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Effect of static magnetic therapy on recovery from delayed onset muscle soreness

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Abstract

Objective: This study evaluated the effect of static magnetic therapy on the pain and stiffness associated with delayed onset muscle soreness. Therapeutic static magnets are sold worldwide and are claimed to reduce pain and enhance recovery by improving blood supply to body tissues. Although anecdotal stories abound regarding the effectiveness of static magnetic therapy, the research evidence is equivocal.

Design: A double-blind, placebo-controlled study design.

Setting: University research laboratory.

Participants: Twenty (10 males, 10 females) untrained, healthy individuals ages 18–32 participated in the study.

Methods: Subjects performed two sets of 25 maximal eccentric elbow flexion repetitions on an isokinetic dynamometer to induce muscular soreness. Immediately after the eccentric exercise session, subjects' arms were randomly assigned to either magnetic or placebo treatments, which were administered via an armband. The armbands were worn continually, except during bathing, for the next 7 days. Pain perception, elbow range of motion, maximal isometric strength, and upper arm girth were assessed using a visual analog scale, Leighton flexometer, isokinetic dynamometer, and Gulick tape, respectively.

Results: A repeated measures group by time ANOVA was used to compare changes between placebo and magnetic treatment. No significant differences between magnetic and placebo control arms were noted for any of the outcome measures.

Conclusions: Results indicate that static magnetic therapy had no effect on the pain associated with DOMS nor did it speed recovery when compared to a placebo control.

Keywords: Pain; Ergogenic aid; Flexibility; Isometric; Strength; Girth

1. Introduction

Many people, at some point in their life, have experienced delayed onset muscle soreness (DOMS), a condition where muscles ache several days after intense activity. DOMS normally occurs in individuals after performing exercises or other physical activities with which they are not accustomed. It is generally accepted that DOMS results from muscle and connective tissue microtrauma and the body's inflammatory response to this microtrauma (Koh, 2002). Since DOMS can be consistently produced in the controlled environment of the laboratory, it was hypothesized that it would be a good model to test the efficacy of magnetic therapy. Any potential positive effects of magnetic therapy on DOMS would be beneficial to the large number of people who experience the condition.

Biomagnetics, the science of the effects of magnetic fields on living cells, is not a new subject area. In fact, magnetic therapy, which involves exposure of areas of the body to magnetic fields with the purpose of healing or treating symptoms, has been dated to as far back as 200 AD (Ratterman, Secrest, Norwood, & Ch'ien, 2002). However, there has been a recent surge in the use of magnetic therapy. It has been estimated that the worldwide sales of magnetic products has exceeded $5 billion (Weintraub, 1999). Claims from popular athletes to testimonials from people of all walks of life advocate magnet usage for everything from treatment of arthritis and tendonitis to improving sport

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performance. Despite the increasing popularity of magnetic therapy and widespread use, relatively little research has been done on the efficacy of static magnetic therapy. Additionally, the United States of America Food and Drug Administration has not approved magnets for the treatment of any specific clinical conditions.

The magnetic products being commercially sold include small, round magnets that are taped or strapped to specific body parts, shoe inserts, bracelets/necklaces, joint wraps, waist belts and mattresses just to name a few. The major claim given by most individuals is that these magnetic products provide almost immediate relief from chronic pain. However, the underlying mechanisms as to how magnets work are presently unclear. Some of the proposed theories regarding how magnets work include increased blood flow at the site of application (attributed to the Hall effect) (Trock, 2000) and stimulation or inhibition of endocrine gland secretion. Additionally, because magnetic fields can have effects on charged particles or membranes magnets have been speculated to alter the pH balance of body fluids, alter enzyme activity or other biochemical processes, and disrupt afferent input from free nerve endings of nociceptors (Weintraub et al., 2003). The increased blood flow theory is often cited since it is assumed that the increase in blood flow to an injured site means increased O_2 availability, which may speed tissue healing and thus bring fast pain relief. Despite the popularity of magnetic therapy and the abundance of theoretical mechanisms as to how it works, the results from research investigating the effectiveness of magnetic therapy is controversial.

