



# CHRONIC FATIGUE SYNDROME - Is prolonged exposure to environmental level powerline frequency electromagnetic fields a co-factor to consider in treatment?

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## ABSTRACT

This paper outlines a brief description of the illness commonly known as Chronic Fatigue Syndrome (CFS) which is becoming increasingly common in modern westernised countries. While CFS has become somewhat of a 'catch-all' of medical symptoms, it is still commonly diagnosed by exclusion of other diseases rather than a specific, unique symptomatology.

One feature of the disorders commonly termed CFS is a depressed immune system. This paper attempts to link the impaired immune function associated with CFS to possible chronic low-level exposure to extremely low frequency (ELF) electromagnetic fields (EMFs). The evidence includes both *in vivo* and *in vitro* studies in both human and animal systems. In particular, the recent link between ELF EMFs, melatonin and the immune system are outlined.

The authors conclude that, although the link between ELF EMFs and cellular dysfunction are far from proven, sufficient evidence exists to suggest a causal link. Lack of full scientific certainty should not be used as a reason for postponing prudent avoidance of ELF EMFs, particularly in cases where CFS has already been diagnosed.

## KEY WORDS

Chronic Fatigue Syndrome; CFS; electromagnetic fields; EMF; 50 - 60 Hz; melatonin; prudent avoidance.

## INTRODUCTION

With any illness characterised by chronic fatigue, such as CFS, Chronic Fatigue (CF) and Immune Dysfunction Syndrome (CFIDS), Chronic Epstein-Barr Virus (CEBV), Myalgic Encephalomyelitis (ME), and Multiple Chemical Sensitivity (MCS), the important outcome is a severely dysfunctional immune system.

Evidence that these conditions involve an immunological disorder is accumulating rapidly. Within the past few years various abnormalities have been found in the immune system of CFS patients, for example. These include alterations in the activity and cell surface structure of two important types of white blood cells: natural killer cells and T-lymphocytes. In some patients, subtle changes have been found in the levels of neuroendocrine hormones in the brain. Evidence indicates that CFS is associated with, if not directly caused by, a persistent, low-level impairment of the immune system.

Irrespective of the 'trigger' of the condition, whether it be viral, an environmental factor, a genetic predisposition, stress, or a combination of these factors, any additional contributing factors which may also detrimentally affect the immune system should be identified, investigated and eliminated (or reduced) as part of the treatment.

In this regard, a co-factor may be considered anything that may cause hormone disruption and biological changes at a cellular level, thus

interfering with immune system function. This co-factor may not have initiated the condition, but exposure to it may further stress an already affected immune system. As long as such a situation exists, any treatment is unlikely to have any lasting effect.

Existing evidence indicates that exposure to environmental level 50 - 60 Hz EMFs may be an immune system stressor with the potential to cause hormone disruption and changes at a cellular level. Therefore, EMF exposure should be evaluated as a potential risk factor for people suffering from disorders with the common feature of unexplained chronic fatigue.

## CHRONIC FATIGUE SYNDROME (CFS)

CFS is a general label used to describe a debilitating illness, the cause of which is still unknown. CFS is also referred to as CFIDS (Chronic Fatigue and Immune Dysfunction Syndrome), CEBV (Chronic Epstein-Barr Virus), ME (Myalgic Encephalomyelitis), as well as several other designations. It is a complex illness which has been intensively studied for the past 40 years without firm conclusions as to its cause. Diagnosis is done largely by exclusion of other possible diseases.

Clinical CFS is characterised by incapacitating fatigue (experienced as exhaustion and extremely poor stamina) of at least 6 months' duration, neurological problems and a constellation of symptoms which can resemble other disorders, including: mononucleosis, multiple sclerosis, fibromyalgia, AIDS-related complex (ARC), Lyme disease, post-polio syndrome and autoimmune diseases such as lupus. These symptoms tend to wax and wane but are often severely debilitating and may last for many months or years. All segments of the population (including children) are at risk, but women under the age of 45 seem to be the most susceptible. As with most diseases, CFS affects people differently. Not everybody reaches the severe end of the CFS spectrum<sup>1</sup>.

There is a difference between CF and CFS. CF is a fairly widespread symptom in the community, whereas CFS is an unexplained debilitating fatigue of at least 6 months duration which severely reduces the level of activity. CFS is considerably less common.

