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Effect of EMG biofeedback compared to applied relaxation training with chronic, upper extremity cumulative trauma disorders

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Summary This study examined the relative effectiveness of EMG biofeedback, applied relaxation training and a combined procedure in the management of chronic, upper extremity cumulative trauma disorder. Forty-eight patients with a history of about 5–6 years of upper extremity pain were randomly assigned to 1 of 4 treatment conditions, namely applied relaxation training, EMG biofeedback, a combined approach or a wait-list control. Treatments were conducted on an individual basis, twice per week for 4 weeks. Patients in all 3 treatment conditions showed significant short-term reductions in pain and psychopathology in comparison to the wait-list group who showed minimal change. Six-month follow-up data were obtained for patients in the treatment conditions, but not the wait-list group. There was some evidence of relapse on measures of depression, anxiety and pain beliefs for treated patients during the 6-month follow-up period, although measures remained significantly below pre-treatment levels for most outcome indices. Self-monitored pain continued to decrease for the treatment groups through follow-up. Contrary to predictions, however, the strongest short-term treatment benefits were shown by patients receiving applied relaxation training on measures of pain, distress, interference in daily living, depression and anxiety. By 6-month follow-up, differences between treatment groups were no longer evident.

Key words: Biofeedback; Relaxation training; Cumulative trauma disorder; Repetition strain injury; Upper extremity pain; Cervicobrachial pain

Introduction

Upper-extremity cumulative trauma disorders (CTDs) refer to a group of musculo-skeletal pain disorders of the upper limbs, neck and shoulders (Putz-Anderson 1988; Keyserling et al. 1993). Such problems are well recognised internationally, being discussed under labels such as repetition strain injury (NOHSC 1986), occupational cervicobrachial disorder (Satow et al. 1988), refractory cervicobrachial pain syndrome (Cohen et al. 1992), and occupational overuse disorder (Swerrissenet al. 1991). These terms do not refer to specific diagnoses as such, but rather are used to summarise the many upper limb pain conditions which are associated with repetitive motion, sustained or constrained postures and/or forceful movements. These disorders include a range of diagnostic conditions such as tenosynovitis, bursitis, tendonitis, carpel tunnel syndrome, and epicondylitis. In addition, many of those with relatively severe and persistent pain lack clear-cut physical pathology and do not fit into current, discrete medical diagnostic groupings. These individuals typically report persistent pain and tenderness following a period of intense repetitive motion work and show varying patterns of symptomatology such as muscle weakness, swelling, reduced temperature in the affected limb(s), skin discolouration, allodynia, hyperalgesia, paresthesia and dysethesia which do not fall neatly into currently accepted medical diagnoses.

Fortunately, the majority of acute CTD cases recover rapidly following periods of rest, redesign of work practices and appropiate medical treatment of

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presenting symptoms (Brown and Dwyer 1987). For some individuals, however, the pain problem persists and the disorder comes to show many of the features of other chronic pain conditions (Feuerstein et al. 1993). A variety of psychological features develop which are less evident in acute cases, including symptoms of depression, anxiety and sick role behaviours (Spence 1990). Such problems indicate the need for a multidisciplinary approach to treatment, of which psychological intervention is an important component. Indeed, cognitive-behavioural interventions have been shown to be of considerable benefit in the rehabilitation of chronic, upper extremity CTD patients (Spence 1989, 1991).

Flor and Turk (1989), in a review of empirical studies, concluded that there is considerable evidence to support the view that many musculo-skeletal pain patients show symptom-specific, elevated muscle tension responses and extended duration of muscle tension during personally stressful situations. This phenomenon was also reported by Moulton and Spence (1992) in a study of musicians with history of upper extremity CTD pain associated with the playing of their instrument. The pattern of site specific muscle hyperreactivity to personally stressful situations was not evident in a pain-free sample of musicians who were matched for age, sex and musical instrument.

If abnormal muscle activity during stressful events plays a role in the maintenance of chronic musculoskeletal pain, then there is a strong case for the development of treatment methods to prevent such responses. Theoretically, it should be feasible to train individuals to identify muscle hyperactivity responses, to recognise the situations in which they occur and to inhibit muscle tension through counter relaxation responses. One method that has been used effectively in the management of chronic low back pain is electromyograph (EMG) biofeedback. Flor and Birbaumer (1993) demonstrated positive benefits from EMG biofeedback with chronic low back pain patients who were provided with feedback about muscle tension levels without any direct instruction in methods of relaxation. These benefits included improvements in psychological adjustment, in addition to reductions in subjective reports of pain.

