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Pain Alleviation by Vibratory Stimulation

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Summary

In the present study 366 patients suffering acute or chronic musculoskeletal pain of different origin were given vibratory stimulation for the pain. Many of the patients had previously had treatments of various kinds without satisfactory relief. The effect of vibratory stimulation was assessed during and after stimulation using a graphic rating scale. Sixty-nine per cent of the patients reported a reduction of pain during vibratory stimulation. The best pain reducing site was found to be either the area of pain, the affected muscle or tendon, the antagonistic muscle or a trigger point outside the painful area. In most patients the best pain reducing effect was obtained when the vibratory stimulation was applied with moderate pressure. To obtain a maximal duration of pain relief the stimulation had to be applied for about 25-45 min.

Introduction

A great number of methods have been used to relieve or diminish the pain arising from muscles, tendons or fascia. In general these methods provide only temporary and partial relief of pain. Many of them involve stimulation of skin receptors by rubbing or massage, application of heat or cold, or the use of transcutaneous electrical nerve stimulation (TENS) [2,5,6,13,27]. Still another technique by which pain relief may be obtained is mechanical vibratory stimulation. Although this method appears to have been widely used, its practical implications have not been systematically studied except for patients suffering acute or chronic orofacial pain [16,23].

The aim of the present study was to evaluate the effects of vibratory stimulation in patients suffering musculoskeletal pain using a scheme presented in Table I. Preliminary results have been presented earlier.

TABLE I
SCHEME OF THE STUDY

I.	Vibratory stimulation trials; different sites are stimulated to determine the best pain reducing site
II.	Vibratory stimulation sessions; stimulation is applied to the best pain reducing site to determine the optimal <ul style="list-style-type: none"> (a) duration of treatment (b) stimulus application (c) stimulation frequency
III.	Vibratory stimulation in comparison with TENS
IV.	'Placebo' vibratory stimulation

Material and Methods

The pain reducing effect of vibratory stimulation was studied in 366 patients (164 males, 202 females) of whom 129 suffered from acute and 237 suffered from chronic pain due to a variety of disorders (Table III). The age range of the patients was 14–73 years (Fig. 1). The patients with acute pain had had pain for less than 14 days while the patients with chronic pain had been suffering for 6 months to 11 years. The patients who had been suffering from pain for 14 days to 6 months were omitted. The patients were admitted from clinics for physical medicine, medical rehabilitation, medicine, neurology or orthopedic surgery where they had been examined and diagnosed. All chronic pain patients had previously been subjected to different therapies, which had resulted in minor, unsatisfactory alleviation of pain.

Before treatment the patients were asked to describe the location of their pain and its characteristic qualities, using a modified McGill Pain Assessment Questionnaire originally described by Melzack [17]. They were also asked to report drug intake, intake of alcohol, smoking habits, activity levels, changes in pain intensity in relation to daily behavior patterns and what made the pain increase or decrease. The intensity of the pain was rated using a 7-grade adjectival scale: 0 — no pain, 1 — light pain, 2 — light to moderate pain, 3 — moderate pain, 4 — moderate to severe pain, 5 — severe pain and 6 — excruciating pain. Fig. 2A illustrates the initial distribution of the subjective pain intensity rated by the patients on the adjectival scale. The patients also rated their subjective pain intensity before stimulation using a visual analogue scale consisting of a 10 cm horizontal line: the left end represented 'no pain' and the right end 'the worst pain ever.' Fig. 2B illustrates the distribution of the subjective pain intensity before the first trial rated by the patients on the visual analogue scale. The visual analogue scales were afterwards divided into 1 cm intervals to allow a graphic representation of the scores.

During stimulation the patient rated the subjective pain intensity using a graphic rating scale consisting of a lever attached to a linear potentiometer, connected to an ink-writer that was out of sight of the patient [16,23]. The patient was instructed to move the lever from zero position (indicating the subjective pain intensity before the start of the stimulation) to one side when pain was reduced and to the opposite

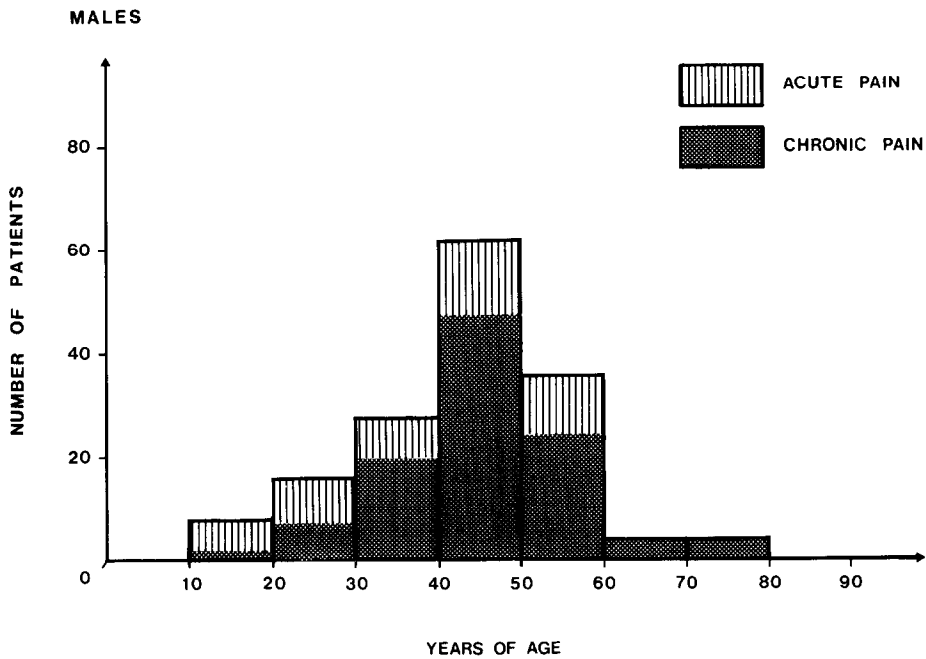
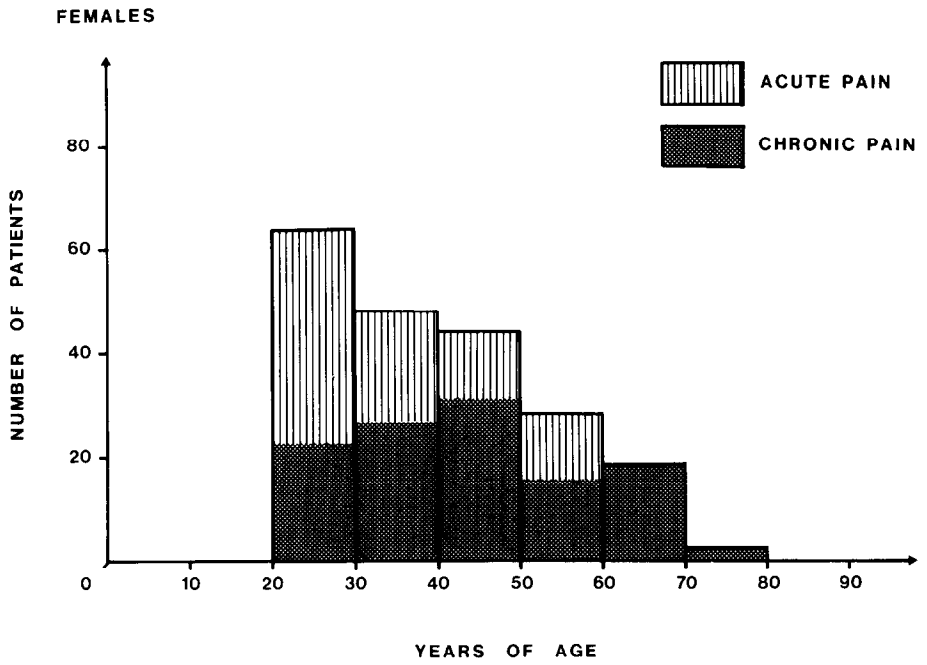


