Magnetic Necklace: Its Therapeutic Effectiveness on Neck and Shoulder Pain

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ABSTRACT. Hong C-Z, Lin JC, Bender LF, Schaeffer JN, Meltzer RJ, Causin P: Magnetic necklace: its therapeutic effectiveness on neck and shoulder pain. Arch Phys Med Rehabil 63:462-466, 1982.

• The effect of the magnetic necklace on chronic neck and shoulder pain was studied on 101 volunteers, 46 males and 55 females. A double-blind method was applied on 4 divided groups (with pain vs without pain matched with magnetic vs nonmagnetic necklace). All the subjects wore the necklace 24 hours per day for 3 weeks. Subjective evaluation from the subjects with pain, either with magnetic or nonmagnetic treatment, was performed before and 3 weeks after the necklace treatment, and revealed a significant placebo effect in terms of decrease in intensity or frequency of pain. The objective tests with electrodiagnostic procedures were done before the treatment and at 3 weekly intervals. The proximal conduction time of the ulnar nerve was significantly reduced by magnetic treatment in the subjects without pain but was not changed in the subjects with pain. There was no significant change in the excitation threshold of the suprascapular nerve in all subjects. The possible mechanism of magnetic effects on pain and the prospect of magnetotherapy for pain relief in physical medicine are discussed.

The application of a static magnetic field as a physical therapy modality for the management of painful and stiff soft tissue lesions has been described previously.[7] In the past 20 years, Nakagawa[21,22] developed some magnetotherapeutic devices, such as the magnetic necklace, to treat his patients with chronic painful and stiff soft tissue lesions in Japan. He believed that magnetotherapy was effective in treating the "magnetic field deficiency syndrome," which includes stiffness of the shoulders, back and scruff of the neck, lumbago, chest pain for no specific reason, habitual headache and heaviness of head, dizziness and insomnia for uncertain reasons, habitual constipation, and general lassitude with no objective pathologic findings.[21] Nakagawa found that application of a static magnetic field with magnetic flux density of 700G (gauss) or 1300G had a significant effect in alleviating the subjective symptoms with no significant side effects. However, he was unable to show a reasonable explanation of interactive mechanisms. To the best of our knowledge, a well-controlled clinical laboratory investigation to clarify the mechanism on a physiologic basis has not been established.

The study of the mechanism of magnetic effects on pain is just as difficult as a study on the mechanism of pain itself. The 1st step of this approach usually is the study of magnetic effects on neuromuscular function. There were numerous previous investigations dealing with the response of the nervous system to a static magnetic field which has been experimentally studied at different levels; for example, central nervous system,[6,8,14-16] neuromuscular preparations,[19,23,24] and excitable membrane.[4,9,12,13,17] Although there is a considerable amount of evidence of an interaction between the static magnetic field and the nervous system, the in vitro studies of the effects of static magnetic field on the conduction velocity of isolated nerves are still controversial.[23] The magnetic effect on the excitation threshold of isolated frog nerve was studied by Liberman and associates[19] who found no change in the excitation threshold after exposure to a constant field of more than 10,000 oersteds (Oe). Vovk and Tkach,[24] on the other hand, found that the fluctuation in the threshold of direct stimulation on isolated frog muscle increased, although the threshold of stimulation practically did not change. Prolonged exposure of the isolated muscle to the magnetic field for 20 hours led to increase in the fluctuation of the threshold as well as increase in the inherent stimulation threshold.

To the best of our knowledge, the in vivo study of magnetic effect on nerve conduction velocity or nerve excitation threshold of human subjects has not been reported previously. Therefore, in this study, in addition to an evaluation of the subjective effects, the effects of magnetic necklace on nerve conduction time and excitability were also investigated on human subjects, using a double-blind experimental design.

MATERIALS AND METHODS

Subjects

We studied 101 volunteers; 46 males and 55 females. Forty-nine of them were subjects without chronic pain symptoms or any neurologic signs from a brief examination. The other 52 subjects (with pain) had had chronic neck and shoulder pain periodically or consistently for more than one year. They were not receiving any treatment other than the necklace during and 6 months before this study. A brief physical examination did not reveal any sign except for muscle spasm and tightness in some cases. The mean age of all subjects was 30 years and the range was between 18 and 62 years.

