HYDRO-GALVANIC AND RISING-TEMPERATURE BATH THERAPY FOR CHRONIC ELBOW EPICONDYLITIS: A COMPARATIVE STUDY

MUCHA C, MD[1]

[1] **Medizinische Rehabilitation und Prävention, Deutsche Sporthochschule Köln.**

ABSTRACT: *The efficacy of two different regimens of physiotherapy for epicondylitis was compared. A combination treatment with hydrogalvanic four-cell bath and arm bath with rising temperature, which had showed good effects in treatment of tennis elbow in an earlier observational study (Mucha 1987), was compared with the analgesic interference current treatment often recommended in the literature (Sadil and Sadil 1994, Noteboom et al 1994, Becker and Reuter 1982).*

For this study, 60 patients with epicondylitis that was resistant to conservative treatment were randomized into two groups for comparison. In group 1, interference currents were administered twice a day for six weeks and group 2 received combination treatment with the hydrogalvanic four-cell bath and rising-temperature arm bath once a day for six weeks.

Criteria for inclusion, control and appraisal were laid down prospectively. Several parameters were used, recorded and statistically evaluated as outcome measures. These were active joint range of movement of the elbow, grip strength, pain provocation with muscle contraction, palpation pain and pain with functional activities.

The results showed a significant superiority of combination treatment over therapy with interference current. It is therefore recommended that hydrogalvanic four-cell bath and arm bath with rising temperature should be carried out before considering surgical treatment for chronic epicondylitis.

KEY WORDS: EPICONDYLITIS, HYDROGALVANIC THERAPY, INTERFERENCE THERAPY, COMPARATIVE STUDY.

INTRODUCTION AND STATEMENT OF THE PROBLEM

Epicondylitis is frequently encountered by medical practitioners. Of these lateral epicondylitis is most commonly seen (Piligian et al 2000).

Etiologically, this condition in the upper limb can be classified as a primary degenerative disease (sometimes with secondary inflammatory components) of the tendon units (Piligian et al 2000, Reveille 1997). However, the aetiology and pathology is still largely unclear. The main characteristics of epicondylitis are likely to be its local origin and development in the muscle-tendon units without connection to intra-articular structures. Its causation is evidently multifactorial. According to present-day knowledge, psychological overstimulation and physical overuse of the a diverse kind frequently lead to triggering of this soft tissue disease (Becker and Reuter 1982, Hotchkiss 2000, Noteboom et al 1994, Piligian et al 2000). The development of small tears in the extensor aponeurosis is followed by an inflammatory response and fibrovascular hyperplasia (Reveille 1997).

Besides processes of aging and other degeneration processes, local hypoxia in this tendon tissue plays a crucial role in the pathogenesis (Almekinders and Temple 1998, Fassbender 1984). This is intensified further by the pain-induced hypertension with contraction ischaemia in the extensor muscle.

Accordingly, therapy would have to be suitable to enhance local blood flow and metabolism besides alleviating pain and lowering muscle tone. Several forms of physiotherapy are appropriate, but hydrogalvanic partial-immersion bath and rising-temperature arm bath are able to combine the single effects specified (Mucha 1987, Sadil and Sadil 1994).

The combination of these forms of treatment in "therapy-resistant" epicondylitis conditions was investigated in an observational study on patients, and its effectiveness was confirmed (Mucha 1987).

In the current study, the efficacy of this concept of treatment was therefore compared with interference current treatment, which is often recommended for treatment of epicondylitis (Becker and Reuter 1982, Noteboom et al 1994, Sadil and Sadil 1994). These interference currents comprise three superimposing circuits of the same frequency (5000 Hz) and variable phasing. The star-shaped electrodes enabling just one bundled pair of electrodes to be attached separately to the patient's elbow.

The effect is determined by the choice of beat frequency: analgesic sedative (100-200 Hz), blood flow-enhancing (100 Hz) or muscle-relaxant (25 Hz) effects.

CORRESPONDENCE TO:
Prof. C Mucha
Medizinische Rehabilitation
und Prävention
Deutsche Sporthochschule
Carl-Diem-Weg 6
D-50933
Köln
E-mail: mucha@dshs-koeln.de

PATIENTS AND METHODS

Sixty patients were allocated randomly to two groups: interference currents were administered in group 1 and combination treatment with four-cell baths and rising-temperature arm bath was applied in group 2.

The following inclusion criteria were applied:

- Patients of both sexes were included in the study.
- No age limits.
- Their lateral epicondylitis was regarded as resistant to treatment by at least two mutually independent treatment centres, so that the question of surgical treatment had been raised.
- The treatment period just completed had to have exceeded 12 weeks.
- Epicondylitis had to have been manifested for more than six months.

TREATMENT

The interference current in group 1 was applied for 15 minutes in the elbow region with the Stereodynator® as Sedat. and Vegetat. Stimulation III Program (200 Hz and 0.1 - 1 Hz) via plate electrodes. In order to obtain quantitative equivalence with the combination therapy in group 2, the application was repeated after a 60-minute break. In group 2, the four-cell bath with cathode switching on the arms and sensory threshold current strength was applied for 20 minutes and the rising-temperature arm bath was given to the affected arm after a break of one hour. The temperature was raised in steps of 1˚C from an initial 39˚C to the maximum tolerable temperature of 44˚ - 45˚C. The temperature elevation took place within 20 minutes during a single application. Both therapies were applied daily for 6 weeks.

On admission of the patients to our hospital, the course of the disease history was documented in addition to the patients' demographic data.

