

## Effects of Green Tea on Electrocardiography of Guinea Pigs Exposed to Electromagnetic Field Emitted by Mobile Phones

Dide KILIÇALP \*  Yeter DEĞER \*\* Ali ÇINAR \*

\* Department of Physiology, Faculty of Veterinary Medicine, University of Yüzüncü Yıl, 65080 Van - TURKEY

\*\* Department of Biochemistry, Faculty of Veterinary Medicine, University of Yüzüncü Yıl, 65080 Van - TURKEY

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### Summary

This study was carried out to determine the effects of green tea on Electrocardiography (EKG) of Guinea pigs exposed to a 900 MHz electromagnetic field emitted by mobile phones. Because green tea has a beneficial effect on endothelial function, tea consumption is associated with decreased cardiovascular risk. Twenty-eight healthy guinea pigs weighing 600-800 g were used. After one week adaptation period, animals were randomly divided into four groups. Four experimental groups labeled as controls (Group A), irradiated (Group B), irradiated receiving green tea extract (Group C) and green tea only (Group D) were formed with seven randomly chosen animals. Group A and D were housed in a separate room without exposing EMF of mobile phones. Irradiation was accomplished by exposing the animals in Group B and C to a 900 MHz electromagnetic field from a 217-Hz pulse rate, 2-W maximum peak power mobile phone placed in the cage where the animals were kept. ECG of guinea-pigs in four groups was recorded by a direct writing electrocardiograph at the end of the 30-day experimental period during exposure to mobile phone. Sinus bradycardia (lower heart beat) and prolongation of the P-R interval was observed in Group B and C after exposure to electromagnetic field ( $P<0.05$ ). Whereas the heart rate in the green tea extract supplemented group was close to the control group's level, it was found to have been the lowest in the only irradiated (Group B). We found measurable effects in the heart rate and P-R interval parameters in the EM-exposed guinea pigs. It was found that EMF exposure for 30 days have some effects on ECG findings of guinea-pigs. The results suggest that exposure of guinea pigs to EM fields can cause disturbances in autonomic cardiac regulation.

**Keywords:** *Green tea, Electromagnetic field, Mobile phone, ECG*

## Mobil Telefonların Oluşturduğu Elektromanyetik Alana Maruz Kalan Kobaylarda Elektrokardiyografi Üzerine Yeşil Çayın Etkisi

### Özet

Bu çalışma cep telefonları tarafından oluşturulan 900 MHz elektromanyetik alana maruz kalan kobay elektro-kardiyogramlarına (EKG) yeşil çayın etkisini belirlemek için yapıldı. Yeşil çayın endotel fonksiyonu üzerinde faydalı etkisi olduğu için, yeşil çay tüketimi kardiyovasküler risklerde yararlı bir sonuç gösterir. Materyal olarak 600-800 g ağırlığında, 28 adet kobay kullanıldı. Hayvanlar, bir hafta adaptasyon süresi sonunda rastgele seçilip dört gruba ayrıldı: kontrol grubu (Grup A), elektromanyetik alana maruz bırakılan grup (Grup B), elektromanyetik alana maruz bırakılıp yeşil çay ekstraktı uygulanan grup (Grup C) ve sadece yeşil çay ekstraktı uygulanan grup (Grup D). A ve D grubu elektromanyetik radyasyona maruz kalmamaları için ayrı bir odada tutuldu. Hayvanlar cep telefonlarının yaydığı 900-MHz elektromanyetik alana (217-Hz pulse rate, 2-W maximum peak power, SAR 0.95 w/kg) maruz bırakıldı. Cep telefonları kafeslerin içine yerleştirildi. Kobayların elektrokardiyogramları otuz günlük deneme periyodunun sonunda kaydedildi. Elektromanyetik alana maruz kalan B ve C gruplarındaki kobaylarda düşük kalp atım sayısı ve P-R aralığında uzama görüldü ( $P<0.05$ ). Kalp atım sayısı kontrol (Grup A) ve yeşil çay ekstraktı uygulanan gruplarda (Grup D) birbirine yakın, radyasyona maruz bırakılan grupta (Grup B) düşük bulundu. Elektromanyetik alanın kobaylarda kalp atım sayısı ve P-R aralığına ölçülebilir etkisi olduğu belirlendi. Otuz gün boyunca elektromanyetik alana maruz kalmanın kobay elektrokardiyogramlarına bazı etkilerinin olduğu bulundu. Bu etkiler, elektromanyetik alana maruz kalmanın, kalp ritminin ve uyarı iletiminin otonom (sempatik ve parasempatik) sinir sistemi tarafından kontrolünde bazı düzensizliklere neden olabileceğinin göstergesidir.