Fig. 1. Age distribution of patients.

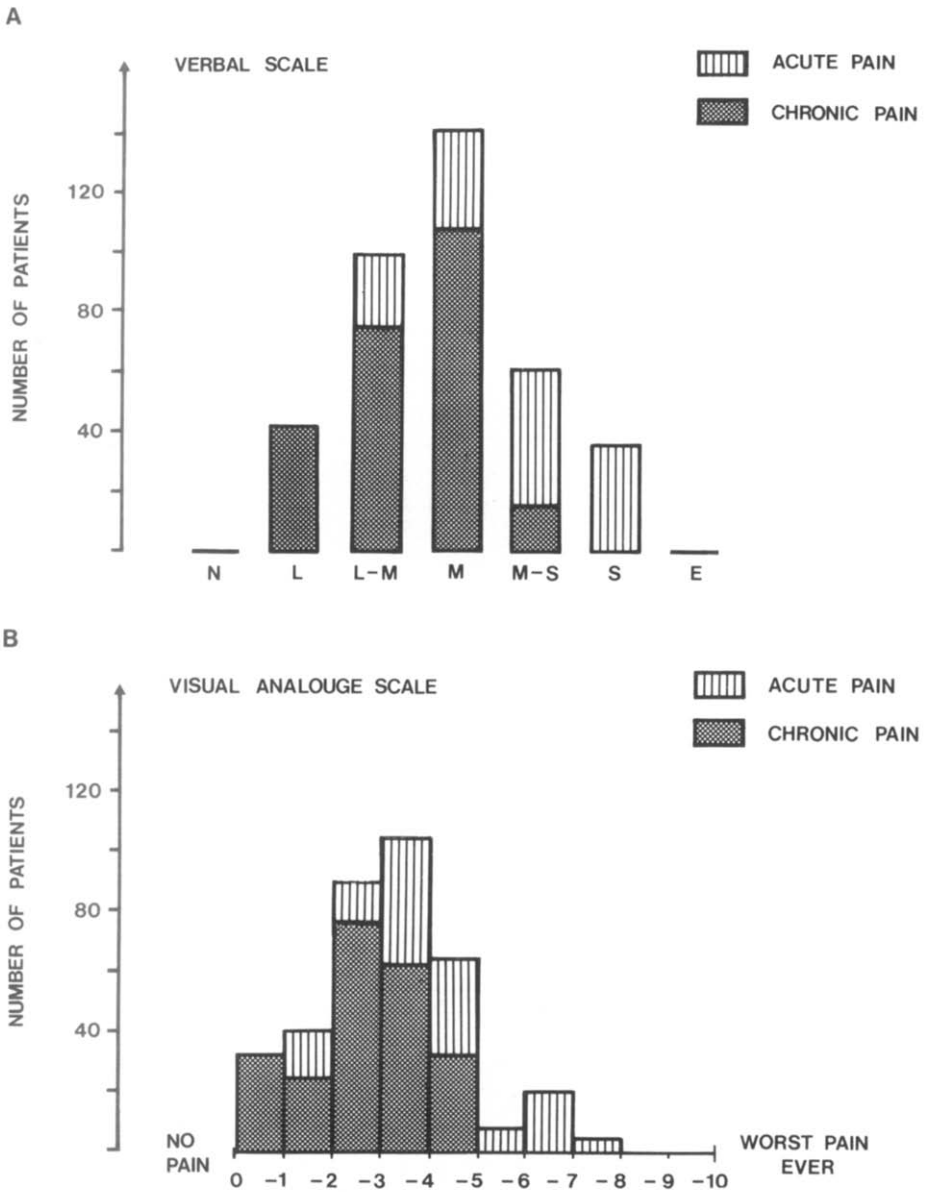


Fig. 2. A: distribution of subjective pain intensities at the first visit of the patients, rated on the adjectival scale. No pain (N), light pain (L), light-to-moderate pain (L-M), moderate pain (M), moderate-to-severe pain (S), excruciating pain (E). B: distribution of subjective pain intensities at the first visit of the patients, rated on the visual analogue scale.

direction if pain increased in intensity. No verbal communication took place with the patient during stimulation.

After stimulation the patient was again asked to rate the pain intensity on the

adjectival and the visual analogue scale. The reason for using 3 pain intensity scales was to allow a comparison with the pretreatment pain intensity scores and the rated pain reducing effect of a treatment, thereby minimizing a scale related effect. The patients were instructed not to take analgesics less than 24 h before treatment or not until pain had returned to its prestimulation intensity.'

The patients received 6 trial stimulations (see below) during the first 2 weeks and during subsequent weeks they received 2–3 sessions per week. The patients suffering from acute pain were treated for a period of less than 3 months. The total number of treatments varied in general from 13 to 36 per patient (6 trials and 7–30 sessions).

