0008-3194/2004/29–35/$2.00/©JCCA 2004

The effect of low force chiropractic adjustments on body surface electromagnetic field

John Zhang, MD, PhD*
Brian J Snyder, DC*
Lori Vernor*

Objective*: The purpose of this study was to investigate the body surface electromagnetic field (EMF) changes using a sensitive magnetometer before and after a specific Toftness chiropractic adjustment in asymptomatic human subjects.*

Method*: Forty-four subjects were randomly assigned into control (20 subjects) and experimental groups (24 subjects) in a pre and post-test design. The Triaxial Fluxgate Magnetometer FGM-5DTAA (Walker Scientific, Worcester, Massachusetts) with five digit display and resolution of 1 nanotesla (nT) was used for EMF detection. The EMF in the research room and on the adjustment table was monitored and recorded. The subjects' body surface (cervical, thoracic, lumbar and sacral areas) EMF was determined in the prone position before and after the chiropractic adjustment. A low force Toftness chiropractic adjustment was applied to the cervical, thoracic, lumbar and sacral areas as determined by the practitioner.*

Results*: The EMF in the research room was recorded as 41611 nT at the Z axis (earth field), 13761 nT at the X axis and 7438 nT at the Y axis. The EMF on the adjusting table changed minimally during the 15 minute observation period. The EMF on the subjects' body surface decreased at 4 spinal locations after chiropractic adjustment. The EMF (mean ± SD in nT) decreased significantly at the cervical region from 42449 ± 907 to 41643 ± 1165 (*$p < 0.01$*) and at the sacral regions from 43206 ± 760 to 42713 ± 552 (*$p < 0.01$*). The EMF at the lumbar and thoracic regions decreased but did not reach a statistically significant level. No significant changes of the body surface EMF were found in the control group.*

Objectif *: Le but de cette étude était d'examiner les changements du champ électromagnétique (EMF) à la surface du corps à l'aide d'un magnétomètre sensible avant et après un ajustement chiropratique spécifique selon la technique Toftness chez des sujets humains asymptomatiques.*

Méthode *: Quarante-quatre sujets ont été affectés au hasard à un groupe contrôle (20 sujets) et à un groupe expérimental (24 sujets) avant et après le plan d'expérience. Le magnétomètre Triaxial Fluxgate FGM-5DTAA (Walker Scientific, Worcester, Massachusetts) à affichage numérique de cinq chiffres et d'une résolution de 1 nanotesla (nT) a été utilisé pour la détection de la fréquence électromagnétique (EMF). La fréquence électromagnétique dans la salle de recherche et sur la table d'ajustement a été contrôlée et enregistrée. La fréquence électromagnétique de la surface du corps (des régions cervicale, thoracique, lombaire et sacrée) des sujets a été prise en position couchée avant et après l'ajustement chiropratique. Un ajustement chiropratique Toftness à pression douce a été appliqué sur les régions cervicale, thoracique, lombaire et sacrée tel que déterminé par le praticien.*

Résultats *: La fréquence électromagnétique enregistrée dans la salle de recherche était de 41 611 nT dans l'axe Z (champ tellurique), de 13 761 nT dans l'axe X et de 7 438 nT dans l'axe Y. La fréquence électromagnétique sur la table d'ajustement a quelque peu changé durant la période d'observation de 15 minutes. La fréquence électromagnétique à la surface du corps des sujets a diminué aux quatre régions vertébrales après l'ajustement chiropratique. Elle a diminué de*

* Logan College of Chiropractic, Research Department, 1851 Schoettler Road, Chesterfield, MO 63006.
Phone: 636-227-2100 ext 320; Fax: 636-207-2417; Email: jzhang@logan.edu

Conclusion*: A low force Toftness chiropractic adjustment in the cervical and sacral areas resulted in a significant reduction of the cervical and sacral surface EMF. No significant body surface EMF changes were observed in the lumbar and thoracic regions. The mechanisms of the EMF reduction after chiropractic adjustment are not known.*
(JCCA 2004; 48(1):29–35)

KEY WORDS: Toftness, chiropractic, electromagnetic field.

manière significative (moyenne ± écart-type en nT) à la région cervicale, passant de 42 449 ± 907 à 41 643 ± 1165 (p < 0,01), et à la région sacrée, passant de 43 206 ± 760 à 42713 ± 552 (p < 0,01). Celle des régions lombaire et thoracique a diminué, mais pas à un niveau statistiquement significatif. Aucun changement notable n'a été remarqué dans la fréquence électromagnétique de la surface du corps du groupe contrôle.