1. Specific clinical functional status was established.
2. Joint status including measurements of the circumference of the upper limb, and active elbow movement (see results).
3. Descriptive muscle status including the shoulder girdle, tenderness to palpation, localization of tenderness, swelling, number and localization of myogelosis.
4. Grip strength of the hand was tested with the Vigorimeter®. Each side was compared and classified as follows: 1 = equal strength on each side (without consideration of lateral dominance), 2 = up to 25% strength reduction in the comparison between sides, 3 = up to 50% strength reduction in the comparison between sides, 4 = up to 75% strength reduction in the comparison between sides.
5. Medial or lateral elbow pain testing included: provocation pain was tested with resistance in dorsal and/or volar flexion of the wrist (lateral or medial or bilateral epicondylitis) and the following classifications were taken as the basis: 1 = no pain, 2 = slight pain with good strength, 3 = still tolerable pain with reduced strength, 4 = intensive pain without resistance.
6. To check the loading pain, the patient had to lift 2 kg, 1 kg and 500 g weights with the elbow extended: 1 = 2 kg weight without pain, 2 = 2 kg weight with pain, 3 = 1 kg weight with pronounced pain, 4 = 500 g weight with intensive pain.
7. Further pain qualities were scaled as follows:

a: Resting pain generalized to elbow area: 1 = no pain, 2 = slight pain under maintained arm position, 3 = distinct to excruciating pain in maintained arm position, 4 = almost constant and excruciating pain, even at night.

b: Movement pain of the forearm and hand: 1 = no pain in routine everyday movement without loading, 2 = slight and transient pain in some load-relief movements, 3 = severe pain in many load-relief movements, 4 = distinct pain in any movement and in some cases with drastic increase of intensity.

c: Pressure pain over the epicondyle: 1 = no pain, 2 = moderate pain, 3 = pronounced pain, 4 = severe pain.

All these measurements were repeated after two weeks, four weeks, six weeks, 12 weeks and again after two years.

Treatment was always administered for six weeks. With a positive course and the good regeneration prognosis, the same therapy was continued until complete freedom from symptoms and restoration of complete everyday routine function. When no or only inadequate effects of treatment were shown after six weeks, administration of the alternative treatment of the comparison group was envisaged. When there was no success under the new therapy, the treatment was to be concluded if appropriate after a further six weeks of treatment. These cases had to be considered as "failed treatments".

Two years after the end of treatment, the patients underwent follow-up examinations. In addition they were asked about the progress of their illness during the preceding period and in particular about any fresh treatment required. They were also asked about their functional capacity at work and in everyday life.

The data obtained were broken down into initial, progress and final criteria and their absolute and relative frequencies were compared by means of descriptive statistics. For the six-week treatment phase, the data in the course were calculated and plotted and the group comparison at the end of this phase of treatment was analyzed with the χ^2 test with Yates correction. The probabilities of error were 5% (* $p < 0.05$) and 1% (** $p < 0.01$).

RESULTS

The mean age of the overall patient population was 41.9 (19-68) years. Women predominated (53%). Sex and age distributions in the comparison group did not show any statistically significant differences. The same also applied to the distribution of occupational groups. Only 13.1% of patients engaged in heavy physical work.

Exactly defined triggering causes could only be rarely established, so that the symptoms developed "spontaneously" in more than 61% of all patients. One-sided strain in recreational activities was the cause in 21.3%. The remainder was caused by sport and occupational strain.

The right elbow was involved in 66%, the left elbow in 34%, the lateral epicondyles in 81%, the medial epi-

condyles in 12% and both epicondyles in 7%. Only three patients in the overall population were left-handed.

All patients had complained of recurrent symptoms for more than six months (= criteria). The longest disease phase was two and a half years (three patients). Four patients had already undergone surgical treatment. The conservative therapy measures used are listed in Table 1. The second most frequent treatment was local cryotherapy, followed by immobilization in plaster casts. The majority of these patients reported an alleviation of pain during immobilization, but without a decisive effect on the subsequent mobilization phase. This benefit was not sustained. The numerous forms of physiotherapy, which were mainly employed in combination could not always be adequately specified (e.g. electrotherapies) and the parameters of implementation (e.g. iontophoresis) could not always be precisely established. As reported, the forms of treatment were mostly changed, when patients did not report an improvement within seven to 14 days.

Functional pain, often associated with transient resting pain was always clinically prominent. Not uncommonly, there were distinctly painful myogelosis at the homolateral shoulder girdle and the neck musculature owing to unilateral guarding, so that patients often found the shoulder and neck pain to be just as intensive as the elbow pain. The pain always radiated into the pertinent extensor or flexor muscles of the forearm. Neurological signs could only be found in patients who had been previously operated on, in some of whom there was hypoesthesias in the vicinity of the scar. Locally, a distinct swelling could be observed in about 20% of the overall population, and rarely a slight difference in temperature comparing the two sides. Unequivocal erythema was never found. If present, differences in circumference were not statistically significant. However, there were distinct, even if only terminal, movement restrictions in mobility of the elbow. On average, there was an active flexor deficit of 10˚ and an extensor deficit of 15˚ ± 5˚. These deficits were the same in lateral and medial epicondylitis. The difference between the sides was significant ($p < 0.01$) at the beginning of treatment. This was also the case for active pronation and supination of the forearm, which were terminally restricted by an average of 10˚. These restrictions of movement which were evidently due to pain regressed spontaneously on reduction of the pain, so that there were no longer any relevant differences between the two sides after six weeks of treatment, e.g. in group 2. However, the differences from group 1 were then statistically significant.

