Effects Of 50 Hz Magnetic Field On Some Factors Of The Immune System In Male Guinea Pigs

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Citation

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Abstract

This study investigated the biological effects of 50 mega Hertz magnetic field (Hz MF) exposure on some Immunological factors (ACTH, cortisol and glucose levels) in male Guinea pigs. The capacity of 50 Hz Electromagnetic Fields (EMF) to interfere in the weakness of endocrine system has been a relevant fact into the scientific community, since we are more susceptible for this kind of exposure, in modern days. Sixty-day-old Guinea pigs, with average weight of 350 - 400 g were divided in to two groups. The test group received interferences of a variable EMF of 50 Hz, intensity 0.207μT, 4 hours a day, for a 5 consecutive days. What the control group received The weight, cortisol and blood glucose levels were measured before and after exposing the guinea pigs to EMF. The results showed that 50 Hz EMF acted on rats without any significant weight change, but affecting ACTH, cortisol and glucose levels in a significant way, 33.06% (p=0.033); 27.00% (p=0.004) and 56.23% (p= 0.014), respectively compared with that of the control group. The data suggests that EMF is able to change the serum levels of ACTH, cortisol and glucose, thus it is possible that it changes the endocrinological regulations.

INTRODUCTION

Over the past few years, considerable attention has been given to the potential biologicaleffects of magnetic field (MF). Epidemiological studies have suggested that MF may increase the risk of various types of cancer, including leukemia, brain and breast tumours. The characteristic biological effects of MF appear to be functional changes in the central nervous system, endocrine and immune systems (Ahlbom, 2001).

Electromagnetic fields (EMF) became increasingly a common constituent of the general and workplace environments early in the 20 th century, but some lifestyles and occupations are associated with more than the average amount of exposure to EMFs. Many patterns of exposure in the general and workplaceenvironments have been identified with increased intensity and duration of exposure to EMFs. The exaggerated rise on Na rates, K-ATPase, when the organism is subjected to EMF of 60 Hz, results in the increase of stress level on population subjected to this kind of produced radiation, mainly, by theproper home electrics or by workplace environment (Blank et al, 1995). There is conflicting evidence about whether exposure to ELF (define ELF) fields can directly alter the structure of DNA and chromatin. Most reviews have concluded that mutational and neoplastic transformation effects are not expected to happen (NRPB, 1994b; Tenforde, 1996). However, some reports suggest that ELF fields may cause direct effects on the DNA (Lai and Singh, 1997). Even so, the population is not free of the low frequency EMF action, radiated from household appliances (Armario et al, 1990).

During the last decade, many studies indicated the possible relations between different kinds of cancer, like child leukemia, brain tumors, lung cancer, breast cancer and lymphomas, among others and residential exposure to ELF magnetic fields (Balcer and Elizabeth, 1995; Erren, 1997; Loomis et al, 1994). Different epidemiological studies reported the risks of cancer related to exposure to EMF (50/60 Hz) from power lines (NRPB, 1994b; Savitz, 1993; Health, 1996; Stevens and Davis, 1996; Tenford, 1996). Similar studies reported the risk of adverse effects on human reproduction associated to EMF (Chernoff et al, 1992; Brent et al, 1993; Shaw and Croen, 1993; Tenford, 1996). Chernoff et al. (1992) reported significant early pregnancy loss from exposure to residential 50 Hz magnetic fields, but low numbers in the high-exposure group confounded the conclusions of the study. The truth is that, if it won't possible to confirm this correlation, it's not also conclusive the fact of that the electromagnetic waves are harmless when fall on live organisms, between a specific potency and frequency. Several reports have shown that exposure of rodents to ELF

magnetic fields reduces the production, secretion or both of melatonin from the pineal gland (Reviewed by Repacholi and Greenebaum , 1999). Exposure of rats for 42 days to circularly polarised magnetic fields (0.02 and 0.1μT) reduced both day-time and night-time melatonin levels by 20-25% (Kato et al, 1991; Bonhomme-Faiver et al, 1998).

