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Evaluation of the Effect of the Magnetic Field Therapy on Motor Unit Action Potentials and Balance of Healthy Subjects

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Abstract. [Purpose] The aim of this study was to investigate the effect of the magnetic field therapy on the motor unit action potentials from the muscles of the sole of the foot and balance of healthy subjects. [Subjects] Twenty-four volunteer students from Yeditepe University Department of Physical Therapy and Rehabilitation participated in this study. [Method] The feet region received 60-Gauss intensity pulsed magnetic field therapy for 20 minutes using a 30-cm solenoid electrode. Motor unit action potentials of the muscles of the sole were evaluated in both the dominant and non-dominant legs before and after the application of magnetic field therapy. One leg standing balance tests under the eyes open and eyes closed conditions in the static and dynamic forms were also evaluated in both the dominant and non-dominant legs before and after the application of magnetic field therapy. [Results] Motor unit action potential values and balance tests results showed statistically significant improvements in the post-treatment period in comparison to the pre-treatment observations. A strongly significant positive correlation was found between the motor unit action potentials and eyes open static balance on the non-dominant side. [Conclusions] Magnetic field therapy improves the activities of muscles and balance of healthy subjects.

Key words: Magnetic therapy, Motor unit action potentials, Balance

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INTRODUCTION

Magnetic therapy is one of the safest and most effective modalities and is widely used due to its rejuvenating and healing effects. It is applied with low frequency (0–100 Hz) and low intensity (5–100 Gauss) in the form of static or pulsed magnetic fields with the aim of activating the natural electromagnetic impulses of the human body[1)]. Physiological effects of magnetic therapy include: increased permeability of plasmatic membranes, increased enzyme and cytochrome activity, improved blood circulation, increased immunity defenses, effects on metabolism, effects on cellular reproduction, effects on the regeneration of tissue, and stimulation of osteogenesis. In addition to pain relief, reduction in swelling, induction of more restful sleep, stress relief and anti-infective properties are observed[1, 2)]. Altering radical dependent biochemical processes, or lipid membranes, and exerting forces on cell intermediates or charged particles such as electrolytes are mechanisms that may alter the firing rate of neurons, change the rate of enzyme-mediated reactions, affect calcium channels, or increase local blood circulation[3, 4)]. Many researchers have demonstrated that thousands of patients have been successfully treated by experienced health professionals using magnetic therapy[1, 5, 6)]. In normal physiological conditions, tissue with more healthy activity, better blood circulation and interstitial fluid microcirculation, will enhance the mechanoreceptors in providing adequate proprioceptive and sensory input from the plantar region of the foot. In the standing position, the plantar region is the first region in contact with the ground, and it plays an important role in informing the central nervous system by means of pressure and proprioceptive information. For load balancing the motor system creates motor responses according to the mechanical load perceived by the foot[7, 8)]. We designed this research to investigate the immediate effect of the magnetic field therapy applied to the feet region on the motor unit action potentials (MUAPs) from the muscles of the sole of the foot and balance of healthy subjects.

SUBJECTS AND METHODS

Twenty-four volunteer students (12 females and 12 males) from Yeditepe University Department of Physical Therapy and Rehabilitation participated in this study. Subjects who had consumed alcohol, or who had plantar ulcers, visual or hearing impairment, or peripheral vascular, neurological or rheumatological diseases were not included in this study. Informed consent was received from each participant. MUAPs from the muscles of the sole of the foot were recorded using the surface EMG of the Chattanooga Intelect Advanced System through two adhesive active electrodes placed on the foot plantar area. One electrode

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was placed on the head of the metatarsals and the other on the heel, with the reference electrode placed parallel to them with full contact. These locations for the active electrodes were chosen because, when standing on the foot, the foot touches the ground mainly at the calcaneus and the heads of the metatarsals. The values were automatically recorded in microvolts for 10 seconds by the System while the subjects stood on one leg without swinging of the foot.

Static balance (SB) was measured using the one-leg standing test on a stable platform with both eyes open (EOSB) and closed (ECSB). The dynamic balance (DB) was measured using trampoline with both eyes open (EODB) and closed (ECDB). The subjects were told to maintain their balance for 60 seconds with their eyes open and 30 seconds with eyes closed. Measurement was stopped when the stance foot shifted in any way or the non-stance foot touched the ground. The maximum time of the balance position was recorded in seconds using a chronometer[7, 9]. The sole was cleaned and dried before the tests and recordings which were performed on both the dominant and non-dominant sides. Each subject rested for 20 minutes before the pre-treatment measurements.

All MUAP recordings and balance tests were performed before and immediatly after the application of the magnetic field therapy which was administered using a BTL-4000 device. The subjects lay in the supine position and inserted their feet region into a 30-cm solenoid electrode for 20 minutes. Magnetic pulsed current with exponential shape, 20 ms pulse duration, 20 ms pause duration, 1 repeat, and 60 Gauss intensity was used.

