
Static magnetotherapy for the treatment of insomnia

Yao Y. Shieh* and Fong Y. Tsai

101 The City Drive South
UCIrvine Medical Center
Orange CA 92868, USA
E-mail: yshieh@uci.edu
E-mail: ftsai@uci.edu
*Corresponding author

Abstract: Magnets have been used for centuries to treat a number of physical disorders. The vast majority of research, however, on static magnet therapy for insomnia has been confined to the auricular type of therapy, with publications limited to Chinese journals. Most of these studies have depended on the subjective self-assessment of participants rather than objective scientific measurements.

In this study, the authors report the positive preliminary results of insomnia treatment using pillows with embedded magnets, magnetic insoles and TriPhase bracelets. The analysis is based on objective actigraphic and polysomnographic data. A theory of accelerated transition from wakefulness to sleep is proposed to explain the process of insomnia relief through low-strength static magnetic fields. Analysis by functional Magnetic Resonance Imaging (fMRI) is used to further investigate the theory.

Keywords: insomnia; magnetotherapy; actigraphy; polysomnography; functional magnetic resonance imaging; fMRI; blood oxygenation level dependent; BOLD.

Reference to this paper should be made as follows: Shieh, Y.Y. and Tsai, F.Y. (2008) 'Static magnetotherapy for the treatment of insomnia', *Int. J. Electronic Healthcare*, Vol. 4, Nos. 3/4, pp.339–349.

Biographical notes: Yao Y. Shieh, PhD, is a Professor at the Department of Radiological Sciences, School of Medicine, the University of California–Irvine, USA. He has done pioneering research in Picture Archiving and Communications Systems (PACS) and teleradiology. His current research interests include medical image instrumentation and processing, fMRI and medical informatics.

Fong Y. Tsai, MD, is a Professor of Radiological Sciences, Surgery and Neurological Surgery, School of Medicine, the University of California–Irvine, USA. He has published numerous articles on stroke, neuro-interventional radiology and other topics in radiology.

1 Introduction

The application of static magnetic fields to various body areas, through the juxtaposition of magnets, has been used worldwide to deal with a wide variety of physical impairments. For many centuries, different peoples have tried to use magnets to cure a number of physical disorders. Mayo Clinic (2007) estimated that \$500 million is spent on various kinds of magnetic therapy – including static magnets and dynamic electromagnets – in the USA each year. Many theories have been developed to explain how static magnetic fields can affect living tissues and cure certain disorders. Although none of them have been verified, many people are inclined to believe in the healing power of magnets due to the alluring and fascinating quality of ferromagnetism.

The research on the efficacy of magnetotherapy in insomnia can be classified into two categories: static magnet therapy and dynamic magnetic therapy. The former relies on permanent magnets whose magnetic fields do not change with time, whereas the latter relies on low energy, time-varying electromagnetic fields. In 1979, the US Food and Drug Administration (FDA) approved the use of dynamic electromagnetic waveforms as safe and efficacious therapy for the treatment of bone fracture (Bassett, 1989). A number of studies using dynamic magnetic therapy to relieve insomnia have been reported by several researchers (Lebet *et al.*, 1996; Reite, 1994; Pelka *et al.*, 2001; Woroger *et al.*, 2004). Static magnets are often embedded in self-care commodities such as shoe insoles, bracelets, and pillows. The vast majority of research in static magnet therapy for insomnia has been confined to the auricular therapy realm and published in Chinese journals (Gao, 1995; Gao and Sun, 1996; Yang, 1997; Xu, 1998; Yang, 1988). Most of these publications depend on the subjective self-assessment of participants rather than objective scientific data. A rare exception is the study report by Suen *et al.* (2002) which was based on actigraphic recordings.

As far as the authors are aware, there have been no reports on the treatment of insomnia using magnet-embedded pillows, magnetic insoles and TriPhase bracelets. In this study, the authors report positive findings of insomnia treatment using pillows with embedded magnets based on objective actigraphic and polysomnographic data. Finally, the influence of the low-strength static magnetic fields of the devices on brain activity during the transition from wakefulness to sleep is analysed using functional Magnetic Resonance Imaging (fMRI) techniques.

2 Methods

2.1 Subjects

2.1.1 Inclusion criteria

Forty years old or older; suffering from sleep disorder of primary insomnia, indicated by:

- a complaint of difficulty falling asleep, staying asleep, or nonrestorative sleep
- duration of more than one month
- the sleep disturbance causes clinically significant distress or impaired functioning
- insomnia is not due to another medical or sleep disorder or effects of medications/substance abuse.

