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Background. **The objective of this study was to determine the efficacy of Jacobson Resonance Magnetic Fields on human subjects suffering with knee pain secondary to osteoarthritis.**

Methods. **One hundred seventy-six patients pooled from four sites completed the study. The subjects were randomly assigned to one of two groups, the placebo group (magnet off) or the active group (magnet on). Each group received eight treatments over a two-week period. Each subject rated his or her pain level from one minimal to ten maximal before and after each treatment session on three separate instances; before treatment trials, during the treatment trials, and two weeks after treatment had terminated. Subjects recorded their pain intensity while out of the treatment environment. The magnetic fields used in this study were generated by Jacobson's Magnetic Resonance Device, which consists of two 18-inch diameter coils of 30 gauge copper wire connected in series (Helmholtz configuration), placed 9 inches apart. The coils were connected to a power supply e.g. HP3325A function generator, and an attenuator to obtain the desired field in the space between the coils. The magnetic field strengths (flux densities) were calculated from the equation $MC^2=BvLq$ (Jacobson's Equation). The range of flux densities utilized was from 2.74×10^{-7} gauss to 3.4×10^{-8} gauss with corresponding frequencies 7.7 Hertz to 0.976 Hertz. While picoTesla range flux densities have been measured to be associated with brain waves and the heart by David Cohen of M.I.T. there exists no classical physical explanation for weak field bioeffects. Jacobson Resonance proposes a mechanism, to resolve the theoretical difficulties.**

Results. **On average, subjects in the magnet**

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"on" group perceived a 46% reduction in pain after a treatment session. On average, subjects in the magnet "off" group perceived an 8% reduction in pain after a treatment session. The results show that there is a significant difference between the two groups. A two-way ANOVA (GLM) of the treatment and session showed that the reduction in pain was significantly greater in the magnet "on" group ($p<0.001$) than the magnet "off" group. Additionally, of the 101 magnet "on" patients evaluated in the treatment sessions, 96% received statistically significant ($p<0.000$) reductions in pain levels. The N=97 (96%) patients who experienced a reduction in pain had on average a 53.25 percent reduction in pain. One hundred 100% of the patients in the magnet "on" group received a reduction in pain levels because of at least one or more treatments with the resonator.

Conclusions. **This study indicates that the prediction of Jacobson Resonance regarding the possibility that pico Tesla range magnetic fields are physiologic must be considered. The results of the study point to a subtlety of life that has yet to be fully appreciated and contemplated.**

Key words: **Jacobson Resonance - PicoTesla Magnetic Fields - Osteoarthritis.**

Osteoarthritis (OA) refers to a disorder of hyaline cartilage and subchondral bone. All tissues in and around the involved joint (knee) are hypertrophic. OA is the most common of articulate disorders and is virtually universal by age 70. Pathologic changes in weight-bearing joints are common by age 40. OA occurs in virtually all vertebrates, which suggests that it occurred concomitant with the evolutionary arrival of the bony skeleton. Investigators had thought bone to be piezoelectric, that is, capable of converting electromagnetic oscillations to mechanical vibrations and *vice versa*. Other structures like collagen, cyto-skeletal system structures and the extracellular matrix were also thought to be piezoelectric. Thus it is not surprising that clinical investigators sought to employ non-invasive magnetotherapeutic approaches to bone healing in the past, and have found success. OA appears to be the result of a complicated system of interacting mechanisms correlating mechanical, biologic, biochemical and electromagnetic forces. Appreciating that atoms are permanent spinning magnets and must communicate interatomically to form molecules, it was logical to assume that magnetic fields can influence the coherent charged states and cooperativity in biological systems.[1,2] Based upon the classical work of David Cohen of MIT with the superconducting quantum interference device it is not also illogical to presume that living systems maintain particular magnetic profiles, more specifically profiles in the picoTesla range.[3] Although these very low level magnetic fields were originally thought to be a magnetic noise secondary to stronger interactions that might be valuable in diagnosis, combining the theoretical work of Jerry Jacobson with Cohen's measurements, it appeared to several clinical investigators that low level, extremely low frequency magnetic fields might be useful in medical therapeutics. In recent years, many reports have been made in the literature concerning the efficacy of picoTesla range magnetic fields at low frequencies (from 2-7 Hertz) in the treatment of neurological disorders like PD, MS and Alzheimer's disease.[4-6] Jacobson *et al.* have now applied picoTesla range magnetic fields at frequencies ranging from 0.952 Hertz to 7.7 Hertz to the treatment of pain and debilitation secondary to osteoarthritis of the knees.[7] The conceptual framework examines that hyaline cartilage is avascular, aneural and alymphatic. Five percent (5%) of cartilage volume is occupied by cells but lesions can and do heal. Chondrocytes divide and increase their rates of both synthetic and degradative processes and divide in response to alteration in the microenvironment. Cartilage health depends upon compression and release of weight bearing and use and may be influenced by changes in the magnetic environment. It was hypothesized that renormalization of magnetic profiles could restructure or remodel biological matter and thus restore function while reducing pain and crepitus from stiffness, instability and pressure.

Although the study discussed here in focuses upon the specific end-point of pain in OA, other studies by Brij Saxena, Director of the Division of Reproductive Endocrinology at Cornell University College of Medicine have shown effects of picoTesla (pT) magnetic

fields (MF) in the regeneration of sciatic nerves of mice *in vitro* indicating various other possibilities relating to altered signal transductive coupling across neuronal cell membranes. Currently, a pilot *in vivo* study utilizing pT MF's in mice at Cornell revealed potential palliation of motor neuropathy (irreversible neuromuscular damage secondary to chemical poisoning) and is ongoing. Additionally, very recent studies at the University of Oklahoma Health Sciences Center have revealed a possible link between the quantitative reduction of electrical potentials in single neurons secondary to stimulation of nociceptive fibers in the heart of rats while exposed to pT MF's. The study's principal investigator is Robert Foreman, Chairman of Physiology, and is ongoing.

Outcomes Analysis Corporation performed an independent analysis of data collected from a double blind controlled study. The objective of the study was to determine the efficacy of Jacobson Resonance Magnetic Fields on human subject suffering with knee pain secondary to osteoarthritis. One hundred seventy-six (176) patients pooled from four sites completed the study. The subjects were randomly assigned to one of two groups, the placebo group (magnet off) or the active treatment group (magnet on). Each group received eight treatments. Each subject rated his or her pain level from one minimal to ten maximal before and after each treatment session. On three separate instances; before treatment trials, during the treatment trials, and two weeks after treatment had terminated, subjects recorded their pain intensity while out of the treatment environment. Patients did not consume pain medication, use topical analgesics or other methods of pain treatment while participating in the study.

The effects of ELF electromagnetic fields (of less than 100Hz) in physiological signaling across cell membranes was reviewed by Adey.[8] The importance of the role of calcium ions in the first steps of transductive coupling at the cell membrane surface and ensuing steps of calcium-dependent trans- membrane signaling to calcium dependent intracellular enzyme systems were examined by Adey *et al.* and Byus *et al.*[9] Initial stimuli associated with weak pericellular EM oscillations caused binding of humoral molecules at receptor sites which elicit an extensive modification of calcium binding to glycoproteins by a cooperative mechanism along the membrane surface. This is a cooperative amplification state in which there is a far greater increase or decrease in calcium efflux than is accounted for in the energy of the imposed EM field.[10,11] The role of intramembranous proteins conveying signals from hormone receptor sites on the membrane surface to the cell interior has been identified by Luben *et al.*,[12] Basset *et al.*[13] and Luben and Cain.[14] Human epidermal growth factor (EGF) and nerve growth factor (NGF) receptor proteins are examples of such membrane coupling proteins. Jacobson and Yamanashi showed that extremely weak magnetic fields in pT range, and the frequency in the ELF range were obtained when the magnetic field strength is calculated from the Jacobson's equation, which relates the mass of critical molecules such as neurotransmitters to the intensity of applied magnetic fields, and the frequency as a function of the intensity from the cyclotron resonance equation.[15]

Materials and methods

The magnetic fields used in this study were generated by two 18" diameter coils constructed of 30 gauge copper wire connected in series (Helmholtz configuration), placed 9" apart. The coils were driven by a frequency and amplitude adjustable sinusoidal AC power supply (Hewlett-Packard Model 3325A synthesizer-function generator) and connected in series to a resistive attenuator to obtain the pre- selected pT range field in the space between coils. In calculating the intensity of the externally applied magnetic field the Jacobson's equation.[16-18]

$$mc^2=Blvq$$

was used, where m is the mass of a particle in a "box" or a "string", B is the magnetic field intensity, c is the velocity of electromagnetic field in space, independent of its in-

ertial frame of reference, q represents a unit charge q=1 coulomb, by defining electromotive force as energy per unit charge, v is the velocity of the carrier or "string" (a one dimensional "box") in which the particle exists, and 1 is its dimension (length). If the "string" is considered closed, then 1 may be the radius of the closed loop (a two dimensional "box"). Particles in this study are the critically important molecules selected on the basis of their roles in nerve repair, growth, and regeneration. The critically important molecules include: nerve growth factor (NGF), homeoboxes, neurotransmitters, cytokines, motor proteins, kinesine, microtubule associated protein (MAP), spectrin, brain specific fodrin, neurofilaments, tubulin, platelet derived growth factor (PDGF), and others. The frequency f was calculated from the ion cyclotron resonance equation,[19]

$$f=qB/2\pi m$$

The original 18" devices, developed at Stennis Space Center, were calibrated and characterized utilizing NASA furnished test equipment calibrated on an annual basis traceable to NIST through the Stennis Calibration and Standards Laboratory. All of the original 18" resonators were verified with precision volt, ohm, and current meters to determine the correct field intensity and uniformity. The calibration and characterization process verifies the uniformity and amplitude of the field. Precision ohmmeters are also utilized to verify resistive networks used to establish the desired current flow through the resonator coils.

