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RESEARCH ARTICLE

Measurement of Heart Rate Variation owing to the Effect of EMF Waves

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ABSTRACT

Tiny electrical current exists in the human body due to the chemical reactions that occur as part of the normal bodily functions, even in the absence of external electric fields so that exposure of external radiation causes high impact to the nerves relaying signals by transmitting electric impulses. The heart is electrically active and its actions are measured using an electrocardiogram. Even a slight variation in heart rate may cause serious effects on the human body. Low-frequency electric fields influence the human body just as they influence any other material made up of charged particles. When electric fields act on conductive materials, they influence the distribution of electric charges at their surface. Low-frequency magnetic fields induce circulating currents within the human body. The strength of these currents depends on the intensity of the external magnetic field. Due to the invention of information technology, the communication devices are more in use resulting in overall emission of radioactive waves affecting heart rate. It depends on Specific Absorption Rate (SAR) which is the measure of the rate at which energy is absorbed by the human body when exposed to radio frequency (RF) electromagnetic field. Heart rate variability is measured by ECG and the results are analysed.

Keywords: Information technology, Radioactive waves, Magnetic field, SAR, Heart rate variation, ECG.

1. INTRODUCTION

Besides natural sources of electromagnetic spectrum, there are also fields generated by human-made sources. The electricity that comes out of every power socket has low frequency electromagnetic fields. Higher frequency radio waves are used to transmit information via TV antennas, radio stations or mobile phone base stations. Modern mobile phones emit electromagnetic fields ranging from 900 to 2000 MHz which are suggested to have an influence on well-being, attention and neurological parameters in mobile phone users. EMF of different frequencies interacts with the body in different ways. Radio frequencies are the natural consequence of wireless and electronic devices which are associated with broadcasting media, such as radio and television. Anything that has an antenna emits radio waves and this includes wireless handsets. The prolonged use of such cellular devices affects the overall health of the human body due the high dose radiation evolving from such electronic devices, causing stress to the cardiac system. The effects can be analysed by using electrocardiogram (ECG) which shows the variability of heart rate. When subjected to electromagnetic radiation, if the heart rate varies to a high degree, it is assumed that heart is in stressed condition. If the result is not analysed properly or in the case of casual negligence, this stress affecting heart may damage the heart muscles leading to cardiac arrest. Based on investigations, it is stated that the one who use mobile phones frequently gets tiredness, depression, fatigue and head ache often than the one who use them rarely. Hence it is recommended to limit frequent use of handsets. Systematic laboratory studies reveal that exposure to electromagnetic radiation affects the internal organs like heart and brain cells directly or indirectly. Such effects may not be noticed in a shorter interval of time. It may even cause side effects in most cases. Adverse effects on exposure to low level radio frequency fields have not been discovered.

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Environmental exposure to man-made electromagnetic fields has been steadily increasing because of high electricity demand and technological growth. Changes in social behaviour have created more artificial sources. Almost all human beings are exposed to a complex mix of weak electric and magnetic fields, both at home and at work. Studies are performed on the amount of radiation absorbed by the body and the corresponding analyses are made.

