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EFFECTS ON PHYSICAL PERFORMANCE AND PAIN FROM THREE DYNAMIC TRAINING PROGRAMS FOR WOMEN WITH WORK-RELATED TRAPEZIUS MYALGIA

Christina Ahlgren,[1] Kerstin Waling,[1,2] Fawzi Kadi,[3] Mats Djupsjöbacka,[4] Lars-Eric Thornell[3] and Gunnevi Sundelin[2]

From the [1]Departments of Public Health and Clinical Medicine, Occupational Medicine, [2]Department of Community Medicine and Rehabilitation, Physiotherapy, [3]Department of Integrative Medical Biology, Section for Anatomy, Umeå University and [4]Centre for Musculoskeletal Research, National Institute for Working Life, Umeå, Sweden

To compare training programs for women with trapezius myalgia regarding physical performance and pain, 102 women were randomized to strength, endurance, co-ordination and non-training groups. Before and after the intervention, static strength and dynamic muscular endurance in shoulder muscles were measured on a Cybex II dynamometer. Muscle activity in shoulder muscles was monitored via surface EMG. The signal amplitude ratio between the active and passive phase of repeated contractions indicated the ability to relax. Pain at present, pain in general and pain at worst were measured on visual analogue scales. After training, within group comparisons showed that the training groups rated less pain, and in the strength training group ratings of pain at worst differed from the non-training group. Using the non-training group as a reference, static strength increased in the strength and endurance training groups and muscular endurance in all training groups. The study indicates that regular exercises with strength, endurance or co-ordination training of neck/shoulder muscles might alleviate pain for women with work-related trapezius myalgia.

Key words: neck/shoulder, pain, dynamic training, isokinetics, rehabilitation.

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Correspondence address: Christina Ahlgren, Department of Public Health and Clinical Medicine, Occupational Medicine, Umeå University, S-901 85 Umeå, Sweden, E-mail: christina.ahlgren@ envmed.umu.se

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INTRODUCTION

Pain from the neck and shoulder area is the most frequent work-related musculoskeletal disorder among women (1). No objective diagnostic methods are available, therefore diagnoses are based on symptom presentation and history of illness. Pain localized to the upper part of the trapezius muscle, tenderness at palpation of the muscle and limitation in neck movement is usually diagnosed as trapezius myalgia (2). In rehabilitation of musculoskeletal disorders physical training is often combined with lectures in anatomy, stress handling, relaxation training, ergonomics, and work adjustments. Studies evaluating physical training programs mostly concern patients with low back pain (3), but patients with neck/shoulder pain can also benefit from physical training (4).

In rehabilitation the training should aim at restoring the functions restricted by the disorder. However, in patients with trapezius myalgia there is no consensus as to the requirements of training. Recommendations for strength training are based on findings that subjects suffering from neck/shoulder pain have reduced strength in neck/shoulder muscles (5, 6). Strength training of these subjects also has shown to reduce pain and increase strength (6).

Muscle endurance training in order to improve blood circulation in the trapezius muscle was proposed by Lindman et al. (7), after their findings that women suffering from trapezius myalgia had large type I fibres with poor capillarization. Studies evaluating the effects of muscular endurance training for neck/shoulder muscles are sparse. Hagberg et al. (8) found reduced shoulder pain after ten weeks of isometric muscular endurance training for shoulder muscles.

Self-reported pain in the neck and shoulder muscles is found to be positively associated with perceived high muscle tension (9). Relaxation training is therefore used in rehabilitation programs assuming that muscle pain is an effect of sustained muscle tension. However, the association between high perceived tension and muscle activity measured with EMG is inconclusive. No association (10) or a positive association only for subjects with an additional high workload (11) has been found between perceived and recorded high muscle activity levels. Elert et al. (12) found that patients with trapezius myalgia are unable to utilize pauses between repetitive arm movements for relaxation of shoulder muscles and Veiersted et al. (13) found that employees who developed trapezius myalgia had few resting periods (gaps) in their trapezius muscle during work. From these findings it is apparent that muscular co-ordination would be more of interest to train than muscle relaxation. Reduced pain from all three training modalities have previously been reported by our group in a study on pain measurements only (14). In the present study the aim is to evaluate the effects of dynamic strength, endurance and co-ordination training of shoulder muscles on physical performance and pain in women with work-related trapezius myalgia.