Conclusion *: Un ajustement chiropratique selon la technique Toftness à pression douce appliqué sur les régions cervicale et sacrée a diminué de façon significative la fréquence électromagnétique des surfaces cervicale et sacrée. Aucun changement significatif de la fréquence électromagnétique de la surface du corps n'a été observé dans les régions lombaire et thoracique. Les mécanismes de réduction de la fréquence électromagnétique après un ajustement chiropratique ne sont pas connus.*
(JACC 2004; 48(1):29–35)

MOTS CLÉS : Toftness, chiropratique, champ électromagnétique.

Introduction

Exposure to natural or man-made EMFs (Electromagnetic fields) have been linked to many health hazards such as cancer, abnormal behavior, memory loss, Parkinson's disease, Alzheimer's disease, sudden infant death syndrome, suicide and psychosomatic effects.[1] EMF is associated with presence of electric charge or potential (Electric fields are measured in Newtons/Coulombs) and electric current (magnetic fields are measured in Tesla).[2] The magnetic field is produced by moving charges (currents). Since most humans live with the modern convenience of electricity with moving charges, magnetic fields are formed around all electric wires. There are extensive studies on the biological effect of EMF on animal and human bodies. Gmitrov (1995) reported that in conscious rabbits, local application of 0.35 T (Tesla) to sinocarotid barereceptors resulted in increased blood pressure, heart rate variability and microcirculation.[3] EMF exposure in healthy human volunteers has resulted in significant increases in time domain and spectral analysis of heart rate variability.[4] Most reports focus on the harmful effects of the high environmental EMF in animals and humans[5–9] but very few studies focused on the possible beneficial effect of lower EMF in humans. In fact, it is not clear what would be the effects of reduced human EMF emission. One theory proposed by I.N. Toftness was that a chiropractic adjustment on specific body surface areas would change the body surface EMF.[10–13] Based on Toftness' theory, clinical studies have reported that specific chiropractic adjustment has resulted in reduced symptoms in acute and chronic back pain, basilar migraine, chronic tension headaches and primary dysmenorrhea.[14–21] Despite the claim that Toftness chiropractic adjustment may reduce body surface EMF, the measurement of electromagnetic field changes before and after the low force Toftness chiropractic adjustment has not been reported.

The purpose of this study was to investigate the changes of electromagnetic field (EMF) on human body surface before and after a low force Toftness chiropractic adjustment. The significance of the proposed research

project is to document whether or not Toftness chiropractic adjustments affect the body surface EMF as monitored by a sensitive EMF magnetometer.

Material and methods

1 Subjects: A total of 44 faculty and students without any symptoms from a college setting were recruited and randomly assigned into the control (20 subjects) and experimental groups (24 subjects) using a random table. Subjects in the control group received no chiropractic adjustment. The participants had not been exposed to the low force Toftness chiropractic adjustment at least three weeks prior to this study. Any individuals with cardiac infarction, heart failure, osteoporosis or bone pathology were excluded from the study. Individuals who did not comply with the written informed consent form approved by the Logan College IRB were excluded from the study.

2 Methods: A non-motorized adjusting table was used for all EMF measurements and adjustments with the subject resting comfortably in a prone position. A motorized adjusting table was tested for EMF strength for comparison with the non-motorized adjusting table. EMF measurements were taken before and after the chiropractic adjustment within a 20 minutes period. Only one adjustment was given to the subjects in the experimental group after EMF measurement was taken on the same table. The practitioner delivered a low force (2–32 oz.) Toftness chiropractic adjustment by a metered hand-held pressure applicator at the cervical, thoracic, lumbar and sacral contact site.[19,21] This applicator is a rubber-tipped, spring-loaded device that indicates the amount of force that is being applied at the contact site. The adjustment contact line of drive, amount of force applied and duration of the contact are determined by constant monitoring of the adjustment site with the Sensometer which consists of an open cone and a meylor membrane.[19] Subjects in the control group followed the same procedure as in the experimental group except chiropractic adjustments were not given. The EMF readings in the control group were taken before and after the Toftness chiropractic assessments.