Table 1: Types of prior treatments in the total patient population (n=60) (multi-referencing)

Types of therapy		Number of patients
pharmacotherapy	oral	59
	local	57
	cortisone injections (>2x)	27 (21)
surgery		4
splint (10-36 days)		54
cryotherapy		57
massages		44
heat packs		13
ultrasound		43
interference currents		31
iontophoresis		19
other electrotherapies		22
exercise therapy		33

There were significant ($p < 0.01$) differences between the groups with regard to all other test parameters after six weeks of treatment. The distribution results are summarized in Figures 1 - 6. Development of the pain parameters for the six-week course of treatment in the two comparison groups is shown in Figures 7 - 12. There were no group differences in any of these test parameters at the beginning of treatment. The manifestation of differences between the groups occurred with increasing duration of therapy and became evermore distinct especially after the second week of treatment. They were statistically significant group differences in the grip strength and all provocation pain as early as the fourth week of treatment. There was as yet no significant group difference at this time of treatment only in the case of rest pain. However, movement pain attained threshold values, although the trend of the overall course is equivalent to that of the other test parameters. There were statistically significant ($p < 0.01$) group differences for this parameter after six weeks of treatment. It is also striking that in contrast to provocation pain movement and rest pain were very much less pronounced at the beginning of therapy. The latter subsided more slowly in the overall course. Apart from the small number of affected patients, these courses are likely to be due in particular to severe epicondylitis.

Even though the effects were much stronger in group 1, almost all parameters showed relatively slight effects of treatment in the first two weeks of treatment. They become increasingly more pronounced only after this latency period. However, it must be assumed that the effects of treatment subside again beyond the sixth week of treatment, since the average duration of treatment in group 2 was 9.6 ± 2.3 weeks. Owing to the very much less pronounced effect of treatment in group 1, these patients afterwards received continued treatment with the combination therapy of group 2 in accordance with our prospective implementation criteria. The average duration of treatment in these cases was 18.2 ± 8.3 weeks.

Four patients of group 1 and two patients of group 2 did not attain any

symptom-free routine everyday function, so that treatment in these patients (10% of the overall population) is to be considered as unsuccessful according to our efficiency criteria.

In the subsequent two-year observation period, 44 patients from the total patient population (73.3%) remained asymptomatic. Six patients (10%) had one recurrence and four patients (6.7%) had two or more recurrences that could be treated conservatively. The remaining six patients (10%) were our therapy failures and had to be treated surgically. Of these, two patients were not free of symptoms even after the operation and one patient was retired early for this reason.

DISCUSSION

Clinically, pain and pain-dependent functional impediments are doubtless most prominent in epicondylitis. Since this is primarily a degenerative local soft-tissue disease, it does not have any systemic clinical test parameter. For this reason, exclusively subjective parameters are available for objective evaluation of therapeutic effects. However, taken together in particular with regard to their progress characteristics they are represent (Hotchkiss 2000). They also allow quantitative appraisal of this pain syndrome (Benjamin et al 1999, Deveraux and Hazleman 1984, Hotchkiss 2000, Kurvers and Verhaar 1995, Pienimäki et al 2002, Piligian et al 2000). All specific diagnostic parameters were therefore used for multivariate comparison in this study in order to detect possible therapeutic differences in the comparison group. Active elbow movement, differences of circumference of the upper limb, grip strength, pain under provocation tests, pain at rest, pain in

Figure 1: Number of patients with reduced grip strength at the end of six weeks of treatment in the comparison groups.

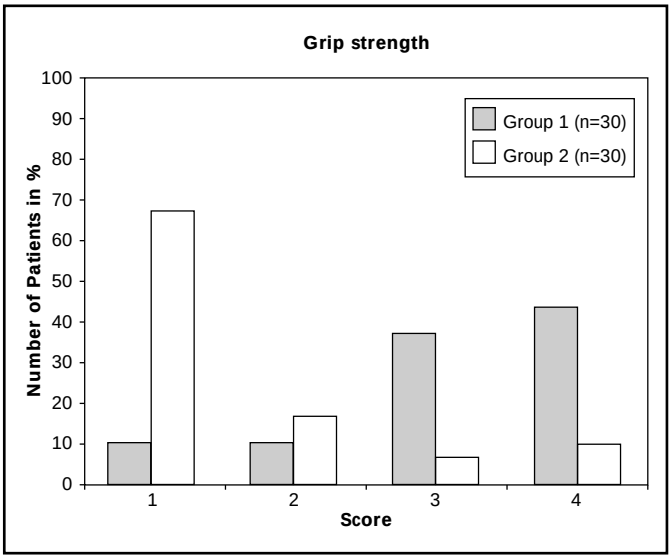


Figure 2: Distribution differences in provocation pain at the end of six weeks of treatment in the therapy groups.

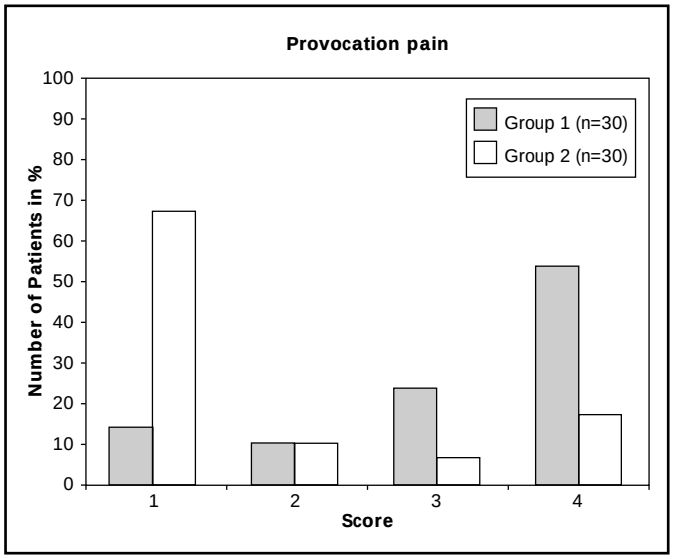


Figure 3: Distribution differences in pain on weight bearing at the end of six weeks of treatment in the therapy groups.

