Influence of electromagnetic radiation on animal spermathogenesis in conditions of cold stress

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Summary

The current ecological situation is characterized by a possible combination of influence of some factors. Numerous studies show that the combined effect of various environmental factors differs from their isolated effects. Nowadays the combined effect of physical factors is quite common. EMR is known to be a rather significant factor, often accompanied by such an anthropogenic factor as positive low temperature. Such conditions may lead to various pathological states, so the study of the combined effect of these two factors is important.

The article contains results of morphological investigations of the influence of electromagnetic radiation of industrial frequency when combined with positive low temperature on the reproductive system of laboratory animals. We have studied the morphological stucture of testes of the animals exposed to a combined effect of EMR and a positive low temperature and revealed substantial changes. Our investigation showed alterations in the histological structure of the testes, which indicate a loss of spermatogenic function.

Keywords:

cold factor, electromagnetic radiation, morphological changes, testes, animals organism.

Introduction

Numerous studies show that the combined effect of factors of a diverse nature is significantly different from the isolated effects of these factors [1,2,3]. The wide use of industrial technologies and household appliances, which is accompanied by the generation of electromagnetic radiation (EMR), creates a potential possibility for its influence on the human body in everyday life as well as at the workplace [4,5,6]. The literature data shows that EMR has a different biological activity. Such systems as nervous, cardiovascular, sexual, endocrine, and immune suffer at the highest degree [7,8,9,10,11,12]. Despite a large number of studies, there is still no generally accepted theory of the effect of EMR on the body, its nature and the mechanisms of action on physiological systems. This may be attributed to the fact that EMR never acts as a monofactor. It is often accompanied by the effect of positive low temperatures. Cold stress induces the activation of the most important regulatory systems in order to maintain a constant body temperature [13,14]. Thus, we have chosen the combination of EMR and a positive low temperature for the experimental study.

The establishment of regularities of the interaction of the organism with environmental factors and the development of adequate measures to prevent the possible adverse effects of subsequent research should also be based on objective criteria of harm. The latter include morphological indices that objectively reflect the morphofunctional state of organs and systems of the organism exposed to environmental factors.

The objective of the study

The purpose of our research was to study the nature of morphofunctional changes of the reproductive function of laboratory animals under the conditions of the combined effect of EMR and a positive low temperature.

Matherials and methods

The experiment was conducted in the exposure chamber equipped with a thermoelectric cooling device connected to a low frequency signal generator (GZ-109).

The experiment was carried out for 30 days on 30 mature male rats. The animals were divided into 3 experimental groups, 10 rats in each: the first group of animals was exposed to a combined effect of electromagnetic radiation (frequency 70 kHz, tension 600 V/m) at a comfortable air temperature of 25±2°C; the second group was kept under conditions of isolated exposure to a positive low temperature 4 ± 2°C; group 3 - the control group - was kept at the comfortable temperature conditions. Expositions were carried out 5 times a week (for 4 hours every day). In order to reveal morphological changes the material was fixed in a 10% aqueous solution of neutral formalin, subjected to alcohol and paraffin processing; sections 4-5 μm thick were made. The visual preparations were stained with hematoxylin and eosin. Studies of microscopic preparations were carried out using microscope "Olympus" BX-41.

Results

The results of morphological studies in the control group showed the generation of spermatogenic cells at different stages of maturation in the seminal glands.

Sertoli's cells are numerous (Figure 1).

Connected tissue between the tubules contains blood vessels, nerves and Leydig's cells in sufficient quantity.

Figure 1 - The morphological changes of testes in the control group

In conditions of isolated influence of positive low temperature, the spermatogenic epithelium layer was greatly expressed in the spermatic glands, spermatogenous cells and Sertoli's cells were numerous (Figure 2).

Between the seminiferous tubules, the blood vessels of the microcirculatory bed and Leydig's cells were determined.

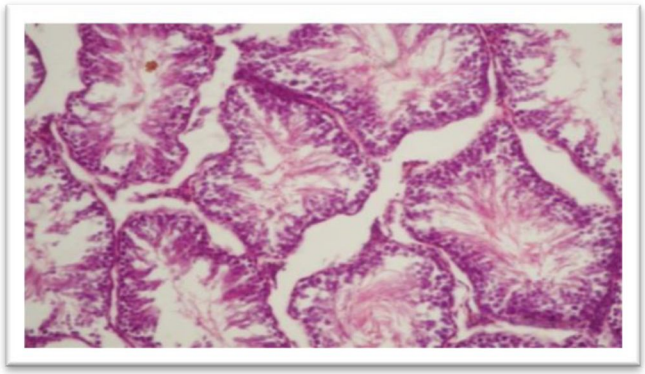

Figure 2 - The morphological changes of testes in the group exposed to isolated effect of a positive low temperature

The rats subjected to the combined effect of EMR and positive low temperature showed significant changes in the histological structure in the testes, which contributed to a loss of spermatogenic function. Objectively: channels were reduced in size due to the exhaustion of spermatogenous cells; no spermatozoa and sperm have been identified, sometimes spermatocytes were absent. There were dystrophic and non-fibrotic changes in stored cells (Figure 3). Sertoli's and Leydig's cells have not undergone any visible changes.

