Scand J Rehab Med 27: 243–252, 1995

THE EFFECT OF PAIN REDUCTION ON PERCEIVED TENSION AND EMG-RECORDED TRAPEZIUS MUSCLE ACTIVITY IN WORKERS WITH SHOULDER AND NECK PAIN

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ABSTRACT. The study was initiated to evaluate the effect of pain-reducing therapies on factors previously associated with work-related shoulder and neck pain, namely increased muscle activity in the upper trapezius and perceived general tension. Thirty-three women in three groups were assessed before and after an intervention period and by questionnaire 6 months later. The purpose of this study was primarily to investigate associations between upper trapezius muscle activity, perceived general tension and pain, and secondly, to compare effects of individually based physiotherapy and group exercise for workers with shoulder and neck myalgia. All three groups reported a significant alleviation of pain and perceived general tension, while the electromyographically (EMG) recorded upper trapezius muscle activity level remained unchanged or increased. Improvements were similar in all three treatment groups, but individual-based therapies were rated more beneficial on subjective measures. Significant correlation was found between pain and perceived general tension ($r = 0.66$, $p < 0.01$), while there was no correlation between pain or perceived general tension and recorded muscle activity.

Key words: shoulder myalgia, pain, muscle tension, musculoskeletal, work-related, intervention, electromyography, physiotherapy.

INTRODUCTION

Recent studies at our laboratory indicated that different and independent mechanisms may be involved in the development of apparently work-related shoulder and neck myalgia. Variables related with psychological, psychosomatic and psychosocial factors were associated with pain in one work group, whereas weak or no such associations were found in another work group (24). In the latter group, however, pain was related to increased upper trapezius muscle activity, as measured by surface EMG both during work and in test situations. No such association was found for the former group (22). There was weak or no association between these two groups of variables, thus indicating an independence of these two factors as risk indicators of shoulder and neck pain (23). Increased self-reported or perceived general tension was however closely related to pain in both work groups, and it was the only variable besides headache found to be related to shoulder and neck pain in both work groups.

These findings evoked an interest in investigating whether these variables could be influenced by successful intervention procedures. In particular, whether perceived general tension and recorded muscle activity can be attributed to the individual's 'trait' or 'state', i.e. related to permanent personality characteristics ('trait') or reflecting present circumstances or conditions ('state'), such as pain status. Perceived tension has been shown to correlate with psychological states, psychosomatic symptoms, psychosocial factors, and pain in cross-sectional studies (18, 23), indicating that this variable may be related to both 'trait' and 'state'. However, it has been found difficult to show a relationship between perceived general tension and recorded muscle activity (23). The effect of pain alleviation on perceived general tension and on recorded muscle activity has not been investigated.

Various exercise therapies have been investigated for work-related muscle pain originating in the shoulder and neck area. A cross-over design with group gymnastics at the work place for neck pain showed no clear effect (17). Strength training during ordinary working hours for 30 min three times a week for 3 months was found to be superior to general exercise for 30 min once a week in terms of increased

Table I. *Mean age and employment time in current job for all three groups*

Range is given in parentheses

	Group 1 $n = 12$	Group 2 $n = 12$	Group 3 $n = 9$
Age (yrs)	39.7 (32–49)	38.1 (25–50)	29.7 (19–55)
Employment time (yrs)	15.0 (6–26)	13.4 (5.5–26)	5.7 (1–15)

strength and reduced pain (3). One year of short exercises at the workplace had no effect on musculoskeletal symptoms in neck and upper limb, but the compliance and exercise intensity were low (16). Positive effects are stated to be dependent on exercise dose, compliance and adherence to the exercise regime (7). A recent review of the effectiveness of therapeutic exercises for chronic neck pain concludes that the literature is sparse (15). The best treatment in terms of various exercise regimes for work-related shoulder and neck pain is thus uncertain.

This study was initiated to investigate whether physiological parameters and subjectively reported risk factors identified in a cross-sectional study were affected by intervention procedures aimed at reducing pain in the shoulder and neck region. The primary purpose was to study associations between recorded muscle activity in the upper trapezius, self-reported or perceived general tension, and pain, when the pain level was manipulated by intervention procedures. Thus, the study also reports comparative results of individually based physiotherapeutic treatment regimes and group exercise for work-related shoulder and neck myalgia.

METHODS

Subjects and study design

Twenty-four female office workers with shoulder and neck pain agreed to participate in the study and were randomized to either individual physiotherapy ($n = 12$) or group exercise ($n = 12$). All subjects included in these groups had experienced shoulder and neck pain at or above 3 on a pain rating scale from 0 to 6 (27), both during the previous 6 months and during the previous 2 weeks, and had experienced pain for at least 3 days continuously during the last 2 weeks before enrolment. These subjects were recruited from the cases participating in a recent case-control study (22, 24). All were fully employed during the intervention period.

An additional group of female *patients* ($n = 9$) with shoulder and neck pain, and with presumably more severe symptoms, were recruited from local physiotherapists and included to strengthen the power of the study. The inclusion criteria for these patients were more stringent, and included pain in the upper trapezius region daily for the past 2 weeks, at least one active trigger point in the upper trapezius muscle, and pain upon passive stretching of the upper trapezius. These assessments were made by the recruiting physiotherapist, and later reassessed upon presentation in our laboratory. Exclusion criteria for all groups were shoulder and neck pain due to injuries or systemic disease, pregnancy, diagnosed fibromyalgia, and symptoms of degenerative joint disease of the cervical spine.