Necklaces

Two kinds of necklaces were used in this study. One was magnetic and the other was not. Besides the magnetic nature,

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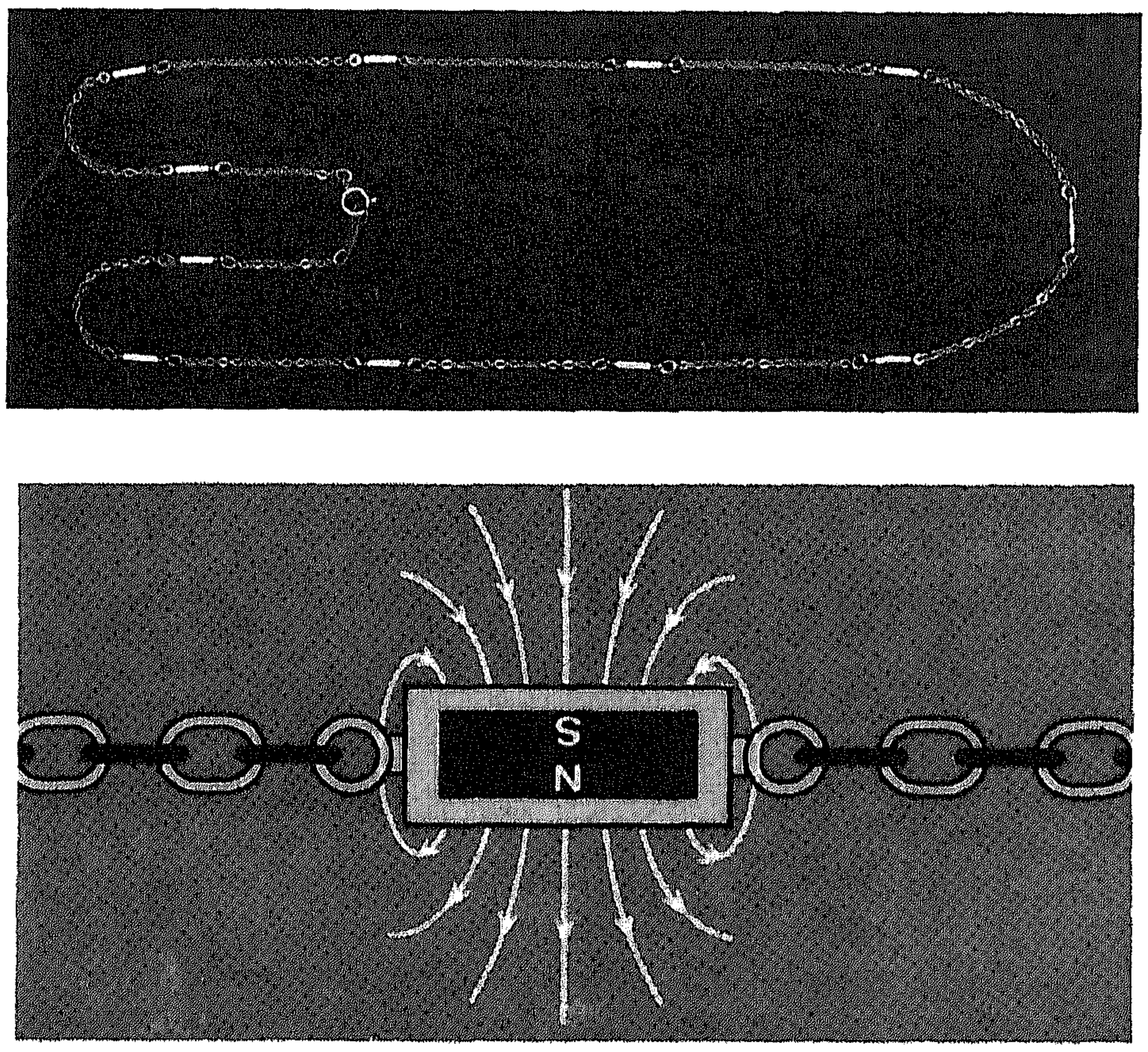

Fig 1 — TDK magnetic necklace (upper) and the magnetic field lines of a drum shaped element (lower).

both had the same characteristics. They were supplied by TDK Magnetic Corporation.[a] Each necklace consisted of samarium cobalt element with brass chains and was plated with either gold or rhodium. The drumshaped element was 8mm in length by 2.2mm in diameter. The TDK magnetic necklace and the direction of magnetic field lines are illustrated in figure 1. The magnetized element has a surface density of approximately 1300G that decreases rapidly away from the surface (fig 2).

Classification of Experimental Subjects

Fifty-two magnetic and 49 nonmagnetic necklaces were randomly assigned to both subjects with and without pain by an experimenter who was not involved in doing the electrodiagnostic tests (table 1). Neither the electromyographer nor the experimental subjects were aware of necklace assignment.

