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# Effects of Permanent Magnets on Resting Skin Blood Perfusion in Healthy Persons Assessed by Laser Doppler Flowmetry and Imaging

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Effects on skin blood perfusion of permanent ceramic magnets [0.1 T (1000 G) surface field], individually (disk shaped, 4 cm diameter × 1 cm thick) or in the form of a 11 × 7 in pad (∼28 × 17.8 cm) with an array of 16 rectangular magnets (4.5 × 2.2 cm), were investigated in 16 female volunteers (27.4 ± 1.7 years, range 21–48 years) using three separate protocols. In protocol A, a disk magnet was placed on the palmar surface of the hand in contact with the thenar eminence (n = 5). In protocol B, the magnet was placed on the hand dorsum overlying the thenar eminence (n = 5). In protocol C, the entire palm and fingers rested on the magnetic pad (n = 6). Magnets were in place for 36 min on one hand, and a sham was in place on the other hand. Blood perfusion was measured on the middle finger dorsum by laser Doppler flowmetry (LDF) and on the index finger by laser Doppler imaging (LDI). Perfusion measurements were simultaneously taken in sham and magnet exposed hands, before and during the entire magnet exposure interval. Magnetic field effects were tested by comparing skin blood perfusion sequences in magnet and sham exposed regions. Results showed no significant changes in either LDF or LDI perfusion at magnet or sham sites during exposure, nor were there any significant differences between sham and magnet sites for any protocol. Measurements of skin temperature at the LDF measurement sites also showed no significant change. It is concluded that in the healthy subjects studied with normal, unstressed circulation, magnets of the type and for the duration used, showed no detectible effect on skin blood perfusion in the anatomical area studied. Bioelectromagnetics 22:494–502, 2001. 

**Key words: human microcirculation; skin blood flow; DC magnetic fields; magnet therapy**

## INTRODUCTION

While reports on the use of lodestones, the predecessor of modern permanent magnets, for pain relief or other salubrious effects, extend from today's popular and medical press into antiquity, the scientific evidence for their efficacy is sparse. Major claims for the efficacy of permanent magnets include their purported beneficial effects on pain reduction and their enhancement of blood circulation, either as a component of the pain reduction process or as a general feature. A few recent studies provide some evidence of a possible therapeutic role for some types of permanent magnets in pain reduction in specific conditions [Colbert et al., 1999; Man et al., 1999; Vallbona et al. 1997]. The role of magnet related changes in blood flow in these pain studies was not addressed.

In fact, there is little scientific evidence to support direct or implied claims that permanent magnets increase human blood circulation. While limited data suggests that pulsed electromagnetic fields at 27.12 MHz may increase skin blood perfusion [Mayrovitz and Larsen, 1992,1995], and a few reports suggest an effect of static magnetic fields on blood vessels in experimental situations [Ohkubo and Xu, 1997, Okano et al., 1999], no systematic evaluation of the effects of permanent magnets on human skin has shown a direct

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increase in microcirculation. One of the claims associated with ''magnetic therapy'' is that its therapeutic efficacy is related to an increase in blood circulation [Frankel and Liburdy, 1996]. However, in a recent abstract [Mayrovitz et al., 2000], it has been reported that resting skin blood perfusion in normal tissue is not affected by a permanent magnet with a surface field strength of 0.1 T (1000 G). In that study, forearm skin blood perfusion was measured adjacent to an applied magnet, and the reported findings are strictly applicable only to this tissue site and mode of magnet application.

The purpose of the present study was thus to expand the foregoing work and to determine whether normal resting blood perfusion in normal tissue could be affected when the tissue was either directly within the field of applied permanent magnets or at sites remote to magnet application. Hand sites of normal volunteers were exposed to single magnets (or shams) and also to magnetic pads (or shams), having surface field strengths in the range of most commercially available magnets marketed for magnetic therapy. Blood perfusion of the skin of the fingers was measured simultaneously using point laser Doppler flowmetry and laser Doppler imaging.

## MATERIALS AND METHODS

***Subjects.*** Healthy female pharmacy students ($N = 16$, age $27.4 \pm 1.7$ years with a range of 21–48 years) participated after signing an informed consent form approved by the institutional review board. Females were chosen for this initial work because of their generally smaller hand size, which facilitated implementation of the protocol by reducing laser Doppler scan time while simultaneously providing maximum magnetic field strength within exposed tissue. No subjects had previously used any form of magnetic therapy, nor were any taking vasoactive medication. Overall, the subjects' heights ($164.1 \pm 1.5$ cm), weights ($62.1 \pm 2.7$ kg), and systolic ($126.6 \pm 3.7$) and diastolic ($81.9 \pm 2.6$) blood pressures (mmHg) were within a normal range. At testing, the time since their last menstrual periods was $17.1 \pm 2.3$ days with a range of 0 to 28 days. The right hand was the dominant hand for all subjects.