Body surface EMF was measured by the Triaxial Fluxgate Magnetometer FGM-5DTAA[22] (Walker Scientific, Worcester, Massachusetts 1999) with five-digit display and a resolution of 1 nT in a 100,000 nT field (Figure 1). Thus small variations in magnetic field can be measured in the presence of a large field such as the Earth's magnetic field. The EMF can be displayed in nanotesla (nT), microtesla (mT) or milligauss (mG). The FGM5DTAA instrument has a sample rate of 69 samples per second for real time EMF measurement. The instrument was calibrated by Walker Scientific before the study with a Certificate of Calibration traceable to the National Institute of Standards and Technology (NIST). EMF assessment sessions for each subject throughout the study were scheduled at 11:00–12:00 AM to prevent diurnal induced variation in the environmental EMF. The adjusting table and location of taking EMF reading was kept constant during the entire study process.

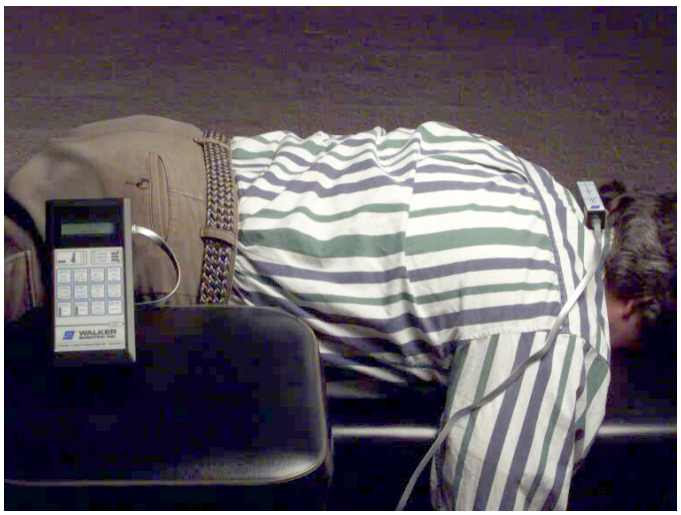

Figure 1 Magnetometer used for body surface EMF measurements. The EMF sensor was placed at the upper cervical region EMF measurements before and after Toftness chiropractic adjustments.

Statistical analysis: All continuous data were expressed in mean ± SD. A paired two tailed Student t-test was used for the pre and post comparisons of continuous variables. An alpha level of < 0.05 was considered significant.

Results

1. Demographics of Participants. Among the 44 participants in the study, 14 were females and 30 were males, ranging in age from 23 to 58 years old. Among the 20

subjects in the control group, there were 6 female and 14 male, with a mean age of 33.2 ± 8.8. Among the 24 subjects in the experimental group, there were 8 female and 16 male with a mean age of 34.7 ± 10.3. There were 6 faculty members and 38 students participating in the study.

2. Room EMF. The room EMF was measured in three dimensions, namely the X, Y and Z axes. While holding the instrument horizontally during testing, the X axis is detecting EMF from the south, the Y axis detecting EMF from the east and Z axis detecting EMF from the ground (earth field). The EMF was 41611 nT at the Z axis, 13761 nT at the X axis and 7438 nT at the Y axis.

3. Table Surface EMF. The plain wood table had EMF readings in the range of 41000 nT. The motorized Hi-Lo table had much higher EMF readings at 73000 nT near the lumbar and sacral regions. The motorized table was not used in the patient care and EMF measurements. Only the plain wood table was used in the study for chiropractic adjustment. The EMF on the table without subject at different times was recorded. The EMF reading was about the same during the 15 minute testing period which is about the same amount of time used for doctor to provide the Toftness adjustment (Figure 3).

