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Combination treatment of physical modalities in the treatment of musculoskeletal pain syndromes: a prospective-controlled study

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Abstract

The aim of the study was to evaluate the effect of combinations of several physical therapies in the treatment of musculoskeletal pain syndromes by a prospective, controlled study. Forty patients (5 men and 35 women, 18-80 years) with musculoskeletal pain syndrome were included. Thirty patients were assigned to the intervention group and 10 patients to the control group. The intervention group received a combination of physical therapies according to the clinical needs (electrotherapy, fango packs, mud packs, ultrasound, massage, exercise therapy). Treatment consisted of 10 sessions. The control group did not receive any physical therapy in the waiting period. The intervention group was examined at the beginning and the end of the treatment period. The control group was evaluated at the beginning and the end of the waiting period (before their physical therapy treatment started). Main outcome measurements were: Visual analogue scale for pain (VAS); Timed Get up and Go Test (TUG); Functional Reach Test (FRT). In addition bodily, emotional and social functioning was accessed by selected ICF-Items and items of the SF-36 health survey (SF-36). The main outcome measures showed significant improvement in the intervention group compared to the control group. Furthermore, ICF- and SF-36-Items also improved. In conclusion significant pain relief and improvement of function was achieved by a combination treatment of physical therapies in patients with musculoskeletal pain syndromes.
Key Words: physical modalities, musculoskeletal, pain, physical therapy, combination

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Musculoskeletal pain syndromes are a common health problem. In Austria, the number of sick leave days caused by musculoskeletal disorders was 8196907 days, including men and women, in 2007 [25]. This has a great impact on Austrian economy. The treatment of musculoskeletal pain syndromes is multimodal. Beside pharmacological and surgical treatment different types of physical therapies are applied. Nonsurgical treatment contains of drug prescription, local infiltration and various physical therapies, like different forms of electrotherapy, thermotherapy, massage therapies, exercise therapies, ultrasound and more. In general combinations of different physical modalities are used. The choice of treatment combination depends on the clinical needs and symptoms of the patient.

There are numerous studies dealing with the physiological effects of physical modalities. The analgesic effect of electrotherapy is probably based on enhanced microcirculation [15], an increase in muscle oxidative capacity [19], local release of neurotransmitters such as serotonin [29], increased mitochondrial ATP production [22], increased release of endorphins [34] or anti-inflammatory effects [1]. The activation of the dorsal column is discussed as another mechanism. The pain input is interrupted by inhibitation of the C-fibres (gate control mechanism) [30]. Mima et al. [20] found a decrease of human motor cortex excitability by using high-frequency TENS.

Topical heat increases small non-myelinated C-fibre activity that inhibits nociceptive signals in the spinal cord and increases proprioception [7,17,26,27]. Heat therapy may also stimulate various regions of the brain, supporting psychosomatic effects [4,6]. The benefit of the heat wrap is thus indirectly mediated in the brain via skin warming, combined with the physical support of body regions affected with pain.

Additionally, the psychological effects of comfort and relaxation have been associated with topical heat therapy, extenuating central integration and coherence of the pain experience [26].

Classic (Swedish) massage has a long history in the treatment of musculoskeletal pain syndromes in Europe [32]. Known effects like muscle relaxation, an increase of the pain threshold and positive psychological impact are possibly due to endorphin release. It is also known to increase local blood flow which could enhance clearance of local pain mediators [9].

Exercise therapy has several direct and indirect effects. Main effects are joint protection and unloading, facilitation, inhibition, sensomotor, trophic and functional adaptation, as well as change of behaviour and psychological adaptation [12,24,18].

Pain can induce limitations in function, activity and participation. All these aspects are represented in the ICF (International classification of functioning, disability and health) [33]. Therefore functioning is an important outcome measurement for pain treatment.

Furthermore psychological effects have to be mentioned. This is especially important for patients with chronic pain. For the assessment of the health-related quality of life the SF-36 health survey is a widely accepted generic instrument [3].