***Magnets.*** Two types of commercially available ceramic magnets were used. One was a single disk shaped magnet and the other an $11 \times 7$ in. ($\sim 28 \times 17.8$ cm) pad, within which were 16 uniformly distributed rectangular ($45 \times 22$ mm) magnets. Both types were kindly provided by the manufacturer (Magnetherapy, Riviera Beach, Florida), who also provided shams that were non-magnetized ceramic pieces, identical in appearance and weight, but without a magnetic field. The disk magnets were 4 cm diameter $\times$ 1 cm thick, weighed 68 g, and had a surface field strength of 0.1 T. Each rectangular magnet imbedded in the pad also had a surface field strength of 0.1 T but the field strength at the surface of the pad was approximately 0.05 T (500 G) (see Fig. 1).

***Skin Blood Perfusion.*** Skin blood perfusion was measured using two simultaneous methods, laser Doppler flowmetry (LDF) and laser Doppler perfusion imaging (LDI). Principles of operation of laser Doppler methods have been previously published [Nilsson et al., 1980; Nilsson, 1984; Jakobsson and Nilsson, 1993; Mayrovitz 1994, 1998]. Briefly, a low intensity laser light signal is transmitted into the skin to a depth of about 1–2 mm and the reflected light is used to measure local blood perfusion. The Doppler shifted signal contains information about the speed and number density of moving red blood cells in a tissue region to a depth of about 1–2 mm. Speed and number density information is processed to yield a parameter, perfusion, that is proportional to blood flow and usually expressed in arbitrary units (a.u.). With LDF, a probe is directly attached to the skin, receives blood perfusion data from a surface area of about 5 $mm^2$, and transmits these data via an optical fiber bundle to the central processor. The response time resolution is about 0.1 s. Skin temperature sensors are an integral part of the probes, thus allowing continuous temperature measurements at the sites of the perfusion measurements.

With LDI, no probe is used and a laser beam directly impinges on the target tissue and scans a selected area [Wardell et al., 1993; Mayrovitz and Smith, 1999]. Penetration depth and signal processing is similar to LDF, but the surface area from which perfusion information is obtained can be as large as 144 $cm^2$. The larger area gives a better spatial representation of perfusion and its change, but the time resolution is limited by the scan time. Typical high spatial resolution full scans of the finger at $64 \times 64$ pixels per scan, as used in the present study, take about 2 min and correspond to a spatial resolution of approximately 1 $mm^2$, according to equipment specifications.

### Laser Doppler Measurements

Measurements of skin blood perfusion invariably need to contend with normal physiological variations that occur. To illustrate these, a typical segment of an LDF recording, made on the finger dorsum of one subject, is shown in Figure 2. Two types of physiological variations are observable. One is associated