Technique used for vibratory stimulation

During the trial stimulations the patients were treated by a specially constructed vibrator producing vibrations at 100 Hz. The vibrator had a small foam rubber covered probe (6 cm²), which was applied with a constant pressure continuously monitored throughout the application. During the treatment sessions, vibration was delivered by an electromechanical vibrator (Bruel and Kjaer, 4809) driven by a generator (Bruel and Kjaer, 1047) the signal of which was amplified by a power amplifier (Bruel and Kjaer, 2706). Before starting a session the amplitude (300 μ m peak to peak) [cf. 23] of the movements of the vibrator probe was measured by a piezoelectric accelerometer (Bruel and Kjaer, 4367) connected to an amplifier (Bruel and Kjaer, 2626). The accelerometer was interposed between the moving coil of the vibrator and the stimulus probe.

'Placebo' stimulation was conducted by disconnecting the probe of the vibrator, i.e., the stimulator produced its characteristic humming sound [21] without transmitting any actual vibrations to the patient. It was also possible to increase the sound of the 'placebo' vibrator and this was used as an additional test in most patients. During the home treatment sessions a commercial vibrator was used.

Stimulation trials

All patients were subjected to 6 trial stimulations in which the best site for pain alleviation was looked for. The stimulus was applied to the points described in Table II. A trial session lasted for about 2 h during which vibration was applied to 8 different points of the body. Each point was stimulated for 10 min and if stimulation reduced the pain, no further trial was carried out until the pain had returned to its prestimulation intensity. The 6 trials were carried out during a period of 2 weeks with the assistance of physiotherapists.

In all patients a 'placebo' trial was conducted using a vibrator with a disconnected probe. During the 'placebo' trial the same procedure was used as during a trial of vibratory stimulation. Fifty-seven per cent of the patients received the 'placebo' trial on their first visit, the other 43% received the 'placebo' trial on their second or third visit. During the 'placebo' trial stimulation was applied to AA-HH (see Table II).

Treatment sessions

Site of treatment

To assess if the best pain reducing site as obtained during a trial of vibratory stimulation was really the site that produced the best pain reduction during treatment, 42 patients suffering from chronic pain (12 epicondylitis, 18 tendinitis, 12 low back pain patients) were subjected to treatment sessions (see below) to all sites that had produced a significant ($> 20\%$ pain reduction) alleviation of pain during a trial.

Duration of treatment

To determine if there was a relation between the duration of vibratory stimulation and pain reduction, the stimulus was applied during two sessions for varying periods of time to the point where the best pain reducing effect had been obtained during the trials (see Results). During a treatment *session* the same point was stimulated for 45 min. If no best point was obtained vibratory stimulation was applied to the most painful area. During these two sessions all patients were stimulated with vibratory

TABLE II

SITES OF APPLICATION DURING TRIALS OF VIBRATORY STIMULATION

A.	Vertex of the skull
B.	10 cm to the right of the spinal process of the 7th cervical vertebra
C.	10 cm to the left of the spinal process of the 7th cervical vertebra
D.	10 cm to the right of the spinal process of the 7th thoracic vertebra
E.	10 cm to the left of the spinal process of the 7th thoracic vertebra
F.	10 cm to the right of the spinal process of the 3rd lumbar vertebra
G.	10 cm to the left of the spinal process of the 3rd lumbar vertebra
H.	Coccyx
I.	Lateral side of right calcaneus
J.	Lateral side of left calcaneus
K.	Sternal angle
L.	Lateral side of right head of humerus
M.	Lateral side of left head of humerus
N.	Right tuberosity of tibia
O.	Left tuberosity of tibia
P.	Right medial epicondyle
Q.	Left medial epicondyle
R.	Right lateral epicondyle
S.	Left lateral epicondyle
AA.	To the site of pain
BB.	Proximal to the site of pain
CC.	Paravertebrally (2–3 cm laterally) over a nerve root related to the site of pain
DD.	At a trigger point near the area of pain [20]
EE.	At the area contralateral to the point of pain
FF.	At an acupuncture point near the area of pain [20]
GG.	Along the affected muscle or tendon
HH.	To the antagonistic muscle

stimulation for 1, 5, 10, 15 and 45 min. The first session was started by applying the vibratory stimulation to the best pain reducing point for 1 min. When the subjective pain intensity had reached its prestimulation value as assessed from the graphic rating scale, stimulation was again applied, this time for 5 min. The same procedure was used when the vibratory stimulation was applied for 10 and 45 min. The second session was started by applying the vibrator to the best pain reducing site for 1 min. When the subjective pain intensity had reached its prestimulation value as assessed from the graphic rating scale, stimulation was again applied, this time for 15 min. The same procedure was used when the vibratory stimulation was applied for 45 min.

In 28 patients periods of 60–90 min of vibratory stimulation were also tried.

Stimulus application

During the treatment sessions, two different application pressures were tried; a light pressure at which mostly superficial tissues were stimulated and a moderate pressure at which contact was achieved with the underlying bone. Also two different modes of applications were used, one with a probe having an area of 6 cm² and one with a cushion, the area of which was 200 cm², both being covered with foam rubber. In this way 4 alternative combinations were tested; (i) light pressure — small probe, (ii) light pressure — cushion, (iii) moderate pressure — small probe and (iv) moderate pressure — cushion.

Stimulation frequency

In order to determine if there was a best pain reducing frequency, 37 chronic pain patients (16 epicondylitis and 21 tendinitis), who had reported a reduction of pain during the trials with 100 Hz stimulation, were subjected to stimulation using 9 frequencies (20, 50, 100, 150, 200, 250, 300, 350 and 400 Hz). The small probe (6 cm²) was used during these sessions, as many of the patients had defined trigger points.

'Placebo'

All patients received a 'placebo' stimulation treatment after the trial sessions. The 'stimulus' was applied to the points where the best pain reducing effect had been obtained for 45 min. Twenty-eight patients who had obtained a pain reduction exceeding 50% during a 'placebo' treatment session were given a 'placebo' vibrator (see Methods) for daily home treatment. The patients were instructed to stimulate the best pain reducing site for 45 min each time for a period of 30 days and to estimate their pain intensity as described above.

Comparison with TENS

Forty-two of the chronic pain patients who had not previously been subjected to TENS received 2 treatments with high frequency TENS and 2 treatments with low frequency TENS for comparison with vibratory stimulation.

