

Millimeter Wave Therapy Publications Review

Low-intensity Millimeter Waves in Biology and Medicine

O. V. Betskii

N. N. Lebedeva

Conclusions

Summarizing the results of the 30-year study of biological effects of low-intensity MM waves, we may ascertain the following. As it often happens, applied research and commercialization have outdistanced fundamental investigations. The wide application of MM waves in medicine, biotechnology, animal husbandry, and plant cultivation has taken a giant step forward. By this time, Russia has manufactured more than 10,000 MM-wave therapy devices, organized more than 2,500 MM-wave therapy rooms, and treated over 2,500,000 patients. Since 1992, twenty-seven volumes of the Journal on Millimeter Waves in Biology and Medicine (*Millimetrovye Volny v Biologii i Meditsine*) have been published as well as 12 symposia on Millimeter Waves in Biology and Medicine and 11 workshops have been held. During this time, we have issued 13 volumes of symposium and workshop proceedings, 4 monographs, 3 popular scientific brochures, and more than 2,600 articles. Furthermore, our scientific attainments have been protected by 22 Russian Federation patents. In the year 2000, we were awarded the Russian Federation State Prize in Science and Technology for our research in this field of science.

However, scientists—biophysicists, physiologists, and physicians—carry on their further scientific investigations into the mechanism of biological effects. By now, they have approached a more complete understanding of the role of low-intensity MM-wave radiation in the vital processes of biological systems at different organization levels.

Source

Institute for Radio Engineering and Electronics of the Russian Academy of Sciences, Moscow, Russia

Institute for Higher Nerve Activity and Neurophysiology of the Russian Academy of Sciences, Moscow, Russia

Attachment

Size

[Low-intensity Millimeter Waves in Biology and Medicine.doc](#) 163 KB

Reactions of Keratinocytes to In Vitro Millimeter Waves Exposure

2001

Imre Szabo

Mikhail A. Rojavin

Thomas J. Rogers

Marvin C. Ziskin

Abstract

The effects of millimeter waves (MW) on human keratinocytes were studied in vitro using the HaCaT keratinocyte cell line. MW-induced modulation of keratinocyte function was

studied in proliferation, adhesion, chemotaxis, and interleukin-1beta (IL-1beta) production assays. Spontaneous proliferation, adhesion to tissue culture plate, random migration, and IL-8- and RANTES induced chemotaxis were not affected by exposure of cells to millimeter waves under the following conditions: frequency, 61.22 GHz; SAR, 770 W/kg; duration of exposure, 15-30 min. However, MW irradiation resulted in a modest but statistically significant increase in the intracellular level of IL-1beta. These data suggest that exposure of human skin (with keratinocytes being the major component of epidermis) to MW can cause activation of basal keratinocytes resulting in an elevated level of IL-1beta production.

Attachment	Size
Reactions of Keratinocytes to In Vitro Millimeter Wave Exposure.pdf	111.2 KB

Links:

[PMID: 11424160](#)

Bioelectromagnetics 22:358–364, 2001

Millimeter waves: Acoustic and electromagnetic

2012

Marvin C. Ziskin

Abstract

This article is the presentation I gave at the D'Arsonval Award Ceremony on June 14, 2011 at the Bioelectromagnetics Society Annual Meeting in Halifax, Nova Scotia. It summarizes my research activities in acoustic and electromagnetic millimeter waves over the past 47 years. My earliest research involved acoustic millimeter waves, with a special interest in diagnostic ultrasound imaging and its safety. For the last 21 years my research expanded to include electromagnetic millimeter waves, with a special interest in the mechanisms underlying millimeter wave therapy. Millimeter wave therapy has been widely used in the former Soviet Union with great reported success for many diseases, but is virtually unknown to Western physicians. I and the very capable members of my laboratory were able to demonstrate that the local exposure of skin to low intensity millimeter waves caused the release of endogenous opioids, and the transport of these agents by blood flow to all parts of the body resulted in pain relief and other beneficial effects.

