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Effect of Mobile Phone Radiofrequency Electromagnetic Fields on Cardiovascular Parameters in Apparently Healthy Individuals

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Summary: Since cell phones emit radiofrequency electromagnetic fields (EMFs), this study tested the hypothesis that cell phones placed near the heart may interfere with the electrical rhythm of the heart or affect the blood pressure. Following informed consent, eighteen randomly selected apparently healthy male volunteers aged 21.44 ± 0.53 years had their blood pressure, pulse rates and ECG measured before and after acute exposure to a cell phone. The ECG parameters obtained were: heart rate (HR), QRS complex duration (QRS), PR interval (PR) and Corrected QT interval (QTc). Results are presented as mean ± SEM. Statistical analyses were done using two-tailed paired t test for blood pressure and pulse rate data and one way ANOVA with a post hoc Tukey test for the ECG data. $P<0.05$ was considered statistically significant. The blood pressure and pulse rates before and after exposure to the cell phone showed no significant difference. The ECG parameters (HR: beats/min, QRS:ms, PR:ms and QTc respectively) did not differ before (66.33 ± 2.50, 91.78 ± 1.36, 151.67 ± 5.39 and 395.44 ± 4.96), during (66.33 ± 2.40, 91.11 ± 1.61, 153.67 ± 5.06 and 394.33 ± 4.05) and after calls (67.22 ± 2.77, 91.11 ± 1.67, 157.44 ± 4.46 and 396.56 ± 4.93) compared to baseline (67.17 ± 2.19, 94.33 ± 1.57, 150.56 ± 4.93 and 399.56 ± 3.88). These results suggest that acute exposure to EMFs from cell phones placed near the heart may not interfere with the electrical activity of the heart or blood pressure in healthy individuals.

Keywords*:* Cell phone radio waves, Blood pressure, Electrocardiogramme.

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INTRODUCTION

There is a tremendous increase in the number of base stations and use of cell phones worldwide including developing African nations such as Nigeria. These base stations and cell phones emit radiofrequency electromagnetic fields (EMFs) and there are concerns about possible adverse effects on health. Recent studies in Nigeria (Ibitoye and Aweda, 2011) and Ghana (Deatanyah et al., 2012) suggest that EMFs emitted from base stations in the areas studied fall within the internationally recommended levels and may not, therefore, be harmful. However, there are still concerns that EMFs from mobile phones may interfere with body physiologic function. Evidence suggests, for instance, that EMFs may interfere with artificial cardiac pacemaker function (Censi et al., 2007). The brain may also get exposed to EMFs emitted from cell phones resulting in some minor alterations in function since cell phones are held to the ear close to the head during calls (van Rongen et al., 2009). A recent report suggested that short-term exposure to cell phone EMFs resulted in DNA single-strand breaks in hair root cells obtained from around the ear that was used for the phone call (Cam and Seyhan, 2012). The latter studies (van Rongen et al., 2009; Cam and Seyhan, 2012) suggest that proximity to EMFs from cell phones may not be as innocuous as generally believed.

In Nigeria, and probably other countries as well, men tend to keep their cell phones in the breast pocket close to the heart resulting in exposure to EMFs and probable untoward effects on the heart. However there are few studies that have examined this. Indeed to our knowledge only two studies (Barker et al., 2007; Barutcu et al., 2011) have examined the possible interference of EMFs from mobile phones on autonomic modulation of the heart. They assessed cardiac autonomic function by analysing heart rate variability (HRV) parameters (Barker et al., 2007; Barutcu et al., 2011). In the current study we tested the hypothesis that exposure to EMFs from cell phones placed close to the heart may interfere with the electrical rhythm of the heart and blood pressure. We did this by measuring the electrocardiogram (ECG) before, during and after exposure to a cell phone. In addition, we examined the effect of acute exposure to cell phone EMFs on blood pressure as a previous report suggested an

increase in blood pressure following exposure to EMFs from cell phones (Braune et al., 1998).

