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THE EFFECT OF EXTREMELY WEAK PULSED ELECTROMAGNETIC FIELD TREATMENTS UPON SIGNS AND SYMPTOMS OF DELAYED ONSET OF MUSCLE SORENESS; A PLACEBO CONTROLLED CLINICAL DOUBLE BLIND STUDY

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ABSTRACT

The effect of pulsed weak electromagnetic fields upon experimentally induced delayed onset of muscle soreness (DOMS) was assessed in a placebo controlled clinical double blind study. DOMS was induced in 36 volunteers and the elbow flexors of the non-dominant arm were used for a standardized eccentric exercise regime. Subjects were randomly allocated to one of the three groups: control (C, n=12), sham-treated (S-T, n=12) and treated with a special kind of pulsed electromagnetic fields (T, n=12) by applying the BEMER 3000 local therapy intensive applicator. Volunteers from group T were electromagnetically stimulated each day with a magnetic field of 86 μT. Subjects from the sham-treated group were treated by deactivated BEMER 3000 systems. One-way analysis of variance (ANOVA) demonstrated significant effects of electromagnetic field treatment on retarding pain intensity as measured by visual analogue scale (VAS) ($p<0.05$). According to standard methods of goniometrical measurements statistically significant differences in the range of movement between the control-, sham-treated- and electromagnetic treated groups were further found on the second day of the experiments. Within the conditions of the current experiments the pulsed electromagnetic (BEMER 3000) field treatment exerts clearcut and favourable effects upon the cardinal signs and symptoms of DOMS.

Key words: pulsed electro-magnetic fields of Bemer 3000 type, delayed onset of muscle soreness

Introduction

The poor standard of research design and analysis in many studies concerning the efficacy of electromagnetic therapy systems published to date precludes any definitive conclusions regarding its efficacy. It could even be argued that many of these reports rather serve to fuel the controversy surrounding electromagnetic field therapy. Distinguished by its scientifically and technically well designed concept of research, however, therapies applying the extremely weak BEMER 3000 type pulsed electromagnetic fields (8, 9, 10), gain exceptionally increasing clinical acceptance, especially for the alleviation of pain of various etiologies, inflammation, sweating, and other pathologies of soft tissues.

The analgesic effects of physical modalities using delayed onset of muscle soreness (DOMS) as a model of clinical myogenic pain treatment have been assessed by a number of researchers but experimental conditions varied significantly concerning the induction of muscle pain (1, 3). Many of the reports do furthermore not fulfil the accepted minimum requirements asked for adequate experimental design of clinical research studies, such as placebo conditions, blinding procedures, crossover designs, etc. Despite controversy surrounding its pathophysiology, the development of a standardized DOMS-induction protocol could thus convey to a useful laboratory model for the investigation of musculoskeletal pain.

DOMS typically occurs in untrained subjects particularly after eccentric exercise. Under this circumstances pain is delayed, occurring between 6 and 12 h post exercise, peaking at between 48 and 72 h and persisting for up to 7 days after the exercise (1). Although the underlying pathophysiology remains a matter of debate, its progression and multifaceted presentation reveals DOMS as a useful laboratory model for assessing the efficacy of different modalities applied for the relief of musculoskeletal pain and the associated dysfunction.

In view of the above a randomized, double blind, placebo-controlled study was performed both to assess the putative efficacy of experimentally induced myogenic pain and dysfunction of movement to investigate the beneficial (pain relieving) effects of one of the few modalities used in physiotherapy by applying the well designed (Fig. 1) extremely low pulsed weak electromagnetic fields (BEMER 3000) mentioned above.

Materials and Methods

Experimental conditions and screening procedure

Subjects for the trial experiments consisting of 36 healthy male student volunteers, aged 18-22 years, were requested to attend the experiments on seven subsequent days. They were randomly allocated to one of the following groups under blind test condition: Control group (C) - subjects allocated in this group rested supine for a period of 20 min. Sham-treated group (S-