There are several studies dealing with treatment of low back pain and musculoskeletal problems using different physical modalities as single treatment compared with other therapy options or placebo. For single treatment options there is varying evidence. In a Cochrane review Hayden et al. [14] described an evidence level B for exercise therapy for the treatment of chronic low back pain. In another Cochrane review Furlan et al. [10] described an evidence level C for massage therapy for the treatment of low back pain. Watson [31] reviewed the current concepts in electrotherapy in the management of musculoskeletal and neurological problems and found that combined with other physical therapies it is likely to achieve the most significant results. Johnson et al. evaluated the effect of electrical nerve stimulation (ENS) on chronic musculoskeletal pain in a meta-analysis. The results indicate that ENS is an effective treatment modality [16]. In a Cochrane review Gadsby et al. found evidence that TENS reduces pain and improves range of motion in chronic back pain patients, at least in the short term [11]. Nadler et al. [21] were able to show positive effects of continuous low-level heat wrap therapy versus oral pain medication in the treatment of acute nonspecific low back pain.

The European Guidelines for the management of chronic non-specific low back pain [2] recommend further investigation of combinations of physical treatments. Therefore, the aim of this study was to evaluate the effect of a treatment combination of several physical therapies in the treatment of musculoskeletal pain syndromes.

Materials and Methods

Patients

Forty patients (35 women and 5 men, age 18-80 years) were included in this prospective, controlled study. Patients were suffering from the following musculoskeletal pain syndromes: back pain including radicular and pseudoradicular syndromes as well as musculoskeletal pain affecting the extremities. Patients, who did not understand German language, patients with psychiatric illness or substance-abuse, patients with dementia, pain caused by malignancy, osteoporosis, rheumatic inflammatory disease, trauma or fractures were excluded. Outpatients of the Department of Physical Medicine and Rehabilitation, Medical University of Vienna, General Hospital were consecutively included into the study. The patients, who could start their physical therapy treatment immediately, were assigned to the intervention group (group A). The patients of the waiting list were assigned to the control group (group B).

Interventions

The intervention group received a combination of physical therapies according to the clinical needs. The combination treatment consisted of 3 out of 5 different types of physical therapies: electrotherapy (transcutaneous electrical nerve stimulation, (pulsed) low frequency stimulation, iontophoresis), heat (mud packs or fango packs), ultrasound, massage and exercise therapy. Physical therapies were chosen according to the clinical needs. One treatment session lasted between 60 and 90 minutes. Overall treatment consisted of 10 sessions and lasted up to 4 weeks.

The control group included patients on the waiting list. They did not receive any physical therapy in the waiting period which lasted 2 weeks. Their physical therapy treatment started afterwards.

All participants gave written informed consent to participate in the study.

Patient characteristics

In the intervention group 6 patients reported acute pain, 5 patients subacute and 19 patients chronic pain. In the control group 1 patient were suffering from subacute pain and 9 patients from chronic pain. In the intervention group pain was reported at the cervical spine, shoulder/shoulder girdle and lumbar spine. Pain at the lumbar spine was sometimes combined with pain of hip and knee. Pain at the cervical spine was sometimes combined with pain of shoulder and shoulder girdle. In the control group the pain location was reported similar to the intervention group with pain at cervical spine, shoulder/shoulder girdle, thoracic spine and lumbar spine. Pain of elbow, hand, hip, knee or foot was not reported. In the intervention

Characteristics	Intervention group n=30	Control group n=10
Age	52.1 years	47.5 years
Sex	5:25 (m:f)	0:10 (m:f)
Height	168.3 cm	166.7 cm
Weight	70.9 kg	69.1 kg
BMI	25.1	24.7

Table 1. Patient characteristics. The patients' mean age, sex, height, weight, and body mass index are shown (m=male, f=female, BMI=Body-Mass Index; cm=centimetres; kg=kilograms).

group 46.7% (14 patients) and in the control group 60% (6 patients) used pain medication (NSAR, opioids) on a regular basis. 20-27% of the patients in both groups have also tried other treatment options like acupuncture or Thai chi. In the intervention group 10% of the patients never had physical therapies before. 20% of the patients had one treatment series before (one series has ten treatment sessions). 53.3% already had more than 2 series and 16.7% had even more than of 4 series of physical therapies. In the control group all patients had physical therapies before. 30% even had more than 4 series of physical therapies. The current living and working situation in the intervention group was as follows: 10 patients were employed, 3 patients unemployed, 11 were in retirement and 6 on sick leave. In the control group 8 patients were employed, 1 patient was unemployed and 1 in retirement.