MATERIALS AND METHODS

This study involved eighteen randomly selected apparently healthy male volunteers. Their ages were recorded and their height (without shoes) and weight (with minimal clothing) were measured using an adult weight and height scale. Their body mass index (BMI) was calculated as weight (kg)/ height $(m)^2$. Following informed consent, they had 12-lead ECG performed on them in the Cardiology unit of the Usman Danfodio University Teaching Hospital (UDUTH) Sokoto, Nigeria. The recordings were done according to recommendations of the American Heart Association, American College of Cardiology and the Heart Rhythm Society (Kligfield et al., 2007). The Electrocardiograph (Dr. Lee, 310A, Korea) contains an in-built computer analysis programme (CAP) that delivers information about the heart rate and rhythm, frontal plane axis of the QRS, P and T-waves, durations of waves and intervals including the corrected QT interval (QTc). The CAP is also capable of detecting cardiac arrhythmias.

The subjects were not on any medication, and did not take alcohol or any caffeine containing drinks. They were also not involved in strenuous exercise at least 24 hours before the study. The study was done in a quiet dimly lit air conditioned room (temperature= 24^oC) between 2-5 pm daily to avoid circadian variations in blood pressure, pulse rate and ECG. The subjects rested for at least 30 minutes to acclimatize before recordings were made. The blood pressure was measured from the left arm with a mercury sphygmomanometer (Accoson, England) using standard procedures (Timmis, 2007) with the subject in the sitting position and the cuff at the level the heart. The systolic pressure was taken at the first appearance of the *Korotkoff* sound while the diastolic was taken at its disappearance corresponding to phases 1 and 5 respectively (Timmis, 2007). The pulse rate was measured using the radial pulse. Thereafter each subject was asked to lie on a comfortable couch for at least 15 minutes and the baseline ECG records were taken. Then a cell phone in the turned on mode was placed on the left chest wall lying astride the nipple and without contact with any of the electrodes, and recordings were made. Thereafter, recordings were made with the phone in the calling mode during which three calls were made from another phone three meters away. Finally, recordings were repeated with the phone in the turn on mode after the calls. The recordings for each phase (i.e. baseline, before calls, during calls and after calls) lasted five minutes. The blood pressure and pulse rate were measured again after the performance of the ECG procedure.

Statistical Analysis

Results are presented as mean ± SEM. The blood pressure and pulse rate data was analysed using two-tailed paired t test. The ECG data, as well as comparison of the pulse rates with the heart rates, were analysed using one way ANOVA with a post hoc Tukey test. $P<0.05$ was taken as statistically significant.

RESULTS

The age and anthropometric parameters of the subjects are presented in Table 1. The blood pressure and pulse rate before exposure to the cell phone did not differ significantly from values obtained after exposure (Table 2).

Comparisons of the ECG parameters obtained before, during and after calls showed no significant difference from baseline or from each other (Table 3). The pulse rates obtained (Table 2) were comparable to the heart rates obtained from the ECG (Table 3) at baseline, before, during and after exposure and they did not differ significantly from one another.

Table 1. The Age and Anthropometric Parameters of Subjects

Age (yr)	Ht (m)	Wt (Kg)	BMI (kg/m^2)
21.44± 0.53	1.68 ± 0.02	58.44 ± 1.43	20.66 ± 0.53

Table 2: The Blood Pressure and Pulse Rate of subjects before and after exposure to radiofrequency electromagnetic fields (EMFs) from a cell phone placed close to the heart.

Parameter	Before	After
Systolic Pressure (mmHg)	104 ± 2.71	103 ± 2.80
Diastolic Pressure (mmHg)	70 ± 1.74	68±1.52
Pulse Rate (beats/min)	69 ± 2.43	69±2.81

DISCUSSION

The results of this study show that the blood pressure, pulse rate and ECG of apparently healthy subjects did not change significantly following acute exposure to a cell phone. This suggests that acute exposure to EMFs from cell phones placed on the left chest wall within the surface anatomy of the heart may not

Table 3: The ECG of subjects at baseline, before, during and after calls were made to a cell phone placed close to the heart.

ECG Parameter	Baseline	Before Calls	During Calls	After Calls
Heart Rate (beats/min)	67.17 ± 2.19	66.33 ± 2.50	66.33 ± 2.40	67.22 ± 2.77
QRS Complex Duration (ms)	94.33 ± 1.57	91.78 ± 1.36	91.11 ± 1.61	91.11 ± 1.67
PR Interval (ms)	150.56 ± 4.93	151.67 ± 5.39	153.67 ± 5.06	157.44 ± 4.46
QTc	399.56 ± 3.88	395.44 ± 4.96	394.33 ± 4.05	396.56 ± 4.93

interfere with the normal electrical rhythm of the heart or affect the blood pressure and pulse rate regardless of the transmission mode.