2. LITERATURE SURVEY

[1] The tissue mass and time period over which the SAR values are to be averaged and the applicable frequency bands for the maximum permissible exposures are determined. The process must be aimed towards improvement beyond the current state affairs through better precision in SAR specification, less uncertainty in exposure assessment, more accurate biological results and greater reliability in health status. Advances in bio-electromagnetic, electronic, computer and wireless technology research continue to facilitate this process. [2] The setting of standards for maximum permissible levels of exposure to RF and microwave radiation is a valid approach in managing the risk of such exposures. The existing standards are based on the results obtained from acute, short-term studies that are similar to the RF exposures associated with the handset of cellular mobile telephones. [3] Low level electromagnetic waves produce a biological effect that is not harmful. But in case of high intensity waves, these effects may be harmful as it produces burns, cataracts, chemical changes, head ache and cardiac problems. Exposure to certain radio frequency waves is useful in the medical field as it acts as a remedy for some types of illness. [4] Exposure of radio-frequency electromagnetic fields prior to sleep reduces heart rate during waking state. Its effect is similar to the waves emitted by cellular phone handsets affecting brain physiology. [5] A number of studies have been featured using techniques of electroencephalography and positron emission tomography to investigate electromagnetic field effects upon human physiology. The sensitivity of various physiological effects and performance measures in the study of biological effects of electromagnetic fields are observed. [6] The effects investigated in Global System for Mobile Communications (GSM)-EMF and Universal Mobile Telecommunications System (UMTS)-EMF are tested. Significant changes in the measured parameters are not produced when compared to sham exposure which is the control group used to simulate the environmental conditions of exposed samples in the absence of exposure. [7] The effect of EMF and sham control exposure was investigated on waking regional cerebral blood flow. Pulse modulated EMF exposure enhanced EEG power in the alpha frequency range prior to sleep onset. Exposure to EMF without pulse modulation did not enhance power in the waking or sleep EEG. This provides a non-invasive method for modifying brain functions in experimental, diagnostic and therapeutic purposes. [8] The study reviews that owing to the cell phone technology which works on electromagnetic radiation, its radiation causes severe and long lasting loss to human health when absorbed by the biological matter of the body due to its frequent exposure. The symptoms may not be noticed all of a sudden. [9] One of the most reliable effects observed in these studies is the increase of EEG power during sleep due to the exposure of pulse-modulated Radio Frequency Electromagnetic Fields (RF EMF) which alters brain activity in the sleep spindle frequency range. [10] Experimental research is conducted among volunteers with mobile phone and sham exposure in which cardiac regulatory mechanism in different Autonomic Nervous Systems (ANS) are assessed. The analysis of the data shows that there was no statistically significant effect due to EMF exposure in case of shorter duration. [11] The main observed health adverse effects have been related either to the induction of electric currents in the body which induce nerve stimulation or to the temperature increase leading to heat stress. Metallic devices are well known to strongly interact with EMF by diffraction leading to a significant local enhancement of field intensity. One of the safety aspects of EMF that should be assessed was the coupling with active and passive metallic implant in the human body as a significant part of the population bears metallic devices including orthopaedic plates, rods, screws, prosthesis, dental implants, stents, electrode wires or electronic devices. [12, 13] The preliminary results show that EMF exposure differently modifies different cell types. The low frequency electromagnetic fields are produced

by electrical devices, high tension electrical distribution networks, residential and occupational sources and power lines. Low-frequency electric fields influence all systems characterized by charged particles as the human body gets affected by these waves. Harmful effects of EMF exposure on living tissue depend primarily on the frequency and density of the field and the duration of radiation exposure on the human body. Further risk factors are the functional state and the sensibility of the exposed organism. The abnormality of the irradiated parts and the distance from the radiation source must be considered. The magnitude of the EMF to which it is regularly exposed has been implicated as a contributory factor to health issues.

3. A STUDY OF HEART AND ECG

The heart is a muscular organ which pumps blood through the network of arteries and veins. It has four chambers.

[1] The right atrium receives blood from the veins and pumps it to the right ventricle.

[2] The right ventricle receives blood from the right atrium and pumps it to the lungs, where it is loaded with oxygen.

[3] The left atrium receives oxygenated blood from the lungs and pumps it to the left ventricle.

[4] The left ventricle pumps oxygen-rich blood to the rest of the body. The contraction of left ventricle creates blood pressure.

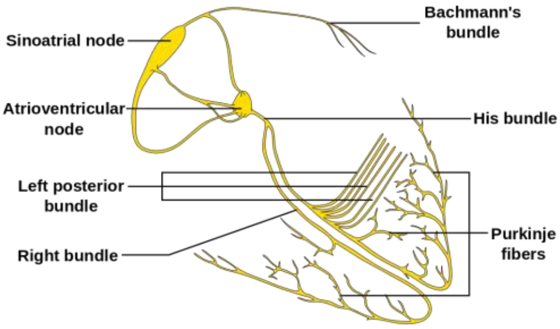

Figure 1.The process of rhythmic contraction of heart

An ECG can be used to measure the rate and rhythm of heartbeats and the size and position of the heart chambers. The conduction system of the heart is given in figure 1. The presence of any disorders in the heart muscle cells or the conduction system, the effect of cardiac drugs and the function of implanted pacemakers are also analysed by ECG.

3.1. Other patient monitoring methods

Electroencephalography (EEG) is the method used to record the electrical activity of the brain. It is typically non-invasive in which the electrodes are placed over the scalp. When the wave of ions reaches the electrodes on the scalp, they can push or pull electrons on the metal in the electrodes. Hence the difference in push or pull voltages between any two electrodes can be measured as EEG.

