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Report SAM-TR-75-51

by Stavinoha, et al.

GROWTH AND DEVELOPMENT OF NEONATAL MICE EXPOSED TO HIGH-FREQUENCY ELECTROMAGNETIC FIELDS

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NOTICES

This final report was submitted by the University of Texas Health Science Center at San Antonio, 7703 Floyd Curl Drive, San Antonio, Texas 78284, under contract F41609-74-C-0018, job order 7757-01-39, with the USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, and by personnel of the Radiation Physics Branch, Radiobiology Division, USAF School of Aerospace Medicine, under job order 7757-01-45. Dr. James W. Frazer (SAM/RAP) was the Laboratory Project Scientist-in-Charge.

The animals involved in this study were procured, maintained, and used in accordance with the Animal Welfare Act of 1970 and the "Guide for the Care and Use of Laboratory Animals" prepared by the Institute of Laboratory Animal Resources - National Research Council.

This technical report has been reviewed and is approved for publication.

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Four-day-old mice were exposed to high-frequency electromagnetic radiation. Growth rate was followed for up to 16 weeks of age. No effect of irradiation on the growth and development of these neonatal mice was evident.

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GROWTH AND DEVELOPMENT OF NEONATAL MICE EXPOSED TO HIGH-FREQUENCY ELECTROMAGNETIC FIELDS

INTRODUCTION

Quantitating the responses of biologic systems to radiofrequency (RF) electromagnetic radiation is very difficult. For the hazards of exposure to RF radiation to be assessed, sensitive indicators of biologic damage must be examined. One such indicator is the growth and development of neonatal animals, comprising a whole spectrum of physiologic and biochemical processes. Generally, the biologic effects of RF radiation are related to the amount of radiant energy transferred to a biologic system. Transfer of electromagnetic energy depends on the intensity, wavelength, and plane of polarization of the radiation and on the electrical properties of the absorbing medium.

Biologic effects of radiation have been classified as "thermal" and "nonthermal." Thermal effects occur indirectly by heat generation through interaction of RF energy with tissue components. Nonthermal effects occur from a direct interaction of electric or magnetic fields with biologic material.

There are many possible targets for an effect of RF radiation on growth and development. For example, Tolgskaya and Gordon (9) reported hypersecretion by the neurons of the hypothalamus as a result of exposure to RF radiation. A change in the secretion of the growth-hormone-releasing factor from the hypothalamus would alter secretion of growth hormone from the adenohypophysis, with a possible drastic effect on the animal's growth.

The studies reported on here were undertaken to investigate possible effects of electromagnetic radiation on the growth and development of neonatal rodents.

METHODS AND MATERIALS

For the initial studies, matings in our laboratory of Swiss Webster mice produced normal litters of approximately 14 pups. At 4 days of age the pups were segregated at random into groups, identified as to group and litter with tattoo ink, and weighed. After exposure in the USAF School of Aerospace Medicine (USAFSAM) exposure device, the pups were returned to the home litter. The exposure device has been described by Mitchell (7). It consists of a rectangular coaxial waveguide with a 2- x 9-meter aluminum-center conductor, terminating in a 50-ohm dummy load. It is driven by a pulsed National Radio Laboratories 40-kWp transmitter, which has a crystal-controlled frequency generator and a tuned power amplifier. Field measurements were made with monopoles constructed and calibrated by the National Bureau of Standards, Boulder, Colorado (3). Each exposure group received a 20-minute exposure by being placed in plastic containers on the center conductor. The measured electric field was approximately 5800 volts/meter. The animals were weighed daily to the nearest milligram for the next 21 days. Control groups were kept in similar containers outside the exposure chamber.

In the second study 20 female Swiss Webster mice in the 16th or 17th day of pregnancy were obtained from ARS Sprague Dawley (Madison, Wisconsin). They were housed individually in plastic cages and allowed water and Wayne Lab Blox food ad libitum. Only litters that contained 9 or more pups were considered large enough for subdivision and use; 11 of the 20 litters met this criterion. Four days after birth the individual pups were marked by a system that combines clipping part of the tail and different toes. Each litter was divided into three groups: (1) Control pups, kept in their individual cages; (2) Thermal-control pups, exposed to an environment of 37°C for 40 minutes for 5 consecutive days; and (3) Irradiated pups, exposed to RF radiation at 19 MHz for 40 minutes each day for 5 days in the USAFSAM near-field synthesizer. This simulator can generate nearly pure electric (E) and magnetic (H) fields. The E-field is generated by capacitor plates and the H-field in a multiple-feed ring (4). As measured by the National Bureau of Standards probes, the H-field was 55 amps/meter and the E-field was 8000 volts/meter, with E and H in coincident planes. During the treatment period, the pups were weighed each day before irradiation or thermal exposure. Weighing was continued every day until the pups were 21 days old, at which time males and females were segregated and placed in separate cages. Subsequently, the mice were weighed once a week for a total of 16 weeks.

