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REVIEW

A dual resonance model for gerotargets and magnetic interaction energies

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A physico-mathematical model representing a new generic form of magnetic resonance (Jacobson Resonance) may be utilized to establish signal-specific magnetic field parameters for affecting Gerotargets e.g. telomeres and telomerase. Thus, a new non-invasive holistic paradigm has been established for amelioration of the aging process and the effects therefrom. Recent experimental data has revealed the possibility for regulation of photon-phonon transduction, i.e. the piezoelectric effect, to prevent telomere shortening upon cell division, and potential for telomerase up-regulation and/or inhibition. Slowing of our genomic biological clocks through selective magnetic resonant interactions with Gerotargets may be possible, based upon a diversity of recent studies. Additionally, aging may actually be a progressive slow burn, resulting from heat energy exigencies enhanced by HPA-axis stimulation of cortisol production over time. The capacity for electromagnetic field modulation of autonomic nervous system tonicity is important. More specifically, aging is proposed to be a slow burn in small volumes of tissues, increasing desiccation of microstructures, quantum state entropy or disorder, and microscopic scarring. Amelioration of the aging process may therein be accomplished through modulation of vagal innervation and sympathetic innervation. Studies revealing this potential for regulating ANS tonicity with physiologic, Pico Tesla range magnetic fields are also referenced.

Keywords: Telomeres; telomerase; photon-phonon transduction; piezoelectric effect; Jacobson Resonance

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Introduction

A new holistic non-invasive paradigm has been presented for amelioration of aging processes and the effects thereof.

The first hypothetical component resides in the possibility that extrinsically sourced, calculable physiologic PicoTesla electromagnetic fields (PTEMF's) may be utilized to prevent telomere shortening. Magnetic resonant energies may be target-specific, and through the mechanism of photon-phonon transduction, i.e. piezoelectricity, PTEMF's may stabilize the structural integrity of telomeres to prevent shortening upon cell division. Various studies have supported this hypothesis [1-4].

Secondly, extrinsic challenges of life produce various stressors, and stimulation of the HPA-axis with production of cortisol. Cortisol's primary function is the redistribution of energy through gluconeogenesis, to regions that need it most, i.e. the brain and major muscles during enhanced sympathetic nervous system stimulation. Therefore, it is hypothesized that the natural exigencies of life produce increased heat energy, enhancing desiccation of tissue microstructures, increasing microscopic scarring, quantum

entropy or disorder, and aging. Thus, the second component postulated concerns electromagnetic field modulation of vagal innervation and sympathetic innervation. Various studies have supported this hypothesis [1, 5, 6].

Biological Entropy

Genes and associated structures can be changed as time-dependent processes increase degrees of entropy on fundamental levels, and vital structural and functional integrity of critical molecules are challenged with age. Therefrom, the atomistic signal transduction coupling mechanisms for molecules and molecular assemblies are denigrated. Now, biological systems may be considered to be intrinsic universes of electromagnetic interactions in constant flux, oscillating about steady state systems. Any system becomes progressively disordered (with increased entropy) as its temperature rises. This holds for processes in which the system remains in equilibrium continuously throughout the complex and multifarious changes. These are "reversible" processes. Thus, the change in entropy for a reversible process maintaining constant temperature is determinable from heat transfer measurements, as well as the temperature. Nevertheless, since a process at equilibrium only changes at an infinitesimal rate (as equilibrium processes are by definition unchanging), real processes can approach, but never attain reversibility. Thus, the entropy change in any real process is always greater than its ideal (reversible) value. When a system departs from and then returns to its initial state, via a real process, e.g. transient states of sympathetic nervous system stimulation, (SNS), the entropy must increase, even though the entropy of the system as a state function does not change [1, 7].

The trillions of biological atomic magnets communicate through long-range electromagnetic forces carried by photons (quanta) or packets of energy. Heat energy is an electromagnetic radiant wave, having lower frequency than visible light. When the atomic structure of cells are challenged and denigrated, the quantum order and balance of life is impugned, with the gradual increase in entropy. A burn is a lesion caused by heat or any cauterizing agent. While heat energy is a normal product of metabolism, basically under genetic control, environmental factors can negatively impact the natural processes of life [1].

