Rehabilitation of Neck-Shoulder Pain in Women Industrial Workers: A Randomized Trial Comparing Isometric Shoulder Endurance Training With Isometric Shoulder Strength Training

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ABSTRACT. Hagberg M, Harms-Ringdahl K, Nisell R, Hjelm EW. Rehabilitation of neck-shoulder pain in women industrial workers: a randomized trial comparing isometric shoulder endurance training with isometric shoulder strength training. Arch Phys Med Rehabil 2000;81:1051-8.

Objectives: To study whether isometric shoulder endurance was more advantageous than isometric shoulder strength training in reducing pain and perceived exertion and to increase shoulder function through improved muscle endurance and strength.

Design: Randomized trial.

Setting: Three occupational health care centers.

Participants: Women industrial workers with nonspecific neck-shoulder pain. The International Classification of Diseases, 10th Revision (ICD-10) diagnosis was ‘‘cervicobrachial syndrome’’ (M53.1). Thirty-eight patients completed the isometric shoulder endurance training and 31 patients completed the isometric shoulder strength training.

Intervention: Twelve weeks of training.

Main Outcome Measures: Self-reported pain and rating of perceived exertion (RPE), arm motion performance test, shoulder muscle strength, shoulder muscle endurance, and shoulder functional tests, as well as follow-up after supervised training had ended.

Results: The isometric shoulder strength training resulted in an almost one-scale step decrease in RPE at work and a 5% to 15% improvement of arm motion performance compared with the endurance training. The isometric shoulder strength training more effectively improved left side shoulder abduction strength ($p < .026$), but no major differences were found for the other strength measurements. The isometric shoulder endurance training was not more successful than the strength training in the endurance test (p .51 to .81).

Conclusions: Physical training programs for neck-shoulder pain may include isometric shoulder muscular strength exercise in addition to isometric shoulder endurance training, rather than endurance training only.

Key Words: Exercise therapy; Female; Occupational diseases; Pain measurement; Prevention; Rehabilitation.

CERVICOBRACHIAL PAIN among women assembly workers is common.[1] Patients often report tenderness, stiffness, and soreness of the upper part of the trapezius muscle.[2] In epidemiologic studies, the terms tension neck syndrome, trapezius myalgia, or neck-shoulder pain are often applied to nonspecific pain and tenderness in the neck-shoulder region.[3] In most cases, this pain would correspond to the ICD-10 diagnosis ‘‘cervicobrachial syndrome’’ (M53.1). Relative risks between 2 and 4 have been reported for cervicobrachial syndrome among women in hand-intensive industrial work.[4]

Muscle strength training may be an important part of the rehabilitation of patients with cervicobrachial pain.[5] Neck-shoulder muscle performance improved more after strength training among women office workers with cervicobrachial symptoms than it did after passive physiotherapy.[6] The important difference between a hazardous exposure, that is, low-level static contraction, and training may be the type, level, duration, and frequency of muscle contraction. In the few previous studies of physical training in the rehabilitation of cervicobrachial pain there were no evaluations of the type of contractions used in the rehabilitation exercises. Considering the specificity of strength and endurance training,[7] the type of contraction used could be of great importance for the success of the rehabilitation.

Our objective in this investigation was to study whether isometric shoulder endurance was more advantageous than isometric shoulder strength training in reducing pain and perceived exertion and in increasing function through improved muscle endurance and strength.

PATIENTS AND METHODS

The study was done as a randomized, multi-center independent trial at 3 occupational health centers. The study design and the methods used were approved by the Ethical Committee of the Karolinska Institute, Stockholm.

Patients

Women industrial workers seeking medical attention for neck or shoulder pain at 3 occupational health centers in Sweden were eligible to participate in the study. Each center served 1500 to 4000 industrial workers. The period during which patients were eligible was 10 months. The criteria for inclusion in the study were: (1) pain in the neck-shoulder region (specific causes, eg, radicular pain, systemic inflammatory diseases, acute local shoulder tendinitis, bursitis, acromioclavicular joint arthritis, and trauma such as whiplash lesions, were excluded); (2) upper trapezius muscle tenderness; (3) pain and tenderness present for at least 3 months before inclusion in the study; (4) not more than 90 days of sick leave during the 6 months preceding inclusion; (5) a job involving a constrained sitting posture with repetitive hand movements and possibly a static load on the upper part of the trapezius muscle (eg, assembly of printed circuit boards); and (6) gradual onset of symptoms that were apparently work related. The ICD-10 diagnosis for all the

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Submitted April 27, 1999. Accepted in revised form January 17, 2000.

Supported in part by AMF-Trygghetsförsäkringar, Stockholm, Sweden.

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit upon the authors or upon any organization with which the authors are associated.