**Anahtar sözcükler:** *Yeşil çay, Elektromanyetik alan, Cep telefonu, EKG*



İletişim (Correspondence)



+90 432 2251024/1520



kilicalp23@hotmail.com

## INTRODUCTION

A variety of neurovegetative and circulatory disturbances have been repeatedly reported in workers exposed to radiofrequency electromagnetic fields. The observed effects included changes in arterial blood pressure, decreased amplitude of electrocardiogram recordings, functional disturbances of heart rhythm, and even symptoms of impaired conduction <sup>1-5</sup>. Bortkiewicz et al.<sup>1</sup> reported that occupational exposure to EM fields may cause irregularity in autonomic control of the circulatory system and lead to development of various functional disturbances of the system.

The heart's natural pacemaker is called the sinoatrial node. It makes the electrical impulses to produce heart-beats. An electric pulse produces a cascade of calcium ions that cause the heart muscle to contract. The electrocardiogram is used to monitor heart activity and can detect heart disease through the altered electrical signals. Hence it is biologically plausible that electric signals, that are shown to interfere with artificial pacemakers, can also interfere with the natural heart-beat. This is a known risk factor for heart disease <sup>6</sup>.

Tea is the most consumed drink in the world after water. Green tea is a non-fermented tea, richer in antioxidant flavonoids than black tea. Recent human studies suggest that green tea may contribute to a reduction in the risk of cardiovascular disease, some forms of cancer, oral health and has other physiological functions that include anti-hypertensive and anti-fibrotic properties, body weight control, antibacterial and antiviral activity, solar ultraviolet protection, increases bone mineral density and protects the nervous system <sup>7,8</sup>.

The aim of the present study was to evaluate the effects of green tea on heart and autonomic control of cardiac function in Guinea pigs exposed to a 900 MHz electromagnetic field from mobile phones.

## MATERIAL and METHODS

A total of 28 Guinea pigs weighing 600 - 800 g were used in this study. Animal handling and maintenance was done following the recommendations of the Ethics Committee, Yuzuncu Yil University. The animals were housed in 60 x 90 x 45 cm cages kept under normal conditions and standard diet for one week.

After this time twenty-eight animals were divided into four groups, as follows:

*Group A (n=7):* Controls, maintained under standard conditions, normal diet.

*Group B (n=7):* Animals exposed to an electromagnetic field daily for one month (*see below for method of exposure*).

*Group C (n=7):* Animals exposed to an electromagnetic field daily receiving an oral dose of 100 mg/kg/day of green tea extract for one month.

*Group D (n=7):* Animals receiving 100 mg/kg/day green tea extract orally for one month.

Animals receiving radiation were exposed to a 900-MHz field (217-Hz pulse rate, 2-W maximum peak power, Specific Absorption Rate (SAR) 0.95 w/kg) from a mobile telephone that was kept on standby for 23 h 40 min and functioning at normal full power for 20 min a day. The mobile phones were placed 0.5 cm under cages. Groups A and D were kept in a separate room to avoid any chance of exposure to EMF radiation.