In addition to persistent and extreme fatigue, usually with an abrupt onset accompanied by an 'infectious-like' illness, other CFS symptoms that have been identified include the following: substantial impairment in short-term memory and concentration; depression; sore throat; tender lymph nodes; muscle pain; multi-joint pain without joint swelling or redness; unusual headaches; unrefreshing sleep; cognitive function problems (such as spatial disorientation and impairment of speech and/or reasoning); visual disturbances (blurring, sensitivity to light, eye pain); chills and night sweats; dizziness and balance problems; sensitivity to heat and cold; irregular heartbeat; abdominal pain; diarrhoea; irritable bowel; low temperature; numbness or a burning sensation in the face or extremities; dryness of the mouth and eyes (Sicca syndrome); hearing disorders; menstrual problems including PMS and endometriosis; hypersensitivity of the skin; chest pains; rashes; allergies and sensitivities to odours (including chemicals and medications); weight changes without changes in diet; hair loss;

controlling the 24-hour daily biological rhythm. Disturbance of the normal diurnal melatonin rhythm is associated with altered oestrogen receptor formation in the breast, a line of experimental evidence now under study, or possible links between ELF field exposure and human breast cancer. . . Further, melatonin has general properties as a free radical scavenger, with the possibility of a preventative role in oxidative stress, recognized as a basic factor in a broad spectrum of human degenerative disorders, including coronary artery disease, Parkinson's and Alzheimer's diseases, and aging."<sup>15</sup>

According to the Committee, problematic sources of ELF EMFs include local electrical distribution systems as well as high voltage power transmission systems. Particular appliances, including electric blankets and video display units also rate highly as problem sources along with "various occupational environments". The Committee states that the evidence points to human health hazards in everyday exposures to EMFs, particularly magnetic fields exceeding 2 mG (0.2 µT) and electric fields at intensities in the range 10-100 V/m (volts per metre).

"...there is an implication that a significant proportion of the world's population may be subjected to a low level of risk, but a risk factor with significant societal consequences, by reason of its pervasive nature and the serious consequences for affected individuals."<sup>16</sup>

## MAGNETIC FIELD EXPOSURE AT THE CELLULAR LEVEL

The inter-relationships between various cellular processes are far too complex for a thorough discussion here. However, the scientific evidence accumulated to date from cell biology, biochemistry and bioelectromagnetics gives an excellent understanding of these processes and how EMFs may possibly interact with these processes. It is important to note that laboratory findings are not necessarily fully applicable to real life situations. Cell-level experiments are intended to detect and characterise an effect in a system simpler than a multi-celled organism. As such, in vitro experimental results are not affected by endogenous homeostatic [repair] mechanisms encountered in the whole organism and thus may be more sensitive to applied fields<sup>17</sup>.

The hormone, melatonin, and the neurotransmitters, serotonin and dopamine, are neurochemical messengers that aid in central nervous system transmission, or in the case of hormones, travel throughout the body to effect cellular changes. There are believed to be more than 100 transmitters and hormones that allow a complex interaction among the CNS, the endocrine system, and the immune system.

The cell membrane, where transmitters and hormones bind or cross into the cytoplasm, is the likely site of any interaction with external man-made EMFs. There are receptor sites both on the cell membrane and inside the cell to which these chemical messengers bind, starting a cascade of chemical events that may eventually alter the cell's behaviour in one of many ways.

An apt description of the cellular communication process was given by Dr W. Ross Adey, the former Associate Chief of Staff for Research and Development at the Pettis Memorial VA Medical Centre at Loma Linda, California, and NCRP committee chairman:

"It is generally agreed that the first detection of ELF and ELF-modulated RF/microwave fields occurs on the membranes that enclose all cells. These complex cell membranes act as detectors, amplifiers, and couplers of weak surface electrical and chemical signals to the cell's interior. Cells also communicate with neighbours by outward signals, faintly 'whispering together' electrically and chemically, through signals that are also sensitive to imposed EMFs."<sup>18</sup>

It is not necessary for external EMFs to penetrate into the cell interior in order to cause changes inside the cell, as reported by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 1996:

"By influencing signal transduction pathways, which in turn can regulate cell proliferation, cell differentiation, and even transformation to a cancer phenotype, ELF-EMFs can potentially be involved in a host of disease processes without ever penetrating the cell membrane in any significant manner."<sup>19</sup>

In summary, EMFs can bring about fundamental changes in both electrical and chemical signalling in the CNS. One chemical messenger that has been shown to be particularly susceptible to the influence of weak ELF EMFs is melatonin.