Attachment	Size
Millimeter Waves Acoustic and Electromagnetic.pdf	319.18 KB

Links:

[PMID: 22926874](#)

[Bioelectromagnetics Volume 34, Issue 1, pages 3–14, January 2013](#)

Can neurons sense millimeter waves?

2001

Barbara G. Goode

Work to determine the impact of Terahertz radiation on biological systems holds promise for noninvasive neuronal response control

Implications: Therapy potential

The findings have implications for the health and safety of millimeter wave exposure, as well as for the potential control of neuronal response through a non-invasive process. If the power levels are not a safety concern, and the millimeter wave stimulation can be configured to selectively induce specific neuronal responses, it opens the door to therapies that might be applied for pain suppression or for neuroprosthetic control of brain functions.

The researchers are hoping to continue and expand their initial work through the National Institutes of Health and other grant mechanisms. The patch clamp measurements were performed at the Huntington Medical Research Institute with the help of Dr. Michael Harrington and Dr. Xianghong Arakaki. Additional experiments were performed at the California Institute of Technology under the support of Professor Scott Fraser (biology) and Professor David B. Rutledge (electrical engineering).

Links:

[BioOptics World 03/01/2010](#)

Modulation of neuronal activity and plasma membrane properties with low-power millimeter waves in organotypic cortical slices

2010

Pikov V

Arakaki X

Harrington M

Fraser SE

Siegel PH

Abstract

As millimeter waves (MMWs) are being increasingly used in communications and military applications, their potential effects on biological tissue has become an important issue for scientific inquiry. Specifically, several MMW effects on the whole-nerve activity were reported, but the underlying neuronal changes remain unexplored. This study used slices of cortical tissue to evaluate the MMW effects on individual pyramidal neurons under conditions mimicking their in vivo environment. The applied levels of MMW power are three orders of magnitude below the existing safe limit for human exposure of 1 mW cm⁻². Surprisingly, even at these low power levels, MMWs were able to produce considerable changes in neuronal firing rate and plasma membrane properties. At the power density approaching 1 microW cm⁻², 1 min of MMW exposure reduced the firing rate to one third of the pre-exposure level in four out of eight examined neurons. The width of the action potentials was narrowed by MMW exposure to 17% of the baseline value and the membrane input resistance decreased to 54% of the baseline value across all neurons. These effects were short lasting (2 min or less) and were accompanied by MMW-induced heating of the bath solution at 3 degrees C. Comparison of these results with previously published data on the effects of general bath heating of 10 degrees C indicated that MMW-induced effects cannot be fully attributed to heating

and may involve specific MMW absorption by the tissue. Blocking of the intracellular Ca(2+)-mediated signaling did not significantly alter the MMW-induced neuronal responses suggesting that MMWs interacted directly with the neuronal plasma membrane. The presented results constitute the first demonstration of direct real-time monitoring of the impact of MMWs on nervous tissue at a microscopic scale. Implication of these findings for the therapeutic modulation of neuronal excitability is discussed.

Links:

[Journal of Neural Engineering 2010 Aug;7\(4\):045003](#)

Millimeter wave treatment promotes chondrocyte proliferation via G1/S cell cycle transition

2012

*Li X, Ye H, Yu F, Cai L, Li H
Chen J, Wu M, Chen W, Lin R, Li Z
Zheng C, Xu H, Wu G, Liu X*

