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The Biologic Effects of Grounding the Human Body During Sleep as Measured by Cortisol Levels and Subjective Reporting of Sleep, Pain, and Stress

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ABSTRACT

Objectives: Diurnal cortisol secretion levels were measured and circadian cortisol profiles were evaluated in a pilot study conducted to test the hypothesis that grounding the human body to earth* during sleep will result in quantifiable changes in cortisol. It was also hypothesized that grounding the human body would result in changes in sleep, pain, and stress (anxiety, depression, irritability), as measured by subjective reporting.

Subjects and Interventions: Twelve (12) subjects with complaints of sleep dysfunction, pain, and stress were grounded to earth during sleep for 8 weeks in their own beds using a conductive mattress pad. Saliva tests were administered to establish pregrounding baseline cortisol levels. Levels were obtained at 4-hour intervals for a 24-hour period to determine the circadian cortisol profile. Cortisol testing was repeated at week 6. Subjective symptoms of sleep dysfunction, pain, and stress were reported daily throughout the 8-week test period.

Results: Measurable improvements in diurnal cortisol profiles were observed, with cortisol levels significantly reduced during night-time sleep. Subjects' 24-hour circadian cortisol profiles showed a trend toward normalization. Subjectively reported symptoms, including sleep dysfunction, pain, and stress, were reduced or eliminated in nearly all subjects.

Conclusions: Results indicate that grounding the human body to earth ("earthing") during sleep reduces night-time levels of cortisol and resynchronizes cortisol hormone secretion more in alignment with the natural 24-hour circadian rhythm profile. Changes were most apparent in females. Furthermore, subjective reporting indicates that grounding the human body to earth during sleep improves sleep and reduces pain and stress.

INTRODUCTION

The objective of this pilot study was to examine the biologic effects of grounding the human body to earth (see Appendix A) during sleep, as measured by cortisol levels and circadian cortisol secretion profiles and subjective reporting of sleep dysfunction, pain, and stress. The hypothesis tested was that diurnal secretion levels of the stress hormone cortisol will change as a result of grounding the human body to earth during sleep. It was also hypothesized that grounding the human body would result in changes in sleep, pain, and stress (anxiety, depression, irritability), as measured by subjective reporting.

Cortisol is a hormone that is associated with psychologic and physical stress, inflammation, and sleep dysfunction in humans. Chronic elevation of cortisol can result in disruption of circadian rhythms, which, in turn, is a contributor to a multitude of adverse health conditions, including sleep disorders, hypertension and cardiovascular disease, stroke, decreased bone density, decreased immune response, mood disturbances, autoimmune disease, and abnormal glucose levels (Alschuler, 2001). Neurologic effects of chronic elevated cortisol secretion include chronic activation of the sympathetic nervous system (flight-or-fight response) leading to hypertension and cardiovascular disease. The hypothalamic–pituitary–adrenal (HPA) axis and the sympathetic nervous system have been utilized as objective markers of stress reactions (Bjorntorp, 2001).

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*See Appendix A.

Cortisol is produced in the adrenal cortex and is an arousal hormone. In an unstressed state, the human body produces a predictable day–night pattern of cortisol secretion. Normal diurnal variation in cortisol secretion produces higher cortisol levels in the daytime (for activity) and lower levels at night (for rest). Disregulation of normal circadian rhythms is clearly associated with abnormal cortisol secretion profiles. Chronically elevated cortisol is a biomarker for stress and is associated with many chronic diseases.

The body reacts to an initial stressor by secreting both inflammatory and anti-inflammatory hormones. Prolonged exposure to stressors can result in persistent inflammation, which, in turn, leads to prolonged secretion of anti-inflammatory hormones. Glucorticoids, including adrenocorticotropic hormone (ACTH), cortisone, and cortisol, exert anti-inflammatory effects primarily by counteracting the formation and release of proinflammatory messenger chemicals including catecholamines, prostaglandins, cytokines, nitric oxide, platelet-activating factor (PAF), and heat-shock proteins (Alschuler, 2001; Seyle, 1956). This adaptive response to stress is beneficial in the short term but can lead to serious problems, such as chronic disease and tissue damage if the process becomes chronic. The endocrine, gastrointestinal, immune, and neurologic systems are most subject to chronic stress, and chronically elevated cortisol secretion is a measurable biomarker.