## MELATONIN

Both human and animal circadian rhythms are synchronised with the natural day/night cycle. The major control gland over this natural cycle is the pineal gland which secretes the neurohormone, melatonin. In mammals, light falling on the eye's retina during the day, produces signals which are biochemically amplified to stimulate the pineal gland to reduce its melatonin output. At night the absence of light allows the pineal gland to produce melatonin. Melatonin directly enters the bloodstream, through which it has access to every cell in the body, passing directly to receptors in the nucleus<sup>20</sup>.

In the cell nucleus, melatonin plays a role in regulating gene expression. The ability of melatonin to enter all cells is essential for one of its other important functions, which is to act as a scavenger of highly toxic oxygen-based free radicals. The production of these free radicals is a consequence of the utilisation of oxygen by all aerobic organisms. About 1% - 2% of inspired oxygen ends up as toxic free radicals, a by-product of the respiration cycle. These oxygen radicals can damage macromolecules such as DNA, proteins and lipids. This damage is referred to as oxidative stress<sup>21</sup>.

Because of its ability to eliminate free radicals, melatonin is regarded as an efficient cell protection and oncostatic agent. At night the increasing level of melatonin helps eliminate the build up of free radicals, thereby allowing DNA synthesis and cell division to occur with a far lower chance of damage. Melatonin also inhibits the release of oestrogen, prolonged exposure to which may increase the risk of breast cancer<sup>22</sup>.

According to Brzezinski, melatonin may enhance the immune system and counteract stress-induced immunosuppression by augmenting the immune response<sup>23</sup>.

## THE MELATONIN HYPOTHESIS

In 1987 Stephens et al. suggested that EMFs reduce melatonin production by the pineal gland and that melatonin suppresses the development of breast cancer<sup>24</sup>. They proposed that EMFs may operate as a co-factor in the development of some cases of this type of cancer. Since then, results from five in vitro studies, conducted in three major laboratories, using human breast cancer cell cultures, have shown that low-level powerline frequency magnetic fields in the order of 12 mG (1.2 µT) can block melatonin's ability to suppress breast cancer cells<sup>25</sup>. This is known as the melatonin hypothesis. In addition, several human exposure studies have found lowered levels of melatonin in people exposed to EMFs. (Section 2.3)

At the Second World Congress for Electricity and Magnetism in Biology and Medicine, held in Bologna, Italy, in June of 1997, the program bulletin states that:

"A number of experimental studies have been conducted to test the [melatonin] hypothesis. Although the literature is still evolving

They found a significant association between MF exposures and lower daytime melatonin levels on the second and third of three days of measurement<sup>38</sup>. The lack of an effect on the first day (following a weekend or equivalent) may indicate a cumulative effect of exposure. Some studies have suggested that EMF effects on melatonin may depend on whether the field is continuous or intermittent. Reif and Burch found that magnetic fields in the home that were “temporally coherent” (less intermittent) had a very significant association with lower melatonin levels at night. They concluded that the intensity and temporal characteristics of MFs may both play a role in the suppression of melatonin<sup>39</sup>.

Visual display units (VDUs) have also been implicated as a significant source of MF radiation. According to Arnetz and Berg, office workers who used VDUs had a significant reduction in circulating levels of melatonin over the course of a working day. No such change was found during days at the office with no VDU use. Levels of the stress hormone, ACTH, increased during the working day and this showed a strong correlation with workers’ subjective assessment of mental strain, but in contrast, mental strain did not significantly correlate with melatonin levels<sup>40</sup>.

Davis (Fred Hutchinson Cancer Centre in Seattle Washington), found that low-level MFs can reduce the nocturnal release of melatonin in women. While the effect was small, it occurred at milliGauss levels and followed a dose-response trend. Davis called the findings “intriguing” given the “very low level of exposure” which reflects “real-world” conditions, but cautioned that the biological significance of the results is not known at this time. Davis stated, “This is the first time we are seeing evidence that relatively small changes in magnetic fields at night can be associated with decreases in melatonin levels that night among humans living in a normal environment”<sup>41</sup>. Davis argues that melatonin inhibits the production of other hormones such as oestrogen. Thus, a drop in melatonin has the potential to cause other hormones to surge<sup>42</sup>.

As with the laboratory research these human field exposure studies indicate a possible link between EMFs and hormone disruption which may be a co-factor in the development of CFS. The link has not been firmly established, but further investigation is certainly warranted.

## DEPRESSION AND EMF EXPOSURE

Research in the United States and Britain has found clinical depression to be the major factor in suicides in both countries. There are many types of depression, from seasonal depression (Seasonal Affective Disorder), which normally occurs in the winter months, to low level chronic depression that may linger for months or years. Among the symptoms of clinical depression are weight loss, early waking, diminished sex drive and a general feeling of hopelessness. On the contrary, some people have what is called atypical depression, which is characterised by weight gain and spending much of the day asleep.