Data were analyzed using SPSS v 16. The arithmetical mean and standard deviation were calculated to summarize the descriptive data. The paired t test was used to compare the pre-treatment and post-treatment values. Pearson's correlation coefficient was used to assess the correlations among the five outcome measures. Statistical significance was accepted for $p<0.05$.

RESULTS

The personal characteristics of subjects are given in Table 1. Their mean age was 20.71 ± 1.12 years, their mean weight was 65.7 ± 14.53 kilograms, and their mean height was 170.46 ± 4.79 centimeters.

The results are shown in Table 2. There were statistically significant differences between the pre-treatment and the post-treatment values of the MUAPs, EOSB, ECSB, EODB, and ECDB for both the dominant ($p<0.05$, $p<0.01$, $p<0.001$, $p<0.01$, $p<0.001$, respectively) and the non-dominant ($p<0.01$, $p<0.05$, $p<0.01$, $p<0.05$, $p<0.001$, respectively) feet.

There was a strongly significant positive correlation between EOSB and EODB ($r=0.600$, $p< 0.01$) and between ECSB and EODB ($r=0.551$, $p< 0.01$) on the dominant side. There was also a strongly significant positive correlation between MUAPs and EOSB ($r=0.613$, $p< 0.01$) and a moderately positive correlation between EODB and EOSB ($r=0.462$, $p< 0.05$) on the non-dominant side.

Table 1. Age, weight and height of the study group (n=24)

Mean ± SD	
Age (yrs)	20.71 ± 1.12
Weight (kg)	65.7 ± 14.53
Height (cm)	170.46 ± 4.79

Table 2. Differences between pre and post-treatment measurements for both the dominant and non-dominant feet

	N	Pre-treatment	Post-treatment
Dominant side			
MUAPs	24	306.12 ± 141.79	367.46 ± 129.18*
EOSB	24	45.83 ± 18.70	56.42 ± 10.31**
ECSB	24	15.87 ± 10.99	22.50 ± 10.00***
EODB	24	41.29 ± 19.79	50.54 ± 17.23**
ECDB	24	4.21 ± 2.08	7.96 ± 3.58***
Non-Dominant side			
MUAPs	24	306.75 ± 132.07	367.62 ± 125.04**
EOSB	24	45.42 ± 19.29	50.66 ± 15.63*
ECSB	24	14.71 ± 10.71	20.42 ± 10.33**
EODB	24	36.58 ± 23.53	45.04 ± 20.88*
ECDB	24	4.08 ± 3.09	7.46 ± 5.72***

MUAPs: Motor unit action potentials (μV), EOSB: Eyes open static balance (seconds), ECSB: Eyes closed static balance (seconds), EODB: Eyes open dynamic balance (seconds), ECDB: Eyes closed dynamic balance (seconds). *: $p<0.05$, **$p<0.01$, ***: $p<0.001$

DISCUSSION

Magnetotherapy is one of the basic physiotherapy procedures. This method has proved successful in some diseases with long-lasting therapeutic effects. It has been demonstrated that this method may be used for the treatment of patients in the acute or chronic stages of diseases in the form of static magnetic field or pulsed magnetotherapy. It has emerged that inserting a quadruple magnet capable of sending a constant magnetic flow into a plaster cast in hand and wrist fractures results in the formation of bone callus in an average time that is 35% shorter than the normal time[1]. Results from the study of Kovács-Bálint et al.[10], who investigated the effect of a single static magnetic field exposure on the thermal pain threshold of 15 young healthy human volunteers, indicate that the static magnetic field induced peripheral neuronal or circulatory mechanisms, which may have been involved in the observed thermal pain threshold increase by the pain fibre adaptation potential to higher levels.

Static magnetic field therapy significantly improves disability, and reduces the pain of patients with chronic pelvic pain[11]. According to Lepilin et al.[12] the use of a pulsed magnetic field leads to quicker patient recovery, quicker reduction of oedema and soft tissue inflammatory infiltration, quicker relief from inflammatory reaction, and improvement of tissue blood supply in the region of fractures in patients with mandible fractures. Recent advances in magnetotherapy suggest that carefully selected pulsed magnetic fields might be helpful in the treatment of Alzheimer's and Parkinson's diseases, as well as reflex sympathetic disorders[13]. The effects and the indications of the magnetic field therapy are well known and, as mentioned above, many studies have investigated its effects on different diseases, and especially on pain. For this reason, we designed this research to differ from previous studies and invesitigated the immediate effects of magnetic field therapy on balance and MUAPs of the sole muscles of healthy subjects. The results show that magnetic field therapy has significant effects on eyes open and eyes closed static and dynamic balance. This may have been an effect of magnetotherapy on the sole region, as the plantar region is the first region in contact with the ground and plays an important role in informing the central nervous system through pressure and proprioceptive information. A magnetic field may alter the firing rate of neurons, change the rate of enzyme-mediated reactions, affect calcium channels, increase interstitial fluid microcirculation, increase local blood circulation and/or provide adequate proprioceptive and sensory input from the plantar region of the foot[3, 4]. Altering the firing rate of neurons may be one of the reasons why the MUAPs showed a significant increase after the treatment. No significant difference was observed between females and males in this study. The greatest effect of the magnetic field therapy was observed in the ECDB test results for both the dominant and non-dominant legs. Maintaining this type of balance requires greater neural activity, and the results may reflect the effect of the magnetic field on the activation of the neural system, and proprioceptive and sensory inputs[3, 4, 14, 15]. Thomas et al.[16] showed significant improvements in normal standing balance and center of pressure, with eyes open or eyes closed, by a specific pulsed 200 µT magnetic field. The magnetic field, central nervous system and proprioception interaction are important factors. The positive correlations between balance types are interesting results, despite there being few studies which have investigated the direct relationship between static and dynamic balance ability[17].