Literature reviews by McLean, Engstrom, and Holcomb (2001) and Ratterman et al. (2002) discuss some of the 2001 and earlier controlled studies that have been performed involving static magnetic therapy. In short, static magnetic therapy has been shown to increase motor nerve excitability (Hong, Harmon, & Yu, 1986), increase bone strength after fracture healing (Bruce, Howlett, & Huckstep, 1987), decrease postural sway in older adults (Suomi & Koceja, 2001), and decrease pain due to vertebral disk disease (Holcomb, Worthington, McCullough, & McLean, 2000), diabetic neuropathy (Weintraub et al., 2003), fibromyalgia (Alfano et al., 2001; Colbert, Markov, Banerji, & Pilla, 1999), and postpolio syndrome (Vallbona, Hazlewood, & Jurida, 1997). Conversely, other studies have not found any benefits to using static magnets for treatment of wrist pain (Carter, Hall, Aspy, & Mold, 2002), rheumatoid arthritis pain (Segal et al., 2001), neck and shoulder pain (Hong, Bender, Schaeffer, Meltzer & Causin, 1982), low back pain (Collacott, Zimmerman, White, & Rindone, 2000), heel pain (Caselli, Clark, Lazarus, Velez, & Venegas, 1997; Winemiller, Billow, Laskowski, & Harmsen, 2003), and muscle pain (Borsa & Liggett, 1998; Reeser et al., 2005). Table 1 includes details on some of the more recent controlled studies not mentioned in past reviews of the literature. If past research shows anything, it is that the effectiveness of static magnet therapy is equivocal and warrants further investigation. Therefore, the purpose of our study was to examine the efficacy of magnetic therapy on pain and recovery from delayed onset muscle soreness using a double-blind, placebo-controlled experimental design.

Table 1
Peer-reviewed studies investigating static magnetic fields in humans

Study	*N*	Condition being treated	Experimental design[a]	Static magnet exposure	Outcome
Holcomb et al. (2000)	2	Vertebral disk disease	Not controlled or blinded; case report	Magnets attached to skin (gauss not reported); 24 h/day	Decreased pain
Segal et al. (2001)	64	Pain from rheumatoid arthritis	R, DB, PC	Magnets affixed at knee; 1900 G; 24 h/day for 1 week	No effect; however, a magnetic placebo was used
Suomi and Koceja (2001)	28	Postural sway during static balance	Not blinded; comparison with or without insole	475 G/insole; acute exposure only for duration of test	Decreased postural sway with magnets
Alfano et al. (2001)	119	Fibromyalgia	R, SB, PC	Magnetic bed pads; 750 or 3950 G; ~6 h/day for 6 months	No effect
Carter et al. (2002)	30	Wrist pain due to carpal tunnel syndrome	R, DB, PC	Acute exposure (45 min); wrist band; 1000 G	No effect
Weintraub et al. (2003)	375	Symptomatic diabetic neuropathies	R, DB, PC	Magnetic insoles; 450 G/insole; 24 h/day	Decreased pain and numbness
Winemiller et al. (2003)	101	Plantar heel pain	R, DB, PC	Magnetic insoles; 2450 G each; >4 h/week for 8 weeks	No effect
Reeser et al. (2005)	23	Delayed onset muscle soreness	Double-blind, placebo control	350 G; 45 min/day	No effect

Details regarding earlier peer-reviewed studies not mentioned in this table can be found in reviews by McLean et al. (2001); Ratterman et al. (2002).
[a] R, randomized; SB, single-blind; DB, double-blind; PC, placebo controlled.