Cortisol-releasing mechanisms may be involved in the regulation of sleep (Follenius et al., 1992). Twenty-four (24) hour hypersecretion of cortisol has been linked to chronic insomnia (Vgontzas et al., 2002). Evening and nocturnal cortisol levels were significantly increased in patients with severe chronic primary insomnia (Rodenbeck et al., 2002). Power-frequency 50–60 Hz extra-low frequency electromagnetic fields and pulsed radiofrequency fields are reported to affect sleep. Sleep disruption has been reported in human populations with night-time exposure to elevated 50–60 Hz electromagnetic fields (Akerstedt et al., 1999; Li et al., 2002). Weak, pulsed radiofrequency radiation at 20 μW/cm2 has been reported to alter the HPA axis with a slight elevation in cortisol serum level (Mann et al., 1998b). Significantly suppressed sleep electroencephalographic (EEG) and disruption of rapid eye movement (REM) sleep are reported after exposure to pulsed radiofrequency (Borbely et al., 1999; Huber et al., 2000; Mann and Roschke, 1996; Mann et al., 1998). Pulsed radiofrequency exposure is reported to alter cerebral blood flow, and sleep and waking EEGs (Huber et al., 2002). Mann et al. (1998) reported significant sleep differences after exposure to weak pulsed radiofrequency radiation, with a predominance of the parasympathetic over sympathetic tone in the autonomic nervous system. Together, these studies indicated that weak exposures to electromagnetic fields can disrupt normal sleep patterns as measured by various parameters, including direct measurement of hormones, sleep quality, duration of sleep, sleep EEG, REM sleep patterns, parasympathetic/sympathetic autonomic nervous system balance, and disruption of normal sleep spectral-power density ranges (see Appendix B).

Reliable reductions in subjective and physiologic indices of stress have shown that relaxation training produces significantly lower levels of postintervention heart rate, state anxiety, perceived stress, and salivary cortisol levels than control subjects as well as increased self-reported levels of relaxation (Pawlow & Jones, 2002).

Disregulation of circadian cortisol profiles is associated with pain perception (Korszun et al., 2002). Aging in humans is accompanied by an increase in adrenal glucocorticoid secretion. Cortisol excess may contribute to impacts of aging as expressed by cognitive impairment and hippocampal neuronal loss (Yen and Laughin, 1998). Major depressive illness is associated with disturbances of pituitary–adrenal function with chronic high cortisol levels and disruption of normal circadian cortisol profiles (Linkowski et al., 1985). Depression, suicide and headache have been linked to exposure to electromagnetic fields (Baris et al., 1996; Baris and Armstrong, 1990; Beale et al., 1997; Brown et al., 1987; Dowson et al., 1988; Kay, 1994; McIntyre et al., 1989; McMahan et al., 1994; Perry et al., 1981; Perry et al., 1989; Poole et al., 1993; Reichmanis et al., 1979; Savitz et al., 1994; Semm et al., 1980; Van Wijngaarden et al., 2000; Verkasalo et al., 1997; Welker et al., 1983; Wilson, 1998). Chronic exposure to electromagnetic fields has also been linked to neurologic changes including amyotrophic lateral sclerosis, cognitive impairment and spatial disorientation (Johansen and Olsen, 1998; Lai, 1996; Lai and Carino, 1998, 1999; Lai et al., 1998).

MATERIALS and METHODS

Subjects

Twelve (12) subjects were selected from a group of individuals responding to a request for research study partic-

TABLE 1. BODY VOLTAGE FOR EACH SUBJECT

	Electric field induced voltage measured on subjects' bodies while lying in their own beds	
Subject	*Before grounding*	*After grounding*
1	3.940 V	0.003 V
2	1.470 V	0.001 V
3	2.700 V	0.004 V
4	1.200 V	0.002 V
5	2.700 V	0.005 V
6	1.670 V	0.005 V
7	5.950 V	0.008 V
8	3.940 V	0.008 V
9	3.750 V	0.010 V
10	2.300 V	0.009 V
11	5.980 V	0.020 V
12	3.640 V	0.006 V