Profiling Physiologic Magnetic Fields

Normal physiologic magnetic profiles of human tissues have been measured with superconducting quantum interference detectors. These magnetic fields are in the PicoTesla range, and one PicoTesla is 50 million times weaker than the geomagnetic field. The existence of the brain's magnetic field, and the difference between the magnetic field profile of the normal brain versus the pathologic brain, has been known from classical work of Cohen and Anninos *et al*. [1, 6, 8] Furthermore, it is projected that proteins (good conductors of electricity), DNA, as well as transforming DNA magnetic domain segments may serve piezoelectric functions due to a quasi-crystalline lattice structure. Additionally, genes change throughout the lifecycle, demonstrated clearly by Tonegawa, McClintock *et al*. [1, 5, 10, 11] Considering the need for a solid-state physics approach in studying living systems, we note that living systems are a complex and ordered quesi-crystalline organization of atomic/molecular and bioplasmic systems; promulgating the idea of electromagnetic immune response mechanisms. These adjustment mechanisms would maintain the balance of total systems quite in accord with quantum theory. It appears certain that quantum theory accounts for the perception that very weak disturbing forces induce alterations of great magnitude within the physical states of systems. Indeed, exceedingly small alterations in the statistical density, within the ensemble of the multifactorial complex system, provides changes of high degree. Therefore, we note that infinitely weak changes due to single systems, e.g. Pico Tesla range profiles, are subject to and require profound amplifications in biosystems. It is hypothesized that adjustments maintaining ordered states of matter are based upon photon-phonon transductions, i.e. the piezoelectric effect. Various biological structures, e.g. keratin, collagen, alpha and beta sheaths of proteins, genomic domains, etc., form an interrupted reticulum that may act as piezoelectric communications networks [12, 13, 14].

Mc^2=BvLq (Jacobson Resonance) is used to determine the magnetic flux density for an externally applied magnetic field encompassing the whole organism; wherein (M) represents the mass of a target, e.g. critical molecule or magnetic domain, (Mc^2) is its intrinsic energy, and (BvLq) is the resultant electromagnetic interaction energy. When a system of dual resonance is achieved, it is postulated that a coherent enhancement of the target's vibrational state is imbued, in cooperation with the oscillatory trajectories of all such targets concomitantly affected. In so doing, mechanical vibrations of targets may be regulable with signal specific calculated electromagnetic oscillations. Induction of particle-jumps, quantum transpositional states and regulation of structure and function may be so produced [1, 2, 5, 15].

PicoTesla range electromagnetic fields have been demonstrated to influence brain wave patterns [16, 17], provide regeneration of nerve ultrastructure [2], affect autonomic nervous system tone, e.g. enhance parasympathetic stimulation to cardiac inputs, and regulate atrio-ventricular conduction mechanisms- affecting rate and rhythmicity [1,3,4];

modulate endogenous opioid action (enkephalin and endorphin) [18, 19, 20, 21]; and affect benefits in neurological disorders such as Parkinson's Disease [22, 23], MS [24, 25], and epilepsy [26, 27], speed healing of sutured and open wounds [28]; diminish viability/proliferation rate of human mammary carcinoma cells (MCF-7) in-vitro [1]; and regulate thoracic spinal neuronal potentials after administration of noxious inflammatory chemicals to the heart (which stimulated nociceptive afferent fibers) [28], just to cite a few of the numerous studies conducted under rigorously controlled conditions [1-3].

To cite other examples concerning the effects of low frequency (low photonic energy), non-ionizing electromagnetic fields on biosystems, we refer to changes in cellular growth rate [29], diminution of cytotoxicity of T-lymphocytes [30], increased availability of ornithine decarboxylase (the growth related enzyme) [31] changes in quantity and quality of RNA transcripts as well as proteins, [32-34] changes in properties of cellular surfaces [35-37] and developmental changes.

Maintaining Telomere Integrity

There are many correlated studies revealing a connection of telomere length and aging, with evidence for an inherited component. Upon cell division, it is known that telomeres shorten. This decrease in telomere length is due to incomplete lagging strand synthesis. While end processing events are not fully understood, along with oxidative stress factors, we may envision that quantum state changes in entropy are considerably relevant.

