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Effect of Electromagnetic Waves Emitted from Mobile Phone on Nerve Conduction Velocity of Median Nerve in Adult Males

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ABSTRACT

Wireless technologies are ubiquitous today and the MP are one of the prodigious output of this technology. Although the familiarization and dependency of MP is growing at an alarming pace, the biological effects due to the exposure of radiations have become a subject of intense debate. EMW may affect the nerve conduction velocity (NCV) by affecting the permeability and conductance of a nerve axon membrane or myelin sheath or both. So present study was to see the acute effects of electromagnetic radiation (EMR) emitted from MP on NCV of median nerve in adult males, in upper limb used to hold the MP before and after exposure to MP. NCV was recorded on RMS EMG EP MK 2 machine in resting condition and again recorded after 10 minutes of exposure to MP (GSM type, Samsung model E 2232). Statistical analysis was done using paired "t" test. There was statistically significant decrease ($p < 0.01$) sensory component and ($p < 0.001$) motor component in conduction velocity of median nerve in upper limb used to hold the MP. So conclusion was that EMW emitted from MP affects the conduction velocity of median nerve in upper limb used to hold the MP.

Keywords: Electromagnetic radiation, Mobile phone, Nerve conduction velocity, Median nerve

INTRODUCTION

Extremely low frequency electromagnetic waves (EMW) are widely employed in electrical appliances such as television sets, microwaves, computers and mobile phones (MP). MP are now an essential part of business, commerce, and communication. India stands second with over 900 million users in the world. MP transmit and receive waves of frequency mainly at 800-1800 MHz.[1-4] Effect of electromagnetic radiation (EMR) emitted from MP have been demonstrated on cognitive funution, immune system, cardiovascular system, reproductive system and the endocrine system. MP conversation decreases the ability to concentrate and impairs the attention necessary to perform complex activities, affects visual evoked potential and electroencephalogram(EEG). Since there is tremendous electrical activity in neuronal processes, the nervous system has been thought to be most sensitive to EMR. Recently it is reported that low dose of microwave radiation affect stress proteins and neurons in brain (Salford et al) 2003. Information processing and transmission in nervous system is based on bioelectromagnetic phenomena but effect of EMR on peripheral nervous system is very scanty and there is controversy in few reports that are available.[5-10] Therefore, it is planned to study the effect of electromagnetic radiation emitted from MP on conduction velocity in median nerve of upper limb in which MP is held in MP users in adult males.

MATERIAL AND METHODS

Nerve conduction study was conducted in the department of Physiology, Pt. B. D. Sharma PGIMS Rohtak, in 30 healthy male subjects in the age groups between 18-40 years, who were using the MP for a minimum period of thirty minutes/ day at least for the last 5 years. Subjects who were having the symptoms of abnormal sensations, numbness, systemic illness like diabetes mellitus, hypertension, history of fracture in upper limbs, injury to nerves and history of drug administration for the past one month were excluded from the study. Subjects were explained about the procedure and written consent was taken from each subject. The basic parameters like height, weight, heart rate, blood pressure and respiratory rate were recorded prior to the exposure. Conduction velocity of median nerve of upper limb used to hold the MP, was recorded in resting conditions before exposure to the MP. Subjects were exposed to electromagnetic radiations emitted from MP (GSM type, Samsung model E2232 having SAR value

0.702 W/Kg) for a period of ten minutes. Conduction velocity of median nerve of upper limb and basic parameters were again recorded after the exposure.

The recordings were done by using RMS EMG EP MK2. Settings were set at sensitivity 2-5 mV/mm, low frequency filter 2-5Hz, high frequency filter 10 KHz and sweep speed was at 2-5 ms/mm.

Median motor nerve conduction velocity was recorded by placing active electrode over the abductor pollicis brevis and reference electrode was placed over the proximal phalanx of the thumb. Ground electrode was placed over the dorsum of the hand. The site of stimulation was at the wrist between the Palmaris longus & flexor carpi radialis tendons at the second crease and at the elbow crease, medial to the biceps tendon & brachial artery.

For sensory conduction velocity in median nerve settings were set at sensitivity 10-20 µV/mm, low frequency filter 5-10 Hz, high frequency filter 2-3 KHz and sweep speed was at 1-2 ms/mm. Active electrode was placed at proximal interphalangeal joint of 2^{nd} digit. Reference electrode was placed at the distal phalanx of 2^{nd} digit. Ground electrode was placed over the dorsum of the hand. The site of stimulation was at the wrist between the palmaris longus and flexor carpi radialis tendon at the 2^{nd} distal-most crease. Supramaximal stimulation was used using a square pulse wave of 0.1 ms duration. Distance between two points of stimulation was measured with a tape and expressed in m/sec.