There was no difference between groups with regards to working hours, nor was there any difference in age or duration of employment between groups 1 and 2, but group 3 were significantly younger and had been employed for a significantly shorter period of time than the subjects in the other two groups (Table I). During the year prior to inclusion, group 2 had fewer contacts with the public health service, sick leave and treatments due to shoulder and neck pain than the other two groups, but there was no difference in perceived pain levels between the groups during the same time period.

Intervention

Individual physiotherapy (group 1): The subjects were treated by a local physiotherapist at a physiotherapy clinic outside the workplace twice a week and given a total of 10 treatments. Each treatment lasted for approximately 1 hour and included therapies for the shoulder and neck muscles as follows; massage (5-10 min), strength and flexibility exercises (20-30 min), stretching (3-4 min) and weight training on apparatus (5-10 min). Passive mobilization of the cervical spine was performed when indicated. Ergonomic principles were emphasized and communicated to subjects during pauses throughout the treatment period. Instructions in home exercises on postural control, and on strength and flexibility training of the shoulder and neck region was handed out and encouraged.

Group exercise (group 2): The group sessions were performed at the workplace during working hours for 30 min three times a week for 6 weeks. The therapy sessions were adopted from a recent publication by Dyrssen et al. (3), who found good effects of this regime, with increased strength in shoulder and neck muscles and reduced pain. The exercises are described in detail in the study by Dyrssen et al. With 1.1 kg dumb-bells in both hands, four arm exercises were each performed 10 times. The exercise cycle was repeated three times. For some individuals the load had to be adjusted early in the treatment period in order to perform 10 repetitions. In short pauses between cycles, the subjects exercised muscles of the abdomen and back, practised correct breathing techniques, and were informed by the physiotherapist of ergonomic principles, equivalent to those given to group 1, as was the emphasis on home exercises. Each session ended with 5 min of stretching exercises for muscles in the shoulder and neck region.

Individual physiotherapy for patients (group 3): As we were interested to see if patients actively seeking physical therapy treatment for their shoulder and neck myalgia behaved differently from the office workers (i.e., groups 1 and 2), a small group of patients ($n = 9$) were evaluated before and after the treatment period by the physiotherapist. The subjects in this group were instructed to return for the second evaluation when they were painfree or when the symptoms were considerably diminished. Full flexibility was allowed regarding both type and number of physiotherapy treatments, since for this group we were mainly interested in the effect of pain reduction on perceived general tension and measured muscle activity. The subjects received an average of 12 (range 8–17) treatments .

Effect variables

The subjects were evaluated on the complete set of variables before and after the treatment period, while a questionnaire on subjectively perceived progress was mailed to the subjects in groups 1 and 2 at follow-up 6 months after the second evaluation. Data were obtained before and after the treatment period on the following variables.

Electromyographic (EMG) measurements: Surface EMG was used to quantify trapezius muscle activity. Integral, integrated-circuit bipolar (Ag) electrodes, 6 mm in diameter and with a 20 mm intercentre distance, were used. The centre of the electrodes was placed at a point 2/3 the distance from the spine of the seventh cervical vertebra (C7) to the lateral edge of the acromion (11). The system noise level with the electrodes on inert biological material was 1.5 μV RMS, corresponding to 0.15% of the signal amplitude at maximal voluntary contraction. This was then equal to the lowest observed EMG level during muscle relaxation. The noise level was estimated for each subject by histograms from the calibration procedure, and then subtracted from the test recordings before full-wave rectification and averaging over intervals of 0.2 s was performed. The EMG method has been described in detail previously (22).

EMG calibrations were carried out before and after the test recordings. Maximal contractions were performed both in shoulder elevation ('shrugs') and in 90° arm abduction (11). The contraction that produced the highest EMG amplitude was used as the basis for the EMG calibration procedure (%EMG_{max}).

EMG test recordings: The muscle coordination or arm movement test was devised to evaluate the muscle activity of the passive and active trapezius while moving the arm of hand dominance. In the test the dominant arm and hand was required to move between three target areas (circles of 70 mm in diameter), at a set speed (88 min^{-1}) provided by a metronome (26, 28). The subject was seated at a desk. The duration of the test was 2 min.

A two-choice reaction time test was used to study the effect of mentally demanding work on attention-related muscle activity (26, 28). The subject was seated with the forearms and hands on a table top at elbow height. A graphical display and an alphanumeric text was presented on a VDU-screen. The test was performed with feedback on performance with respect to speed and accuracy (29). No pecuniary reward was given. The response was signalled by a key-depression of the left or right index finger on two push buttons placed in front of the subject. Apart from the finger movement there was no requirement of body movement during the test.

EMG recordings at rest: A test was devised to quantify resting EMG levels in the upper trapezius. During the test ('informed rest'; standing and sitting), the subjects were instructed to perform 5 tasks while seated at a desk and 3 tasks while standing upright. The tasks were performed continuously, each lasting 30 s, separated by 30 s rest pauses, during which the individuals were asked to maintain an upright sitting or standing posture without moving the head, arms, or shoulders. Before the start of this session the subjects were told that the aim of the test was to observe muscle relaxation during the rest periods.