The reduction on melatonin secretion and the increased release of ACTH and cortisol suggest that the exposed builds. Dumanshii (1976) presented the first study indicating that environmental exposure to power frequency (50 and 60 Hz), EMF might increase the risk of chronic disease – in this case mortality – from cancer in children. Three years later this study was followed by a report by Milham on the relationship between cancer and occupations with presumed exposure to EMF . These original studies have been followed by a substantial number of subsequent reports on various cancer diseases. To a certain extent these reports have confirmed the original findings, in particular with respect to childhood leukaemia (Health , 1996) . The established mode of interaction between EMF and humans is by means of induced currents, and sufficiently strong fields may result in acute health effects. Nevertheless, the epidemiological research has gradually expanded and has also come to include outcomes other than cancer, for examples neurodegenerative diseases, suicide and depression (Ahlbom, 2001). A study on Alzheimer's disease reported an apparent three-fold increase in risk for magnetic-field exposure (Sobel, 1996). The increase was attributable to a limited number of occupations that typically receive high exposure levels, such as swing machine operators. This author has also reported an association between exposure and amyotrophic lateral sclerosis. A several number of neurodegenerative diseases, including cancer, become difficult to characterize. It is observed that the most difficult thing resides on the impossibility of registering the neurological injuries, cancer and other appeals (De Boer, 1990; Lai and Singh, 1997 ; Lerchl et al , 1997 ; Loescher et al , 1993).

MATERIALS AND METHODS

ANIMALS

Male Guinea pigs (Pasteur Institute, Iran) weighing 350-400g at the time of experiments were housed at 25°C in a cage (five per cage?) under a 12/12 h light/dark cycle, with free access to food and water. Guinea pigs (n=12) in the test group were exposed to MF (0.207?T -50 Hz; 4h/day) for 5 consecutive days. Control and treated animals were sacrificed under light anesthesia (halothane 2.5%, in air).

EXPOSURE SYSTEM

The control group A (n=15) and the exposed group B (n=15) were housed in six standardised cages (five animals per cage, 120 cm length, 90cm width and 50 cm height) put on supports made in polystyrene with 135cm width, 110cm length and 135cm height, every cages located in the same room. Not clear. The group B, was exposed to EMF of 50 Hz, senoidal, of 0.207μT, measured by a gaussimeter, on the scale of 0-100 mG, four hours a day; two hours in the morning from 8:00h to 10:00h and two hours in the afternoon from 14:00h to 16:00h, for 5 consecutive days. It was used, as radiation fonts, transformers of 220/110 volts of 500 VA, working with opened secondary, and controlled by an electronic timer, connected to a tension estabilizator. Control animals were accomplished by simply leaving the transformers from the polystyrene supports not clear. The transformers, put on under the polystyrene supports, were previously examined and tested at Department of Biology – University of Urmia to confirm their working parameters. The electromagnetic field was measured inside the cage and it kept constant independent of the position. Not clear It should be noted that, except for the weekly cage cleaning, the rats were not moved or handled during this experiment. The animals were weighed at the first day of experiment and at the 5th day using a mechanic balance. On the terminal day of the experiment, at the 6th day, all animals were anaesthetized with ethylic ether. Three milliliter of blood was taken by cardiac puncture and the serum was separated (from 8 to 9h in the morning).

METABOLIC ASSESSMENT

Serum concentration of ACTH was measured by quimiluminescent reaction, using the ACTH Immulit kit, DPC name? (USA) and the Immulit equipment, DPC (USA).

Serum concentration of cortisol was measured by radioimunoassay technique (RIE) using the cortisol coat-A-count kit, DPC (USA) and the analysis was made in a gama meter of scintillation, auto-gamma, CobraII (Packard a Camberra Company), at the Departamento de Fisiologia da UFPE. Serum glucose levels were measured by the glucose oxidase method using the PAPglucose kit – Labtest Diagnostic – Iran. Every measure was done duplicated. Physical Weight (g)

STATISTICAL ANALYSIS

Data were analyzed using Stat SPSS software (Version 12). The results were expressed as means ± SEM and comparison of two means was made using Student's t-test. A value of $p <$

0.05 was considered significant.

