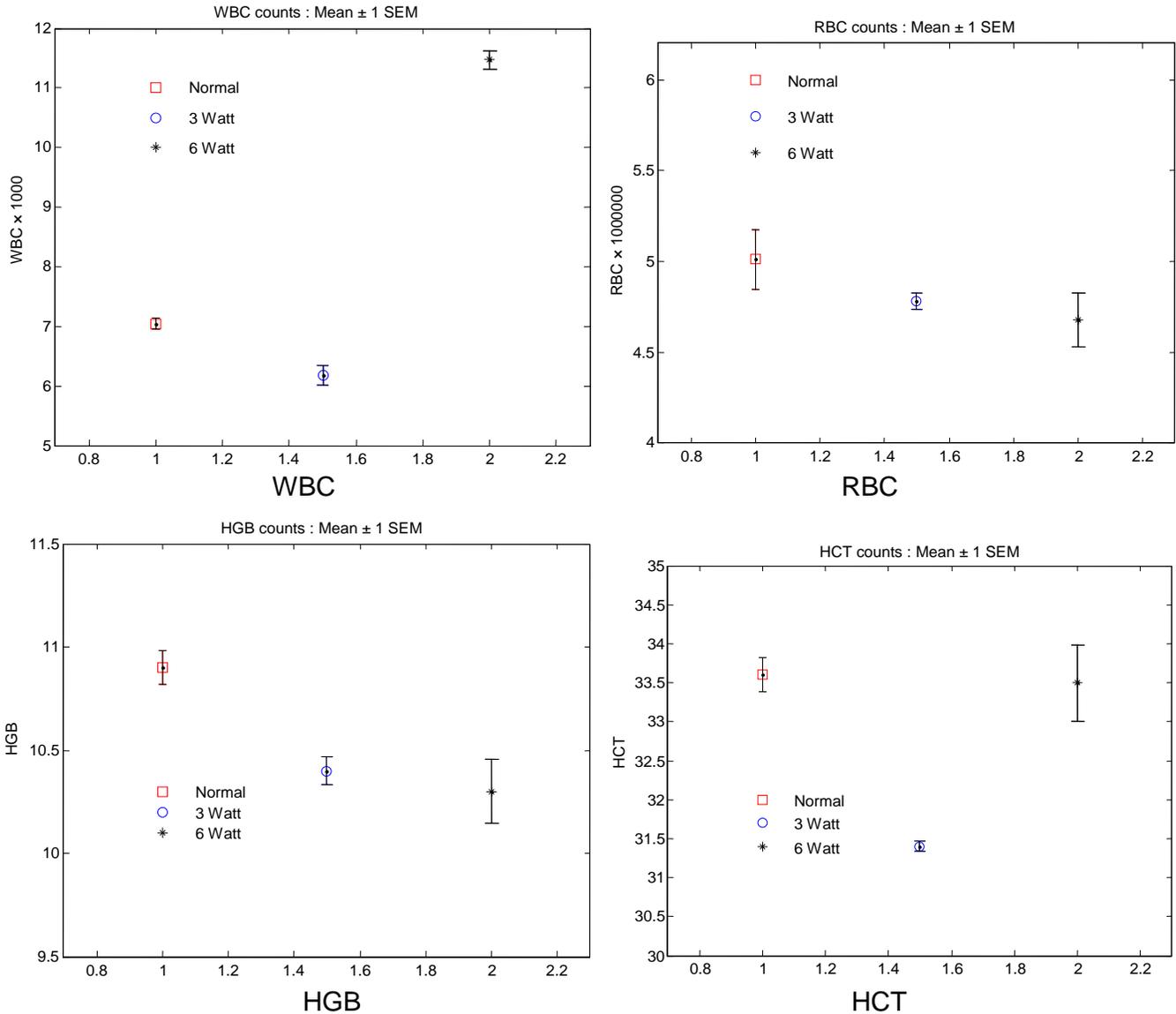


Figure 2. The level of WBC, RBC, HGB and HCT in normal (control), 3 and 6 W groups.

of lymphocytes in the 6 W group in the present research may be attributed to direct non-ionizing or genotoxic effects of EMF which was studied by some authors (Zotti et al., 2005); as such, they were not determined in our study. Also, the micronucleous (MN) assay and chromosomal studies or production of heat shock proteins suggested by others (Lim et al, 2005) were not designed in our survey. An important finding of this study is the impact of 950 MHz cell phone radiation on platelet counts which interestingly decreased in 3 W exposed group, but increased in 6 W exposed group. To the best of our knowledge, there are few authors dealing with this issue of 950 MHz EMF exposure. Results of this study suggest that the two main groups of blood cells which are leukocytes and thrombocytes are disturbed as a result of

mobile phone EMF exposure. So, it is possible that this kind of electromagnetic field could affect constant cell counts of peripheral blood. Signals transmitted by a mobile phone, even if it is a hands-free, will reach all parts of the body including bone marrow, lymphoid organs and circulatory system. Due to shorter survival time of leukocytes and platelets in the circulation, it is suggested that WBC and PLT counts are affected more easily than RBC count; although, the duration of exposure to EMF (2 weeks) plays a role in the present study. For better evaluations, it is suggested that a survey should still be done on bone marrow of the affected animals. Gorlitz et al. (2005) showed that radiofrequency (RF) field after 1 week exposure had no influence on the formation of red blood cells and their