The device is based on Helmholtz coil theory, where a uniform magnetic field exists between two coils spaced half the distance of the diameter of the coils. Research and theories define how low intensity magnetic fields can be used for biomagnetic purposes. The device utilized to produce the low intensity magnetic fields has been termed the Jacobson Resonator.

System descriptions

The basic system consists of a function generator, attenuator unit, the coils, and support apparatus for the coils. The electronic theory of the system is very simple in design, using a signal generator to produce a precise low intensity voltage, attenuating the voltage with precision resistors to match coil size to generate a very low intensity magnetic field.

The mechanical design has been kept as simple as possible to reduce weight, ease of operation, and simplicity for manufacturing.

A) *Coils.*—The coils are comprised of 5--turns of #37 gauge magnet wire wrapped around an 18" Lexan disc. The wire is covered with epoxy to protect the coils from damage. Each coil is wired in series with the attenuator unit to form a complete circuit.

B) *Attenuation Unit.*—The attenuator unit is comprised of three sets of precision resistors to match the coil diameter and turns to the signal generator. Each set of resistors provides a specific range of operation. Typically the resonator operates in the milli, micro, and nano gauss ranges. The micro gauss range is the most predominant within the primary protocols.

C) *Generator Unit.*—The signal generator is the heart of the system, producing the precise amplitude and frequency for the desired magnetic field. The generator is an HP3325A signal generator capable of DC to 20-Megahertz frequency generation and 1 millivolt to 10 volts amplitude generation. In conjunction with the attenuator unit this equates to a magnetic range of one femtogauss to 10 milligauss.

The resonator system was located in a room at least 10'×10' with no ferrous metal located in the room with the device. The chairs in which the patients were seated for the treatments were made from plastic or wood and had cushions to aid in comforting the patients. Jerry Jacobson provided all protocols which were utilized for the treatment of patients. The protocol settings were comprised of three basic elements: the frequency, the amplitude, and the time required for each setting. A sine wave form was utilized. Each setting was entered at the appropriate time until the protocol was complete. The range of flux densities encompassed 2.74×10^{-7} gauss to

Fig. 1.—Side view of patient's knee while being treated with the Jacobson Resonator.

Fig. 2.—Front view of the patient's knee while being treated with the Jacobson Resonator Helmholtz coils spaced nine (9) inches apart and having diameters of eighteen (18) inches. Positioning the Helmholtz coils about the patient's knee allowed use, of uniform homogeneous and isotropic flux lines to create the field exogenously applied.

3.4×10^{-8} gauss. Frequency range was 0.976 Hertz to 7.7 Hertz, a delta pattern to a low alpha. There are no direct connections to the patient of any type. The treatment is induced through exposure to low intensity picoTesla range magnetic fields. Positioning the Helmoholtz coils about the patient's Kince allowed use of uniform, homogenous and isotropic flux lines to create the field exogenously applied (Fig. 1, 2).

The study was randomized and an "on-off" switch was out of sight to the clinician and the patient. All control participants occupied precisely the same position with respect to the resonator as experimental participants, except that a third party would randomly turn the field off without anyone else knowing.

Neither the examining physician nor the clinician administering the treatment and collecting data knew who was experiencing the field and who was not. Upon completion of the study, the data was submitted to an independent biostatistician for evaluation.

The treatments administered consisted of the following protocols in Table I.

TABLE I.—*Protocol for OA Study.*

Exposure time (minutes)	B field (in gauss)	F (frequency in Hertz)
6	2.74×10^{-7}	7.7
6	2.0×10^{-7}	5.6
6	1.5×10^{-7}	4.1
6	1.26×10^{-7}	3.5
6	9×10^{-8}	2.5
6	7.8×10^{-8}	2.1
6	5×10^{-8}	1.4
6	3.4×10^{-8}	0.976

Results

Outcomes Analysis Corporation performed an independent analysis of data collected from the four site, placebo-controlled, randomized double blind controlled study.

Summary

On average, subjects in the magnet "on" group perceived a forty-six percent (46%) reduction in pain after a treatment session.

On average, subjects in the magnet "off" group perceived an eight percent (8%) reduction in pain after a treatment session.

The results show that there is a significant difference between the two groups. A two-way ANOVA (GLM) of the treatment and session showed that the reduction in pain was significantly greater in the magnet "on" group ($p<0.001$) than the magnet "off" group.

The test statistic Eta-squared was used to gauge effect size in a second ANOVA. The last after- treatment data showed that 36.30% of the variance in the treatment sample data could be explained by the independent variable, the magnet status.

In addition to an immediate reduction of pain after each session, the data for the "on" treatment group showed a successive decrease in pain levels in before- and after-treatment sessions as the study progressed. The mode (most frequent) pain-rating value in the first before-treatment session was seven. The mode value for the last before-treatment session was five. The mode value for the last after-treatment session was one A four point drop.

By comparison, the mode value for before-treatment of the "off" group was eight and ended the study with a before-treatment pain level of six. The mode value of the last after-treatment session (data collected period #TS8 After) was five, a drop of one point. This value is four points higher than the finale mode value of the "on" treatment group.

Expressed in percentages, the highest frequency values of the first before-treatment session (TSI Before) showed 27% (N=27) of the 101 subjects in the magnet "on" group rated their pain level at seven. The data from the first after-treatment session (TS I After) showed 26% (N=26) of the subjects in the magnet "on" group rated their pain level at four. This reflects a 3-point drop in pain levels. Seventy-eight percent (N=79) of the "on" group reported an after-treatment pain level of four or less *versus* 29% (N=22) in the "off" group. Twenty percent (N=15) of 74 subjects in the magnet "off" group rated their before-treatment pain level at 8. After the first treatment session, 27% (N=20) of the subjects in the magnet "off" group rated their pain level at six. This reflects a 2-point drop in pain level.

By comparison, an analysis of highest pain rating of the last treatment sessions (TS8 Before) showed 18% (N=18) of the 101 subjects in the magnet "on" group rated their pain level at five. After the last treatment session (TS8 After), 39% (N=39) of the subjects in the magnet "on" group rated their pain level at one. This reflects a 4-point drop in pain levels. Ninety-one percent (N=91) of the "on" group reported an after-treatment pain level of four or less *versus* 40% (N=30) in the "off" group. Twenty-three percent (N=17) of 74 subjects in the magnet "off" group rated their before-treatment pain level at six. After the last treatment session (TS8 After), 23% (N=17) of the subjects in the magnet "off" group rated their pain level at five. This reflects a 2-point drop in pain level as was seen in the first treatment session.

Analysis of the Diary data show that two weeks after the study concluded, the mean score (3.198) for pain level of subjects participating in the magnet "on" group was 49% lower than the mean pain level (6.327) of their pre-treatment Diary scores. This reduction was statistically significant at $p<0.000$.

Analyses of the Diary data show that two weeks after the study concluded, the mean score (5.364) for pain level of subjects participating in the magnet "off" group was 9% lower than the mean pain level (5.198) of their pretreatment Diary scores. This reduction was not statistically significant.

There were no missed treatment sessions in the "on" treatment group. Whereas 6.75 percent of the "off" treatment group missed a treatment session. Two subjects missed the sixth treatment session. Examination of their individual treatment data showed their pain levels from before and after-treatment to be the same, with two exceptions. One subject dropped one point, from eight to seven, during the third treatment session. The other subject dropped one point, from three to two, during the fourth session. The remaining three subjects with missing treatment sessions had, on average, pain levels greater than five and held similar after-treatment pain levels.