RESULTS AND DISCUSSION

The results of the first study are shown in Figures 1 through 3. The growth rate in the mice did not differ at any of the frequencies used (10.5 MHz, 19.27 MHz, or 26.6 MHz).

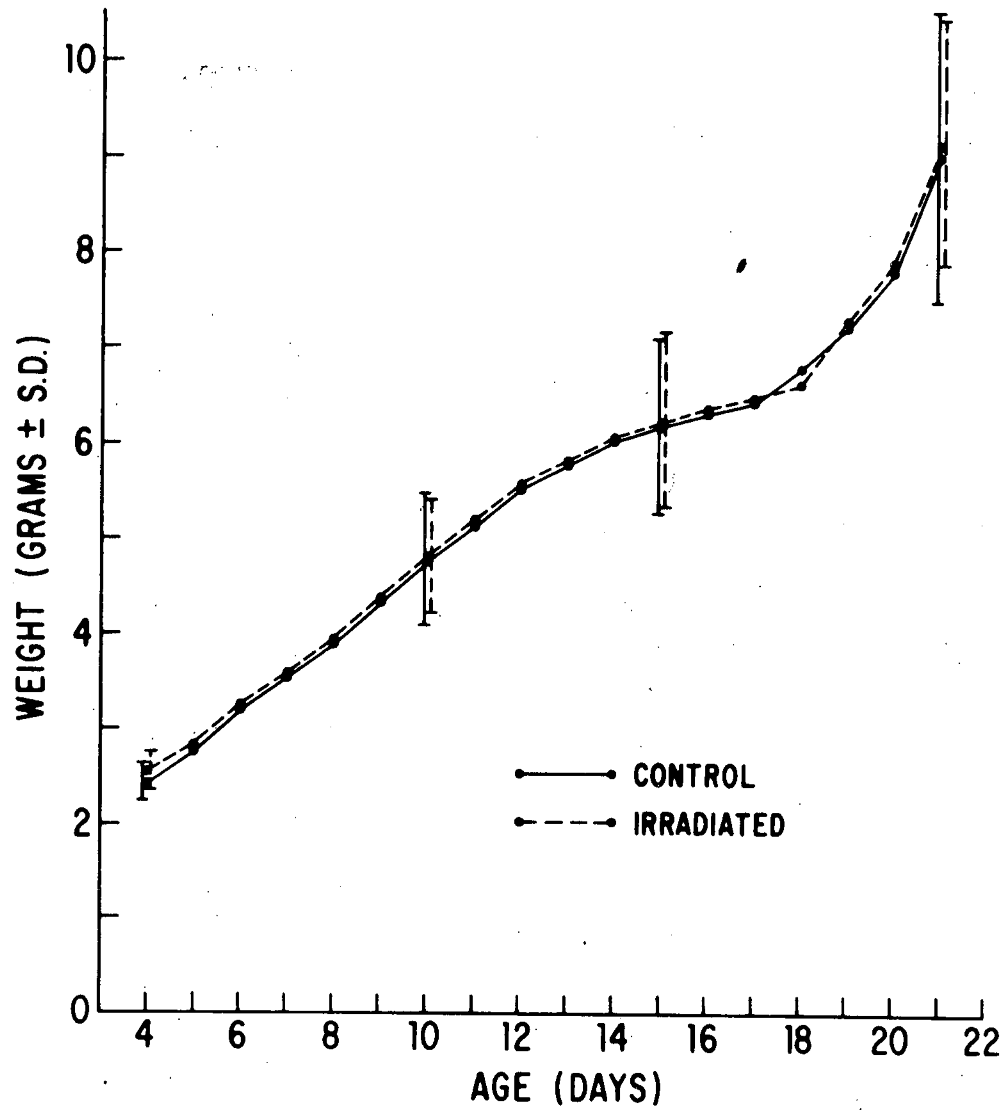

Figure 1. Growth of neonatal mice after a single 20-minute exposure to 10.5-MHz irradiation on the 4th day of life. The field intensity was 5800 volts/meter.