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0003-9993/00/8108-5595$3.00/0

doi:10.1053/apmr.2000.7582

Table 1: Pretraining (Baseline) Values for Patient Characteristics, Reported Neck-Shoulder Pain, and Rating of Perceived Exertion (RPE) of Job Activities, by Training Group

Characteristic	Endurance Group				Strength Group				Groups Compared	
	Mean	SD	Range	*n*	Mean	SD	Range	*n*	Difference (Mean)	95% CI
Age (yrs)	39.8	7.6	22-58	38	37.6	9.9	23-58	31	2.2	−1.31-5.71
Weight (kg)	65.7	8.8	50-87	38	64.0	10.5	51-90	29	1.7	−2.24-5.64
Height (cm)	165	6.6	150-178	38	166	6.1	154-180	30	−1	−3.60-1.60
BMI (kg/m^2)	24.2	3.1	19.4-32.7	38	23.3	4.4	18.7-35.4	28	0.9	−0.640-2.44
Employment (yrs)	7.6	8.4	0.1-28	37	7.0	6.7	0.3-24	30	0.6	−2.55-3.75
Neck-shoulder pain										
Worst of preceding week	43	28	0-92	36	35	26	2-87	31	8	−3.08-19.1
Present pain	42	27	0-92	36	34	27	0-84	31	8	−3.04-19.0
Pain duration (yrs)	4.6	5.0	1-20	36	4.9	4.7	0.5-20	26	−0.3	−2.40-1.80
RPE of the job	6.2	2.5	1-11	36	6.4	2.5	2-11	30	−0.2	−1.23-0.831

Abbreviation: BMI, body mass index.

patients was "cervicobrachial syndrome" (M53.1). Altogether, 77 patients were enrolled.

Dropouts. Five participants from the endurance training group dropped out: 2 because of vacations or unexplained absence of more than 3 weeks, 1 because of increased pain, 1 because of personal problems, and 1 because of an accident. Three participants from the strength training group dropped out: 1 because of vacations or unexplained absence of more than 3 weeks, 1 because of increased pain, and 1 because of an incompatible shift work schedule.

Study groups. Thirty-eight patients completed the isometric shoulder endurance training and 31 completed the isometric shoulder strength training. Bilateral symptoms were present in two-thirds of the patients; only 8 patients had unilateral left-sided symptoms. Only small differences existed in age, height, weight, and employment time between the two groups (table 1).

Methods

Questionnaire. All patients eligible for the study answered a questionnaire concerning demographic, psychologic, social, medical, and other background variables before being included in the study.

Physical examination. Patients were examined according to a standardized protocol by a physiotherapist before being included in the study. The protocol included range of motion, tests of pain at isometric contraction, and manual palpation of the cervical spine, shoulder girdle, and arm. Two clinical tests were performed. In the first, the foramen compression test of the cervical spine, the patient was in a sitting position which the examiner rotated and laterally flexed the patient's head while putting some pressure on it; the test was positive if it elicited pain in the arm or hand, the second test was the abduction-external-rotation test (Roos test) for thoracic outlet engagement. If any of the test was positive, or if the patient had neurologic symptoms of tingling and paraesthesia, she was referred to a physician for further diagnostic procedures and was excluded from the study.

Randomization. Patients meeting the criteria for inclusion after the questionnaire and the physical examination were offered participation in the training program. We informed the patient that this was a randomized trial and she would be randomly placed into 1 of 2 programs. After the patient volunteered to participate in the program the physiotherapist contacted the principal investigator, who listed the patient and assigned by chance (dice) the training program in which the patient would participate. The physiotherapists performing the training could not change the randomization designated by the

Table 2: Pretraining (Baseline) Effects, by Training Group

Effect	Endurance Group				Strength Group				Groups Compared	
	Mean	SD	Range	*n*	Mean	SD	Range	*n*	Difference (Mean)	95% CI
Shoulder strength										
Flex R (Nm)	30.9	9.8	9.2-56.1	38	29.9	11.9	9.2-54.5	31	1.0	−3.36-5.36
Flex L (Nm)	31.1	8.4	13.5-44.6	38	29.2	11.3	5.4-51.6	31	1.9	−2.06-5.86
Abd R (Nm)	27.7	8.8	6.3-37.4	37	26.7	10.7	6.6-46.8	31	1.0	−2.94-4.94
Abd L (Nm)	27.2	8.0	8.6-38.8	38	25.3	10.5	5.2-45.3	31	1.9	−1.82-5.62
Out R (Nm)	17.9	5.0	8.5-28.0	37	17.5	6.3	6.9-29.6	31	0.4	−1.89-2.69
Out L (Nm)	17.6	3.9	8.4-25.4	37	16.9	6.7	5.8-31.3	31	0.7	−1.48-2.88
Grip R (kPa)	78.3	18.3	46-115	32	72.0	32.3	9-124	22	6.3	−5.26-17.9
Grip L (kPa)	76.2	19.8	30-121	32	72.2	26.5	13-116	21	4.0	−6.66-14.7
Shoulder endurance										
RPE 1min right	6.6	2.4	3-11	38	6.7	3.2	1-13	30	−0.1	−1.23-1.03
RPE 1min left	6.4	2.4	1-11	38	6.1	2.8	0-12	30	0.3	−.753-1.35
RPE 2min right	10.0	2.4	4-14	35	9.2	3.2	2-14	30	0.8	−.362-1.96
RPE 2min left	9.4	2.8	3-14	35	9.3	3.2	1-14	27	0.1	−1.18-1.38
Shoulder function										
Arm R motion (sec)	10.7	1.9	8.0-14.7	38	13.4	10.4	6.4-65.4	31	−2.7	−5.57-.166
Arm L motion (sec)	10.9	1.9	8.4-14.9	38	12.0	3.9	6.3-21.9	31	−1.1	−2.30-.0978