Outcome Measures

Patients were examined twice (baseline and follow-up). In the intervention group outcome measures were evaluated before and after the treatment period which lasted for about 4 weeks. The control group was examined at the beginning and at the end of the waiting period (before their physical therapy treatment started). The waiting period lasted for 2 weeks. Pain was measured using the visual analogue scale (VAS). The patients had to indicate the current pain situation. Functional Reach Test (FRT) [8] is a simple measure of balance. The patients stood and reached forward as far as possible, using a fixed base of support. The

VAS	Intervention group		Control group		p-value
pain	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
Baseline	5.65 (2.19)	5.5 (1.0-9.0)	6.15 (1.86)	6.25 (3.0-8.5)	
Follow-up	3.76 (2.49)	3.5 (0-10.0)	6.3 (1.65)	6.3 (4.0-9.0)	
DIFF-VAS	-1.89 (2.37)		0.15 (1.62)		0.016

Table 2: VAS score pain. VAS score for pain at baseline and follow-up assessment and difference of VAS scores is shown for both groups (SD=standard deviation; DIFF-VAS=Difference of VAS Scores).

FRT	Intervention group		Control group		p-value
in cm	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
Baseline	26.59 (7.0)	24.75 (15.5-44.5)	24.75 (5.94)	23.0 (17.5-37.5)	
Follow-up	29.68 (7.97)	27.75 (13.5-47.0)	23.15 (6.28)	21.5 (16.5-35.5)	
DIFF-FRT	3.09 (4.39)		-1.6 (1.85)		0.002

Table 3: Functional Reach Test. Results of the FRT at baseline and follow-up assessment and difference of FRT scoring are shown (FRT=Functional Reach Test; SD=standard deviation; cm=centimetres; DIFF-FRT= difference of FRT scoring).

distance between arm's length and maximal forward reach was noted. Subjects were given three trials. Their performance was recorded and averaged. The Timed Get up and Go Test (TUG) [23] measures the time taken (in seconds) to rise from a chair, walk three meters, turn, walk back and sit again at a self determined comfortable speed (as fast as possible). Pain characteristics (duration and localisation) were assessed. The duration of pain was divided into acute (<3 months), subacute (3-6 months) and chronic (>6 months) Additionally pain location was described: cervical spine, thoracic spine, lumbar spine, shoulder/shoulder girdle, elbow, hand, hip, knee and foot. The survey also included current pain medication and whether physical therapies or other treatment options like acupuncture were utilized so far. The current living and working situation (employment, retirement, or sick leave) was also part of the survey. Patients were asked to describe their general health perception with: excellent/very good, good, fair/ poor.
To assess quality of life selected items of the SF-36 were used: Items dealing with bodily pain, reported health transition, role emotional and social functioning, were selected. To assess limitations in activities of daily living the following ICF-Items were used: Changing and maintaining body position (d429), walking and moving (d469), caring for body parts (d520), dressing (d540), acquisition of goods and services (d620), preparing meals (d630), acquiring, keeping and terminating a job (d845). The grading for existing limitations was 1 and 0 for no limitations. At the end of the treatment period the intervention group was asked to grade the effect of the treatment (improved, unchanged, and worsened).

Statistical Analysis

Normal distribution was tested by the Kolmogorov-

TUG	Intervention group		Control group		p-value
in sec	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
Baseline	9.22 (1.76)	9.28 (5.18-13.27)	8.08 (0.83)	7.83 (7.1-9.5)	
Follow-up	8.35 (1.72)	8.42 (4.81-12.18)	8.47 (0.98)	8.28 (7.5-10.23)	
DIFF-TUG	-0.87 (1.46)		0.39 (0.58)		0.012

Table 4: Timed up and Go Test. Results of the TUG at baseline and follow-up assessment and the difference of TUG scoring are shown (TUG= Timed up and Go Test; SD=standard deviation; sec=seconds; DIFF-FRT=difference of TUG scoring).