TABLE 2. CIRCADIAN CORTISOL LEVELS BEFORE AND AFTER SLEEPING GROUNDED TO EARTH

	8 PM	*Midnight*	*4 AM*	*8 AM*	*Noon*	*4 PM*
Subject 1 Female 24						
Before grounding	11.3	6.8	23.9	35.9	8.7	12.5
After grounding	13.0	3.3	6.9	37.5	8.2	7.5
Change	**15%**	**−51%**	**−71%**	**4%**	**−6%**	**−40%**
Subject 2 Female 53						
Before grounding	7.6	14.3	3.3	58.4	18.9	23.8
After grounding	4.1	3.9	11.4	38.7	12.4	15.5
Change	**−46%**	**−73%**	**245%**	**−34%**	**−34%**	**−35%**
Subject 3 Female 50						
Before grounding	5.5	3.3	3.7	41.1	10.4	12.5
After grounding	4.5	8.3	10.9	48.6	22.2	8.9
Change	**−18%**	**152%**	**195%**	**18%**	**113%**	**−29%**
Subject 4 Female 42						
Before grounding	2.5	6.0	19.3	27.6	11.2	9.3
After grounding	2.6	2.4	5.7	33.8	11.1	8.3
Change	**4%**	**−60%**	**−70%**	**22%**	**−1%**	**−11%**
Subject 5 Female 51						
Before grounding	4.2	4.2	22.2	72.6	4.4	3.6
After grounding	5.6	2.6	3.6	42.0	7.7	5.7
Change	**33%**	**−38%**	**−84%**	**−42%**	**75%**	**58%**
Subject 6 Female 52						
Before grounding	6.0	8.6	12.4	23.5	5.2	12.7
After grounding	4.5	3.8	7.1	29.2	6.3	7.5
Change	**−25%**	**−56%**	**−43%**	**24%**	**21%**	**−41%**
Subject 7 Female 44						
Before grounding	8.6	14.8	3.2	25.4	6.1	6.1
After grounding	8.4	7.7	10.3	44.7	9.3	7.9
Change	**−2%**	**−48%**	**222%**	**76%**	**52%**	**30%**
Subject 8 Female 31						
Before grounding	2.1	5.2	11.6	24.3	9.5	7.1
After grounding	2.8	2.6	12.8	39.3	17.1	8.1
Change	**33%**	**−50%**	**10%**	**62%**	**80%**	**14%**
Subject 9 Male 72						
Before grounding	11.1	3.7	5.0	27.5	19.7	15.9
After grounding	4.2	10.8	15.9	27.8	17.6	8.0
Change	**−62%**	**192%**	**218%**	**1%**	**11%**	**−50%**
Subject 10 Male 37						
Before grounding	5.0	3.1	23.2	28.7	12.7	10.9
After grounding	6.1	2.8	23.9	29.8	13.7	8.6
Change	**22%**	**−10%**	**3%**	**4%**	**8%**	**−21%**
Subject 11 Male 50						
Before grounding	2.4	2.8	3.9	27.9	30.9	7.9
After grounding	2.8	2.9	5.6	33.4	14.4	8.6
Change	**17%**	**4%**	**44%**	**20%**	**−53%**	**9%**
Subject 12 Male 39						
Before grounding	4.6	3.2	21.9	20.7	11.0	7.2
After grounding	4.2	3.2	22.8	24.3	10.3	7.3
Change	**−9%**	**0%**	**4%**	**17%**	**−6%**	**1%**

ipants with sleep disorders, pain, and stress. The 8 female and 4 male subjects ranged in age from 24 to 72, with the average age being 45. Subjects were interviewed via telephone to confirm the presence of chronic sleep, stress, and pain problems. Prospective subjects were not accepted as participants if they were using corticosteroids, antidepressants, narcotics, or oral sleep aids. Informed consent and completed health questionnaire forms were obtained from all selected subjects. Subject participation was supervised by a research coordinator who contacted subjects weekly, was available for questions, and confirmed that subjective data was being accurately recorded by subjects.

Grounding to earth during sleep

Subjects were grounded to earth (see Appendix A) during sleep by placing a conductive mattress pad, provided by Earth Tether International Corporation (model #2455-8;

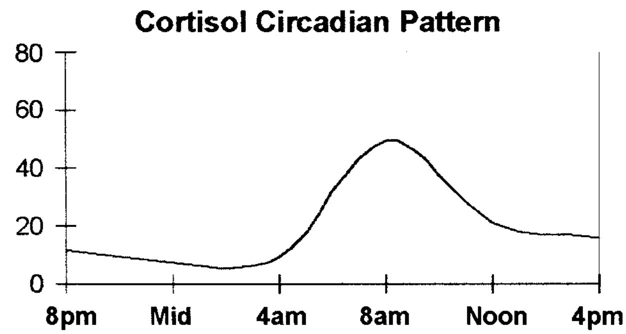

FIG. 1. Normal circadian cortisol secretion profile. Sabre Sciences Laboratory, 2002.

Earth Tether International Corporation, West Covina, CA), under their fitted sheets. Each mattress pad (containing conductive carbon fibers and having a dissipative surface resistance of 1×10^5 ohms) was attached to a ground cord that was connected at the other end to a 12″ ground rod. The ground cord was run outside, via each subject's bedroom window, and the attached ground rod was driven into the earth. The ground cord contained an inline 10 mA ground fault-protection fuse.

Electric field–induced voltage (from lamps, clocks, wiring in walls, etc.) created on the subjects' bodies, in their respective beds, was measured before and after grounding with the use of a MASTECH (model MS8216; MASTECH, Kowloon, Hong Kong) Digital Multi Meter (DMM). The DMM was grounded directly to earth and each subject's 60-Hz electric field induced body voltage was measured by skin contact with the ungrounded terminal of the DMM, while the subject was in bed.

The subjects' average pregrounding 60-Hz electric field induced body voltage was measured at 3.27 V (3.27 volts or 3270 millivolts) and dropped to an average of 0.007 V (7 millivolts) in bed while lying on the grounded mattress pads (Table 1). This drop in voltage demonstrates that the grounding effect of the conductive mattress pads significantly reduced electric field–induced voltage created on subjects' bodies.

Laboratory cortisol hormone testing

In order to obtain a baseline measurement of the hormone cortisol, each subject, prior to being grounded, completed a self-administered 24-hour (circadian rhythm) collection of saliva samples. At each collection time, subjects chewed a Dacron salvette for 2 minutes, then placed it in the appropriate time-labeled sampling tube, and stored it in the refrigerator. Self-administered sample collections began at 8 AM and were repeated every 4 hours. After 6 weeks of being grounded, subjects repeated this 24-hour saliva test. The samples were processed by Sabre Sciences Laboratory of San Diego, CA, using a standard radioimmunoassay. Results of saliva tests (cortisol levels) for each subject for each test interval are shown in Table 2.