Treatment with high frequency TENS

The TENS apparatus (CEFAR SIII, Lund, Sweden) produced monopolar square

waves of pulse duration 0.2 msec, frequency 100 Hz. The electrodes were of rubber with an area of 16 cm². The stimulus intensity was 2–3 times perception threshold and just below the pain threshold [3]. In order to determine the best pain reducing site the stimulation was applied for 10 min, to the following points [19,20]: the area of pain, the peripheral nerve, a point proximal to the painful area, the related nerve roots paravertebrally, a trigger point near the area of pain, a contralateral point, an acupuncture point near the painful area. The stimulation was then applied to the best pain reducing site for 45 min. If no pain reducing site was found, the stimulus was applied to the most painful area [19].

Treatment with low frequency TENS

The TENS apparatus (CEFAR SIII) produced trains of monopolar square wave pulses with a duration of 0.2 msec. Each pulse train (8 pulses) had a total duration of 84 msec and was delivered at 2 trains/sec (2 Hz). The intensity was adjusted to 3–5 times the perception threshold which produced muscular contractions in the stimulated area [3].

Results

Fig. 3. illustrates the general procedure used. The patient, a 41-year-old man, had been suffering for 9 months from epicondylitis (tennis elbow) of his right lateral epicondyle. Previous treatments included ultrasound, high frequency TENS, low frequency TENS and 3 injections of hydrocortisone. These treatments had produced only short-lasting pain relief. 'Placebo' control by application of the vibrator (without any vibratory stimulation) on the right shoulder had no effect on the pain and was discontinued after 10 min. Application of vibratory stimulation to most points as indicated in Fig. 3A had no effect on the patient's pain while some pain reducing effect was obtained at other points. When stimulation was applied over the right lateral epicondyle the patient at first indicated an increase of pain. However, the pain soon began to diminish and after 10 min of stimulation pain was reduced to about 60% of its original intensity. After cessation of vibration pain returned within 4 min to its initial intensity. By prolonging the stimulation a more long-lasting effect could be obtained (Fig. 3B). After 45 min of stimulation over the lateral epicondyle the patient was relieved of pain for about 4 h.

The observations made on this patient illustrate some interesting facts common to all patients in the present study. The effect obtained with vibratory stimulation always varied from one point of stimulation to another and there was usually a best site at which stimulation had a greater pain reducing effect than at all other tested points. The pain reducing effect obtained at the best site was reproducible.

Stimulation site

Fig. 4 illustrates the distribution of the points of the patients whose pain was alleviated by vibratory stimulation. The epicondylitis pain patients reported that the best site was located in or close to the painful area or at the antagonistic muscle or

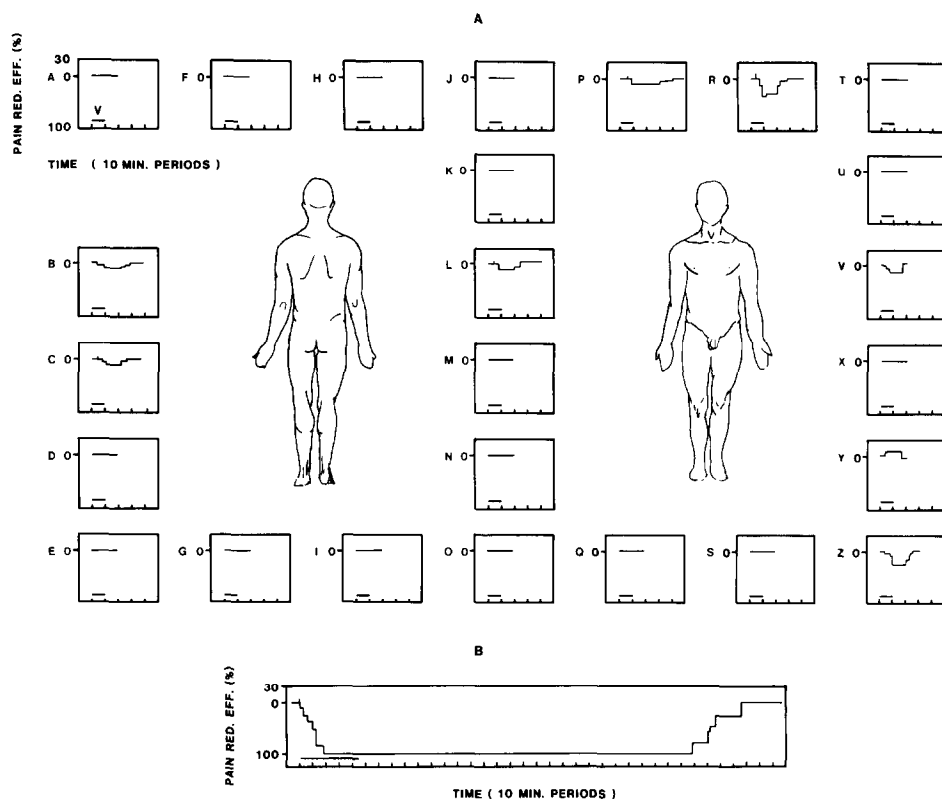


Fig. 3. Records obtained from trial stimulation (A) at different points in a patient suffering chronic epicondylitis pain in the right arm. Record B shows the effect of prolonged (45 min) stimulation of the right lateral epicondyle. During the trials the vibratory stimulation was applied for 10 min to the following sites: vertex (A), 10 cm to the right of the 7th cervical vertebra (B), 10 cm to the left of the 7th cervical vertebra (C), 10 cm to the right of the 7th thoracic vertebra (D), 10 cm to the left of the 7th thoracic vertebra (E), 10 cm to the right of the 3rd lumbar vertebra (F), 10 cm to the left of the 3rd lumbar vertebra (G), coccyx (H), right calcaneus (I), left calcaneus (J), sternal angle (K), right head of humerus (L), left head of humerus (M), right tuberosity of tibia (N), left tuberosity of tibia (O), right medial epicondyle (P), left medial epicondyle (Q), right lateral epicondyle (R), left lateral epicondyle (S), over the right extensor carpi radialis muscle (T), 10 cm proximal to the site of pain (U), a trigger point just outside the area of pain (V), right Ho'Ku point (X), the extensor carpi radialis longus tendon (Y), the flexor carpi radialis muscle (Z). The pain reducing effect is given in each record. Abscissa, time in minutes; ordinate, subjective pain intensity; zero indicates pain intensity before vibratory stimulation. Downward deflection, pain reduction, 100% indicating complete relief of pain. Upward deflection, increase in subjective pain intensity. Horizontal bars, duration of vibratory stimulation.

tendon. In patients suffering from tendinitis pain the best site was located in the painful area, at a trigger point near the area of pain or at the antagonistic muscle or tendon. The patients suffering from pain due to arthritis or peripheral nerve lesion reported that the best site was located in or close to the painful area, proximal to the painful area or at the area contralateral to the point of pain.

subjected to stimulation applied to acupuncture points [22] a marked reduction of pain was only seen when a site near or related to the area of pain was stimulated.