From a theoretical perspective it is suggested here that, in order to reduce muscle hyperreactivity responses to stressful events in chronic musculoskeletal pain conditions, treatment should aim to (1) teach individuals to be aware of their muscle tension levels, (2) to identify those situations in which muscle hyperreactivity occurs, (3) to use methods of muscle relaxation and (4) to apply these relaxation approaches in real-life stressful situations. When used as a sole treatment method, EMG biofeedback (without any instruction in how to relax) or applied relaxation training (without the use of biofeedback to facilitate awareness of muscle tension levels) should therefore be less effective than a combined procedure. Thus, one would expect the most effective approach to teaching patients to reduce muscle hyperactivity to be one that combines awareness of muscle tension levels with direct instructions in methods of tension reduction (i.e., a combined EMG biofeedback plus relaxation training approach). The present study was therefore designed to evaluate the effectiveness of EMG biofeedback (EMG), applied relaxation training (ART) and a combination of these approaches (CO) in the treatment of chronic, upper-extremity CTD patients. It was predicted that the combined procedure would be more effective in producing reductions in pain levels and subsequent symptoms of psychopathology than either approach when used in isolation.

Method

Subjects

Forty-eight chronic pain patients were referred to the study, all of whom had a history of musculoskeletal pain problems in the upper limbs, neck and/or shoulders associated with repetitive tasks in the workplace. The criteria for inclusion in the study included a history of upper limb pain persisting for longer than 10 months, which had been attributed by their medical practitioner to repetitive work practices. Other criteria included an average pain index score > 5.0 during a 7-day monitoring period, indicating a pattern of greater than 2 h per day of mild-to-moderate pain during waking hours (Spence 1991). This measure is described in more detail below. Participants were required to have an adequate ability to read and understand basic English. Exclusion criteria included the presence of other chronic pain conditions, illnesses or injuries or a history of psychosis or alcohol abuse.

The average age of participants was 42.09 ($SD = 7.86$) years, with a mean duration of pain of 5.68 ($SD = 2.62$) years. Eighty-four percent of the sample were women, 54.5% were married, 31.8% single and 13.6% divorced. Fifty percent of subjects were not employed at the onset of the study, with 38.6% in full-time employment, 9.1% in part-time employment and 1 subject was retired. At the time of onset of the pain problem, occupational groups were described as: keyboard workers (15%), clerical/secretarial (22%), factory worker/ machinists (13%), cashier (11%), cleaners (11%) and other occupations (28%).

Prior to inclusion in the study, subjects attended a physical examination with a physiotherapist who was experienced in the assessment of the range of symptoms and signs compatible with upper-extremity CTDs. A standardised protocol was used to guide the assessment and recording process. In terms of the presenting pain problem, 63% of subjects reported bilateral pain, 24% right side only and 13% left side only. Pain was reported in the forearm by 87% of participants, with pain in the neck (67%), shoulder (72%), wrist (41%) and hand (59%). More extensive data from physical examination were available for 31 of the 48 subjects. The following signs were identified from examination: swelling in affected limb (65%); discolouration in affected limb (74%), reduced grip strength (71%); signs of sympathetic overactivity (84%; including skin temperature reduction in affected limb(s) 45%); nociceptor hyperactivity (vasodilation or wheal; 55%); paresthesia from nerve stretch, pressure or percussion (48%); dysethesia from neural stretch, pressure or percussion (23%); diffuse allodynia (32%) and diffuse muscle hyperalgesia (42%). The majority of cases were classified as chronic, non-specific upper-limb pain syndrome. Additional diagnoses included tenosynovitis (3%), tendonitis (10%), carpal tunnel syndrome (10%), rotator cuff syndrome (26%), de Quervains (26%), thoracic outlet syndrome (10%), and mild reflex sympathetic dystrophy (3%).

Fifty-two percent of the sample did not use medication, with most of the remainder using over-the-counter (22.7%) or non-narcotic prescription medications (18.2%). Very few subjects (n = 3, i.e., 6%) reported using narcotic analgesics. Subjects reported a wide variety of previous treatments, typical of chronic pain patients, including various forms of medication, prescribed rest, detachable splints, physiotherapy, occupational therapy, acupuncture, chiropraction, TENS, and hydrotherapy. Only 1 patient reported previous surgery.