Subjective testing

Each subject completed a Daily Sleep Survey (a modified National Sleep Foundation Diary) for a 1-week duration to establish a pregrounding sleep baseline. To establish pregrounding pain and stress (anxiety, irritability, depression) baselines, subjects completed a Weekly Pain Survey and a General Health Survey (Modified SF-12 Survey Form), which included questions regarding emotional health. During the 8-week grounding phase of the study, subjects continued to complete Daily Sleep Surveys and Weekly Pain Surveys. At the end of the 8-week recording period, subjects again completed the General Health Survey and also completed an End of Study Questionnaire to report their overall experience with sleeping grounded and the most significant changes they noticed.

RESULTS

Cortisol hormone test results

Results of laboratory analysis of saliva samples of cortisol collected prior to and after 6 weeks of sleeping grounded to earth are shown in Table 2. Figure 1 graphically represents the normal 24-hour circadian cortisol pattern. See Figure 2 for circadian cortisol profiles for individual subjects, pre- and postgrounding.

At the end of the 6 weeks, there were two cortisol sample periods, 12 midnight and 8 AM (of the six sample time periods from 8 PM until 4 PM), when the most significant shifts in cortisol occurred. Both of these shifts occurred most noticeably in females. At midnight, cortisol levels lowered in 8 of the 12 subjects (more synchronous with the normal circadian profile) and 7 of these subjects were female (there were a total of 8 female subjects in the study). The average drop in night-time cortisol levels for these 7 female subjects at midnight was 53.7%. At 8 AM, cortisol levels rose in 10 of the 12 subjects (more synchronous with the normal circadian profile); the average increase was highest amongst females. Of the 8 female subjects in the study, 6 had higher cortisol levels at 8 AM and these levels rose an average of 34.3%. The cortisol levels of the other 2 female subjects (#2 and #5), whose pregrounding cortisol levels (at 8 AM) were abnormally high in relation to the group, dropped to more normal levels, averaging 38% lower (Table 2).

Subjective sleep, pain, and stress results

At the end of the 8-week test period, 11 of 12 subjects reported that it took less time to fall asleep while grounded to earth. All 12 subjects reported waking fewer times during the night. The average number of times that subjects re-