At the end of the 30-day experimental period during exposure to mobile phone for ECG recordings, the animals were placed on a table in sternal position. The arm leads were placed the skin on *m. triceps brachii*, and the leg leads were placed the skin on *m. biceps femoris*. Electrode gel was rubbed into the skin in the area where the alligator clips were attached to act as a degreasing agent and thereby decrease the resistance of the skin. Electrocardiogram was recorded by a direct writing electrocardiograph (Cardio fax 6851; Nihon Kohden, Tokyo). All ECGs were standardized at 1 mv=10 mm, with a chart speed of 50 mm/sec. Leads I, II, III, aVR, aVL, aVF were recorded. The durations and amplitudes of waves on the trace were measured in lead II, and the electrical axis was also measured in leads II and III <sup>9</sup>.

The results are expressed as means±standard deviation. Duncan's test was used for statistical analysis. Differences were considered significant at P<0.05.

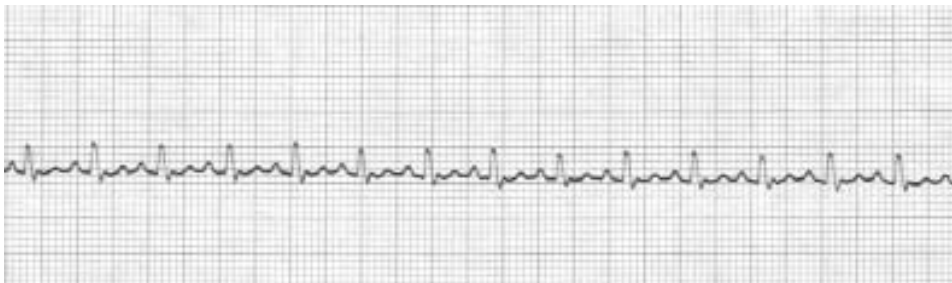
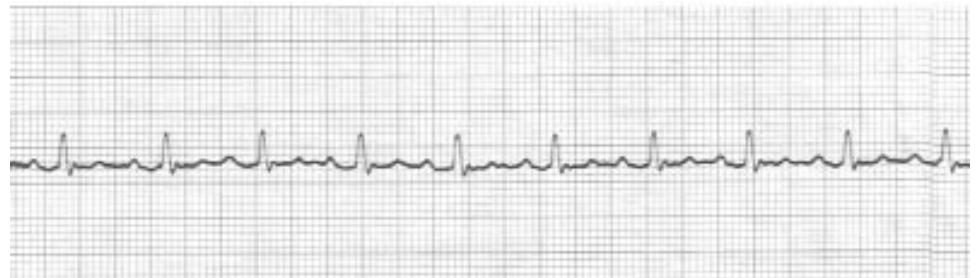
## RESULTS

The durations and amplitudes of all waves are shown in *Table 1*. The *Figure 1, 2, 3* and *4* shows the ECG of Group A, Group B, Group C and Group D. All

**Table 1.** Amplitudes and durations of waves and heart rate of lead II in the guinea pigs (Mean±SE)**Tablo 1.** Kobaylarda II. derivasyondaki dalgaların yükseklik ve süreleri ve kalp atım sayısı (Mean±SE)

Parameter	Group A (n = 7)	Group B (n = 7)	Group C (n = 7)	Group D (n = 7)
P (sn)	0.03±0.00	0.02±0.00	0.03±0.00	0.02±0.00
P (mV)	0.10±0.00	0.10±0.00	0.10±0.00	0.10±0.00
QRS (sn)	0.04±0.00	0.04±0.00	0.04±0.00	0.04±0.00
QRS (mV)	0.30±0.00	0.33±0.02	0.31±0.04	0.32±0.04
T (sn)	0.03±0.00	0.04±0.00	0.04±0.00	0.04±0.00
T (mV)	0.13±0.03	0.10±0.00	0.10±0.00	0.12±0.02
P-R (sn)	0.06±0.00 <sup>a</sup>	0.18±0.07 <sup>b</sup>	0.18±0.00 <sup>b</sup>	0.06±0.00 <sup>a</sup>
Q-T (sn)	0.10±0.00	0.11±0.00	0.11±0.01	0.10±0.00
Heart-beat (beat/min)	333.22±0.11 <sup>a</sup>	220.19±10.52 <sup>b</sup>	273.23±21.34 <sup>b</sup>	314.54±12.28 <sup>a</sup>
Electrical axis	+25.00±0.00°	+23.88±1.38°	+25.83±1.53°	+28.00±1.22°