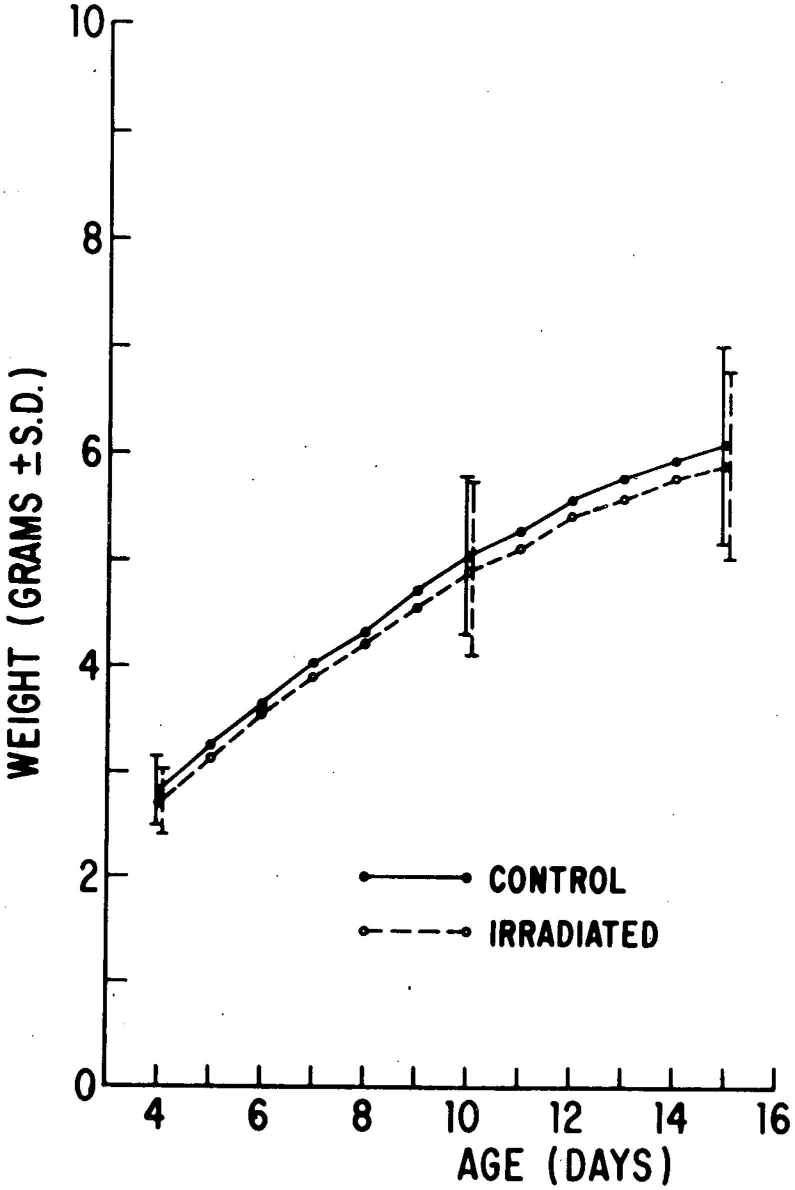

Figure 2. Growth of neonatal mice after a single 20-minute exposure to 19.27 MHz irradiation on the 4th day of life. The field intensity was 5800 volts/meter.