Our fundamental thesis states: Interatomic communications through electromagnetic forces are at the root of all signal transductive coupling mechanisms. When the binding protein for telomeres undergoes atomic conformational changes as a result of incomplete lagging strand DNA synthesis (mechanical error), electromagnetic signals are transmitted to the rest of the DNA, inhibiting normal genetic information transfer mechanisms. It is therefore hypothesized that telomeres, (our biological clocks) may serve as targets for magnetic resonance energies, to maintain the structural and functional integrity therein. It may also be possible to target telomerase (or components thereof) with their inhibition and/or stimulation for up-regulation, as the result. Whether inhibition or up-regulation is the result of magnetic resonance targeting of telomerase, it may be dependent upon the electrophysiological quantum environment of the affected cells. Affectation of telomeres as well as the telomerase enzyme may be dependent on changes that have already occurred, referring to chromatin instability, damage to DNA, and stress signals like oncogenic overexpression. Extensive research utilizing this new promising model of Jacobson Resonance is indicated, as the usage of PicoTesla range magnetic resonance therapy is still in its infancy [1, 38-44].

Target-Specific Magnetic Resonance Energies In Cancer Studies

Studies at Mississippi State University, Department of Basic Sciences and Veterinary Medical Research, led by Cody Coyne [1], screened a number of PicoTesla range magnetic field schedules. Calculations using the Jacobson Resonance equation were based upon molecules thought to be related to human mammary carcinoma cells (HTB-126 and MCF-7). Two PicoTesla range protocols compromised the viability and/or rate of proliferation for HTB-126 and MCF-7 cell types compared to untreated controls. Replicate studies (N-7) using calculated signal parameter sequences consistently inhibited the viability from 31%-35%, compared to untreated negative reference controls. Additionally, membrane-associated complexes were identified. These were expressed at higher or lower levels in MCF-7 cells. One mRNA sequence was expressed at higher levels whereas two mRNA sequences were uniquely expressed in MCF-7 cell populations. Importantly, these cells were exposed to PicoTesla range sequences for 30 minutes each time in only five treatment sessions, whereas, mice were exposed for 56 minutes, twice weekly for 8.5 weeks in nerve regeneration studies; that revealed significant restoration of radial nerve ultra structures concomitant with restorations of grip strength [2]. It is the experience of this author that outcome measures are generally directly related to exposure time- in addition to the conditions of resonance determined by accuracy of flux densities and frequencies.

Nevertheless, collective interpretation of experimental findings revealed an ability of PicoTesla range magnetic field protocols, utilizing physiologic extremely low-frequencies to induce changes in viability and/or proliferation rate, and expression profiles of: (1) cytosol-soluble and membrane associated protein fractions; and (2) genetic transcription of mRNA sequences compared to negative (non-exposed) reference controls. In this context, these alterations appear to be of a different pattern when experimental samples were immediately processed following MCF-7 exposure to the final protocol. In contrast, somewhat different and slightly subtler differences were observed when an intentional delay of several hours was implemented between the last exposure and preparation of the sample. This implies that maximum changes in protein expression and mRNA transcription might well have occurred during or soon after exposure periods. In addition, there was also a relative difference in the biological change excited by single sets of signal parameters, i.e.

amplitude and frequency combinations, contained within the "Master" multi-frequency PicoTesla schedule. Ultimately, these laboratory findings may serve as an experimental foundation for future research investigations devoted to delineating (1) time frames that PicoTesla magnetic fields provide a biological affect, (2) duration of PicoTesla magnetic field induced molecular/genetic changes, (3) identity of specific PicoTesla magnetic fields that selectively exert particular biological changes in living systems, and (4) identify molecular/ genetic "targets" that PicoTesla magnetic fields interact with in a manner that creates a biological alteration.

Nerve Regeneration Studies

It is noted that the level of energy and electrical potential of nerves can be modulated by PicoTesla range electromagnetic fields (PTEMF's) [18] For the following nerve regeneration studies, the field magnitudes, frequencies and sequences, were calculated in accord with Jacobson Resonance theory, considering the various subcellular components that are vital for the functionality of nerves. Target molecules included EGF, kinesine, dynein, Map, NF, tubulin, acetylcholine, calmodulin and cholinesterase. It was determined that the electromagnetic field profile for mice resides in the micro gauss range ($1\,\mu G = 100 PT$). A sequence of extremely low-level EMF amplitudes with corresponding biological frequencies (<300 Hz) was utilized. The effects of these non-ionizing, extremely low frequency micro gauss level magnetic fields on the restoration of forelimb grip strength and radial nerve ultrastructure was examined in mice with motor neuropathy induced by neurotoxin [2].