Stimulation duration

There was a clear relationship between the duration of stimulation and the pain reducing effect and duration, illustrated in Fig. 5. When vibration was applied for periods of 1, 5, 10 or 15 min respectively, the poststimulatory pain relieving effect was relatively brief. By prolonging the stimulation, a more pronounced and long-lasting effect could be obtained. After vibratory stimulation for 45 min pain did often not return until after several hours (see below). However, vibratory stimulation for more than 45 min (60–90 min) did not prolong the poststimulatory duration of pain relief.

Stimulation effects

Several modes of vibratory stimulation compared light versus moderate pressure, a small probe versus a cushion and placebo versus vibratory stimulation: stimulation was applied for 45 min to the best point. If no best point was found the stimulation was applied in the most painful area in the following sessions. During the first treatment session of vibration (100 Hz), stimulation was applied at light pressure, using the small probe (6 cm²). In the patients who experienced pain relief during the first treatment session, pain usually began to diminish in less than 10 min (Fig. 6) after beginning of stimulation. Fifty-six of the 64 patients suffering acute pain

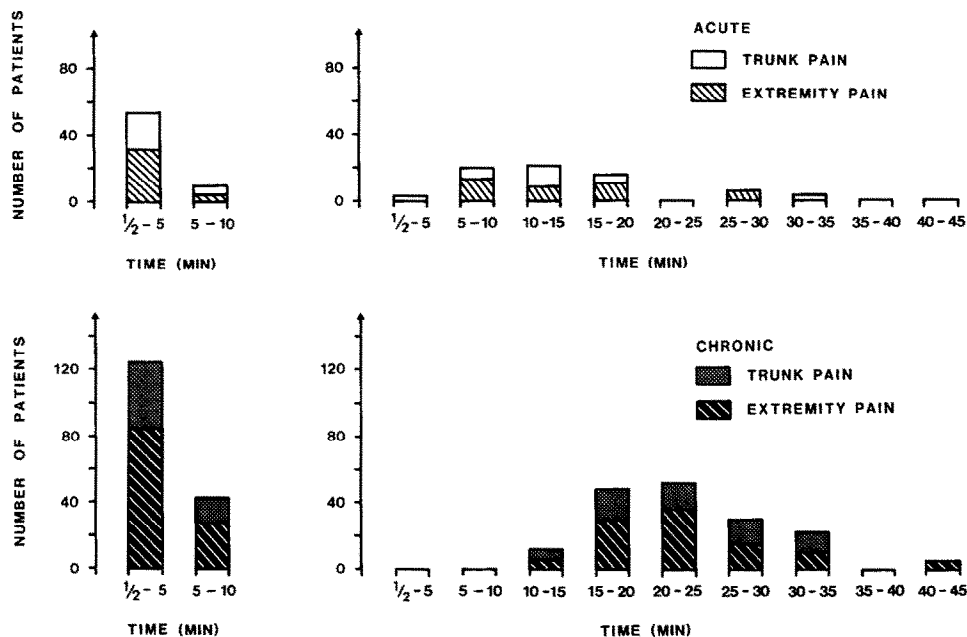


Fig. 6. Time for first subjective pain reduction (left side diagrams) and for maximal obtained subjective pain reduction (right side diagrams).

experienced maximal pain relief within about 20 min. Eight of the patients obtained maximal pain reduction after 25–35 min. Of the 156 chronic pain patients having pain relief during the first treatment session, all required more than 10 min of treatment to obtain maximal pain reduction. Of these patients 54 required more than 25 min of stimulation. In several patients, during subsequent treatment sessions it was observed that a shorter time of stimulation was needed to obtain a maximal pain reduction when moderate pressure was used.

From Table III it can be seen that 64 (28 trunk and 36 extremity pain patients) of the 129 patients suffering from acute pain and 156 (53 trunk and 103 extremity pain patients) of the 237 patients suffering from chronic pain experienced pain relief during the first treatment. All the patients who reported an alleviation of pain during the first treatment session reported a reduction of 20% or more as assessed from the graphic rating scale and the visual analogue scale. As illustrated in Fig. 7, 142 patients had a pain reduction of more than 50% and 58 patients (20 acute and 38 chronic pain patients) reported complete relief of pain.

It is interesting to note that 22 of the patients reporting complete relief of pain at one point reported an increase of pain at another point during the preceding trials. In 88 patients (40 acute and 48 chronic pain patients) the pain reduction was 50% or

TABLE III
NUMBER OF PATIENTS SUFFERING ACUTE OR CHRONIC PAIN WHO WERE TREATED WITH VIBRATORY STIMULATION AND NUMBER OF PATIENTS WHO EXPERIENCED PAIN REDUCTION DURING THE FIRST TREATMENT SESSION

The patients are grouped according to their pain syndrome.

Clinical pain syndrome	Acute pain		Chronic pain	
	No. of patients		No. of patients	
	treated	pain reduced	treated	pain reduced
<i>Extremity pain</i>				
Epicondylitis	29	16	48	34
Tendinitis	34	18	31	24
Neuralgia	–	–	28	22
Bursitis	4	2	–	–
Arthritis	–	–	37	19
Diabetic neuropathy	–	–	8	2
Phantom limb pain	–	–	2	2
<i>Trunk pain</i>				
Wryneck	12	7	2	2
Myalgia	6	5	12	10
Tendinitis	3	2	–	–
Low back pain	41	14	40	25
Cervical spondylosis	–	–	21	10
Arthritis	–	–	8	6
Total	129	64	237	156