2. Methods

2.1. Participants

A total of 20 subjects (10 males and 10 females) were recruited via advertisement and screened via phone interview to ensure they met our inclusion/exclusion criteria (see below). The average male subject in this study was 19.5 ± 1.2 years old, 180.6 ± 6.1 cm in height, and weighed 74.9 ± 6.1 kg. The female subjects on average were 18.8 ± 1.2 years old, 173.7 ± 2.8 cm in height, and weighed 66.2 ± 6.4 kg. Subjects were recruited via advertisements posted around the university campus and via word of mouth. Inclusion criteria were that subjects needed to be college students who were not currently performing resistance training exercise on a regular basis and were not currently taking any medications for pain and/or inflammation. Exclusion criteria included resistance training in the last 6 months, diagnosed neurological and/or musculoskeletal diseases, acute or chronic upper extremity pain, or a history of trauma or surgery to the elbow or elbow flexor muscles.

2.2. Procedure

The experimental procedures used in this study were approved by the Indiana University–Purdue University Indianapolis Institutional Review Board. To investigate the effect of magnetic therapy on muscle soreness we induced soreness via isokinetic eccentric muscle exercise and then tracked pain, arm girth, range of motion, and isometric strength in the subjects for 7 days using a double-blind, placebo-controlled experimental design.

Each subject's initial visit was scheduled on a Monday. During the initial visit, subjects were given information about the study, gave their informed consent, and then began baseline assessment. Besides the basic anthropometrical measurements (height and weight), upper arm circumference, range of motion, isometric strength, and pain perception were evaluated for each arm. Following baseline assessment, each subject performed an eccentric exercise regimen (see below) to induce muscle soreness on a Kin-Com 500H (Chattecx, Hixson, TN) isokinetic dynamometer. The subject was then given two armbands, one each for the right and left arm. Each armband contained three magnetic disks (Nikken, Inc., Irvine, CA) and when worn held the magnetic disks in position over the anterior, medial, and lateral aspects of the elbow flexor muscles. Each magnetic disk was 4 cm in diameter and rated according to the manufacturer at 750 G. The treatment (i.e. magnet) armband had the magnets turned so that the magnetic field was oriented towards the muscle and the other band (i.e. placebo control) had the shielded, non-magnetic side of the magnet placed next to the muscle. The armbands were randomly assigned and clearly marked as right or left. Both the subject and test administrator were blinded as to armband assignment. The subject was instructed to wear them at all times except while bathing. Subjects were instructed to return to the laboratory at the same time for the remaining weekdays and the following Monday so that assessments of upper arm soreness, arm girth, range of motion, and isometric strength could be repeated. Upper arm soreness was also assessed by the subject over the weekend (i.e. Saturday and Sunday) and thus was the only measure evaluated over 7 consecutive days.

2.2.1. Muscle soreness protocol

The first step of the soreness protocol required the measurement of unilateral, maximal isokinetic (60°/s) eccentric elbow flexor strength of the arm that was about to be exercised. The maximal eccentric strength of the arm was assessed so that markers could be placed at 75 and 50% of maximum strength on the Kin-Com monitor during the ensuing eccentric exercise session. The markers provided feedback to both the subject and test administrator regarding the effort being exerted on each repetition performed during the eccentric exercise session. Subjects were encouraged to exceed the 75% marker on each repetition thereby helping to ensure that each arm was exposed to the same relative intensity of eccentric exercise.

During the eccentric isokinetic exercise protocol, subjects were seated upright in an adjustable chair with their upper body stabilized using restraining straps. The chair was adjusted such that their feet were off the floor and the elbow was aligned with the axis of rotation of the isokinetic dynamometer. The exercise protocol used was similar to that of Nosaka and Clarkson (1996, 1997) and consisted of two sets of 25 maximal eccentric isokinetic repetitions performed at an angular velocity of 60°/s. The eccentric muscle actions were performed through a preset range of motion of 110–45° of elbow flexion. Subjects were allowed to rest for 15 s between repetitions and given 5 min to recover between the two sets (Teague & Schwane, 1995). Upon completion of the isokinetic soreness protocol, subjects were asked to report to the laboratory once a day at the same time for the following week (except for Saturday and Sunday). During each visit, isometric muscular strength was assessed.