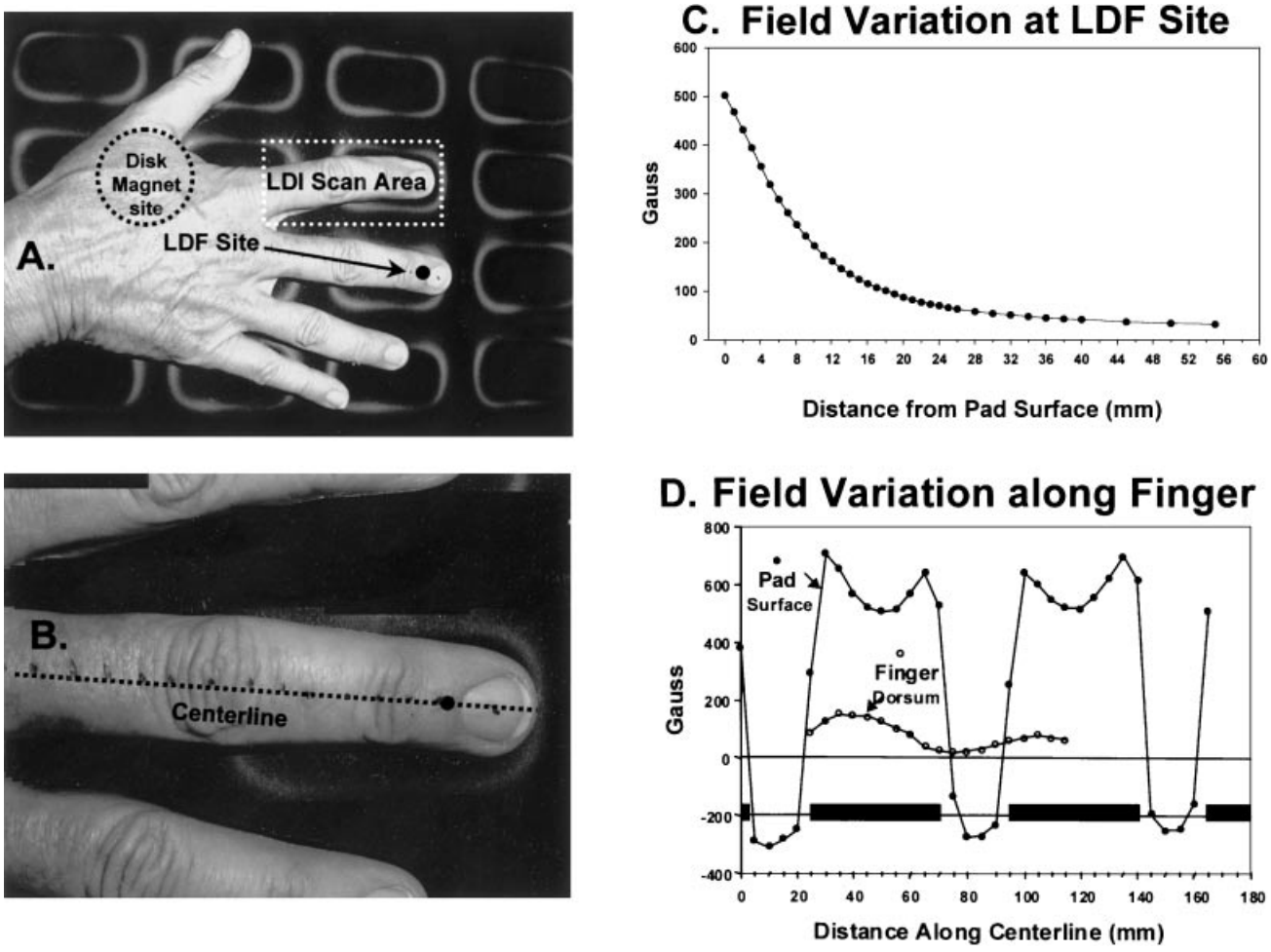


Fig. 1. Set-up and measurements. Panel A: Subject's hand is shown on magnetic pad. Imbedded magnets are rendered visible for photographic purposes via a plastic sheet containing iron filings within an oil base. The long finger is placed with its tip at the edge of the magnet and the dark circle indicates the approximate location of the laser Doppler probe site. The index finger region scanned by the laser Doppler imager (LDI) is outlined by the rectangular box. The location of the disk magnet (protocols A and B only) is shown by the dashed circle. In protocol A, the disk magnet is on the dorsal surface and in protocol B, it is on the palmar surface. Panel B: Enlargement of the long finger placement on the magnetic pad with a centerline indicating the path for magnetic field intensity measurements. Panel C: Measured field variation at the LDF measurement site as a function of the vertical distance from the pad surface. Panel D: Measured field variation along the finger direction. The solid rectangles represent the imbedded magnets.

with changes due to the transmission of the cardiac pulse, and the other is due to normal slower modulations in perfusion due to both local vasomotion and other systemic physiological variations. As may be seen LDF is sufficiently sensitive to detect both types of perfusion changes, which in the case of pulses can be less than 5% of the mean.

However, as indicated by the standard deviation of the baseline mean ($139.0 \pm 11.9$ a.u.), physiological variation affects the absolute detection of mean perfusion changes that might occur with a superimposed perturbation. This is illustrated in the figure, which reflects the request to the subject to take a single rapid and deep inspiration and then hold the breath for 10 s. This process induces a transient neurovascular vasoconstriction that causes a perfusion decrease and is sometimes followed by a compensatory perfusion increase, as was the case for this subject. It may be seen that the pulse amplitude decreases during the vasoconstriction phase and increases during the vasodilation phase. Both changes are rapidly and clearly detected by the LDF measurement. A more conservative estimate of the detection threshold for mean perfusion increases is indicated in the figure by a