Procedure

Following physical assessment, subjects completed pre-treatment assessment questionnaires, self-monitoring data and a structured interview to determine suitability for inclusion in the study. Subsequently, participants were randomly assigned to 1 of 4 treatment conditions, namely (1) applied EMG biofeedback (EMG), (2) applied relaxation training (ART), (3) combined applied EMG biofeedback plus relaxation training (CO), and (4) waiting-list control (WLC). This provided 12 patients in each experimental condition. Table I summarizes the demographic characteristics of the subject sample for each group.

Post-treatment phase data were available for all subjects in the EMG group, with 1 drop-out occurring in each of the other conditions. Following the 8-week period between pre- and post-treatment assessments, the WLC patients commenced treatment themselves and ceased to form part of the study. Subjects were reassessed at 6-month follow-up. At this point 11 subjects were available from the EMG, 7 from the ART and 9 from the CO condition.

Psychological adjustment measures

Beck Depression Inventory. The BDI (Beck 1961) was selected as an indication of self-reported symptoms of depression. The mean score with general medical patients on the BDI is generally slightly elevated by around 3–4 points to produce a mean score of around 10–12, which may be due to the focus of certain items on symptoms such as loss of interest in sex or sleep disturbance, reflecting general ill health rather than necessarily indicating symptoms of depression (Schwab et al. 1967). State anxiety was assessed using the Spielberger State-Trait Anxiety Inventory (STAI) (Spielberger et al. 1970).

Pain Beliefs Questionnaire. The PBQ (Gottlieb 1984, 1986) is a 43-item questionnaire which assesses pain beliefs across 4 factors, namely (1) disability expectations, (2) self-efficacy, (3) depression, and (4) pain as a threat. A total score is also produced that assesses the degree to which patients adhere to beliefs that could promote disability and engender psychological distress, with higher scores indicating less adaptive belief systems.

West Haven-Yale Multidimensional Pain Inventory. The activity scale of the WHYMPI (Kerns et al. 1985) was used to provide an indication of participation in common daily activities concerning household chores, outdoor work, activities away from home and social activities.

Self-monitored pain, distress, interference and medication. Self-monitoring (Spence 1989, 1991) was carried out 3 times a day for 7 days at each assessment occasion. Each day is divided into three 8-h sessions for which the patient records the number of hours of pain. Eleven-point (0–10) Likert scales are used to rate intensity of pain, degree of interference in daily living caused by pain and distress caused by pain. A pain index score is produced from Intensity × Duration (hours) of pain for each 8-h period, averaged over the number of observation periods. Subjects were also asked to record the type and quantity of any medication used to control pain. An attempt was made to quantify medication usage by means of a 5-point rating scale (5 = nil; 4 = over-the-counter analgesics for 2/7 days or less; 3 = over-the-counter analgesics for 3/7 days or more; 2 = prescription medication for 2/7 days or less; 1 = prescription medication for 3/7 days or more).

Treatments

Treatments were conducted by 2 psychologists and involved 8 individual therapist–client sessions, each lasting around 1.5 h over a 4–6 week period. Therapists were counterbalanced across conditions.

Applied EMG biofeedback. The applied EMG biofeedback approach used an Autogenics AT33 machine to provide auditory feedback concerning muscle tension levels. Feedback was provided from various sites, commencing with the forearm flexor of the arm of least pain, progressing to the forearm flexor of the arm of most pain and subsequently to the trapezius muscles if pain occurred in these areas. No instructions were given regarding methods of relaxation and subjects were asked to develop their own, individual methods of reducing the signal on the machine. Trials varied in duration between 1 min and 3 min, depending upon the degree of difficulty experienced in maintaining a relaxed state. In addition to learning to reduce muscle tension levels, clients were taught to discriminate between relaxed and tense muscle states of increasingly fine distinctions. During home-based assignments, subjects were asked to monitor their muscle tension levels and to attempt to reduce muscle tightness if they detected tension. They were taught to use cues within the environment, such as the ringing of a telephone, to prompt their use of monitoring and relaxation. In the later sessions, stressful or physically demanding tasks were administered, both in imagination, roleplay or invivo, during which the EMG biofeedback signal was to be kept to a minimum. Stressful situations were identified for each client and included events such as making an assertive request in the workplace or refusing unreasonable requests from others. This process also served to demonstrate to subjects how muscle tension levels tend to increase during times of stress and how

TABLE I

MEAN VALUES FOR DEMOGRAPHIC INFORMATION FOR ALL EXPERIMENTAL GROUPS WITH STANDARD DEVIATIONS (in parentheses)

ART = applied relaxation training; EMG = applied EMG biofeedback; CO = combined procedure; WLC = waiting-list control.