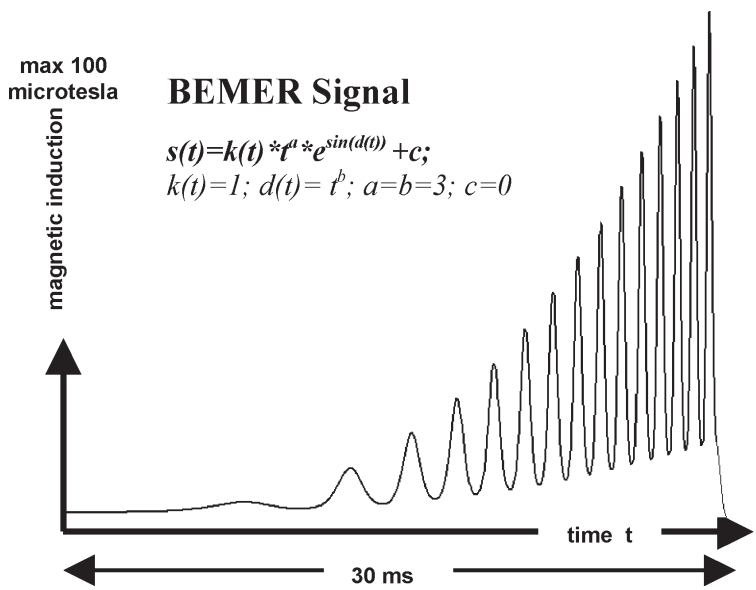

Fig. 1. *The mathematical formula and the graph of elecromagnetic field typed BEMER 3000 (8)*

T) - subjects in this group received pseudo-treatment of electromagnetic field (equipment was deactivated). True treated by electromagnetic field group (T) - subjects in this group received 86 μT on the elbow.

All subjects were screened for current injury or pain, ingestion of any form of drugs, any hematological diseases, diabetes, asthma, weight-training, and participation in a similar experiments within the past year. All were instructed to avoid any form of exercise for the duration of the study. Subjects were requested to attend the tests for a full working week on consecutive days (Monday-Friday, i.e. 5 days in total).

Tenderness

Once the screening procedure was completed, mechanical-pain threshold (MPT) measurements were performed over the biceps brachii muscle of the non-dominant arm as a correlate of tenderness as described by Barlas et al. (2). The measurements were accordingly performed on eight equidistant points on the flexor of the subjects' brachius, each marked with semi-permanent ink. These points were standardized by first identifying the intersection of the biceps brachii on the radius and marking this as the first point. The next seven points were then marked at 3 cm intervals proximal to the first one, on a line joining the insertion of the biceps brachii (on the radius) and the acromion. Pressure was applied through the spherical ending (1 cm diameter) of a pressure algometer (Electronic Force Gauge, Salter, West Bromwich, UK) with increasing force for periods of 1 to 10 s, until either the subject reported the sensation to be painful, or the exerted pressure reached 40 N (used as a cut off value to avoid bruising).

Range of movement

After assessment of MPT, ranges of movement (ROM) were measured using a standard universal goniometer. For this, two anatomical points were marked with a semipermanent ink as reference points: the styloid process of the radius and a point corresponding to the greater tuberosity of the humerus. A total number of three measurements were taken, all in the erect position: elbow flexion (FANG), elbow extension (EANG), and elbow relaxed angle (RANG) according to standardized procedures used in rehabilitation (3).

Induction procedure

DOMS was induced in the non-dominant arm using a dumb-bell and free weights. For the DOMS induction procedure, the subject sat on a custom-made apparatus (Preacher's bench), and the greatest amount of weight that the subject could lift concentrically on a single occasion was determined (i.e. one experimenter lifted the pre-determined weight to the point of FANG, and the subject was instructed to lower the weights as slowly as possible). This continued until the subject was no longer able to lower the weights under control. A 30-s rest interval was then allowed and the procedure repeated twice more (with further intervening 30-s rest periods), to ensure exhaustion of the elbow flexors.

Pain measurement

After completing the DOMS induction procedure, the subjects rated their current level of pain on a computerized visual analogue scale (VAS). Briefly, a customized program was used, whereby VAS could be displayed on a computer monitor at 30 s intervals. A line anchored with „No pain" and „Maximum pain" at either end appeared on the screen in random orientation. With the help of a mouse control, subjects were able to move a marker along the scale and, using the integral switch of the mouse, to mark a point to indicate their current level of pain. The distances of the marker along the scale, representing individual current-pain intensity scales, were stored automatically as percentages of the total length of the line. VAS scores were obtained for all subjects for each attendance: the mean values of four pre-and four post-treatment (respectively) scores were used as the basis of analysis.

Statistical analysis

All results are expressed as the mean ±SEM of individual observations. Statistical analysis was performed with one factor ANOVA. The statistical significance level was accepted at 95%. For the purposes of statistical analysis, all data were standardized (for each subject) as differences from the individual baseline by subtracting the values of the pre-induction measurements from those obtained during subsequent attendances.