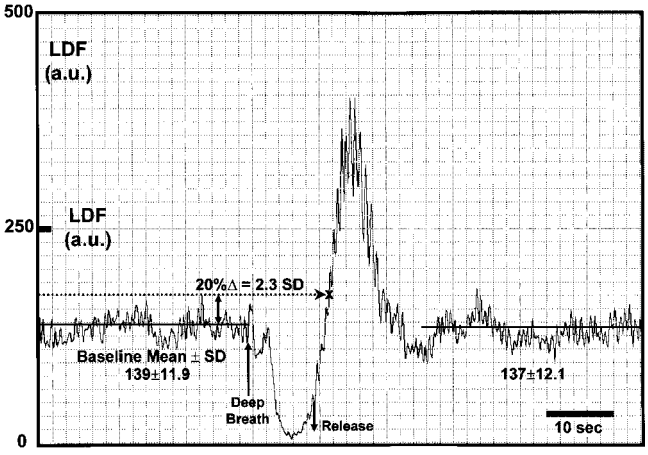


Fig. 2. Normal physiological blood perfusion variations measured by laser Doppler. Perfusion variations synchronous with the heart beat and due to local vasomotion and other systemic changes contribute to the normal variability of blood perfusion. The central portion of the figure illustrates a rapid biphasic response detected when the subject takes a single deep and rapid breath that is held for 10 s. The point X denotes the response point corresponding to a 20% increase from baseline average. For this subject this represents an increase of 2.3 SD from the mean.

line at the perfusion level that corresponds to a 20% increase from baseline.

***Initial Procedures.*** Subjects sat quietly with their hands placed comfortably, palm down, on a soft supporting surface on their laps for 20 min prior to testing. Laser Doppler probes (Moor Instruments, integrating probes), connected to a dual-channel laser Doppler system (Moor Instruments, model DRT4) were gently taped to the dorsal surface of the middle finger of each hand just proximal to the nailfold. These probes were used to obtain continuous laser Doppler "point" blood perfusion recordings (LDF). A laser Doppler imaging head (Lisca Development AB, Model PIM 1.0) was then positioned such that similar regions of both hands could be simultaneously scanned with LDI. The primary target scan region was the index finger. Baseline blood perfusion was measured for 12 min, during which time fingertip perfusion was continuously recorded and three LDI scans were obtained. Over all test sessions and protocols, room temperature remained within 22.2 to 25.5°C ($22.9 \pm 0.5$°C) and relative humidity within 46.0 to 59.0% ($52.7 \pm 0.8$%). For any given subject, room temperature variation was $< \pm 1.0$°C and humidity variation was $< \pm 3.0$%.

***Magnet Placement.*** Three separate magnet placement protocols were used. In five subjects, a disk magnet was placed under the thenar eminence on the palmar surface (Protocol A); in five other subjects, a disk magnet was placed on the dorsal surface overlying the thenar eminence (Protocol B); and in six other subjects, the entire palmar surface of the hand and fingers rested directly on the magnetic pad (Protocol C). In each protocol, the control hand was exposed to a sham (disk or pad) similarly placed. In all cases the south pole of the magnet was placed facing the hand. The locations of the disk magnets coincided with areas of circulatory and/or acupuncture pathways. The dorsal placement area lies in the vicinity of the branching of the radial artery into the digital arteries of the thumb and index finger [Clemente, 1987]. This is also the area of the acupuncture/acupressure point "Large Intestine 4," (L.I.4, or "Hegu"), the stimulation of which is reported effective for analgesia [Stux and Pomeranz, 1998]. If, as has been reported, the efficacy of magnetic fields in pain reduction is related to enhanced circulation, then the placement of a magnet at L.I.4 might be expected to provoke some measurable change. The site of palmar placement, opposite the dorsal location, is near the emergence of the princeps pollicis artery, which also supplies the thumb and index finger. This is, coincidentally, the area of the acupuncture/acupressure point "Lung 10," (Lu 10, or "Yuji"), which is stated to be "... an influential point for the vascular system." [Teeguarden, 1996].

Magnets and pads were identified only by number, and the hand on which a particular device was placed was determined by a random draw at the time of placement. The calculated average pressure exerted by the disk magnet weight is 4.0 mmHg (protocol B only.) This pressure level had no detectible effect on LDF perfusion at the measuring site, which was at least 12 cm distant from the point of application. This was verified by observing perfusion recordings at the instant of disk placement. Magnets and shams were left in place for 36 min, since most recommended magnetic therapies specify a 30–35 min treatment. During this time LDF data were continuously monitored and recorded on a computer. Laser Doppler scans were initiated immediately after magnet/sham placements and continued at 4-min intervals. Neither the subjects nor the investigator who placed the devices knew which was the magnet until after the experiment. A second investigator, who was blinded as to magnet versus sham, did the analysis.