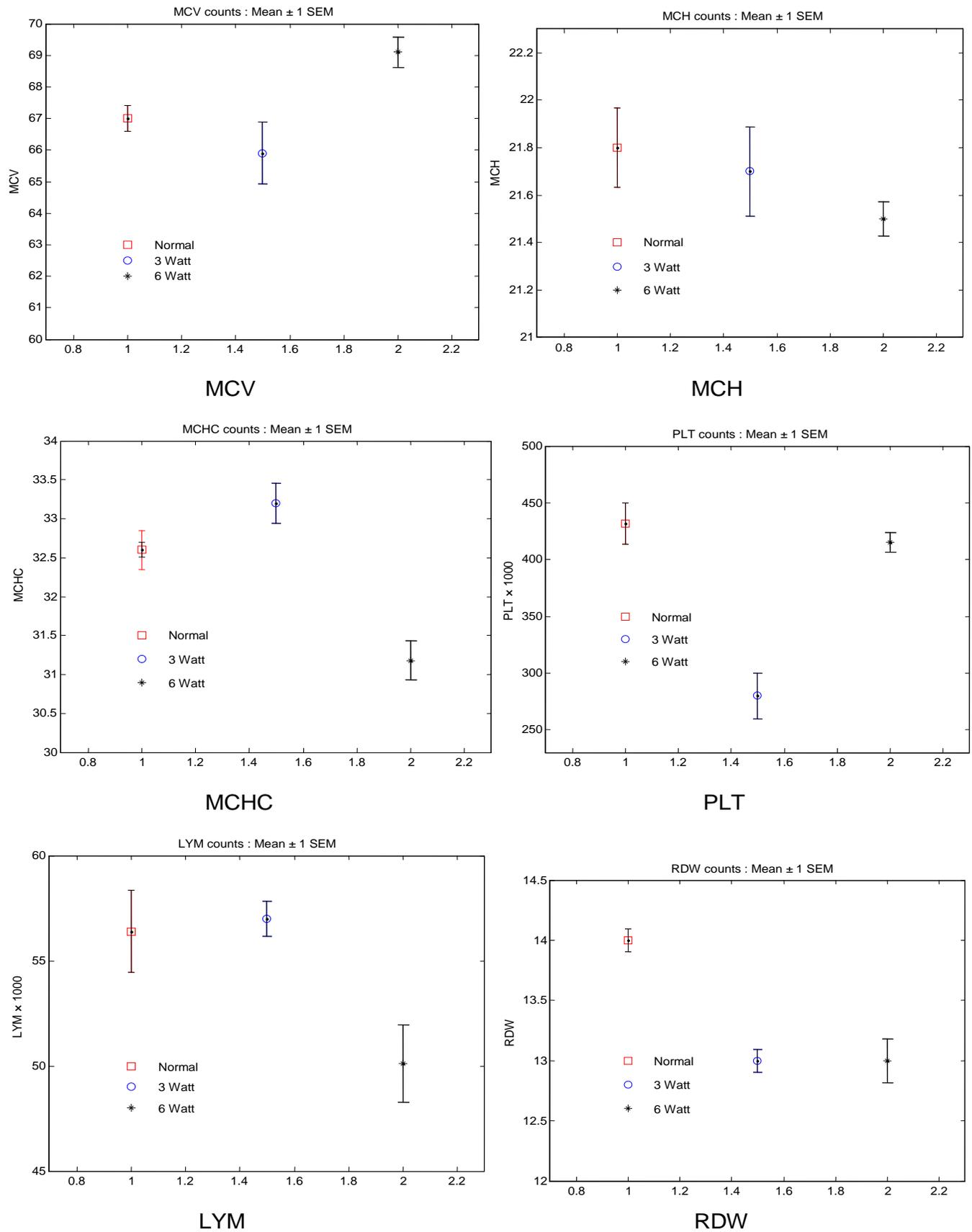


Figure 3. The level of MCV, MCH, MCHC, PLT, LYM and RDW in normal (control), 3 and 6 W groups.

precursors at bone marrow in mice. But Juutilainen et al. (2007), working on micronucleus formation (as an index of genotoxic effects) on precursors of erythrocytes after long term (1 year) exposure did not show any effect of RF fields in mice. In conclusions, it is difficult to compare the results of our investigation with investigations conducted by others. The reasons are differences between animal species and strains, differences between conditions of exposure and differences between biological parameters selected for investigation.

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