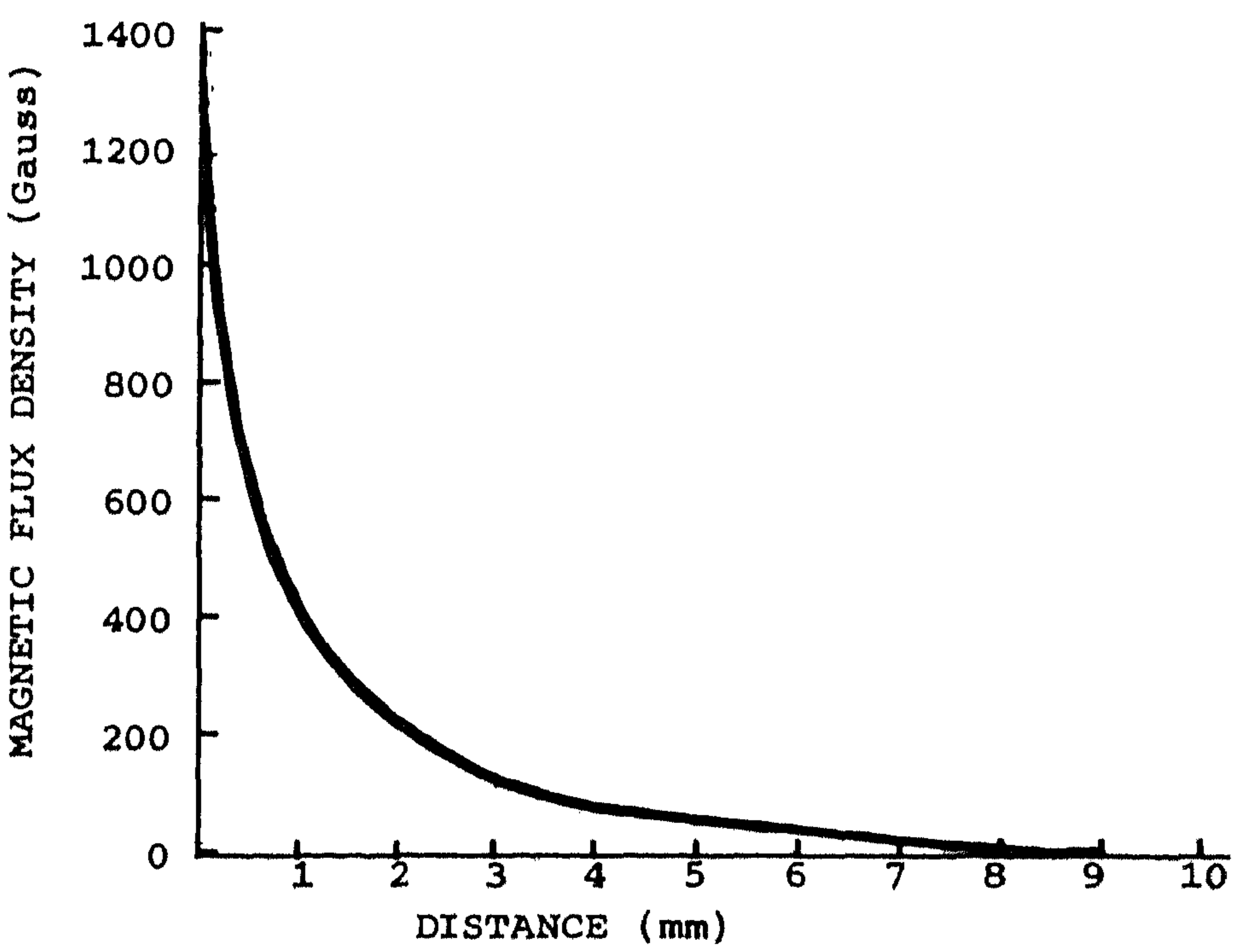

Fig 2—Variation of magnetic flux density of drum shaped samarium-cobalt magnetic element.