4. Body Surface EMF before and after the Toftness chiropractic adjustment. EMF strengths at the cervical, thoracic, lumbar and sacral areas were measured before the chiropractic adjustment. The average EMF reading from the 24 subjects in the experimental group was shown in Table 1. The 24 subjects in the experimental group

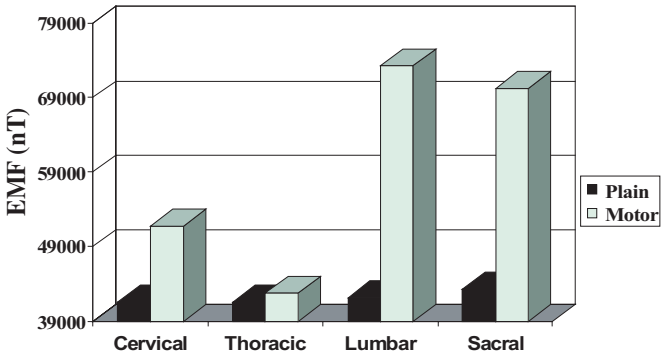

Figure 2 EMF measured on an unoccupied adjusting table with or without an electric motor at 4 locations approximating the 4 spinal locations.

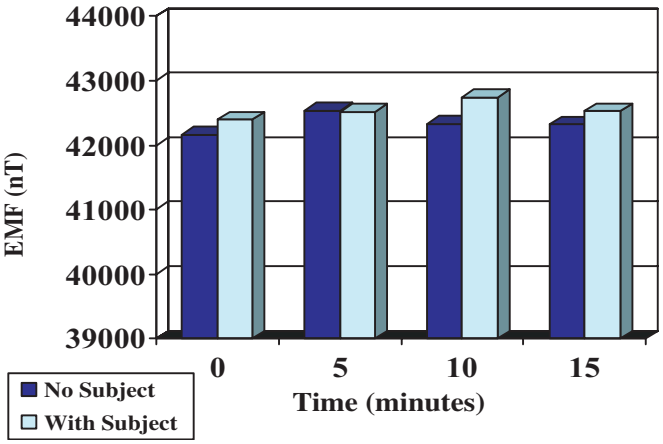

Figure 3 EMF measured with and without a subject on the adjusting table 40 cm from the location of the side of the subject's head at 0, 5, 10 and 15 minutes.

Table 1
Body Surface EMF Before and After Chiropractic Adjustment (nT)

Location	Before Adj. (Mean ± SD)	After Adj. (Mean ± SD)	P
Cervical	42449 ± 907	41643 ± 1165	0.000913
Thoracic	42459 ± 744	42225 ± 981	0.113
Lumbar	42973 ± 767	42822 ± 939	0.348
Sacral	43206 ± 760	42713 ± 552	0.00445

Table 2
Body Surface EMF in the Control Group (nT)

Location	Before (Mean ± SD)	After (Mean ± SD)	P
Cervical	42711 ± 3175	43020 ± 3119	0.115
Thoracic	43982 ± 3212	43854 ± 3166	0.187
Lumbar	43738 ± 2951	43686 ± 2875	0.583
Sacral	43995 ± 3061	44074 ± 2778	0.505

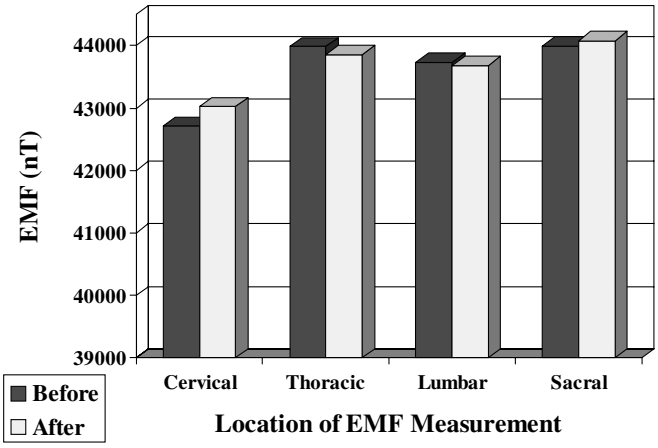

Figure 4 EMF measured on the control subjects' body surface at 4 spinal locations before and after a chiropractic assessment without adjustment (n = 20).