2.1.2 Exclusion criteria

- current participation in any other investigational drug evaluation
- current user of implant devices which are sensitive to magnetic field
- being or becoming pregnant.

Voluntary participants that satisfy the inclusion and exclusion criteria of our study are classified into two groups. Group 1 consists of subjects who do not take medication for insomnia, whereas Group 2 consists of subjects who had taken medication on a regular basis but agree to stop medication during the period of study. One subject from each group was randomly selected for this pilot study.

2.2 Procedures

Three magnetic devices manufactured by Nikken Inc. were used to conduct the study. They are:

- 1 Kenko Dream Deluxe pillow with embedded static magnets (800 Gauss)
- 2 MagStep – a magnet insole
- 3 TriPhase bracelet – a bracelet containing static magnets, negative ion and far-infrared components.

Various combinations of these three magnetic devices were used to evaluate the efficacy of sleep improvement. Data collection began when the lights were turned off and ended when the subject woke up in the morning.

The experiment was conducted at the residence of each subject to minimise confounding variables and potential disturbances to each subject's sleeping habits.

2.2.1 Actigraphy

Model Actiwatch 64 (Mini Mitter, a Respironics Company, Bend, Oregon, USA) actigraph wrist watch was worn by the subject on the non-dominant wrist to record the actigraphic data with epoch length set to 30 sec. Actiwatch 64 is equipped with a solid-state piezoelectric type of accelerometer with a sensitivity of 0.025 G, which is able to detect motion changes in all directions and thereby measure gross body activities. The actiwatch stores an integration of movement (including directional aspects) as activity counts, at sampling frequency of 32 Hz. The recorded actigraphic data are subsequently analysed by Actiware, a sleep/wake analysis software provided by Mini Mitter Inc. Actiware calculates the 'Filtered Activity Count' (FAC) for each epoch by summing up activity counts for the epoch in question and those immediately surrounding it according to a certain weighting scheme. The particular weighting scheme adopted for this study is shown below:

$$\text{FAC}(i) = 0.04 * \text{AC}(i - 2) + 0.2 * \text{AC}(i-1) + \text{AC}(i) + 0.2 * \text{AC}(i + 1) + 0.04 * \text{AC}(i + 2),$$

where AC(i) stands for the recorded activity count for the *i*-th epoch.

The filtered activity count for the i -th epoch is then compared with a threshold set by the user. If it exceeds the threshold, the epoch in question is scored as 'wake'. Otherwise, it is scored as sleep. The threshold was set to 'Medium' for this study.

2.2.2 Polysomnography (PSG)

Polysomnograms were recorded with 30-sec epochs using the Grass TeleFactor system (An Astro-Med Inc., West Warwick, RI 02893, USA). PSG recordings consist of Electroencephalogram (EEG: C3-A2, C4-A1, O1-A2, O2-A1), Electro-oculogram (EOG: LOC-A2, ROC-A1) and chin Electromyogram (EMG). The Fully-Automated Sleep Stager (FASS) Software bundled with the PSG hardware is used to identify standard Rechtschaffen and Kales sleep stages automatically by deriving information from various parameters of the EEG, EOG and Chin EMG.

2.2.3 Subjective questionnaire

A sleep diary questionnaire was given to each subject to fill out in the morning as a self evaluation of the sleep condition of the previous night. The sleep diary is shown in Table 1.

Table 1 Sleep diary

<i>Sleep diary</i>		
Name:		
Date:		
<i>Question</i>	<i>Example</i>	<i>Your answer</i>
1 I went to bed at _____ o'clock and turned the lights out at _____ o'clock.	10:30 11:15	
2 After turning the lights off, I fell asleep in _____ minutes.	45 min	
3 My sleep was interrupted _____ times (specify number of nighttime awakenings)	3	
4 My sleep was interrupted for _____ minutes (specify duration of each awakening)	20 30 15	
5 I woke up at _____ o'clock.	6:15	
6 I got out of the bed at _____ o'clock.	6:40	
7 When I got up this morning I felt _____ (1 = exhausted, 5 = refreshed)	2	
8 Overall, my sleep last night was _____ (1 = very restless, 5 = very sound)	1	