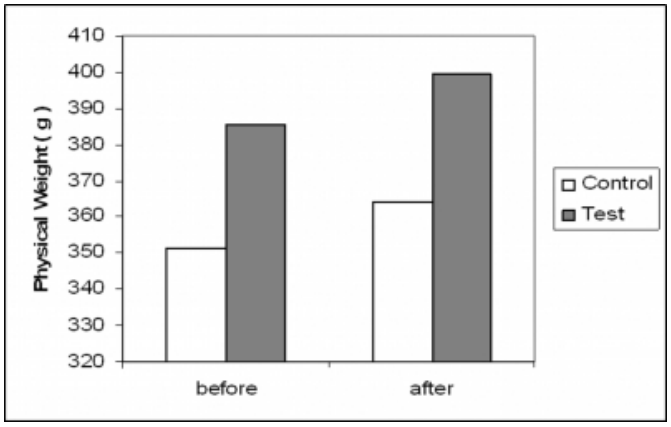
RESULTS

PHYSICAL WEIGHT

The results show that the initial body weight average of control group (n=15) was 351.33±0.23g and the final average was 364.23± 0.54 g, while the initial body weight average of exposed group (n=15) was 385.34±1.34g and the final average was 399.45± 0.12g. The fig.1, shows that exposure to electromagnetic radiation did not cause any significant alteration in body weight when compared to the control group.

Figure 1

Figure 1: Determination of body weight, in g, of control animals and exposed animals to electromagnetic (test), before and after 5 exposure days. The results obtained are the average ± standard detour (SD). N=15, p=0.021.

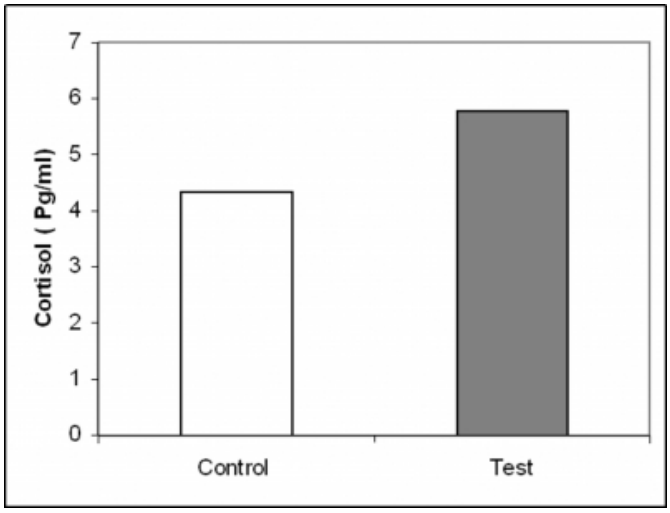


CORTISOL CONCENTRATION

The results showed that the initial concentration of cortisol in the control group (n=15) was 4.33±0.02 pg/ml while in the exposed group (n=15) it was 5.78±0.11 pg/ml> The serum cortisol concentration, after 5 exposure days, in the exposed group, showed an increase of 27% when compared to group A (p=0.004), fig 2. (x10 $^{-4}$)

Figure 2

Figure 2 : Determination of cortisol serum concentration in pg/ml of control animals and exposed animals to EMF. The results obtained are the average ± standard detour (SD). N=15 p=0.004.



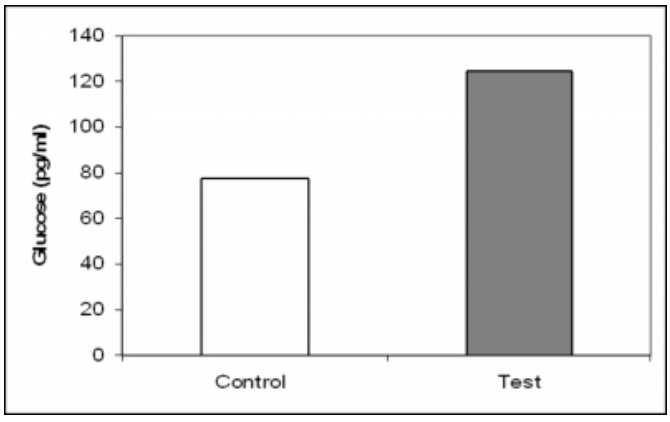
GLUCOSE SERUM CONCENTRATION

In relation to glucose serum concentration after the exposure to electromagnetic radiation, results showed that the average of control group (n=15) was 77.66±9.32

Mg/ dL while the average of exposed group (n=15) was 124.16±8.05 and at the exposed group it was observed an increase of 56.23%, when compared to control group, in a significant way (p=0.014), fig.3. (x 10 $^{-4}$)

Figure 3

Figure 3: Determination of glucose serum concentration in mg/dl of control animals and exposed animals. The results obtained are the average ± standard deviation (SD). N=15 p=0.014.