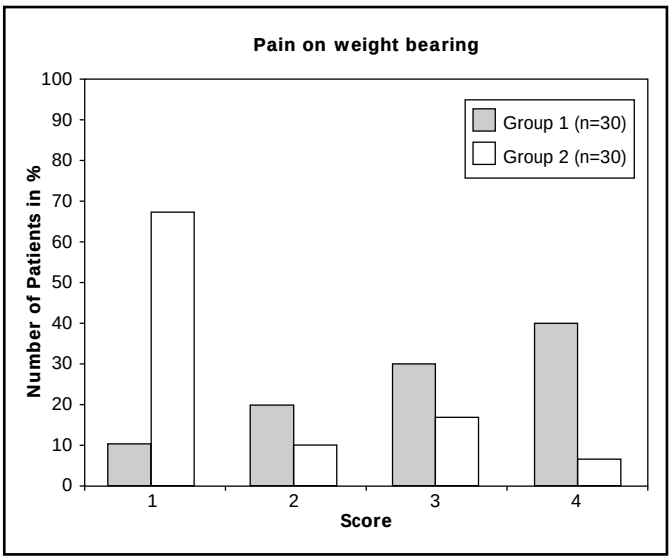
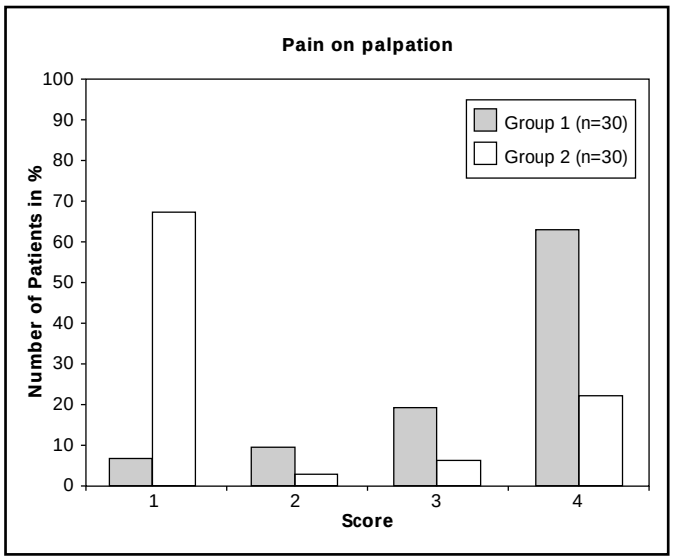


Figure 4: Distribution differences in pain on palpation at the end of six weeks of treatment in the therapy groups.



movements and daily activity were established in the course of treatment and their differences in normalization were compared between the treatment groups. The salient demographic data of the overall patient population in this investigation hardly differs from those described in the literature (Dijs et al 1990, Kurvers and Verhaar 1995, Noteboom et al 1994, Pienimäki et al 2002, Sevier and Wilson 1999). There are sometimes differences in the occupational groups with those engaged in heavy work being represented very much less than was reported in earlier investigations, which indicated that epicondylitis appears to be more frequent in this occupational category. On the other hand, more recent publications (Piligian 2000) already indicate that occupational features as well as sport strain have recently become less prominent than other characteristics, in particular recreational activities. It is probable that qualitative overstrain plays a greater role under the technologically more sophisticated working conditions of the present day. However, such differences are hardly likely to affect the acute course of the disease and its treatment.

Different distributions of the other initial baseline criteria in the comparison groups would be of crucial importance for our treatment study, since they influence the course of the disease. However, they are homogeneously distributed in the two comparison groups. For this reason, differences in the development in the comparison groups during treatment must be attributed to their effect. Distinct divergences between the therapy groups are already shown after two weeks of treatment for all test parameters. A very much more pronounced and more rapid regression of all clinical symptoms took place in group 2. The greater intensities manifested in the provocation tests at the beginning of treatment are entirely consistent with clinical experience. The movement pain in load removal and rest pain are correspondingly less. These were only rarely permanent and in most instances do not affect all patients. However, their manifestation is likely to involve especially pronounced disease courses, which are the more difficult to influence. The slower regression of these disease characteristics (Fig. 11 and 12) in our treatment course is doubtless attributable to this.

All test parameters show a typical time course. Initially, they show no or only slight effects of therapy in the first two weeks. The time course of the clinical effect is thus the opposite of what is usually encountered in pharmacotherapy. This observation is evidently a special feature of many forms of physiotherapy which as reaction therapy are accompanied by delayed onset of action (Lange 2003). Not only for this reason, they therefore have to be applied in series and planned as long-term treatment.

This is important in the present context because the kinds of physiotherapy that were used in the prior treatments in this patient population had mostly been switched after one or two weeks owing to reported lack of effect. Consequently, there were deficits in their implementation. The effectiveness of physical forms of treatment is crucially determined by the quality of their implementation (Lange 2003).