Abstract

Millimeter waves, high-frequency electromagnetic waves, can effectively alleviate the clinical symptoms in osteoarthritis patients, as a non-pharmaceutical and non-invasive physical therapy regimen. However, the molecular mechanisms of the therapeutic effects of millimeter wave treatment are not well understood. In the present study, the effect of millimeter waves on the G1/S cell cycle progression in chondrocytes and the underlying mechanism was investigated. Chondrocytes isolated from the knee of SD rats were cultured and identified using toluidine blue staining. The second generation chondrocytes were collected and stimulated with or without millimeter waves for 48 h. Chondrocyte viability was analyzed using the MTT assay. The cell cycle distribution of chondrocytes was analyzed by flow cytometry. mRNA and protein expression levels of cyclin D1, cyclin-dependent kinases 4 and 6 (CDK4 and CDK6) and p21 were detected using real-time PCR and western blotting, respectively. Millimeter wave stimulation was found to significantly enhance chondrocyte viability. Moreover, the percentage of chondrocytes in the G0/G1 phase was significantly decreased, whereas that in the S phase was significantly increased. In addition, following millimeter wave treatment, cyclin D1, CDK4 and CDK6 expression was significantly upregulated, whereas p21 expression was significantly downregulated. The results indicate that millimeter wave treatment promotes chondrocyte proliferation via cell cycle progression.

Links:

Int J Mol Med. 2012 May;29(5):823-31. doi: 10.3892/ijmm.2012.919. Epub 2012 Feb 16.

Electromagnetic millimeter wave induced hypoalgesia: frequency dependence and involvement of endogenous opioids.

2008

Radzievsky AA, Gordiienko OV, Alekseev S, Szabo I, Cowan A, Ziskin MC.

Abstract

Millimeter wave treatment (MMWT) is based on the systemic biological effects that

develop following local skin exposure to low power electromagnetic waves in the millimeter range. In the present set of experiments, the hypoalgesic effect of this treatment was analyzed in mice. The murine nose area was exposed to MMW of "therapeutic" frequencies: 42.25, 53.57, and 61.22 GHz. MMWT-induced hypoalgesia was shown to be frequency dependent in two experimental models: (1) the cold water tail-flick test (chronic non-neuropathic pain), and (2) the wire surface test (chronic neuropathic pain following unilateral constriction injury to the sciatic nerve). Maximum hypoalgesic effect was obtained when the frequency was 61.22 GHz. Other exposure parameters were: incident power density = 13.3 mW/cm², duration of each exposure = 15 min. Involvement of delta and kappa endogenous opioids in the MMWT-induced hypoalgesia was demonstrated using selective blockers of delta- and kappa-opioid receptors and the direct ELISA measurement of endogenous opioids in CNS tissue. Possible mechanisms of the effect and the perspectives of the clinical application of MMWT are discussed.

Links:

[PMID: 18064600](#)

Bioelectromagnetics. 2008 May;29(4):284-95.

Effect of millimeter wave irradiation on tumor metastasis

2006

Logani MK, Szabo I, Makar V, Bhanushali A, Alekseev S, Ziskin MC.

Abstract

One of the major side effects of chemotherapy in cancer treatment is that it can enhance tumor metastasis due to suppression of natural killer (NK) cell activity. The present study was undertaken to examine whether millimeter electromagnetic waves (MMWs) irradiation (42.2 GHz) can inhibit tumor metastasis enhanced by cyclophosphamide (CPA), an anticancer drug. MMWs were produced with a Russian-made YAV-1 generator. Peak SAR and incident power density were measured as 730 +/- 100 W/kg and 36.5 +/- 5 mW/cm², respectively. Tumor metastasis was evaluated in C57BL/6 mice, an experimental murine model commonly used for metastatic melanoma. The animals were divided into 5 groups, 10 animals per group. The first group was not given any treatment. The second group was irradiated on the nasal area with MMWs for 30 min. The third group served as a sham control for group 2. The fourth group was given CPA (150 mg/kg body weight, ip) before irradiation. The fifth group served as a sham control for group 4. On day 2, all animals were injected, through a tail vein, with B16F10 melanoma cells, a tumor cell line syngeneic to C57BL/6 mice. Tumor colonies in lungs were counted 2 weeks following inoculation. CPA caused a marked enhancement in tumor metastases (fivefold), which was significantly reduced when CPA-treated animals were irradiated with MMWs. Millimeter waves also increased NK cell activity suppressed by CPA, suggesting that a reduction in tumor metastasis by MMWs is mediated through activation of NK cells.