General health perception	Intervention group		Control group	
	Baseline	Follow-up	Baseline	Follow-up
Excellent/ very good	1 (3.3%)	6 (20%)	0	0
Good	9 (30%)	17 (56.7%)	2 (20%)	1 (10%)
Fair/poor	20 (66.7%)	7 (23.3%)	8 (80%)	9 (90%)

Table 5: General health perception. Results of the number of patients whose general health perception has changed are shown.

Smirnov Test. We compared the differences of parameters between the two dates of examination by the unpaired t-Test. Significance level was set at 0.05. Pain characteristics, ICF-Items, and SF-36-Items were evaluated descriptively.

Results

Patient characteristics

Thirty patients were assigned to the intervention group (group A) and 10 patients to the control group (group B). Patients' age, sex, height, weight, and body mass index are listed in table 1.

Visual Analogue Scale

VAS score at baseline and follow-up assessment is shown in table 2 for both groups. Comparing group A and B the difference of VAS scoring between the two examinations was significant (p=0.016). In the intervention group pain was reduced (mean value and SD at baseline 5.65 ± 2.19, at follow-up 3.76 ± 2.49), whereas in the control group an increase from 6.15 ± 1.86 to 6.3 ± 1.65 (mean values and SD) was found.

Functional Reach Test

Results of the FRT at baseline and follow-up assessment are shown in table 3 for both groups. Comparing group A and B the difference of FRT scoring between the two examinations was significant (p=0.002). Patients in the intervention group improved from 26.59 ± 7.0 cm to 29.68 ± 7.97 cm (mean values and SD) in the FRT. The control group showed a decrease from 24.75 ± 5.94 cm to 23.15 ± 6.28 cm (mean values and SD).

Timed up and Go Test

Results of the TUG at baseline and follow-up assessment are shown in table 4 for both groups. Comparing group A and B the difference of TUG scoring between the two examinations was significant (p=0.012). The intervention group improved from 9.22 ± 1.76 sec. at baseline to 8.35 ± 1.72 sec. (mean values and SD) at follow-up. The control group worsened from 8.08 ± 0.83 sec. at baseline to 8.47 ± 0.98 sec. (mean values and SD) at follow-up.

General health perception

Table 5 shows the results of the patients' general health perception. In the intervention group there was an improvement after therapy. In the control group there was no change in health perception. One patients' general health perception worsened.

Selected items of the SF-36

Bodily pain

At baseline, in the intervention group 60% of the patients reported a moderate limitation, 36.7% felt extremely limited and 3.3% were not limited at all. At baseline, in the control group there was an even distribution between patients who felt extremely limited and those who felt moderately limited.
At follow-up, in the intervention group there was an improvement. Only 13.3% felt extremely limited. Eighty percent were moderately limited and 6.7% were not limited at all. In the control group there was a change for the worse at follow-up. Seventy percent reported extreme limitation, and 30% were moderately limited.

Reported health transition

Table 6 shows the impact on the reported health transition compared to one year ago. At baseline, in the intervention group 10% reported improvement in health transition compared to one year ago, 26.7% reported no change and 63.4% a reduction in health

Reported general transition	Intervention group		Control group	
	Baseline	Follow-up	Baseline	Follow-up
Much better now than a year ago	1 (3.3%)	3 (10%)	0	0
Somewhat better now than a year ago	2 (6.7%)	6 (20%)	0	0
About the same as one year ago	8 (26.7%)	6 (20%)	1 (10%)	1 (10%)
Somewhat worse now than one year ago	8 (26.7%)	10 (33.3%)	5 (50%)	1 (10%)
Much worse now than one year ago	11 (36.7%)	5 (16.7%)	4 (40%)	8 (80%)

Table 6: Reported general transition. The number and percentage of patients who noticed an impact on the reported health transition compared to one year ago is shown.

transition compared to one year ago. At baseline, in the control group 0% reported improvement in health transition compared to one year ago, 10% reported no change and 90% a reduction in health transition compared to one year ago. At follow-up, in the intervention group 30% reported improvement in health transition compared to one year ago, 20% reported no change and 50% a reduction in health transition compared to one year ago. At follow-up, in the control group 0% reported improvement in health transition compared to one year ago, 10% reported no change and 90% a reduction in health transition compared to one year ago.

