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ORIGINAL ARTICLE

The Effect of Electromagnetic Field Exposure on Fetal Development

Elektromanyetik Alan Maruziyetinin Fetal Gelişime Etkisi

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ABSTRACT

Aims: The aim of our study is to evaluate the effect of electromagnetic field exposure during pregnancy on fetal anthropometric measurements by means of ultrasonography.
Methods: This is a cross sectional study. The study was conducted among 261 pregnant women who applied to the Obstetrics and Gynecology outpatient clinic. A face-to-face questionnaire was applied to 261 volunteer pregnant women and fetal anthropometric measurements (head circumference (HC), abdominal circumference (AC), femur length (FL), biparietal diameter (BPD)) were performed by transabdominal ultrasound.
Results: The mean age of the pregnant women in this study was 29.65 ± 6. Of the pregnant women 140 (53.6%) were between the ages of 25-34, 260 (99.6%) were married, 85 (32.6%) were high school graduates and 184 (70.5%) were housewives. The income of 116 (44.4%) pregnant women was equal to their expenses. The frequency of those exposed to electromagnetic fields at home is 98.5%. There was no difference between FL, AC, HC and BPD values and electromagnetic field exposure at home, exposure to x-ray or tomography (p>0.05). It was observed that FL, HC, BPD ultrasonographic measurement values were significantly lower in people exposed to electromagnetic field at work compared to those not exposed to electromagnetic field at work.
Conclusion: It was observed that FL, HC, BPD ultrasonographic measurement values were significantly lower in people exposed to electromagnetic field at work. There are studies that show the negative effects of electromagnetic field on the fetus, especially during pregnancy, although there is no definitive evidence. Studies to be carried out on this subject can be a guide for protection from the negative effects of electromagnetic field.

Keywords: electromagnetic field, radiation, fetal development, fetal growth, maternal exposure, environmental health

ÖZ

Amaç: Çalışmamızın amacı gebelikte elektromanyetik alan maruziyetinin fetal antropometrik ölçümler üzerine etkisini ultrasonografi yardımıyla değerlendirmektir.
Yöntemler: Bu kesitsel bir çalışmadır. Araştırma Kadın Hastalıkları ve Doğum polikliniğine başvuran 261 gebe ile gerçekleştirildi. 261 gönüllü gebeye yüz yüze anket uygulandı ve transabdominal ultrason ile fetal antropometrik ölçümler (baş çevresi (HC), karın çevresi (AC), femur uzunluğu (FL), bipariyetal çap (BPD)) yapıldı.
Bulgular: Araştırmaya katılan gebelerin yaş ortalaması 29,65±6,140 idi. Gebelerin 140'ı (%53,6) 25-34 yaş aralığında, 260'ı (%99,6) evli, 85'i (%32,6) lise mezunuydu. 184'ü (%70,5) ev hanımıydı. 116 (%44,4) gebenin geliri harcamalarına eşitti. Evde elektromanyetik alanlara maruz kalanların sıklığı %98,5'ti. FL, AC, HC ve BPD değerleri ile evde elektromanyetik alan maruziyeti, röntgen veya tomografiye maruz kalma arasında fark bulunamadı (p>0,05). İş yerinde elektromanyetik alana maruz kalan kişilerde FL, HC, BPD ultrasonografik ölçüm değerlerinin iş yerinde elektromanyetik alana maruz kalmayanlara göre anlamlı derecede düşük olduğu görüldü.
Sonuç: İş yerinde elektromanyetik alana maruz kalan kişilerde FL, HC, BPD ultrasonografik ölçüm değerlerinin anlamlı derecede düşük olduğu görüldü. Kesin bir kanıt bulunmamakla birlikte, özellikle hamilelik döneminde elektromanyetik alanın fetüs üzerindeki olumsuz etkilerini gösteren çalışmalar bulunmaktadır. Bu konuda yapılacak çalışmalar elektromanyetik alanın olumsuz etkilerinden korunmak için yol gösterici olabilir.