Links:

[PMID: 16437545](#)

Effect of millimeter waves on natural killer cell activation

2005

Makar VR, Logani MK, Bhanushali A, Kataoka M, Ziskin MC.

Abstract

Millimeter wave therapy (MMWT) is being widely used for the treatment of many diseases in Russia and other East European countries. MMWT has been reported to reduce the toxic effects of chemotherapy on the immune system. The present study was undertaken to investigate whether millimeter waves (MMWs) can modulate the effect of cyclophosphamide (CPA), an anticancer drug, on natural killer (NK) cell activity. NK cells play an important role in the antitumor response. MMWs were produced with a Russian-made YAV-1 generator. The device produced modulated 42.2 +/- 0.2 GHz radiation through a 10 x 20 mm rectangular output horn. Mice, restrained in plastic tubes, were irradiated on the nasal area. Peak SAR at the skin surface and peak incident power density were measured as 622 +/- 100 W/kg and 31 +/- 5 mW/cm², respectively. The maximum temperature elevation, measured at the end of 30 min, was 1 degrees C. The animals, restrained in plastic tubes, were irradiated on the nasal area. CPA injection (100 mg/kg) was given intraperitoneally on the second day of 3-days exposure to MMWs. All the irradiation procedures were performed in a blinded manner. NK cell activation and cytotoxicity were measured after 2, 5, and 7 days following CPA injection. Flow cytometry of NK cells showed that CPA treatment caused a marked enhancement in NK cell activation. The level of CD69 expression, which represents a functional triggering molecule on activated NK cells, was increased in the CPA group at all the time points tested as compared to untreated mice. However, the most enhancement in CD69 expression was observed on day 7. A significant increase in TNF-alpha level was also observed on day 7 following CPA administration. On the other hand, CPA caused a suppression of the cytolytic activity of NK cells. MMW irradiation of the CPA treated groups resulted in further enhancement of CD69 expression on NK cells, as well as in production of TNF-alpha. Furthermore, MMW irradiation restored CPA induced suppression of the cytolytic activity of NK cells. Our results show that MMW irradiation at 42.2 GHz can up-regulate NK cell functions.

Links:

[PMID: 15605409](#)

Terahertz Electromagnetic Fields (0.106 THz) Do Not Induce Manifest Genomic Damage In Vitro

2012

Henning Hintzsche

Christian Jastrow

Thomas Kleine-Ostmann

Uwe Kärst

Thorsten Schrader

Helga Stopper

Abstract

Terahertz electromagnetic fields are non-ionizing electromagnetic fields in the frequency range from 0.1 to 10 THz. Potential applications of these electromagnetic fields include the whole body scanners, which currently apply millimeter waves just below the terahertz range, but future scanners will use higher frequencies in the terahertz range. These and other applications will bring along human exposure to these fields. Up to now, only a limited number of investigations on biological effects of terahertz electromagnetic fields have been performed. Therefore, research is strongly needed to enable reliable risk assessment. Cells were exposed for 2 h, 8 h, and 24 h with different

power intensities ranging from 0.04 mW/cm² to 2 mW/cm², representing levels below, at, and above current safety limits. Genomic damage on the chromosomal level was measured as micronucleus formation. DNA strand breaks and alkali-labile sites were quantified with the comet assay. No DNA strand breaks or alkali-labile sites were observed as a consequence of exposure to terahertz electromagnetic fields in the comet assay. The fields did not cause chromosomal damage in the form of micronucleus induction.