***Magnetic Field Measurements.*** Magnetic field strength was determined using a gaussmeter (Walker Scientific, model MG-3AB) and Hall effect probe (model HP-13R), which has a sensing area of 4 $mm^2$ and a stated accuracy of 1%. Figure 1C shows the field variation at the level of the laser Doppler probe, as a function of the vertical distance away from the

magnetic pad surface. The field pattern for the disk magnet (protocols A and B) was similar in shape but, since the disk magnet was in direct contact with the skin without the intervening padding of the magnetic pad, the skin surface field at its center was 0.1 T. Figure 1D shows the field variation along the length of the finger as measured directly on the magnetic pad surface and on the finger dorsal surface.

### Analysis

Analyzed perfusion sequences consisted of the pre-exposure interval and the nine contiguous 4 min intervals during magnet/sham exposure. Average LDF perfusion in each 4 min contiguous interval after exposure was determined for magnet $(Q_{mag})_i$ and for sham $(Q_{sham})_i$ sites ($i = 1$–$9$). Baseline preexposure intervals were averaged, and a single average baseline perfusion for magnet $(Q_{mag})_0$ and sham $(Q_{sham})_0$ was used. LDI perfusion scan data was handled similar to the LDF data. To test for magnet related perfusion changes due to exposure, perfusion differences between magnet and sham exposed sites were determined for each of the 9 contiguous averaged intervals. Plots of absolute perfusion (arbitrary units, a.u.) versus exposure time, for each protocol, were used as a preliminary basis for judging possible temporal effects of the magnet devices.

To statistically test for possible magnet effects, sequential perfusion parameters (LDF and LDI) at magnet and sham sites from baseline through the end of exposure, were individually tested for each protocol using Friedman's non-parametric test for k-related samples. The adjusted sequential percentage differences between sham and magnet sites were similarly tested. Possible differences in effects among protocols were tested with the Kruskal–Wallis non-parametric test for k-independent samples. Possible differences between preexposure perfusions at magnet and sham sites were tested with the Wilcoxon (Mann–Whitney) test. In all statistical tests, a level of $P \leq 0.05$ was considered significant.

## RESULTS

### Preexposure Blood Perfusion

Baseline blood perfusion, measured with LDF or LDI (Table 1), did not significantly differ between magnet and sham sites in any of the three protocols ($P > 0.3$, Wilcoxon paired test), nor were the baseline perfusions at magnet and sham sites significantly different among protocols ($P > 0.3$, Kruskal–Wallis test). The large differences in perfusion values between LDF and LDI reflect in part the different intrinsic gains settings of the LDF and LDI instrumentation and in part the fact that LDI values are averages for the finger whereas the LDF samples the higher perfusion near the finger tip.

### Perfusion During Exposure

Blood perfusion showed no significant change during the 36 min exposure interval, whether expressed as absolute LDF or LDI perfusions (Figs. 3 and 4) or expressed as percentage differences between magnet and sham site LDF and LDI perfusions (data not shown). Asymptotic significance levels (Friedman test) for all protocols (magnet sites and sham sites) were $> 0.30$. During exposure, there was no significant difference between perfusions among protocols as determined by Kruskal–Wallis tests ($P > 0.5$). There were no significant differences in perfusion values between magnet-exposed intervals and baseline values, suggesting no systemic effect.

### Skin Temperatures

Skin temperatures at the site of LDF perfusion measurements showed no significant change from baseline through the end of the magnet/sham exposure interval. Baseline values as averaged over the 12-min baseline interval for magnet and sham hands were (mean $\pm$ SD) $29.8 \pm 3.0$ versus $29.7 \pm 2.9$°C, respectively ($P = 0.684$). Corresponding temperatures during the final 12-min exposure interval were $30.3 \pm 2.4$ versus $30.5 \pm 1.9$°C ($P = 0.710$).

**TABLE 1. Preexposure Blood Perfusion laser-Doppler Flowmetry**

| | LDF perfusion (middle finger) | | | LDI perfusion (index finger) | | |
|---|---|---|---|---|---|---|
| Protocol | Magnet | Sham | *P* value[b] | Magnet | Sham | P value[b] |
| A (disk) | $156 \pm 12$[a] | $135 \pm 11$ | 0.343 | $0.77 \pm 0.14$ | $0.78 \pm 0.14$ | 0.715 |
| B (disk) | $120 \pm 28$ | $105 \pm 32$ | 0.500 | $0.85 \pm 0.11$ | $0.89 \pm 0.22$ | 0.343 |
| C (pad) | $117 \pm 27$ | $106 \pm 31$ | 0.345 | $0.55 \pm 0.12$ | $0.60 \pm 0.15$ | 0.345 |

[a]Mean $\pm$ SEM in arbitrary units (a.u.).
[b]Wilcoxon nonparametric paired test.