Results

Mechanical pain threshold (MPT)

Figure 2 shows an increase in tenderness or sensitivity in all groups as a result of the induction procedure. There are consistent patterns of differences between groups. Analysis of these data using repeated measures ANOVA showed a significant change in MPT over the 5 days of the experiment, reflecting the effects of the induction procedure. The reduced values of MPT represent an increase in tenderness or worsening of the condition. The mean values of all eight points spanning the length of the biceps brachii were calculated in order to monitor the effects of treatment along the whole muscle. Figure 2 shows an increase in tenderness in all groups as a result of the induction procedure, as well as a partial recovery on the final day of the experiment. Significant ($p<0.05$) differences (effects) between the groups S-T vs. T and C vs. T were found from the 3rd onwards.

Visual analogue scale (VAS)

The graphs in Figure 3 represent the values of the mean pain intensity pre-treatments on any day in reference to those which were calculated on day one as a baseline. ANOVA analysis revealed a significant difference in the VAS values over

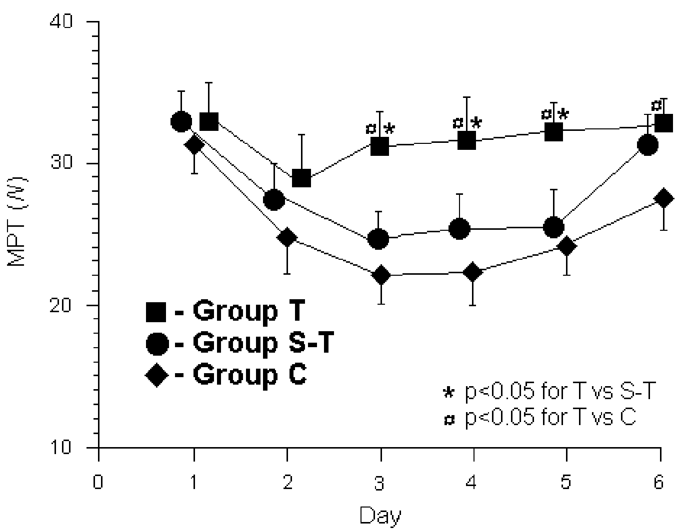

Fig. 2. *Mechanical pain threshold (MPT) as mean values for all eight points on the biceps brachii muscle. Decreasing values represent a decrease in MPT and thus an increase in tenderness or worsening of the condition.*

the experimental period and a significant interactive effect, indicating significant differences between the test groups over time. Further analysis of VAS difference values using one-factor ANOVA (with relevant Fisher tests) revealed isolated significant differences (pre-treatment) on the second day between the control group and other experimental groups (S-T placebo and T treatment group).

Range of movement (ROM)

The values deriving from the measurement of the range of movement reveal a clearcut effect of DOMS induction upon ROM during the 5 days of testing and render a significant statistical difference between the relevant groups. ANOVA revealed not only a significant effect over time but also showed well separated differences between the individual test groups. Increasing EANG values reflect the inability of subjects to fully extend the arm. Decreases in FANG represent loss of flexion owing to swelling, and increased RANG reflects lack of extension, thus resulting in the conclusion that the ranges of movement of subjects treated by the pulsed electromagnetic (BEMER 3000) fields were already enhanced at the second day of the experiment (Fig. 4).

Discussion

The aim of this study was to investigate the effects of the Bemer 3000 type electromagnetic field upon experimentally induced muscle pain and motor dysfunction (the standardized DOMS-induction protocol) under randomized, double blind, placebo-controlled conditions. Measurements of the elbow range of movement (flexion, extension, relaxed angle), and pain as well as visual analogue scores (VAS), and tenderness (using a pressure algometer) were employed to indicate the treatments´effectiveness. Measurements of the elbow range of movement and tenderness were made prior to DOMS induction on the first day, and repeated post-treatment on subsequent days. Pain intensity was assessed using visual analogue scales post-induction and post-treatment each day of the whole treatment. The results indicate a clearcut beneficial effect induced by the applied physical modality of the Bemer 3000 type electromagnetic stimulation.

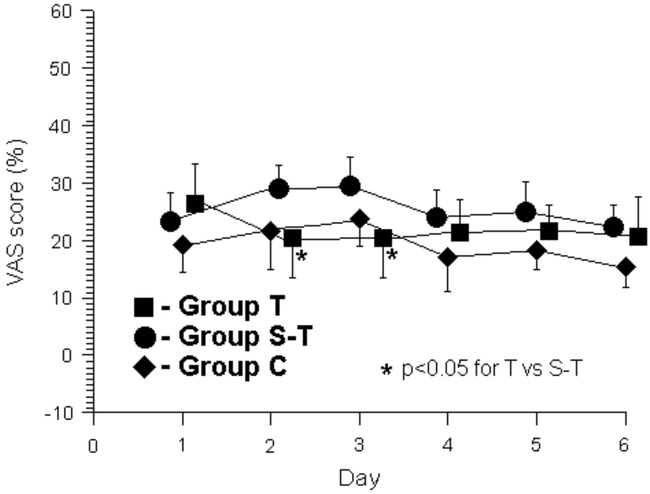

Fig. 3. *Visual analogue scale scores (VAS) as the mean pain intensity pre-treatment on any day (%; mean ± SEM)*