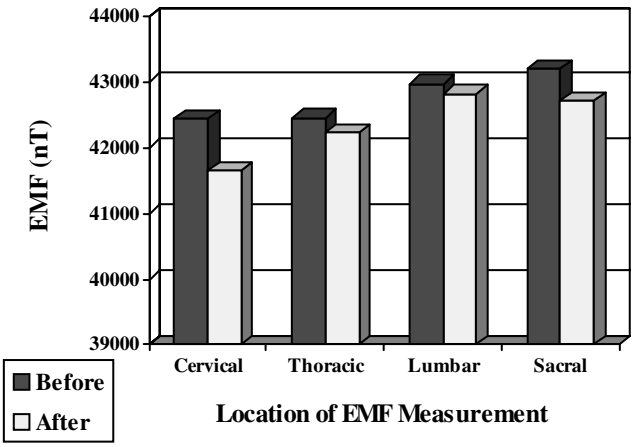

Figure 5 EMF measured on the experimental subjects' body surface at 4 spinal locations. (n = 24) before and after the Toftness chiropractic adjustment.

showed a significant decrease in EMF (mean ± SD in nT) after Toftness chiropractic adjustment at the cervical region from 42449 ± 907 to 41643 ± 1165 ($p < 0.01$) and at the sacral regions from 43206 ± 760 to 42713 ± 552 ($p < 0.01$). The EMF at the lumbar region decreased from 42973 ± 767 to 42822 ± 939 ($p > 0.05$) and the EMF decreased at thoracic region from 42459 ± 744 to 42225 ± 981 ($p > 0.05$), but did not reach a statistically significant level (Figure 5). The average decreases of the EMF in the cervical region and in the sacral region were 806 nT and 493 nT, respectively (Table 1).

In the control group, EMF readings were taken in the same fashion as in the experimental group but there were no significant EMF changes in all four locations (Table 2, Figure 4).

Discussion

It has been well documented that electrical current exits at all muscle and nerve cells to maintain resting membrane potential and action potentials.[23] This electrical current is easily measured on the body surface using the electrocardiogram (ECG) for recording of the electrical activities of the heart.[24,25] Electromyogram (EMG) is another commonly used instrument to determine the muscle electrical activities under varying conditions.[26,27]

An electromagnetic field (EMF) is produced whenever there is electrical current flowing around the body. The EMF strength on the body surface is determined to a large extent by the muscle mass and nerves that supply the muscle fibers.[28] This can be demonstrated using a surface EMG on the forearm muscles. The EMG tracing shows minimal deflections during resting but shows maximal deflections as the muscles are engaged in strenuous contractions. When the muscles fatigue, the deflections on EMG tracing become reduced, indicating a lowered electrical current across the muscle fibers. The increase and decrease in electrical current is always associated with the changing body surface EMF. Therefore, it is certain that EMF exists on the body surface. However, it has not been previously determined whether a Toftness chiropractic adjustment affects the EMF of the body surface.

There was evidence that chiropractic adjustments affect certain parameters that may change body surface EMF. Examples of these include (1) electrical potential changes across the cell membrane by K^+, Na^+ and Ca^{++} movement, (2) the electrical current at a cellular level; and (3) the muscle mass of a human subject. However, relaxation of muscles after chiropractic adjustment may cause changes in EMF. Relaxation of muscles reduces the electrical deflections which are closely correlated with lower body surface EMF.[29] It is also quite possible that relaxation of muscles causes a decrease in the electrical current around the cells leading to reduction of EMF on subjects' body surface.