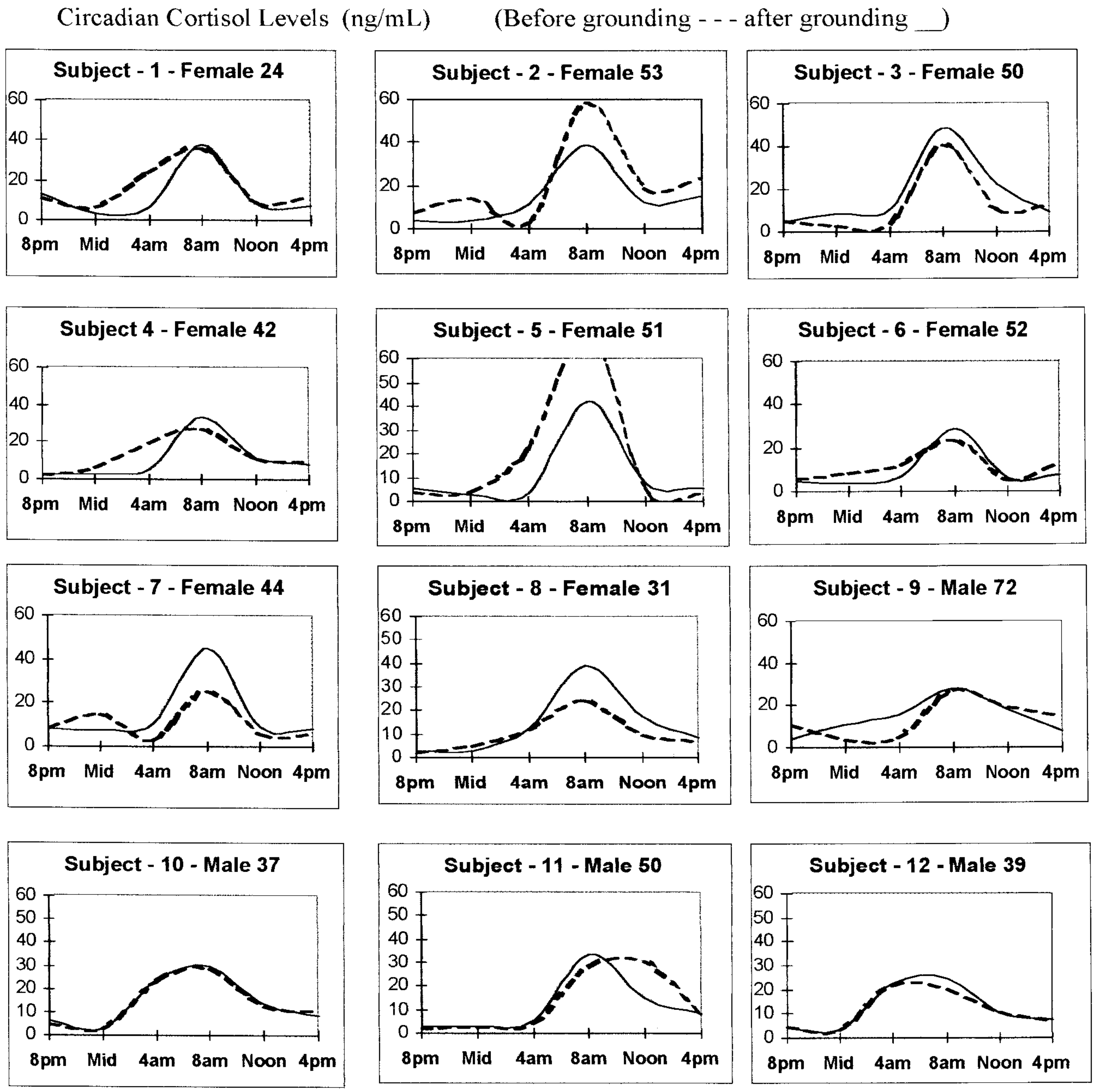

FIG. 2. Individual circadian cortisol secretion profiles (Subjects 1–12).

ported waking up during the night, pregrounding, was 2.5 times per night (group average), and this average dropped to 1.4 times per night or a 44% reduction.

Nine (9) of the 12 subjects reported improvement in fatigue (more refreshed/less fatigued), 2 reported no change, and 1 reported feeling worse.

Ten (10) of 12 subjects reported decreased pain with sleep, 1 reported no change, and 1 reported worsening of pain.

Of the 11 subjects who reported, pregrounding, that pain interfered with general activities, 7 reported improvement and 4 reported no change after sleeping grounded to earth.

Nine (9) of 12 subjects reported improvement in daytime energy levels and 3 subjects reported no change.

Nine (9) of 12 subjects reported reduction in emotional stress level. They were less bothered by problems such as anxiety, depression and irritability. Two (2) subjects reported no change and 1 reported worse stress levels.

End of Study Questionnaire reports

Subjects were asked to provide written narrative comments regarding conditions that were mentioned in the initial screening interview but were not formally measured in the subjective measurement tools. Of the 7 subjects who reported gastrointestinal (GI) disorders prior to sleeping grounded, 6 reported improvement. Of 6 female subjects who reported problems related to premenstrual syndrome and/or hot flashes prior to being grounded, 5 subjects reported a decrease in symptoms. All 3 subjects who reported temporal–mandibular joint (TMJ) pain prior to being grounded reported a decrease in symptoms after sleeping grounded to earth.

Many subjects reported that improvements in these conditions—as well as improvements in sleep, pain, and stress—often occurred rapidly within the first few days of grounding rather than gradually over the 8-week test period.

DISCUSSION

Cortisol secretion profiles

Results indicate that the majority of subjects tested who had high- to out-of-range night-time secretion levels experienced improvements by sleeping grounded to earth as measured by night-time cortisol reductions and restoration of normal day–night cortisol secretion profiles (Figure 2). All but 2 subjects had cortisol secretion profiles more synchronous with the normal 24-hour circadian pattern as a result of sleeping grounded (Figure 2). (See Figure 1 for normal circadian pattern, highest at 8 AM and lowest at midnight.) One (1) of the 2 subjects had no change because his cortiol secretion was the same pre- and postgrounding, already in alignment with the normal circadian pattern. The postgrounding composite (Figure 3) indicated that cortisol profiles synchronized intragroup; the group's profile, as a whole, trended more in alignment with the normal circadian pattern of cortisol secretion.

The study sample size (8 females and 4 males) is not large enough to make gender-related conclusions. However, it should be noted that improvements in circadian cortisol secretion profiles were much more apparent for females than for males.

Sleep, pain, and stress

Subjectively reported improvements in sleep were significant. It is possible that these improvements (11 of 12 subjects reported that they fell asleep more quickly and all 12 reported waking fewer times at night) are the result of a reduction in stress as a result of being grounded to earth; stress reduction being indicated by the restoration of more normal circadian cortisol profiles. Grounding the body to earth at night during sleep also appears to affect morning fatigue levels, daytime energy, and night-time pain levels.

The reports of feeling less fatigue and feeling more refreshed upon waking in the morning (9 of 12 subjects) were probably associated with improved sleep and/or reduction of night-time pain. Reports of increased daytime energy may have been related to the finding that cortisol levels rose at 8 AM in 10 of 12 subjects. Eight AM is the time when circadian cortisol levels should be highest (depressed daytime levels are often associated with low energy).