Subjects in the "on" group had a median pain level of 5 for six of the eight before-treatment sessions. The median pain level after treatment for five of the eight sessions was 2. This shows a 3-point reduction on the pain rating scale. In contrast, the median for pain level before- treatment for eight of the eight sessions for the non-treatment (magnet "off") is 6. The median pain level after treatment for eight of the eight sessions is 5. This shows a 1-point reduction on the pain rating scale for those in the "off" group.

A case-by-case analysis was conducted using SPSS 8.0. The objective was to determine how many patients received at least a one--

point reduction of pain, how many experienced no change in pain level and how many experienced an increase of one point or more. Three tests were performed on the Treatment Sessions data and the Diary data, Runs Test with 1) median, 2) mode and 3) mean. Multiple Selections with Frequencies and Crosstabulations were performed on the Treatment Sessions. All tests were run on the "Magnet On" data. The case-by-case analysis was performed using a selection criterion. The data were selected from the "Magnet On" table if they satisfied a condition. The condition was that the value of the first Treatment Session (TS 1 Before) had to be equal to or less than the pain level value of the last treatment of the study (TS8 After). The selection criteria were run 10 times, once for each level of pain, on the Treatment Sessions and the Diary data. The data that met the criteria were summarized, using SPSS, case-by-case. The criterion was the variable and the last Treatment Session (TS8 After) was the grouping variable in all of the summaries. Each case that satisfied the "less than/greater than" criteria was pulled and analyzed for this report

Data summary of case-by-case analysis

Of the 101 "Magnet On" patients evaluated in the Treatment Sessions, 96 percent received statistically significant ($p<0.000$) reductions in pain levels (Fig. 3, Table II).

Of the 101 "Magnet On" patients evaluated in the Diary data, 97 percent received statistically significant ($p<0.000$) reductions in pain levels.

The N=97 (96%) patients who experienced a reduction in pain, had on average a 53.25 percent reduction in pain.

100 percent of the patients in the "Magnet On" group received a reduction in pain levels because of at least one or more treatments with the resonator. The data from the 4 percent of the patients whose ending pain level was parity or greater than their first recorded level had reported reduced pain levels during the course of treatment.

The Diary data shows 100 percent of the patients in the "Magnet On" group received

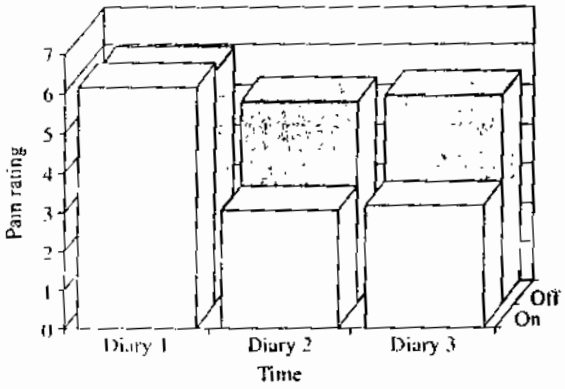

Fig. 3.—Mean Pain Rating of Diary Data.

a reduction in pain levels because of at least one or more treatments with the resonator. The data from the 3 percent of the patients whose ending pain level was parity or greater than their first recorded level had reduced pain levels during the course of treatment.

Two of the four patients whose ending pain level was parity or greater than their first recorded level for the Treatment Sessions had an ending pain level of parity or greater value than their first recorded level for the Diary data.

The patient (#6018) with the highest after-treatment pain level[10] for the last Treatment Session (TS8 After) had a pain level of 9 for the first Diary recording, 6 for the second and 5 for the third and final pain level recording. This patient had a 44 percent reduction in pain according to their Diary data. Analysis of this patient's data showed an average of 6.75 before-treatment pain level and an average of 3.125 after-treatment pain level across all eight Treatment Sessions. With the exception of the last and final Treatment Session, this patient, on average, experienced a 54 percent reduction in pain levels as a result of the resonator treatment.

The conclusion was that a case-by-case and multiple selection analysis of the "Magnet On" data show that 100 percent of the patients experienced a reduction in pain levels at a given point, during the course of the study. The multiple selection analysis showed an average pain reduction of 53 percent. The average before-treatment pain level rating was 5.046 and the average after-treatment

TABLE II.—*Jacobson Resonance Treatment Study Statistics*

Data collection period	N		Mean	Median	Mode	SD	Variance	Skewness	SE of Skewness	Minimum	Maximum	Percentiles		
	Valid	Missing										25	50	75
Magnet status	176	0												
Diary T1	175	1	6.154	6	6[a]	1.961	3.844	-0.330	0.184	1	10	5	6	8
Diary T2	175	1	3.983	4	3[a]	2.041	4.166	0.380	0.184	1	9	2	4	6
Diary T3	175	1	4.114	4	2	2.065	4.263	0.277	0.184	1	9	2	4	6
TS1 before	175	1	6.069	6	7	2.039	4.156	-0.389	0.184	1	10	5	6	8
TS1 after	176	0	4.125	4	4	2.148	4.613	0.351	0.183	1	10	2	4	6
TS2 before	175	1	5.766	6	7	2.075	4.307	-0.510	0.184	1	10	5	6	7
TS2 after	175	1	3.954	4	4	2.022	4.090	0.202	0.184	1	9	2	4	5
TS3 before	175	1	5.257	5	7	2.151	4.629	-0.233	0.184	1	9	4	5	7
TS3 after	175	1	3.680	4	3[a]	1.965	3.865	0.410	0.184	1	9	2	4	5
TS4 before	176	0	5.199	5	6	2.159	4.663	-0.167	0.183	1	10	3	5	7
TS4 after	176	0	3.631	3	1	2.033	4.131	0.434	0.183	1	9	2	3	5
TS5 before	175	1	5.057	5	6[a]	2.204	4.859	-0.093	0.184	1	10	3	5	7
TS5 after	175	1	3.486	3	1	2.111	4.458	0.528	0.184	1	10	2	3	5
TS6 before	174	2	4.994	5	6	2.130	4.538	-0.196	0.184	1	10	3	5	7
TS6 after	174	2	3.351	3	1	2.005	4.021	0.753	0.184	1	10	2	3	5
TS7 before	176	0	4.756	5	6	2.147	4.609	-0.211	0.183	1	10	3	5	6
TS7 after	176	0	3.313	3	1	1.980	3.919	0.519	0.183	1	9	2	3	5
TS8 before	176	0	4.676	5	6	2.243	5.032	-0.172	0.183	1	9	3	5	6
TS8 after	176	0	3.358	3	1	2.147	4.608	0.746	0.183	1	10	2	3	5

[a]Multiple modes exist. The smallest value is shown.

pain level rating was 2.694. Additionally, all of the tests show statistical significance at ($p<0.000$) for before- and after- treatment comparisons.

Data analysis

Methodology.—The data were analyzed using SPSS 8.0 and SAS software. The Treatment Sessions and Diary data were analyzed separately. The center, variability and shape of distribution of the data were computed on the complete data set as well as the treatment variable. Missing values in the data are noted. The following statistical tests were run on the treatment sessions. A two-way ANOVA with treatment and sessions crossed using SAS. SPSS was used to perform a one-way ANOVA to test for treatment effects. Crosstabulation of treatment by session were performed on the data from the Treatment Session with the objective of assessing directional measures. The test statistic Somers'd was used to evaluate significance and variable value. All three models showed a significant difference between treatment groups and treatment sessions. A two-sample t-test and a paired sample t-test were performed on the Diary data. Again, both models revealed statistical significance for treatment effect.

A secondary source to validate content reliability and analysis agreement was utilized.

Descriptive statistics.—An analysis of the descriptive statistics: median, standard deviation, mode and the means of the Treatment Sessions shows the data has a normal distribution. The data were analyzed as three separate groups: 1) total sample size (N=176), 2) treatment "On" group (N=101) and 3) treatment "Off" group (N=75). The results suggest using parametric analyses for three groups. The distribution shape and curve for the three groups reflects the significance of the treatment "on" effect, both immediately after a treatment session and over the duration of the study. The before-treatment distributions for the total sample are fairly consistent in their distribution across the pain rating scale, the peak (mean) is approximately in the center, 4-6 on the X axis and the Y axis (frequency) varies with the N and the group. The support for the alternative hypothesis, which states that the means of the

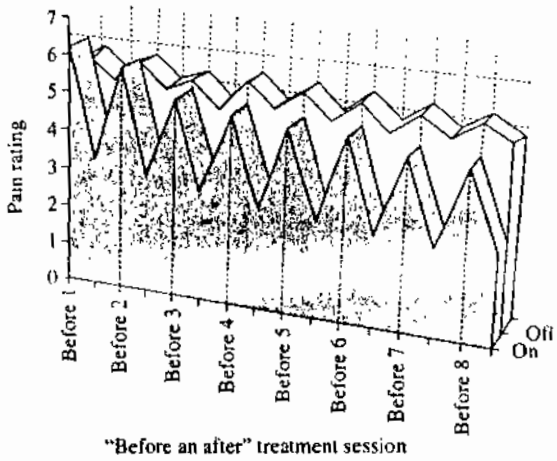

Fig. 4.—Graph of the mean pain ratings for the treatment sessions.