**a,b:** The differences among the different letters in the same line were significant ( $P<0.05$ )

**Fig 1.** ECG of control (333 beat/min)**Şekil 1.** Kontrol grubuna ait EKG (333 atım/dak)**Fig 2.** ECG of animal exposed to an electromagnetic field (214 beat/min)**Şekil 2.** Elektromanyetik alana maruz kalan hayvana ait EKG (214 atım/dak)**Fig 3.** ECG of animal exposed to an electromagnetic field daily receiving an oral dose green tea extract (250 beat/min)**Şekil 3.** Elektromanyetik alana maruz bırakılıp ağızdan yeşil çay ekstraktı uygulanan hayvana ait EKG (250 atım/dak)**Fig 4.** ECG of animal receiving green tea extract (300 beat/min)**Şekil 4.** Ağızdan yeşil çay ekstraktı uygulanan hayvana ait EKG (300 atım/dak)

waves were seen in all of the leads. Sinus bradycardia (lower heart beat) and prolongation of the P-R interval was observed in irradiated (Group B) (Fig 2) and irradiated receiving green tea extract (Group C) (Fig 3) after exposure to cell-phone ( $P < 0.05$ ). Heart rates increased significantly ( $P < 0.05$ ) in control (Group A) (Fig 1) and green tea only (Group D) (Fig 4).

## DISCUSSION

Mobile phones are widespread using in the world. There are more than 1 billion phones in the worldwide. Mobile phones allow people to communicate with flexibility and easily. In addition, having a personal and mobile means of communication has helped to save lives through quicker notification of accidents, trauma, and other dangers. But concerns about the safety of mobile phones have been raised <sup>10</sup>.

The electrocardiogram is used to determine the type, origin and severity of the irregularity. The P-R interval is extremely important in evaluating the cardiac rhythm. The P-R interval is prolonged by increases in vagal tone, slow heart rate (bradycardia), atrial myocardial or A-V nodal disease <sup>9</sup>.

Savitz et al.<sup>11</sup> found an increased rate of mortality from arrhythmia-related conditions and acute myocardial infarction among workers with a long duration of work (rate ratios were 1.4-1.5 for the longest employment intervals) and workers with high exposure to magnetic fields (rate ratios were 1.6-2.4 in the highest exposure category). Sastre et al.<sup>12</sup> observed significantly reduced heart rate variability (HRV) in volunteers sleeping in 60Hz fields. Extrinsic EMR signals interfere with hearts and cause heart disease and death. Braune et al.<sup>13</sup> showed that cell phone significantly increased systolic and diastolic blood pressure during EMF exposure and absolute heart rate values decreased significantly during rest. In the present study, we observed slow heart rate and prolongation of the P-R interval in irradiated (Group B) and irradiated plus receiving green tea extract (Group C) after exposure to mobile phone ( $P < 0.05$ ). These data might suggest a possible association between magnetic fields and arrhythmia.

Wile'n et al.<sup>14</sup>, compared heart rate and heart rate variability (HRV), respiration, local blood flow, electrodermal activity, critical flicker fusion threshold (CFFT), short-term memory, and reaction time between subjects "experiencing subjective symptoms when

using mobile phones" and control subjects. No significant differences related to RF exposure conditions were detected. Also no differences in baseline data were found between subject groups, except for the reaction time, which was significantly longer among the cases than among the controls the first time the test was performed. This difference disappeared when the test was repeated. However, the cases differed significantly from the controls with respect to HRV as measured in the frequency domain.