An electromyogram (EMG) measures the electrical activity of muscles at rest and during contraction by placing small electrodes to the skin or around the fingers. It is used to find diseases that damage the muscle tissue, nerves or the junctions between nerve and muscle.

Electroretinography (ERG) is an eye test used to detect abnormal function of the retina. During the test, an electrode is placed in front of the eye to measure the electrical responses of the cells that sense light in the retina at the back of the eye.

Electrooculography (EOG) is the recording of the difference in electrical charges between the front and back of the eye that is correlated with the eyeball movement. It is obtained by the electrodes placed on the skin near to the eye.

An electrogastrogram (EGG) is similar to an electrocardiogram of the heart. It carries out the recording of the electrical signals that travel through the muscles of the stomach and control the contraction of muscles.

3.2. Theory of electrocardiography

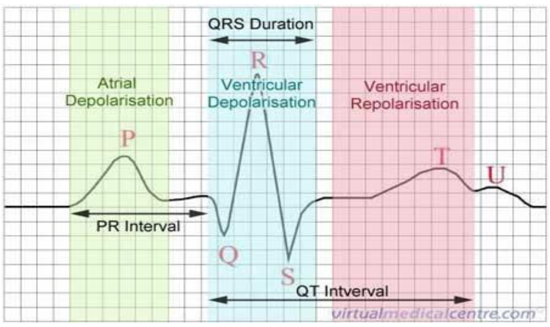

Figure 2.Representation of normal ECG

QRS wave (figure 2) is upright in a lead when the axis is aligned with its lead vector. The overall direction of depolarization and repolarization produces a vector that produces positive or negative deflection in the ECG. Normal rhythm produces four entities namely P wave, QRS complex, T wave and U wave where,

P wave represents atrial depolarization, QRS complex represents ventricular depolarization, T wave represents ventricular repolarization and U wave represents papillary muscle repolarization.

3.3. Resting and action potential

Certain types of cells such as nerve and muscle cells lie in a semi permeable membrane that permits some substances to pass though the membrane.

The action potential concept is represented in figure B1. Cells are surrounded by body fluids. These fluids are conductive solutions containing charged atoms known as ions such as sodium (Na^+), potassium (K^+) and chlorine (Cl^-). The membrane of excitable cells readily permits the entry of potassium and Cl^- ions but effectively blocks the entry of Na^+ ions. This membrane potential is called the resting potential of the cell which is normally negative. A cell in the resting state is said to be polarized. When a section of the cell membrane is excited by the flow of ionic current, the membrane changes its characteristics and begins to allow some of the Na^+ ions to enter. This movement of Na^+ ions into the cell constitutes an ionic current flow. As a result, the cell has a slightly positive potential internally due to the imbalance of K^+ ions. This K^+ is known as the action potential and is approximately +20mV. A cell that has been excited and that displays an action potential is said to be depolarized. The process of changing from the resting state to the action potential is called depolarization. By an active process called Na pump, the Na^+ ions are quickly transported outwards the cell and the cell gets polarized again. It assumes the resting potential and the process is called repolarization. It begins at resting potential, depolarises and returns to resting potential after depolarization.

4. METHODOLOGIES

Cardiart ECG machine 108T Digi and silver chloride electrodes were used to conduct the experiments on different phone modes. Five Iraqi students were subjected to the experiment and their ECG under normal and vibration + ring modes were recorded for further analysis. Four limb electrodes on both hands and legs and one suction cup electrode on the chest were used to perform this demonstration.

4.1. Silver chloride electrodes

Silver/silver chloride electrodes are used in bio-monitoring sensors as a part of electrocardiography (ECG) to deliver current. Most bio-monitoring electrodes are silver/silver chloride sensors which are fabricated by coating a thin layer of silver on plastic substrates and the outer layer of silver is converted to silver chloride. The operation principle is the conversion of ion current at the surface of human tissues to electron current which is delivered through the lead wire to the reading instrument. Electrolyte gel is applied between the electrode and tissues which contains free chloride ions such that the charge can be carried through the electrolyte. Therefore the electrolyte can be considered as a conductive medium between the electrode and the human tissues. The reaction allows passing of current from the electrolyte to electrode which in-turn is passed to the lead wire and finally to the display unit.