Pain ratings and perceived general tension: Average pain intensity during the week before each evaluation was scored on a 10 cm visual analogue scale (VAS), with 0 indicating no pain and 10 unbearable pain. Perceived general tension during the previous 2 weeks was scored in a similar manner. In addition, the patients were asked to make note of the daily pain intensity during the intervention period. A scale from 0 to 4 was used, 0 indicating no pain and 4 severe pain. Half-point scores were allowed.

Trigger points: An algometer was used to measure pressure pain sensitivity bilaterally in the upper trapezius muscle (TP1; see ref 21). Pressure was given at a rate of 1 kg/s and the subject was asked to report the first sensation of referred pain into the area described by Travell & Simons (21). Pain referred to other areas was ignored. No pain at a pressure of 4 kg was recorded as such and assumed negative. The procedure was repeated three times for both the left and right upper trapezius and the lowest value on each side was recorded. The average of these two lower values was used in the analysis. Standard values for muscle pressure sensitivity in normals have been provided (6), and the normal mean value for the upper trapezius in females is 3.7 (SD 2.0–5.6) kg/cm^2. The cut-off point of 4.0 kg/cm^2 for no pain used in the present study is thus acceptable.

In addition, the following muscles or sites were palpated for active trigger points: levator scapula, sternocleidomastoid, infraspinatus, the scaleni, and the suboccipital area at the site of the greater occipital nerve. Active trigger points were recorded but not measured. The number of trigger points in the left and right trapezius (max. 4) and the total number of trigger points (max. 18) were used for the analysis.

Strength: Strength was measured for Group 3 only ($n = 9$), and recorded in maximal shoulder elevation ('shoulder shrugs') before and after the treatment period. Adjustable straps were positioned over the shoulders and connected to strain-gauge force transducers, and the subject was asked to elevate the shoulders maximally for 4–5 s. Two contractions were performed both before and after the EMG test recordings, and the highest recorded value was used for analysis.

Statistical analysis

Repeated measures ANOVA was used to test overall differences, with all three groups included. Variables showing significant differences were retained for post hoc analyses. Student's paired t-test was then used for parametric data and Wilcoxon signed-ranks test for nonparametric data to test within group differences. The Mann-Whitney U-test was used to test between group differences. Comparisons were performed two-tailed and differences were considered significant at the $p < 0.05$ level. These results are expressed as median values with 95% confidence intervals.

Pearson product moment for normally distributed data and Spearman rank order for nonparametric data were used to test correlations.

The agreement index (AI) was used on the EMG variables to evaluate the agreement between test 1 and test 2 (1, 2). The index is based on the SD of the difference between test 1 and test 2 divided by the mean of test 1 and test 2, and defined as AI = 1-[(2*SD of difference between test 1 and test 2)/mean (test 1, test 2)]. The ± 2SD limits are expected to include about 95% of the observations, defined as the 95% limits of agreement (2). An agreement index of 1 means perfect agreement between two measurements or methods, while lower positive values indicate decreasing agreement. A negative value means that the size of the 95% agreement limits is larger than the mean value for the two measurements, which is usually regarded as poor agreement.

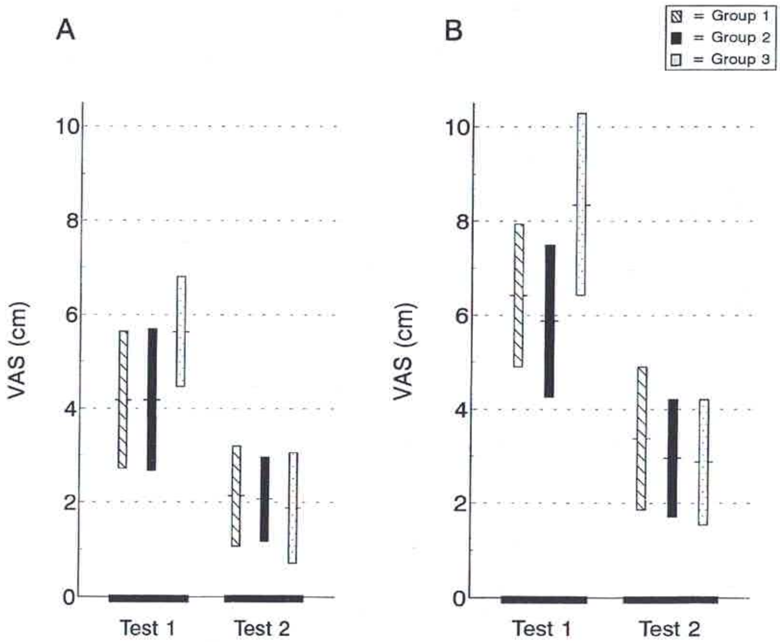

Fig. 1. Pain during the week prior to each evaluation (A) and perceived general tension (B) before (test 1) and after (test 2) the intervention period for all three treatment groups. A visual analogue scale (VAS) was used for scoring of both pain (0; no pain, 10; unbearable pain) and perceived general tension (0; low, 10; high). Mean values with 95% CI are given.