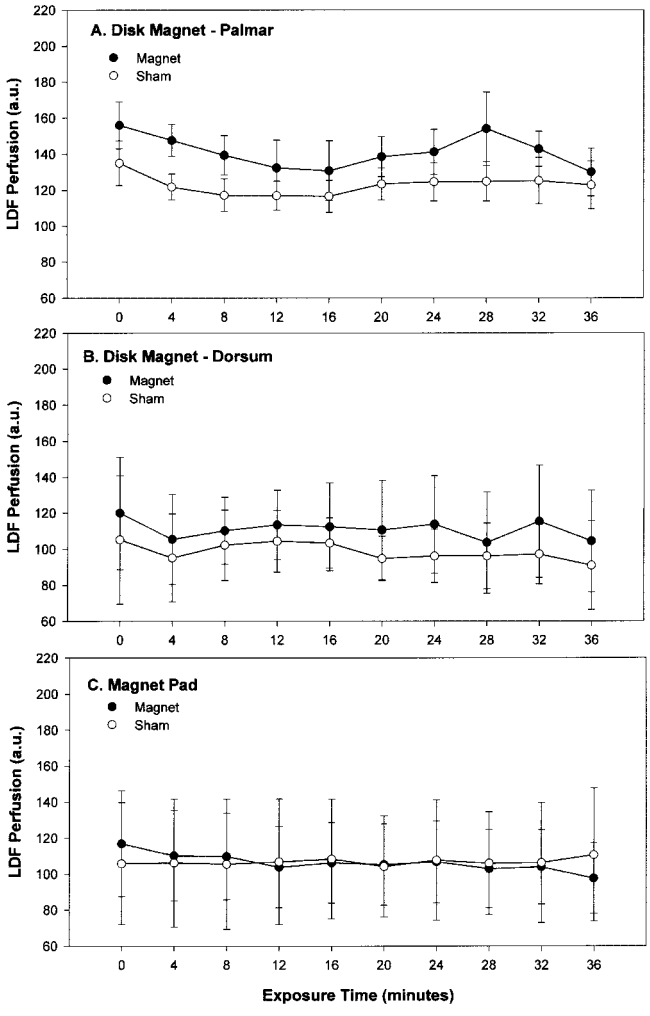


Fig. 3. Sequential skin blood perfusion of middle finger by laser Doppler flowmetry (LDF). Panel A is for protocol A, with disk magnet on thenar eminence; B is for protocol B, with disk magnet on hand dorsum overlying the thenar eminence, C is for protocol C with the palm and fingers on the magnetic pad. Perfusion is in arbitrary units (a.u.) ± SEM. There was no significant change in either magnet or sham perfusions.