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SUBJECTS AND METHODS

Subjects

One hundred and thirty-six women with neck/shoulder pain participated in the study. The women included were less than 45 years of age and suffered from pain in the neck and shoulder muscles with a duration of more than one year and yet were fully employed. The subjects had to regard their work as contributing to the disorders, and the pain had to be of an intensity that caused the subjects to experience difficulty in performing their work at least once a week. The subjects could not be on sick leave when entering the study, nor could they have been on sick leave for more than one month during the year prior to the study. Subjects, who met these inclusion criteria, were invited to apply for participation through advertisements on bulletin boards in local work places and in staff papers. All applicants were interviewed and examined by a doctor and a physiotherapist to ensure that the inclusion criteria were fulfilled. In the clinical examination signs such as a reduced range of motion in lateral flexion and/or rotation of the neck, and one or more tender points in the neck/shoulder muscles at palpation were requested. Exclusion criteria were orthopaedic, neurological, rheumatological and metabolic diseases.

Ten subjects did not fulfil the inclusion criteria. The remaining 126 subjects were randomly distributed into three training groups and a non-training group. To make it possible for a working population to participate a semi-randomization was performed. Available training hours were given and the participants were able to choose hours suiting their own work schedules. Thereafter the content of the four programs was revealed to them. Twenty-four subjects did not complete training due to e.g. persistent colds and pregnancy and thus 102 subjects completed the training programs. Anthropometric data and other background variables did not differ between the groups except for the co-ordination training group reporting a higher exercise activity (Table I). Dropouts did not differ significantly from the subjects completing the intervention regarding anthropometric data or pain duration, but were lower for the all day active category.

Study design

Before and after a ten-week training period, oxygen consumption, muscular strength, endurance and co-ordination were measured, and perceived pain was rated. The testing order was the same for all subjects and for measurements pre- and post-training. Participants were asked not to change their exercise aside from that intervened in the study.

In 21 women, representing all training groups, a muscle biopsy from the descending part of the trapezius muscle was taken before and after the training period (15). The committee of research ethics at Umeå University gave approval for the study. The subjects participated in the study after informed consent.

Intervention

Three exercise programs were designed. The programs aimed at increasing strength, endurance or co-ordination in neck/shoulder muscles, respectively. All training groups were supervised by a physiotherapist. The training was conducted in one-hour sessions, three times a week for ten weeks. The non-training control group studied stress and stress handling. This group was supervised by an occupational nurse and met for a two-hour session once a week over ten weeks. All group activities were performed during working hours, except for subjects in shift work for which training sessions could occur during leisure time.

All training sessions started with a 15-minute warming up, followed by 40 minutes of specific exercises. Strength and endurance training sessions ended with stretching of exercised muscles while training sessions for the body awareness group ended with a 5 minute verbal summary of individual experiences.

Strength training. This was performed on training machines that provided resistance only in the concentric part of the movement (air machines). Exercises in rowing, triceps press, shoulder press and latissimus pull-down were performed. Loading was individually set to allow 12 repetition maximum (RM) and two sets of each exercise were made. The initial load was maintained for four weeks and then increased to three sets for each exercise. When three sets were comfortable the load was increased.

Endurance training. This was performed by cycling on an arm-ergometer alternating with exercises using rubber expanders. The arm-ergometers were loaded to give an experienced effort between light 11 and somewhat hard 13 on an RPE (rating of perceived exertion) scale (16) during three minutes of cycling. Random measurement of cardiovascular load in training sessions showed a heart rate of 110–120 beats per minute. Four 3-minute periods of arm cycling were completed during each session. In exercises with rubber expanders it was not possible to quantify the load in Newtonmeter (Nm). Participants were instructed to adjust their distance from the attachment of the rubber expander, so the resistance in the expanders was high enough to permit 30–35 repetitions per set. The movements should be controlled, in both the concentric and the eccentric part and performed through a subjectively fixed range of motion for each exercise. Three sets with 30–35 RM of each latissimus pull back, rowing and shoulder forward flexion were performed.

Co-ordination training. As a modality for co-ordination training, body awareness training was used. This program aimed at giving a more relaxed movement pattern and thus a more economic use of muscle force. Movements used in the program closely followed movements proposed by Roxendahl (17) in body awareness therapy. This type of body awareness therapy is developed in psychiatric physiotherapy and adjusted to fit non-psychiatric patients as well. Exercises focus on movements starting from the centre of the body, to move from a good balance and to co-ordinate movements with breathing. Movements are performed in both the standing and supine position. Participants are instructed to direct their attention on their bodily experiences, and the movements are repeated long enough to enable that. Combinations of movements are gradually developed.