Table 1: Classification of Subjects

Groups of subjects		Male	Female	Total
Group A	Nonmagnetic Without pain	13	11	24
Group B	Nonmagnetic With pain	8	17	25
Group C	Magnetic Without pain	16	9	25
Group D	Magnetic With pain	9	18	27
Total		46	55	101

Experimental Procedure

All the subjects were told that they would receive a treatment with a magnetic necklace for a period of 3 weeks, whether they had neck and shoulder pain or not. They were not aware that some of them were given the nonmagnetic necklace. Before the necklace treatment, an electrodiagnostic test was performed on each subject. This test included 2 separate parts: the excitation threshold test and the conduction measurement. The excitation threshold of the suprascapular nerve was determined by stimulating the nerve at a certain point on the lower portion of the posterior triangle of the neck and by picking up the action potential from the supraspinatus muscle. The threshold voltage was measured by an oscilloscope[b] having a 2-volt resolution. The proximal conduction time of the ulnar nerve was determined as axillary F-loop latency (AFLL).[11] After the electrodiagnostic test, subjects were instructed to wear the necklace 24 hours a day and to keep the necklace in contact with the skin. The length of the necklace was adjusted to fit the individual neck size and the mean number of magnets or nonmagnetic elements was 9(±2). Further electrodiagnostic tests were made at weekly intervals 3 more times. The necklace was temporarily removed before each test, and put on again after each test by another experimenter who did not do the electrodiagnostic tests. A small waterfast stain was put on the neck to mark the stimulation point for threshold study after each session of test. Room temperature was maintained at 24±1C during the electrodiagnostic test.

Subjective Evaluation

Subjects in the groups with pain were asked to describe the intensity and the frequency of pain and stiffness before and after the experiment to see if there was any improvement during or after the necklace treatment by using a scale ranging from 0 to 4 for either intensity or frequency of discomfort as follows: intensity: 0 = no discomfort, 1 = very little discomfort, 2 = minor discomfort, 3 = annoying discomfort, and 4 = painful; frequency: 0 = never, 1 = seldom, 2 = occasionally, 3 = often, and 4 = always.

Statistical Analysis

We employed a randomized group design to increase

Table 2: Subjective Evaluations

Groups* of subjects	Before treatment	After treatment	Improvement
Intensity of pain			
Group B (NM)	2.84 ± 0.55	2.56 ± 0.58	−0.28 ± 0.54 $p < 0.001$
Group D (M)	3.11 ± 0.51	2.74 ± 0.71	−0.37 ± 0.49 $p < 0.001$
Comparison: NM vs M	$p = 0.99$	$p = 0.78$	$p = 0.53$
Frequency of pain			
Group B (NM)	2.76 ± 0.55	2.52 ± 0.59	−0.24 ± 0.52 $p < 0.001$
Group D (M)	2.93 ± 0.62	2.52 ± 0.70	−0.41 ± 0.50 $p < 0.001$
Comparison: NM vs M	$p = 0.67$	$p = 0.25$	$p = 0.24$

NM designates nonmagnetic necklace; M, magnetic necklace.

the efficiency of the experiment. It was conducted in 4 replicates over a period of 8 months. Subjects in each replicate were interviewed and classified in a like manner and allocation of necklace was random. Thus the electrodiagnostic measurements and the subjective evaluations were statistically analyzed as a whole using the following procedures:

1. A 2-way analysis of variance was used to assess the differences in electrodiagnostic measures and subjective evaluations of the treatment.
2. A 2-sided t-test was employed for determining if significant differences exist across electrodiagnostic sessions within the group.
3. For statistical analysis a $p = 0.05$ level of significance was used. If the p-value was ≤ 0.05, then the difference between the 2 means was considered statistically significant.

RESULTS

Subjective Evaluation

Among the subjects with chronic pain, 14 (52%) of the 27 subjects reported improvement after magnetic necklace treatment, and 11 (44%) of the 25 subjects treated with nonmagnetic necklaces reported subjective improvement. Table 2 summarizes the means and standard deviations of the subjective effect of the necklace treatment. The intensity and frequency of pain were significantly reduced after treatment in both magnetic and nonmagnetic groups. However, treatment condition (magnetic or nonmagnetic) did not affect subjective reports of intensity and frequency of pain, nor affect changes in reported intensity and frequency of pain. Thus there is evidence of a placebo effect.