Anahtar Kelimeler: elektromanyetik alan, radyasyon, fetal gelişim, fetal büyüme, maternal maruziyet, çevre sağlığı

Introduction

A person is both affected by the environment he lives in and can affect the environment. People are exposed to electromagnetic field (EMF) from basic radio, electrical and telecommunications stations, as well as direct radiation from individuals, such as cell phones. Each person will potentially be exposed to several EMF sources simultaneously(1). As a result of the development of technology over the years, the concept of electromagnetic field, which is included in our lives in many fields, has gained considerable importance. Radiation can be grouped into non-ionizing radiation, which is considered less harmful, and ionizing radiation, which is potentially harmful to cells and DNA. Ionizing radiations are more harmful because they cause DNA damage by breaking chemical bonds. Ionizing radiation causes mutagen, carcinogenic or teratogenic effects, cataracts, infertility problems, premature aging and skin problems in humans. The risk of exposure is greatest in the 'in utero' period (2–4). Non-ionizing radiations, on the other hand, lack the energy needed to break chemical bonds. Examples of this type of radiation are visible light, ultraviolet light, infrared light, radio waves and microwaves. Non-ionizing radiation can have harmful effects on the body(2,3). In 2011, an expert working group of the International Agency for Research on Cancer (IARC) classified

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radiofrequency radiation emitted by mobile phones and other wireless devices as a Group 2B ("probable") human carcinogen(5). There are studies showing that the electromagnetic field increases the risk of cancer (6,7).

Pregnancy, infancy and childhood are critical periods of vulnerability, especially for the rapidly developing brain(8). Although few studies have been conducted on human exposure to non-ionizing electromagnetic fields in utero, there are numerous negative effects on pregnancy and the health of offspring who are regularly exposed to electromagnetic field (9). While some studies have not found a relationship between radiation exposure during pregnancy and the weight of newborn babies (10,11), some studies have found a relationship between the exposure of pregnant women to EMF during pregnancy and problems such as the risk of miscarriage and fetal development disorders (12–14). The risk of miscarriage, stillbirth, and birth defects was not significantly higher among pregnant women who lived near electromagnetic fields compared to the control group(15).

Examples of common sources of electromagnetic fields are radio and TV broadcast antennas, Wi-Fi access points, routers and clients (e.g. smartphones, tablets), wireless and mobile devices, base stations (16). Researches on the relationship between cell phone use and pregnancy has shown conflicting results. In a study conducted in Turkiye, the pregnancy period was found shorter in mothers using mobile phones and computers(17). In a study conducted with four birth cohorts, a relationship was shown between mobile phone use and premature birth and shortening of the pregnancy period, but no relationship was found with fetal growth(18). In a cohort conducted in Norway, no relationship was found between the mother's pre-pregnancy exposure to mobile phones and pregnancy outcomes such as premature birth and low birth weight(19). A study conducted in Turkiye showed that watching TV, mobile phone usage and living near a base station during pregnancy may have negative effect on the anthropometric measurements of the newborn (20).

In a review that collected studies examining the effects of electromagnetic field emitted by mobile phones and other wireless devices, symptoms related to learning, memory, attention and behavior problems and diseases such as autism, attention deficit movement disorder were associated(21).

This study is different in that it evaluates the effects of electromagnetic field exposure on the fetus during the prenatal period. The aim of our study is to evaluate the effect of electromagnetic field exposure during pregnancy on fetal anthropometric measurements by means of ultrasonography.

Material and Methods

This is a cross-sectional study. The study was conducted among pregnant women who applied to the Obstetrics and Gynecology outpatient clinic of Adıyaman Training and Research Hospital.

The questionnaire form was prepared by reviewing the necessary literature. The applied questionnaire consists of 27 questions. In addition to the questions about sociodemographic information, there are questions about the sources of electromagnetic fields to which exposure at home and, if they work, exposure at work. Inclusion criteria in the study group are pregnant women aged 18 and over admitted to the obstetrics clinic.

The people included in the study were women who applied consecutively and accepted the study as of 15/04/2022. The formula $n= Nt^2pq/ d^2 (N-1)+t^2pq$ was used to determine the number of people to be sampled, and the number of people to be sampled was calculated as 273 people with a 95% confidence interval and 5% deviation. Necessary permission was obtained from Adıyaman University Non-Interventional Clinical Research Ethics Committee (decision dated 15.03.2022 and numbered 2022/3-21). Starting on the first working day after the permission was granted, 95.6% (261) of the targeted number of people has been reached. A face-to-face questionnaire was applied to 261 pregnant women on voluntary basis and fetal anthropometric measurements (head circumference (HC), abdominal circumference (AC), femur length (FL), biparietal diameter (BPD)) were performed by transabdominal ultrasound.