2.2.2. Isometric strength assessment

Isometric strength was measured using the isometric mode on the Kin-Com 500H (Chattecx Corporation, Hixson, TN). Subject positioning was the same as for the muscle soreness protocol described above except that the dynamometer arm was positioned such that the subject's elbow was flexed at 90°. The subject then performed three 5 s maximal isometric contractions. The average isometric force was determined for each isometric contraction and then averaged to represent their isometric strength for that day.

2.2.3. Pain assessment

Pain perception was evaluated using a visual analog scale (VAS) (Flandry, Hunt, Terry, & Hughston, 1991;

Price, McGrath, Rafii, & Buckingham, 1983). The VAS consisted of a 10 cm horizontal line, with 'no pain' at the extreme left (i.e. 0 cm) and 'pain as bad as it possibly could be' at the extreme right (i.e. 10 cm). Subjects were asked to draw a vertical line within the scale that best represented their current perception of pain/soreness. The distance of the vertical line from the 'no pain' end of the line was then measured and recorded. Subjects were instructed not take any pain medications over the course of the following week.

2.2.4. Measurement of arm circumference

Upper arm girth was measured using a Gulick anthropometric tape following a modified version of the protocol reported by Clarkson, Nosaka, and Braun (1992). Using a semi-permanent surgical marker, the anterior upper arm was marked at 4, 6, and 8 cm proximal to the elbow joint. Corresponding marks were also made on the medial and lateral aspects of the arm to assure proper orientation of the tape during circumference measurement. Each site was measured three times and the average was used to represent the arm girth for that day.

2.2.5. Range of motion assessment

Range of motion (ROM) of the elbow was evaluated using a Leighton flexometer (Leighton, 1955). This device measures the ROM based on the movements of two independently moving, gravity-dependent dials. ROM was measured with the subject in an upright, seated position and the upper arm supported by a pad located on a table such that it was parallel to the floor. The subject was asked to extend the elbow as far as possible at which point the flexometer was zeroed. While maintaining the upright, seated posture, the subject then flexed the elbow as far as possible and the degrees of flexion were recorded. Three trials were performed and the average of the three trials was used to represent that day's range of motion.

2.3. Statistical analysis

Means, standard deviations, and standard error of the means were calculated for subject demographics and multiple trial data measurements. A paired group-by-day analysis was used to test for significant differences in the return to baseline for pain, range of motion, isometric strength, and girth. Specifically, we used a repeated measures analysis of variance (ANOVA) for paired data using the Mixed Procedure program developed by SAS (Cary, NC). Statistical significance was set at $p < 0.05$.

3. Results

The eccentric exercise protocol elicited significant soreness (i.e. pain) in both the right and left arms (Fig. 1). In addition, the pain caused by the isokinetic eccentric exercise protocol was the same in both arms since no significant differences in the perception of pain were found upon comparison between arms (Fig. 1). The recovery (i.e. return to baseline) of pain (Fig. 1), flexibility (Fig. 2), isometric strength (Fig. 3), and arm girth (Fig. 4) were not significantly different between placebo and magnetic interventions.