A strongly significant positive correlation was also found between the MUAPs and EOSB on the non-dominant side. Studies investigating similar relationships are also sparse. We expected this correlation between the MUAPs and the other types of the balance, but the sample size, which consisted of only 24 healthy subjects, may have influenced the results.

In conclusion, magnetic field therapy improves the activities of muscles and balance of healthy subjects. We suggest further studies, especially on athletes to investigate their balance-related performance, or on the physically disabled persons in relation to their balance and gait.

REFERENCES

1) Costantino C, Pogliacomi F, Passera F, et al.: Treatment of wrist and hand fractures with natural magnets: preliminary report. ACTA Biomed, 2007, 78: 198–203. [Medline]
2) Laakso L, Lutter F, Young C: Static magnets − what are they and what do they do? Rev Bras Fisioter, 2009, 13: 10–23. [CrossRef]
3) Wolsko PM, Eisenberg DM, Simon LS, et al.: Double-blind placebo-controlled trial of static magnets for the treatment of osteoarthritis of the knee: results of a pilot study. Altern Ther Health Med, 2004, 10: 36–43. [Medline]
4) Ramey DW: Magnetic and electromagnetic therapy. Sci Rev Altern Med, 1998, 1: 13–19.
5) László JF, Farkas P, Reiczigel J, et al.: Effect of local exposure to inhomogeneous static magnetic field on stomatological pain sensation − a double-blind, randomized, placebo-controlled study. Int J Radiat Biol, 2012, 88: 430–438. [Medline] [CrossRef]
6) Weintraub MI, Wolfe GI, Barohn RA, et al.: Static magnetic field therapy for symptomatic diabetic neuropathy: a randomized, double-blind, placebo-controlled trial. Arch Phys Med Rehabil, 2003, 84: 736–746. [Medline] [CrossRef]
7) Cımbız A, Gulbandılar E, Bayazıt V, et al.: Relationship between skin resistance level and one leg standing balance in healthy subjects. J Med Sci, 2006, 6: 286–291. [CrossRef]
8) Cho SH, Chunn SI: The bazal electric skin resistance of acupuncture points in normal subjects. Yonsei Med J, 1994, 35: 464–474. [Medline]
9) Shimada H, Uchiyama Y, Kakurai S: Specific effects of balance and gait exercises on physical function among the frail elderly. Clin Rehabil, 2003, 17: 472–479. [Medline] [CrossRef]
10) Kovács-Bálint Z, Csathó A, László JF, et al.: Exposure to an inhomogeneous static magnetic field increases thermal pain threshold in healthy human volunteers. Bioelectromagnetics, 2011, 32: 131–139. [Medline] [CrossRef]
11) Brown CS, Ling FW, Wan JY, et al.: Efficacy of static magnetic field therapy in chronic pelvic pain: a double-blind pilot study. Am J Obstet Gynecol, 2002, 187: 1581–1587. [Medline] [CrossRef]
12) Lepilin AV, Raĭgorodckiĭ IM, Nozdrachev VG, et al.: Dynamic magnetotherapy use in comprehensive treatment phlegmons of maxillofacial region and mandible fractures. Stomatologiia, 2007, 86: 55–57. [Medline]
13) Markov MS: Pulsed electromagnetic field therapy history, state of the art and future. Environmentalist, 2007, 27: 465–475. [CrossRef]
14) Aydın T, Yıldız Y, Yıldız C, et al.: Proprioception of the ankle: a comparison between female teenaged gymnasts and controls. Phys Med, 2000, 3: 11–20.
15) Barrack RL, Skinner H, Brunet M: Joint kinesthesia in the highly trained knee. J Sports Med Phys Fitness, 1984, 24: 18–20. [Medline]
16) Thomas AW, Drost DJ, Prato FS: Human subjects exposed to a specific pulsed (200 µT) magneticfield: effects on normal standing balance. Neurosci Lett, 2001, 297: 121–124. [Medline] [CrossRef]
17) Hrysomallis C, McLaughlin P, Goodman C: Relationship between static and dynamic balance tests among elite Australian Footballers. J Sci Med Sport, 2006, 9: 288–291. [Medline] [CrossRef]