Furthermore, the question as to the effectiveness of the treatments employed remains unresolved. There are only a few controlled studies on this topic (Hotchkiss 2000). Strikingly, for most data reported in the literature (Becker and Reuter 1982, Dijs et al 1990, Noteboom et al 1994) the indication criteria for the individual forms of physiotherapy were differentiated hardly at all or only to a small extent. In most cases, analgesia was the prime objective of treatment. Its efficacy in treatment of epicondylitis is mostly appraised positively. This also applies to pharmacotherapy and suggestions for surgical treatment (Hotchkiss 2000, Kurvers and Verhaar 1995, Noteboom et al 1994, Reveille 1997). Such results are likely to be based on insufficient differentiation of inclusion criteria in patients with epicondylitis (Hotchkiss 2000). It is

Figure 5: Distribution differences in movement pain at the end of six weeks of treatment in the therapy groups.

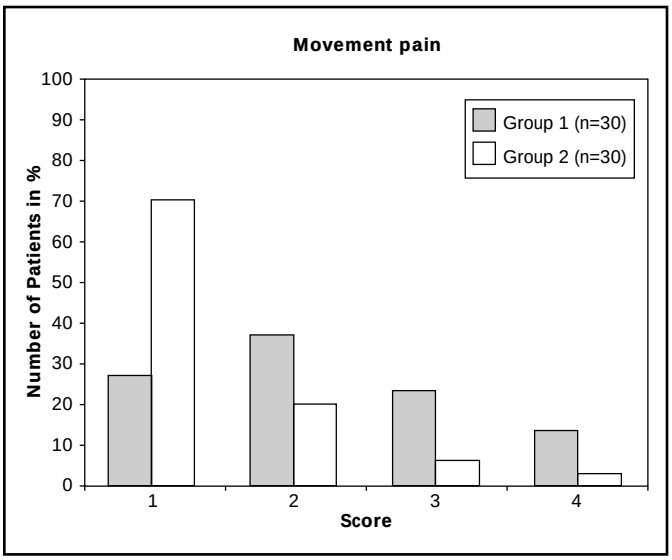


Figure 6: Distribution differences in resting pain at the end of six weeks of treatment in the therapy groups.

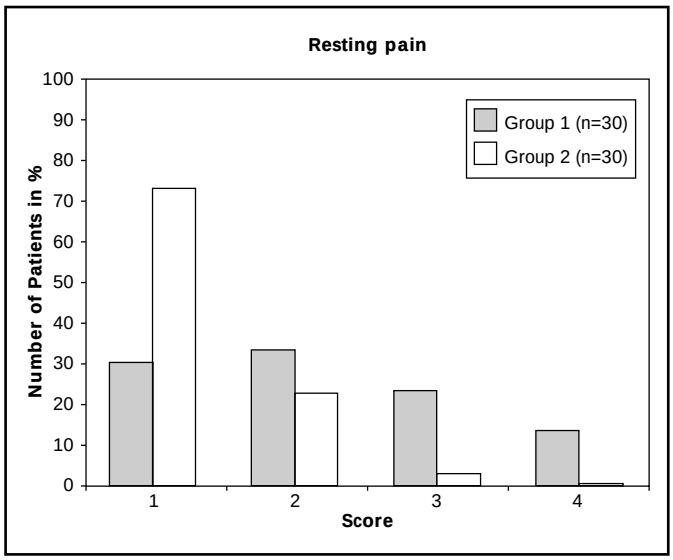


Figure 7: Development of grip strength for the six week-course of treatment in the comparison groups.

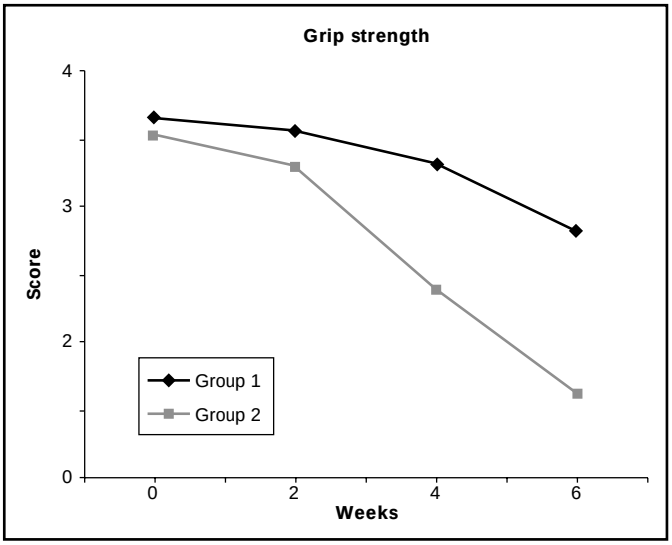


Figure 8: Development of provocation pain for the six week-course of treatment in the therapy groups.

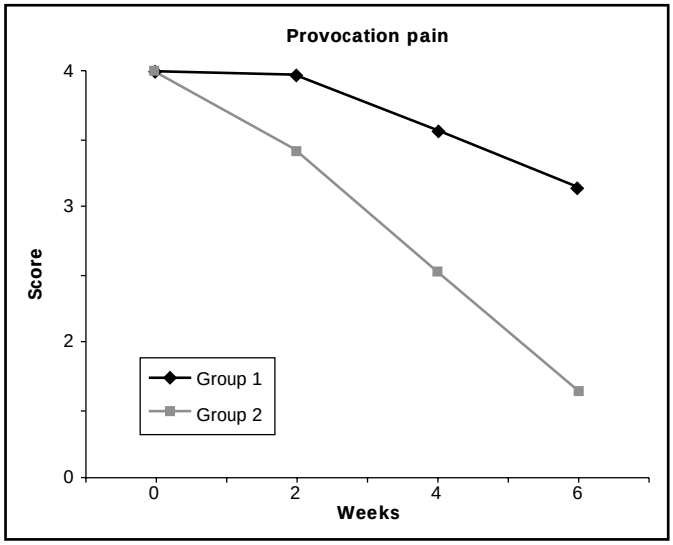


Figure 9: Development of pain on weight bearing for the six week-course of treatment in the therapy groups.