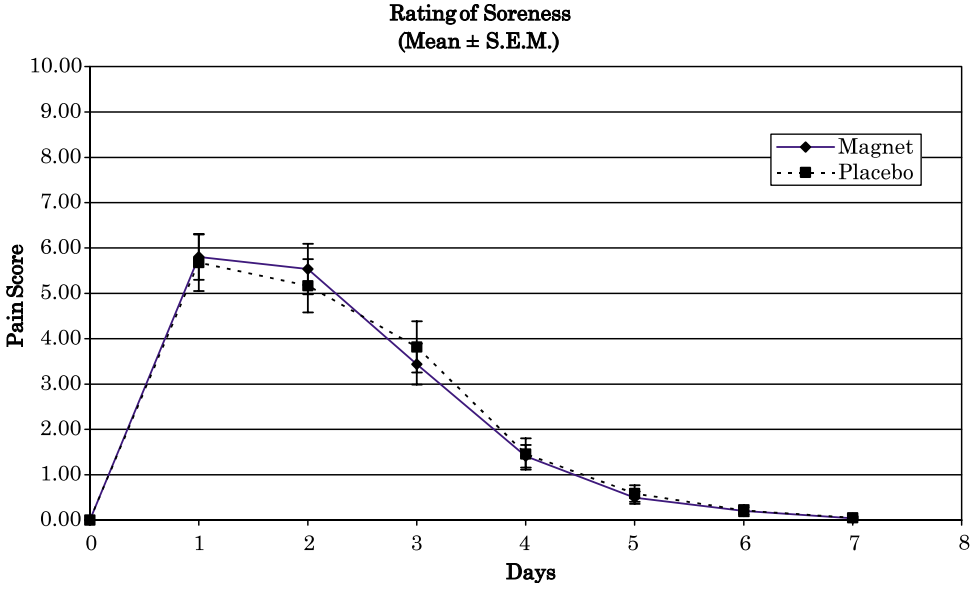

Fig. 1. Rating of soreness scores spanning from immediately prior to the eccentric exercise protocol for eliciting soreness (i.e. baseline = Day 0) to 7 days after eccentric exercise (Day 7). 'Magnet' represents data from the 20 arms that received exposure to a static magnetic field. 'Placebo' represents data from the 20 arms that were not exposed to a static magnetic field.

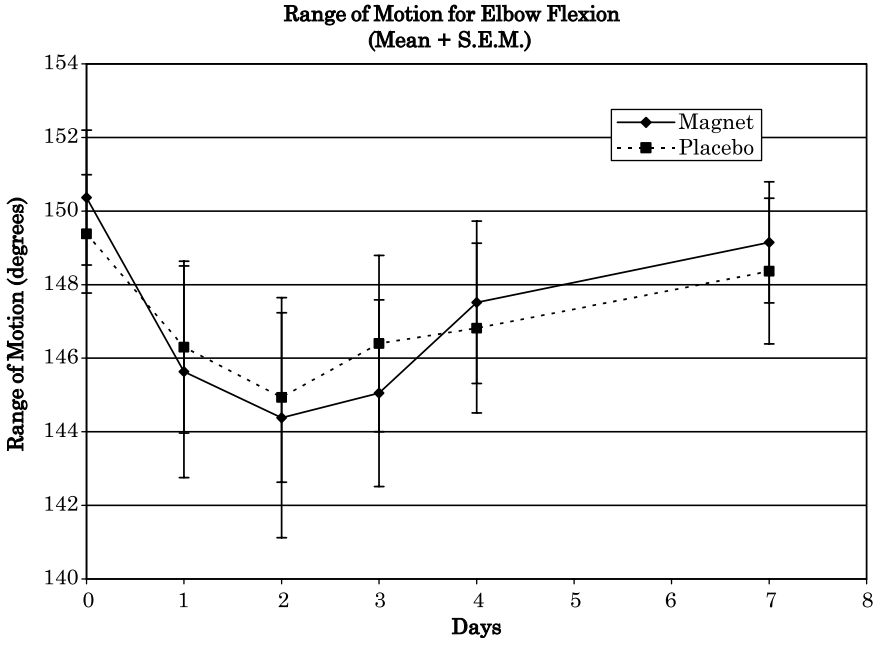

Fig. 2. Elbow range of motion data spanning from immediately prior to the eccentric exercise protocol for eliciting soreness (i.e. baseline = Day 0) to 7 days after eccentric exercise (Day 7). 'Magnet' represents data from the 20 arms that received exposure to a static magnetic field. 'Placebo' represents data from the 20 arms that were not exposed to a static magnetic field.

4. Discussion

The eccentric exercise protocol designed to cause DOMS was effective and resulted in significant pain and discomfort that was equal in both arms. There was some concern that the unilateral exercise might result in differences in soreness due to the dominant arm being used more on a daily basis and thus experiencing less DOMS. However, this was not the case due to the fact that the resistances utilized during the soreness protocol were not absolute but relative to the muscles' capacity for force development. The finding that there was no difference in pain between arms and the fact that the magnetic therapy intervention was randomized between arms removed any potential for dominant arm bias in our experimental design.