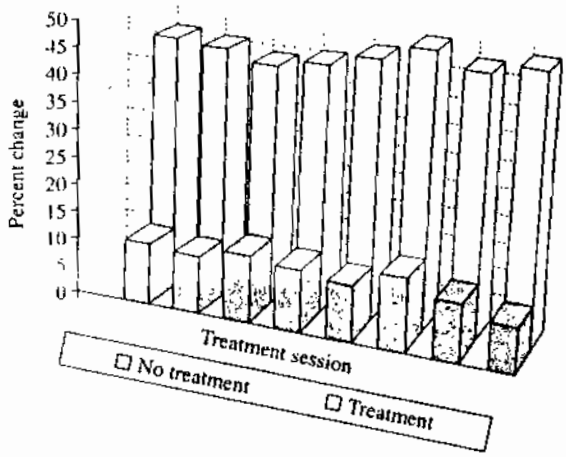

Fig. 5 —Comparison of Average Percent Reduction of Pain.

two treatment groups are different, is the skewness of the curve and the slope. The distribution of the magnet "On" group for the before-treatment sessions are negatively (median > mean) skewed and the after-treatment sessions are positive (median < mean). The distribution of the magnet "Off" groups' values are positively (median < mean) skewed for the before- and after-treatment sessions. Although the differences between the median and mean values of either group are not great, it is enough to suggest a difference between the two groups. The histograms in the Data Output Section are good graphical representations of these variations in distribution.

The standard deviation for the magnet "on" group decreases, in both before- and after-treatment sessions as the sessions progress. This points to a consistency in treatment effect between subjects, over time. The standard deviation of the magnet "off" group fluctuates, which supports the alternative hypotheses that there is a significant between treatment groups.

The mean pain ratings of the treatment sessions for the magnet "on" group show a consistent reduction in levels, starting from 3.2475 after the first treatment session to 2.2079 after the eighth or last treatment session.

Figure 4 is a graph of the mean pain ratings for the treatment sessions. It compares the means for the magnet "on" group and magnet "off" group. The "on" group peaks before treatment and drops, on average, approximately 2.5 points, or 49%, after treatment. The "off" group has a significantly less incline between peaks and shows no overall downward trend as seen in the "on" group.

Comparison of mean pain rating of treatment groups

Using the differences between the before- and after-treatment means the average percent of pain reduction was calculated and graphed in Figure 5. The magnet "on" group, on average, reported experiencing a 46.31 percent reduction in level of pain. The magnet "off" group, on average, reported experiencing a 7.97 percent reduction in level of pain.

Crosstabulation

Following is a discussion of the crosstabulation of treatment sessions by magnet status. Significance, strength and direction of the relationship between treatment and magnet status are not included in this crosstab analysis because the treatment variable is binary. A robust calculation of correlation should be made with varying levels of treatment. Nonetheless, an unofficial test was done on

the data using Somers'd test for directional measure. The findings for the values of r for each treatment session did show significant values of *r* in the after-treatment data for the "On" treatment group. Each value in the after-treatment data reflected a degree of strength between the treatment session and magnet status. The speculation, based on the inconclusive test, showed a potential increase in strength as the treatment sessions progressed, suggesting a linear relationship between the two conditions. As such, the conjecture is the strength of the relationship will increase with additional treatment sessions.

Diary data analysis

Descriptive statistics

The magnet "on" group had a 6.327 mean rating of pain level for the first diary, 3.069 for the second and 3.198 for the third. The "On" group had a 49% drop in pain level from the start of treatment session one to two weeks after the eight treatment sessions terminated. The magnet "off" group had 5.918 for the first, 5.229 for the second and 5.364 for the third. This group showed a 9% drop in pain level during the same duration. The median values for the magnet "on" group were: Diary 1=6, Diary 2=3, Diary 3=3. The median values for the magnet "off" group were: Diary 1=6, Diary 2=6, Diary 3=6.

The largest number, N=22 (21.8%), of subjects in the magnet "on" group rated their pain level at 6 for the first diary. The largest number, N=24 (23.8%), of subjects in the magnet "on" group rated their pain level at 2 for the second diary and N=27 (26.7%) rated their pain level at 2 for the third diary. A 4 point drop in pain level.

The largest number, N= 18 (24.0%), of subjects in the magnet "off" group rated their pain level at 8 for the first diary. The largest number, N=22 (29.3%), of subjects in the magnet "off" group rated their pain level at 6 for the second diary and N=17 (22.7%) rated their pain level at 7 for the third diary. A 1-point drop in pain level.

The standard deviation for the magnet "on" group moved closer to a symmetrical distribution in the second and third diary ratings. Although the standard deviation for the magnet "off" group was modestly reduced in the second and third diary ratings, it was not enough to denote a movement towards a symmetrical distribution.

TABLE III — *Paired samples statistics.*

Pair	Mean	No	SD	SE mean
1				
—Diary T1	6.1782	174	1.9406	0.1471
—Diary T2	3.9943	174	2.0415	0.1548
2				
—Diary T1	6.1782	174	1.9406	0.1471
—Diary T3	4.1264	174	2.0643	0.1565
3				
—Diary T2	3.9829	175	2.0412	0.1543
—Diary T3	4.1143	175	2.0646	0.1561

SD=standard deviation; SE=standard error

Pair sample t-test of diary data

The following Table III hold the means for the Diary data. The means of Diary T2 and Diary T3 are not significantly different. Pairs 1 and 2 are. These data show a change in the subjects' perception of pain level from the first session to the middle of the study and from the first session to two weeks after the study has terminated.

Independent samples test

Levene's Test for Equality of Variances conducted on all three diary pain ratings controlling for magnet status showed statistically significant differences between the three periods. Again, the differences between Diary 1 and Diary 2 t (173)=8.100, p<0.000, and Diary 1 and Diary 3 t (173)=8.00, p<0.000.

Table III shows the results of the test.

This test used magnet status as the independent variable. The test reflects a change in the patient's perception of pain as a function of the magnet status. The first Diary shows no significance, as would be expected since the subjects have not experienced a "treatment" at that point in time. This test shows that there is a significant difference (p<0.000) in subjects' perception of pain as a result of the magnet status.

TABLE IV.—*Independent Samples Tests of Diary Data - Testing for differences as a results of Magnet status.*

Data collection period	Levene's test for Equality of Variances		"t"-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	SE difference	95% Confidence interval of the difference	
								Lower	Upper
Diary T1									
-Equal variances assumed	2.481	0.117	-1.363	173	0.175	-0.4078	0.2993	-0.9985	0.1829
—Equal variances not assumed			-1.333	144	0.185	-0.4078	0.3059	-1.0124	0.1967
Diary T2									
—Equal variances assumed	2.970	0.087	8.100	173	0.000[a]	2.1604	0.2667	1.6340[b]	2.6869
—Equal variances not assumed			7.878	140	0.000	2.1604	0.2742	1.6182	2.7026
Diary T3									
—Equal variances assumed	3.753	0.054	8.006	173	0.000	2.1668	0.2706	1.6327	2.7010
—Equal variances not assumed			7.760	138	0.000	2.1668	0.2792	1.6147	2.7190

[a]Significance value at (<0.05). [b]The confidence interval for the mean difference does not contain zero, this also indicates that the difference is significant.