	ART (n = 12)	EMG (n = 12)	CO (n = 12)	WLC (n = 12)
Women	91%	83%	73%	91%
Compensation case	82%	58%	64%	82%
Age	43.27 (9.40)	43.41 (6.52)	40.00 (6.57)	41.55 (9.21)
Socio-economic status rating	5.39 (1.26)	5.23 (0.79)	4.99 (1.22)	4.99 (0.99)
Years of pain	5.55 (3.01)	4.67 (2.11)	6.55 (2.03)	6.14 (3.08)

TABLE II

MEANS AND STANDARD DEVIATIONS (in parentheses) FOR TREATMENT OUTCOME MEASURES AT PRE- AND POST-TREATMENT FOR ALL EXPERIMENTAL GROUPS

ART = applied relaxation training; EMG = applied EMG biofeedback; CO = combined procedure; WLC = waiting-list control.

		ART (n = 11)		EMG (n = 12)		CO (n = 11)		WLC (n = 11)		F Time effect $df = 1.41$	Group × Time effect $df = 3.41$
		Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-		
BDI	Mean	14.55	08.55	16.17	14.08	15.36	13.55	11.64	13.00	11.03 **	5.39 **
	SD	(10.47)	(05.77)	(9.64)	(09.11)	(09.27)	(09.90)	(03.50)	(05.24)		
Spielberger State	Mean	45.54	35.64	48.75	47.00	49.09	41.27	40.46	43.55	6.42 *	3.28 *
Anxiety	SD	(19.51)	(10.59)	(11.85)	(12.97)	(16.91)	(12.22)	(15.78)	(17.56)		
WHYMPI	Mean	2.37	2.52	1.99	2.06	2.54	2.55	2.32	2.31	0.46	0.17
Activity levels	SD	(0.60)	(0.74)	(0.63)	(0.69)	(1.02)	(0.66)	(0.70)	(0.41)		
PBQ	Mean	60.18	50.18	55.75	46.92	52.82	46.27	53.27	54.09	8.40 **	1.30
	SD	(26.18)	(16.81)	(17.41)	(12.27)	(18.66)	(18.09)	(15.10)	(19.58)		
Self-Monitored	Mean	24.37	16.69	17.26	13.85	21.09	17.69	20.34	21.25	6.57 *	1.71
Pain Index	SD	(14.29)	(13.29)	(09.40)	(06.75)	(11.82)	(10.71)	(11.20)	(13.30)		
Interference in	Mean	3.67	2.39	3.80	2.96	3.67	3.00	3.53	3.67	9.23 **	1.84
Daily Living	SD	(2.04)	(1.80)	(1.86)	(1.29)	(1.98)	(1.76)	(1.75)	(1.98)		
Distress Caused	Mean	4.00	2.02	3.49	2.76	3.18	1.90	3.07	3.53	10.61 **	3.57 *
by Pain	SD	(2.26)	(1.93)	(1.95)	(1.31)	(2.08)	(1.40)	(1.89)	(2.31)		

* $P < 0.01$; ** $P < 0.05$.

these levels can be reduced. Similarly, patients were taught to engage in physically demanding tasks which tend to cause pain (e.g., typing or knitting) while attempting to keep muscle tension levels to a minimum. Home-based assignments included exposure to situations, during which attempts were to be made to relax the muscles in the arms and trapezius. Such situations included physical stressors (e.g., typing) or emotional events (e.g., discussing an area of conflict with one's boss).

Applied relaxation training. The content of the applied relaxation approach resembled that of the EMG programme, but participants were taught a range of relaxation techniques, including progressive muscular relaxation and imagery methods. Given that pain tends to be triggered by muscle tension, subjects were not asked to contract their muscles before releasing them during relaxation training. This method relied on subjective awareness of muscular tension and relaxation, rather than use of the EMG equipment for this purpose. Otherwise the approach to home-based tasks and within session practice of relaxation and exposure to tasks was identical to that already described.