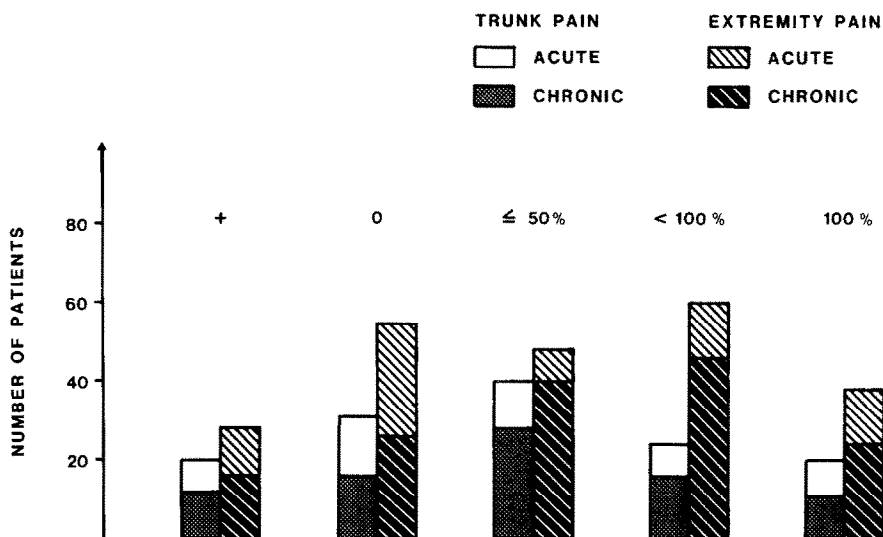


Fig. 7. Effects of vibratory stimulation (100 Hz) on subjective pain intensity. Pain increase (+), no change in pain intensity (0), pain reduction 50% or less ($\leq 50\%$), pain reduction more than 50% and less than 100% (<100%), complete relief of pain (100%).

less and 136 patients reported no reduction of pain, and 48 of the pain patients (20 acute and 28 chronic pain patients) reported an increase, some of the patients who at first did not obtain any pain relief did do so at a following session when the stimulation was applied at a slightly greater pressure. Altogether 254 out of the 366 patients using vibration experienced a reduction of the pain (73 acute and 18 chronic pain patients). Thirty-four patients of these patients were completely relieved of pain so they discontinued treatment. There were 16 patients who stopped the treatment as it increased their pains.

Duration of pain relief

The duration of pain relief was reported by the patients after each treatment (see Methods). The scores after the first treatment (45 min) are presented in Fig. 8.

Most of the patients suffering from acute trunk or extremity pain, or chronic extremity pain experienced pain relief lasting for 3 h or more. Many of the patients had pain relief lasting for 12 h or more. In the patients suffering from chronic trunk pain the duration of pain relief in general was of short duration. In patients who experienced short-lasting pain relief pain was more widespread. The most likely explanation to the short-lasting effect appears to be that (for practical reasons) only a restricted area of the painful region could be stimulated.

There was a positive correlation between the degree and the duration of pain relief. In the patients whose pain was reduced by less than 50%, the pain relief generally lasted less than 6 h while in the patients who experienced pain relief of 50–100% it lasted in general for more than 6 h. In some of the patients the treatment

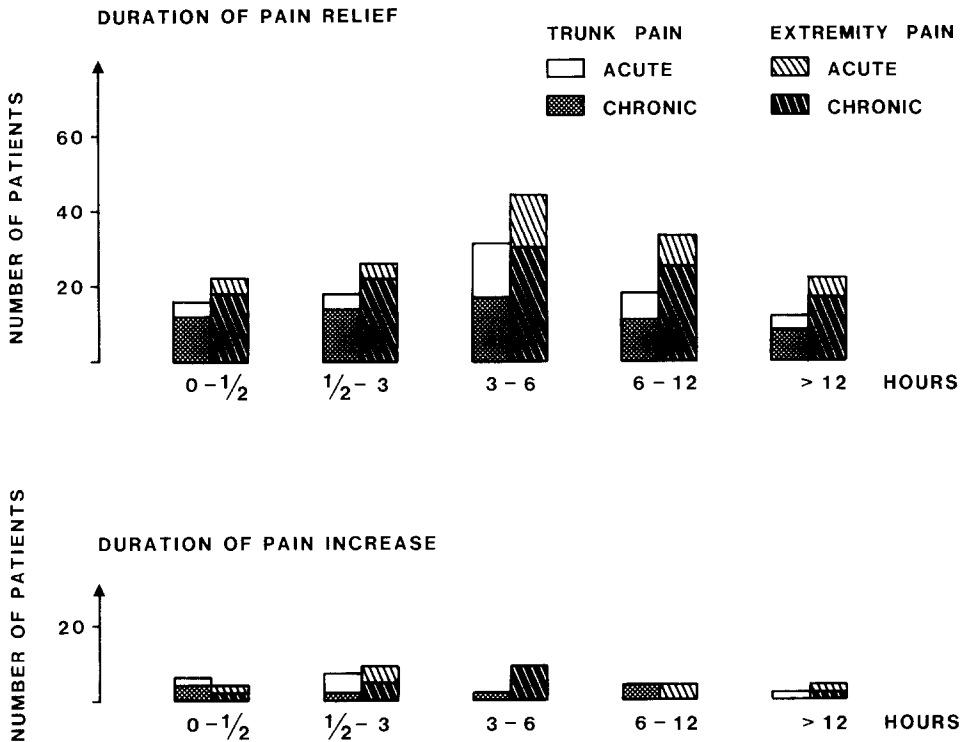


Fig. 8. Duration of pain relief and pain increase after the first treatment (45 min of 100 Hz vibratory stimulation).

caused increased pain. In the lower part of the diagram in Fig. 8 the duration of pain increase is shown.

Pain reducing effect of different modes of vibratory stimulation

In most (about 70%) of the patients suffering chronic pain, except for those who had pain localized to a small area ($< 10 \text{ cm}^2$) or to a trigger point, treatment with the cushion (200 cm^2) had a better pain reducing effect than the small probe (6 cm^2). Also, by using the cushion the duration of pain relief generally increased. Furthermore, 48 patients reported an increase of pain when the small probe was used while only 18 patients experienced an increase of pain when treated with the cushion.

Stimulation frequencies

As described in Methods, all patients suffering from extremity pain received 20 Hz vibratory stimulation at the first treatment session and 50, 100, 150, 200, 250, 300, 350 and 400 Hz at the following treatment sessions. During each session stimulation was applied with light pressure for 35 min. During the last 10 min the pressure was increased, to complete a period of 45 min of stimulation. In a second

series of 9 similar treatments, stimulation was applied with moderate pressure for 35 min, followed by 10 min of light pressure.