Links:

[PMCID: PMC3459899](#)

[PMID: 23029508](#)

Low-Intensity Electromagnetic Millimeter Waves for Pain Therapy

2006

Taras I. Usichenko

Hardy Edinger

Vasyl V. Gizhko

Christian Lehmann

Michael Wendt

Frank Feyerherd

Abstract

Millimeter wave therapy (MWT), a non-invasive complementary therapeutic technique is claimed to possess analgesic properties. We reviewed the clinical studies describing the pain-relief effect of MWT. Medline-based search according to review criteria and evaluation of methodological quality of the retrieved studies was performed. Of 13 studies, 9 of them were randomized controlled trials (RCTs), only three studies yielded more than 3 points on the Oxford scale of methodological quality of RCTs. MWT was reported to be effective in the treatment of headache, arthritic, neuropathic and acute postoperative pain. The rapid onset of pain relief during MWT lasting hours to days after, remote to the site of exposure (acupuncture points), was the most characteristic feature in MWT application for pain relief. The most commonly used parameters of MWT were the MW frequencies between 30 and 70 GHz and power density up to 10 mW cm⁻². The promising results from pilot case series studies and small-size RCTs for analgesic/hypoalgesic effects of MWT should be verified in large-scale RCTs on the effectiveness of this treatment method.

Links:

[PMCID: PMC1475937](#)

Mechanisms of electromagnetic interaction with cellular systems

1992

Grundler W

Kaiser F

Keilmann F

Walleczek J

Abstract

The question of how electromagnetic fields--static or low to high frequency--interact with biological systems is of great interest. The current discussion among biologists, chemists, and physicists emphasizes aspects of experimental verification and of defining microscopic and macroscopic mechanisms. Both aspects are reviewed here. We emphasize that in certain situations nonthermal interactions of electromagnetic fields occur with cellular systems.

Links:

[PMID: 1480219](#)

Enhanced absorption of millimeter wave energy in murine subcutaneous blood vessels

2011

Stanislav I. Alekseev

Marvin C. Ziskin

Abstract

The aim of the present study was to determine millimeter wave (MMW) absorption by blood vessels traversing the subcutaneous fat layer of murine skin. Most calculations were performed using the finite-difference time-domain (FDTD) technique. We used two types of models: (1) a rectangular block of multilayer tissue with blood vessels traversing the fat layer and (2) cylindrical models with circular and elliptical cross-sections simulating the real geometry of murine limbs. We found that the specific absorption rate (SAR) in blood vessels normally traversing the fat layer achieved its maximal value at the parallel orientation of the E-field to the vessel axis. At 42 GHz exposure, the maximal SAR in small blood vessels could be more than 30 times greater than that in the skin. The SAR increased with decreasing the blood vessel diameter and increasing the fat thickness. The SAR decreased with increasing the exposure frequency. When the cylindrical or elliptical models of murine limbs were exposed to plane MMW, the greatest absorption of MMW energy occurred in blood vessels located on the lateral areas of the limb model. At these areas the maximal SAR values were comparable with or were greater than the maximal SAR on the front surface of the skin. Enhanced absorption of MMW energy by blood vessels traversing the fat layer may play a primary role in initiating MMW effects on blood cells and vasodilatation of cutaneous blood vessels.

Links:

[PMCID: PMC3118398](#)

[Bioelectromagnetics Volume 32, Issue 6, pages 423–433, September 2011](#)

Anti-inflammatory effects of low-intensity extremely high-frequency electromagnetic radiation: frequency and power dependence

2008

Gapeyev AB

Mikhailik EN

Chemeris NK

Using a model of acute zymosan-induced footpad edema in NMRI mice, the frequency and power dependence of anti-inflammatory effect of low-intensity extremely high-frequency electromagnetic radiation (EHF EMR) was found.

Abstract

Using a model of acute zymosan-induced footpad edema in NMRI mice, the frequency and power dependence of anti-inflammatory effect of low-intensity extremely high-frequency electromagnetic radiation (EHF EMR) was found. Single whole-body exposure of animals to EHF EMR at the intensity of 0.1 mW/cm² for 20 min at 1 h after zymosan injection reduced both the footpad edema and local hyperthermia on average by 20% at the frequencies of 42.2, 51.8, and 65 GHz. Some other frequencies from the frequency range of 37.5-70 GHz were less effective or not effective at all. At fixed frequency of 42.2 GHz and intensity of 0.1 mW/cm², the effect had bell-shaped dependence on exposure duration with a maximum at 20-40 min. Reduction of intensity to 0.01 mW/cm² resulted in a change of the effect dependence on exposure duration to a linear one. Combined action of cyclooxygenase inhibitor sodium diclofenac and EHF EMR exposure caused a partial additive effect of decrease in footpad edema. Combined action of antihistamine clemastine and EHF EMR exposure caused a dose-dependent abolishment of the anti-inflammatory effect of EHF EMR. The results obtained suggest that arachidonic acid metabolites and histamine are involved in realization of anti-inflammatory effects of low-intensity EHF EMR.