Non-training. For the non-training group stress and bodily reactions due to stress were studied. Lessons were scheduled according to a course book and importance was laid on discussions and sharing of personal experiences. Exercises for relaxation were instructed and practised a couple of times, thereafter participants were themselves responsible for further training.

Evaluation of training effects

Muscle strength. Static strength maximum voluntary contractions (MVC) in elevation of the right shoulder girdle was measured with a

Table I. *Anthropometric data and other background factors (*n = *102)*

	Strength training group	Endurance training group	Co-ordination training group	Non-training group
Completed the program	29	28	25	20
Age (mean)	38 ± 6.0	38.5 ± 5.6	37.7 ± 6.2	38.9 ± 5.4
Pain duration (year)	6.3 ± 3.5	6.5 ± 4.4	6.6 ± 4.5	7.7 ± 4.1
Height (cm)	166 ± 6.1	165.5 ± 5.7	165.4 ± 5.7	165.8 ± 5.4
Weight (kg)	68.7 ± 12.7	66.3 ± 8.0	65.9 ± 9.4	64.1 ± 9.7
Exercise regularly (%)	13.8	14.3	28.0	9.5
All day active[a] (%)	69.0	67.9	60.0	71.4
Rate of attendance (%)	77.1 ± 24.2	79.6 ± 6.6	75.2 ± 11.5	70.8 ± 12.4

[a] Walk or cycle to work

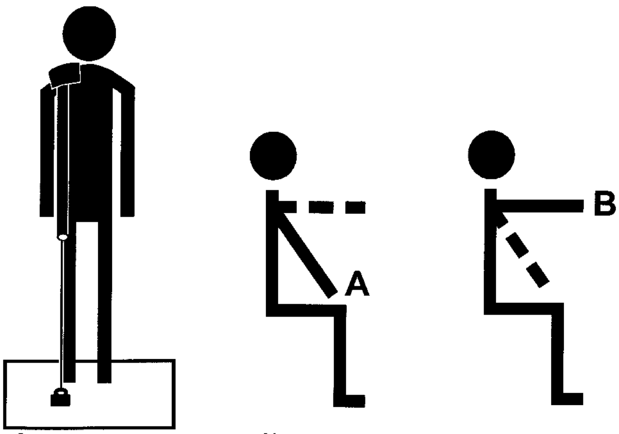

Fig. 1. Testing positions for (a) shoulder girdle elevation with a strain gauge dynamometer and (b) static strength in 30 (A) and 90 (B) degrees of shoulder flexion and dynamic muscular endurance in shoulder forward flexion (A–B) in a Cybex II dynamometer.

strain gauge dynamometer.The subjects were instructed to elevate their shoulder without bending over (Fig. 1a). Three trials were performed with a short rest in between. Static strength (MVC) in 30 and 90° of shoulder forward flexion was tested in an isokinetic dynamometer (Cybex II, Lumex Inc, New York). The right shoulder was tested and during the test the subjects were secured in a sitting position to allow movements in the shoulder only (Fig. 1b). Great care was taken to align the glenohumeral joint with the rotational axis of the dynamometer. The arm was held with the elbow extended and the hand semi-pronated while gripping a handle. The length of the lever arm was individually adjusted to achieve an optimal position with extended elbow. Verbal encouragement was given during the tests and three tests with a short rest in between were made in each position. In the analyses the highest values of the three tests in 30 and 90° of forward shoulder flexion (Nm) and shoulder girdle elevation (N) were used.