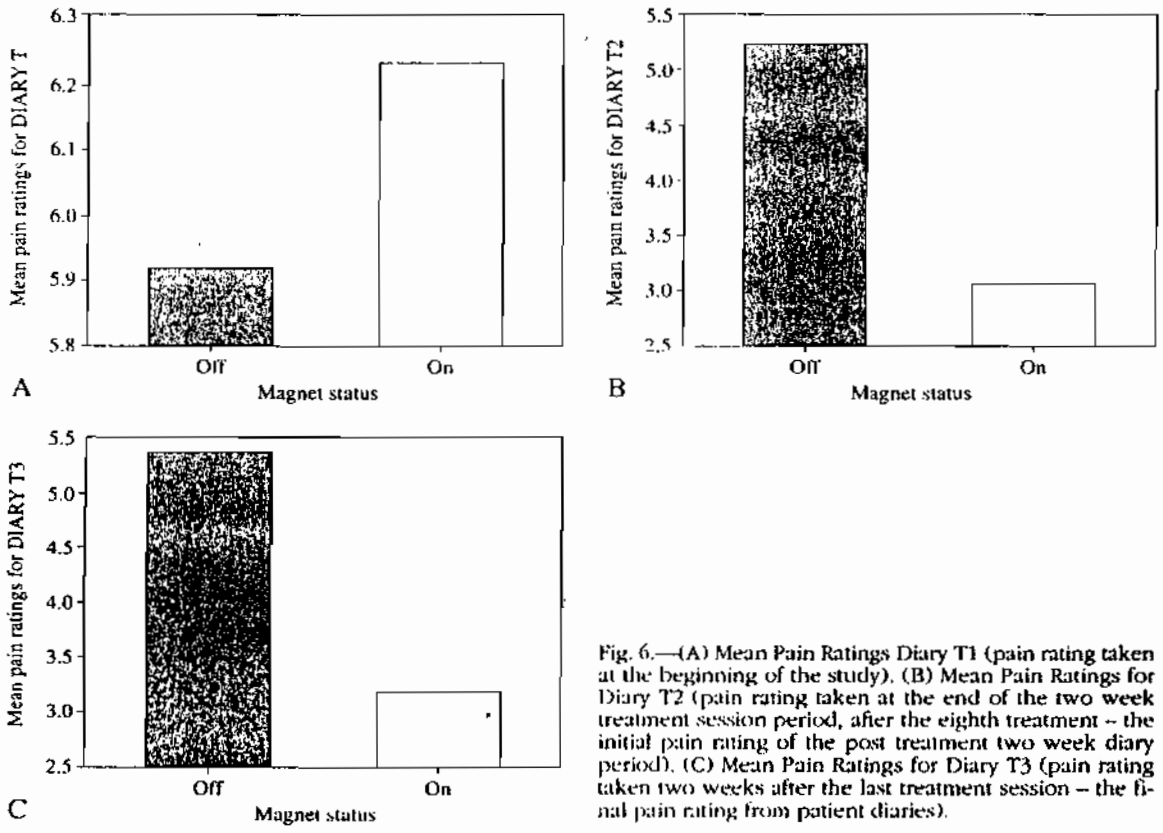

Fig. 6.—(A) Mean Pain Ratings Diary T1 (pain rating taken at the beginning of the study). (B) Mean Pain Ratings for Diary T2 (pain rating taken at the end of the two week treatment session period, after the eighth treatment – the initial pain rating of the post treatment two week diary period). (C) Mean Pain Ratings for Diary T3 (pain rating taken two weeks after the last treatment session – the final pain rating from patient diaries).

Figure 3 shows the mean pain rating of diary data. Table IV represents an independent samples test of diary data: testing for differences as a results of magnet status. Figures 6 A-C represent bar chart comparison of mean pain levels by magnet status.

TABLE V.—*Independent Samples Tests of differences between treatment groups. Magnet "Off" and "On".*

Data collection period (assumptions)	Levene's test for Equality of Variances		"t"-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	SE difference	95% Confidence interval of the difference	
								Lower	Upper
TS1 before									
—Equal variances assumed	1.021	0.314	-1.436	173	0.153	-0.447	0.311	-1.060	0.167
—Equal variances not assumed			-1.415	148	0.159	-0.447	0.316	-1.070	0.177
TS1 after									
—Equal variances assumed	1.613	0.206	6.137	174	0.000	1.827	0.298	1.239	2.414
—Equal variances not assumed			5.984	143	0.000	1.827	0.305	1.223	2.430
TS2 before									
—Equal variances assumed	0.674	0.413	-0.269	173	0.788	-0.086	0.318	-0.714	0.543
—Equal variances not assumed			-0.266	150	0.791	0.086	0.323	-0.723	0.552
TS2 after									
—Equal variances assumed	0.279	0.598	7.389	173	0.000	1.999	0.271	1.465	2.533
—Equal variances not assumed			7.291	149	0.000	1.999	0.274	1.457	2.541
TS3 before									
—Equal variances assumed	0.075	0.785	0.851	173	0.396	0.280	0.329	-0.370	0.931
—Equal variances not assumed			0.855	160	0.394	0.280	0.328	-0.367	0.928
TS3 after									
—Equal variances assumed	2.264	0.134	6.897	173	0.000	1.842	0.267	1.315	2.369
—Equal variances not assumed			6.769	146	0.000	1.842	0.272	1.304	2.380
TS4 before									
—Equal variances assumed	0.368	0.545	1.854	174	0.065	0.606	0.327	-0.039	1.251
—Equal variances not assumed			1.870	164	0.063	0.606	0.324	-0.034	1.246
TS4 after									
—Equal variances assumed	2.029	0.156	8.646	174	0.000	2.247	0.260	1.734	2.760
—Equal variances not assumed			8.404	141	0.000	2.247	0.267	1.718	2.775
TS5 before									
—Equal variances assumed	0.117	0.733	1.872	173	0.063	0.627	0.335	-0.034	1.288
—Equal variances not assumed			1.860	154	0.065	0.627	0.337	-0.039	1.293
TS5 after									
—Equal variances assumed	4.757	0.031	8.055	173	0.000	2.226	0.276	1.680	2.771
—Equal variances not assumed			7.791	136	0.000	2.226	0.286	1.661	2.791
TS6 before									
—Equal variances assumed	0.275	0.601	1.920	172	0.057	0.623	0.325	-0.017	1.264
—Equal variances not assumed			1.929	158	0.055	0.623	0.323	-0.015	1.262
TS6 after									
—Equal variances assumed	4.907	0.028	9.036	172	0.000	2.299	0.254	1.797	2.801
—Equal variances not assumed			8.608	125	0.000	2.299	0.267	1.770	2.827
TS7 before									
—Equal variances assumed	2.360	0.126	2.547	174	0.012	0.821	0.322	0.185	1.457
—Equal variances not assumed			2.587	168	0.011	0.821	0.317	0.195	1.447
TS7 after									
—Equal variances assumed	5.624	0.019	9.965	175	0.000	2.406	0.241	1.930	2.883
—Equal variances not assumed			9.597	134	0.000	2.406	0.251	1.910	2.902
TS8 before									
—Equal variances assumed	1.765	0.186	2.646	174	0.009	0.890	0.336	0.226	1.553
—Equal variances not assumed			2.672	165	0.008	0.890	0.333	0.232	1.547
TS8 after									
—Equal variances assumed	6.164	0.014	9.146	174	0.000	2.466	0.270	1.934	2.999
—Equal variances not assumed			8.829	136	0.000	2.466	0.279	1.914	3.019

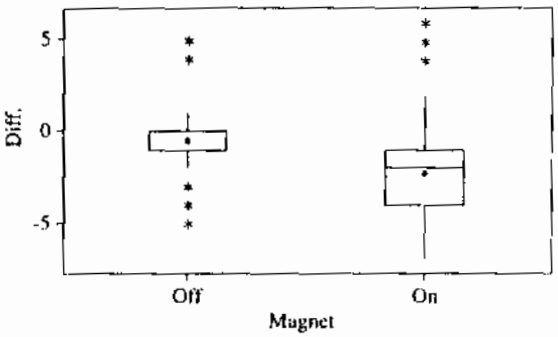

Fig. 7.—Boxplots of Diff by Magnet (mean are indicated by solid circles).

The results of the analysis presented show there is a statistically significant reduction in pain levels for patients suffering with knee pain secondary to osteoarthritis as a result of the magnet "On" status. On average, subjects have reported a 49% reduction in pain as a result of the Jacobson Resonance Magnetic Fields. The pain reduction appears to have a degree of longevity as indicated by statistically significant post-treatment data obtained with the third Diary pain levels.

Other than one outlier in the after-treatment levels, the highest level of pain experienced by any subject receiving the magnet "on" treatment during the last treatment session was 6 and that was indicated by only 3% (N=3) of the 101 subjects. Conversely, 4% (N=3) of subjects in the magnet "off" group expressed a pain level of 9.

The placebo effect can be used to explain some of the lowered pain levels found in the magnet "off" group. Although, not expressly tested for in this study, it is common to find similar levels of perceived benefits in the literature. In this study, an average of 9% of the subjects perceived a 1 to 2 point reduction in their level of pain. This one point reduction is not considered statistically significant.

The efficacy of Jacobson Resonance Magnetic Fields for the treatment of knee pain was found statistically significant in this trial on human subjects.

The next step would be the quantification of treatment levels over time; thus creating the opportunities to predict levels of pain reduction as a function of treatment "dosage".

Table V shows an independent samples test of differences between treatment groups: magnet "off" and "on".