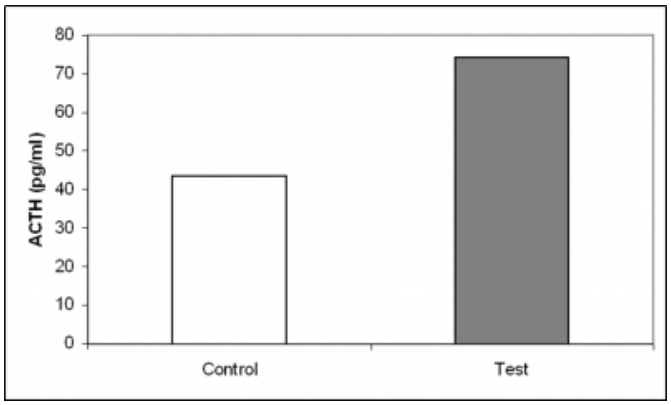
ACTH LEVEL

The Fig. 4 shows that the exposure to electromagnetic radiation causes an increase of more than 33. 06% in ACTH

level of group B (n=15) compared to group A. It is observed that the average of control group (n=15) was 45.33±1.66 pg/ml while the average of exposed group (n=15) was 77.23±5.23 (n=15), presenting a degree of significance of p=0.033.

Figure 4

Figure 4: Determination of ACTH serum concentration in pg/ml of control animals and exposed animals to EMF. The results obtained are the average ± standard deviation (SD). N=15 p=0.033



DISCUSSION

Male normal Guinea pigs were exposed to EMF of 50 Hz, senoidal of 0.207μT, four hours a day for 4 days. The animals were maintained in normal conditions of lighting (day and night), environment temperature varying from 26º to 30º C and with water and food ad libitum. The exposed animals presented lifelong similar to the control animals, as well as the body weight average of exposed group is comparable to control group in this study. The choice of intensity of 0.207μT was because of the necessity in using a higher intensity than in residences and most work-places, the average 50/60 Hz magnetic fields are between 0.1 and 0.3μT (NRPB, 1994b), so that it was used a value ten times higher than the maximum value expected, by the fact of that depending on the distance between the conductors and ground, and magnetic flux densities can average 22μT, depending on the current load in the line (Siomn, 1992) and this value could depend on also the geographic location of the kind of magnetic material near the area.

In our experiment, the animals subjected to EMF did not show any statistical difference in relation to the body weight when compared to the animals of control group that is in agreement with Bonhomme – Fraive's study (1998) which reports that Swiss mice, continuously exposed to ELF of 50Hz and 50μT for 350 days, at different study times, showed no significant difference in body weight between the exposed and unexposed animals. However, Wilson et al (1999) shows that animals exposed to SL (short-light, 8h light: 16h dark) and a steady state 60 Hz magnetic field for 3h/day for 42 days resulted in a statistically significant reduction in body weight, compared to sham-exposed SL animals. Nevertheless, it seems to us that this reduction in body weight is more associated with the absence of light than the exposure to EMF. The reason for measuring the cortisol serum concentration in this experiment was because the cortisol is well known as being a stress indicator (Marti and Armario, 1997 ; Radon et al, 2001).

In our study we observed a statistically significant increase in serum cortisol concentration in the exposed animals when compared to control group, the same occurring with the serum ACTH levels, indicating that the exposure to EMF of 50Hz, in spite of being considered a low frequency, it is capable to stress the organism. This result is

in agreement with Tenforde's study (1996), when exposure of monkeys produced an increase in urinary corticoids which lasted about 6 days, after which the corticoid levels returned to baseline despite continued exposure to the field. Rephrase! In another study, a similar effect on corticoids in rats persisted for 4 months (Dumanshii, 1976). Our results also confirm the Stevens' hypothesis (Stenvens and Davis, 1996) that suggests that field exposure have effects not on melatonin, but also on the reproductive hormones and the immune system. In other way, some reports indicate that acute exposure for one night to a linearly polarized magnetic field at 10μT has no effect on hormonal or immune parameters in healthy male volunteers (Selmaoui et al., 1996b). This result could not be used as a parameter to our studies, because they worked with acute exposure, only one night, while our animals were exposed for five consecutive days, characterizing a chronic exposure or stress. According to Radon, et al (2001), human exposure to EMF does not cause any alteration on cortisol concentration, however, once again, it is difficult to compare with our findings, because we used high frequency EMF and for much shorter time.