Muscular endurance and co-ordination. Muscular endurance and co-ordination were measured during repeated dynamic shoulder forward flexion movements in the Cybex dynamometer. The subjects were seated in the same fixed position as for the static strength tests. The performance of the test and the test position of the subjects were performed in accordance with the method used by Elert & Gerdle (18). One hundred and fifty repeated maximal contractions at a pre-set velocity of 90°. s^{-1} were performed. The range of motion was set from 30 to 100° of forward flexion. The subjects were instructed to lift the lever arm by performing a maximal contraction with the right arm, and to completely relax and follow the lever arm during the lowering phase. When the handle reached the thigh, they were instructed to lift the lever arm again without delay. Verbal encouragement was given throughout the test and subjects were not informed in advance about the number of contractions (150) they were to perform. Before the test the subjects were allowed to practice the movement at another velocity than that used in the test in order to experience how relaxation in shoulder muscles was achieved. Muscle activity during the endurance test was recorded with surface EMG in order to assess the ability to relax during the lowering phase of the contraction cycle as described by Elert & Gerdle (18). The EMG signal was analysed with respect to the signal amplitude ratio (SAR), which refers to the ratio between the RMS during the passive and the active phase in each contraction cycle. A high SAR indicates a high activity during the lowering phase and thus a poor ability to utilise rest periods (18). EMG signals were recorded with surface-EMG from the descending part of the trapezius, the infraspinatus and the anterior deltoid in the right shoulder. Bipolar surface silver–silver chloride electrodes (Medicotest, Ølstykke, Denmark) with a contact diameter of 6 mm and a centre to centre distance of 2 cm were used. Electrode positioning was done according to a careful designed scheme in order to replace them as near as possible to the previous position in the re-test. Small Medinic amplifiers were used for linear amplifications of the EMG-signals with a bandwidth of 5–500 Hz. For sampling and synchronizing of biomechanical and EMG signals the data acquisition system MYSAS was used (19). Calculated parameters from EMG and torque signals were RMS (root mean square) (μV), SAR (%), peak torque (Nm) and work (J).

The mechanical output in the endurance test followed the same pattern as in a previous study (18) with a steep decrease of power during the initial contractions followed by a steady state (endurance level). The following values were calculated and represent measurements on endurance and co-ordination:

Initial value: mean peak torque and mean work for contractions 1–5
Endurance level: mean peak torque and mean work for contraction 60–150
Co-ordination: SAR for the descending trapezius, the anterior deltoid and the infraspinatus, respectively
SAR initially: mean of SAR for contractions 1–5
SAR endurance level: mean of SAR for contractions 60–150.

Aerobic power. Maximal oxygen uptake (VO_2 max) was estimated from the subject's performance on a sub-maximal test on a mechanically braked ergometer bicycle (Cardionics AB). Heart rate was recorded with electronic equipment (Sport tester PE 3000). The mean value of the heart rate at the fifth and sixth minute was considered as the heart rate response to the actual workload. Absolute maximal aerobic power (VO_2 max in l. min^{-1}) was estimated according to the nomogram developed by Åstrand & Rodahl (20). Individual values were adjusted for age, and relative maximal power was calculated as VO_2 max in relation to body weight (VO_2 max · kg^{-1} · min^{-1}).

Ratings of pain. Perceived pain was rated on a 100 mm visual analogue scale (VAS) with the scale endpoints no pain at all (0 mm) and worst possible pain (100 mm). Three VAS scales representing pain at present, pain in general and pain at worst were rated prior to the pre- and post-measurements. To assess if pain increased because of the tests, pain at present was also rated immediately after the endurance test, which completed the test series.

Statistics

Statistical packages SPSS for Windows (version 7.5, SPSS Inc. Chicago, Illinois, USA) was used for analyses. For comparisons of pre- and post-training data within groups a paired t-test was used for normally distributed data (static strength, oxygen uptake, endurance initially and endurance level) and Wilcoxon's test for ordinal and non-normally distributed data (VAS ratings and SAR). For between group comparison a one way analysis of variance (ANOVA) was used for normally distributed data and a Kruscal-Wallis test for data on ordinal level and for non-normally distributed data. In order to assess the effects of physical improvements on pain ratings, linear multiple regression models were constructed. In the regression models, pre-/post-differences in physical parameters (static strength in shoulder elevation, 30 and 90° of shoulder forward flexion, peak torque, work and SAR on the endurance level and maximal oxygen uptake) were included. Forward stepwise analyses were then performed with pain at present, pain in general and pain at worst as the dependant variables respectively. In the multiple regression analysis only participants in the training groups ($n = 82$) were included. Sixteen subjects were not able to perform 150 contractions. In order not to lose information in the regression analysis on important variables, peak torque, work and SAR were extrapolated for these subjects. Nine of these subjects had reached an acceptable plateau for which a mean value could be calculated. Thus 75 subjects were included in the multiple regression analysis. A significance level of 95% was requested in all analyses.

RESULTS

The participants attended 70–80 % of the training sessions.

Aerobic power

In the within group comparisons VO_2 max increased significantly for the endurance and co-ordination training groups.