The Control Group 1 (n=10) was neither poisoned nor treated with EMF. Groups 2 and 3 (n=20) were poisoned to induce motor neuropathy. Group 2 (n=10) after poisoning, was treated with low-level EMF, whereas Group 3 was poisoned but not exposed to EMFs. Comparison of the forelimb grip strength of all mice (n=30) at baseline was analogous, such that there was no significant difference. Induction of motor neuropathy was accomplished by administration of iminodiproprionitrile (IDPN) put into drinking water ad lib, for a period of 9.5 weeks. Forelimb grip strength was measured with a force gauge meter, and grip strength was noted to decrease to 47% compared to Control Group 1, a significant difference (P<0.004)

The normal age related increased grip strength of Control Group 1 was taken into consideration for statistical analysis. Group 3 (poisoned but unexposed to EMF) degenerated to a 56% decline in grip strength. Electron micrographs of radial nerves showed axonal demyelination, an orthodox conformational state of mitochondria (inactive), and a significant uneven dispersion of neurofilaments and microtubular structures. In contrast, Group 2 (poisoned and treated) exhibited remyelination of axons, a condensed mitochondrial state (indicating anabolism) and quite evenly dispersed neurofilaments and microtubular structures. These manifestations were clearly consistent with the grip strength recovery noted in Group 2.

Exposure was accomplished with 18" Helmholtz coils having an intercoil distance of 9". This prototypical Jacobson Resonator was built at the John C. Stennis Space center by NASA engineers. Two mice at a time were held in two-chambered (8 inch by 6 inch) Lucite boxes that were perforated. Magnetic fields were applied twice weekly for 8.5 weeks to Group 2, resulting in 87% recovery ($p < 0.05$) of grip strength that was maintained after the final exposure at an 82% level until the 27th week of analytical observation. Group 3, in the absence of exposure after poisoning, exhibited significantly low grip strength compared to both exposed Group 2 ($p< 0.001$) and Control Group 1 ($p< 0.000$) The effect of the neurotoxin persisted in Group 3 with a lower grip strength by 56% compared to Control Group 1. There was a consistent increase in grip strength for Group 2 as it approached the level of Group 1.

The loss of forelimb grip strength in Group 3 was indicative of a change in nerve conduction, and was substantiated by uneven dispersion of axonal neurofilaments. Neurofilaments determine growth of axonal diameters, and the slow axonal transport mechanisms for conduction of nerve impulses. The uneven distribution of microtubular structures affected normal longitudinal growth and fast axonal transport mechanisms, and was a vital sign of nerve degeneration. The orthodox state of mitochondrial conformation indicated ADP deficiency. Reversal to condensed state of mitochondrial conformation for Group 2 (treated) is correspondent to an oxidative phosphorylation reaction, in addition to ATP synthesis. ATP synthesis is dependent upon ADP and mitochondrial proton permeability. Therefore, Group 3 manifested reduced metabolic activity. In contrast, Group 2 having revealed a condensed state of mitochondria, indicated a metabolically active state in axons and Schwann cells.

In a prior study at Cornell, excised sections of sciatic nerves of mice, in-vitro culture medium, maintained a normal myelin sheath structural integrity. The sciatic nerve sections also grew longer and wider secondary to magnetic field exposure; whereas, the unexposed nerve sections degenerated. This manifestation may be attributable to the activity of Schwann cells, enhanced by EMF. Schwann cells are a source of neurotropins for nerve growth and repair.

Schwann cells provide polypeptide nerve growth factors, (NGF), and nerve injury reveals induction of increases in NGF output [45].

The in-vivo studies possibly provided two sources of NGF, one from central nervous system neurons, and the other from Schwann cells; especially from Golgi bodies. Therefore, magnetic field exposure may have enhanced Schwann cell action in IDPN treated Group 2. The Schwann cells noted in electron photomicrographs indicated distinct Golgi bodies, and this stimulation of NGF secretion may have resulted in the remyelination of axons.