To our knowledge only two other studies have investigated the effects of magnets on delayed onset muscle soreness (Borsa & Liggett, 1998; Reeser et al., 2005). Borsa

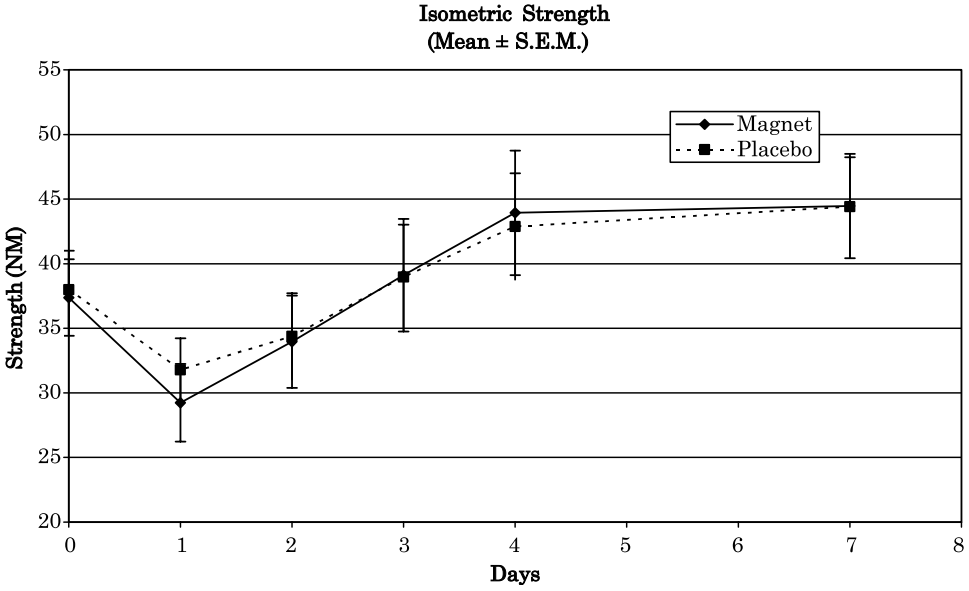

Fig. 3. Isometric strength data spanning from immediately prior to the eccentric exercise protocol for eliciting soreness (i.e. baseline = Day 0) to 7 days after eccentric exercise (Day 7). 'Magnet' represents data from the 20 arms that received exposure to a static magnetic field. 'Placebo' represents data from the 20 arms that were not exposed to a static magnetic field.

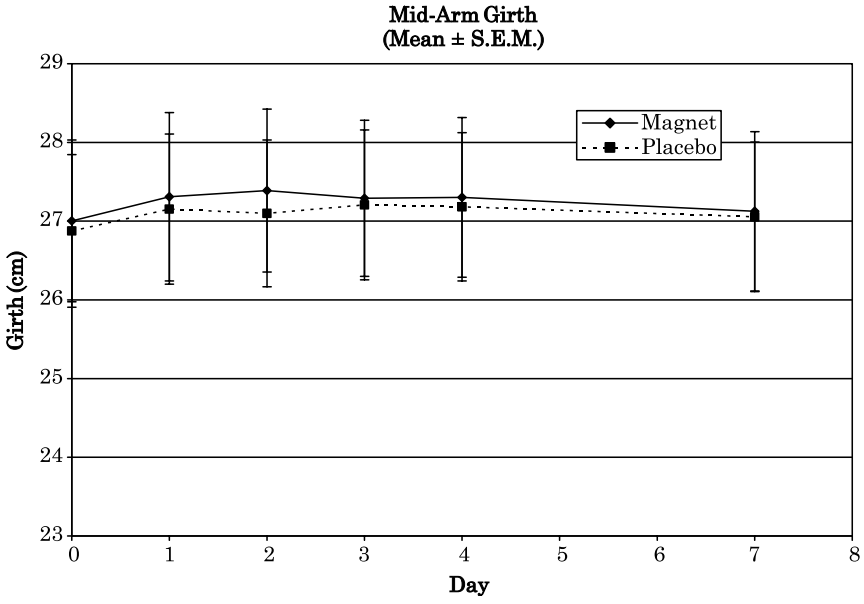

Fig. 4. Arm girth data spanning from immediately prior to the eccentric exercise protocol for eliciting soreness (i.e. baseline = Day 0) to 7 days after eccentric exercise (Day 7). 'Magnet' represents data from the 20 arms that received exposure to a static magnetic field. 'Placebo' represents data from the 20 arms that were not exposed to a static magnetic field.