Table II. *Static muscular strength, muscular endurance and oxygen uptake before and after the intervention period (mean and 1 SD). Differences are presented as within group differences (T-test) and between group differences (one-way ANOVA) with the non-training group as the reference group. The values on muscular strength and oxygen uptake represent all participants* (n^1 = 102), *while the values on muscular endurance represent participants completing 150 contractions in the endurance test* (n^2 = 84)

	Strength training group (n^1 = 29) (n^2 = 24)				Endurance training group (n^1 = 28) (n^2 = 22)				Coordination training group (n^1 = 25) (n^2 = 20)				Non-training group (n^1 = 20) (n^2 = 18)		
	Pre	Post	Within group	Between groups	Pre	Post	Within group	Between groups	Pre	Post	Within group	Between groups	Pre	Post	Within group
Muscle strength[1]															
Peak torque in:															
30° flexion (Nm)	49.4 ± 8.4	57.7 ± 9.2	*	*	45.4 ± 8.1	52.3 ± 6.7	*	*	48.7 ± 8.9	54.1 ± 8.2	*	NS	46.3 ± 10.5	47.0 ± 5.8	NS
90° flexion (Nm)	31.1 ± 4.7	36.8 ± 5.7	*	*	29.7 ± 5.6	34.0 ± 6.0	*	NS	31.5 ± 5.7	34.9 ± 5.6	*	NS	29.9 ± 6.7	31.1 ± 4.0	NS
shoulder elevation (N)	428 ± 101	484.8 ± 80.8	*	*	417.7 ± 108.4	430.5 ± 86.1	NS	NS	377.3 ± 97.0	419.2 ± 81.8	*	NS	399.2 ± 89.6	389.8 ± 71.3	NS
Muscular endurance[2]															
Peak torque:															
Initially (Nm)	52 ± 11.9	66.4 ± 11.8	*	NS	51.7 ± 9.8	59.5 ± 10.4	*	NS	48.2 ± 6.9	58.0 ± 14.9	*	NS	49.3 ± 12.3	58.2 ± 9.1	*
Endurance plateau (Nm)	29.1 ± 5.9	35.8 ± 6.1	NS	NS	30.4 ± 6.5	32.2 ± 6.2	*	NS	30.6 ± 5.0	33.4 ± 6.8	*	NS	25.1 ± 5.5	29.0 ± 6.3	NS
Work:															
Initially (J)	23.8 ± 6.1	34.9 ± 3.7	*	*	24.1 ± 6.4	32.3 ± 3.5	*	*	23.6 ± 5.5	33.1 ± 6.5	*	*	28.9 ± 8.4	30.0 ± 2.7	NS
Endurance plateau (J)	13.2 ± 2.6	18.9 ± 2.7	*	*	14.2 ± 4.3	17.7 ± 4.4	*	*	13.9 ± 3.3	18.1 ± 4.3	*	*	14.8 ± 3.9	14.4 ± 2.3	NS
VO_2 max[1] ($ml \cdot min^{-1} \cdot kg^{-1}$)	35.2 ± 7.9	36.9 ± 8.1	NS	NS	36.4 ± 8.8	40.3 ± 8.8	*	NS	3 4.3 ± 8.2	36.9 ± 9.0	*	NS	39.9 ± 7.3	40.8 ± 9.5	NS

* $p < 0.05$. NS = not significant. n^1 participants with measurements of muscular strength and oxygen uptake. n^2 participants with muscular endurance test.

However, no statistically significant differences were detected between groups (Table II).

Static strength

In the within group comparisons static strength in 30 and 90° significantly increased in all three training groups and shoulder elevation increased within the strength and the co-ordination training groups. In between group comparisons only the strength training group significantly differed from the non-training group regarding the increases in static strength in 30 and 90° of forward flexion and shoulder girdle elevation (Table II).

Muscular endurance

Muscular endurance and co-ordination were analysed only for the 84 subjects who were able to perform 150 contractions in the tests before and after training.

Work initially and on the endurance level increased in all training groups both within groups and when compared to the non-training group (Table II).

Peak torque initially increased within all groups including the non-training group and peak torque on the endurance level increased within the endurance and the co-ordination training groups. No significant difference in peak torque (initially or on the endurance level) was found in between group comparisons (Table II). Subjects unable to perform 150 contractions did not differ from those who managed regarding initial values of peak torque or work pre-test.