Statistical package (SPSS 12.00) program was used in the evaluation of the data. Descriptive variables were provided as numbers and percentages. Chi-Square and Fischer's exact Chi-Square tests were used to explore the correlations between the variables in the categorical structure. The means were compared using one-way ANOVA and the t test. Means were provided with standard deviation. The results were evaluated at 95% confidence interval and $p<0.05$ was accepted as significant.

Results

The mean age of the pregnant women is 29.65 ± 6. Of the pregnant women 140(53.6%) were between the ages of 25-34, 260 (99.6%) were married, 85 (32.6%) were high school graduates and 184 (70.5%) were housewives. The income of 116 (44.4%) pregnant women was equal to their expenses (Table 1).

The mean number of pregnancies was 3.0 ± 2.0, and the number of births was 1.7 ± 1.5. Of the pregnant women 106 (40.6%) had miscarriage before. 70 (26.8%) of the pregnant women had a chronic disease before pregnancy.

The frequency of those exposed to electromagnetic fields at home is 98.5%. 252 (96.9%) of the pregnant women were using the phone. 249 (95.8%) of the pregnant women had a TV at home, 148 (56.9%) had a hair dryer, 148 (56.9%) had a wi-fi modem, 95 (36%, 5) stated that they had air conditioning, 81 (31.2%) had a computer and 63 (24.2%) had a microwave oven. The houses of 39 (14.9%) of the pregnant women were close to the base station and the houses of 38 (14.6%)

Table 1. Certain sociodemographic characteristics of pregnant women.

	n, %
Age	
<24 years	57 (21.8)
25-34 years	140 (53.6)
≥35 years	64 (24.5)
Marital Status	
Married	260 (99.6)
Divorced	1 (0.4)
Educational Status	
Illiterate	22 (8.4)
Primary School Graduate	44 (16.9)
Secondary School Graduate	41 (15.7)
Highschool Graduate	85 (32.6)
University Graduate	69 (26.4)
Employment Status	
Housewife	184 (70.5)
Working	77 (29.5)
Household Income	
Income more than expense	69 (26.4)
Income less than expense	76 (29.1)
Income equal to expense	116 (44.5)

difference in fetal FL, AC, HC and BPD measurement values of pregnant women who had exposure to x-ray or tomography compared to the group that had no exposure (p>0.05) (Table 2).

When the pregnant women's home was close to the high-voltage line and fetal anthropometric measurement values were examined, there was no difference between the measurement values of those who were close to the high-voltage line and those who were not (p>0.05).

155 (59.4%) of the pregnant women had a television and 56(21.5%) had a wi-fi modem in the room where they spent most of their time. 186(%74,7) of the pregnant women did not turn off the wi-fi modem at night.

There was no difference between the presence of television and modem in the room where the most time was spent and education level (p>0.05). As the education level increases, the situation of turning off the modem at night increases (p<0.05).

Discussion

Fetal effects of electromagnetic field exposure during pregnancy have been tried to be related to pediatric measurements mostly made after birth (22,23). In our study, the investigation of this relationship by means

Table 2: The effect of electromagnetic field exposure on fetal anthropometric measurements.

Electromagnetic field exposure status		FL		AC		HC		BPD	
		Mean±SD, p		**Mean±SD, p**		**Mean±SD, p**		**Mean±SD, p**	
EMF exposure at work	Yes	32.8±3.4	t= 3.72 **p<0.01**	32.3±3.9	t=1.347 p>0.05	33.5±3.3	t=3.639 **p<0.01**	33.2±3.4	t=3.478 **p<0.01**
	No	34.7±3.7		36.3±25.4		35.2±3.4		34.9±3.7	
EMF exposure at home	Yes	34.1±3.7	t=0.194 p>0.05	35.2±21.5	t=0.092 p>0.05	34.7±3.4	t=0.269 p>0.05	34.4±3.7	t=0.222 p>0.05
	No	34.5±3.0		34.2±3.4		35.2±3.5		34.0±3.4	
Exposure to X-ray or tomography	Yes	32.9±4.2	t=1.062 p>0.05	32.7±3.9	t=0.345 p>0.05	33.5±4.0	t=1.041 p>0.05	32.8±4.0	t=1.295 p>0.05
	No	34.2±3.6		35.2±21.7		34.7±3.4		34.5±3.7	

Abbreviations: EMF: Electromagnetic Field, SD: Standard Deviation, FL: Femur length, AC: Abdominal Circumference, HC: Head Circumference, BPD: Biparietal Diameter

Independent sample t test was used to analyze the data for Table 2.

were close to the high voltage line.