2.2.4 Functional Magnetic Resonance Imaging (fMRI)

fMRI has emerged as a powerful modality for the imaging of *in vivo* brain activity, the field of which was previously dominated by Positron Emission Tomography (PET). The majority of fMRI studies of brain activation performed today are based on the Blood Oxygenation Level Dependent (BOLD) contrast. The BOLD effect depends on changes of Cerebral Blood Flow (CBF), Cerebral Blood Volume (CBV), and Cerebral Metabolic

Rate of Oxygen (CMRO₂). The chain of events of a typical BOLD based fMRI study starts with a stimulus which triggers localised neural activity, which in turn triggers metabolic activity. This metabolic activity is characterised by a large localised increase in CBF, a moderate increase in CBV and a small increase in CMRO₂. The result is an overall increased blood oxygenation level in the area of brain activation (Buxton, 2002). In other words, BOLD based fMRI attempts to map the neural activities by measuring the concomitant metabolic activities in an indirect manner.

In this insomnia study, we are more interested in the general metabolic level of the brain than in specific localised activities. Previous studies (Buchsbaum *et al.*, 1989; Maquet *et al.*, 1990) have demonstrated a 23% reduction of glucose metabolism across the entire brain for healthy human subjects during the transition from wake to Non-Rapid Eye Movement (NREM) sleep. In other words, the reduced global metabolism associated with NREM seems to correlate with the common theory that NREM sleep plays a restorative role. The fact that we are measuring global metabolic change rather than localised metabolic change makes a precise motion correction unnecessary. Another study (Germain *et al.*, 2004) reported that the transition from wakefulness to NREM sleep was characterised by persistently higher brain metabolism in depressed patients when compared with healthy subjects. Such findings support the possibility that a failure of reduction in brain metabolism may be a common pathway leading to insomnia symptoms.

Our hypothesis is that the overall amount of deoxyhemoglobin in the brain increases when a person makes the transition from wakefulness to sleep. Consequently, the MR signal of the brain decreases during this transition. Furthermore, the quicker the rate of decrease the quicker the transition takes. Such a shortened transition is translated into a shortened latency before the onset of sleep.

Many specific changes of the body can be identified during the transition from wakefulness to sleep (Shneerson, 2005). Metabolic rate is decreased in NREM sleep by 5%–10% compared with wakefulness. The cerebral blood flow decreases by 10%–20% in NREM sleep. The respiratory drive is reduced in NREM sleep, resulting in slower and shallower breathing which retains more CO₂. All of these events contribute to a higher concentration of deoxyhemoglobin, which in turn causes the BOLD signal to drop. Consequently, the reduction of overall BOLD signal in brain fMRI images is closely coupled with a gradual settlement into the ‘rest’ state characterised by the slower metabolic rate of the brain.

The magnets embedded in the pillow precluded the possibility of having the patient use the magnet pillow in the fMRI scanner. However, we were able to perform fMRI scans while using the other locally applied magnetic devices – magnet insoles and ankle TriPhase bracelets – and compare them to scans without the magnetic devices. This was possible for the ‘head first, supine’ scanning configuration because the magnetic insoles and ankle bracelets were sufficiently distant from the bore of the MRI scanner to prevent adverse effects on the images. Acupuncture points are often chosen by acupuncturists to be preferred sites of magnet placement for either adjunct or standalone therapy. Application of magnet insoles to the soles and TriPhase bracelets around the ankles is in agreement with the guidelines of the Traditional Chinese Medicine (TCM), which proclaims that the human soles and ankles are a special body part from which all human meridians are accessible.

A subject was scanned for fMRI twice by the Siemens MAGNETOM Trio a Tim System with a main magnetic field of 3 Telsa. During the first scan, the subject was placed on the MR table without magnetic devices present. The scan commenced at the onset of light out and lasted for about 30 min. A week later, the second fMRI was conducted in which the same subject was placed on the MR table with a magnet-free pillow, but wearing magnetic insoles and TriPhase bracelets on ankles. Again, the scan commenced at the onset of light out and lasted for about 30 min. The Siemens's standard BOLD imaging protocol was used for fMRI with the exception that no stimulus was used in the block paradigm. That is, instead of repeating three times the 'stimulus/rest' block paradigm by having ten measurements with stimulus followed by ten measurements without stimulus, a complete block paradigm consisted of 60 measurements without stimulus. Motion correction via the Siemens StandardMoco algorithm was used to reduce the relative motion between the datasets acquired from each measurement. Sixty measurements of a complete block paradigm, which took 3.2 min to complete, were averaged to create a data point. A time series was created to cover the time-span of 30-min fMRI scan by repeating the same complete block paradigm consecutively. Subsequently, the image intensities of such a time series were used to evaluate the rates of signal decrease for each scan.