Abbreviations: Flex, flexion; Abd, abduction; Out, outward rotation; R, right; L, left.

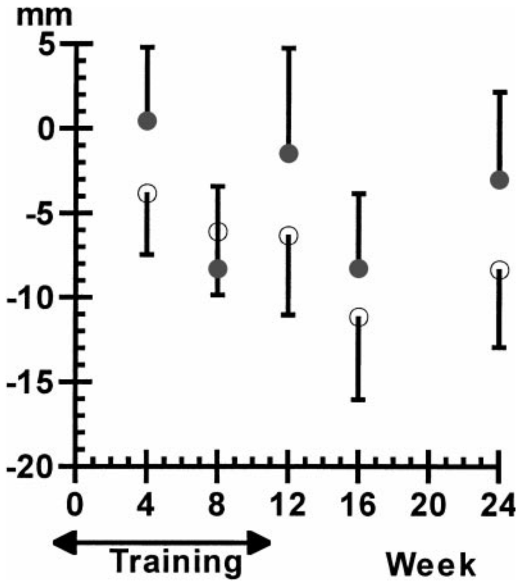

Fig 1. Weekly pain ratings: mean change (mm on VAS) for the different types of training: ○, endurance; ●, strength. The patient rated the worst pain experienced during the previous week. A negative value indicates less pain. The error bar indicates the standard deviation from the mean (standard error of measurement).

principal investigator. The physiotherapist administered the training and the effect measurements.

Measurements. Two effect measurements were recorded on separate days before training began. Effect measurements were also performed after 4, 8, and 12 weeks of training. Follow-up measures were made 4 and 12 weeks after training had stopped. The effect measures consisted of self-reported pain and perceived exertion, arm motion performance test, and shoulder muscle strength, shoulder muscle endurance, and shoulder function tests. The patients also reported sick leave from work, as well as drug use.

Self-reported pain and perceived exertion. Pain was rated on a 100-mm visual analog scale (VAS). The patient was asked to mark her worst pain during the past week, and her present pain in neck or shoulder. The patients assessed the physical work load during work and during household work as perceived exertion according to the Borg[8] rating of perceived exertion (RPE).

Arm motion performance test. In the arm motion test the patient was timed moving her hand between the back of her head and the lumbar back (L4-L5) as fast as possible ten times.[9] Only the second of 2 trials on each test occasion was recorded. The right arm and the left arm were tested separately.

Shoulder muscle strength. Isometric strength was measured in 3 trials using a mechanical dynamometer calibrated with a weight before each trial. The patient was asked to slowly increase the contraction during 1 to 2 seconds and reach maximum contraction after 3 seconds. The patient rested at least 30 seconds between trials. A mechanical dynamometer was used in all strength measurements. The positions used for the isometric strength measurements were chosen according to the American Academy of Orthopaedic Surgeons.[10]

Shoulder forward flexion. For shoulder forward flexion the patient sat with a lumbar support. The measurement was performed with 90° flexion in the shoulder joint and a straight arm. A sling to the dynamometer attached to the floor was applied just proximal to the elbow joint. The distance between the shoulder joint and the sling was measured and the isometric force was expressed as torque, in newton meters (Nm).

Shoulder abduction. Shoulder abduction was measured with the shoulder in 90° abduction, with the patient sitting. This measure was also expressed as torque (Nm).

Shoulder outward rotation. Shoulder outward rotation was measured with the patient supine with the upper arm close to the trunk, the elbow in 90° flexion, and the forearm vertical. The sling to the dynamometer was applied just proximal to the wrist with a horizontal pull. This measurement was also expressed as torque (Nm).