Muscular co-ordination

The SAR initially decreased significantly for both the descending trapezius and the infraspinatus muscles within the strength-training group. The SAR during the endurance level was significantly lowered for the infraspinatus muscle within in the strength-training group and for both the descending trapezius and the infraspinatus muscles within the co-ordination training group. In the between group comparisons there was no significant decrease in SAR in the training groups compared to the non-training group for any of the muscles (Table III).

Table III. *Signal amplitude ratio (SAR) (muscular co-ordination) before and after the intervention period (mean and 1 SD). Differences are presented as within group differences (Mann–Whitney test) and between group differences (Kruskal-Wallis test) with the non-training group as the reference group. The values represent participants completing 150 contractions in the endurance test (n = 84)*

	Strength training group ($n = 24$)				Endurance training group ($n = 22$)				Co-ordination training group ($n = 20$)				Non-training group ($n = 18$)		
	Pre	Post	Within group	Between groups	Pre	Post	Within group	Between groups	Pre	Post	Within group	Between groups	Pre	Post	Within group
SAR initially:															
Trapezius (%)	12.9 ± 9.9	9.1 ± 5.8	*	NS	13.2 ± 9.4	11.7 ± 8.5	NS	NS	12.2 ± 6.3	9.9 ± 6.4	NS	NS	9.1 ± 6.3	7.1 ± 7.2	NS
Infraspinatus (%)	15.6 ± 8.4	11.4 ± 5.5	*	NS	13.6 ± 6.8	12.2 ± 6.9	NS	NS	14.8 ± 6.8	12.7 ± 8.3	NS	NS	14.2 ± 7.2	11.6 ± 5.5	NS
Deltoideus (%)	16.7 ± 7.4	14.7 ± 6.8	NS	NS	17.9 ± 9.1	16.8 ± 8.5	NS	NS	19.7 ± 6.6	17.0 ± 8.6	NS	NS	18.8 ± 14.4	14.0 ± 6.4	NS
SAR endurance level:															
Trapezius (%)	11.2 ± 7.3	9.9 ± 9.1	NS	NS	10.0 ± 6.1	9.6 ± 10.9	NS	NS	10.9 ± 6.8	8.2 ± 8.3	*	NS	13.6 ± 13.5	12.3 ± 9.2	NS
Infraspinatus (%)	15.3 ± 8.7	9.7 ± 6.5	*	NS	11.2 ± 7.5	9.6 ± 7.9	NS	NS	15.3 ± 10.4	10.1 ± 7.9	*	NS	19.4 ± 17.3	13.2 ± 11.0	NS
Deltoideus (%)	14.4 ± 11.8	9.6 ± 7.6	NS	NS	12.7 ± 9.1	14.3 ± 9.5	NS	NS	13.5 ± 8.8	9.2 ± 7.1	NS	NS	11.9 ± 9.5	9.5 ± 6.6	NS

* $p < 0.05$. NS = not significant.

Table IV. *Pain before and after the intervention period (mean and 1 SD). Differences are presented as within group differences (Mann–Whitney test) and between group differences (Kruskal Wallis test) with the non-training group as the reference group (n = 102)*

	Strength training group ($n = 29$)				Endurance training group ($n = 28$)				Co-ordination training group ($n = 25$)				Non-training group ($n = 20$)		
	Pre	Post	Within group	Between groups	Pre	Post	Within group	Between groups	Pre	Post	Within group	Between groups	Pre	Post	Within group
VAS at present (mm)	23 ± 17	11 ± 16	*	NS	32 ± 22	19 ± 14	*	NS	34 ± 20	24 ± 25	*	NS	32 ± 23	30 ± 21	NS
VAS in general (mm)	36 ± 15	22 ± 18	*	NS	43 ± 20	31 ± 17	*	NS	40 ± 15	30 ± 17	*	NS	42 ± 22	38 ± 24	NS
VAS at worst (mm)	72 ± 14	54 ± 27	*	*	70 ± 17	59 ± 21	*	NS	76 ± 12	67 ± 19	*	NS	75 ± 17	74 ± 19	NS

* $p < 0.05$. NS = not significant.

Ratings of pain

In the within group analysis all training groups rated significantly less pain after 10 weeks of training. In between group comparisons there was a significant decrease in pain at worst for the strength training group compared to the non training group but no significant decrease in pain at present and pain in general for any of the training groups (Table IV).