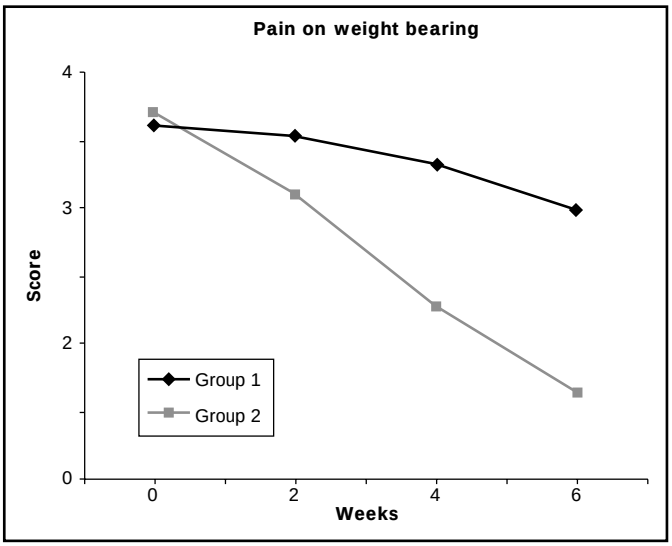


Figure 10: Development of pain on palpation for the six week-course of treatment in the therapy groups.

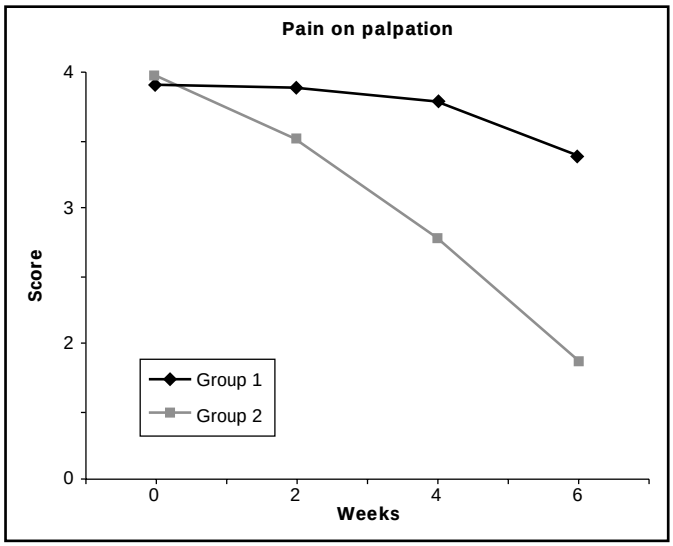


Figure 11: Development of movement pain for the six week-course of treatment in the therapy groups.

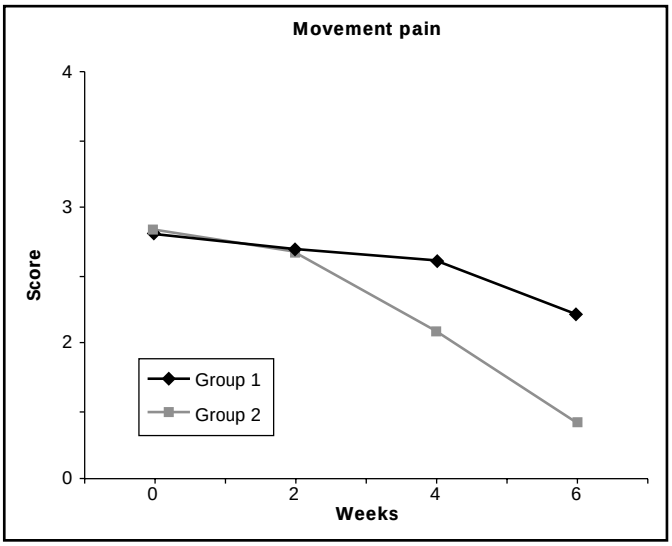
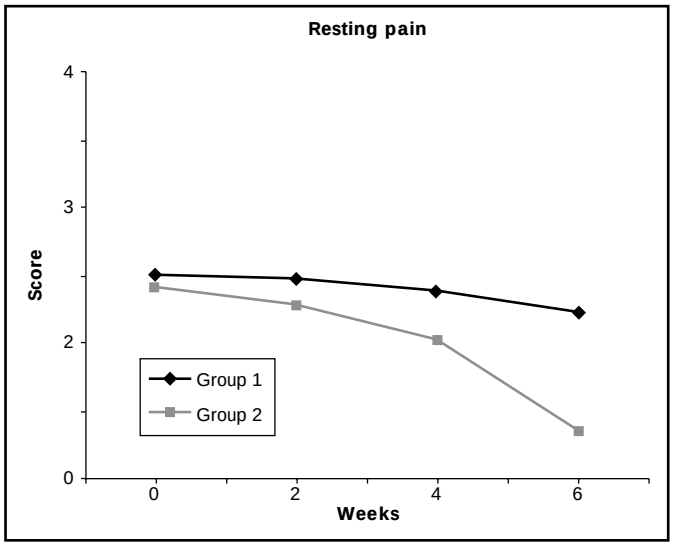


Figure 12: Development of resting pain for the six week-course of treatment in the therapy groups.



known that they tend to show a varying course and partial avoidance of strain in consequence of pain already leads to spontaneous improvement in a high percentage of cases. It is therefore problematical to determine the specific effect of treatment.