Grip strength. Grip strength was measured using a Vigorimeter[a] with a medium-sized ball. The patient sat with 90° flexion in the elbow joint and the hand resting in the lap, radial side up. She gripped the ball with 4 fingers (no thumb). This measurement was expressed in kilopascal (kPa).

Shoulder endurance. To assess endurance with 90° shoulder forward flexion, the patient sat with both arms in 90° forward flexion, elbows straight, and forearms semipronated (thumbs up). She rated the perceived exertion in the neck-shoulder region on each side on the Borg RPE scale every 30 seconds.[8] After 180 seconds the test was ended.

Training Programs

Patients exercised both sides of the body simultaneously. The training was usually performed at the occupational health care center, but for some sessions patients were allowed to train at home after they had learned the exercises; the physiotherapist supervised the training at least once a week. Compliance was controlled by diary. The mean number of sessions at home was 11.0 for the strength group and 10.8 for the endurance group, out of the 36 scheduled sessions.

The isometric shoulder endurance training was intended to improve endurance in the upper part of the trapezius muscle. In a sitting posture, the patient had to lift the arm to 90° of forward flexion with a straight arm and the forearm semipronated. She was to hold this position for 2 minutes. The exercise was done 4

Table 3: Mean Change (mm) From Baseline in Rated Pain on VAS for the Different Types of Training

	4 Weeks		8 Weeks		12 Weeks*		16 Weeks		24 Weeks	
	Mean	*p*	Mean	*p*	Mean	*p*	Mean	*p*	Mean	*p*
Worst pain last week										
Endurance	−3.9	.28	−6.2	.10	−6.4	.17	−11.3	.026	−8.4	.072
Strength	.45	.92	−8.3	.063	−1.5	.82	−8.3	.073	−3.0	.56
Present pain										
Endurance	−7.3	.018	−8.5	.029	−8.8	.036	−12.3	.0047	−10.6	.025
Strength	−0.1	.99	−7.1	.20	−6.8	.21	−7.5	.11	−7.4	.16

A negative value indicates less pain than baseline rating. The *p* value is the probability of change different from 0.
* Supervised training ended at 12 weeks.

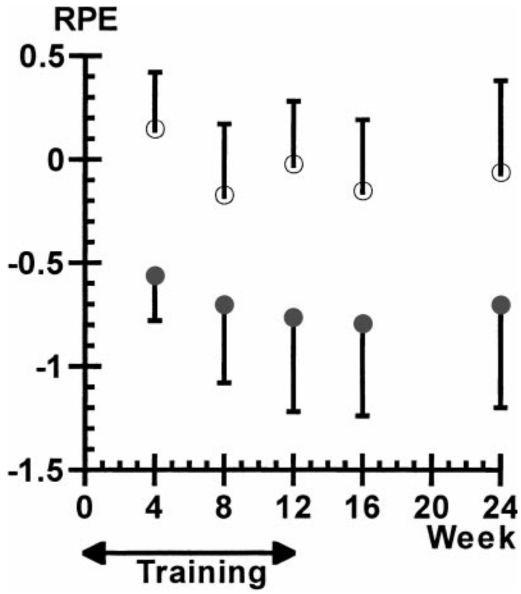

Fig 2. Perceived exertion on the job (RPE): mean change (Borg[8] scale) for the different types of training: ○, endurance, ●, strength. A negative value indicates less exertion. The error bar indicates the standard deviation from the mean (standard error of measurement).

times with 2 minutes of rest in between, 3 times weekly for 12 weeks. This exercise corresponds to a contraction level of about 20% to 30% of maximal shoulder joint torque, and approximately the same contraction level for the upper part of the trapezius.[11]

The isometric shoulder strength training was intended to improve strength in the upper part of the trapezius, and mainly involved the type 2 muscle fibers. The patient was in a sitting posture with the arms in 90° of forward flexion and the forearm semipronated. A sling from the floor was attached to the arms just proximal to the elbow joint. The training contraction was performed as a maximal contraction held for 5 seconds followed by a rest for 2 minutes. The exercise was done as 10 contractions with 2-minute rests in between. The attempt was to have the 2 types of training equally aggressive and fatiguing.

Statistics

Descriptive parametric statistics are presented. The effect of training was analyzed intraindividually, each patient's registration being compared with a baseline, defined as the second pretraining measurement. The first pretraining effect measurements were disregarded since they were considered a learning session. We computed the mean change in each training group and the probability of a zero-effect (ie, no change) with a t statistic by using the univariate procedure in the SAS software package.[12] The two training groups were assessed by comparing the improvement (or impairment) during and after the training with the baseline. The comparisons between the two training groups were done with repeated-measures analysis of variance (MANOVA) by the GLM procedure in the SAS software package.[13]

RESULTS

The two training groups, which both underwent isometric training for the first 12 weeks of the study, were similar in background and effect variables before training (tables 1, 2). Strength, endurance, and strength/endurance measures were recorded a the second pretraining measurement. The variations in the pain ratings, endurance, and strength were large within each training group (table 2).