3 Results

3.1 Actigraphy

Table 2 Sleep quality measurement based on actigraphic data

<i>Utilised devices</i>	<i>Subject #1</i>	<i>Subject #2</i>
	<i>(no medication history)</i>	<i>(previously on sleep disorder medication)</i>
	<i>Sleep efficiency (%)</i>	<i>Sleep efficiency (%)</i>
Baseline	84.1	83
Magnetic pillow	89.2	89.1
Magnetic pillow + Magnetic insole	93.2	88.7
Magnetic pillow + Magnetic insole + TriPhase bracelet	92.5	90.2

Note: Sleep efficiency – total sleep time divided by time in bed, as a percentage.

3.2 PSG

It is worth noting that the big gap between LTO and LTPS for the baseline is completely eliminated when magnetic devices were used. It suggests that perhaps magnet devices improve the sleep quality by transforming shallow sleep into solid sleep.

Table 3 Sleep quality measurement based on polysomnographic data

Utilised devices	Subject #1				Subject #2			
	LTO	LTPS	SE (%)	SM (%)	LTO	LTPS	SE (%)	SM (%)
Baseline	7	24.5	86.7	88.7	28.5	56	77.4	82.3
Magnetic pillow	5	5	90.8	92.9	8.5	8.5	84.8	87.9
Magnetic pillow + Magnetic insole	9	9	94.3	96.3	10	10	83.4	85.6
Magnetic pillow + Magnetic insole + TriPhase bracelet	4.5	4.5	93.5	94.6	9.5	9.5	83.8	85.9

Notes: LTO: Latency to Onset of Sleep (in minutes).
 LTPS: Latency to Persistent Sleep (in minutes).
 SE: Sleep Efficiency – total sleep time divided by time in bed, as a percentage.
 SM: Sleep Maintenance – total sleep time divided by the duration between sleep onset and final wake time.

3.3 Subjective questionnaire

Subject #1 reported that she fell asleep quicker when using the pillow embedded with static magnets. Subject #2 reported significant reduction of nightly dreams on those nights using magnetic devices, with a clearer mind on the next mornings.

3.4 fMRI

Regions of significant fMRI signal elevation/reduction by comparing Data Point #9 (25.6 min after light out) of the time series against Data Point #5 (12.8 min after light out) without using magnetic devices are shown in the mosaic image format 6 × 6 in Figure 1. Red pixels depict areas where the BOLD signal at 25.6 min after light out is significantly higher than that at 12.8 min after light out, whereas green pixels depict areas where the BOLD signal is significantly lower. The criterion of significant elevation/reduction was determined by a threshold which was subjectively chosen to provide a brain map that relatively large signal changes had been observed. Pixels which are neither red nor green depict areas of no significant change. Likewise, Figure 2 shows regions of significant fMRI signal elevation/reduction from Data Point #5 to Data Point #9 when magnetic insoles and TriPhase bracelets were used. Pixels are colour coded in a similar manner.

In order to calculate the rate of signal intensity change for the whole brain, pixel intensities of the 36 slices of the 6 × 6 mosaic image are added together. Since the sum of pixel intensities for the whole brain was used, such an analysis was insensitive to relative motions between scans at different data points. The trend of BOLD signal change for the whole brain throughout the transition period of 30 min or so commencing at light out was evaluated by first-order approximation using linear regression method. The time series consisting of blue data points (in asterisk) is approximated by a straight line consisting of red data points based on the least squares criterion. Subsequently the decay rate of aggregated signals is calculated from the slope of such a straight line. As shown in Figure 3, the aggregated signal for the baseline decays at a rate of 0.081% per minute which is smaller than 0.113% per minute when magnetic insoles and TriPhase bracelets were used. It indicates that Subject #1 decreased in metabolic activity at a rate 40% faster than normal when magnetic insoles and TriPhase bracelets were used.