Figure 7 shows boxplots of *diff* for magnet on and magnet off groups. Note that the centers of distribution (dots represent means and the line across the box represents the median) are both lower in the magnet on case, indicating a greater reduction in pain score than the magnet off group.

Discussion

The mechanism underpinning the biological effects demonstrated secondary to impingement of picoTesla magnetic fields upon said organism is based possibly in the subatomic realm. Perhaps there is a connection between the particles that comprise atoms (which are themselves permanent spinning magnets) and the cells that comprise us. It seems logical to presuppose that every level of structure and function underlies another and forms part of the basis for that perceived function. While the workings of living things are miraculous, the workings are knowable and may be regulated for our benefit. If the applied field is physiologic, or natural to the system, then there might be a reorientation of order and coherence in the tissue, including bone, connective tissue and muscle, thus producing less inflammation, improved circulation and diminution of pain with improved mobility. Improved cooperativity of systems and coherent charged states of course are manifest as ionic channels are influenced, *e.g.* calcium influx and efflux, and transductive coupling of signals is adjusted. Yet while the pain signal diminishes if the etiological factors diminish, the rapid response to the field also indicates an initial interference in signal transductive coupling such that the pain signal is not transmitted from the body part to be perceived by the brain. Regeneration may be induced through magneto-genomic interactions.

Previous to this study showing the palliative effect of the pT ELF magnetic fields in the treatment of osteoarthritic knees, there were several studies suggesting that there must be

several orders of magnitude amplification of initial EM stimuli which are recognized at the cell membrane surface needed to account for the observed effects. These included: EM field far weaker than the EEG that influence circadian rhythms in man and birds reported by Wever, and time estimation in monkeys observed by Gavalas-Medici *et al.*, and navigation and predation in sharks and rays studies by Kalmijn.[20] Following are some of the studies, observations, and proposed models that may account for these, as well as the studies in which pT ELF magnetic fields demonstrated significant nerve regenerative effects. Calcium levels are high in the fluid around cells (2.0 mM), and very low in the cytoplasm (10^{-7} M), while entry of micromolar amounts of calcium into the cell is powerful stimulus to intracellular systems, including activation of major enzyme systems. In order for the interactions to occur at athermal levels (*i.e.*, below kT) in biological substrates and with EM fields at the low frequency, Turing presented iomolecular models exhibiting cooperative patterns of organization. Othmer and Scriven extended these cooperative organization models to include cellular networks.[21] In biologic systems, these cooperative dynamic patterns are initiated and sustained by continuous inputs of energy. They are termed as "dissipative" processes and occur at far from equilibrium states with respect at least to one important parameter in the system (Katchalsky and Curran[22]). These non-equilibrium processes are characterized by resonant or window phenomena, an important aspect in the tissue interaction with weak EM fields. Other cooperative processes studies include: phase transitions, hysteresis, and avalanche effects (Schmitt *et al.*[23], Wyman and Allen[24]). Trigger signals to cooperative processes may be weak and the amplified responses are orders of magnitude greater as in the sharply non-linear release of[25] Ca^{2+} from binding sites in cerebral tissue by adding Ca ions, (Kaczmarek and Adey); and in a series of Ca-dependent processes at cell membranes that include the large generation of cAMP by glucagon binding to membrane receptors. Both frequency and intensity windows and somewhat irregular behavior are predicted from chaotic models of Kaiser in which selfsustained oscillations are required for interaction of regular external perturbations with internal oscillations, resulting in synchronization of the system to the external stimuli (entrainment). Liboff observed that for a mean value for the earth's geomagnetic field of 0.5 gauss, most of the singly and doubly charged ions of biological interest have cyclotron resonance frequency in the range of 10 to 100 Hz. Liboff proposed that imposed EM fields at frequencies close to a given resonance may couple to the corresponding ionic species to selectively transfer energy to these ions. Adey and Lawrence proposed a transductive coupling model from the membrane surface to the cell interior.[27] The initial step is dissipative and highly cooperative modulation of Ca binding at sites on terminals of stranded glycoproteins. The following steps involve solitary waves (or solitons) similar to those proposed by Davydov moving in sequence down the length of glycoprotein and lipoprotein molecules. These solitons may arouse the interaction of phonons and excitons along linear molecules that result in nonlinear molecular vibrations.[28 29] Adey, using the solitons and the non-linear models, attempted to explain how ELF fields millions of times weaker than the transmembrane gradient of 10^5 V/cm, can modulate cell response to surface stimuli. However, with the intramembranous proteins (IMP's) crossing the phospholipid bilayer being hydrophobic, and the necessity for photonic recycling of cell surface interaction after dissipation of energetic states, their model appears to further require structural and thermodynamic properties to maintain the necessary and sufficient energy (ΔE) sources for such an amplification. ELF fields apparently modulate surface electrochernical events, amplifying the trigger action of the ligand-receptor bond. Even though one accepts that the ligand-receptor association alters the conformation of the extracellular, extruding portion of the IMP's at the cell surface, and that this change can be transmitted to the cytoplasm by the transmembranous helical segment, by a receptor aggregation, or by nonlinear vibration of the helical proteins

with generation of soliton waves, one still needs to account for the differential by a factor of 10 12 between the photonic energy of a ELF wave and the Boltzman energy kT. When an extremely weak electromagnetic field (the magnetic component of which is in pT range) is impinging upon a biological system, the magnetic component will pass through the membrane while the electric component is sharply attenuated due to the high impedance. According to Clegg,[30] the ligand-receptor association is followed by cytoskeletal-mediated events and by the production of a 2nd messenger (cAMP or gCMP) by activation of the cyclase enzyme in the membrane itself or in its proximity. The microtrabecular reticulum establishes connections with membrane receptors and other structures in the cytoplasm. These reticulum-receptor connections result in an excellent means of intracellular communication. The microtrabecular reticulum consists of actin filaments and ATP molecules. It has been suggested that this may supply the necessary energy (ΔE) to activate the cyclase enzyme which requires a large input to produce the cyclic nucleotides (2nd messengers). Clegg stated that the growth sites of actin filaments are very close or directly connected to specific plasma receptors. The effect is the facilitation of the synthesis of a 2nd messenger and the transmission of external stimuli which reach the surfaces of cells directly, and rapidly communicate with the entire cell. Consequently extremely weak stimuli may be amplified and athermal effects by non-ionizing radiation may be produced. One may rationalize that magnetic fields produce piezoelectricity through the intracellular matrix, converting electromagnetic oscillations to mechanical vibrations (*i.e.*, photonphonon transductions), to induce molecular vibrations of frequencies specifically responsible for biological amplifications of extremely weak triggers at the membrane surface, as well as junctions. The frequency of the oscillating phenomenon related to hydrogen bonds is described by Bistolfi.[31] The frequencies appear to be limited in the vast infrared (IR) frequency band, from near IR (10^{14} Hz) to far IR neighboring MW 10^{12}-10^{11} Hz). The hydrogen bonds of considerable importance are those in proteins and DNA. They have oscillation frequencies in the lower range at about 10^{11} Hz[32] for DNA hydrogen bonds and around 10^{12} Hz for some proteins such as hemoglobin, lysozyme, keratin, poly-L-alanine and several poly crystalline aminoacids.[33]

DNA and protein hydrogen bonds, therefore, may be considered as centers of EM radiation emission in the range from the mm microwaves to the far IR. Piezoelectricity may be the common denominator for the aspecific actions of the various non-ionizing, order-inducing biological physical effects. Piezoelectric mechanisms may be present in all physiological processes. Examples are cells specialized in reception of external stimuli (heat, pressure and sound). These cells may convert the special types of energy and are sensitive to the energy (ΔE) which is order inducing and regulates the ATP metabolic engine. Various structures are thought to be piezoelectric, such as bone tissue, blood vessel walls, collagen fibers, keratin, albumin, and globulin, lipo- and glyco-proteins, nucleoproteins, histones, DNA and microtubules. Recent studies by Murzin and Finkelstein[34] have reported that proteins containing more than one α-helix have a nearly spherical polyhedron geometry. This structure renders the proteins quasi-crystalline, one of the characteristics that is associated with their being piezoelectric. Many of the molecules which are recognized as piezoelectric have α-helices present, and have an ordered polypeptide structure and a set of ordered dipoles which correspond to the definition of electret. Electrets are parallel molecular assemblies where the microscopic subunits and the whole unit have stable and permanently oriented dipoles. Electrets fulfill the requirement for an ideal cooperative system described by Adey, in which the system's microcomponents are: coherent, with congruent oscillatory trajectories, and ordered. In a near ideal cooperative system, due to the ordered structure, the entropy is retained at a minimum and biologically ordered free energy (ΔE) is maximized and made available by the interaction with the external stimuli and