Ten (10) of 12 subjects reported reductions in pain, particularly night-time pain, including musculoskeletal pain, GI problems, headaches, menstrual cramps and TMJ symptoms. This reported pain reduction may have been related to improved sleep or to better regulation of cortisol levels. There is a recognized relationship between imbalances in cortisol and inflammatory pain (Alschuler, 2001; Korszun et al., 2002; Seyle, 1956).

Nine (9) of the 12 subjects reported feeling less emotional stress such as anxiety, depression, and irritability. Normalized diurnal cortisol secretion after sleeping grounded to earth allows for better night-time rest and improved daytime energy levels, which, in turn, may account for reported improvements in mood disturbances with reduction in anxiety, depression, and irritability.

In many cases, subjects reported that their perceived improvements in sleep, pain, and psychologic stress (as well as reported improvements from various health complaints) often occurred rapidly, sometimes within the first few nights of sleeping grounded to earth. Because chronically elevated night-time cortisol and disregulation of the circadian profile for cortisol is a biomarker for stress and is associated with poor sleep, pain, psychologic stress, and many chronic diseases, the normalization in night-time secretion of cortisol (10 of 12 subjects) and resynchronization with the normal circadian rhythm, indicates that grounding the human body to earth during sleep reduces stress.

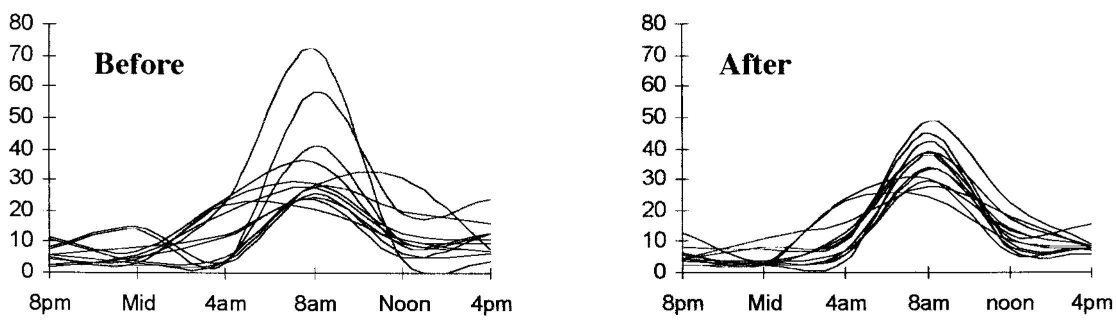

FIG. 3. Composite cortisol circadian levels before and after grounding to earth during sleep.

CONCLUSIONS

Results indicate that grounding the human body to earth during sleep reduces night-time levels of cortisol and resynchronizes hormone cortisol secretion more in alignment with the natural 24-hour circadian rhythm profile. Changes were most apparent in females. Furthermore, subjective reporting indicates that grounding the human body to earth during sleep improves sleep and reduces pain and stress.

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REFERENCES

Akerstedt T, Arnetz B, Ficca G, Paulson LE, Kallner A. A 50-Hz electromagnetic field impairs sleep. J Sleep Res 1999;8:77–81.

Alschuler L. Stress: Thief in the night. Int J Integ Med 2001;3:27–34.

Baris D, Armstrong BG, Deadman J, Thériault G. A case cohort study of suicide in relation to exposure to electric and magnetic fields among electrical utility workers. Occup Environ Med 1996;53:17–24.

Baris D, Armstrong B. Suicide among electric utility workers in England and Wales. Br J Ind Med 1990;47:788–792.

Beale IL, Pearce NE, Conroy DM, Henning MA, Murrell KA. Psychological effects of chronic exposure to 50 Hz magnetic fields in humans living near extra-high-voltage transmission lines. Bioelectromagnetics 1997;18:584–594.

Bjorntorp P. Do stress reactions cause abdominal obesity and comorbidities? Obes Rev 2001;2:73–86.

Borbely AA, Huber R, Graf T, Fuchs B, Gallmann E, Achermann P. Pulsed high-frequency electromagnetic field affects human sleep and sleep electroencephalogram. Neurosci Lett 1999;275:207–210.

Brown RP, Kocsis JH, Caroff S, Amsterdam J, Winokur A, Stokes P, Frazer A. Depressed mood and reality disturbance correlate with decreased nocturnal melatonin depressed patients. Acta Psychiatr Scand 1987;76:272–275.

Dowson DI, Lewith GT, Campbell M, Mullee MA, Brewster LA. Overhead high-voltage cables and recurrent headache and depressions. Practitioner 1988;232:435–436.

Follenius M, Brandenberger G, Bandesapt JJ, Libert JP, Ehrhart J. Nocturnal cortisol release in relation to sleep structure. Sleep 1992;15:21–27.

Huber R, Treyer V, Borbely A, Schuderer J, Gottselig JM, Landol HP, Werth TE, Berthold T, Kuster N, Buck A, Achermann P. Electromagnetic fields, such as those from mobile phones, alter regional cerebral blood flow and sleep and waking EEG. J Sleep Res 2002;11:289–295.

