

Active Neck Muscle Training in the Treatment of Chronic Neck Pain in Women

A Randomized Controlled Trial

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NECK DISORDERS REMAIN A common problem in modern, industrialized countries. Neck pain has been the most common chief complaint among working-aged women visiting their physicians.^{1,2} In a Canadian study,³ 54% of the general population had experienced neck pain during the past 6 months, and approximately 5% were highly disabled by neck pain. The prevalence of chronic neck pain has been reported to be 7% in women and 5% in men in Finland.⁴ Patients with chronic neck pain used health care services twice as much as the population on average.² Sick leave, therapy, and specialist care form the major part of the costs incurred by neck pain, whereas investigations at the primary health care level play a minor role.⁵

The origin and exact pathophysiologic mechanisms of chronic neck pain often remain obscure because trauma or severe degenerative conditions at working age are found only in

Context Active physical training is commonly recommended for patients with chronic neck pain; however, its efficacy has not been demonstrated in randomized studies.

Objective To evaluate the efficacy of intensive isometric neck strength training and lighter endurance training of neck muscles on pain and disability in women with chronic, nonspecific neck pain.

Design Examiner-blinded randomized controlled trial conducted between February 2000 and March 2002.

Setting Participants were recruited from occupational health care systems in southern and eastern Finland.

Patients A total of 180 female office workers between the ages of 25 and 53 years with chronic, nonspecific neck pain.

Interventions Patients were randomly assigned to either 2 training groups or to a control group, with 60 patients in each group. The endurance training group performed dynamic neck exercises, which included lifting the head up from the supine and prone positions. The strength training group performed high-intensity isometric neck strengthening and stabilization exercises with an elastic band. Both training groups performed dynamic exercises for the shoulders and upper extremities with dumbbells. All groups were advised to do aerobic and stretching exercises regularly 3 times a week.

Main Outcome Measures Neck pain and disability were assessed by a visual analog scale, the neck and shoulder pain and disability index, and the Vernon neck disability index. Intermediate outcome measures included mood assessed by a short depression inventory and by maximal isometric neck strength and range of motion measures.

Results At the 12-month follow-up visit, both neck pain and disability had decreased in both training groups compared with the control group ($P < .001$). Maximal isometric neck strength had improved flexion by 110%, rotation by 76%, and extension by 69% in the strength training group. The respective improvements in the endurance training group were 28%, 29%, and 16% and in the control group were 10%, 10%, and 7%. Range of motion had also improved statistically significantly in both training groups compared with the control group in rotation, but only the strength training group had statistically significant improvements in lateral flexion and in flexion and extension.

Conclusions Both strength and endurance training for 12 months were effective methods for decreasing pain and disability in women with chronic, nonspecific neck pain. Stretching and fitness training are commonly advised for patients with chronic neck pain, but stretching and aerobic exercising alone proved to be a much less effective form of training than strength training.

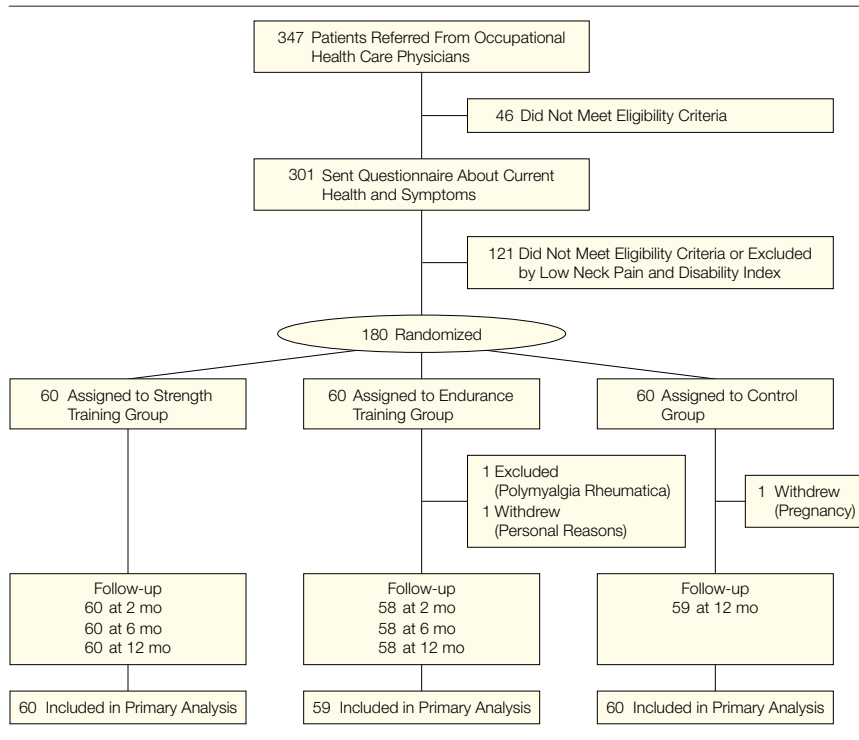
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Figure 1. Participant Flowchart

a few cases. The origin of neck pain is thought to be multifactorial. Excessive physical strain may cause micro-trauma in connective tissues, and psychosocial stress may lead to increased muscular tension.⁶ Degenerative changes in cervical vertebrae and disks are common and increase with advanced age in asymptomatic people. Thus, examination using radiographs or magnetic resonance imaging does not elucidate the origin of pain in most cases.⁷⁻¹⁰

Evidence for many of the standard treatment approaches to neck pain is lacking.¹¹ Conservative management of neck disorders includes both passive and active therapies, neither of which have been shown to be effective.¹² However, these treatments are widely prescribed by physicians.¹³ The aim of our study was to investigate the efficacy of intensive isometric neck strength training and lighter endurance training of neck muscles in rehabilitation of women with chronic, nonspecific neck pain.