Combined applied EMG biofeedback and relaxation training. The combined treatment taught subjects to use a variety of relaxation methods in order to facilitate their ability to reduce muscle tension

TABLE III

MEANS AND STANDARD DEVIATIONS (IN PARENTHESES) FOR TREATMENT OUTCOME MEASURES FOR SUBJECTS AVAILABLE AT PRE- AND POST-TREATMENT AND 6-MONTHS FOLLOW-UP

ART = applied relaxation training; EMG = applied EMG biofeedback; CO = combined procedure.

		ART (n = 7)			EMG (n = 11)			CO (n = 9)			Pre-follow-up F Time effect $df = 2.48$	Group × Time effect $df = 4.48$
		Pre-	Post-	F-up	Pre-	Post-	F-up	Pre-	Post-	F-up		
BDI	Mean	17.28	9.86	14.14	15.55	13.73	13.18	16.00	14.00	12.67	8.05 **	0.09
	SD	(12.20)	(6.59)	(12.48)	(9.85)	(9.46)	(10.16)	(10.21)	(11.01)	(9.73)		
Spielberger State	Mean	53.28	39.57	44.57	48.55	47.27	46.82	49.11	41.78	50.44	2.60	2.21
Anxiety	SD	(19.96)	(9.93)	(12.95)	(12.41)	(13.57)	(12.62)	(18.80)	(13.25)	(15.21)		
WHYMPI	Mean	2.39	2.48	2.38	2.02	2.08	2.26	2.60	2.59	2.39	0.01	0.79
Activity Levels	SD	(0.73)	(0.64)	(0.62)	(0.65)	(0.72)	(0.88)	(1.03)	(0.59)	(0.81)		
PBQ	Mean	65.86	58.00	53.14	56.91	46.09	46.36	58.00	50.78	61.67	3.55	2.20
	SD	(30.04)	(14.90)	(20.09)	(17.77)	(12.52)	(15.92)	(16.39)	(16.81)	(21.46)		
Self-Monitored	Mean	23.73	19.26	13.42	17.61	14.33	11.41	22.77	19.73	17.70	15.68 **	0.68
Pain Index	SD	(14.77)	(14.77)	(9.03)	(9.77)	(6.85)	(8.90)	(12.16)	(10.30)	(10.47)		
Interference in	Mean	3.76	3.03	3.10	3.97	3.03	3.05	3.80	3.34	3.45	3.29	0.23
Daily Living	SD	(2.22)	(1.94)	(1.62)	(1.85)	(1.32)	(1.66)	(2.18)	(1.73)	(2.32)		
Distress Caused	Mean	3.67	2.54	3.01	3.62	2.83	2.78	3.26	1.99	2.63	3.36	0.03
by Pain	SD	(2.41)	(2.27)	(1.56)	(1.98)	(1.35)	(1.68)	(2.32)	(1.50)	(2.53)		

* $P < 0.05$; ** $P < 0.01$.

levels using the biofeedback equipment. The auditory signal was available during relaxation practice and exposure to stressor tasks. Home-based practice and within-session tasks were equivalent to those already described.

Results

Comparison between groups for all pre-treatment dependent variables and demographic features revealed no significant differences between groups. Table II summarises the scores on all outcome measures at pre- and post-treatment. Given the problems getting patients to respond to the 6-month follow-up assessment, the results are reported separately in Table III for those patients who provided information at all 3 assessment occasions.

Pre- to post-treatment changes

Repeated-measures multivariate analysis of variance (MANOVA) including all dependent variables from pre- to post-treatment showed a significant difference between groups over time (Hotellings F (21, 101) = 1.72, $P < 0.04$). Univariate comparisons showed that the groups differed in changes in depression, anxiety, and distress caused by pain (see Table II). Post-hoc comparisons showed that all 3 treatment groups showed greater reductions in depression scores following intervention compared to the WLC group. The groups did not differ from each other and the WLC showed no change over time. From a clinical perspective, however, only the ART group showed a reduction in depression scores to within the non-depressed, normal range.

In terms of anxiety, the CO and ART treatments both showed significantly greater reductions compared to the WLC, to within the normal range. No significant differences were evident between the EMG versus WLC, or between the 3 treatments, although there was a non-significant trend for the ART group to show greater reductions in anxiety than the EMG patients. The ART condition also showed significantly greater changes than the WLC for self-monitored distress. No significant differences were found between groups on the measures of WHYMPI activity levels, self-monitored pain index, interference, or pain beliefs. Inspection of Table II, however, indicates that all 3 treatment groups showed a shift in PBQ scores in the direction of more adaptive pain beliefs and reductions in interference caused by pain, whereas the WLC showed no change over time. The failure to find statistically significant differences between groups on these measures may have reflected the high variance in scores.