In an attempt to rule out such spontaneous improvements in the course, only patients whose disease course was rated as resistant to therapy by at least two independent treating physicians and who showed a chronic course according to the definition were included in this study. The effect of a positive spontaneous course can therefore be ruled out at least for our appraisal phase of six weeks. In addition, such effects are not likely to be significant for the controlled group comparison, because they would affect the course of the disease to an equal extent in both groups given the demonstrated homogeneous distribution of the random sample.

On the other hand, the regression of all clinical functional symptoms was very much more rapid in group 2 than in comparison group 1. After six weeks of treatment, all parameters show significant ($p < 0.001$) group differences. The unequivocal therapeutic superiority of group 2 in which four-cell baths and rising-temperature arm baths were used as combination therapy was already manifested in this early phase compared to group 1 in which interference currents were applied.

Moreover, the result is underscored by the fact that despite the six-week delay in treatment, the patients of group 1 could afterwards likewise be treated successfully with the combination therapy. However, an additional delay effect had to be accepted, since the average treatment time of these patients was 18.2 weeks, and was thus substantially prolonged beyond the first six weeks of treatment. Early use and consistent implementation of combination therapy can therefore additionally improve the overall success of treatment.

Therapeutic effects of interference current therapy in group 1 are doubtless discernible, even though these occurred with a delay in the course of treatment and are demonstrably less than in quantitative terms those in therapy group 2. It is already known from comparative studies (Mucha and Zysno 1984) on the analgesic effect in ischaemic muscle pain that interference current therapy is less effective than hydrogalvanic baths. This is also confirmed in the present condition-specific treatment. Moreover, it must be assumed from investigations published so far (Mucha 1993) that with interference current in contrast to hydrogalvanic baths the increase in blood flow in muscle optimally and tendon tissue is inadequate. The pronounced effect of hydrogalvanic baths on the increase in blood flow is also known and documented in deep tissue layers (Maslov and Smirnov 1993, Sadil and Sadil 1994). It can therefore be assumed that this combination of effects of the four-cell bath in decreasing pain and increasing blood flow are able to influence the pathogenetically inadequate blood flow and supply in the affected tendons and muscles in epicondylitis. There may also be an increase of blood flow in the bone, so that the major sources of blood supply to the tendon are likely to be activated. Consequently, there is probably an improvement in the overall supply of nutrients.

Corresponding effects can be attained with the rising-temperature arm bath. A reaction interval of at least one hour is indispensable since new reaction sequences and thus additive effects can only be expected again after the vascular tonus has normalized. With our application form, an additional local effect of heat (maximum tolerable temperature application) was to be exercised in addition to the vascular stimulus in order to increase the local rate of metabolism in the bradytrophic tendon tissue besides the effects on the contraction ischaemia in the musculature. Moreover, a heat-induced inhibition of proliferation of the connective tissue cells can also be assumed (Schmidt and Hatzfeld 1979). An increased proliferation of the connective tissue cells in the affected tendon areas is also known from morphological investigations (Fassbender 1984). It is probably a result of the relative cell hypoxia.

Since the effects both of the four-cell bath and the rising-temperature arm bath should be able to influence important pathogenetic factors in lateral epicondylitis, we implemented this concept of combination therapy in a first observational study (Mucha 1987). The success attained therefore justifies using this concept of therapy as a reference therapy in the present comparison study. The overall results confirm once more the convincing effectiveness of this concept of therapy with its mainly pathogenetic approach.

The present results show that combination treatment with four-cell baths and rising-temperature arm baths is clearly superior to interference current therapy. The mainly analgesic effect of the interference current (Mucha and Zysno 1984, Sadil and Sadil 1994) is evidently not sufficient for effective treatment of epicondylitis. An attenuation of the effect by habituation can be ruled out in the application of interference current (twice a day) since the progress results of all test parameters show a tendency to regression with increasing length of application, and there are thus no indications for delayed effects which would otherwise be expected.

With some reservations, the distinct differences in effectiveness of the therapy forms used also allow conclusions with regard to possible effects of other forms of physiotherapy. The forms of pretreatment used during the unsuccessful treatment in this test population also did not always fulfill the theoretical conditions for an absolute indication. This is to be assumed above all for cryotherapy and the immobilization in plaster casts. Although cryotherapy has good analgesic effects (Mucha and Zysno 1984), the simultaneous suppression of blood flow and metabolism (Liman et al 1982) are likely to exacerbate the pathogenetic conditions in epicondylitis. Secondary inflammatory reactions in epicondylitis mainly involve proliferative forms of inflammation. However, an effect selection can only be achieved by a pathogenetic and disease-specific adaptation of the forms of therapy. Relief might be attained by plaster cast immobilization, but the question as to concomitant negative immobilization effects on the course of the disease remains unanswered. Vascular dysregulations for example and

insufficient blood supply to bradytrophic tissue associated with this already occur in brief immobilization (Mucha et al 1987). Compared to radical immobilization, however, functional relief is indicated and evidently sufficient by specific monitoring of movement activity in the course of treatment. The results of controlled investigations reported by Little (1984) also indicate that better results cannot be expected from plaster cast immobilization.

The following conclusions can be drawn from our results: with the appropriate qualitative and quantitative implementation criteria (e.g. reaction pause of at least one hour between the individual applications), combination treatment with four-cell bath and rising-temperature arm bath are efficient even in severe chronic epicondylitis and the results that can be attained are entirely comparable to those of surgery (Kurvers and Verhaar 1995, Piligian 2000). This regime should therefore be recommended before deciding to carry out surgery. Ultrasound and iontophoresis have been promoted and are useful treatments. But there is no evidence in the literature to support the use of any of one modality over another (Hotchkiss 2000). More investigation is needed to determine the efficacy.