Pain and perceived exertion. A decrease in VAS-rated ''worst pain during last week'' and ''pain right now'' was seen in both training groups during and after training (fig 1, table 3). We found no consistent difference in the pain rating when we compared the two training types during and after the training period (MANOVA, $F = .14$-.20). The RPE on the job decreased in the isometric shoulder strength training group during and after training (fig 2, table 4). The MANOVA analysis pointed toward a difference in effect between the two training types ($F = 2.81$, $p = .099$).

Arm motion performance test. Patients performed better on the arm motion performance test during and after both types of training (fig 3, table 5) and their improvement was greater with the isometric shoulder strength training for the right arm (MANOVA, $F = 4.23$, $p = .044$). The difference in effect between the 2 types of training was less on the left side (MANOVA, $F = .95$, $p = .33$).

Muscle strength. We found an increase in shoulder abduction strength during and after training (table 6), compared with baseline. The increase was greater for strength training than for endurance training on the left side (fig 4, table 6), with only a tendency on the right side (MANOVA, left $F = 5.22$, $p = .0260$; right $F = .82$, $p = .37$)). Shoulder forward flexion strength increased during both types of training with no major differences between the two types of training (table 6, MANOVA, right $F = .84$, $p = .36$; left $F = 1.36$, $p = .25$). There was also an increase in shoulder outward rotation for both types of training and both sides (table 6). Results were substantially the same for both types of training (table 6, MANOVA, right $F = .06$, $p = .81$; left $F = .23$, $p = .64$). There were no major training effects on grip strength (table 6), and the two types of training yielded similar results (table 6, MANOVA, right $F = 1.64$, $p = .21$; left $F = .71$, $p = .41$).

Shoulder forward flexion endurance. The RPEs at minute 1 and at minute 2 improved during training (fig 5, table 7). Results were substantially the same for the two training types (MANOVA, $F = .06$ to .45, $p = .51$ to .81).

Sick leave and drug use. Approximately one-fourth of the patients had been on sick leave for neck or shoulder pain 3 weeks before beginning the training programs. More than one-third of the patients had been taking nonsteroidal anti-inflammatory drugs (NSAIDs) to relieve neck or shoulder pain within 3 days before the training. Sick leave for neck or

Table 4: Mean Change (Borg[8] Scale) From Baseline in Perceived Physical Exertion on the Job (Job RPE) for the Different Types of Training

	4 Weeks		8 Weeks		12 Weeks*		16 Weeks		24 Weeks	
	Mean	p	Mean	p	Mean	p	Mean	p	Mean	p
Job RPE										
Endurance	.14	.61	−.18	.61	0	.92	−.16	.65	−.06	.88
Strength	−.57	.010	−.71	.066	−.77	.099	−.80	.081	−.71	.16

A negative value indicates less exertion than baseline. The p value is the probability of change different from 0.
* Supervised training ended at 12 weeks.

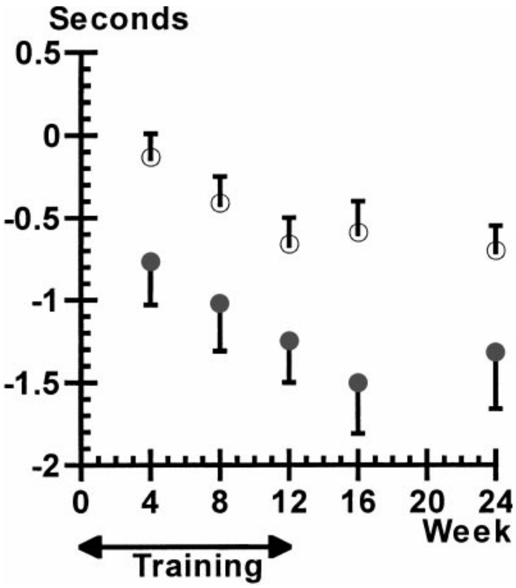

Fig 3. Arm motion (right arm): mean change (sec) in arm motion performance test for the different types of training: ○, endurance; ●, strength. A negative value indicates an improvement compared with baseline. The error bar indicates the standard deviation from the mean (standard error of measurement).

shoulder pain tended to decrease in the 2 groups, as did the number of patients using NSAIDs. Results were substantially the same for both training groups.

DISCUSSION

Isometric shoulder strength training seemed better for lowering perceived exertion of work and improving arm motion performance. As expected, the isometric shoulder strength training was more effective in improving strength, but the differences between the two types of training programs were not great. This finding is explained by isometric shoulder endurance training's being, in effect, low resistance isometric strength training. In a study of equivolume strength training in sedentary women their isometric strength was equally improved with 25% and 85% of maximum contractions.[14] A lower relative load can explain the reduction of perceived exertion at work in the strength group on the shoulder during work since training increases maximal voluntary contraction.