Indeed, a link has been established between calculated non-ionizing magnetic field signal parameters and renormalized Schwann cell function. From a theoretical perspective, it appears that regulation of quantum entropic states is possible through predictable photon-phonon transductions coupling with exogenously sourced signal specific magnetic fields and critical molecules. These critical molecules have intrinsic energies which are set in dual resonance with electromagnetic interaction energies propitiated by exposure of the whole organism to PTEMF's. The renormalized state of mitochondria observed, indicated restored membrane permeability as well as ATP synthesis recovery. The molecular transductive coupling of signals across axonal membranes, amplified by a factor of 10^{12}, may possibly be modulated with low photonic radiation energy that previously was thought impossible. This state of affairs was due to consideration of thermodynamic principles thought to require ostensible heating.

Thus, the notion of biological piezoelectricity has now perhaps modified our thinking, as it appertains to the subtle mechanisms at work in living systems, and the need for new physical models.

Osteoarthritis and Magnetic Resonance Therapy

A double blind, randomized and placebo controlled study was designed to determine the efficacy of calculated PicoTesla magnetic field signals on subjects suffering with osteoarthritic knee pain. One hundred seventy-six patients from four sites completed the clinical study. Subjects were assigned to one of two groups, the placebo group having magnet-off status, or the active group, having magnet-on status. Each group experienced eight sessions over a two-week period. Each subject had to rate his level of pain from one minimal to ten maximal before and after treatment sessions. Pain evaluation was accomplished on three separate occasions: before initiation of the trials, during treatment trials, and two weeks after treatment cessation. Subjects also recorded pain levels while out of the treatment environment in diaries. The Pico Tesla range magnetic field parameters utilized were generated by the Jacobson Resonance device, consisting of two 18 inch diameter coils having 30 gauge copper wires, and coils were connected in series (Helmholtz configuration). The coils were placed 9 inches apart, and were connected to a function generator power supply i.e. HP3325A. An attenuator was used to obtain the desired low-level field in the space between the coils. The calculated flux densities were in the Pico-Tesla range and associated ELF frequencies (<10Hz) were utilized. Physiologic correlated frequencies were used, employing the cyclotron resonance equation. On average, subjects in the 'on' group perceived a 46% pain reduction after a treatment session. On average, subjects in the 'off' group perceived an 8% reduction in pain after a treatment session.

The results showed a significant difference between the groups. A two-way ANOVA (GLM) of the sessions showed the reduction in pain for the 'on' group ($p<0.001$) was significantly greater than the 'off' group. Of the 101 patients in the experimental group who actually received treatment, 96% received statistically significant ($p<0.000$) reduction in levels of pain. The 97 patients in the experimental group who experienced a reduction in pain, had on average a 53.25% pain reduction.

This study indicated that the prediction of the Jacobson Resonance theory regarding the possibility that PicoTesla range MF's are physiologic, should be considered. The results of this study point to a subtlety of life that has yet to be fully appreciated, as the benefits were shown to be durable [21].

Application of Jacobson Resonance to Biosystems: Sample Calculation

Mc^2=BvLq (Jacobson Resonance) is used to determine the magnetic flux density (B) of an externally applied magnetic field to the whole organism, having longest dimension (L), e.g. for humans, it is the height of the subject. (mc^2) represents the intrinsic energy of a potential target mass (m) which can be any atomic or molecular species, e.g. peptide hormone trophic factor, enzyme, neurotransmitter, DNA structure such as a telomere (TTAGGG), or any immunogenic transmissible particle. (BvLq) represents the electromagnetic interaction energy (wave energy), wherein the entity of length (L) containing the mass (m) interacts with the magnetic field (B) to provide a system of dual resonance, i.e. mc^2= BvLq. It is proposed that a coherent excitation is induced in the target mass (m) via a photon-phonon transduction, i.e. the piezoelectric effect. (v) Represents any inertial velocity such as Earth orbital velocity, because Newton's laws of motion do not distinguish between

terrestrial and celestial velocity; and, (q) is normalized as a unit of electrical charge, or a single ab-coulomb in the CGS unitary system; established by defining electromotive force as energy per unit charge. A detailed description of this physico-mathematical model, as it applies to biosystems, is available in the literature; including the derivation, rationale for the variables m, B, v, L and constants c and q; and the correlation to known resonance phenomena: ion cyclotron resonance and Zeeman resonance. Whereas, (c) is the velocity of light, and also the velocity of the force carrier (photon) for a magnetic field moving independently of the inertial frame of reference/source.