Findings in this study show that the Toftness chiro-

practic adjustment may reduce the EMF on subjects' body surface. In order to confirm that this reduction of EMF was not associated with changes of those environmental factors, such as EMF in the room and on the adjusting table on varying times, the EMF in the room and on the motorized and non-motorized adjusting tables were recorded. It was determined that there were no significant EMF changes in the room and the plain wood adjusting table. The EMF reading changed minimally when recorded every five minutes on the table surface without human subject. Even with the subjects lying on the adjusting table, the EMF showed no significant reductions on the body surface. The reduction of EMF was only found in the cervical and sacral areas in subjects after receiving the Toftness adjustment. The motorized table showed very high EMF readings and was not used for the Toftness chiropractic adjustments in the study.

The reduction of EMF in the cervical and sacral regions following adjustment reached statistical significance. The average changes in EMF after chiropractic adjustment were 806 nT in the cervical and 492 nT in the sacral area. It was interesting to note that the reductions of EMF in the cervical or sacral area correspond to relatively low EMF pre-reading in the cervical area and high in the sacral area. In this study the EMF readings can be high or low before the chiropractic adjustment and it was the adjustment that led to the reduction of the EMF. Furthermore, the low force adjustments were given in most cases to the cervical and sacral regions. This might be another contributing factor in that the cervical and sacral regions were the areas that showed significant changes after the chiropractic adjustment. Although thoracic adjustments were attempted in some cases, the EMF readings were too variable to show a statistically significant difference after the adjustment despite a clear trend of reduction of EMF as a group. The lumbar region showed EMF reduction after the adjustment but did not reach a significant difference. These findings are similar to a previous report by Toftness[7] that the sacral and cervical regions are the areas of highest sensitivity using the proper analytical procedures[16]. Subjects in both groups did not know the EMF testing but most of the students had learned Toftness adjustment in classes.

The major limiting factor for the study was that the EMF reading was taken before and after only one adjustment for each subject. This is not normally practiced by field chiropractors. A typical patient care consists of a few weeks of care and a number of adjustments. Therefore, a long-term study on the effect of chiropractic adjustment on body surface EMF is needed.

Conclusions

Normal human subjects showed a significant decrease in body surface EMF in the cervical and sacral regions after the chiropractic adjustment. The mechanism of the reduction of body surface EMF is not yet understood, but it might partially be due to relaxation of the surrounding muscles. This pilot observation provides basis for further large scale randomized controlled studies. Another unsolved issue is the significance of the reduced EMF reading after the Toftness chiropractic adjustment and it's relation to clinical conditions. These concerns and questions will be investigated further on patients with clinical conditions.

References

1 Kjellstrom T. Health and environmental effects of exposure to static and time varying electric and magnetic fields (update March 1996), in Five-Year International Project at the World Health Organization. The International EMF Project, WHO, Geneva, Switzerland, 1996, 1–11.
2 Novini A. Fundamental issues on electromagnetic fields (EMF). Acupuncture & Electro-Therapeutics Res., INT J 1993; 18:23–31.
3 Gmitrov J, Ohjubo C, Yamada D, Gmitrova, A and Xu S. Static magnetic field effect on sinocarotid baroreceptors in rabbits exposed under conscious conditions. Electro-Magnetobiol 1995; 14(1):217–228.
4 Gmitrov J. Static magnetic field effect on sinocarotid baroreceptors in humans. Electro- Magnetobiol 1996; 15(1):183–189.
5 Gmitrov J, Ohjubo C. Static magnetic field and calcium channel blocking agent combined effect on baroreflex sensitivity in rabbits. Electro- Magnetobiol 1999; 18(1):43–55.
6 Zhang Q, Tabrah FL, Whittow GC. Effect of an electromagnetic field on avian embryonic growth and oxygen consumption. J Electro-and Magnetobiology 1993; 12(1):27–37.
7 Litvak E, Foster KR, Repacholi MH. Health and safety implications of exposure to electromagnetic fields in the frequency range 300 Hz to 10 MHz. Bioelectromagnetics 2002 Jan; 23(1):68–82.
8 Dasdag S, Sert C, Akdag Z, Batun S. Effects of extremely low frequency electromagnetic fields on hematologic and immunologic parameters in welders. Arch Med Res 2002 Jan-Feb; 33(1):29–32.