The endurance training was not more successful than the strength training considering the result of the rating of perceived exertion that patients reported during the endurance test. However, the endurance test functioned as a pain provocation test and the RPE measure was influenced by pain at exertion. An improvement in almost all effect measures was seen with time. Whether this is an effect of the training or an effect of time, that is, spontaneous recovery, is unknown. Strength improvement with training during the first few weeks is attributed to neural and psychologic adaptations; after about 8 weeks, further progress is due to muscular hypertrophy.[15] The reduction of pain after training has also been reported in trials involving the low back; among patients with cervical pain (75% of the patients were diagnosed as having cervical strain by the authors[16]), cervical extensor training reduced pain and increased isometric strength.[16] The increase in endorphins that occurs after training, and better neuromuscular control, may decrease activity-related pain. Strong muscle contractions activate muscles' ergo-receptors (stretch receptors).[17] The afferents from the receptors cause endogenous opioids to be released and also cause the release of β-endorphin from the pituitary.[17] These secretions may cause both peripheral and central pain to be blocked.

Histopathologic investigations of ''work-related trapezius myalgia'' (can be viewed as cervicobrachial syndrome) have shown objective signs of muscle changes.[18,19] In patients with chronic trapezius myalgia, whose type I fibers were significantly larger than in healthy subjects, the researchers[19] suggested that this difference was attributable to an adapted response to occupational strain. Type I predominance has been reported among patients with work-related trapezius myalgia compared with healthy subjects.[18] Thus two independent studies reported strain on the type I fibers in possible work-related trapezius myalgia.[18,19] Isometric shoulder endurance training would seem appropriate if the rehabilitation is aimed at strengthening the endurance characteristics of type I fibers. On the other hand assuming that type I fibers may be damaged by low-level static load during work involving the neck-shoulder muscles, it might be advantageous to train the type II fibers, thus decreasing the strain on the type I fibers. No study has compared the effect of low-level isometric shoulder endurance training involving the type I fibers with that of isometric shoulder strength training involving the type-II muscle fibers among patients with cervicobrachial pain. The result from the present study would at first glance favor strength training giving lower RPE at work. Another consideration, however, is the lower ratio of capillaries to cross-sectional area reported[19] for type I fibers in persons with trapezius myalgia, perhaps indicating a selected increase in the cross-section of the muscle fiber area, accompanied by an insufficient increase in capillary supply. The imbalance between muscle fiber size and capillary supply may be an important factor in muscle pain. With this consideration, exercises that stimulate continuous circulation and capillary growth with appropriate energy-saving motor control are beneficial. Endurance training is claimed to increase capillary density.[15]

Table 5: Mean Change (sec) From Baseline in Arm Motion Performance Test Results for the Different Types of Training

	4 Weeks		8 Weeks		12 Weeks*		16 Weeks		24 Weeks	
	Mean	*p*	Mean	*p*	Mean	*p*	Mean	*p*	Mean	*p*
Right arm motion										
Endurance	−.14	.34	−.42	.019	−.67	.0006	−.60	.0058	−.71	.0001
Strength	−.77	.0071	−1.01	.0017	−1.25	.0001	−1.50	.0001	−1.32	.0006
Left arm motion										
Endurance	−.26	.030	−.52	.0018	−.71	.0001	−.80	.0001	−.79	.0001
Strength	−.49	.019	−.78	.0037	−.96	.0002	−1.13	.0003	−1.15	.0013

A negative value indicates an improvement compared with baseline. The *p* value is the probability of change different from 0 (*t* statistic).
* Supervised training ended at 12 weeks.

Table 6: Mean Change From Baseline in Shoulder Strength (Nm) and Grip Strength (kPa) for the Different Types of Training