Nerve growth factor (NGF) exhibits trophic influences on a variety of neuronal populations; promoting survivability, regulation of transmission across synapses, and plasticity at adult synapses in various regions of the central nervous system; and homeostatic regulation of neuronal intrinsic excitability. NGF contains an anti-apoptosis inducing segment to prevent cell death. Choosing NGF as a target, we consider the following:

(1) NGF is 26,500 Dalton, or 4.425×10^{-20} gram

(2) $C^2 = 9 \times 10^{20}$ cm ^{2} sec^{-2}

(3) (L) is the height of a human, or 177 cm.

(4) (V) is Earth orbital velocity, or 3×10^6 cm sec^{-1}

(5) (q) is one ab-coulomb (unit charge by definition)

The CGS system of physical units is chosen, because, in the MKS (SI) system force is determined between moving charges, whereas in the CGS system force is determined between stationary charges. Therefore, we desire:

$Mc^2 = BvLq$

$(4.425 \times 10^{-20} gm)$ $(9 \times 10^{20} cm^2 sec^{-2}) =$

(7.5 x 10^{-8} Gauss) (3 x 10^6 cm sec^{-1}) (177cm) (ab-coulomb) (3)

Then, we note that (q) is normalized in CGS. Consequently, when converting from CGS to MKS, mc^2 =BvLq becomes mc^2 = BvL (10q), because 1 ab-coulomb is equal to 10 coulomb. Therefore, when using the MKS expression, f = qB/2πm, we must use f= 10 qB/2πm, and we note:

$$f = \frac{10(1.6 \times 10^{-20}\ ab{-}coul)(7.5 \times 10^{-8}\ Gauss)}{(6.2832)(9.11 \times 10^{-28}\ gm)} = 2.1 \text{ Hz} \qquad (4)$$

Where, (q) is the charge of an electron and (m) is its mass.

Normalization permits the process of introducing a numerical factor into an equation and is of importance in quantum mechanics. Furthermore, the signal, 7.5 Pico-Tesla @2.1 Hz, has been successfully utilized in the treatment of Parkinsonians and improving the quality of life for these patients [22, 23].

Interestingly, Quality of Life (QOL) is not significantly improved with most current medication therapies for Parkinson's disease. In contrast, in our studies (including a positive Phase-II double-blind, randomized and placebo controlled study), subjects reported positive improvements in 7 of 8 subscales of the PDQ-39 averaging 24%. This is similar in magnitude to the impact on QOL for Deep Brain Stimulation (DBS). Non-motor symptoms have been increasingly recognized as a major source of disability in PD. Our subjects reported improvement in fatigue, depression, bodily discomfort, sleep quality and quantity, and even the sense of smell. Future studies utilizing standardized tests to measure these outcomes are indicated, and if successful, will be unique in PD treatment, most especially because our approach is non-invasive and of non-significant risk [23].

PicoTesla Magnetic Fields Modulate Autonomic Nervous System Tonicity

In accord with the diversity of possibilities presented herein, concerning biological effects secondary to application of non-ionizing extremely low intensity and low frequency EMF's, we point to studies executed at the University of Oklahoma Health Sciences Center, Heart Rhythm Institute.

Truly, it appears that a distinctive, and quite unique potential is unfolding from the physiologic sciences for amelioration of aging and effects thereof.