When fetal anthropometric measurements of pregnant women with exposure to electromagnetic fields at work were examined, FL, HC and BPD values were lower than those without exposure to electromagnetic fields at work (p<0.05) (Table 2).

When fetal anthropometric measurements of pregnant women exposed to electromagnetic field at home were examined, there was no difference in FL, AC, HC and BPD values compared to those who were not exposed to electromagnetic fields at home (p>0.05) (Table 2).

When the exposure status of pregnant women to x-ray or tomography and fetal anthropometric measurements were examined, there was no

of ultrasonography before the birth may be guiding in the study of the early effects of the electromagnetic field.

In a study conducted in 2019, the most common sources of electromagnetic fields that pregnant women were exposed to during pregnancy were listed as television (92.8%), mobile phone (91.3%), and wi-fi (52%). In the same study, while 28.7% of the participants stated that their home was near the base station, this rate was 14.9% in our study (22). In our study, pregnant women stated that they were most frequently exposed to sources such as telephone (96.9%), television (95.8%), and wi-fi modem (56.9%). Sources of electromagnetic fields exposed at home are of similar frequency.

In a study examining the data of pregnant women who

were exposed to electromagnetic fields due to high voltage line and those who were not, no significant difference was found between the two groups in terms of birth weight, height and head circumference values of the babies (24). In a study conducted in England, it was shown that maternal residence close to electromagnetic field sources is associated with inadequate fetal growth (25).

In a descriptive study examining the proximity of the houses to the high voltage lines and the presence of symptoms, the proximity to the high voltage line and the electromagnetic field values measured at the house showed a positive correlation, but no relationship was found between these values and symptoms (26).

In our study, when the pregnant women's home was close to the high voltage line and fetal anthropometric measurement values were examined, no statistically significant difference was found between those who were close to the high voltage line and those who were not ($p>0.05$). This may be due to the fact that we have done a study on the statements of individuals.

In a cohort study conducted in Norway, no evidence of adverse neurodevelopmental effects of prenatal cell phone use was reported (27).

In a different study, those who were more exposed to mobile phones had a shorter gestational period and increased risk of preterm birth compared to those who were less exposed (28). Babies of pregnant women who use more than one phone during pregnancy have lower birth weight and shorter stature than babies of pregnant women who use one phone (22).

In a study involving 138 women in China, it was stated that exposure to electromagnetic field sources such as mobile phones, televisions during the first trimester of pregnancy significantly increases the risk of embryo development arrest (29). In a cohort study, it was found that exposure to video display terminal use at home or at work during pregnancy was not associated with fetal development retardation (30). In a birth cohort conducted in China, exposure to high prenatal electromagnetic field exposure was associated with growth in baby girls but not in boys (23).

In our study, while the electromagnetic field exposure of pregnant women at home did not make a significant difference in fetal measurements, the electromagnetic field exposed by pregnant women at work caused significant changes in fetal measurements such as femur length, head circumference, and biparietal diameter.

More studies are needed to evaluate the effects of home or work-induced electromagnetic field exposure during pregnancy on fetal development and to raise awareness in pregnant women.

Conclusion

It was observed that FL, HC, BPD ultrasonographic measurement values were significantly lower in people exposed to electromagnetic field at work compared to those not exposed to electromagnetic field at work. There are studies that show the negative effects of electromagnetic field on the fetus, especially during pregnancy, although there is no definitive evidence. Studies to be carried out on this subject can be a guide for protection from the negative effects of electromagnetic field.

Ethics Committee Approval

This research complies with all the relevant national regulations, institutional policies and is in accordance the tenets of the Helsinki Declaration and has been approved by the Adıyaman University Non-Interventional Research Ethics Committee (Decision dated 15.03.2022 and numbered 2022/3-21).

Informed Consent

All the participants' rights were protected and written informed consents were obtained before the procedures according to the Helsinki Declaration.

Author Contributions

F.K.: Conceptualization, Methodology, Software, Validation, Formal analysis, Writing - Review & Editing. M.C.N.: Resources, Visualization, Data Curation. E.F.T.Ç.: Formal analysis, Investigation, Writing - Original Draft.

Conflict of Interest

The authors have no conflict of interest to declare.

Financial Disclosure

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Limitations

Limitations of the study are that electromagnetic field exposure was not measured objectively with a device in our study but was only questioned through a questionnaire. The fact that this study was conducted in a single center limited its generalizability to the community. The subject studied needs further research.

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