Statistical analysis

NCS in sensory and motor component of median nerve were recorded and compared before and after exposure to MP. At the end of the study, data was compiled and statistically analyzed by SPSS 10 version using paired ‘t’ test. P value was taken as significant if found to be less than 0.05.

RESULTS

Present study was conducted on 30 healthy male subjects having age 18-40 (mean 26.97 years), height from 160-180 (mean 166.83 ± 5 cm), weight varies from 42-87 (mean 62.9 ± 10.01 kg). There was statistically significant increase in latency (p<0.01) and decrease in sensory conduction velocity (p<0.01) in median nerve after exposure to MP for 10 minutes (Table 1, Fig. 1).

Table 1: Comparison of Nerve Conduction Study in Median Nerve (sensory component) before and after exposure to MP.

Parameters	Before Exposure (mean ± SD)	After Exposure (mean ± SD)	p value
Latency(ms)	2.3033±0.25	2.3750±0.27	**<0.01**
Amplitude (µV)	96.6800±43.71	82.1200±35.38	**<0.05**
Conduction velocity(m/s)	53.6003±4.61	52.1283±4.56	**<0.01**

P value <0.05 significant
<0.01 highly significant

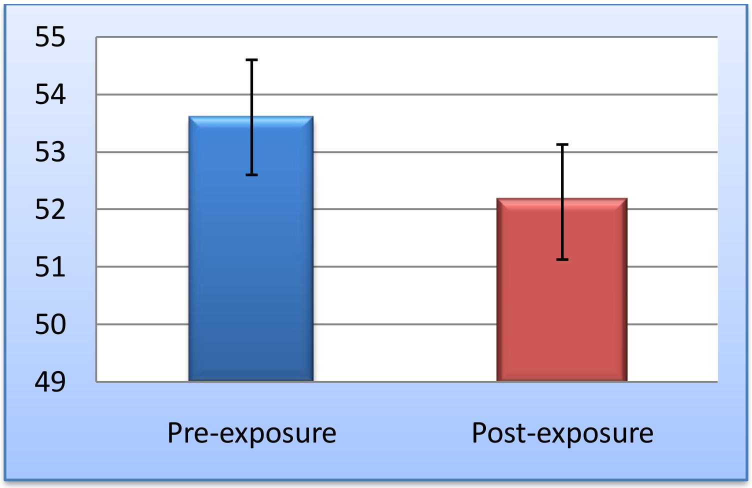

Fig.1: Comparison of conduction velocity of sensory nerve fibers in median nerve before and after exposure to MP (mean ± SD)

On comparison of motor nerve conduction velocity latency increases ($p<0.001$) and decrease in conduction velocity ($p<0.001$) significantly in post vs pre-exposure to EMR emitted from MP. There was no statistically significant effect on amplitude of wave (Table-2, Fig.2).

Table 2: Comparison of Nerve Conduction Study of Motor Nerve Conduction in Median Nerve before and after exposure to MP.

Parameters	Before Exposure (mean ± SD)	After Exposure (mean ± SD)	p value
Latency (ms)	4.0903±0.33	4.1737±0.33	**<0.001**
Amplitude (mV)	13.6233±5.85	13.9733±6.52	**>0.05**
Conduction velocity (m/s)	56.081±3.40	54.873±3.25	**<0.001**

P value <0.001 highly significant

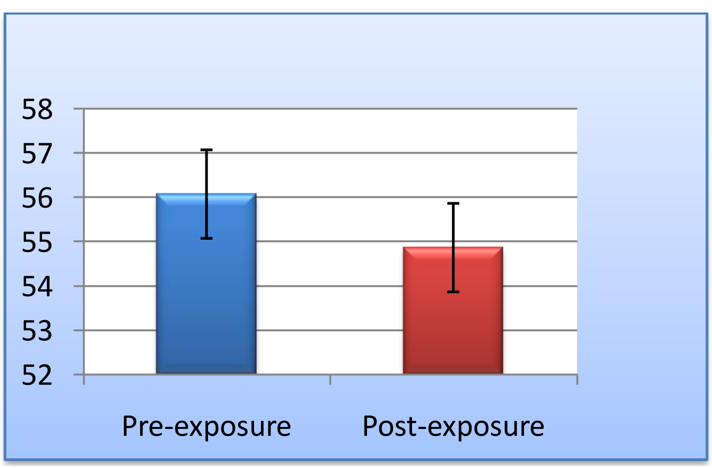

Fig.2: Comparison of conduction velocity of motor nerve fibers in median nerve before and after exposure to MP (mean ± SD)