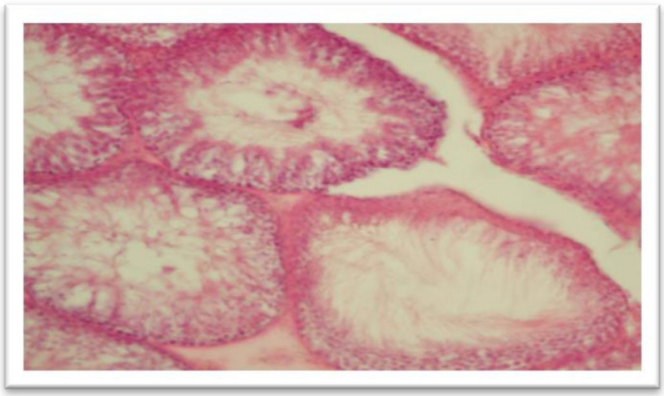

Figure 3- The morphological changes of testes in the group exposed to combined action of EMR and a positive low temperature

Discussion

A study of testes of rats showed that the isolated effect of the cold factor did not lead to changes in the morphological structure of the testes of animals, in contrast to the combined effect of electromagnetic radiation and a positive low temperature. The group of combined effects had significant histological changes in the spermatogenic epithelium, which indicate the development of a gonadotropic effect. Such results give us the opportunity to assume that the greatest influence among exogenous factors had electromagnetic radiation. These effects require consideration when setting the measures for the normalization of unfavorable factors exposure as well as the development and implementation of preventive measures, since the reproductive system was proved to be vulnerable to the negative effects of a complex of ecological factors. Identified morphological changes that may be accompanied by a functional impairment of the reproductive function may contribute to the development of male subfertility and infertility, as well as mutations in the sex cells which could be passed on to the next generations, encumbering the gene pool of the population.

Conclusion

In the morphological study of testes of the animals exposed to the combined effect of EMR and a positive low temperature, we have established changes in the histological structure of the seminal glands, which indicate a loss of spermatogenic function.

Morphology of testes of the animals exposed to a combined effect of EMR and a positive low temperature demonstrated the changes in the histological structure of the seminal glands, which indicated a loss of spermatogenic function.

The comparison of the isolated effect of a positive low temperature and its combination with EMR suggests that the EMR had the greatest influence according to the alterations in the morphological structure of the testes. Therefore, such results strongly denote the disorder of spermatogenesis in the laboratory animals.

Reference

[1] Pellerin N, Candas V (2003) Combined effects of temperature and noise on human discomfort. Physiol Behav 78(1): 99-106

[2] Ezenobi NO, Okpokwasili GC (2016) Research article combined effect of temperature and Ph on pseudomonas aeruginosa from a cosmetic product. International Journal of Current Research 8(8): 37124-37130

[3] Malik AH, Kuktaite R, Johansson E (2013) Combined effect of genetic and environmental factors on the accumulation of proteins in the wheat grain and their relationship to bread-making quality: Journal of Cereal Science 57(2) 170-174

[4] Hardell L, Sage C (2008) Biological effects from electromagnetic field exposure and public exposure standards. Biomed Pharmacother 62(2): 104–109

[5] Institute of Electrical and Electronic Engineers Inc (IEEE). IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz; IEEE: Piscataway, NJ, USA, 2006.

[6] Spitzer M (2014) Information technology in education: Risks and side effects. Trends Neurosci Educ 3: 81–85. doi: 10.1016/j.tine.2014.09.002.
[7] Hardell L (2017) World Health Organization, radiofrequency radiation and health - a hard nut to crack (Review). International Journal of Oncology 51(2): 405-413. doi:10.3892/ijo.2017.4046.
[8] International Agency for Research on Cancer . Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields. WHO Press; Lyon, France: 2013. IARC monographs on the evaluation of carcinogenic risks to humans, Volume 102.
[9] Maziarz A, Kocan B, Bester M, Budzik S (2016) How electromagnetic fields can influence adult stem cells: positive and negative impacts. Stem Cell Res Ther 7(1): 54
[10] Yakymenko I, Tsybulin O, Sidorik E, Henshel D, Kyrylenko O, Kyrylenko S (2016) Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation. Electromagn Biol Med 35: 186–202. doi: 10.3109/15368378.2015.1043557.
[11] Dasdag S, Taş M, Akdag MZ, Yegin K (2015) Effect of long-term exposure of 2.4 GHz radiofrequency radiation emitted from Wi-Fi equipment on testes functions. Electromagn Biol Med 34: 37–42. doi: 10.3109/15368378.2013.869752.
[12] Ross CL, Harrison BS (2015) An introduction to electromagnetic field therapy and immune function: a brief history and current status. J. of Science and Applications: Biomedicine 3(2): 18-29. Retrieved from: http://inter-use.com/uploads/soft/150302/1-150302163S4.pdf
[13] Castellani JW, Tipton MJ (2015) Cold Stress Effects on Exposure Tolerance and Exercise Performance. Compr Physiol 6(1): 443-69. doi: 10.1002/cphy.c140081.
[14] Cannon B, Nedergaard J (2011) Nonshivering thermogenesis and its adequate measurement in metabolic studies. The Journal of experimental biology 214: 242-253

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