The best pain reducing effect (> 50% reduction of pain) was obtained with 100–200 Hz stimulation when a light pressure was used during the initial 35 min (see Fig. 9A) and 50–150 Hz with moderate pressure during the initial 35 min (see Fig. 9B). In many patients frequencies above 200 Hz caused a discomforting radiating sensation, while stimulation at frequencies below 50 Hz had no significant pain reducing effect in most patients.

Most of the patients reported an enhancement of the pain reducing effect when the pressure was increased from light to moderate. This was especially true for the patients stimulated at 150 Hz or less. When a moderate pressure was applied initially for 35 min, an additional 10 min of vibratory stimulation applied with a light pressure did not affect the degree of reduction of pain.

'Placebo' effects

During trial stimulations, 98 out of the 366 patients experienced a reduction of pain with 'placebo' stimulation. In almost all these patients the most effective location of 'stimulation' was the painful area.

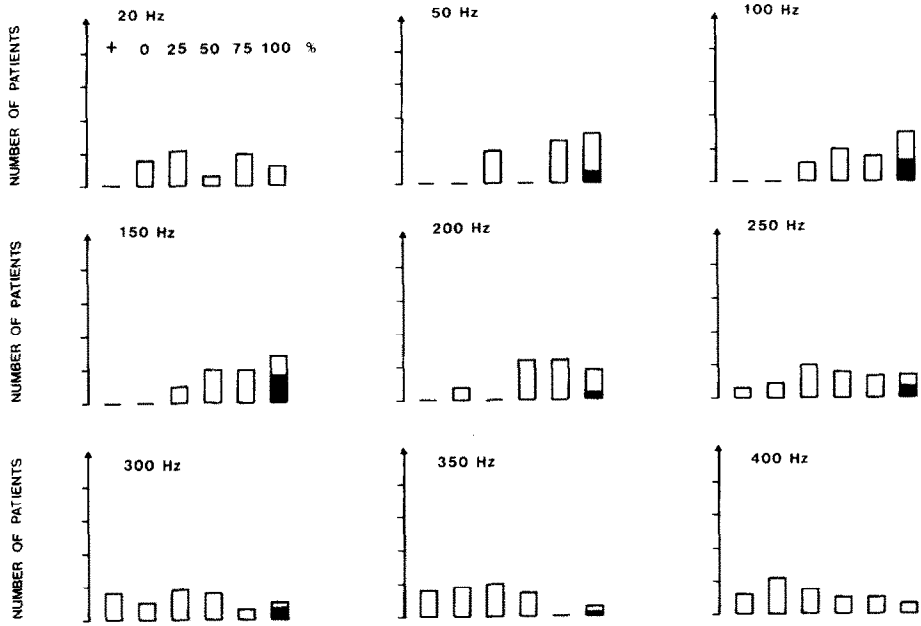
During the 'placebo' stimulation treatment sessions, 122 patients (38 acute and 84 chronic pain patients) reported a reduction of pain. Eighty-seven per cent of the patients who obtained an alleviation of pain from 'placebo' stimulation reported that the best pain reducing site was in the painful area. Out of the 122 patients who reported an alleviation of pain 42 experienced a pain reduction of more than 50%. The pain reduction in these 42 patients lasted for more than 2 h. A reduction of pain was generally reported within 15 min after the start of 'placebo' stimulation and maximal pain reduction was attained after about 25 min. The patients who obtained a relief of pain during 'placebo' vibratory stimulation usually reported an enhanced pain reduction if the sound emitted by the placebo stimulator was increased. Thirty-seven patients (16 acute and 21 chronic pain patients) reported an increase of pain during 'placebo' stimulation.

In the 28 patients who were given the 'placebo' vibrator to use at home, the pain alleviating effect of 'treatment' was short-lasting. After 2 weeks of home treatment with the 'placebo' vibrator only 9 of the patients reported an alleviation of pain exceeding 50% and after another 2 weeks only 4 patients obtained a pain reduction of 50% or more. Fig. 10 illustrates the effect of vibratory stimulation treatment carried out during a period of 2 months. Also, in Fig. 10 an extrapolation of the results of the 'placebo' vibratory stimulation treatment during a similar treatment interval is shown.

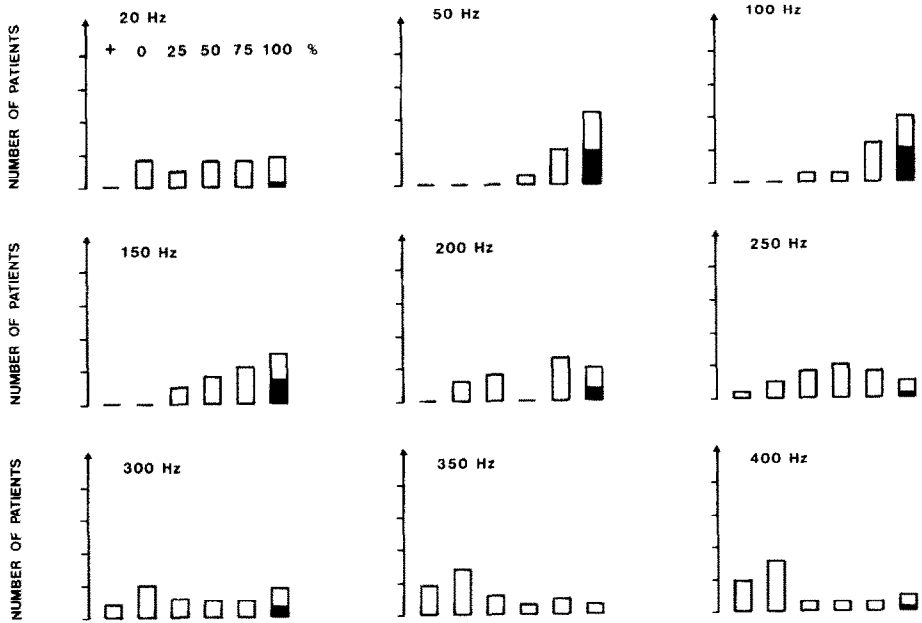
TENS stimulation

The 42 chronic pain patients who had not previously been subjected to TENS received 2 treatments with high frequency TENS and 2 treatments with low frequency TENS to compare these with vibratory stimulation. Table IV presents the number of patients that experienced a reduction of pain after the first stimulation treatment with high frequency TENS, low frequency TENS and vibratory stimula-