In our study the serum glucose concentration also had a significant increase on the exposed group when compared to control group, in accordance with Armario; Martí; De Boer et al (1990); Marti and Armario (1997), which shows that repeated stress is associated with the sensitivity of glucose, inducing hyperglycaemia. Obtained data in this experiment make us to believe that the EMF of 60Hz, in spite of being a low frequency EMF, activates the hypothalamic-hipophyse-adrenal axis with consequent increase on cortisol and

glucose characteristic of immune depressed patient. In spite of the obtained data confirm our point of view and many published papers', we believe that many experiments are still necessary, with the purpose of explaining which frequency, intensity, exposure time and other parameters involved with the EMF, to protect us from harms that life can cause to us (Selmaoui et al, 1997 ; Simon et al ,1992 ; Welker et al ,1983 ; Wilson et al , 1981 ; Wilson et al , 1999 ; Yellon, 1996). Not convincing!

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References

r-0. Ahlbom, A., 2001. Neurodegenerative Diseases, Suicide and Depressive Syntoms in Relation to EMF.Bioelectromagnetics Supplement, Stockolm, Sweden, 5:132-143.
r-1. Armario, A.,J.Marti , and M.GIL,1990. The Serum glicose response to acute estresse is sensitive to the intensity of the stressor and to habituation. Psychoneuroendocrinology, 15:341-347.
r-2. Balcer, K., and K. Elizabeth, 1995. Gene Expression Flowing 60-Hz Magnetic Field Exposure. Enviromental Health Perspectives, Boston, MA, p. 18-22, June.
r-3. Blank, M., L. Soo, and V.Papstein, 1995. Efeito dos campos magnéticos de baixa freqüência na atividade do Na, K-ATPase. Bioelectrochemistry and Bioenergetics, 38:267-273.
r-4. Bonhomme-Faiver, L.,A.Mace,Y.Bezie,S.Marion,G.Bindoula,A.M. Szekely,N.Frenois,H.Auclair,O.S.Arbouys, and E.Bizi,1998. Alterations of biological parameters in mice chronically exposed to low-frequency (50 Hz) electromagnetic fields. Life Sciences, 62(14): 1271-1280.
r-5. Brent, R.L.,D.A.Beckman, and C.P.Landel,1993. Clinical teratology. Curr. Opin. Pediatr., 5:201-211.
r-6. Chernoff, N., J.M. Rogersm, and R. Kavet, 1992.A review of the literature on potential reproductive anddevelopmental toxicity of electric and magnetic fields. Toxicology, 74: 91-126.
r-7. De Boer, S.F.,S.J.Koopmans,J.L.Slangen, and V.J.Gugten,1990. Plasma catecholamine, corticosterone and glucose responses to repeated estresse in rats: effect of interstressor interval length. Physiol Behav, 47: 1117-1124.
r-8. Dumanshii, U.D., 1976. Hygienic evaluation of electromagnetic field generated by high-voltage power lines. Gigyena I Sanitariya, 8:19-23.
r-9. Erren, T. C., 1997.Epidemiologic studies of EMG and breast cancer risk: a biologically based overview. In: The melatonin hypothesis: breast cancer and the use of electric power. Columbus: Battelle Press.
r-10. Health, C.W.,1996. Electromagnetic field exposure and cancer: a review of epidemiological evidence. Cancer J. Clin, 46:29-44.
r-11. Juutilianem, J.,P.; Matilainen, S.Saarikoski, E.Laara and S.Suoniio,1993. Early pregnancy loss and exposure to 50-Hz magnetic fields. Bioelectromagnetics, 14:229-236.
r-12. Kato, M., K.I. Homna, T.Shigemitsu, and Y.Shiga , 1991. Effects of exposure to a circularly polarized, 50 Hz magnetic fields on melatonin levels in rats. Bioelectromagnetics, 14:97-106.
r-13. Lai, H., and N.P. Singh , 1997. Melatonin and a spin-trap compound blocked radiofrequency, radiation induced DNA strand breaks in rat brain cells. Bioelectromagnetics, 18: 446-454.
