

# SERUM TESTOSTERONE AND STATIC MAGNETIC FIELD EXPOSURE

## Introduction

Several recent reviews have provided an overview of the effects of electromagnetic fields on biological systems (Male and Norris, 1980; Lee et al, 1982; Sheppard 1983). In general the literature suggests that electromagnetic field exposure is of relatively low potential toxicity. The literature falls into two groups: epidemiological studies of occupational and community exposures and experiments with laboratory animals.

The epidemiological studies suffer from a lack of exposure measurements and a lack of a control group; they are often little more than symptom surveys. Two such surveys of American farmers working near electric fields were essentially negative (Dummsky et al, 1977; Busby et al, 1974) as was a French study (Strumza, 1970).

Stoops et al (1979) surveyed an occupationally exposed cohort and found no significant health effects in nervous system function, blood chemistry, cardiovascular function, or general physical well-being. In Sweden, Knave et al (1979) looked at a number of health measures but only found a difference between exposed and unexposed workers with respect to their fertility: exposed workers had fewer offspring and a lower percentage of male offspring. Other studies in Sweden found an increased frequency of chromosomal breakage in a few workers exposed to electromagnetic fields at a power substation (Nordstrom et al, 1981) and an increase in congenital anomalies among the offspring of these substation workers (Nordstrom et al, 1983).

Most relevant to the current study is a report from Italy of a reduction in serum testosterone among men exposed to strong electromagnetic fields generated by an electric current in a chloralkali plant (Saia et al, 1981). These men were, however, also exposed to mercury, and it was unclear which exposure caused the change in testosterone levels.

Far more literature is available on the effects of electric fields and the magnetic fields which inevitably accompany them on animals than on man. Only the effects of such fields on animal endocrinology and reproductive function are relevant to the proposed study.

The effects of electromagnetic field exposure on many of the major hormones have been measured in laboratory animals (Phillips et al, 1979). Possible effects have only been observed in three: corticosterone, melatonin, and testosterone. Different studies have reported the electromagnetic field exposure increases, decreases, and has no effect on corticosterone levels in animals (Hackman and Graves, 1981; Marino et al, 1976; Seto et al, 1982). Pineal melatonin levels were significantly reduced in rats exposed to 40 kV/m for 30 days (Wilson et al, 1981). Finally, serum testosterone levels were significantly reduced in rats after 12-day exposures to 100 kV/m (Free et al, 1981).

Several studies have examined the effects of weak electric fields on chicken-egg development with negative results (Durfee et al, 1975; Kreuger et al, 1975; Bankoske et al, 1976). At higher field strengths (100 kV/m) no effects of exposure on the reproductive ability, fertility, or mortality of rats and mice were demonstrated (Sikov et al, 1979; Knickerbocker et al, 1967).

To summarize, there is some evidence that electric field exposure has a range of physiological effects. It can effect endocrine function, and, more specifically, testosterone levels, in both exposed workers and laboratory animals. The mechanism for this endocrine effect is unclear, and it has yet to be adequately confirmed. It is also unclear whether the observed excess of chromosomal breakage, the reduction in fertility, and the increase in congenital anomalies among the offspring of men working in electric fields are related consequences of this exposure. It may be that the endocrine and genetic effects are both the result of exposing gonadal tissue to this form of energy. More human data is necessary to ascertain whether these effects are real.

The aluminum mills in Washington State house a large population of men with considerable occupational exposure to electromagnetic fields. Aluminum production is concentrated in Washington because of the plentiful supply of electricity which this industrial process requires. Men working aluminum "potrooms" work in close proximity to high-amperage currents and are thus exposed to magnetic fields on the order of 100 gauss. These men constitute an exposed population which can be utilized to study the effects of chronic, heavy exposures to magnetic fields. One outcome which appears to be effected by such exposure and is readily measured is serum testosterone.

### Methods

Twenty-six men were randomly selected from the potroom workers at the Kaiser Aluminum Plant in Tacoma. Twenty-three controls were selected from among the non-potroom hourly employees. Venous blood samples (3 cc) were drawn from each man, at a location convenient to the plant. Blood was refrigerated and carried to the University of Washington Hospital Laboratory for testosterone determinations.

## Results

(See Table and Figure) The mean testosterone in the exposed group was 5.26 ng/ml (standard deviation = 1.34 ng/ml). No association was found between number of years in the potroom and testosterone level. The average testosterone level was 5.23 ng/ml (standard deviation = 2.02 ng/ml) in the unexposed group. The laboratory reported that the average normal testosterone was 5.83 (standard deviation = 1.94, normal range = 1.9 to 9.7) based on 43 samples from normal volunteers not working at Kaiser.

The difference between the exposed and unexposed groups at Kaiser was small and not statistically significant. Neither Kaiser group differed significantly from the lab's group of normal men nor did the combined group of all Kaiser workers tested differ significantly from the lab normals. None of the 49 men tested at Kaiser had testosterone levels below the lower limit of normal.

## Discussion and Conclusion

We conclude from these results that exposures to static magnetic fields in the potrooms at Kaiser-Tacoma do not have a clinically significant effect on serum testosterone. The Kaiser men as a group did have slightly lower testosterone levels than the lab normals, but this difference could well have occurred by chance. This study cannot, however, rule out a small effect of magnetic fields on serum testosterone. A larger study would have more power to detect such small differences.

No changes in the workplace are indicated by this study.

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