Maintenance of results at 6-month follow-up

The results for subjects who were available for the follow-up assessment are shown in Table III. From pre-treatment to 6-month follow-up a significant change over time was found on the MANOVA comparison for the 3 treatment groups combined (Hotellings F (7, 18) = 3.38, $P < 0.02$) but there was no difference between treatments over time. Univariate comparisons indicated significant decreases in depression and self-monitored pain from pre-treatment to follow-up for the 3 treatments. No significant changes from pre-treatment to follow-up were evident for other outcome measures. There were no significant differences between treatments for any of the outcome measures from pre-treatment to follow-up.

The post-treatment to follow-up MANOVA comparison showed a significant change for the 3 treatment groups combined (Hotellings F (7, 18) = 3.99, $P < 0.008$). Univariate repeated-measures ANOVAs indicated significant changes over time for the combined treatment groups on the measures of state anxiety (F (1, 24) = 5.98, $P < 0.05$) and pain (F (1, 24) = 4.27, $P < 0.05$). Table III shows that the ART and CO groups lost much of the improvement in anxiety scores over the follow-up period, although the EMG group remained relatively unchanged (as indeed they had during the treatment phase). Self-monitored pain index levels, on the other hand, continued to decline over the follow-up period for all 3 treatment groups. There was a significant difference between treatments from post-treatment to follow-up on the MANOVA (Hotellings F 14, 34) = 2.66, $P < 0.01$). However, post-hoc contrasts between treatments indicated no significant differences for any of the variables in terms of changes from post-treatment to follow-up.

Although there were no statistically significant effects for pain beliefs, and self-monitored interference in daily living or distress caused by pain, Table III shows that improvements on these measures were generally maintained, although there was a slight return of maladaptive pain beliefs for the CO group.

Discussion

The present study was designed to evaluate the effectiveness of EMG biofeedback, applied relaxation training and a combined procedure in the management of chronic, upper extremity CTD. It was predicted that both EMG biofeedback and applied relaxation training would be beneficial in terms of impact upon pain and psychological adjustment. However, it was also hypothesized that a combined procedure, integrating applied EMG biofeedback with instruction in relaxation methods, would be superior to either technique alone.

The results of the study confirmed that all 3 treatment approaches were associated with short-term benefits on at least 1 of the outcome measures, whereas the WLC group showed minimal improvement during the treatment period. In contrast, the ART procedure showed significant short-term reductions in depression, anxiety and distress caused by pain. The combined treatment approach manifested short-term improvements in depression and anxiety, with the EMG condition showing improvements only on the measure of depression. Although the short-term benefits shown by the ART condition were not statistically superior to those of the other treatment conditions, the ART group showed significantly greater improvement than the WLC on more of the outcome measures than the EMG or CO methods. Furthermore, the clinical significance of the results needs to be taken into account. Only the ART group showed reductions in depression and anxiety to within the normal range and significant reductions in distress caused by pain. Thus, the hypothesis that the CO approach would be superior to either EMG or ART alone was not supported and the ART approach was associated with greater short-term improvements than either of the treatments involving the biofeedback machines.

It is interesting to speculate why this might be the case. It is possible that the applied relaxation training method has the benefit of generating a greater feeling of self-control over one's ability to regulate muscle tension levels during stressful situations, and thus to control pain. Perhaps introducing machinery into this process in the EMG procedure served to limit this sense of control. Alternatively, the use of a machine may serve to reinforce beliefs relating to physical aetiology of the disorder and thereby reduce the patients motivation to apply psychological methods to reduce muscle tension levels or to cope with their pain. Another possible explanation could be that it is difficult to carry over the muscle awareness and tension reduction skills acquired from EMG biofeedback in the clinic to real life settings where the EMG machine is not available. In contrast, it may be that applied relaxation produces skills that are more easily transferred from the clinic to real life situations.