Figure 1 Regions of significant fMRI signal elevation/reduction from wakefulness to sleep using no magnetic devices (see online version for colours)

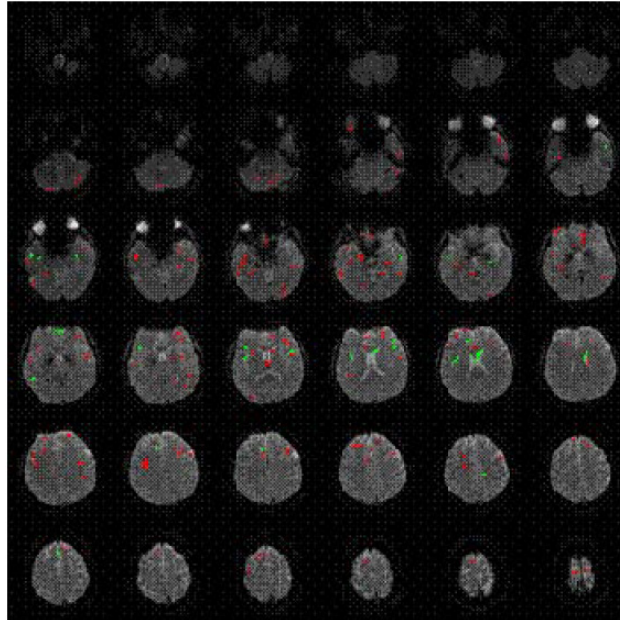


Figure 2 Regions of significant fMRI signal elevation/reduction from wakefulness to sleep using magnetic insoles and bracelets (see online version for colours)

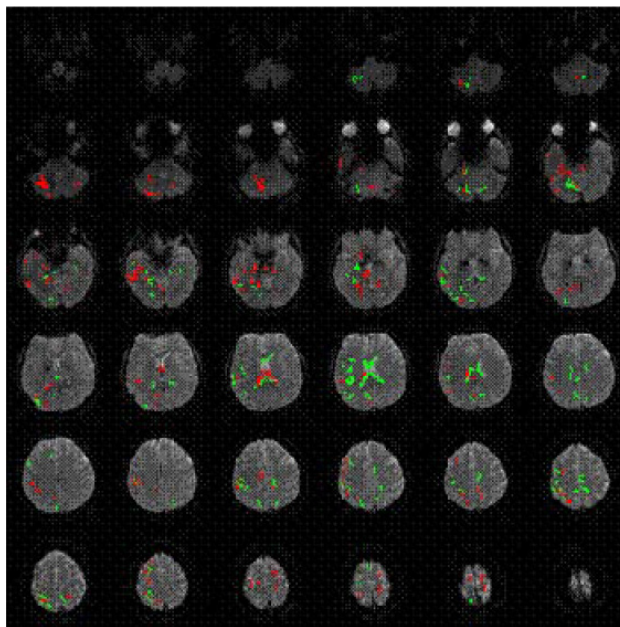
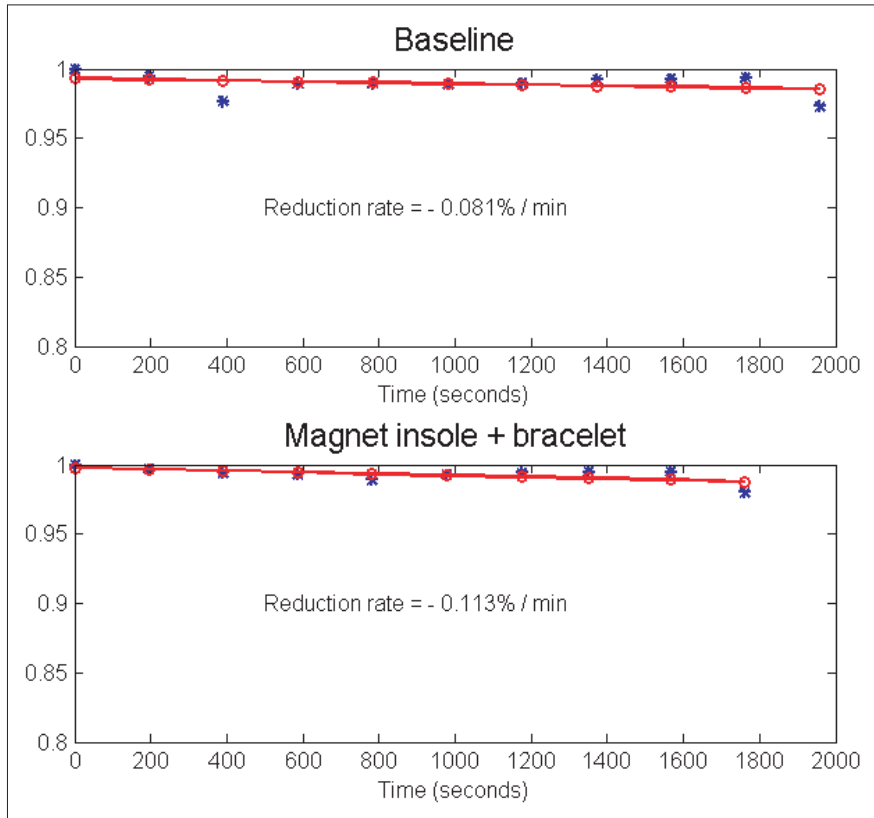