and colleagues used a single-blind experimental design and divided study participants into three separate groups (control, placebo, and experimental). Similar to our findings no effect was observed, however, one limitation of Borsa's work was that pain was compared between groups. Pain is a very subjective measure. Comparing pain scores across separate groups of individuals increases variability in the pain perception measures and thus can make it difficult to find statistically significant differences. Our design enabled intra-subject comparisons of pain with or without magnetic intervention. In other words, each subject served as their own control thus diminishing the potential for variability between subjects and groups. Additionally, we carried out the treatment for 7 days unlike Borsa's group which only followed symptoms for 3 days. Since the normal course for DOMS involves symptoms that persist for 5–7 days, we felt following the course of symptoms four additional days might provide additional information. Finally, Borsa's subjects wore one 700 G magnet while those in our study wore three in hope of increasing the area of tissue exposed to the magnetic fields. Despite what we felt were stronger experimental design features, our findings were similar to those of Borsa and Liggett (1998) lending further support to their findings that magnetic therapy does not appear to decrease pain and/or speed recovery from DOMS.

Similar to our findings, a recent paper (Reeser et al., 2005) also found that static magnetic therapy did not diminish symptoms of DOMS. However, there were some areas of limitations in the Reeser et al. report that we feel our findings have addressed. First, it does not appear that their soreness protocol elicited severe muscle soreness. On a 100 mm visual analog scale (0 = no pain; 100 = excruciating pain) their subjects experienced a mean rating of 35. A concern could be that the pain was not severe enough for magnetic therapy to make a significant difference. However, our subjects reported almost double the pain and magnetic therapy still did not have an impact. Also, the subjects in the Reeser et al. study were subjected to acute exposure of a single magnet of 350 G for 45 min prior to reassessment of pain and function. Our subjects were subjected to 24 h of continuous exposure of three 750 G magnets prior to reassessment. Regardless of the increased field strength or exposure time, magnets still did not have a significant effect on pain or function of the elbow flexors.

Whether static magnet therapy has an effect on other more chronic conditions such as tendonitis, bursitis, arthritis, and other clinical conditions is still unclear. Although caution must be exercised in transferring our findings to other clinical situations, it should be noted that there are studies that have investigated the effects of static magnetic therapy on other more chronic conditions (McLean et al., 2001; Ratterman et al., 2002). Many of the recent studies that include a placebo control in their experimental design, and have looked into clinical conditions such as carpal tunnel syndrome (Carter et al., 2002), rheumatoid arthritis (Segal et al., 2001), plantar fascitis (Winemiller et al., 2003), fibromyalgia (Alfano et al., 2001), and chronic low back pain (Collacott et al., 2000), have reported results similar to ours (i.e. no significant differences between placebo and treatment groups). Conversely, magnets have been reported to decrease pain in post-polio patients (Vallbona et al., 1997), individuals with osteoarthritis of the knee (Wolsko et al., 2004), and diabetics with neuropathy (Weintraub et al., 2003). Clearly, findings regarding the effects of magnets on pain in more severe

clinical conditions are controversial and still worthy of further research.

5. Conclusion

Based on the data from this double-blind, placebo-controlled study, static magnetic therapy was shown not to diminish pain perception associated with DOMS nor did it speed recovery. Athletes, recreational enthusiasts, and others experiencing muscle soreness due to unfamiliar exertion are advised to follow the recommendations of rest and/or light activity to recover (Sayers, Clarkson, & Lee, 2000) rather than use magnets for pain and symptom relief.

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