RESULTS

Compliance with the treatment regime was good for both groups 1 and 2; 92% and 86%. There were no drop-outs. The compliance rates are estimated on the basis of the total number of treatment sessions offered in each group. Two subjects in group 1 and 5 in group 2 did not carry out the home exercises nor performed any other form of exercise during the intervention period.

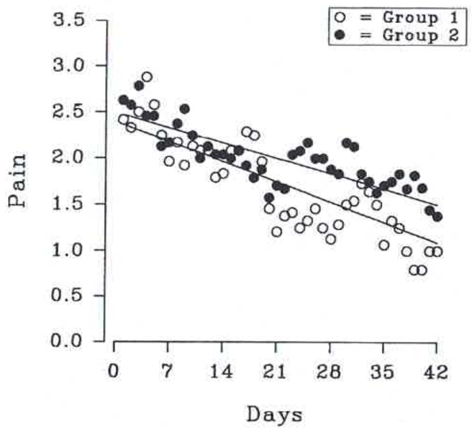

Fig. 2. Pain diary during the intervention period for the office workers, i.e. group 1 and 2. Mean daily pain levels (higher values imply greater pain) and regression lines for each group are shown.

Intervention

Pain and perceived general tension: The pain level in test 1, expressed as the average pain level for the past week on a VAS, was almost identical for groups 1 and 2, and considerably higher although not significant for group 3 (Fig. 1A). All groups showed a marked reduction in pain level from test 1 to test 2 ($p < 0.05$). Similar results were seen for perceived general tension, which decreased significantly in all groups from test 1 to test 2 ($p < 0.05$), (Fig. 1B). The reduction of both pain and perceived general tension was largest in group 3. There was no difference between the two intervention procedures, i.e. group 1 vs. group 2. There was a significantly larger decrease in perceived general tension for group 3, both when compared with group 1 ($p = 0.03$) and vs. group 2 ($p < 0.05$).

Daily pain levels were recorded by the subjects in groups 1 and 2 throughout the intervention period (Fig. 2). A steady decrease was seen for both groups,

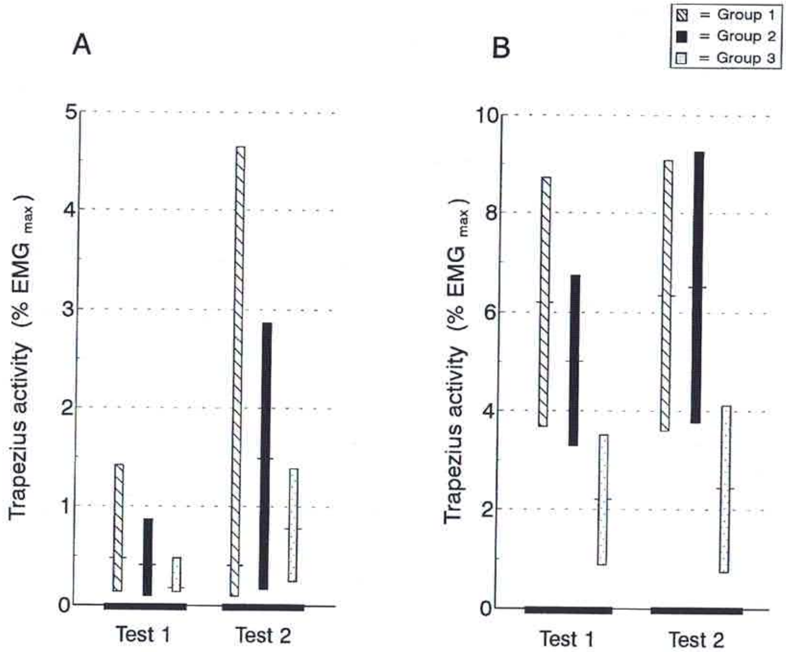

Fig. 3. Trapezius activity during the attention test (mean of right and left side; A) and for the active side during the arm movement test (B) before (test 1) and after (test 2) the intervention period for all three treatment groups. Median values with 95% CI are given in (A) and mean values with 95% CI are given in (B).

with a larger decrease for the group receiving individual physiotherapy ($p < 0.01$).

Muscle activity: The muscle activity levels during the mentally-demanding attention test were mostly unchanged from test 1 to test 2 in group 1, and showed a non-significant tendency to increase in groups 2 ($p = 0.07$) and 3 ($p = 0.10$), (Fig. 3A). In other words, the intervention procedures did not lead to reduced muscle activity levels for any of the groups. In fact, a significant increase in the muscle activity level was found when all three groups were analysed together ($p = 0.02$). There was no change in the muscle activity levels on the active side during the arm movement test, and virtually identical levels were found in tests 1 and 2 for all three groups (Fig. 3B). Group 3 had a consistently lower muscle activity level in this test, compared with the other two groups. Results from the recordings of the EMG resting levels and the arm movement test on the passive side were consistent with the results for the trapezius on the active side in the movement test.

Strength: Strength in shoulder elevation was recorded in group 3 only. A marked, but insignificant increase in strength was found from test 1 to 2. The average strength level increased by almost 20% from test 1 (45.4 kg, CI: 33.6–57.1) to test 2 (54.0 kg, CI: 44.1–64.0). The result may well have reached statistical significance with a larger sample size (Type 2 error). A weak negative correlation between strength and pain the previous week ($r = -0.44$, $p = 0.07$) was found when test 1 and 2 were pooled.