Figure 3 Comparison of fMRI signal reduction rates for the whole brain (see online version for colours)



4 Discussion

Two participants receiving magnetic therapy using pillows embedded with static magnets, magnetic insoles and TriPhase bracelets demonstrated significant improvement in sleep quality. A popular theory in an attempt to explain the biological mechanism responsible for the low-energy magnetic therapy is that the static magnets create an energy field that helps to restore the human body back toward the stable state of ying-yang balance. In the context of sleep/wakefulness, a person is either in the state of sleep or wakefulness depending on the balance of two forces promoting and prohibiting sleep (Johns, 1998). A normal person’s body operates on sleep/wakefulness cycles in proper synchronisation with the natural circadian rhythm; perhaps the magnets help to restore a synchronised or balanced state, corresponding to a state of ying-yang balance in the model of Traditional Chinese Medicine. However, there exist reports of headaches caused by the strong magnetic fields of modern MR scanners, which suggests a different type of effect than that of restoration to normal/balanced states, associated with low-strength magnets.

This is the first study that reports the efficacy of magnet therapy on the improvement of sleep quality for patients of insomnia based on objective measurements of actigraphic and polysomnographic data. The improvements are quite significant. Most strikingly, Subject #2 randomly selected from the pool of insomnia patients who took sleep medication regularly has discontinued medication ever since she participated in this study about three months ago. Now she uses the Nikken Deluxe Dream pillow and enjoys restful sleep.

Another contribution of this report is that the present findings suggest that low-energy static magnets may help shorten the latency to onset of sleep for insomnia patients by accelerating the reduction of brain metabolic rate. Such findings shed new light on possible mechanisms in which static magnetic fields may enhance the sleep quality of patients suffering from insomnia.

For the purpose of cross-study comparison and analysis in the future, it is essential to emphasise that, in our study, 'the pillow embedded with static magnets', 'magnetic insoles' and 'TriPhase bracelets' are represented by Kenko Dream Deluxe Pillow, Magsteps, and Nikken TriPhase Bracelets, manufactured by Nikken Inc. Findings of this study are linked to the specific combination of these devices which have been engineered with Nikken proprietary technology and therefore may not necessarily be generalised to other similar products.

A limitation of this report is that it is a preliminary result based on a very small number of participants. However, the selection of the two subjects follows the principle of stratified random sampling, in that the pool of insomnia patients are divided into two strata – patients taking no medication and patients taking medication – and then a random sample was drawn from each stratum. Each single subject from each stratum fits into the classical single-case experimental design, with the additional merit that each of the single-case subjects were randomly chosen from the volunteer patient population. The classical technique of repeated measures was applied here to better ensure consistency of measured data. In other words, the experimental results quoted in this study were the average over repeated multiple-evening measurements. Furthermore, the A-B-A design scheme is adopted in that we began with baseline phase, followed by the treatment phase which is in turn followed by a return to the baseline condition (Smith and Davis, 2007). The similar improvements demonstrated on both strata tend to validate each other.

Another limitation of this study is the lack of placebo control. To this end, we have obtained placebo pillows which look exactly like Kenko Dream Deluxe pillows except those metal pieces that look like magnets are not magnets.

The two subjects that were randomly selected from the pool of volunteers happen to have insomnia of the 'deficiency syndrome' type versus that of 'excessive syndrome'. Their sleep efficiency before using the magnetotherapy was about 84%. The next phase of this study is a stratified study that first screens volunteers based on actigraphic scores to include patients with excessive syndrome (whose sleep efficiency before treatment is below 70%) as well as patients with deficiency syndrome. It will be interesting to see if larger improvement can be achieved for patients with excessive syndrome. In the meantime, our study is moving into full-scale operation by having all the recruited volunteers go through the experiment with placebo controls, so that a statistical analysis can be conducted.