Our findings on ECG are in agreement with those of Barker et al., (2007) and Barutcu et al., (2011) who studied the effect of EMFs emitted by mobile phones on autonomic modulation of the heart. They studied time and frequency domain heart rate variability (HRV) parameters before and after exposure to EMFs from a cell phone in different transmission modes. HRV was obtained by feeding the ECG data into a computer and using HRV software to obtain the time and frequency domain parameters (Barutcu et al., 2011). It is a very useful noninvasive technique for assessing autonomic cardiovascular function in the clinic and the time and frequency domain parameters obtained from it are recommended for short term recordings (Barutcu et al., 2011). Since such facilities were not available to us, we simply used resting 12-lead ECG parameters and compared them before, during and after exposure. Notwithstanding the differences in methods, our findings were similar.

The subjects studied were young apparently healthy male subjects with anthropometric parameters that fall within the normal values reported for Nigerians (Taura, 2011; Adediran, Adebayo and Akintunde, 2013) and had normal baseline ECG which was not influenced by acute exposure to cell phone EMFs. Our findings do not agree with the earlier report by Braune et al., (1998) which showed an increase in blood pressure following exposure to cell phone EMFs. A large double blind sham-controlled study (Barker, 2007) that sought to confirm the finding by Braune et al., (1998) reported, like the present study, no effect of EMFs on blood pressure.

The baseline ECG parameters of the subjects all fell within the normal range for black African males as reported by Araoye (2004). Values obtained during and after exposure also fell within the normal range and the sinus rhythm remained consistent confirming that acute exposure to EMFs from mobile phones placed close to the heart may not interfere with the electrical rhythm of the heart in healthy young men. The pulse rate was comparable to the heart rate before, during or after exposure regardless of the cell phone transmission mode suggesting that there was no atrial fibrillation. The period of exposure to the cell phone EMFs in this study (five minutes), fall short of the level of exposure occurring in men who keep their mobile phones habitually in the pocket. This is a limitation of this study and an earlier one by Barutcu et al., (2011). Hence it may be worthwhile to carry out a study with longer periods of exposure. However, a large double blind sham-controlled study by Barker et al., (2007) seemed to have addressed these issues. Their study involved measurement of blood pressure, heart rate variability and blood catecholamine in 120 healthy volunteers before and after six exposure sessions to different radio frequency signals from both GSM and TETRA handsets in different transmission modes (Barker et al., 2007). In spite of their comprehensive approach, with multiple exposure sessions for longer periods and with twenty four hour ambulatory recordings, no effect was found (Barker et al., 2007).

The lack of effect of acute exposure to EMFs emitted by GSM mobile phones on the ECG in this study suggests that acute exposure may be safe. Barutcu et al., (2011) have suggested that the safety of the mobile phones may be associated with their design. GSM mobile phones emit maximal power during the initiation of a call and then the radiofrequency waves fall to low levels sufficient to sustain the call (Barutcu et al., 2011). This ensures that exposures to EMFs are minimal during calls. However the effect of acute or chronic exposure remains to be determined in those with cardiovascular diseases.

Although the results of the present study suggest that acute exposure to EMFs from cell phones may be safe, a recent study has reported the presence of a subset of people that are hypersensitive to radiations from lap tops and or cell phones (Hänninen et al., 2013). The symptoms reported included cooling of the hands when holding a cell phone or typing on a lap top and a transient increase in blood pressure following a short exposure to a cell phone in a volunteer with a cardiac pacemaker. The cooling of the hands and the rise in blood pressure were attributed to the effects of EMFs on the sympathetic nervous system (Hänninen et al., 2013). They concluded that unnecessary exposure to radiations from computers and cell phones should be avoided.

In conclusion, our data suggest that acute exposure to mobile telephony placed within the surface anatomical location of the heart may not alter the blood pressure, pulse rate and the electrical rhythm of the heart in healthy individuals.

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