Huber R, Graf T, Cote KA, Wittmann L, Gallmann E, Matter D, Schuderer J, Kuster N, Borbely AA, Achermann P. Exposure to pulsed high-frequency electromagnetic field during waking affects human sleep EEG. Neuroreport 2000;11:3321–3325.

Johansen C, Olsen JH. Mortality from amyotrophic lateral sclerosis, other chronic disorders, and electric shocks among utility workers. Am J Epidemiol 1998;148:362–368.

Kay RW. Geomagnetic storms: Association with incidence of depression as measured by hospital admissions. Br J Psychiatry 1994;164:403–409.

Korszun A, Young EA, Singer K, Carlson NE, Brown MB, Crofford L. Basal circadian cortisol secretion in women with temporomandibular disorders. J Dent Res 2002;81:279–283.

Lai H, Carino M. 60-Hz magnetic field and central cholinergic activity: Effects of exposure intensity and duration. Bioelectromagnetics 1998;20:284–289.

Lai H, Carino M, Ushijima I. Acute exposure to a 60 Hz magnetic field affects rats' performance in the water maze. Bioelectromagnetics 1999;19:117–122.

Lai H, Carino M. Intracerebroventricular injections of mu- and delta-opiate receptor antagonists block 60-Hz magnetic field-induced decreases in cholinergic activity in the frontal cortex and hippocampus of the rat. Bioelectromagnetics 1998;19:432–437.

Lai H. Spatial learning deficit in the rat after exposure to a 60 Hz magnetic field. Bioelectromagnetics 1996;17:494–496.

Li CY, Chen PC, Sung FC, Lin RS. Residential exposure to power frequency magnetic field and sleep disorders among women in an urban community of Northern Taiwan. Sleep 2002;25:428–432.

Linkowski P, Mendlewicz J, Leclercq R, Brasseur M, Hubain P, Golstein J, Copinschi G, Van Cauter E. The 24-hour profile of adrenocorticotropin and cortisol in major depressive illness. J Clin Endocrinol Metab 1985;61:429–438.

Mann K, Roschke J, Connemann B, Beta H. No effects of pulsed high-frequency electromagnetic fields on heart rate variability during human sleep. Neuropsychobiology 1998b;38:251–256.

Mann K, Roschke J. Effects of pulsed high-frequency electromagnetic fields on human sleep. Neuropsychobiology 1996;33:41–47.

Mann K, Wagner P, Brunn G, Hassan F, Hiemke C, Roschke J. Effects of pulsed high-frequency electromagnetic fields on the neuroendocrine system. Neuroendocrinology 1998a;67:139–144.

McIntyre IM, Judd FK, Marriott PM, Burrows GD, Norman TR. Plasma melatonin levels in affective states. Int J Clin Pharmacol Res 1989;9:159–164.

McMahan S, Ericson J, Meyer J. Depressive symptomatology in women and residential proximity to high-voltage transmission lines. Am J Epidemiol 1994;139:58–63.

Pawlow LA, Jones GE. The impact of abbreviated progressive muscle relaxation on salivary cortisol. Biol Psychol 2002;60:1–16.

Perry FS, Reichmanis M, Marino AA, Becker RO. Environmental power-frequency magnetic fields and suicide. Health Phys 1981;41:267–277.

Perry S, Pearl L, Binns R. Power frequency magnetic field, depressive illness and myocardial infarction. Public Health 1989;103:177–180.

Poole C, Kavet R, Funch DP, Donelan K, Charry JM, Dreyer NA. Depressive symptoms and headaches in relation to proximity of residence to an alternating-current transmission line right-of-way. AMJ Epidemiol 1993;137:318–330.

Reichmanis M, Perry FS, Marino AA, Becker RO. Relation between suicide and the electromagnetic field of overhead power lines. Physiol Chem Phys 1979;11:395–403.

Rodenbeck A, Huether G, Ruther E, Hajak G. Interactions between evening and nocturnal cortisol secretion and sleep parameters in patients with severe chronic primary insomnia. Neurosci Lett 2002;324:159–163.

Savitz DA, Boyle CA, Holmgreen P. Prevalence of depression among electrical workers. Am J Ind Med 1994;25:165–176.

Semm P, Schneider T, Vollrath L. Effects of an earth-strength magnetic field on electrical activity of pineal cells. Nature 1980;288: 607–608.

Seyle, H. The Stress of Life, rev. ed. New York NY: McGraw-Hill, 1956.

van Wijngaarden E, Savitz DA, Kleckner RC, Cai J, Loomis D. Exposure to electromagnetic fields and suicide among electric utility workers: A nested case-control study. Occup Environ Med 2000;57:258–263.

Verkasalo PK, Kaprio J, Varjonen J, Romanov K, Heikkilä K, Koskenvuo M. Magnetic fields of transmission lines and depression. Am J Epidemiol 1997;146:1037–1045.