Links:

[PMID: 18044738](#)

Bioelectromagnetics. 2008 Apr;29(3):197-206.

Treatment of chronic pain with millimetre wave therapy (MWT) in patients with diffuse connective tissue diseases: a pilot case series study

2003

Usichenko TI

Herget HF

Abstract

BACKGROUND: Pain relief is reported to be the most common clinical application of electromagnetic millimetre waves.

AIM: To evaluate safety and pain relief effect of millimetre wave therapy (MWT) for treatment of chronic joint pain in a group of patients with diffuse connective tissue diseases.

METHODS: Twelve patients with diffuse connective tissue diseases received MWT in addition to their analgesic medication with non-steroidal anti-inflammatory drugs. MWT procedure included the exposure of tender points around the painful joints to electromagnetic waves with frequency 54-78GHz and power density of 2.5mW/cm². The time of exposure was 35 +/-5 min and the total number of sessions ranged from 5 to 10 (median 6). Intensity of pain, medication requirement, joint stiffness and subjective assessment of therapy success were measured before, during and immediately after the treatment, and after a 6-months follow-up.

RESULTS: No adverse effects of MWT were noted. Pain intensity and required medication decreased significantly after the treatment ($p < 0.05$) and remained at the same level throughout the follow-up period. The joint stiffness decreased and the subjective assessment of the treatment success after 6 months did not change except in only one patient.

CONCLUSION: MWT applied to tender points around the affected joints was safe under the conditions of our study and after an appropriate full-scale double-blind clinical study, may be recommended as an effective adjunct therapy for chronic pain treatment in patients with diffuse connective tissue diseases.

Links:

[European Journal of Pain Volume 7, Issue 3, pages 289–294, June 2003](#)

Millimetre wave therapy for pain relief after total knee arthroplasty: A randomised controlled trial

2008

Taras I. Usichenko

Hardy Edinger

Torsten Witstruck

Abstract

Millimetre wave therapy (MWT) is a promising complementary method for pain relief, however rigorous investigations of its effectiveness are needed. The purpose of this study was to examine if MWT can reduce opioid requirement compared to sham procedure applied for relief of acute pain in patients after total knee arthroplasty (TKA). Eighty patients undergoing TKA were randomly assigned to receive MWT or sham procedure. Patients and evaluators were blinded to the group allocation. MWT consisted of six sessions, each session of 30min duration. During each session the knee wound was exposed to electromagnetic waves with frequency 50–75GHz and power density 4.2mW/cm². Postoperative analgesia with piritramide, a weak opioid with 0.7 potency of morphine delivered via patient-controlled analgesia pump, was directed to achieve pain intensity of less than 40 on a 100mm visual analogue scale (VAS). The primary outcome measure was postoperative piritramide requirement for three days after surgery. Secondary outcome measures were: total ibuprofen requirement from the fourth postoperative day to discharge; success of patients' blinding; patients' satisfaction with pain relief; incidence of analgesia-related side effects; heart rate and blood pressure. Piritramide requirement was similar in both groups whereby all patients reported adequate pain relief measured on a VAS. Secondary outcome measures were also comparable in both groups. The majority of patients in both groups believed they had received true MWT and wanted to repeat it in future. Millimetre waves applied to surfaces of surgical wounds did not reduce opioid requirement compared to the sham procedure after TKA.