	4 Weeks		8 Weeks		12 Weeks*		16 Weeks		24 Weeks	
	Mean	*p*	Mean	*p*	Mean	*p*	Mean	*p*	Mean	*p*
Abd R										
Endurance	2.12	.029	2.16	.027	3.86	.0003	3.95	.0010	4.46	.0009
Strength	3.02	.028	4.33	.0010	5.14	.0015	3.93	.0022	3.49	.0096
Abd L										
Endurance	1.53	.045	1.52	.067	2.66	.0034	3.63	.0001	3.41	.0011
Strength	3.99	.0001	4.82	.0001	5.28	.0001	3.83	.0007	4.11	.0003
Flex R										
Endurance	3.40	.0012	3.27	.0031	4.68	.0003	4.89	.0001	5.17	.0001
Strength	4.88	.0001	5.57	.0001	5.86	.0005	5.09	.0014	5.03	.0024
Flex L										
Endurance	1.53	.079	1.49	.19	3.57	.0033	3.47	.0007	3.66	.0017
Strength	3.40	.0017	4.01	.0009	5.03	.0002	3.31	.0044	4.01	.0009
Out R										
Endurance	.80	.10	1.35	.0009	1.61	.0041	1.19	.0027	1.71	.0002
Strength	1.02	.039	1.44	.0081	1.59	.027	1.34	.057	1.55	.0095
Out L										
Endurance	.59	.10	1.14	.034	1.32	.0046	.88	.049	1.18	.026
Strength	1.03	.051	1.13	.029	1.87	.0035	1.00	.15	1.71	.0061
Grip R										
Endurance	.81	.70	3.00	.19	3.96	.12	5.78	.060	4.44	.075
Strength	6.45	.24	10.1	.076	13.4	.034	10.7	.079	8.95	.13
Grip L										
Endurance	.23	.90	2.11	.31	3.27	.090	3.33	.085	3.74	.038
Strength	2.37	.35	5.32	.061	7.39	.11	2.29	.40	4.50	.15

Positive values indicate improvement from baseline. The *p* value is the probability of change different from 0 (*t* statistic).
Abbreviations: Abd, abduction; Flex, flexion; Out, outward rotation; R, right; L, left.
* Supervised training ended at 12 weeks.

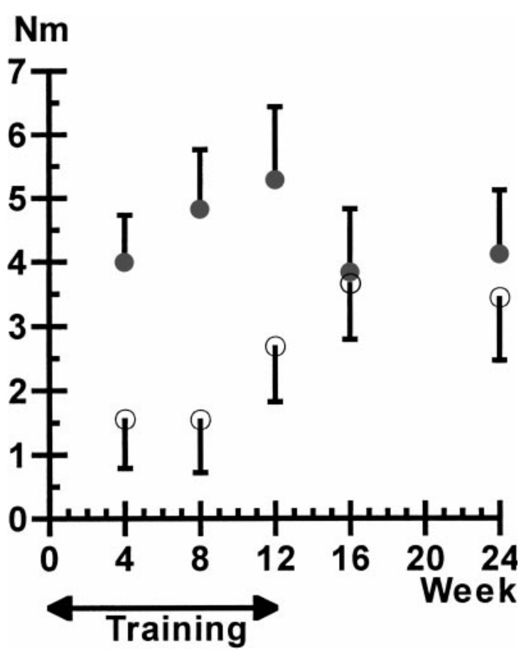

Fig 4. Shoulder muscle strength (left arm): mean change (Nm) in shoulder abduction strength for the different types of training: ○, endurance; ●, strength. A positive value indicates an improvement compared with baseline. The error bar indicates the standard deviation from the mean (standard error of measurement).

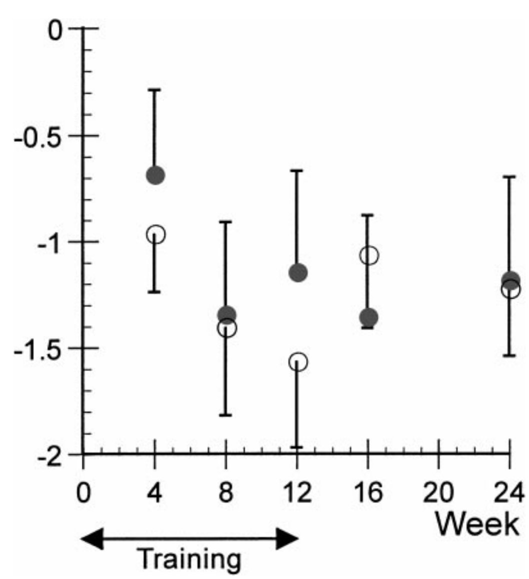

Fig 5. Perceived exertion during training: mean score change (Borg[8] scale) in perceived exertion at the end of the 2nd minute of the shoulder forward flexion endurance test for the different types of training; ○, endurance; ●, strength. A negative value indicates less exertion during the test than that exerted in the baseline test.