In our initial experimental study we used 2 different sized Helmholtz coils to apply micro Gauss (μG) levels of electromagnetic fields (EMFs) either to the vagosympathetic trunks or across the chest of anesthetized dogs. [4]

From previous reports on frequency analysis of heart rate variability, the parasympathetic activity averaged 0.043 Hz. Using the Jacobson ($mc^2 = q_J\ v\ BL$) and Cyclotron Resonance ($f = \frac{q\ B}{2\ \pi\ m}$) equations, we calculated the corresponding EMF amplitude value of 2.87×10^{-6} Gauss for parasympathetic activity. Applying these EMFs at the vagal trunks invasively or across the chest non-invasively, we found enhanced parasympathetic effects on the heart rate and atrioventricular conduction (AVC), both properties

influenced by parasympathetic innervation. The peak heart rate changes in the experimental versus the control groups were 29% as opposed to 12% (P = 0.03). The same EMF stimulation decreased the voltage applied to the vagal trunks by 60% for the experimental group as opposed to a 5% increase in the control group (P = 0.005).

We note the right and left femoral veins were cannulated in order to deliver fluids and anesthetics, and for insertion of electrode catheters, which were advanced for positioning against the lateral atrial wall in the low right atrium, indicated for atrial pacing. Using another level of EMF, (amplitude, 0.34 μG and 2 kHz) determined empirically, applied as above, there was a significant increase in atrial arrhythmias, including atrial fibrillation (AF) atrial premature depolarizations, and atrial tachycardia, which could be suppressed by applied magnetic field, (2.87 μG at 0.043 Hz). It should be pointed out that 2kHz is a non-physiologic frequency and 0.34 micro gauss is sympathomimetic.

A shortcoming of these studies was the need for a mechanism underlying these responses to low level EMFs. Subsequently, a series of experimental studies have been published [48-52] using very low-level vagosympathetic trunk electrical stimulation at levels 10% and 50% lower than the level of electrical stimulation that slowed the heart rate or slowed atrio ventricular conduction (AVC). In an experimental model of induced AF, it was found that the nerve clusters called ganglionated plexi (GP) found in specific vulnerable sites in the atria became hyperactive under the influence of excessive release of cholinergic (parasympathetic) and adrenergic (sympathetic) neurotransmitters. In this regard, Smith *et al*. [53] tested the function of the GP, weeks after separation of the vagal and sympathetic nerves from the aforementioned structures. Not only did the intrinsic GP neurons remain viable but their responsiveness was enhanced. To emphasize this point, the neural connection from the brain to the GP was severed in experimental animals and it was found, after 10 weeks, there was a progressive increase in the occurrence of paroxysmal atrial fibrillation [54]. In a recent experimental study, the neural activity of the ganglionated plexi was recorded and it was found that several hours of induced AF caused a significant increase in the amplitude and frequency of nerve firing, whereas low level vagal nerve stimulation not only suppressed AF propensity but also markedly decreased the magnitude and frequency of the hyperactive GP [52]. A recent clinical report confirmed that low-level vagal nerve stimulation could mitigate AF in patients with the paroxysmal form of this arrhythmia [55].

Realizing that electrical stimulation of nerves induces actions via release of chemicals, a specific peptide was identified, namely vasostatin-1; (VS-1). VS-1 was released at low-levels of nerve stimulation (50% below the voltage that causes slowing of the heart rate) and even at very low levels of vagal nerve stimulation (80% below the slowing threshold). Indeed, further studies in the experimental model of induced AF, showed that vasostatin-1 suppressed AF by inhibiting hyperactivity of the GP by an anti-adrenergic action mediated by nitric oxide [56].

Returning to the earlier studies using low-level electromagnetic fields to affect heart rate and rhythm, we inserted the molecular weight value for VS-1 into the Jacobson and Cyclotron Resonance equations to derive the amplitude (0.034 μG, or 3.4 PT) and frequency (0.952 Hz), respectively. Applying the calculated PTEMFs at the vagal trunks and across the chest we found that these low level fields significantly suppressed AF and also decreased the amplitude and frequency of the neural activity of the hyperactive GP [57].

Conclusion

The Plethora and diversity of studies conducted over the past 30 years have indicated without question profound effects of non-ionizing (extremely low photonic energies) electromagnetic fields on biological systems in the PicoTesla range. Additionally, the diversity of reports concerning usage of PicoTesla range magnetic fields for the palliation of various clinical pathologies leads one to seriously consider the promise of this new non-invasive holistic paradigm for the amelioration of aging and the effects therefrom. While Jacobson Resonance research is still in its infancy, both from a technological and clinical point of view, positive studies have unquestionably pointed to the need for further research in this field.

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