r-14. Lerchl, A., K.O. Nonaka, and R.J.Reiter , 1997 . Marked rapid alterations in nocturnal pineal serotonin metabolism im mice and rats exposed to weak intermittent magnetic fields. Biochem Biophys Res Commun, 169:102-108.
r-15. Loescher, W., M. Mevissen, W.Lechmacher ans A.Stamm,1993. Tumor promotion in a breast cancer model by exposure to a weak alternating magnetic field. Cancer Lett, 71:75-81.
r-16. Loomis, D. P., D.A. Savitz, C.V.Ananth, 1994.Breast cancer mortality among female electrical workers in the United States. J Natl Cancer Inst, 86:885-886.
r-17. Marti, O., and A. Armario, 1997. Influence of exposure to chronic estresse on the pattern of habituation of pituitary-adrenal hormones, prolactin and glucose. Stress, 1:179-189.
r-18. National Radiobiological Protection Board, 1994b. Electromagnetic fields and risk of cancer: Supplementary report by the Advisory Group on Non-ionizing Radiation of 12 April 1994. Radiol. Prot. Bill., 154:10-12.
r-19. Radon, K., D. Parera, D.M.Rose, D.Jung, and L.Vollrath , 2001. No effects of pulsed radio frequency electromagnetic fields on melatonin, cortisol and selected markers of the Immune system in man. Bioelectromagnetics, 22:280-287.
r-20. Repacholi, M.H., and B.Greenebaum , 1999. Interaction of static and extremely low frequency electric and magnetic fields with living systems: health effects and research needs. Bioelectromagnetics, 20:133- 160.
r-21. Savitz, D.A.,1993. Overview of epidemiological research on electric and magnetic fields and cancer. Am. Ind. Hyg. Ass. J., 54:197-204.
r-22. Selmaoui, B., A. Bogdan , A.Auzeby, J. Lambrozo, and Y.Touitou , 1996b. Acute exposure to 50 Hz magnetic field does not affect hematologic or immunologig functions in healthy young men. Bioelectromagnetics, 17:364-372.
r-23. Selmaoui, B.,J.Lambrozo , and Y.Touitou , 1997. Endocrine functions in young men exposed for one night to a 50 Hz magnetic field. A circadian study of pituitary, thyroid and adrenocortical hormones. Life Science, 61:473-486.
r-24. Shaw, G.W., and L.A.Croen, 1993. Human adverse reproductive outcomes and electromagnetic fields exposures: review of epidemiologic studies. Environ. Health Persp, 101:107-119.
r-25. Simon, N.J.,1992. Biological effects of static magnetic fields: a review. International Cryogenic Materials Comission, Boulder, Colorado, p.284.
r-26. Sobel, E., 1996. Eletromagnetic field exposure may cause increased production of amyloid beta and eventually lead to Alzheimer`s disease (hypothesis). Neurology, 47:1594-1600.
r-27. Stenvens, R.G., and S. Davis , 1996. The melatonin hypotheses: electric power and breast cancer. Environ. Health Persp., 104(1): 135-140.
r-28. Tenforde, T.S.,1996. Interaction of ELF magnetic fields with living system. In: Polk, C.; Postow, E., eds. Biological effects of electromagnetic fields. Boca Raton, FL: CRC Press; PP:185-230
r-29. Welker, H.A.,P.Semm, R.P.Willing, J.C.Commentz , W.Iltschko , and L. Vollrath , 1983.Effects of an artificial magnetic field on serotonin N-acetyl transferase activity and melatonin content of the rat pineal gland. Exp Brain Res. 50:426-432.
r-30. Wilson, B.W., L.E. Anderson, D.I.Hilton nad R.D.Phillips,1981. Chronic exposure to 60-Hz electric

fields: Effects on pineal function in the rat. Bioelectromagnetics, 2:371-380.
r-31. Wilson, B.W., K.S. Matt, J.E.Morris , L.B.Sasser , D.L.Miller and E.A. Larry , 1999. Effects of 60 Hz Magnetic Field Exposure on the Pineal and Hypothalamic-Pituitary-Gonadal Axis in the Siberian Hamster (Phodopus Sungorus). Bioelectromagnetics, 20;224-232.
r-32. Yellon, S. M., 1996. Acute 60 Hz magnetic field exposure effects on the melatonin rhythm in the pineal gland and circulation of the adult Djungarian hamster. J Pineal Res, 16:136-144.

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