its components for required amplification and driving the metabolic ATP engine. Alpha-helices seem designed for vectorialized conduction of phonon like energy pulses from the centers of energy release (redox reactions, ATP hydrolysis) to the site where it is used. Alpha-helices can therefore be compared to piezoelectric polypeptide springs able to transform chemical and electromagnetic energy into mechanical energy, and mechanical energy into electromagnetic energy. Thus the amplification of weak triggers by a factor of about 10^{12} is thought to occur through mediation of the magnetic component (of EM field) by piezoelectric structures both extra cellularly and intracellularly. Since the magnetic component may pass freely through the extremely high impedance for electric component (of EM Field) of the lipo-protein domain of the cell membrane, the amplifications secondary to photon-phonon transductions are made possible, and provide reduction of configurational entropy with available free energy (ΔE) to enable the utilization of the ATP-driven metabolic engine in promotion of growth, repair, and balanced function. We conclude by saying that responses of critical molecules to certain magnetic field signals may include enhanced vibrational amplitudes, increased quanta of thermal energies, and order producing interactions. For example, NGF may be considered as an "electret-like", *i.e.*, piezoelectric, semi-crystalline structure, and can be defined physically as an aggregation of charged particles whose integrated vectors have a quantum magnetic moments, and can be influenced with an extreme sensitivity by external magnetic fields. In general these interaction possibly re-orient submolecular magnetic domains and improve communications between and among critical molecules that comprise and engender the dance of life.[35,36]

In terms of an initial physical mechanism in the treatment of human pathology with externally applied pT ELF magnetic field, Jacobson and Yamanashi derived Equation (1) from the Faraday's law and the definition of the induced emf defined as energy per unit charge.[17] Jacobson's equation, Equation (1) states that the intrinsic energy of a particle in a magnetic field is equal to the energy propitiated by the Lorentz force, and it correctly predicted pT magnetic field intensity used for successful treatment of Parkinson's disease, MS and Epilepsy (Anninos *et al.* and Anninos, Tsagas and Sandyk) from the masses of NGF, of interferon, and of platelet derived growth factor (PDGF) respectively. The frequencies used in these treatments were also correctly predicted from using the pT magnetic field intensities thus obtained and substituted then in the cyclotron resonance equation, Equation (2) along with the mass values of the particles. We have been asked why have we used Jacobson's equation to predict the magnetic field intensity values and the Cyclotron resonance equation to calculate the frequency values. In response, first we derive equivalence in the energy (hence frequency) of Jacobson resonance to that of Zeeman resonance (*i.e.*, zero-order magnetic resonance) from the DeBroglie's wave-particle equation, Equation (3), then derive the equivalence of Jacobson resonance energy to that of Cyclotron resonance. DeBroglie expressed the momentum mv of a particle to its wavelength λ by

$$mv=h/\lambda \qquad (3a)$$

for a particle, where m is the mass and the v is the velocity of the particle, and h is the Plank's constant, and for an EM field,

$$mc=h/\lambda \qquad (3b)$$

(3b) can be written in terms of energy E,

$$E=mc^2=hc/\lambda \qquad (3c)$$

and

$$E=h\nu \qquad (3d)$$

since $\nu\lambda=c$. (3d) is the definition of the energy of a quantum.

For a particle in a closed "string" of radius 1, $\lambda=2\pi l$, so that Equation (3) becomes

$$mv=h/2\pi l \qquad (4)$$

rearranging Equation (4) and considering a particle with charge q, we have

$$qvl=qh/2\pi m \quad (5)$$

placing this particle in a magnetic field B and introducing g factor (for example: g=2.002322: electron, g=5.85486: proton), (5) can be expressed in terms of energy E, using the DeBroglie-Einstein expression (3c), we have,

$$E=mc^2=qvlB=qghB/4\pi m \quad (6)$$

and since the magneton β is defined as $\beta=qh/4\pi m$, Equation (6) becomes

$$E=mc^2=qvlB=g\beta B \quad (7)$$

(7) is the equivalence of energies between Jacobson resonance and Zeeman resonance for a single charged particle in a 2 dimensional closed "string" of circumference $2\pi l$. Similarly, the equivalence of energies between Jacobson resonance and Cyclotron resonance can be derived from Equation (1). Starting from Equation (5), and placing the particle in a magnetic field B, we have,

$$E=qvlB=qhB/2\pi m \quad (8)$$

Equation (8) is the equivalence of energy between Jacobson resonance and Cyclotron resonance. We have previously shown the equivalence of energy between the Cyclotron resonance and Zeeman resonance.[17] These equivalencies suggest that the qvBl is one of the fundamental expressions of energy of a charged wave-particle in magnetic fields, just as Zeeman and Cyclotron resonance energy expressions, $g\beta B$ and $qhB/2\pi m$ are, and is applicable to all charged particles in boxes (or "strings").

The justification for the selected v-values in this study is that all particles traveling with the earth through space share common cosmic inertial velocities. The particle-in-a-box is moving in relative translatory motion with respect to the earth frame of reference, whether the particles exhibit terrestrial motion or not with respect to the frames of reference which are localized on earth. The "particle-in-a-box" thus may be said to be moving with the orbital velocity of the earth, and with the rotational velocity of the earth as it moves through space maintaining a relatively fixed position with respect to local earth geography, and with the velocity of the solar system as it moves within the local star cluster following a vortical pattern about the center of the Milky Way Galaxy, etc. Furthermore, in accordance with Einstein's theory of Special Relativity, the magnetic component B cannot be said to be traveling with the earth as such because all electromagnetic radiation travels at speed c, the velocity of light, independent of its inertial frame of reference. Thus there is a spontaneous, independent, and incessant interaction of magnetic vector B and the charged "particle-in-a-box" which propitiates a Lorentz force. The Lorentz force produced by the action of inertial mechanisms may not necessarily manifest electromagnetic force. Einstein stated, "In contrast to the electric and magnetic fields, gravitational fields exhibit a most remarkable property, which is of fundamental importance. Bodies which are moving under the sole influence of a gravitational field receive an acceleration, which does not in the least depend either on the material or on the physical state of the body." An analogy between Maxwell's electromagnetism theory and Einstein's theory of gravity is that just as electromagnetic waves are created by the vibration of electric charges, gravitational waves are created by the vibration of masses. Furthermore, just as a traveling electromagnetic wave exerts a force by shaking other electric charges, a gravity wave travels through space to shake other masses. The notion that the gravity wave is the basis of Photon-phonon transductions in biological piezoelectricity and vibrational waves (solitons) represents a possibility explicating the causal nexus in the multi-magnitude biological amplification processes.[36,37]

Conclusions

This study has demonstrated that picoTesla range magnetic fields are a safe and effective modality by which to palliate chronic pain secondary to osteoarthritis of the knees.

More importantly, this study has revealed that extremely low level magnetic fields are

in some very critical way connected to the workings of our biomechanism. This fundamental connection gives hope for general applications since the underlying mechanism may indeed be Jacobson Resonance, pointing to a causal link between the very small and the very large. The link may represent the very essence of natural law and the nexus of causation. Just as intermediate bosons like mesons connect nucleons so may bosons like gravitons and photons be connected to heavy baryons which collect to form substantial material bodies. PicoTesla fields may represent a quantum gravity as very weak and subtle forces regulate the particles that comprise interacting heavenly masses. The universe becomes perhaps then unified by one simple relation that is so general it cries simplicity, elegance and beauty, the perfection of the universe.

The Zeeman energy term (right side of Equation (7)) is also an expression for a single charged particle such as an electron or a proton, placed in a magnetic field, and will only be a gross approximation for an atomic or molecular system. As an example, for a hydrogen atom, in order to analyze the magnetic resonance spectra, the spin energy levels in the wave equation of the hydrogen atom can be solved exactly by finding the eigenvalues of the complete energy matrix. The diagonal elements of this matrix, the spin Harniltonian, include both nuclear and electron Zeeman terms, and contact hyperfine (Fermi interaction) terms. The electron-nuclear dipolar terms averages out to be zero whenever the electron orbital is spherical. For a hydrogen atom with its spherical symmetry, the spin Hamiltonian has isotropic g-factors for the electron Zeeman and nuclear Zeeman terms ahd isotropic terms. But in molecules in solids and semi- solids, these factors very with direction and the spin Hamiltonian becomes anisotropic. The Zeeman term will be expressed in the second rank tensor and the g-factor becomes a 3×3 g-matrix. Similarly Jacobson resonance term (left side of Equation (7)) is an approximate expression describing a molecular or macromolecular system as a single charged particle in a closed "string" of radius 1 (a two dimensional "box"), or an open "string" (a one dimensional box) of length 1. Equation (1) and Equation (2) are useful in selecting the ranges for pT magnetic field intensities and corresponding frequencies for target molecules, some of which perhaps resulted in the regeneration of damaged neurons in this study.

