

# No Effect of 85 mT Permanent Magnets on Laser-Doppler Measured Blood Flow Response to Inspiratory Gasps

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Although no effects of permanent magnets on resting skin blood flow (SBF) in humans have yet been demonstrated, the possibility that magnet related effects might modify dynamic SBF changes has not been previously studied. We hypothesized that magnets may alter local neurovascular mechanisms to cause changes in normal SBF vasoactive responses. To test this, we studied the effects of a magnet on SBF reductions induced by sympathetic reflexes associated with deep inspirations. SBF was continuously monitored by a dual channel laser-Doppler flowmeter with probes on the middle finger dorsum of both hands of 24 healthy subjects. In the first of two successive intervals, each of the fingers rested on sham ceramic magnets (control interval). Subsequently, one finger rested on an active magnet and the other finger on a sham (experimental interval). Skin temperatures were also measured. The magnet was a 37 mm diameter × 14 mm thick ceramic magnet with a surface field strength of 85 mT measured in the geometrical center of the magnet. Field strength at the finger dorsum, 13 mm above magnet, was 31.5 mT. During each interval, three deep breaths were used to elicit SBF reductions. Responses were calculated as the percent reduction in SBF from its prior 20 s average. Breaths in each interval were spaced 3 min apart to permit full recovery between responses. The experimental interval started after an active magnet was in place for 20 min. Results showed no significant difference in either vasoconstrictive responses or skin temperature due to the magnet. We conclude that magnets of the type, strength and duration used, have no significant effect on vasoconstrictive processes associated with this sympathetic reflex in this group of healthy subjects. *Bioelectromagnetics* 26:331–335, 2005. © 2005 Wiley-Liss, Inc.

**Key words:** human microcirculation; skin blood flow; static magnetic field; vasoconstriction

## INTRODUCTION

Commercial claims for the efficacy of static magnets for a variety of salubrious effects often imply or aver that the magnets influence blood flow in a beneficial manner. However, in studies that report evidence of magnet related reduction of pain [Vallbona et al., 1997; Brown et al., 2002], edema [Man et al., 1999], or sympathetic diabetic neuropathy [Weintraub et al., 2003], the question of magnet related enhancement of blood flow has not been addressed. While some studies have documented the influence of pulsed electromagnetic fields on skin blood perfusion [Mayrovitz and Larsen, 1992, 1995], and others have suggested an effect of static magnetic fields on blood vessels in experimental situations [Ohkubo and Xu, 1997; Okano et al., 1999; Xu et al., 1998], no systematic evaluation of the effects of permanent magnets on human skin has shown a change in resting microcirculatory flow [Mayrovitz et al., 2001, 2002]. However, possible effects of static magnets on neurovascular responses that produce arteriolar vasoconstriction and blood flow

reduction have not been previously studied. Thus our specific aim was to investigate whether a local static magnetic field of a permanent magnet affects the amount of skin blood flow reduction caused by the rapid and deep inspiration known as the “inspiratory gasp reflex” [Mayrovitz and Groseclose, 2002a,b].

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## MATERIALS AND METHODS

Healthy subjects ( $N = 24$ , age =  $25.7 \pm 0.9$  years, 12 male) participated after signing a consent form approved by the university's institutional review board. Subjects had not used any form of magnetic therapy and were not taking vasoactive medication. Subjects' heights ( $67.8 \pm 1.3$  in,  $172 \pm 3$  cm), weights ( $161 \pm 13$  lb,  $73 \pm 6$  kg) and systolic ( $117 \pm 4$  mm Hg), and diastolic ( $77 \pm 2$  mm Hg) blood pressures were within normal ranges. The right hand was dominant for all subjects. The experimental magnetic field was produced by a commercial ceramic magnet (37 mm diameter  $\times$  14 mm thick, surface field at its center of 85 mT; (Magnetherapy, Riviera Beach, FL) which was placed under the middle finger of one hand with its South pole facing the skin. Shams, which were non-magnetized pieces, identical in appearance to the magnet, were placed under the middle finger of each hand during a control interval of 15 min (Fig. 1). Thereafter, both shams were removed and replaced with one sham and one active magnet during a 20 min experimental interval. Selection of the hand to place the active magnet was decided based on a coin flip.

Skin blood flow (SBF) was measured continuously on the dorsum of each middle finger using a dual channel laser-Doppler flowmetry system (Moor Instruments MBF3D, Wilmington, DE) and integrating type probes (DP7a). Principles of laser-Doppler perfusion measurements have been previously published [Nilsson et al., 1980; Oberg et al., 1984; Mayrovitz, 1998]. Briefly, a low intensity laser light signal is transmitted into the skin to a depth of about 1–2 mm