Vgontzas AN, Zoumakis M, Papanicolaou DA, Bixler EO, Prolo P, Lin HM, Vela-Bueno A, Kales A, Chrousos GP. Chronic insomnia is associated with a shift of interleukin-6 and tumor necrosis factor secretion from nighttime to daytime. Metabolism 2002;51:887–892.

Welker HA, Semm P, Willig RP, Commentz JC, Wiltschko W, Vollrath L. Effects of an artificial magnetic field on serotonin N-acetyltransferase activity and melatonin content of the rat pineal gland. Exp Brain Res 1983;50(2–3):426–432.

Wilson BW. Chronic exposure to ELF fields may induce depression [review]. Bioelectromagnetics 1998;9:195–205.

Yen SS, Laughlin GA. Aging and the adrenal cortex. Exp Gerontol 1998;33(7–8):897–910. Review.

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Appendix A

Grounding (Earthing)

Electrically grounding the human body refers to maintaining the body at the natural electrical potential (voltage) of the earth. The voltage of the earth is a measure of the free electrons that reside on the earth's surface (Gish, 1936).

Grounding the human body by close coupling it with a ground plane in the form of a conductive mattress pad, placed under a bed sheet and connected directly to the earth, significantly reduces the 60 Hz electric field–induced body voltage by offsetting the attraction of a 60 Hz electric field from the body (which is small) to the earth (which is large). This creates a stabilizing effect on the electrons of the body that were previously disturbed by the attraction of the 60 Hz electric field to the body.

60 Hz ELECTRIC FIELD–INDUCED BODY VOLTAGE

An electric field is created by the excitation of the space surrounding an electrified object. All energized electrical wires and electrical devices create an electric field. In space, an electric field travels in an isotropic pattern away from its source at the speed of light. However, when a conductive object such as a human body, which is composed primarily of mineralized water, is in the proximity of an electric field, it becomes an antenna and the lines of force of the electric field bend toward the body and become denser between the body and the source of the electric field. The effect of an electric field on the body is that it electrifies it (creates voltage in the body) by exciting electrons of the body. This process is called "electrical induction," which is different from "electrical conduction," which is electrification by contact (a direct flow of electrons from one object to another). (Dolbear, 1898)

The human body may be most chronically exposed to and electrified by 60-Hz electric fields when in bed (Coghill, 1996). (During a 6–10-hour period, a person's body is within inches of energized electrical wires in the wall at the head of the bed and energized electrical cords and appliances near the bed.)

REFERENCES

Coghill, RW, Steward J, Philips, A. Extra low frequency electric and magnetic fields in the bedplace of children diagnosed with leukaemia: A case-control study. Eur J Cancer Prev 1996;5:153–158.

Dolbear, AE. On physical fields. Science 1889;14:442–444.

Gish, OH, The natural electric currents in the earth. Sci Monthly 1936;43:47–57.

Appendix B

State of the Science of Electromagnetic Fields and Adverse Health Consequences to Public Health

The National Institute of Environmental Health Sciences reported in 1999 that a comprehensive review of epidemiologic studies of ELF-EMF and cancer support a finding of Group 2B (possible carcinogen) using the World Health Organization International Agency for Research on Cancer (IARC) criteria for carcinogenicity. [See National Institute of Environmental Health Sciences (NIEHS). NIEHS Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic fields. NIH Publication No. 99-4493, 1999, available from NIEHS P. O. Box 12233, Research Triangle Park, NC 27709.]

The World Health Organization has concluded that ELF-EMF is a Group 2B carcinogen (possible carcinogen) and has published a monograph indicating that exposure to electric and magnetic fields at extra-low power frequencies (50–60 Hz) should be considered possibly carcinogenic (IARC, 2001).

A previous review of the international scientific literature on electric and magnetic fields published between 1979 and 1996, reporting epidemiologic bioeffects of ELF-EMF, showed that approximately 90% of all 46 residential studies and 88% of all 96 occupational studies reported positive risk ratios for cancer and pregnancy outcome (Sage, 1996).

The majority of these studies and reviews have concentrated on magnetic-field effects (as opposed to electric-field effects). However, it should be noted that the electric field is always present where there is electricity but the magnetic field is present only when the light is turned on, electric current is being conducted and electrons actually flow. The magnetic field is a part-time compliment of electricity and occurs only when electricity is actually being used at the load end (the light, the oven, the air conditioner, etc). The electric field is present regardless of whether or not electricity is flowing (being used up at a load end). The consequence is that many studies that examine only end measurements of exposure to the magnetic field will overlook the presence (and possible bioactivity) of the electric field in producing disease. The few studies looking solely at electric-field exposure, or the presence of electricity report clear association to human disease.

REFERENCES

IARC. Static and Extremely Low Frequency Electric and Magnetic Fields: Monographs of the International Agency for Research on Cancer (IARC), vol. 80 (Lyon, France: IARC, June 19–26, 2001; updated March 2002.

Sage CL. Epidemiology for Decisionmakers: A Visual Guide to the Residential and Occupational EMF Studies (1979–1998). Bioelectromagnetics Society Annual Meeting, 1996.