References

- Bassett, C.A. (1989) 'Fundamental and practical aspects of therapeutic uses of Pulsed Electromagnetic Fields (PEMFs)', *Critical Reviews in Biomedical Engineering*, Vol. 17, No. 5, pp.451–529.
- Buchsbaum, M.S., Gillin, J.C., Wu, J., Hazlett, E., Sicotte, N., Dupont, R.M. and Bunney, W.E. (1989) 'Regional cerebral glucose metabolic rate in human sleep assessed by positron emission tomography', *Life Sciences*, Vol. 45, pp.1349–1356.
- Buxton, R.B. (2002) *Introduction to Functional Magnetic Resonance Imaging. Principles & Techniques*, Cambridge University Press.
- Gao, J.W. and Sun, Y.X. (1996) 'Using auricular pill pressing therapy on cases with severe insomnia', *Journal of Shaanxi College of Traditional Chinese Medicine*, Vol. 19, No. 4, pp.27–27.
- Gao, Y. (1995) 'Using auricular pressing therapy on 128 cases with insomnia', *Shanghai Journal of Acupuncture and Moxibustion*, Vol. 14, No. 4, pp.161–162.
- Germain, A., Nofzinger, E.A., Kupfer, D.J. and Buysse, D.J. (2004) 'Neurobiology of non-REM sleep in depression: further evidence for hypofrontality and thalamic dysregulation', *Am J Psychiatry*, Vol. 161, No. 10, pp.1856–1863.
- Johns, M. (1998) 'Rethinking the assessment of sleepiness', *Sleep Medicine Review*, Vol. 2, pp.3–15.
- Lebet, J.P., Barbault, A., Rossel, C., *et al.* (1996) 'Electroencephalographic changes following low energy emission therapy', *Ann Biomed Eng.* Vol. 24, pp.424–429.
- Maquet, P., Dive, D., Salmon, E., Sadzot, B., Franco, G., Poirrier, R., Frenckell, R. and Franck, G. (1990) 'Cerebral glucose utilization during sleep-wake cycle in man determined by positron emission tomography and [18F]2-fluoro-2-deoxy-D-glucose method', *Brain Research*, Vol. 13, pp.136–143.
- Mayo Clinic (2007) *Mayo Clinic Book of Alternative Medicine*, New York: Time Inc.
- Pelka, R.B., Jaenicke, C. and Gruenwald, J. (2001) 'Impulse magnetic-field therapy for insomnia: a double-blind, placebo-controlled study', *Advances in Therapy*, Vol. 18, No. 4, pp.174–180.
- Reite, M., Higgs, L., Lebet, J-P., *et al.* (1994) 'Sleep inducing effect of low emery emission therapy', *Bioelectromagnetics*, Vol. 15, pp.67–75.
- Shneerson, J.M. (2005) *Sleep Medicine. A Guide to Sleep and Its Disorders*, Blackwell Publishing Ltd.
- Smith, R.A. and Davis, S.F. (2007) *The Psychologist as Detective*, 4th ed., New Jersey: Pearson Prentice Hall.
- Suen, L.K.P., Wong, T.K.S. and Leung, A.W.N. (2002) 'Auricular therapy using magnetic pearls on sleep: a standardized protocol for the elderly with insomnia', *Clinical Acupuncture and Oriental Medicine*, Vol. 3, pp.39–50.
- Woroger, X.T., Davis, S.S., Emerson, S.S., Mirick, D.K., Lentz, M.J. and McTiernan, A. (2004) 'Effect of a nighttime magnetic field exposure on sleep patterns in young women', *American Journal of Epidemiology*, Vol. 160, pp.224–229.
- Xu, L.Q. (1998) 'Combined therapies using acupuncture and auricular pressing therapy on 63 cases with differential diagnosis of insomnia', *Clinical Journal of Anhui Traditional Chinese Medicine*, Vol. 10, No. 2, pp.80–81.
- Yang, C.L. (1988) 'Clinical observation of 62 cases of insomnia treated by auricular point imbedding therapy', *Journal of Traditional Chinese Medicine*, Vol. 8, No. 3, pp.190–192.
- Yang, X.B. (1997) 'Acupuncture combined with auricular pressing therapy on 42 cases with insomnia', *Chinese Acupuncture and Moxibustion*, Vol. 17, No. 5, p.284.