Detection of ECG, RR interval and QRS complex is crucial for a wide range of heart diseases like tachycardia, bradycardia, arrhythmia, palpitations etc. Electrocardiogram or ECG is the record containing electrical activities of the heart. Electrocardiogram is widely used to diagnose different heart abnormalities <sup>15</sup>.

Szmigielski et al.<sup>16</sup> reported no changes in mean values of mean, systolic, and diastolic blood pressures or in heart rates in workers presumably exposed to RFE (radiofrequency electromagnetic fields), compared with controls. Day/night ratios and amplitudes of diurnal rhythms of heart rate and blood pressure, however, were significantly lower. The authors concluded that RFE can evoke measurable cardiovascular effects, but, so far, no potential hazards can be assigned to these effects.

Bortkiewicz et al.<sup>3</sup>, a higher percentage of workers at AM broadcast stations had more abnormalities in the ECG (both resting and 24-h results combined) when compared with workers at radio-link stations (presumed to have low RFE exposure). Abnormalities in either resting ECG or 24-h ECG individually, however, were not significantly different between the two groups of workers.

In another study of Bortkiewicz et al.<sup>5</sup> reported "a significant relationship between blood pressure and neurovegetative regulation disorders and exposure parameters" of mobile-phone RFE in occupationally exposed workers. The study seemed to be related to lifetime dose levels, but there were not enough details in the literature evaluation.

Tahvanainen et al.<sup>17</sup>, 35-min exposures to cellular phones (900 and 1800 MHz) had no significant effects on heart rate or blood pressure. Muller et al.<sup>18</sup> found no changes (compared with sham exposures) in heart rate electrocardiographic parameters (P-Q, Q-S and S-T ECG intervals), systolic and diastolic blood pressure, skin temperature and conductance or respiration in 50

test persons, due to 77-GHz RFE microwave exposure. They conclude that exposure to those microwaves does not result in physiologically relevant alterations of autonomic nerve activity and cardiovascular function.

Johansen et al.<sup>19</sup> did not identify an increased frequency of pacemaker implantation associated with occupational exposure to electromagnetic fields. They conclude that the results of their study do not support the hypothesis of a link between occupational exposure to 50-Hz electromagnetic fields and excess risk of severe arrhythmia-related heart diseases. Their results are largely reassuring, since they do not support the hypothesis of a link between occupational exposure to electromagnetic fields and an excess risk of severe cardiovascular arrhythmia leading to permanent implantation of a pacemaker.

Whereas the heart rate in the green tea extract supplemented group was close to the control group's level, it was found to have been the lowest in the only irradiated (Group B), but in the irradiated plus receiving green tea extract (Group C) it was found to have been higher compared to the only irradiated (Group B). In the parallel of our study, Alexopoulos et al.<sup>20</sup> had also reported the effects of green tea on the cardiovascular function.

The water extract of green tea contains soluble polyphenols and pigments that have antioxidant properties that contribute to the protective effects of green tea against cancer and cardiovascular diseases<sup>21,22</sup>. Green tea consumption has an acute beneficial effect on endothelial function, assessed with FMD of the brachial artery, in healthy individuals. This may be involved in the beneficial effect of tea on cardiovascular risk<sup>20</sup>.

The observed effects included changes in functional disturbances of heart rhythm, prolongation of the P-R interval of ECG recordings. On the basis of these results, it was concluded that occupational exposure to EM fields may cause autonomic irregularity towards sympathetic activity of the circulatory system and lead to development of various functional disturbances of the system. These powerful evidences suggest that mobile phones could increase the risk of arrhythmia related heart disease. Green tea brings the heart beat to near control values; supporting the idea that green tea as a supplement might be having a protective effect against the reducing effects of electromagnetic radiation on the heart beat.

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