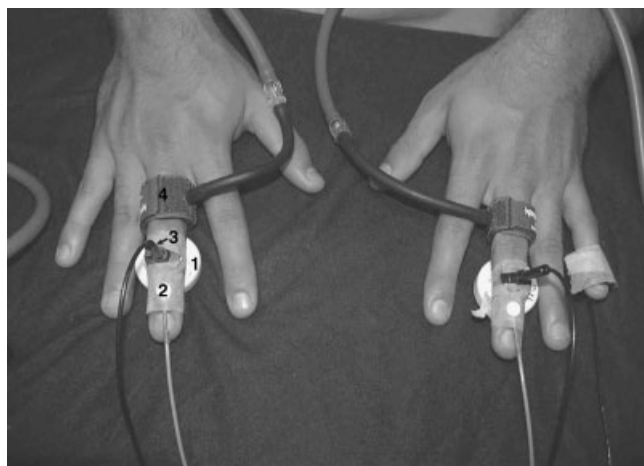


Fig. 1. Hand position during the experimental procedure. Ceramic magnet (1) placed below middle finger dorsum, thermocouple (2) and laser-Doppler probe (3) placed on the finger dorsum, vascular occluder-cuff (4) placed at the base of the middle finger.

[Jakobsson and Nilsson, 1993]. The Doppler-shifted return signal contains information about the speed and number density of moving red blood cells, which is processed to yield a parameter, perfusion, that is proportional to blood flow. Skin temperature was monitored continuously with a thermocouple (Physitemp, Model TH-8, Clifton, NJ) placed on each finger dorsum slightly distal to the laser-Doppler probe.

Magnetic field strength was determined using a Gaussmeter (Walker Scientific, MG-3AB, Worcester, MA) and Hall effect probe (HP-13R) which has a sensing area of  $4 \text{ mm}^2$  and a stated accuracy of 1%. Average finger thickness at the SBF measurement site was  $13.2 \pm 0.40$  mm. The magnetic field strength measured at the SBF measurement site on the finger dorsum was  $31.5 \pm 1.1$  mT.

A single rapid and deep inspiration induces arteriolar vasoconstriction that causes a transient decrease in blood flow in the finger (Fig. 2). This phenomenon has been well studied [Allen et al., 2002; Mayrovitz and Groseclose, 2002a,b; Rauh et al., 2003], and has been used to characterize and assess neurovascular responses in a number of settings [Netten et al., 1996; Birklein et al., 1998; Hilz et al., 1999; Littleford et al., 1999]. Here it is used to determine whether the magnitude of the vasoconstriction response is affected by permanent magnet exposure. The parameter used to assess the response is termed inspiratory gasp vascular response (IGVR). IGVR is the ratio of minimum skin blood perfusion measured after the gasp ( $\text{SBF}_{\min}$ ) to the average blood perfusion ( $\text{SBF}_0$ ) determined during the 20 s interval prior to that gasp, that is,  $\text{IGVR} = 100 \times (\text{SBF}_0 - \text{SBF}_{\min}) / \text{SBF}_0$ . Accordingly, the maximum range of IGVR is 0–100%.

Data recording was started at the beginning of the control interval. After 15 min, the first gasp was initiated and was followed 3 min later by a second gasp and then 3 min later by a third. Both sham magnets were then removed and one replaced with an active magnet and one replaced by a different sham magnet. Placement of the sham and magnet constituted the start of the experimental interval. After 20 min, the three-gasp sequence was repeated.

An investigator who was masked as to magnet versus sham did the analyses. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) software (Version 10). The data were evaluated for ANOVA suitability with respect to normality of distribution and homogeneity of variances; no data were omitted from analysis. To determine whether the introduction of a permanent magnet influenced IGVR, a repeated measures analysis of variance was performed over the control and experimental sessions.

