ELSEVIER

Effects of 60-Hz Magnetic Field Exposure on Nocturnal 6-Sulfatoxymelatonin, Estrogens, Luteinizing Hormone, and Follicle-Stimulating Hormone in Healthy Reproductive-Age Women: Results of a Crossover Trial

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PURPOSE: Exposure to residential magnetic fields may disrupt the normal nocturnal rise in melatonin levels, resulting in increased risk for breast cancer, possibly through increased levels of reproductive hormones. We investigated whether exposure to a 60-Hz magnetic field under controlled conditions is associated with a decrease in urinary nocturnal 6-sulfatoxymelatonin level and increase in luteinizing hormone (LH), follicle-stimulating hormone (FSH), and estrogen levels in healthy premenopausal women.
METHODS: Using a crossover design, half the participants were assigned to magnetic field exposure of 5 to 10 mG greater than ambient levels for 5 consecutive nights during the early to midluteal phase of the menstrual cycle. On the last night of exposure, a nocturnal urine sample was collected. The next month, participants were sham exposed. The other half of participants were assigned the reverse order of exposure.
RESULTS: Magnetic field exposure was associated with decreased 6-sulfatoxymelatonin levels, but no changes in reproductive hormone levels were observed. Participants using prescription medications and anovulatory participants had more pronounced decreases in 6-sulfatoxymelatonin levels with magnetic field exposure.
CONCLUSION: This study provides further evidence that exposure to magnetic fields is associated with decreased nocturnal melatonin levels, but does not support the hypothesis that such exposure results in increased urinary levels of estrogens, LH, or FSH.
Ann Epidemiol 2006;16:622–631.

KEY WORDS: Breast Cancer, Circadian Rhythm, Electromagnetic Fields, Environmental Carcinogens, Estrogen, Melatonin, Pineal.

INTRODUCTION

It has been suggested that exposure to magnetic fields can disrupt the normal nocturnal increase in melatonin levels, resulting in increased risk for breast cancer through either direct oncostatic action or increased circulating levels of reproductive hormones relevant to the development of breast cancer (1, 2).

Although there is considerable evidence in animals that exposure to magnetic fields can disrupt the nocturnal release of melatonin (3–9), there have been very few such studies of humans. There is anecdotal evidence that blood melatonin levels are decreased in human volunteers exposed to magnetic fields (10) and limited evidence of an effect of magnetic field exposure on circulating melatonin from experimental studies of humans in controlled environments (11). Previously, we reported that increased exposure to magnetic fields in the bedroom at night was associated with decreased nocturnal melatonin levels that same night in a population-based sample of approximately 200 healthy women (12). However, it remains unknown whether such exposures can alter elements of the endogenous hormonal environment important in the etiology of breast cancer in women. This study was undertaken to determine whether exposure to a 60-Hz magnetic field in a woman's typical sleeping environment under controlled (experimental) conditions is associated with a decrease in nocturnal melatonin levels and increase in urinary levels of luteinizing hormone (LH), follicle-stimulating hormone (FSH), and estrogens in healthy premenopausal women.

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This research was supported by grant no. R01CA80346 from the National Cancer Institute.

Received August 12, 2005; accepted November 20, 2005.

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1047-2797/06/$–see front matter
doi:10.1016/j.annepidem.2005.11.005

List of Abbreviations and Acronyms

LH = luteinizing hormone
FSH = follicle-stimulating hormone
PDG = pregnanediol 3-glucuronide
BMI = body mass index
E_1 = estrone
E_2 = estradiol
E_3 = estriol

METHODS

Study Participants

A schematic description of participant identification and data collection procedures are shown in Figure 1. Participants were women aged 20 to 45 years recruited as volunteers from the Seattle, WA, metropolitan area. Advertisement for the study included fliers posted in a variety of locations, newspaper advertisements, and public service announcements. An abbreviated list of eligibility criteria and a number to contact the study office were provided in all advertisements. A brief screening interview was administered to each person calling the study office to determine eligibility. Eligibility criteria included having regular menstrual periods between 25 and 35 days; having a body mass index (BMI) between 18 and 30 kg/m^2; not using hormonal contraceptives or other hormones at least 30 days before the screening interview; no history of breast cancer; not having undergone chemotherapy or tamoxifen therapy; not having been pregnant or breast-feeding within the past year; not working the night shift; not using supplements containing melatonin, phytoestrogens, or isoflavones; and not consuming more than five servings/week of soy-based foods. These criteria were intended to ensure as much as possible that the participant exhibited normal ovarian function and was not under the influence of factors that may alter levels of the hormones under study.

Data Collection

Overview. Participation in this crossover study consisted of five in-home visits over 3 consecutive months. Date of ovulation was established in month 1, followed by a 2-month period of exposure and "sham" exposure during precise intervals of the participant's luteal phase. Data collection was limited to the summer because we previously found a more pronounced effect of magnetic field exposure on nocturnal melatonin levels during months with the fewest hours of darkness (12).

Participants were randomly assigned to exposure in month 2, then sham exposed month 3, or the reverse. An in-home visit was made in month 1 to document the participant's menstrual cycle by using a daily calendar and to instruct her on the use of an ovulation kit (Assure LH; Conception Technologies, San Diego, CA). Height and weight were measured in all 3 months, and a brief questionnaire on exercise habits and dietary supplementation during the previous month was administered.

Participants called the study office to report their first positive ovulation reading, and staff determined the date the participant should begin testing for the next ovulatory period. A home visit was scheduled for placement of the exposure device upon the next positive ovulation reading. The device, the charging base of an electric toothbrush that emitted a steady magnetic field, was placed underneath the bed (discussed later) beginning day 1 postovulation for 5 consecutive nights. During the last night, the participant collected all urine excreted, including the first void the next morning. Procedures in month 3 were the same, but the appliance was turned off (sham exposure). Half the participants were exposed in month 2 and sham exposed in month 3, and the other half were the reverse. Participants were blinded to the on/off status of the appliance.

In-person Interview and Nightly Diary. At the first in-home visits of months 2 and 3, the technician conducted an in-person interview regarding employment, travel, diet, and stress levels during the previous month and instructed the participant on the completion of a nightly diary. The diary recorded bed and wake times, medication use, alcohol consumption, and tobacco use for each night of exposure assessment and asked about protocol violations.

Exposure protocol. After the in-person interview, the exposure device was placed under the participant's bed directly underneath her sleeping location. With the appliance turned off, the technician measured the ambient magnetic field level at the pillow, using an EMDEX II meter (Graseby Electronics, Orlando, FL). With the appliance turned on, the technician adjusted the height of the appliance until the magnetic field at the pillow was between 5 and 10 mG greater than the ambient magnetic field level measured with the device turned off. Five participants were excluded because there was insufficient room under the bed to place the device. The technician conducted the same placement protocol both months to ensure the participant was blinded regarding exposure status. On completion of each exposure period, the technician returned the meter and appliance to the study office. Meter data were uploaded and inspected to ensure that meter measurements remained relatively stable throughout the measurement period. This indicated that no one had tampered with the on/off status of the appliance while it was in the participant's home.

Urine sample collection. On the last night of exposure, each participant was instructed to void her bladder just before going to bed, and to collect all urine excreted throughout the night and first void of the next morning. Participants completed a urine sample adherence form after the first morning void, which included questions about times the subject urinated; number of times the participant got up