DISCUSSION

Nerve conduction study is a part of electro diagnostic procedures that help in establishing the type and extent of the abnormality of nerves. The conduction velocity of the nerve depends on the fiber diameter, degree of myelination and the internodal distance. Onset latency is a measure of conduction in the fastest conducting motor fibers, the amplitude correlates with the density of nerve fibers.[11-12]

EMW of microwave range has been reported to alter central and peripheral nervous system structure. Structural modifications in both neurons and glia have been described. Short-duration (less than 1 hour) single exposure to continuous wave EMW at power densities from 20- 100 m^w/cm^2 and wavelengths of about 10 cm alter neuronal structure. Fragmentation and increased argyrophilia of cutaneous sensory nerve fibers have been detected after exposure to microwaves of millimeter wavelength. Long-term (minimum of 1 month) repeated exposure to continuous wave EMR at a power density of 10 m^w/cm^2 and a wavelength of about 10 cm has also been reported to alter neuronal structure.[13] Hamada et al (2011) discussed the mechanisms of MP operation and explained that the sound waves produced from the speaker go through a transmitter that converts the sound into a sine wave.

This sine wave then travels to the antenna, which then projects the wave out into space.[14] Redmayne and Johansson (2014) demonstrated that myelin integrity is vital to healthy nervous system development and functioning.[15] EMW can affect the permeability and conductance of a nerve axon membrane or fiber myelin sheath or both. Changes in membrane permeability and through that in rest potential of active membrane affect nerve conduction velocity.[10] Increase in latency period in sensory and motor components of median nerve could be because of increase in sodium current and increase in threshold voltage. The changes in current and potential have approximately the same sensitivity to the changes in the rest potential. Therefore, the possible effect of EMW on rest potential is not obligatory followed by changes in latency period, if the changes in sodium current and threshold potential do not balance their effects, it could cause changes in latency period.[16] Decrease in conduction velocity in sensory and motor components of median nerve could possibly be because of increase in rest potential through increase in sodium current and threshold voltage.

The changes in current and potential have approximately the same sensitivity to the changes in the rest potential. Therefore, the possible effect of EMW on rest potential is not obligatory followed by changes in conduction velocity but the occurred changes in sodium current and threshold voltage if do not balance each other, there may be changes in NCV.[10] There are surprisingly little data available in each area, but considered together a picture begins to emerge in EMW exposed cases that there are significant morphological lesions in the myelin sheath of rats and effects in the proteins related to myelin production.[15]

The role of EMW on myelin impedance is possibly negative means EMW decreases the myelin impedance[17] thus decrease in conduction velocity. It is reported that EMW cause increased production of ROS such as superoxide anion, hydroxyl radical and hydrogen peroxide[17] and decrease in melatonin concentration. ROS are neutralized by melatonin and it is found that melatonin concentration is decreased on exposure to EMW so the protective effect of melatonin against ROS decreases.[18] Increased ROS could affect the myelin sheath[15] and we know that myelin integrity is very essential for proper functioning of nervous system. Other possible mechanism responsible for decrease in conduction velocity may be gross reduction in internodal distance due to regeneration phase to axonal neuropathy.[16]

Contrary to our result, Hinrikus et al (2005) showed that there was not significant change in nerve conduction velocity in post exposure conditions. However their result was opposite to their preliminary study where they observed relatively small (about 4%) statistically significant increase in conduction velocity following exposure to low-level microwave radiation.[10]

Our findings of increase in latency period and decrease in conduction velocity are in corroboration with Coskun et al (2012) who demonstrated increase in latency period and decrease in conduction velocity in median nerve following exposure to electromagnetic field.[16] Our earlier study performed on ulnar nerve also demonstrated that there is increase in latent period and decrease in conduction velocity in ulnar nerve after exposure to mobile phone in the limb used to hold the MP.[19] So it is advisable to wisely use the MP for the minimum duration and as hand free especially when engaged in long talks to avoid adverse effects of EMR emitted from MP.

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