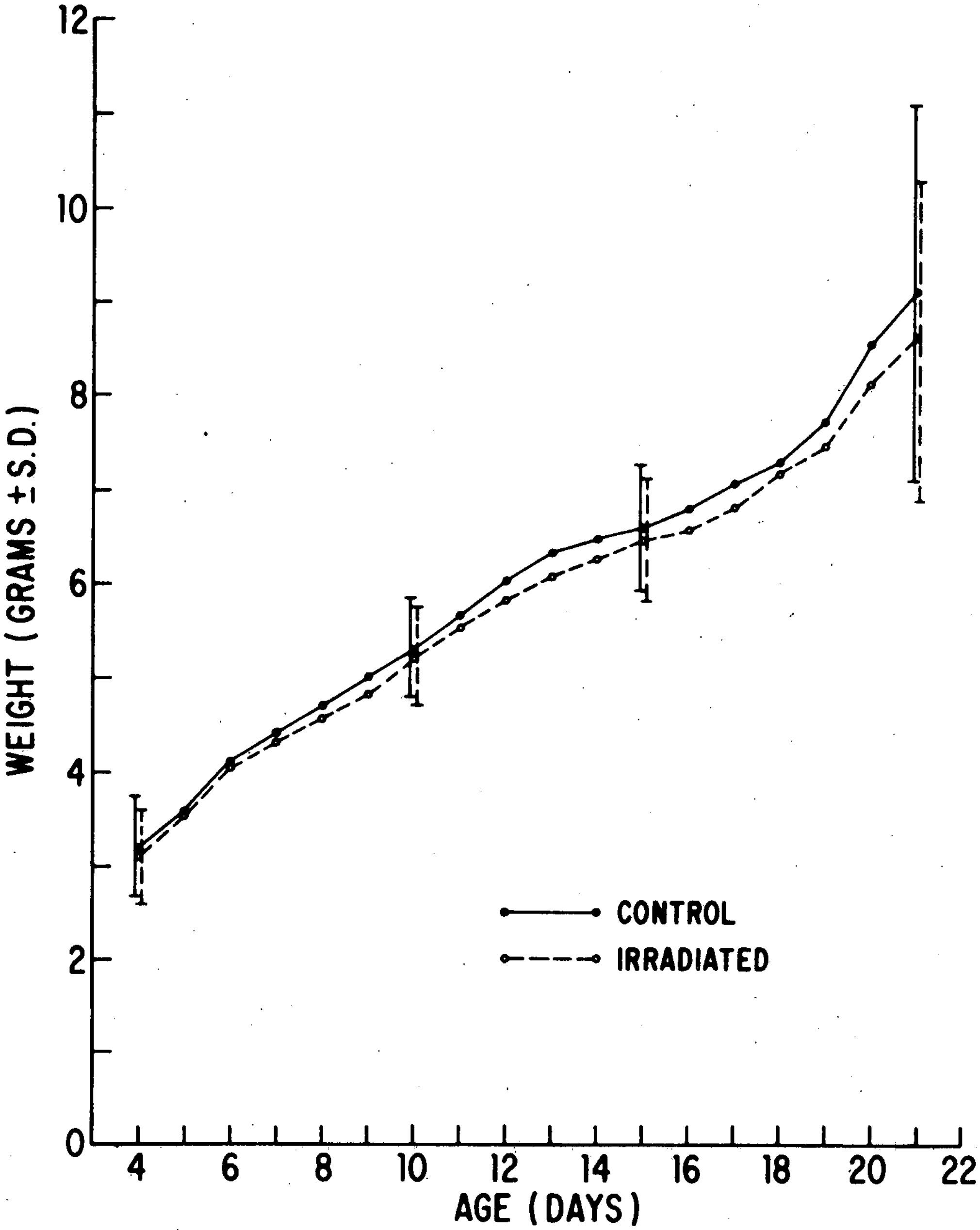

Figure 3. Growth of neonatal mice after a single 20-minute exposure to 26.6 MHz irradiation on the 4th day of life. The field intensity was 5800 volts/meter.

Growth curves for male and female mice from the second study are shown in Figures 4 and 5 respectively. The analyses of the growth data were based on calculation of the growth constants where α, β, and K were derived for each mouse by the method of Fabens (2). The equation used was:

$$W = \left[\alpha\left(1 - \beta_{\exp}{}^{-(Kt)}\right)\right]^3$$

where K = the growth rate constant

α^3 = final weight

β = related to birth weight

F-ratios from an analysis of variance for each constant indicated no statistical differences among groups.