Trigger points: A successful reduction of trigger point sensitivity of the TP1 of the upper trapezius was seen in all three groups following the intervention procedures (Table II). No effect was found on the number of trigger points in the upper trapezius muscle nor on the total number of trigger points (Table II), with the exception of total number of trigger points in group 3. The individual variability was large, however, and not all subjects presented an active trigger point in TP1 of the upper trapezius.

Follow-up and subjective assessments: A questionnaire was mailed to the office workers (group 1 and 2) 6 months after test 2. The average reported pain levels during the previous week (median value with 95% CI) as measured on the same VAS scale as used in tests 1 and 2, were 2.4 (0.4–3.9) and 2.9 (0.2–4.1) for groups 1 and 2, respectively. Similarly, the perceived general

Table II. *Trigger point sensitivity (kg; mean of left and right trapezius), number of trigger points in left and right trapezius (max. 4), and total number of trigger points (max. 18) in all three groups before (test 1) and after (test 2) the intervention period*

Median values with 95% CI are given, with *p*-values (Wilcoxon signed rank)

		Trigger point sensitivity (kg)[1]	*p*	Number of trigger points in trapezius	*p*	Total number of trigger points	*p*
Group 1	Test 1	1.0 (0.7–1.3)	0.04	2 (1–4)	0.23	9.5 (8–13)	0.56
	Test 2	1.4 (1.2–4.0)		1 (0–4)		7.5 (6–12)	
Group 2	Test 1	0.8 (0.5–4.0)	0.04	2 (0–3)	0.74	8 (4–11)	0.31
	Test 2	1.0 (0.6–4.0)		2 (0–4)		9 (5–13)	
Group 3	Test 1	1.0 (0.2–4.0)	0.02	2 (0–4)	0.11	9 (8–12)	<0.01
	Test 2	4.0 (1.0–4.0)		0 (0–3)		4 (0–10)	

[1] A maximum value of 4 kg is given to all with no radiating pain. Lower values indicate increased sensitivity to pressure.

tension level was 3.8 (1.8–6.7) for group 1 and 5.0 (1.8–5.6) for group 2. This indicates that the effects seen after the intervention period (see Fig. 1A,B) were maintained to a certain extent, more so in group 1 than 2. This was also reflected in the subject's own judgement of effect, where 75% (9/12) at the end of treatment and 50% (6/12) at follow-up regarded themselves much better or painfree in group 1. In group 2, the corresponding values were 17% (2/12) and 25% (3/12), (Table III). There was no difference in exercise frequency between the groups in the same period.

Four subjects in group 1 and 2 subjects in group 2 made contact with the health care system due to shoulder and neck pain in the follow-up period. In general terms, there was a tendency towards a slightly better outcome on subjective judgements for group 1 as compared with group 2, both at the end of treatment and at follow-up. Those that kept exercising during the follow-up period regardless of treatment group reported lower mean pain (1.82) and perceived general tension (3.50) at follow-up than those who did not exercise (3.45 and 4.47, respectively). However, these differences were also present in test 1 (3.49 vs. 5.0 for pain and 5.38 vs. 7.06 for perceived general tension) and test 2 (1.45 vs. 2.88 for pain and 2.67 vs. 3.76 for perceived general tension).

Risk indicators

Measured muscle activity, pain and perceived general tension: No significant correlations were seen between trapezius activity in the active arm during the movement test and perceived general tension (Fig. 4A), nor between trapezius activity in the active arm during the movement test and pain the previous week (Fig. 4B). This was the case when all individual results from tests 1 and 2 were analysed collectively, for tests 1 and 2 separately, and for each treatment group (test 1 and 2 together). Nor were there any correlations between pain or perceived general tension and any of the other EMG variables.

Table III. *Subjective judgement of pain status at end of treatment and at 6 months follow-up, compared with before treatment*

Frequency counts (number of subjects) are given.

	Group 1 ($n = 12$)		Group 2 ($n = 12$)	
	End of treatm.	Follow-up	End of treatm.	Follow-up
Worse	0	1	0	1
No change	0	1	3	6
Slightly better	3	4	7	2
Much better / No pain	9	6	2	3