Table 3: Mean and Standard Deviation of Excitation Threshold

Session	Magnetic necklace (volts)	Nonmagnetic necklace (volts)
With pain		
1st	61.38 ± 26.50	60.73 ± 23.78
2nd	63.92 ± 26.34	62.88 ± 26.15
3rd	65.63 ± 24.30	58.34 ± 25.65
4th	62.17 ± 27.43	63.05 ± 24.93
Without pain		
1st	53.56 ± 24.23	54.74 ± 23.72
2nd	51.87 ± 18.07	53.75 ± 23.52
3rd	53.20 ± 23.38	56.96 ± 25.59
4th	52.47 ± 19.37	56.13 ± 27.45

Table 4: Comparison of Mean Excitation Threshold Between the First and Subsequent Sessions (t-test)

Groups* of subjects	df	t	p value
Session 1:session 2			
Group A (NM-NP)	23	0.19	0.85
Group B (NM-P)	24	−0.48	0.64
Group C (M-NP)	24	0.42	0.68
Group D (M-P)	26	−0.43	0.67
Session 1:session 3			
Group A (NM-NP)	23	−0.40	0.70
Group B (NM-P)	24	0.41	0.69
Group C (M-NP)	24	0.07	0.94
Group D (M-P)	26	−0.81	0.42
Session 1:session 4			
Group A (NM-NP)	23	−0.24	0.81
Group B (NM-P)	24	−0.56	0.58
Group C (M-NP)	24	0.22	0.83
Group D (M-P)	26	−0.13	0.90

*NM designates nonmagnetic; M, magnetic; NP, no-pain, and P, pain.

Excitation Threshold of Suprascapular Nerve

The threshold voltage in general varied between 20 and 100 volts from subject to subject depending on several factors such as skin impedance, subcutaneous tissues, and the position of the recording electrode, and the like. The mean excitation threshold and the standard deviation from the mean for each of the 4 groups of subjects are presented in table 3. Analysis of variance showed that there were no significant differences between treatment conditions (magnetic and nonmagnetic). Comparison of the mean excitation threshold (table 4) within each group across all sessions also did not reveal any significant difference among the experimental conditions.

Because the variance in excitation threshold was large, an analysis of the percentage change in excitation threshold from the 1st session (baseline session) was performed among the 4 groups and within each group of subjects. The results showed that there were no significant differences among experimental conditions.

Axillary F-Loop Latency of Ulnar Nerve

The means and standard deviations for F-wave latency are presented in table 5. Analysis of variance for each experimental condition showed that there were no significant differences for any of the experimental sessions, including base. Moreover, treatment conditions did not alter the measured F-wave latency.

The changes in F-wave latency from the baseline (1st) session are compared in table 6. The AFLL for subjects without pain, treated with magnetic necklace, was significantly higher at the 4th session than at baseline session.

Table 5: Mean and Standard Deviation of Axillary F-loop Latency

Session	Magnetic necklace (msec)	Nonmagnetic necklace (msec)
With pain		
1st	9.39 ± 0.79	9.18 ± 1.25
2nd	9.48 ± 0.90	9.13 ± 1.19
3rd	9.21 ± 1.09	9.05 ± 1.07
4th	9.14 ± 1.07	8.99 ± 1.12
Without pain		
1st	9.04 ± 0.88	9.37 ± 0.64
2nd	9.30 ± 0.94	9.16 ± 0.81
3rd	8.81 ± 1.02	9.44 ± 1.09
4th	8.74 ± 0.88	9.28 ± 0.94

Table 6: Comparison of Axillary F-loop Latency Between the First and Subsequent Sessions (t test)

Groups of subjects	df	t	p-value
Session 1:session 2			
Group A (NM-NP)	15	0.87	0.40
Group B (NM-P)	19	0.32	0.75
Group C (M-NP)	20	−1.82	0.08
Group D (M-P)	18	−0.46	0.65
Session 1:session 3			
Group A (NM-NP)	15	−0.23	0.83
Group B (NM-P)	19	0.59	0.57
Group C (M-NP)	20	1.06	0.30
Group D (M-P)	18	0.73	0.48
Session 1:session 4			
Group A (NM-NP)	15	0.35	0.73
Group B (NM-P)	19	1.07	0.30
Group C (M-NP)	20	2.22	0.04
Group D (M-P)	18	1.04	0.31

NM designates nonmagnetic; M, magnetic; NP, no pain; P, pain.

DISCUSSION

From the subjective evaluation we are unable to prove the therapeutic effect of a magnetic necklace on painful neck and shoulder syndrome. This contrasts with the results of studies in Japan. Some of the Japanese studies also involved the blind tests. However, Nakagawa[22] stated that it was difficult or almost impossible to apply the blind test generally to the magnetic necklace because the participant can easily notice whether the device has magnetic field or not. In our study, we tried to eliminate this possible deviation, and told the subjects to wear the necklace all the time, except when the electrodiagnostic tests were being taken, at which time the necklace was removed by one of us who did not do the electrodiagnostic tests. We found that almost all of the subjects believed that their necklaces were magnetized. Therefore, the placebo effects of the magnetic necklace are considered significant in our study group.