Effects on perceived pain from physical improvements

Pain at present was positively associated with improved shoulder elevation and oxygen uptake and negatively associated with static strength in 90° of forward flexion. In the model with pain at present as the dependent variable, 15% of the improvement could be explained by physical variables (Table V). Pain at worst was positively associated with static strength in 30° of forward flexion and explained 9% of the variation (Table V).

DISCUSSION

Women with trapezius myalgia improved their physical performance in relation to training performed and rated less pain after 10 weeks of strength-, endurance-, or co-ordination training of neck/shoulder muscles, while a non-training group did not. The type of training was not found to be different in reducing perceived pain at present and in general. However, strength training more efficiently reduced the perception of worst possible pain. This can be appreciated by a significant difference in the ratings of worst possible pain for the strength but not for the other groups in the between group comparison as shown in Table IV. Both strength and aerobic fitness training were previously reported to reduce pain in subjects with neck/shoulder pain (6, 21). Our study as well as other studies comparing more than one type of training failed to find a distinction between different types of training regarding their effect on neck/shoulder pain (4, 8). This could be attributed to our findings that the reduction in perceived pain only to a minor degree could be explained by physical improvements.

Training effects

It could be discussed if the design of the training programs was specific enough since static strength increased even in the endurance training group and dynamic muscle endurance increased in all training groups. Compliance with training was 70–80%, and since the training was supervised the expected amount of training and the correctness in movements can be assured. Recommended loading for muscle strength covers a range of 75–90% of MVC (22, 23). Subjects in our study had pain, were untrained and unfamiliar with maximal effort, therefore a load higher than 75% of MVC could not be accepted. Holten & Faugli (24) propose that in rehabilitation the actual load to increase strength is between 60 and 80% of MVC. The specificity of the strength training in our study was supported by biopsies from the trapezius muscle with a conversion of muscle fibres from type I to type II fibres as well as an increased area of type II fibres (15). In order to achieve an increased muscular endurance the load in our study was set to 60% of MVC and obtained by 30–35 RM with rubber expanders and cycling on an arm-ergometer loaded to give a heart rate of 110–120 beats per minute. Earlier studies have shown that cycling with one leg increased capillarization in the quadriceps muscle (25). As the aim with the endurance training in our study was to increase local circulatory capacity in the shoulder muscles, it was hypothesised that arm-ergometers could fulfil the demands. Muscle biopsies from the descending part of the trapezius muscle also showed an increased number of capillaries in both the strength and the endurance training groups (15). Subjects in the strength training group did not perform arm-ergometer training and muscular endurance measured as output of work on the endurance level increased in all training groups. This could imply that the increased capillarization in the trapezius muscle might not be due to the arm-ergometer training alone but could be a result of the dynamic loaded arm movements. The close relation between the parameters muscle strength and muscular endurance could explain the overlap of training effects between the strength and endurance training groups. Other studies trying to separate effects on muscle strength and endurance in rehabilitation training have faced the same difficulty as we have. Studies by Genaidy et al. (26) evaluating effects on work tolerance of training programs conclude that strength training performed as 10 RM also increased the participants muscular endurance and if the load exceeded the participant's value at start with 50% both static and dynamic strength improved.

None of the training groups displayed a decreased SAR on the endurance level, compared to the non-training group. However, despite a large intra-individual difference in the SAR values, SAR significantly decreased for the trapezius and the infraspinatus muscles in the co-ordination training group in the within group comparison. To reach significance in between group comparisons a larger population would likely have been necessary.

Methods

The exercise equipment for strength training was easy to handle which facilitated the establishment of a distinct load. The control of the load in the endurance training was less precise. The loading of the arm-ergometers was based on recommendations to achieve improved aerobic fitness and cannot directly be transferred to muscle load. A more precise load would have been achieved if the strength training machines could have been used for endurance training as well, but these could not be loaded low enough for this purpose. To obtain a load of 30–35 RM in the rubber expanders, the participants were instructed to place themselves at an accurate distance from the attachment of the expander. The individual load could therefore either be slightly over or below the intended. This design could be considered to lack precision but it was chosen for practical reasons. As the range is wide for at which rate of the MVC muscular endurance

Table V. *Multivariate linear regression models. Models with pain at present and with pain at worst as the dependent variable regression coefficients for variables in the model; p-values and the percentage of variance (R^2) explained by the model are presented*

	Coefficient	*p*-value	R^2
Pain at present			
Shoulder elevation	0.09	0.002	15%
Static strength in 90° of forward flexion	−1.09	0.047	
Oxygen uptake	23.16	0.003	
Pain at worst			
Static strength in 30° of forward flexion	0.90	0.011	9%

is achieved, the training was regarded to have acceptable specificity.