Significant differences of pain levels were furthermore found between the intergroups (C vs. T and S-T vs. T). Non significant differences were observed between control and sham-treated group. The intergroup difference in VAS scores were found on the second day of the experiments. Some authors have assessed the assumed analgesic effects of physical modalities using DOMS as a model of myogenic pain. However, results and conclusions are often conflicting. The benefit of physical modalities such as transcutaneous electrical nerve stimulation and ultrasound were reported by Denegar et al. (5) and Hasson et al. (7) but others have failed to demonstrate any such effects (4, 11). Too small numbers of test persons and the lack of control and sham-treated groups cause both reasons for such discrepancies. In the case of this study care was taken to address these issues to ensure the validity of the findings. The comparison of existing studies regarding electromagnetic field as an analgesic modality is confounded by the wide variety of induction measurements and doses used, but, in common with previous research in this area of physiotherapy (electromagnetic field therapy) precludes replication on account of the lack of detailed description of the experimental setup and procedures. The presented clinical methods of experiments of this paper, however, were based on the rules of Good Clinical Practice and design according to Barlas et al. (2).

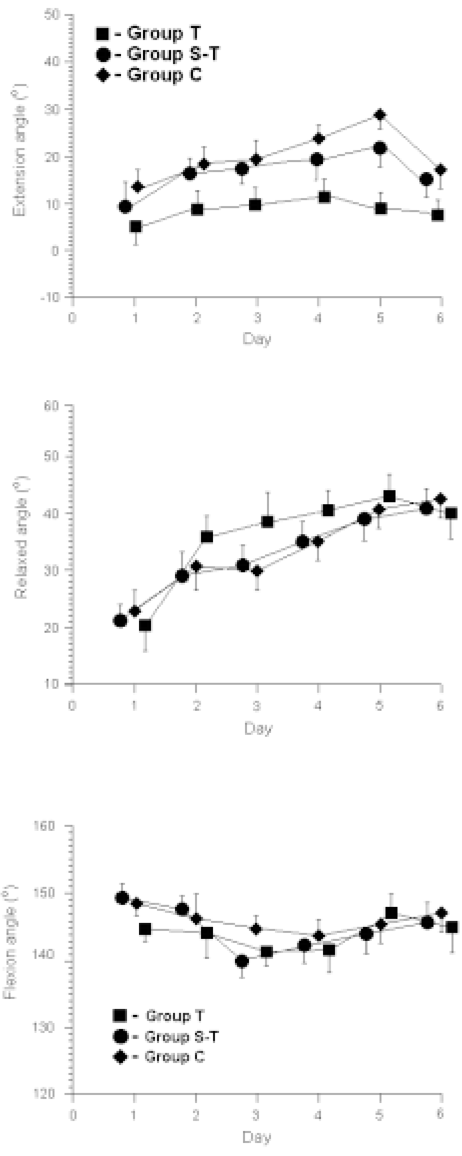

Fig. 4. *The ranges of movement scores (degrees; mean ± SEM) pre-treatment on any day. (Upper graph: mean values for EANG, middle graph mean values for FANG and lower graph mean values for RANG). Increasing EANG values reflect the inability of the subjects to fully extend their arm; decreasing FANG values represent loss of flexion due to swelling; increasing RANG values reflect a lack of extension at rest. The statistical significant differences between the groups are not shown.*

Significant differences in the range of movement were found between the intergroups (S-T vs. T and C vs. T). The ANOVA showed a significant effect over time and significant differences were detected between the groups in all of the ROM measurements. The beneficial effect of the Bemer 3000 type electromagnetic field on ranges of joint movement can be explained by the retarded pain intensity during the periods of exposition on this therapeutic modality. The implication of muscle receptors can be the proposed mechanisms of action of this modality. On the other hand, in accordance with the findings of increased rate of synthesized ATP in red blood cells (12) changes in metabolism in skeletal muscle tissue must be taken into consideration as well. Bemer 3000 stimulation might also be effective in activating endogenous-opioid systems as for example it exists in acupuncture (6) but this hypothesis requires further exploration.

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