Effect of mobile waves affecting human heart is studied (microwaves in the range of 108 to 1010 GHz). The analysis is based on the following diagram.

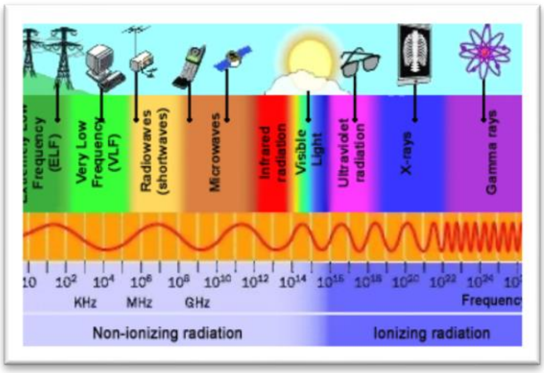

Figure 3.Microwave range

The microwave spectrum in figure 3 is usually defined as an electromagnetic energy ranging from approximately 1 GHz to 100 GHz in frequency. Most common applications are within the 1 to 40 GHz range. Ionizing radiation carries enough energy to free electrons from atoms or molecules where as non-ionizing radiation refers to any type of electromagnetic radiation that does not carry photon energy to ionize atoms or molecules. Ionizing radiation can be a health hazard.

Gamma rays, X-rays and higher ultraviolet rays are ionizing, whereas the lower ultraviolet rays and the lower part of the spectrum below UV are non-ionizing radiations.

4.2 Cellular phone stress

Subject's blood pressure is checked to ensure whether the subject is in normal condition. As per the criteria, subject is chosen and the required pulses are recorded over both hands and legs. Then, ECG jelly is applied while placing the limb electrodes on the hands and legs. One suction cup electrode is placed on the chest near the SA node of the heart. Finally, ECG of the object under normal condition is taken and thereby the waveforms are analysed.

5. RESULT ANALYSIS

The normal ECG of an Iraqi student is given in figure B2. For the analysis, the ECGs of five Iraqi male students, aged between 20 and 30 are recorded by using 3 lead ECG as shown in figure 4.

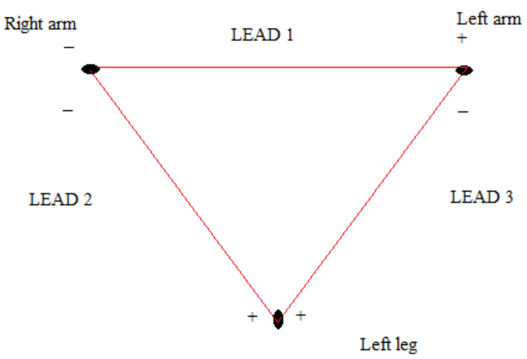

Figure 4.Lead ECG

The 3 lead ECG is the most commonly used ECG in continuous monitoring of the person with any cardiac problem. It is simple to use and capable of picking up the specific electrical rhythm of the heart without interference.

Table A1 shows the ECG value of five Iraqi students. The heart rate (bpm) of Mahmood, Ali Iran, Ashraf, Dyyah and Fahad under normal condition of phone are 60, 59.8, 60, 84, 60 respectively and the average bpm for the above readings is 64.76

In vibration + ring condition, the heart rate readings of Mahmood, Ali Iran, Ashraf, Dyyah and Fahad are found to be 66, 66.6, 59.13, 86 and 60 respectively. The average bpm for the above results is 67.34

The variation in bpm average is found out. Heart rate reading in normal and vibration + ring condition is tabulated in table A2. Heart rate changes considerably in the normal mode due to the maximum utilization of EMF radiation which are very harmful to the heart whereas a part of the signal is utilised for vibration and ringtone in vibration + ring condition.

6. CONCLUSION AND FUTURE ENHANCEMENT

The difference in variation of heart rate readings in Iraqi students in normal and vibration + ring mode is recorded and analysed. Heart rate (bpm) is calculated from the measures of PR, QT, ST and QRS interval by using three leads. One way to manage stress is to avoid frequent use of cellular phones and thereby reduce the exposure of electromagnetic waves. It is encouraged to switch off these devices emitting electromagnetic waves when not in use. By doing so, EMF radiation exposure to the body is prevented to a certain time limit. Cellular phones with low specific absorption rate are considered for better use. Text messages to voice calls are preferred in which the exposure of EMF waves to brain cells are reduced. In future, techniques may emerge so as to reduce the emission of EMF waves from mobile phones or to introduce any filtering methods to limit such waves. For the protection of general population and workers, safety standards, recommendations and guidelines for exposure to radio frequency and microwave energy have been developed by a number of international and national organizations.