Role emotional

Table 7 shows the change on the impact of emotional problems on work or other daily activities. Fifty percent of the intervention group and 60% of the control group reported that they had to cut down the amount of time they spent on work or other activities at baseline, whereas 43.3% of the intervention group and 40% of the control group did so at follow-up. In the intervention group 36.7 % and 30% of the control group reported that they accomplished less than they would like at baseline, whereas 20% of the intervention group and 50% of the control group did so at follow-up. In the intervention group 13.3 % and

	Intervention group		Control group	
	Baseline	Follow-up	Baseline	Follow-up
Cut down the amount of time you spent on work or other activities	15 (50%)	13 (43.3%)	6 (60%)	4 (40%)
Accomplished less than you would like	11 (36.7%)	6 (20%)	3 (30%)0	5 (50%)
Didn't do work or other activities as carefully as usual	4 (13.3%)	11 (36.7%)	1 (10%)	1 (10%)

Table 7: Role emotional. The number and percentage of patients who noticed change on the impact of emotional problems on work or other daily activities is shown.

ICF	Intervention group		Control group	
	Baseline	Follow-up	Baseline	Follow-up
ICF d429	20	9	7	7
ICF d469	15	6	2	2
ICF d520	6	3	0	0
ICF d540	10	4	5	3
ICF d620	10	4	4	4
ICF d630	0	0	0	0
ICF d845	16	5	8	8

Table 8: ICF-Items. The number of patients who noticed change of limitations on daily life according to selected ICF-Items is shown (ICF=International Classification of Functioning, Disability and Health; d429=changing and maintaining body position; d469=walking and moving; d520=caring for body parts; d540=dressing; d620=acquisition of goods and services; d630=preparing meals; d845=acquiring, keeping and terminating a job).

10% of the control group reported that they did not do work or other activities as carefully as usual at baseline, whereas 36.7% of the intervention group and 10% of the control group did so at follow-up.

Social functioning

At baseline, in the intervention group 50% of the patients were not limited at all, 37.7% were slightly and 13.3% were moderately limited in their social activities. In the control group 80% were not limited at all and 20% were slightly limited in their social activities at baseline.
At follow-up, in the intervention group 63.3% were not limited at all, 30% were slightly and 6.7% were moderately limited in their social activities. In the control group 60% were not limited at all and 40% were slightly limited at follow-up.

ICF-Items

Table 8 shows the change of limitations on daily life according to selected ICF-Items. The intervention group improved in all items that showed limitations at baseline evaluation. In the control group only 1 item (d450 dressing) showed improvement in limitations, whereas 6 items showed no change.

Subjective success/effect of therapy

At the end of the treatment period in the intervention group 73.3% reported an improvement, 26.7% reported no change of complaints.

Discussion

In our study we evaluated the effect of combined physical therapies in patients with musculoskeletal pain syndromes. The main outcome measurements, VAS for pain assessment, FRT and TUG for functional assessment showed significant improvements in the intervention group compared to the control group. Functional restoration, especially with regard to vocational rehabilitation, is an important goal in the treatment of patients with musculoskeletal pain syndromes and may be sometimes even more important than pain relief itself. That is why these validated measurement tools were used to perform simple tests regarding function (FRT as a measure of balance performance and TUG as a basic evaluation of functional mobility) in addition to recording changes in pain.
Our patients' improvements in pain and function are also reflected in an improvement in the ICF and SF 36 items. It may be assumed that pain reduction leads to improved mobility and improved performance in the activities of daily living. This may improve the mental situation as well as social integration with potential positive effects on pain coping.
The observation period differed between the two groups. In the intervention group it lasted up to 4 weeks, whereas in the control group it lasted 2 weeks. Even though the observation period between the two groups was different, the control group worsened during the observation period and showed no spontaneous remission.
Our clinical experience shows, that by using a combination of physical therapies good results can be achieved in patients with musculoskeletal pain syndromes. When looking at the literature dealing with physical therapy treatment, publications are predominantly testing single physical therapy interventions. This is also stated by the European Guidelines for the management of chronic non-specific low back pain [2] and they recommend studies evaluating combination treatment of physical therapies. Therefore we decided to examine the effect of the combination of physical modalities for the treatment of patients with musculoskeletal pain syndromes. The selection of our treatment modalities was made according to the clinical needs of our patients.