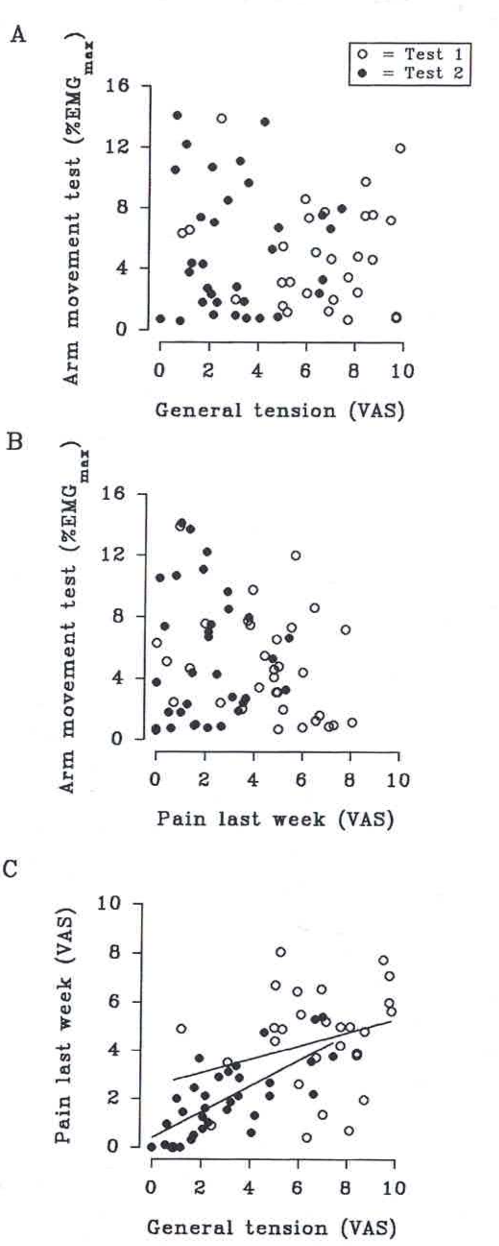

Fig. 4. Correlation between trapezius activity during the arm movement test for the active side and perceived general tension (A), and pain during the week prior to the evaluations (B) for tests 1 and 2, and correlation between pain during the week prior to the evaluations and perceived general tension (C) for tests 1 and 2. See Fig. 1 for phrasing of VAS anchor points.

There were no indications that the intervention procedures or the pain reduction affected the maximal EMG levels (i.e., performed during the EMG calibrations). Close correlations between tests 1 and 2 with near identical mean levels were found both for the right ($r = 0.81$, $p < 0.001$ and AI = 0.66) and left ($r = 0.57$, $p < 0.001$ and AI = 0.59) side.

Pain and perceived general tension: A significant correlation was found between pain and perceived general tension when results from tests 1 and 2 for all three groups were pooled ($r = 0.66$, $p < 0.01$), (Fig. 4C). The best correlation was found for the lower score levels seen in test 2 ($r = 0.72$, $p < 0.001$), while there was no significant correlation between perceived pain and perceived general tension in test 1 ($r = 0.31$, $p = 0.10$). Intermediate score levels were seen in test 3 (at follow-up; groups 1 and 2 only), with a relatively good correlation between the two variables ($r = 0.62$, $p < 0.01$).

Measured muscle activity (EMG): There was no significant correlation between tests 1 and 2 for the muscle activity level in the attention test ($r = 0.18$, $p = 0.32$), while consistent results were seen between tests 1 and 2 for the active side movement test ($r = 0.83$, $p < 0.001$; AI = 0.07), (Fig. 5A,B). This indicates that the latter test, although not affected by the intervention procedure, had a fairly high test–retest reliability. Significant correlation between tests 1 and 2 was also seen for resting tension in standing ($r = 0.65$, $p < 0.001$), but not in sitting ($r = 0.28$, $p = 0.12$).

DISCUSSION

Variables reflecting the subjects' perceived general tension and pain were successfully reduced in this study by all intervention procedures, while measured muscle activity remained unchanged in the tests applied. The only exception was a tendency to higher muscle activity level after pain alleviation for the attention test, which was statistically significant only when results from all three groups were pooled. Similar effects were seen for all three treatment groups. In terms of pain alleviation, individual physiotherapy was rated more favourably by the subjects than group exercise. No relationship was found between physiological measurements of muscle activity in the upper trapezius muscle and subjective assessments like perceived general tension and pain in the shoulder and neck area. High test-retest reliability between test 1 and test 2 was found for the recordings of trapezius activity on the active side in the movement test.

Perceived general tension has been shown to

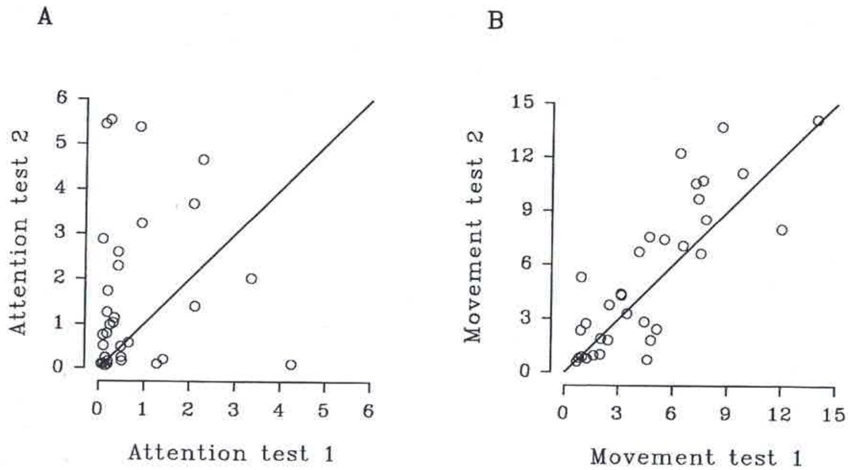

Fig. 5. Correlation between tests 1 and 2 for the the attention test (A) and the arm movement test for the active side (B). The line of equality is shown in both graphs. Values indicate $\%EMG_{max}$.

correlate with personality and psychosocial variables, and with work-related shoulder and neck pain (23, 24). The fact that perceived general tension was markedly reduced by the intervention procedures, favours the notion that this variable largely reflects transient circumstances (i.e. 'state') rather than permanent personality characteristics (i.e. 'trait'). The variable may thus serve as an indicator of risk for developing work-related shoulder and neck pain and as an outcome variable in measurements of treatment effect. The correlation found between this variable and pain might suggest that these two variables can be used interchangeably. However, the correlation was poor for the higher pain and perceived tension levels as in the pre-intervention situation, which was also the case for the larger material in the case-control study ($r = 0.19$, $p = 0.24$). The two variables should therefore be treated as interrelated, but separate entities.