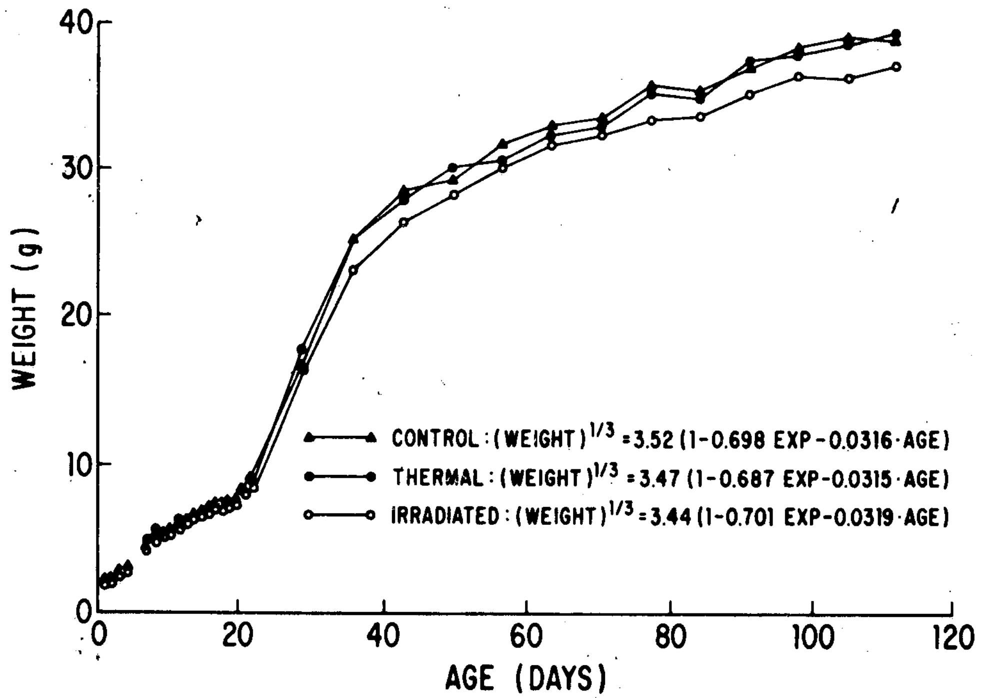

Figure 4. Growth curve of male mice. The irradiated group was exposed to 40 minutes of RF radiation for 5 days beginning at the 4th day of life. Irradiation was at 19 MHz with an H-field of 55 amps/meter and an E-field of 8000 volts/meter. There were 12-18 animals in each group.

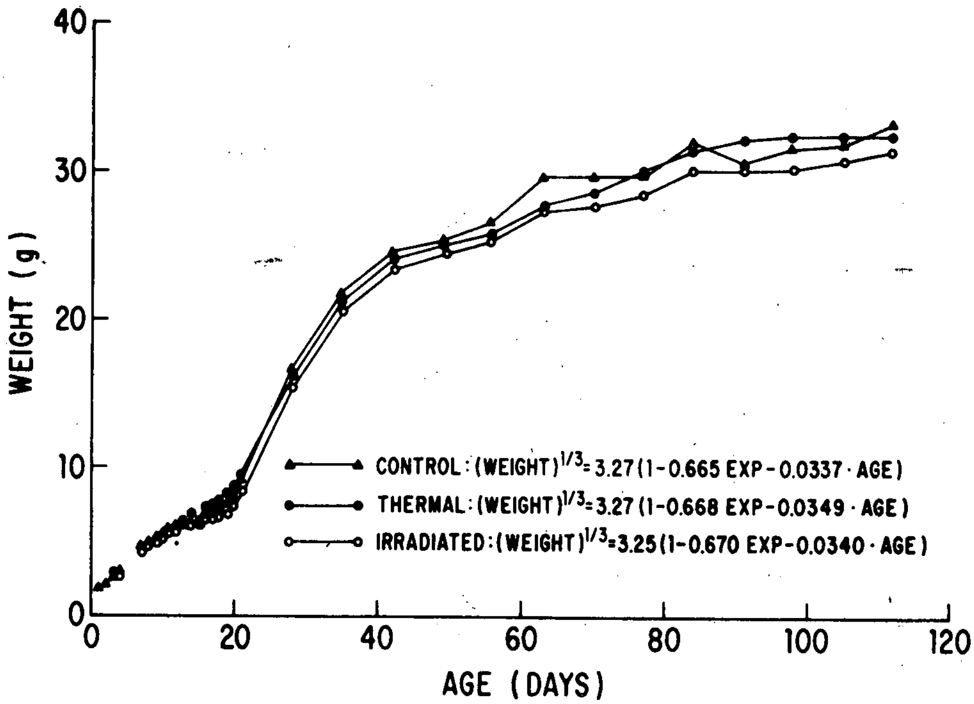

Figure 5. Growth curve of female mice. The irradiated group was exposed to 40 minutes of RF radiation for 5 days beginning at the 4th day of life. Irradiation was at 19 MHz with an H-field of 55 amps/meter and an E-field of 8000 volts/meter. There were 12-23 animals in each group.

There have been conflicting reports in the literature concerning the effect of nonionizing electromagnetic radiation on the growth of mice. In 1957, a report appeared purporting to show a stimulating effect of microwaves on growth (8). These data were later published in an article on the effects of acute and chronic microwave irradiation on mice (5). This study was repeated later, correcting what some of the original investigators believed were faulty experimental conditions and inadequate statistical treatment. The results of this repeated investigation show no effect of microwave irradiation on mouse growth (6).

A recent study has shown that very low frequency band (25 kHz) irradiation has no effect on the growth and development of neonatal mice (1). It appears then, from the data recorded in this report and from other work cited here, that nonionizing radiation at the frequencies used has no effect on neonatal mouse growth. It is realized, of course, that these tiny mice are much smaller than the wavelengths used and that their bodies probably absorbed only a relatively small amount of energy.

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