As a rule there are no major functional impediments in these patients and they are spontaneously reactivated with the reduction of pain, exercise therapy is not necessary during acute treatment. The extent to which it should be used as a secondary prevention measure in the asymptomatic stages must be established individually and depends on the motor deficits actually present (Barry and McGuire 1996). Since the objectives of treatment differ greatly from patient to patient, the establishment of the indication must of course be considered critically since the commencement of unusual activities is the most frequent cause for the manifestation of epicondylitis in this test population.

REFERENCES

Almekinders LC, Temple JD 1998 Etiology, diagnosis, and treatment of tendonitis: an analysis of the literature. Medicine and Science in Sports Science 30:1183-1190

Barry NN, McGuire JL 1996 Overuse syndromes in adult athletes. Rheumatic Disease Clinics of North America 22:515-530

Becker R, Reuter H 1982 Epicondylitis humeri: Diagnose und Therapie. Zeitschrift für physikalische Medizin, Balneologie, medizinische Klimatologie 11:496-501

Benjamin SJ, Williams DA, Kalbfleisch JH, Gorman PW, Panus PC 1999 Normalized Forces and Active Range of Motion in Unilateral Radial Epicondylalgia (Tennis Elbow). Journal of Orthopaedic and Sports Physical Therapy 29:668-676

Devereaux M, Hazleman B 1984 Grip strength as a measure of response to treatment for lateral epicondylitis. British Journal of Rheumatology 23:154-155

Dijs H, Mortier G, Driessens M, De Ridder A, Willems J, De Vroey T 1990 A retrospective study of the conservative treatment of tennis-elbow. Medica Physica 13:73-77

Fassbender HG 1984 Strukturelle Ansatzpunkte für eine Behandlung mit nichtsteroidalen Antirheumatika. In: Miehlke K (ed) Fortschritte in der perkutanen Therapie rheumatischer Erkrankungen, pp15-31. pmi, Frankfurt/Main

Hotchkiss RN 2000 Epicondylitis - Lateral And Medial. A Problem-Oriented Approach. Hand Clinics 16:505-508

Kurvers H, Verhaar J 1995 The Results of Operative Treatment of Medial Epicondylitis. The Journal of Bone and Joint Surgery 77:1374-1379

Lange A 2003 Physikalische Medizin, pp l4-14. Springer Verlag, Berlin Heidelberg

Liman W, Fricke R, Taghawinejad M, Bernstein H 1982 Arterielle Durchblutung unter Kryotherapie bei chronischer Polyarthritis. Zeitschrift für physikalische Medizin, Balneologie, medizinische Klimatologie 11:196-201

Little TS 1984 Tennis elbow - to rest or not to rest? Practitioner 228:457

Maslov AG, Smirnov VP 1993 Vliianie transkardial'noi galvanizatsii na sostoianie mikrotsirkuliatornogo rusla periinfarktnoi zony pri eksperimental'nom infarkte miokarda. (The effect of transcardiac galvanization on the function of the microcirculatory bed of the peri-infarct area in experimental myocardial infarct). Bjulleten Ekspimentalnoj Biologii Mediciny 116:85-86

Mucha C 1987 Sind Kombinationsbehandlungen sinnvoll? Therapiewoche 37:3460-3474

Mucha C 1993 Einflufl motorisch erregender Stromformen auf die Unterarmdurchblutung. Physical Therapy 14:9-14

Mucha C, Wieland B, Zysno EA 1987 Veränderungen der peripheren Durchblutung unter Immobilisation und funktioneller Frührehabilitation. Zeitschrift für physikalische Medizin, Balneologie, medizinische Klimatologie 16:183-189

Mucha C, Zysno EA 1984 Vergleichende Untersuchungen zur analgetischen Wirkung medizinisch-physikalischer Therapieverfahren auf experimentelle ischämische Muskelschmerzen - Teil 1 und 2. Zeitschrift für physikalische Medizin, Balneologie, medizinische Klimatologie 11, 544-557, 1982 und 13, 253-259, 1984

Noteboom T, Cruver R, Keller J, Kellogg B, Nitz AJ 1994 Tennis Elbow: A Review. Journal of Orthopaedic and Sports Physical Therapy 19:357-366

Pienimäki TT, Siira PT, Vanharanta H 2002 Chronic Medial and Lateral Epicondylitis: A Comparison of Pain, Disability, and Function. Archives of Physical Medicine and Rehabilitation 83:317-321

Piligian G, Herbert R, Hearns M, Dropkin J, Landsbergis P, Cherniack M 2000 Evaluation and Management of Chronic Work-Related Musculoskeletal Disorders of the Distal Upper Extremity. American Journal of Industrial Medicine 37:75-93

Reveille JD 1997 Soft-Tissue Rheumatism: Diagnosis and Treatment. The American Journal of Medicine 102:23S-29Sm

Sadil V, Sadil S 1994 Elektrotherapie. Wiener Medizinische Wochenschrift 144:509-520

Schmidt KL, Hatzfeld Th 1979 Zur Wirkung kurzdauernder heifler B‰oder auf experimentell ausgelöste Entz¸ndungen. Zeitschrift für Physikalische Medizin 8:145-148

Sevier TL, Wilson JK 1999 Treating Lateral Epicondylitis. Sports Medicine 28:375-380