Musculoskeletal pain syndromes have different etiologies. Pain or functional loss may present in a similar way, even so in one patient it is due to beginning osteoarthrosis whereas in the other patient it is due to muscle weakness. Even so the clinical presentation is similar, the treatment strategy will be different. Moreover, patients differ in work load, fitness, biomechanical preconditions, and gender [5] which are important factors in choosing the adequate form of treatment.
Similar findings to our results were shown by a Norwegian research group. In a randomised single-blind multicenter study by Torstensen et al., results of a group with combined physical therapy and a group with medical exercise therapy was superior to self-exercise by walking in regard to pain and patients' satisfaction in patients with chronic low back pain. The group with combined physical therapy was superior to the medical exercise group regarding costs due to sick leave [28]. Hansen et al. [13] compared a group with dynamic back exercise to a group with combined physical therapy as well as a placebo group. Both intervention groups were superior to the placebo group. Subgroup analysis showed a higher benefit for men with high working loads from combined physical therapies and a higher benefit for women with sedentary job functions from additional dynamic back exercise. These results stress the importance of selecting treatment regimens according to the clinical needs of the patients.
Significant pain relief (p=0.016) and improvement of function (p=0.002) was achieved by a combination treatment of physical therapies in patients with musculoskeletal pain syndromes. To identify which single treatment or combination is more effective than another will be the subject of further studies with a larger sample size and randomisation.

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References

[1] Ailioaie C, Lupusoru-Ailioaie LM: Beneficial effects of laser therapy in the early stages of rheumatoid arthritis onset. Laser Ther 1999; 11: 79-87.
[2] Airaksinen O, Brox JI, Cedraschi C, Hildebrandt J, Klaber-Moffett J, Kovacs F, Mannion AF, Reis S, Staal JB, Ursin H, Zanoli G. Chapter 4: European guidelines for the management of chronic nonspecific low back pain. Eur Spine J 2006; 15: S192-S300.
[3] Bullinger M, Kirchberger I, Ware J: Der deutsche SF-36 health survey. Z Gesundheitswiss 1995; 3: 21-36.
[4] Cameron MH: Physical agents in rehabilitation—from research to practice. Philadelphia: WB Saunders; 1999. p 149-73.
[5] Cammarata ML, Dhaher YY: Evidence of gender-specific motor templates to resist valgus loading at the knee. Muscle Nerve 2010, 41: 614–623.
[6] Davis KD, Kwan CL, Crawley AP, Mikulis DJ: Functional MRI study of thalamic and cortical activations evoked by cutaneous heat, cold, and tactile stimuli. J Neurophysiol 1998; 80: 1533-1546.
[7] DePace DM, Newton R: Anatomic and functional aspects of pain-evaluation and management with thermal agents. In: Michlovitz SL, editor. Thermal agents in rehabilitation. 3rd ed. Philadelphia: FA Davis; 1996. p 30-57.
[8] Duncan PW, Weiner DK, Chandler J, Studenski S: Functional reach: a new clinical measure of balance. J Gerontol 1990; 45(6): M192-197.
[9] Ernst E, Fialka V: The clinical effectiveness of massage therapy – a critical review. Forsch Komplementärmed 1994; 1: 226-232.
[10] Furlan AD, Brosseau L, Imamura M, Irvin E: Massage for low-back pain. Cochrane Database Syst Rev. 2002; 2: CD001929.
[11] Gadsby JG, Flowerdew MW: Transcutaneous electrical nerve stimulation and acupuncture-like transcutaneous electrical nerve stimulation for chronic low back pain. Cochrane Database Syst Rev. 2000; 2: CD000210.
[12] Guttenbrunner Ch, Glaesener JJ: Rehabilitation, Physikalische Medizin und Naturheilverfahren. Springer Medizin Verlag Heidelberg 2007, ISBN-10 3-540-33411-4, ISBN-13 3-540-978-3-540-33411-8.
[13] Hansen FR, Bendix T, Skov P, Jensen CV, Kristensen JH, Krohn L, Schioeler H: Intensive, dynamic back-muscle exercises, conventional physiotherapy, or placebo-control treatment of low-back pain. A randomized, observer-blind trial. Spine 1993, 18: 98-108.
[14] Hayden JA, Tulder MW van, Malmivaara A, Koes BW: Exercise therapy for treatment of non-specific low back pain. Cochrane Database Syst Rev. 2005; 3: CD000335.
[15] Jacobs MJ, Jorning PJ, Joshi SR, Kitslaar PJ, Slaaf DW, Reneman RS: Epidural spinal cord electrical stimulation improves microvascular blood flow in severe limb ischemia. Ann Surg 1988; 207: 179–183.
[16] Johnson M, Martinson M: Efficacy of electrical nerve stimulation for chronic musculoskeletal pain: A meta-analysis of randomized controlled trials. Pain 2007; 130: 157–165.