In 1978, Perry published the findings of an EMF survey which examined the addresses of some 600 suicides reported in the Birmingham U.K. area and found that in homes where the magnetic field was above 1 mG (0.1  $\mu$ T) the relative risk of depressive illness was elevated<sup>43</sup>. Perry and Pearl conducted a study of 43 high-rise blocks with over 3,000 housing units (a total of approximately 6,000 occupants). The aim of the research was to determine whether there was any correlation between occupants’ level of depression and their proximity to EMFs. Participants suffering from certain types of heart disease and from depression were more likely to be living near the main electrical supply cables in the apartment blocks. Magnetic field strengths measured in all 43 blocks with a single rising cable showed significantly higher magnetic field exposures in the apartments ‘near’ the cable. These fields averaged 3.15 mG (0.315  $\mu$ T) nearest the cable and 1.61 mG (0.16  $\mu$ T) in the ‘distant’ apartments. A further finding was that, if only those blocks with under floor or storage

electric heating were considered, the proportion of cases of depression in occupants living in apartments categorised as ‘near’ the rising cable rose to 82%<sup>44</sup>.

Changes in serotonin levels are known to be associated with depression. For example, lowered levels of this chemical in the brain have been linked to an increase in suicide frequency<sup>45</sup>. Wolpaw examined the brain functions of monkeys exposed to 60 Hz magnetic fields. He measured the levels of neurohormones in the spinal fluid of monkeys thus exposed for three weeks. It was found that the levels of serotonin and dopamine were significantly depressed immediately following exposure, and that only the dopamine returned to normal levels several months after<sup>46</sup>.

Low night-time melatonin concentrations have been reported in patients with depression, and patients with Seasonal Affective Disorder have phase-delayed melatonin secretion<sup>47</sup>.

Robert Becker, a leading researcher on EMF exposure and depression, summarises his own work, and that of others as follows:

“It seems that there may be two types of clinical depression: one which is produced by simple psychosocial factors, and one which is produced by some external factor which influences the production of these psychoactive chemicals by the pineal gland. In view of the known relationship between the pineal gland and magnetic fields, it is advisable that the search for the responsible factor include an evaluation of the effect of abnormal electromagnetic fields”<sup>48</sup>.

## OTHER RELEVANT RESEARCH FINDINGS

Since 1979, when, in a seminal paper, Wertheimer and Leeper first reported a correlation between exposure to power line MFs and childhood leukaemia, there have been well over 30 major epidemiological studies examining the EMF/cancer question. Few studies, however, have looked for evidence of association between environmental power-frequency magnetic field exposure and immune-related illnesses in humans.

In one notable study, Beale et al. examined eight immune-related and chronic illnesses (variables) in a group of 560 adults living near extra high voltage transmission lines in Auckland New Zealand. Using a cross-sectional design to examine the dose-response relationship between MF exposure of adults in their homes and prevalence of these illnesses, five of the eight health variables showed a linear dose-response relationship with exposure. After adjustment for possible confounding, significantly elevated odds ratios were obtained both for asthma and combined chronic illnesses at higher exposure levels. As reported in the paper abstract, “The results are consistent with a possible adverse effect of environmental magnetic field exposure on immune-related and other illnesses”<sup>49</sup>.

Human peripheral blood lymphocyte activity may be affected by exposure to electric fields. For example, Coghill et al. (1998), exposed human peripheral blood lymphocytes in mu-metal- enclosed (EMF shielded) cultures to the donor’s own endogenous electric field overnight and tested for viability by trypan blue exclusion. This showed a 70% viability. The controls (no endogenous electric field) and sham-exposed (same gold wire feed, but unattached to body) both showed about 50% viability. When they fed a 50 Hz electric field into the lymphocyte cultures (same power density, same period of exposure, same temperature, etc.), the viability fell to 40%. This study suggests that 50 Hz electric fields (not magnetic) adversely affect human peripheral blood lymphocytes<sup>50</sup>. A decrease in human peripheral blood lymphocytes could be implicated in the development of CFS.

A 1998 study by Bonhomme-Faivre et al. found “evidence that chronic human exposure to environmental low frequency EMFs ...

## CAVEAT

The authors wish to express the strong view that they do not support nor condone the use of any devices which claim to cleanse or protect the body from EMFs and have not been scientifically proven to do so.

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