Surface EMG recordings of the upper trapezius activity both during work and in test situations have been used to examine a possible correlation between muscle activity and muscle pain, with mixed results (10, 22, 25). Increased muscle activity in the upper trapezius in subjects with work-related myalgia has been reported during the relaxation phase of repetitive arm flexion movements as compared with healthy controls (4). Active relaxation training has been shown to reduce the trapezius EMG activity level both in test situations and during work (20). In the present study, pain and perceived general tension were reduced without a concurrent reduction in recorded muscle activity levels. This result may be influenced by the fact that muscle load at work and in laboratory tests for the office workers (i.e., groups 1 and 2) in the present study did not differentiate between workers with shoulder and neck pain and their matched, painfree controls, as reported previously (22). The EMG results in the present study might have been different if a group of workers with elevated muscle activity compared with healthy controls had been selected (5, 22). Vocational EMG recordings would probably not have changed these results, as EMG activity on the active side in the movement test has been found to correlate well with muscle activity during work (22, 28).

This study corroborates the positive effects of physiotherapy, with emphasis on strength training, in reducing work-related shoulder and neck pain, as reported by Dyrssen et al (3). Increased strength, range of motion and endurance along with alleviated pain or discomfort have been reported in several studies (3, 9, 12, 13). Aerobic exercise was superior to stress management in alleviating muscle pain in insurance office workers (8). Exercise breaks during working hours have been shown to reduce musculoskeletal discomfort and to increase productivity (19).

A critical remark to our study design in evaluating the effects of the intervention procedures is the lack of a control group. Nevertheless, as many as 75% of the office workers in the individual physiotherapy group reported positive effects of the intervention procedure, well above commonly accepted placebo effects. However, controlled studies are still warranted.

The positive effects of exercise found in study groups 1 and 2 were partially maintained at 6 months' follow-up, at least for group 1 (individual physiotherapy). This happened despite the fact that only about half of the subjects in both groups continued exercising on their own on a regular basis in the follow-up period. These results are contradicted by others who have found that the effects of exercise are lost upon ceasing training (7, 13). It appears that those who kept exercising in the follow-up period, as opposed to those who did not, reported lower pain and perceived general tension levels 6 months after the intervention period. The interpretation of this result is uncertain, since similar differences were also present in tests 1 and 2. It might indicate heterogeneous personality characteristics, indicating that inactive individuals are more likely to report complaints, or that those who report more pain are less likely to exercise.

A successful reduction of trigger point sensitivity (i.e., increased pain threshold) was found for all three groups in our study. This is in agreement with another study (14) which reported that pressure pain thresholds in the trapezius muscle were significantly lower in workers with high complaints of shoulder and neck pain as opposed to those with low complaints. In that study, the subjects with the highest pain levels showed lower EMG amplitudes during work than the subjects with lower reported pain. These results add more support to the notion that the level of vocational EMG muscle activity is a poor predictor of musculoskeletal complaints, at least for groups with low biomechanical demands at work.

In conclusion, no correlation was found between upper trapezius muscle activity and shoulder and neck pain or perceived general tension. Good test–retest reliabilities were seen for some of the EMG variables. A marked reduction in pain and perceived general tension was seen in all three intervention groups in this study, while no effect on or a slight increase in recorded muscle activity in laboratory tests were seen during the same period. Individually based outpatient physiotherapy and group exercise at the workplace were approximately equally effective in alleviating pain and perceived general tension. The former group was however more satisfied with the intervention effects on their health status, and they also seemed to maintain this improvement better at 6 months' follow-up than the subjects participating in the group exercise regime.

ACKNOWLEDGEMENT

This study was supported by The Norwegian Fund for Postgraduate Education in Physiotherapy and by The Norwegian Research Council.