Evidence of magnetic effect on nervous tissue has been demonstrated in previous studies[3-6,8,9,12,13,15-17] in which we found the following important factors determining the biologic effect of static magnetic field:

1. *Magnetic dose.* Barnothy[2] introduced the term of "magnetic dose" to imply the cumulative effects of magnetic field in relation to the intensity and duration of exposure to the field. In reviewing the 2 reports of clinical magnetotherapy with excellent results to relieve pain, we found that 1300G of magnetic field was applied for 2 weeks in Nakagawa's study[22] and more than 10,000G (estimated) applied in Hansen's treatment.[10] This seems to agree with Barnothy's concept of "magnetic dose." In vitro animal studies also revealed that high-strength field[6] or longer duration of exposure[24] had higher chance to demonstrate a significant biologic effect.
2. *Magnetic direction* (or orientation of specimen). The magnetic anisotropy of the molecule causing the different susceptibilities in different orientation might play an important role in the experimental results obtained from different orientation of the specimen.[1,5,12,13,17,20] Increase in nerve conduction velocity might be more evident from magnetic exposure in parallel direction than in perpendicular direction.[23]
3. *Homogeneity of magnetic field.* A nonhomogeneous field may exert an accelerating force upon particles which are more paramagnetic or more diamagnetic than their surroundings, whereas a homogeneous field does not exert such force.[2] The nerve tissue has higher susceptibility (more paramagnetic) than some other tissues, such as bone, muscle, and blood vessels.[17] Therefore, a nonhomogeneous field may be more favorable to induce significant effects on the nervous tissue.

Based on these factors, we might expect some functional changes in the nervous tissue if we apply nonhomogeneous static magnetic field with higher intensity than that afforded by the TDK necklace to the area of the skin where the nerve is superficial enough to be susceptible to magnetism for a sufficient period of time. In previous reports, there is evidence of magnetic effects on the excitable membrane, including a decrease in sodium transport[9] and the Hall effects.[4,17] The magnetic field-induced changes may be accompanied often by changes in membrane properties and perhaps in active transport.[1] The etiologic basis for these membrane effects may conceivably involve liquid crystals that are highly magnetic anisotropic.[1,18] The phospholipids, the important constituents of the membrane, may have the liquid crystal properties that are susceptible to the magnetic field.[17]

We can assume, therefore, that the magnetic field acts on the phospholipids or other constituent of the nerve membrane and makes some of the molecules of the phospholipid (or other molecules on the membrane) rotate to the direction of maximal susceptibility because of the magnetic anisotropic nature, or even induce movement of the molecules in the nonhomogeneous magnetic field. This then induces the changes of membrane properties, causing depression of sodium pump activities and development of Hall voltage. In this way, the excitability and conductivity of the nerve is changed. If the excitability and conductivity of the large fibers are increased and that of the small fibers are decreased, the transmission of pain information to the higher center may be interrupted according to the gate theory. This is the hypothetical mechanism of pain relief from magnetotherapy.

We found that the proximal conduction time of the ulnar nerve (large fibers) was significantly reduced in the subjects without pain after 3 weeks of magnetic necklace treatment. But this did not happen in the subjects with chronic pain.

Possibly this magnetic field can increase the impulse transmission in the normal nerve, but is not strong enough to cause any significant changes in the "diseased nerve." Unfortunately, we are unable to detect any changes in excitation threshold from magnetic treatment. This is probably due to the inadequate magnetic design or the insensitive technique to detect the small changes.

CONCLUSIONS

1. We were unable to demonstrate any significant therapeutic effect of the Japanese TDK magnetic necklace on chronic neck and shoulder pain and stiffness.
2. We found significant decrease in nerve conduction time from magnetic necklace treatment in the subjects without pain, but not in the subjects with pain. There was no significant change in nerve excitability in all subjects.
3. The possible mechanism of magnetic effect on pain may be related to the changes of nerve excitability and conductivity (increased in the large fibers and decreased in the small fibers).
4. Probably, a greater intensity of the magnetic field is neccessary to produce a measurable effect, and more sensitive technique may be necessary to detect the small changes in neuromuscular function.
5. Magnetotherapy may become a useful modality in physical medicine in the near future, if an adequate design of magnetic field can be developed.

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Suppliers

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b. Tektronix Inc, 24155 Drake Rd., Farmington, MI 48024

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