Links:

[European Journal of Pain Volume 12, Issue 5, pages 617–623, July 2008](#)

[PMID: 18042413](#)

Treatment of rheumatoid arthritis with electromagnetic millimeter waves applied to acupuncture points—a randomized double blind clinical study

2003

Usichenko TI

Ivashkivsky OI

Gizhko VV

Abstract

The aim of the study was to evaluate the efficacy and safety of electromagnetic millimeter waves (MW) applied to acupuncture points in patients with rheumatoid arthritis (RA). Twelve patients with RA were exposed to MW with power 2.5 mW and band frequency 54-64 GHz. MW were applied to the acupuncture points of the affected joints in a double blind manner. At least 2 and maximum 4 points were consecutively exposed to MW during one session. Total exposure time consisted of 40 minutes. According to the study design, group I received only real millimeter wave therapy (MWT) sessions, group II only sham sessions. Group III was exposed to MW in a random cross-over manner. Pain intensity, joint stiffness and laboratory parameters were recorded before, during and immediately after the treatment. The study was discontinued because of beneficial therapeutic effects of MWT. Patients from group I (n=4) reported significant pain relief and reduced joint stiffness during and after the course of therapy. Patients from group II (n=4) revealed no improvement during the study. Patients from group III reported the changes of pain and joint stiffness only after real MW sessions. After further large-scale clinical investigations MWT may become a non-invasive adjunct in therapy of patients with RA.

Links:

[Acupuncture & Electro-Therapeutics Res., Int. J., Vol. 28, pp. 11-18, 2003](#)

Effect of millimeter waves and cyclophosphamide on cytokine regulation

2012

Logani MK

Alekseev S

Bhopale MK

Slovinsky WS

Ziskin MC

Abstract

We have reported previously that millimeter waves (MMWs) protect T-cell functions from the toxic side effects of cyclophosphamide (CPA), an anticancer drug. Since the effect of MMWs has been reported to be mediated by endogenous opioids, the present study was undertaken to investigate the role of endogenous opioids in protection of T-cell functions by MMWs. The effect of MMWs (42.2 GHz, incident power density = 38 mW/cm²) was studied on CPA-induced suppression of cytokine release by T cells in the presence of selective opioid receptor antagonists (ORA). Production of cytokines was measured in CD4 T cells isolated from splenocytes. Treatment of mice with CPA suppressed the formation of Th1 cytokines (TNF- α , IFN- γ , and IL-2), shifting the overall

balance toward Th2 (IL-4 and IL-5). MMW irradiation of CPA-treated groups up-regulated the production of Th1 cytokines suppressed by CPA. Treatment of the CPA+MMW group with selective kappa (κ) ORA further potentiated this effect of MMWs on Th1 cytokine production, whereas treatment with μ or δ ORA increased the imbalance of cytokine production in the Th2 direction. These results provide further evidence that endogenous opioids are involved in immunomodulation by MMWs.

Links:

[PMID: 21649551](#)

Special function of the "millimeter wavelength waves-aqueous medium" system in nature

2000

Sinitsyn NI

Petrosyan VI

Yolkin VA

Devyatkov ND

Gulyaev YuV

Betskii OV

Abstract

New findings of an investigation of the interaction between electromagnetic waves in the millimeter range and water and biological media are reported.

Links:

Crit Rev Biomed Eng. 2000;28(1-2):269-305.

[PMID: 10999396](#)

Does human skin truly behave as an array of helical antennae in the millimeter and terahertz wave ranges?

2010

Ney M

Abdulhalim I

Abstract

The sweat ducts of the human perspiration system are helically shaped tubes, filled with a conductive aqueous solution. Recent studies have claimed that these ducts act as an array of low-Q helical antennae and are dominant in shaping the spectral response in the subterahertz region. Using local homogenization theory for the skin embedded with sweat ducts, we found that multiple interference effects from the skin layers play the major role in determining the skin electromagnetic characteristics in the millimeter and terahertz regions without the need for the assumption of the sweat ducts acting as low-Q helical antennae.

Links:

Opt Lett. 2010 Oct 1;35(19):3180-2. doi: 10.1364/OL.35.003180.

[PMID: 20890326](#)