"*Perhaps the success of the Heisenberg method points to a purely algebraical method of description of nature. It is not unimaginable that human ingenuity will some day find methods which will make it possible to proceed along such a path*" (Einstein).[38]

The clinical data indicating restoration to normal, of EMG profile after treatment, improved clinical symptoms, and laboratory analysis of blood and sera need to be correlated with changes in molecular structure, conformation, and other molecular, cellular, or histological properties resulting from the exposure to the picoTesla magnetic field. The following remain to be determined: (i) the specific nature of the molecular, cellular, or histological changes, (ii) the evidence that magnetically induced phonons can cause such molecular or microscopic changes, and (iii) the effects of such initial molecular, macromolecular, or microbiological changes on the known biochemical pathways of human endocrinology, immunology, and genetics, and (iv) the experimental determination of the criteria separating beneficial from hazardous or undesirable magnetic field effects.

The fundamental concept implicit in these conclusory remarks is that Einstein's view of gravitational ether is correct, and the gravitational field participates in the motion of ordinary matter. In addition, gravitational ether, shadow matter and dark matter provide the medium of electromagnetic fields. Einstein stated that everyday reality compels us to believe that the causal linking of natural phenomena involves the communication of motion through impact or contact. The Kalusa-Kline theory assigned a fifth coordinate for gravity in unifying gravity with electromagnetism. Supersymmetry and superstring theoreticians accomplished a similar abstract mathematical unification by proposing the concept of shadow-matter (or dark-matter) and

several additional dimensions. The Newtonian action-at-a-distance concept, which does not account for the force carrier in free space, is not accepted by either Einstein or modern theoreticians.

Further theoretical details which need to be addressed include: magnetic anisotropies typical in crystalline and liquid crystalline materials, magnetic interactions such as Fermi contact (or electron-nuclear hyperfine interactions) in free radicals, electron dipole-dipole interaction in the photo-excited triplet states and stable paired radicals, or electron spin-orbit (Russel-Saunders) coupling in organotransition metal complexes. All of these magnetic interactions further split the Zeeman energy levels into several discreet energy levels. Spin-orbit and electron dipole-dipole interactions exist at zero applied field and hence the pathogenic particles that may contain this interaction may require correction arising from these additional magnetic interaction terms (Hamiltonians).

Another important consideration is that the MEG profile of normal individuals may vary depending upon the states of mind. The MEG profiles corresponding to the α-wave, and those corresponding to the θ-wave are expected to be different. What constitutes the normal MEG profile? Is the efficacy of magneto-therapy distinguishable from the psychological effects of the patients upon receiving psychotherapy? Future clinical studies should be designed to answer some of these questions.

The intensity B of the externally applied magnetic field B and frequency f used in the recent successful clinical trials utilizing extremely weak (in picoTesla range) magnetic fields to treat patients with Parkinson's disease, epilepsy, and multiple sclerosis were correctly predicted from the *Jacobson and ion cyclotron resonance* equations [(1) and (8) respectively]. The former is used to predict the B-values of possible therapeutic efficacy, from the known mass m of a molecular species suspected to be involved in the disease process. The latter was determined for thef-values of possible therapeutic efficacy, from the known mass m and B-values calculated with the use of (1). We conclude that the physical mechanism operative in the magneto therapy of osteoarthritis and other diseases includes both *Jacobson and ion cyclotron resonance* (or *Zeeman resonance*). The Jacobson resonance is used to predict b-values for any particle (including pathogenic particles), placed in an external magnetic field B, whereas the *ion cyclotron resonance* is used for predicting f-values of the charged ionic species (electrons, protons, Na^+, K^+, Ca^{2+}, PO^+, etc.) placed in an external magnetic field B. For many pathogenic or pathology related particles (molecular species) including homeoboxes the B-value turns out to be in extremely weak picoTesla range, and the f-value in the extremely low frequency (ELF) range.

It is further considered in conclusion that recent data derived of *in vitro* mouse sciatic nerve studies at Cornell University Medical College in New York City utilizing the picoTesla range magnetic signals analogous to the osteoarthritis study hereunder delineated revealed marked regenerative capacity of these physiologic signals. Myelin sheaths were maintained in the experimental group as the control nerve segments degenerated and the myelin grew much thicker as well. Cellular and subcellular components were retained generally in the experimental group. This points to a generic action of extremely weak, physiologic magnetic fields with living systems, exciting indeed the continuance of research fervently looking for the ultimate explanation of life.[36]

Riassunto

Sperimentazione presso quattro centri dei campi magnetici nell'ambito di intensità picoTesla, sperimentazione clinica a doppio cieco per il trattamento del ginocchio affetto da osteoartrite

Obiettivo. Lo scopo del presente studio era quello di valutare l'efficacia dei Campi Magnetici di Risonanza Jacobson su soggetti umani affetti da dolore alle ginocchia doyuto a osteoartrite.

Metodi. La sperimentazione è stata effettuata su centosettantasei (176) pazienti in cura presso quattro centri diversi. I soggetti sono stati divisi in due gruppi con assegnazione randomizzata: un gruppo è stato trattato con placebo (trattamenti con il magnete non attivo) e l'altro sottoposto al trattamento attivo

(magnete attivo). Ogni gruppo ha ricevuto otto trattamenti nell'arco di due settimane. Ciascun soggetto ha attribuito un punteggio al livello di dolore percepito (da uno, per dolore minimo, a dieci, per dolore massimo) prima e dopo ciascuna delle sessioni di trattamento, in tre diverse occasioni: prima della sperimentazione, dopo la sperimentazione e a due settimane dalla fine della sperimentazione. I soggetti hanno registrato l'intensità del dolore provato al di fuori dell'ambiente di cura. I campi magnetici utilizzati nell'ambito del presente studio erano generati tramite il Dispositivo per la Risonanza Magnetica Jacobson; tale dispositivo è costituito da due bobine aventi diametro pari a 18 pollici, in filo di rame con diametro 30 AWG, collegate in serie (configurazione Helmholtz), poste alla distanza di 9 pollici l'una dall'altra. Le bobine sono collegate ad un alimentatore, come ad esempio il generatore di funzione HP3325A, e ad un attenuatore per ottenere il campo desiderato nello spazio compreso tra le spire. L'intensità del campo magnetico (densità di flusso) è stata calcolata con l'equazione $MC^2=BvLq$ (equazione di Jacobson). L'ambito delle densità di flusso impiegate andava da $2{,}74\times10^{-7}$ gauss a $3{,}4\times10^{-8}$ Gauss, con le frequenze corrispondenti pari a 7,7 Hertz e 0,976 Hertz. Mentre per le densità di flusso picoTesla si sono effettuate misurazioni che le mettono in correlazione con le onde cerebrali e il cuore, ad opera di David Colien del M.I.T., non esiste alcuna spiegazione nel campo della fisica classica per gli effetti biologici dei campi deboli. La Risonanza di Jacobson propone un meccanismo inteso a risolvere le difficoltà teoriche.

Risultati. In media, i soggetti appartenenti al gruppo trattato con il magnete attivato hanno avvertito una riduzione del dolore del quarantasei percento (46%) dopo la sessione di trattamento. I soggetti appartenenti al gruppo trattato con il magnete inattivo, invece, hanno avvertito una riduzione del dolore, a seguito della sessione di trattamento, dell'otto percento (8%). I risultati indicano l'esistenza di una differenza significativa tra i due gruppi. L'analisi della varianza ANOVA secondo il metodo lineare generale (GLM) del trattamento e della sessione ha dimostrato che la riduzione del dolore è stata significativamente maggiore nel gruppo trattato con il magnete attivato rispetto al gruppo di controllo ($p<0{,}001$). Inoltre, dei 101 pazienti del primo gruppo valutati nel corso delle sessioni di trattamento, il 96% ha beneficiato di riduzioni significative del dolore ($p<0{,}000$). I pazienti N=97 (96%) che hanno provato una riduzione del dolore hanno avuto in media una riduzione del dolore del 53,25%. Il cento percento (100%) dei pazienti del gruppo trattato con magnete attivato ha ottenuto una riduzione dei livelli di dolore a seguito di (almeno) uno o più trattamenti con il dispositivo per la risonanza.

Conclusioni. Lo studio indica che vale la pena di considerare la previsione della Risonanza Jacobson riguardo alla possibilità che i campi magnetici dell'intervallo picoTesla siano fisiologici. I risultati dello studio fanno ipotizzare un effetto biologico delle energie sottili che deve ancora essere considerato e analizzato in modo più approfondito.

Parole chiave: Osteoartrite, terapia - Campi magnetici.

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