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APPENDIX A

Table A1.ECG readings in both normal and vibration phone modes

Iraqi Students		Mahmood	Ali Iran	Ashraf	Dyyah	Fahad
Normal mode	P	0.062	0.08	0.08	0.10	0.06
	PR	0.18	0.16	0.16	0.12	0.18
	QT	0.29	0.29	0.34	0.36	0.28
	ST	0.32	0.226	0.27	0.34	0.32
	QRS	0.076	0.12	0.08	0.08	0.08
	RR	25.92	25.06	25	17.73	26.1
	bpm	60	59.8	60	84	60
Vibration mode	P	0.062	0.10	0.08	0.75	0.06
	PR	0.16	0.16	0.16	0.12	0.16
	QT	0.35	0.38	0.36	0.36	0.32
	ST	0.32	0.32	0.32	0.28	0.2
	QRS	0.08	.086	0.08	0.08	0.07
	RR	22.66	22.50	25.8	17.4	25
	bpm	66	66.6	58.13	86	60

Table A2.Heart rate readings in normal and vibration mode

Factor	Mahmood		Ali Iran		Ashraf		Dyyah		Fahad	
	NM	VM	NM	VM	NM	VM	NM	VM	NM	VM
HR	60	66	59.8	66.6	60	58.13	84	86	60	60
Avg HR	64.76	67.34	64.76	67.34	64.76	67.34	64.76	67.34	64.76	67.34
HR-Avg HR (x)	-4.76	-1.34	-4.96	-0.74	-4.76	9.21	19.24	18.66	-4.76	-7.34
x^2	22.65	1.79	24.6	0.54	22.65	84.82	370	348	22.65	53.87
Delta	2.37	0.66	2.47	0.36	2.37	4.60	9.61	9.32	2.37	3.66

NM=Normal Mode, VM=Vibration Mode, HR=Heart Rate, Avg=Average

APPENDIX B

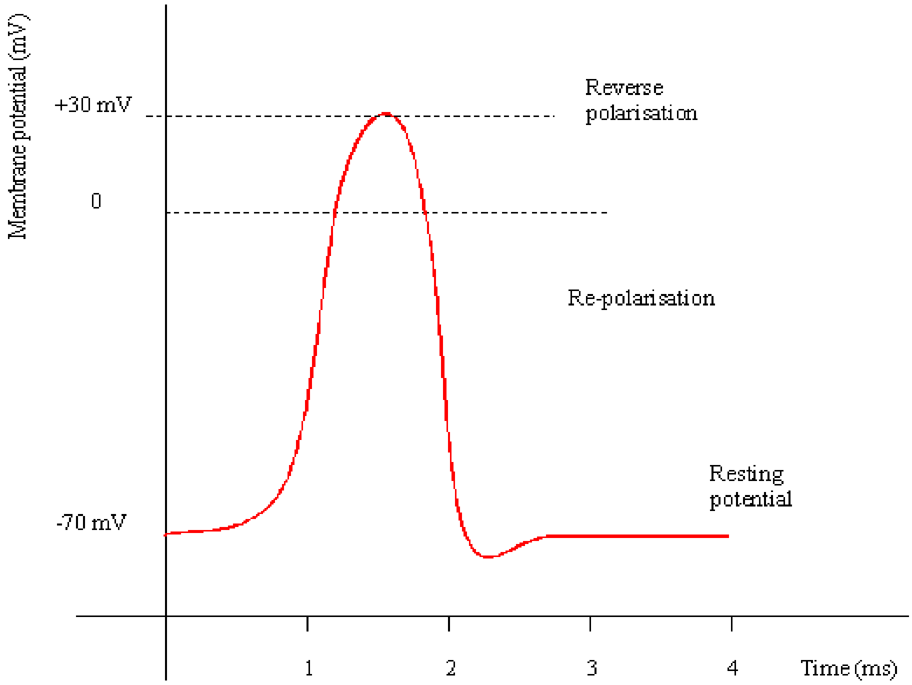

Figure B1.Waveform of action potential

Figure B2.Normal ECG of an Iraqi student