A LIGHT PRESSURE



B MODERATE PRESSURE



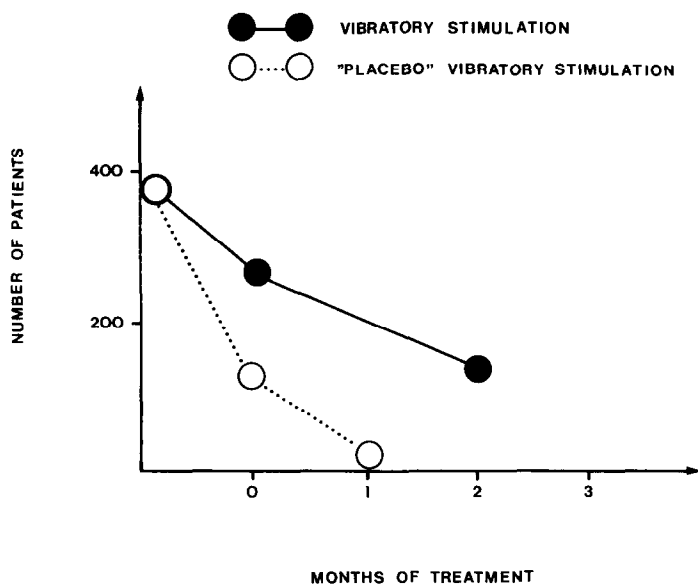


Fig. 10. Number of patients obtaining an alleviation of pain from vibratory stimulation and 'placebo' vibratory stimulation.

TABLE IV

FORTY-TWO PATIENTS WITH CHRONIC PAIN GROUPED ACCORDING TO PAIN SYNDROME AND TREATED WITH VIBRATORY STIMULATION (VS), HIGH FREQUENCY TENS (H TENS) AND LOW FREQUENCY TENS (L TENS)

Clinical pain syndrome	No. of patients treated	No of patients having more than 20% reduction of pain		
		VS	H TENS	L TENS
<i>Extremity pain</i>				
Epicondylitis	12	8	6	3
Tendinitis	9	5	5	3
<i>Trunk pain</i>				
Myalgia	2	2	1	0
Low back pain	13	6	8	9
Cervical spondylosis	6	3	4	4

Fig. 9. Effects of different frequencies and pressures, of 35 min vibratory stimulation on subjective pain intensity in patients suffering chronic extremity pain. Pain increase (+), no changes in pain intensity (0), pain reduction 25% or less (25), pain reduction 25–50% (50), pain reduction 50–75% (75), pain reduction 75–100% (100). Number of patients experiencing total pain relief represented by black areas.

tion. No difference in pain reduction was found between the different treatment sessions using the same mode of stimulation. The results obtained suggest that vibratory stimulation is more effective than TENS in reducing epicondylitis pain while TENS is more effective in relieving patients of low back pain.

As an additional test vibratory stimulation was applied during or after a treatment with TENS. In 11 patients this resulted in a potentiation of the pain alleviation. Interestingly, the 11 patients had obtained a reduction of pain of 40–80% during TENS treatment.

During an additional treatment session the 42 chronic pain patients who had not been subjected to TENS received vibratory stimulation for 45 min. Six out of the 42 patients experienced a potentiation of the pain alleviation when TENS was applied during or after vibratory stimulation treatment. The results taken together appear to suggest that in a limited number of patients it is possible to increase the alleviation of pain by applying more than one mode of stimulation.

Discussion

The strategy for dealing with acute and chronic pain has changed significantly during the last decade. Various modes of electrical stimulation and acupuncture are now used as alternatives to analgesics and surgical procedures. But many patients do not get a relief of musculoskeletal pain using any of these modes of treatment. Previous studies showed that vibratory stimulation was an effective procedure in relieving patients of acute or chronic orofacial pain [16,23]. The present study shows that vibration reduces acute or chronic pain of musculoskeletal origin.

With regard to the placebo effect, several lines of evidence suggest that the long-term pain reduction was not due to placebo effect. Thus pain reduction was only observed at certain sites and there was usually a best point at which vibration had greater effect than at other sites. Also, stimulation at some points added to the pain. Furthermore, home treatment with vibratory stimulation was clearly more effective than home treatment with 'placebo' stimulation (cf., Fig. 10). These findings, taken together, suggest that the long-term pain alleviation was due to mechanisms other than placebo effects. This conclusion draws support from earlier observations showing that vibration causes an elevation in subjective detection threshold of experimental induced pain or itch [19,26].

It has been proposed that activity in large diameter sensory fibers interacts with impulse transmission in pain pathways [9,20], thereby alleviating pain. A relevant question is then what kind of receptive units are excited by the vibratory stimulus. Several studies have shown that superficial and deep cutaneous mechanoreceptors are sensitive to vibratory stimulation [4,14,15,25]. Among the receptors with high sensitivity to vibrations are the Pacinian corpuscles [11,12,14] and the primary endings of the muscle spindle [1,7,8,10]. The observation that more effective pain reduction was obtained when the stimulus was applied with moderate pressure and cushion, so that a large area and underlying tissues were stimulated, might indicate that the pain alleviation could be attributed to activation of Pacinian corpuscles in

connective tissue, ligaments or joints and primary endings of muscle spindles. However, activation of other types of receptors in skin, subcutaneous tissues and bone may also contribute to the effect.

One effect exerted by vibratory stimulation is a depression of the excitability of motoneurons innervating the antagonistic muscle via reciprocal inhibition [7,8]. This may explain the obtained reduction of pain in some patients when vibratory stimulation was applied at a muscle antagonistic to the painful area.

An interesting observation was that vibratory stimulation for 45 min regularly caused a redness of the skin and a feeling of warmth in the stimulated area. It can therefore not be excluded that part of the pain reducing effect may be attributed to autonomic effects.

In summary, the results of the present study show that vibratory stimulation relieved the pain in about 70% of the patients. Vibratory stimulation can easily be self-administered by the patients and used for long-term home treatment. Most patients experienced the best pain reducing effect when vibratory stimulation was applied with moderate pressure using a cushion. However, in patients suffering pain from trigger points or a small area, the most significant pain reduction was experienced when vibratory stimulation was applied using the small probe. The best pain reducing frequencies were found to be between 50 and 200 Hz. To achieve a maximal duration of pain relief stimulation had to be applied for a period of about 45 min. It would therefore appear that vibratory stimulation in many patients suffering from acute or chronic pain merits consideration as a mode of treatment.

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