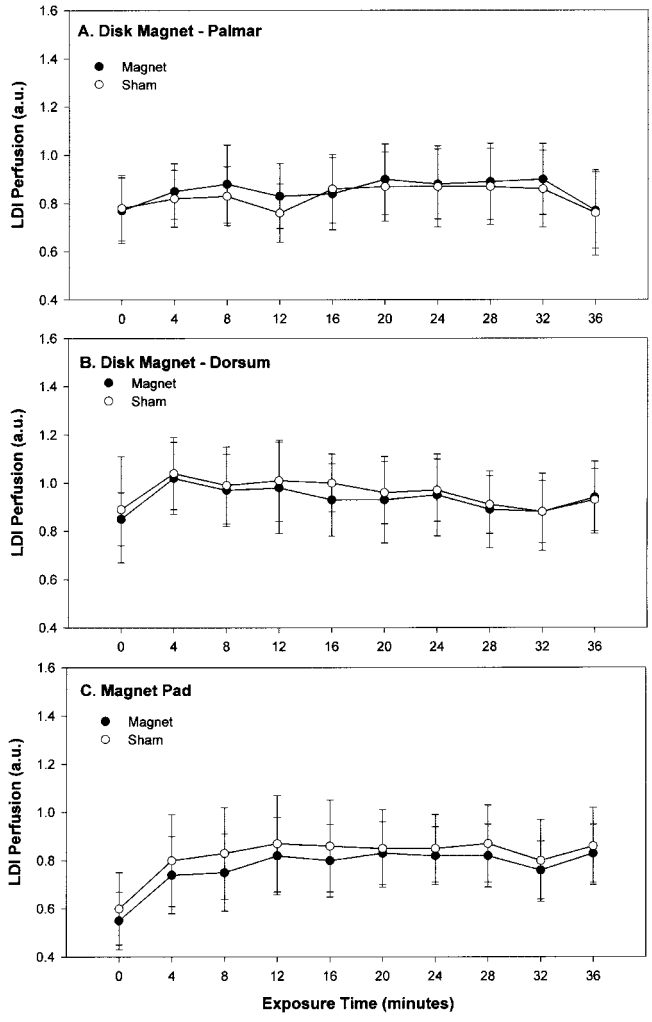


Fig. 4. Sequential skin blood perfusion of index finger by laser Doppler imaging (LDI). Panels A, B, and C correspond to protocols A, B, and C. Perfusion is in arbitrary units (a.u.) ± SEM. There is no significant change in either magnet or sham exposed perfusions.

## Laser Doppler Statistical Detection Limits

The number of subjects studied per protocol and the standard deviation of and correlation between baseline and magnet exposed perfusion levels, affect the least detectible magnet related perfusion increase. Therefore in principle, the forgoing main results, which showed no increase in perfusion, should be viewed within this context. The detection limits were estimated for LDF measures by determining the standard deviation of baseline measures and of each of the three consecutive 12-min intervals during magnet exposure. The overall correlation coefficients between baseline average and each of these sequential intervals were also determined and were found to be 0.946, 0.925, and 0.848, respectively. The corresponding standard deviations and correlations were then used to determine the standard deviation of the differences between baseline and each interval and to estimate the

**TABLE 2. Least Detectible LDF Perfusion Increases as Percent of Baseline**

| | Sequential 12-min intervals during magnet exposure | | |
|---|---|---|---|
| Protocol | 1 | 2 | 3 |
| A (n = 5) | 8.1 ± 1.0[a] | 10.6 ± 1.1 | 13.2 ± 1.4 |
| B (n = 5) | 10.9 ± 1.9 | 11.4 ± 2.0 | 17.2 ± 4.6 |
| C (n = 6) | 11.6 ± 2.7 | 13.4 ± 2.4 | 15.7 ± 2.5 |

[a]Percentage of average baseline ± SEM.

**TABLE 3. Least Detectible LDI Perfusion Increases as Percent of Baseline**

| | Sequential 12 min intervals during magnet exposure | | |
|---|---|---|---|
| Protocol | 1 | 2 | 3 |
| A (n = 5) | 19.4 ± 7.4[a] | 18.7 ± 5.1 | 18.4 ± 4.5 |
| B (n = 5) | 16.8 ± 3.0 | 19.5 ± 6.3 | 17.7 ± 6.0 |
| C (n = 6) | 19.6 ± 6.3 | 18.0 ± 6.5 | 19.0 ± 6.7 |

[a]Percentage of average baseline ± SEM.

least detectible perfusion increase (as a percentage of the baseline) for each protocol and interval with 95% confidence ($\alpha = 0.05$). Table 2 summarizes the results of this analysis.

Corresponding detection thresholds for the LDI measurements were similarly estimated based on calculated correlation coefficients between baseline and intervals 1, 2, and 3 and determined to be 0.792, 0.735, and 0.730, respectively. The results of this analysis are summarized in Table 3.

Finally, since a relatively small sample size was used for each protocol and the null hypothesis of no increase was not rejected, the issue of possible type II errors is relevant. The associated powers (one sided) were thus determined and found to be greater than 90% ($\beta < 0.1$) for all levels indicated in tables 2 and 3, even for the small sample size used in the present study.

## DISCUSSION

The composite findings of the present study suggest that permanent magnets of the type and field strength and for the limited duration used, do not acutely affect skin blood circulation in normal healthy individuals. These findings are consistent with previous preliminary work that also showed no effect of a 0.1 T surface strength permanent magnet on normal resting skin blood perfusion when disk shaped ceramic magnets of the type used in this study, were applied to the forearms of healthy volunteers [Mayrovitz et al., 2000]. It is important to note however that these findings do not rule out possible blood flow effects that might be present in persons with pathologically reduced or otherwise altered or disturbed blood circulation. This possibility derives from a conceptual view that responses to applied magnetic fields may depend in part on the amount that the target tissue or organism deviates from normality [Pilla, 1976; Colaccico and Pilla, 1984; Markov, 1994; Markov and Pilla, 1995, 1997; Pilla et al., 1999; Chiabrera et al., 2000]. Thus, physiological deviations in circulatory parameters, such as those associated with enhanced vasoconstriction or vasodilation, may provide a suitable environment for magnet related effects on blood vessels [Ohkubo and Xu, 1997; Okano et al., 1999] and thereby demonstrate magnet related effects on blood circulation. Since all of our subjects had healthy vascular systems and were studied without imposed vascular perturbations, the present results do not address this issue.