[17] Kanui TI: Thermal inhibition of nociceptor-driven spinal cord neurones in the cat: a possible neuronal basis for thermal analgesia. Brain Res 1987; 402: 160-163.
[18] Mannion AF, Taimela S, Müntener M, Dvorak J: Active therapy for chronic low back pain part 1. Effects on back muscle activation, fatigability, and strength. Spine 2001; 26: 897-908.
[19] Martin TP, Stein RB, Hoeppner PH, Reid DC: Influence of electrical stimulation on the morphological and metabolic properties of paralyzed muscle. J Appl Physiol 1992; 72(4): 1401-1406.
[20] Mima T, Oga T, Rothwell J, Satow T, Yamamoto J, Toma K, Fukuyama H, Shibasaki H, Nagamine T: Short-term highfrequency transcutaneous electrical nerve stimulation decreases human motor cortex excitability. Neurosci Lett 2004; 355: 85–88.
[21] Nadler SF, Steiner DJ, Erasala GN, Hengehold DA, Abeln SB, Weingand KW: Continuous low-level heatwrap therapy for treating acute nonspecific low back pain. Arch Phys Med Rehabil 2003; 84(3): 329-334.
[22] Passarella S: He-Ne laser irradiation of isolated mitochondria. J Photochem Photobiol B 1989; 3(4): 642-643.
[23] Podsiadlo D, Richardson S: The timed ‘‘Up & Go’’: a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 1991; 39: 142–148.
[24] Sjöström R, Alricsson M, Asplund R: Back to work--evaluation of a multidisciplinary rehabilitation programme with emphasis on musculoskeletal disorders. A two-year follow-up. Disabil Rehabil 2008; 30: 649-655.
[25] Statistisches Handbuch der Österreichischen Sozialversicherung 2008; p. 85.
[26] Stevens JC, Green BG: Temperature-touch interaction: Weber’s phenomenon revisited. Sens Processes 1978; 2: 206-209.
[27] Stevens JC: Temperature and the two-point threshold. Somatosens Mot Res 1989; 6: 275-284.
[28] Torstensen TA, Ljunggren AE, Meen HD, Odland E, Mowinckel P, Geijerstam S: Efficiency and costs of medical exercise therapy, conventional physiotherapy, and self-exercise in patients with chronic low back pain. A pragmatic, randomized, single-blinded, controlled trial with 1-year follow-up. Spine 1998; 23: 2616-2624.
[29] Walker J: Relief from chronic pain by low power laser irradiation. Neurosci Lett 1983; 43: 339-44.
[30] Watkins ES, Koeze TH: Spinal cord stimulation and pain relief. BMJ 1993; 307: 462.
[31] Watson T: Current concepts in electrotherapy. Haemophilia 2002; 8: 413–418.
[32] Westhof E, Ernst E: Geschichte der Massage. Dtsch Med Wschr 1992; 117: 150-153.
[33] WHO-International Classification of Functioning, Disability and Health (ICF); 2001: Geneva: World Health Organization.
[34] Yamamoto H, Ozaki A, Iguchi N, Kinoshita S: antinociceptive effects of laser irradiation of Hoku point in rats. Pain Clin 1988; 8: 43-48.