9 Li CY, Sung FC, Wu SC. Risk of cognitive impairment in relation to elevated exposure to electromagnetic fields. J Occup Environ Med 2002 Jan; 44(1):66–72.
10 Toftness IN. Re-searching the chiropractic adjustment (thesis). Cumberland, WI: Toftness Post-Graduate School of Chiropractic, 1961.
11 Toftness IN. Philosophy of chiropractic correction. In: A look at chiropractic spinal correction. Cumberland, WI: Toftness Post-Graduate School of Chiropractic, 1977.
12 Toftness IN. The phenomenon of neurological analysis. Todays Chiro 1978; Nov/Dec:77–78.
13 Toftness IN. New device detects microwave emissions in biological systems. J Wis Chiro Assoc 1982; 36:10–11.
14 Gemmell HA, Jacobson BH, Henge DJ. Effectiveness of Toftness sacral apex adjustment in correcting fixation of the sacroiliac joint: preliminary report. Am J Chiro Med 1990; 3:5–8.
15 Gemmell HA, Jacobson BH, Sutton L. Toftness spinal correction in the treatment of migraine: a case study. Chiropractic Technique 1994; 6:57–60.
16 Gemmell HA. Interexaminer agreement in locating the area of highest spinal stress using the Toftness electromagnetic radiation detector. Am Chiro 1987; Apr:10–13.
17 Gemmell HA, Jacobson BH, Edwards SW, Henge DJ. Interexaminer reliability of the electromagnetic radiation receiver for determining lumbar spinal joint dysfunction in subjects with low back pain. J Manipulative Physiol Ther 1990; 13:134–137.
18 Gemmell HA, Henge DJ, Jacobson BH. Interexaminer reliability of the Toftness radiation detector for determining the presence of upper cervical subluxation. Chiropractic Technique 1990; 2:10–12.
19 Hawkinson EJ, Snyder BJ, Sanders GE. Evaluation of the Toftness system of chiropractic adjusting for the relief of acute pain of musculoskeletal origin. Chiropractic Technique 1992; 4:57–60.
20 Snyder BJ, Sanders GE. Evaluation of the Toftness system of chiropractic adjusting for subjects with chronic back pain, chronic tension headaches, or primary dysmenorrhea. Chiropractic Technique 1996; 8:3–9.
21 Snyder BJ. Thermographic evaluation for the role of the sensometer: evidence in the Toftness system of chiropractic adjusting. Chiropractic Technique 1999; 11(2):57–61.
22 Triaxial fluxgate magnetometers, FGM-5DTAA. Walkerscientific.com. 1999.
23 Schultz SG, Frizzell RA, Nellans HN. Active sodium transport and the electrophysiology of rabbit colon. J Membr Biol 1977; May 12 33:3–4; 351–84.
24 Mattera JA, Arain SA, Sinusas AJ, Finta L, Wackers FJ. Exercise testing with myocardial perfusion imaging in patients with normal baseline electrocardiograms: cost savings with a stepwise diagnostic strategy. J Nucl Cardiol 1998; Sep–Oct 5:5 498–506.
25 Menown IB, Patterson RS, MacKenzie G, Adgey AA. Body-surface map models for early diagnosis of acute myocardial infarction. J Electrocardiol 1998; 31 Suppl 180–188.
26 Collins DF, Knight B, Prochazka A. Contact-evoked changes in EMG activity during human grasp. J Neurophysiol 1999; May 81:5 2215–2225.
27 Mayer JM, Graves JE, Robertson VL, Pierra EA, Verna JL, Ploutz-Snyder LL. Electromyographic activity of the lumbar extensor muscles: effect of angle and hand position during Roman chair exercise. Arch Phys Med Rehabil 1999 Jul 80:7 751–755.
28 Guyton AC. Textbook of Medical Physiology. Eighth Edition. Saunders 1991; p. 84–85.
29 Ferdjallah M, Wertsch JJ. Anatomical and technical considerations in surface electromyography. Phys Med Rehabil Clin N Am 1998; Nov 9:4 925–931.