REFERENCES

1. Altman, D. G. & Bland, J. M.: Measurement in medicine: the analysis of method comparison studies. Statistician *32:* 307–317, 1983.
2. Bland, J. M. & Altman, D. G.: Statistical methods for assessing agreement between two methods of clinical measurements. Lancet*:* 307–310, 1986.
3. Dyrssen, T., Paasikivi, J. & Svedenkrans, M.: Beneficial exercise programme for office workers with shoulder and neck complaints. In: Work with Display Units 89 (eds. L. Berlinguet & D. Berthelette), pp. 129–138, Elsevier Science Publishers B.V., North-Holland, 1990.
4. Elert, J. E., Rantapää-Dahlqvist, S. B., Henriksson-Larsèn, K., Lorentzon, R. & Gerdle, B. U. C.: Muscle performance, electromyography and fibre type composition in fibromyalgia and work-related myalgia. Scand J Rheumatol *21:* 28-34, 1992.
5. Erdelyi, A., Sihvonen, T., Helin, P. & Hänninen, O.: Shoulder strain in keyboard workers and its alleviation by arm support. Int Arch Occup Environ Health *60*: 119–124, 1988.
6. Fischer, A. A.: Pressure algometry over normal muscles. Standard values, validity and reproducibility of pressure threshold. Pain *30:* 115–126, 1987.
7. Grønningsæter, H.: Physical exercise, job stress, and health. University of Oslo, Faculty of Sport and Physical Education, Thesis, Oslo, 1992.
8. Grønningsæter, H., Hytten, K., Skauli, G., Christensen, C. C. & Ursin, H.: Improved health and coping by physical exercise or cognitive behavioral stress management training in a work environment. Psychol Health *7:* 147–163, 1992.
9. Highland, T. R., Dreisinger, T. E., Vie, L. L. & Russell, G. S.: Changes in isometric strength and range of motion of the isolated cervical spine after eight weeks of clinical rehabilitation. Spine *17 (suppl. 6):* s77–s82, 1992.
10. Jensen, C., Nilsen, K., Hansen, K. & Westgaard, R. H.: Trapezius muscle load as a risk indicator for occupational shoulder-neck complaints. Int Arch Occup Environ Health *64*: 415-423, 1993.
11. Jensen, C., Vasseljen, O., Jr. & Westgaard, R. H.: The influence of electrode position on bipolar surface EMG recordings of the upper trapezius muscle. Eur J Appl Physiol *67:* 266–273, 1993.
12. Jordan, A. & Mehlsen, J.: Cervicobrachial syndrome: Neck muscle function and effects of training. J Musculoskel Pain *1:* 283–288, 1993.
13. Levoska, S. & Keinänen-Kuikaanniemi, S.: Active or passive physiotherapy for occupational cervicobrachial disorders? A comparison of two treatment methods with a 1-year follow-up. Arch Phys Med Rehabil *74:* 425–430, 1993.
14. Nakata, M., Hagner, I. M. & Jonsson, B.: Trapezius muscle pressure pain threshold and strain in the neck

and shoulder regions during repetitive light work. Scand J Rehab Med *25:* 131–137, 1993.
15. Rodriquez, A. A., Bilkey, W. J. & Agre, J. C.: Therapeutic exercise in chronic neck and back pain. Arch Phys Med Rehabil *73:* 870–875, 1992.
16. Silverstein, B. A., Armstrong, T. J., Longmate, A. & Woody, D.: Can in-plant exercise control musculoskeletal symptoms? J Occup Med *30:* 922–927, 1988.
17. Takala, E. P., Viikari-Juntura, E. & Tynkkynen, E. M.: Does group gymnastics at the workplace help in neck pain? Scand J Rehab Med *26:* 17–20, 1994.
18. Theorell, T., Harms-Ringdahl, K., Ahlberg-Hultén, G. & Westin, B.: Psychosocial job factors and symptoms from the locomotor system - A multicausal analysis. Scand J Rehab Med *23*: 165–173, 1991.
19. Thompson, D.A.: Effect of exercise breaks on musculoskeletal strain among data-entry operators: A case study. In: Promoting Health and Productivity in the Computerized Office: Models of successful ergonomic interventions (eds. S.L. Sauter, M.J. Dainoff & M.J. Smith), pp. 118–127, Taylor & Francis, New York, 1990.
20. Toivanen, H., Helin, P. & Hänninen, O.: Impact of regular relaxation training and psychosocial working factors on neck-shoulder tension and absenteeism in hospital cleaners. J Occup Med *35:* 1123–1130, 1993.
21. Travell, J.G. & Simons, D.G.: Myofascial Pain and Dysfunction. The trigger point manual. Williams & Wilkins, Baltimore, 1983.
22. Vasseljen, O., Jr. & Westgaard, R. H.: A case-control study of trapezius muscle activity in office and manual workers with shoulder and neck pain and symptom-free controls. Int Arch Occup Environ Health *67:* 11–18, 1995.
23. Vasseljen, O., Jr. & Westgaard, R.H.: Can stress-related shoulder and neck pain develop independently of muscle activity? Pain (*in press*), 1995.
24. Vasseljen, O., Jr., Westgaard, R. H. & Larsen, S.: A case-control study of psychological and psychosocial risk factors for shoulder and neck pain at the work place. Int Arch Occup Environ Health *66:* 375–382, 1995.
25. Veiersted, K. B., Westgaard, R. H. & Andersen, P.: Electromyographic evaluation of muscular work pattern as a predictor of trapezius myalgia. Scand J Work Environ Health *19:* 284–290, 1993.
26. Westgaard, R. H. & Bjørklund, R.: Generation of muscle tension additional to postural muscle load. Ergonomics *30:* 911–923, 1987.
27. Westgaard, R. H. & Jansen, T.: Individual and work-related factors associated with symptoms of musculoskeletal complaints. I. A quantitative registration system. Br J Ind Med *49:* 147–153, 1992.
28. Westgaard, R. H., Jensen, C. & Nilsen, K.: Muscle coordination and choice-reaction time tests as indicators of occupational muscle load and shoulder-neck complaints. Eur J Appl Physiol *67:* 106–114, 1993.
29. Wærsted, M., Bjørklund, R. & Westgaard, R. H.: The effect of motivation on shoulder-muscle tension in attention-demanding tasks. Ergonomics *37:* 363–376, 1994.

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