The choice of body awareness training as co-ordination training was based on clinical experiences. Results on changes in muscle tension and movement patterns through body awareness training are based on clinical assessments (17). Since EMG, to our knowledge, has not been used to evaluate body awareness training, a validation of the SAR measurements against the clinical assessment by Roxendahl should be performed. The repeatability of EMG measurements has been questioned, but the SAR method is shown to be reproducible even in long term (27).

The accuracy of isokinetic testing to evaluate training has been questioned, due to differences in both movement patterns and movement velocity. However, for evaluation of effects of an intervention a standardised measuring procedure is of importance. Due to the complex anatomy of the shoulder joint, standardisation of functional movements is especially difficult. Exercises in our study focused on dynamic arm movements requiring stabilisation of muscles around the shoulder and all training forms included movements in shoulder forward flexion. The isokinetic measurement method elaborated by Elert & Gerdle (18) therefore seemed to be accurate for evaluation. During the endurance test a substantial variation in peak torque between the repeated contractions was seen, while work expressing a mean of the biomechanical output during the contraction varied less. This could be due to that the subjects were unfamiliar with maximum contractions and feared an increased pain. Elert et al. (27) found peak torque to be more reliable than work in a re-test after one year. In a one-year time interval the memories of effort during maximum contractions might influence the performance less than after 10 weeks. The increase in work for all training groups could also be regarded as an effect of the participant's familiarity with the training equipment at re-test. On the other hand the non-training group in our study did not improve either regarding physical performance on the endurance level or in pain ratings so familiarity with the test equipment seemed to have little influence. In the studies by Elert et al. (18, 27) an angular velocity of 60°. s^{-1} was used. In a preceding pilot study we found that several subjects had to interrupt the endurance test before 150 contractions due to the experienced high load at 60°. s^{-1}. A higher velocity of 90°. s^{-1} giving less resistance was tolerable.

Pain ratings

Only the decrease in the ratings of pain at worst on the VAS-scale differed significantly between the strength training and the non-training group. On the scales for pain at present and pain in general the median ratings were 30 and 40 mm, respectively and the improvement after training resulted in a decreased rating of 10–15 mm on the scale. With a difference that small between before and after values a larger population would have been needed to separate the programs on their effect of pain reduction. As suggested by Linton (28) a change of 10 mm on the VAS scale for pain in general is a minimum to be of clinical importance. The statistical power to detect a reduction of 20 mm on the VAS scale for pain in general was 90% in this study, but the power to detect a reduction of 10 mm was lower than 50%. Women in our study rated lower on the pain scale compared to subjects in the studies by Takala et al. (29), who reported median ratings of 50 mm on the VAS scale before training. The difference could indicate that our subjects had a more moderate form of myalgia as suggested by the fact that they were working and were willing participants in a training study. Consequently our results can not be applied to patients suffering from severe pain.

As improved physical function only explained 9–15% of the pain reduction in the multiple regression models VAS ratings should be supplemented with other outcome measures, for example self efficacy and/or coping strategies in order to more fully elucidate the relation between training and pain reduction.

Recommendations for training

As long as pain reduction in the shoulder muscles is the purpose of the training either strength, endurance or co-ordination training for shoulder muscles can be recommended.

Important aspects in the design of training programs for reduction of muscle pain seem to be the frequency and intensity of the training. Ten weeks of training with focus on shoulder muscles in three one-hour sessions a week can result in pain reduction as seen in our study as well as in other studies (22, 30). Group gymnastics once a week during ten weeks did not on the other hand reduce pain (29, 30).

Participants in an intensive training program also remained on a lower pain level at 6 and 12 months follow-up than those in a less intensive program (4). In our study the intensity of strength training (75% of MVC (maximal volume contraction)) was needed to significantly reduce perceived pain at worst. This could indicate, that in order to affect the individual's perception of worst possible pain, the effort demanded in training has to exceed the effort needed in every day life activities.

When trapezius myalgia is related to work tasks a training program can be helpful in prevention and rehabilitation by reducing pain and improving functional capabilities. However, for successful work rehabilitation and secondary prevention, changes in the work place are also necessary.

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