Table 7: Mean Change (Borg[8] Scale) in Perceived Exertion During Forward Flexion Endurance Test (Right and Left Shoulder) for the Different Types of Training

	4 Weeks		8 Weeks		12 Weeks*		16 Weeks		24 Weeks	
	Mean	*p*	Mean	*p*	Mean	*p*	Mean	*p*	Mean	*p*
Right RPE 1										
Endurance	−.57	.031	−1.20	.0019	−1.53	.0001	−.88	.0063	−.97	.0050
Strength	−.86	.014	−1.04	.014	−.89	.027	−1.00	.015	−.79	.11
Left RPE 1										
Endurance	−.49	.077	−1.00	.021	−1.53	.0001	−.67	.084	−.45	.21
Strength	−.61	.094	−.94	.0066	−.54	.13	−.59	.14	−.54	.24
Right RPE 2										
Endurance	−1.09	.011	−1.74	.0007	−1.57	.0020	−1.23	.017	−1.23	.0098
Strength	−1.00	.018	−1.31	.0041	−.92	.085	−1.28	.013	−1.12	.044
Left RPE 2										
Endurance	−.71	.033	−1.45	.0027	−1.30	.0042	−.70	.15	−.48	.24
Strength	−.75	.090	−1.34	.0016	−.79	.084	−1.14	.019	−1.02	.040

A negative value indicates less exertion than that perceived in the baseline test.
Abbreviations: RPE 1, RPE at the end of 1 minute; RPE 2, RPE at the end of 2 minutes.
* Supervised training ended at 12 weeks.

Study Design and Power Considerations

In the present study we attempted to evaluate whether physical training programs for patients with cervicobrachial pain should include isometric endurance or isometric strength exercises for the shoulder/neck muscles. We found no or minor advantages with the endurance training compared with the strength training. It is possible that the training program design in this study was not optimal for neck-shoulder muscles. We cannot be certain that the two treatments (strength and endurance training) were of equal therapeutic intensity. Unfortunately, no information exists on optimal strength or endurance exercise regimens for increasing muscle mass or function in the shoulder muscles. The use of a special device to constrain the motion of the cervical spine provides an opportunity to train isometric cervical spine motion, affording an increase in strength and a decrease in pain in patients with cervical strain.[16] Furthermore, although no statistically significant differences existed between our two training groups at entry, the endurance training group rated more pain, had more sick leave from work, and consumed more NSAIDs.

We assumed that the cause of our patients' cervicobrachial syndrome was in fact trapezius myalgia. Despite a careful history and a thorough examination before inclusion in the study we cannot be certain of the morphologic diagnosis, since no biopsy was taken. The patients' cervicobrachial pain may have been caused by strain of ligaments (enthesopathies),[20] joint capsules, tendons, or nerves in the shoulder or neck region. Possibly, patients with non-muscular-related neck-shoulder pain could have been impaired by the loading in our exercises. If this occurred, mixed tissue disorders would have distorted the results.

The patients in the present study were not the most severe cases, since one of the inclusion criteria was that the patient should not have been on sick leave for more than 90 days during the 6 months before inclusion. This protocol enabled us to exclude from the study patients with chronic pain syndrome perhaps aggravated by psychologic and social factors. The clinically apparent difference in the pain rating at patients' entry into the study, although not significant (see table 1), may have affected the results. If so, the endurance training group's potential for improvement was greater, since the pain rating in the endurance group was numerically higher than that in the strength training group.

We allowed our patients to continue any current medical treatment or physiotherapy. Examples of such therapies were NSAIDs, anaesthetic injections, acupuncture—all of which are standard treatments for painful shoulder conditions.[21] It was not possible for us to check the extraoccupational health care therapies, which may also have influenced the evaluation of our two training programs.

Unfortunately, there are few other randomized controlled trials with which to compare our results. Such studies are difficult to perform and are demanding in terms of resources. In a randomized controlled study of 119 patients with chronic neck pain researchers found no clinical difference among intensive cervical muscular training, physical therapy, and chiropractic treatment.[22] As seen in the evaluation of interventions for neck/shoulder disorders, the use of a control group not receiving therapy may lead to incorrect conclusions since the placebo effect may give as much as 30% change in effect measures.[23]

Our patients in the present study had great variation in pain perception and other effect measures. Using the variance of the pain measurements (pain right now = 21mm on the VAS), a power analysis showed that 604 patients are needed to detect a "significant" ($p = .10$) 5-mm difference in pain rating between two programs with 90% probability.

CONCLUSION

Isometric shoulder strength training seemed slightly better than isometric endurance training for obtaining a low RPE of work and an improvement in arm motion performance. As expected, isometric shoulder strength training was more effective in improving strength, but the differences between the two types of training were not great. Isometric endurance training was not more successful than strength training in improving RPE during the endurance test. When considering physical training of patients with cervicobrachial syndrome, inclusion of strength training may be more advantageous than only endurance training.

Acknowledgments: The authors appreciate the training and evaluation of patients done by the physical therapists: Inga Lindblom and Lars Ludvigsson from ABB Medical Service, Västerås; Britt-Marie Jenestrand, Tove Kling, Elisabeth Melin, and Clairy Wiholm from Ericsson Telecom, Stockholm; Anders Hägerfors from Nobel Koncern Services, Karlskoga; and Eva Hansson Risberg, NIWL, Solna, Sweden, Marika Wenemark BSc, NIWL, also from Solna, assisted with the statistical analysis.

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