However, a number of inferences with respect to blood circulation linkages and pain reduction have been drawn in the literature. Kanai et al. [1998] applied groups (35–40) of samarium cobalt disk shaped magnets with a surface field strength of 18 mT (180 G) to 85 people with low back pain (56 women, 29 men, 64.7 ± 4.8 years, range 23–90 years) and monitored skin temperature by thermography and muscle temperature with thermometry. Comparisons of skin and muscle temperatures between people whose painful region was treated with active magnets and those who received sham magnet treatment, showed that temperatures in the initially colder painful areas increased during a 2–3 week treatment interval. The increase in temperature more-or-less paralleled the pain reduction perceived by the patients. However, laser Doppler perfusion measures showed no statistical differences between the groups.

Prior work by this same group [Kanai et al., 1996] had used a similar approach, but with 3 days of treatment for 95 people with neck and shoulder pain (48 women, 47 men, 65.3 ± 4.9 years, range 16–83 years). They reported pain improvement within 48 h, as well as skin and muscle temperature increases by Day 2 of treatment. However, skin blood perfusion differences between active and sham treated sites were present only on the third day. Because this time point also coincided with a dramatic decrease in perfusion at sham treated sites, the causal effect of the magnet is unclear.

Okano et al. [1999] reported an effect of a static electromagnetic field on skin microcirculation in rabbit ears, based on studies of magnet related changes in blood vessel vasomotion (a rhythmical and oftentimes spontaneous variation in microvessel diameter). An ear chamber was used, and the ear vasculature was exposed to static fields ranging from 1–10 mT (10–100 G) for 10 min. Changes in vasomotion patterns were assessed under vasoconstricted and vasodilated states induced respectively by infused norepinephrine (NE) or acetylcholine (Ach). The results suggested that the presence of the field altered the vasomotion patterns such that both the NE and Ach induced vasomotion were blunted. The authors interpreted these findings to indicate a biphasic magnetic effect.

In a related study, in which the same experimental design and magnet were used, magnetic field

exposure could cause an increase or a decrease in vasomotion with a latency of about 10 s from field activation and without pharmacological alteration of vascular tone [Ohkubo and Xu, 1997]. These experimental findings in animals have been interpreted to be consistent with the concept of a static magnetic field effect that causes vasodilation in the presence of high vascular tone and vasoconstriction in the presence of low vascular tone.

In a similar rabbit model, but with a samarium cobalt permanent magnet [0.18 T (1800 G)] applied for 1–28 days, an apparent initial increase in microvascular vasodilation through Day 5 has been reported [Xu et al. 1998]. After two weeks of magnet application, the vasodilation was reversed, and by 3 weeks vasoconstriction was observed. However, it is unclear if these sequential individual vessel changes are directly related to magnet exposure or to normal variability that occurs in the rabbit ear chamber vessels. Although microvascular blood flow was not directly measured in these animal studies, the reported direct observation of some vascular changes suggests a possible effect.

Thus, in spite of some clinical evidence of permanent magnet efficacy with respect to pain reduction and possible linkages between this process and magnetic field induced alterations in skin blood flow, there is little direct evidence that permanent magnets increase skin blood perfusion in humans. Thus the main focus of the present work was to test the hypothesis that static magnetic fields, as produced by standard ''therapeutic'' permanent magnets in the 0.1 T range, can acutely affect human skin blood flow in normal tissue.

Two aspects of this question were investigated. One was to determine if blood perfusion increases could be detected in tissue that was directly within the field of applied magnets. This was studied by exposing the hand and fingers to the field of a magnetic pad. The second aspect was to determine if localized field exposure of tissue at a proximal site could evoke a blood perfusion increase at a distal site. This was investigated by applying disk magnets at both the palmar and dorsal surfaces in the region of the thenar eminence.

## CONCLUSIONS

Within the bounds of the detection limits previously discussed, the present results provide no evidence of magnet related increases in the skin circulation of the healthy subjects studied during the time of application of the magnets. This was clearly demonstrated by the lack of any significant increase in skin blood perfusion in any of the protocols. However, as previously noted, since the biological target of the field and the specific field strength and configuration needed to interact with it, are as yet unknown, the present lack of effect does not rule out possible effects that might be present in persons with pathologically reduced or otherwise altered or compromised blood circulation, or possibly with longer duration of application of magnets. Further systematic investigation of these possibilities is currently under way.

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