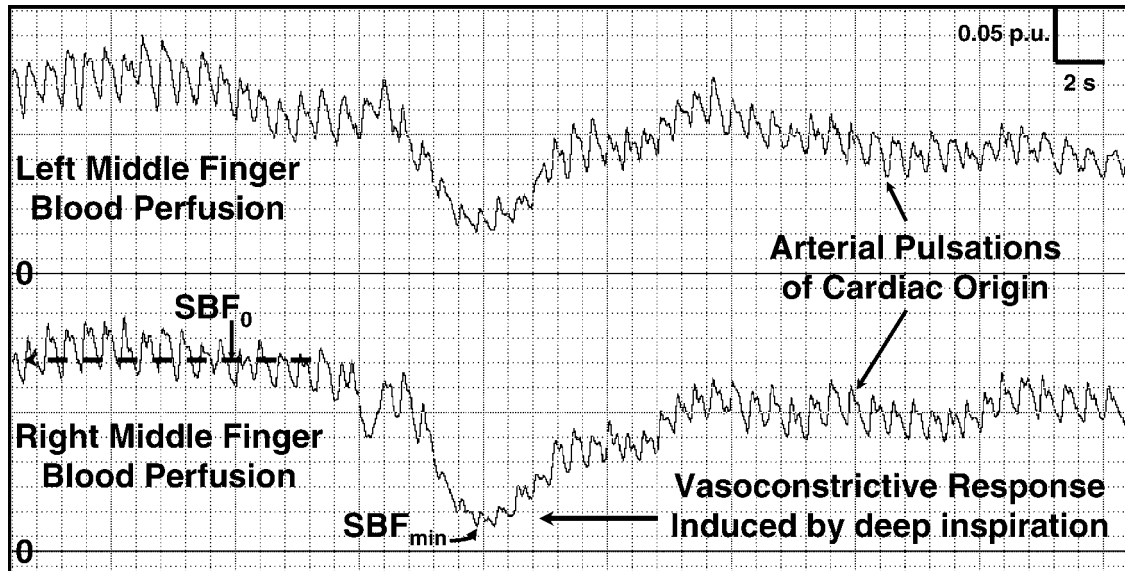


Fig. 2. Inspiratory gasp vascular response (IGVR). A deep inspiration causes a vasoconstriction and a transient decrease in measured blood perfusion.

## RESULTS

For convenience of expressing results, the finger exposed to sham magnets in both the control, and experimental intervals is designated as Finger S and the finger that is exposed to a sham magnet in the control interval but an active magnet in the experimental interval is designated as Finger M. Values obtained for IGVR, and skin temperatures expressed as mean  $\pm$  SD are summarized in Table 1. Results of the analysis of variance revealed no significant difference in IGVR between control and experimental intervals ( $F_{(1,24)} = 0.661$ ;  $P = .420$ ) or any significant interaction between IGVR and interval ( $F_{(1,24)} = 0.364$ ;  $P = .550$ ). Similarly, there were no significant differences in skin temperature. To determine if the magnitude of inter-individual standard deviations in IGVR (Table 1) may have overwhelmed a possible magnet related effect, individual paired differences in IGVR between sham and magnet exposed fingers (sham finger–magnet finger) were determined for each IGVR during control

and experimental intervals and an average for each interval obtained. The mean difference as a percent of the sham for the control interval was determined to be  $1.30 \pm 10.9\%$ , which was not significantly different from the value obtained for the experimental interval  $-0.59 \pm 11.3\%$ ,  $P = .911$ . Using the standard deviations of these differences and the correlation between control and experimental interval differences ( $r = 0.660$ ,  $P < .001$ ), an estimate of the detectable difference in IGVR at a power of 0.8 and 0.9 was determined to be 5.5% and 6.3%, respectively with corresponding upper and lower 95% CI of 1.69–9.31% and 2.49–10.1%.

## DISCUSSION

Limited reports in the literature have indicated possible effects of static magnetic fields on blood circulation in animal studies. In experiments with very high fields (8 T), reduction in blood flow has been

TABLE 1. Effect of Magnet on IGVR (%) and Skin Temperature in Control and Experimental Intervals

	IGVR (%)		Skin temperature ( $^{\circ}$ C)	
	Control	Treatment	Control	Treatment
Sham finger	$81.4 \pm 12.2$	$81.7 \pm 11.4$	$33.8 \pm 1.1$	$33.7 \pm 1.1$
Magnet finger	$80.9 \pm 11.2$	$81.8 \pm 10.1$	$33.7 \pm 1.3$	$33.7 \pm 1.2$

Means  $\pm$  SD. There is no significant difference in either IGVR or temperature with respect to treatment.

reported [Ichioka et al., 2000], whereas at lower field strengths (0.25 T) an increase in blood flow has been reported [Gmitrov et al., 2002]. Indirect evidence of vascular changes with acute [Ohkubo and Xu, 1997] and longer term [Xu et al., 1998] application of low intensity fields (0.001–0.18 T) in animals has also been reported. However, other workers have failed to demonstrate any magnet related blood flow effects in animals [Steyn et al., 2000] or in humans [Mayrovitz et al., 2001, 2002; Martel et al., 2002] at field strengths of about 0.1 T.

The findings reported here suggest that in healthy persons, permanent magnets of the type and field strength used do not affect the magnitude of vasoconstriction induced by a deep inspiration. The absence of an effect is thus consistent with the prior negative findings [Steyn et al., 2000; Mayrovitz et al., 2001, 2002; Martel et al., 2002]. Moreover, the fact that magnet exposure was not associated with a measurable increase in skin temperature is also consistent with previous negative reports [Sweeney et al., 2001].

The generalization of these negative findings is constrained, since the findings do not rule out blood flow effects that might be observed in persons with reduced blood flow. This possibility is expressed by the concept that responses to applied magnetic fields may depend on the amount that a target tissue or organism deviates from normality [Muehsam and Pilla, 1999]. However, significant physiological deviations in circulatory parameters, such as those associated with enhanced vasoconstriction as studied here, might be thought to be suitable targets to examine potential static magnetic field effects. But, since the present data show no effect, even with extreme flow reductions, it is reasonable to conclude that if there are effects of moderate field strength permanent magnets on blood flow, such effects should be sought out in conditions that are characterized by true derangements in the circulatory apparatus. Until such time that direct evidence emerges which clearly links permanent magnets to blood flow modification in humans, it is our view that claims of such effects be viewed with the utmost caution.

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