With respect to long-term follow-up results, the findings were variable. Given the problem of drop-out of patients from the follow-up assessment, particularly for the ART group, it is important that these data are interpreted with caution. It is possible that those patients who were unavailable for follow-up were those who had made the most progress during treatment. Visual comparison of mean values across Tables II and III, particularly for the ART group, suggests that patients who completed the 6-month follow-up evaluation showed lower reductions in depression, anxiety, maladaptive pain beliefs and pain during treatment compared to the larger sample of patients who completed treatment. This difference implies that those patients who were unavailable for the 6-month follow-up are likely to have shown larger improvements on these measures during treatment. This suggestion is also borne out in the known reasons for failure to complete the follow-up assessment. For example, 3 patients in the ART group gave excessive work commitments as their reason for non-completion, suggesting a high level of occupational functioning. Another had moved to live overseas.

At 6-month follow-up, all 3 groups manifested significant reductions in depression and self-monitored pain levels, in comparison to pre-treatment values. Pain levels continued to decline during the follow-up period for all treatment groups, with minimal difference between them. This finding was particularly encouraging, given that the reduction pain by 6-month follow-up was not only statistically significant, but reflected an impressive reduction in clinical terms. The mean reduction in pain index by 6-month follow-up was around 10–15, which can be interpreted as a decrease of around 5 h of mild-to-moderate pain, or 2 h of moderate-to-severe pain per 8-h period. For chronic pain patients, with a long history of pain (4–6 years), this reduction in pain is of considerable benefit.

On the measure of depression, however, there was some relapse for the ART group who had shown such marked improvements during the follow-up period. There was also a tendency for anxiety levels to return towards pre-treatment levels for those groups that improved during the treatment phase (ie., CO and ART). It was encouraging to note that the reduction in distress caused by pain was generally maintained during the 6-month follow-up. There was no evidence of differential effectiveness of treatments at the follow-up assessment. The superior effects of ART that had been noted at post-treatment were no longer evident 6 months later. Thus, overall, the longer-term results indicated minimal differences in outcome between applied relaxation training, EMG biofeedback or a combined procedure. All 3 treatments were associated with beneficial long-term reductions in pain and depression.

Although the improvements in pain and psychological adjustment were encouraging, it is important to note that pain levels were still relatively high and continued to produce distress and interference in daily living. At 6-month follow-up, pain index levels were around 11–17, which is indicative of mild-to-moderate pain for around 5-h duration per 8-h period, or moderate-to-severe pain for around 2-h per 8-h period. Only 1 of the 27 patients available at 6-month follow-up was pain free. Thus, these treatment approaches should be regarded as assisting in the management of pain, rather than being curative.

There are several methodological limitations of the present study that restrict the conclusions that can be drawn. First, the small subject numbers, particulary at

6-month follow-up, must be acknowledged. Second, the lack of long-term follow-up for the WLC means that long-term changes amongst the treatment groups could potentially reflect the passage of time. This possibility, however, is unlikely given that most participants had an extensive 4–6 year history of chronic pain. Third, the absence of an attention placebo comparison group means that non-specific treatment effects cannot be ruled out as contributors to any changes shown by the treatment groups. Again, this possibility is unlikely given that most subjects had a long history of involvement in numerous therapies in the past which had not generally been helpful. Nevertheless, future studies should aim to correct these methodological limitations.

Despite these criticisms, we can draw some tentative conclusions from this study. The findings are generally in keeping with the results predicted by a site-specific muscle hyper-reactivity model. All 3 treatments were predicted to produce reductions in muscle hyper-reactivity to stress situations and thereby produce reductions in pain and ultimately psychological adjustment. However, this proposal requires further testing in order to demonstrate conclusively that relaxation and EMG biofeedback are successful in reducing site-specific muscle hyper-reactivity responses. Futher studies are now in progress to determine whether these treatments are effective in producing alterations in EMG responses to stressor situations.

In summary, the prediction that a combined approach would produce superior results to either applied relaxation training or EMG biofeedback alone was not supported. Applied relaxation training, EMG biofeedback and a combined procedure were all found to to be associated with reductions in pain, symptoms of depression, distress and interference caused by pain, which were continued through to follow-up. The improvements shown were also found to be clinically significant and meaningful. Short-term reductions in anxiety were found during the treatment phase, but were not generally maintained. In the short term, the applied relaxation training group manifest the strongest benefits, but by follow-up there was little difference in outcome between the 3 treatments. It is concluded that treatments that aim to increase awareness of muscle tension levels and to reduce muscle tension in stressful situations offer promise as a therapy component in the rehabilitation of chronic, upper extremity CTDs.

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