METHODS

Study Design and Recruitment of Patients

A randomized controlled trial was conducted between February 2000 and March 2002. The ethics committee of the Punkaharju Rehabilitation Center, Punkaharju, Finland, approved the study design. In southern and eastern Finland, occupational health care services that were known to provide health care for women who work in offices were informed about the study and the inclusion and exclusion criteria. On the basis of clinical examination, physicians working in the occupational health care services referred suitable patients, who then completed an application form in their local offices of the Social Insurance Institution, which provides rehabilitation in Finland. The ordinary criteria for state-financed rehabilitation were matched against the information given on the form, and the accepted applications and referrals were sent to the Punkaharju Rehabilitation Center. A questionnaire on their cur-

rent health and symptoms was mailed to the prospective participants to confirm their status regarding the inclusion and exclusion criteria and to enable further selection to be made (FIGURE 1).

All the participants gave written consent before entering the study. The participants were randomized into 2 training groups and into a control group, with 60 patients in each group. The block randomization into 3 groups of 10 persons was performed blind before inviting the participants to the rehabilitation center. As each group of 30 referrals meeting the inclusion criteria were obtained, they were ranked by the neck and shoulder pain and disability index¹⁴ and divided into 10 blocks of 3 groups. From each block, 1 patient was randomized to 1 of the 2 training groups or to the control group.¹⁵ This procedure ensured that patients with equal severity of neck symptoms were present in each group.

Patients

A total of 180 female office workers, recruited from various workplaces through their respective occupational health care systems, were selected for the study (Figure 1). The following inclusion criteria were used: female sex, aged 25 to 53 years, office worker, permanently employed, motivated to continue working, motivated for rehabilitation, and constant or frequently occurring neck pain for more than 6 months. Exclusion criteria were severe disorders of the cervical spine, such as disk prolapse, spinal stenosis, postoperative conditions in the neck and shoulder areas, history of severe trauma, instability, spasmodic torticollis, frequent migraine, peripheral nerve entrapment, fibromyalgia, shoulder diseases (tendonitis, bursitis, capsulitis), inflammatory rheumatic diseases, severe psychiatric illness and other diseases that prevent physical loading, and pregnancy. These states were assessed mainly by medical history and clinical examination before entering the study.

Baseline and Outcome Assessment

Baseline variables included age, weight, height, duration of symptoms, and smoking status. Outcome measurements were taken at the baseline and after the 12-month intervention period in all 3 groups. Subjectively perceived neck pain was assessed by a visual analog scale,¹⁶ and the disability was assessed by the modified neck and shoulder pain and disability index¹⁴ and Vernon neck disability index.¹⁷ On each scale, the theoretical range was 0 to 100. At the 12-month follow-up visit, patients were asked to describe how the training affected their neck pain on a 6-point scale (1 indicating much more pain and 6 indicating complete relief from pain).

Intermediate outcome measures were mood assessed by a short depression inventory (theoretical range, 0-21)¹⁸ and by maximal isometric neck strength¹⁹ and range of motion (ROM).²⁰ General physical function was assessed with the grip-strength test²¹ and a submaximal bicycle ergometer test by an exercise physiologist.²² All the strength and ROM tests were performed blind by the same experienced physical therapist before the intervention and after 12 months for all groups. The training groups were also tested at 2 and 6 months. The chief researcher (J.Y.), biostatistician (H.K.), and tester were not affiliated with the rehabilitation institution.

Participants were asked about their use of analgesics before the study and at the 12-month follow-up visit. They were also asked about visits made to a physician and therapies performed to ameliorate neck pain during the previous year.

Description of Interventions

Training Groups. Each training group of 10 patients, alternating between strength and endurance training, started the 12-day institutional rehabilitation program at 1-month intervals during the year. Both training regimens consisted of 5 sessions per week, each lasting approximately 45 minutes. Thus, patients in each group participated in

9 practice sessions to enable them to learn the program properly. Every other session was performed at only half intensity to avoid excessive loading.

The endurance training group exercised neck flexor muscles by lifting the head up from the supine position in 3 series of 20 repetitions. The strength training group used an elastic rubber band (Theraband, Hygiene Corp, Akron, Ohio) to train the neck flexor muscles in each session, performed in a sitting position a single series of 15 repetitions directly forward, obliquely toward right and left, and directly backward.²³ The aim was to maintain the level of resistance at 80% of the participant's maximum isometric strength recorded at the baseline and at follow-up visits. The load was checked with a handheld isometric strength testing device (Force-Five, Wagner Instruments, Greenwich, Conn) during the training sessions at the baseline and follow-up visits.

After specific neck training, both groups performed dynamic exercises for the shoulders and upper extremities by doing dumbbell shrugs, presses, curls, bent-over rows, flyes, and pullovers. The endurance training group performed 3 sets of 20 repetitions for each exercise with a pair of dumbbells each weighing 2 kg. The strength training group exercised with an individually adjusted single dumbbell. The group performed only 1 set for each exercise with the highest load possible to perform 15 repetitions.

Members in both training groups thereafter performed exercises in the same way for the trunk and leg muscles against their individual body weights by doing a single series of squats, sit-ups, and back extension exercises. Each training session concluded with stretching exercises for the neck, shoulder, and upper limb muscles for 20 minutes. Training instruction was given by the same specially trained physical therapist who had several years of experience. The training groups were also advised to perform aerobic exercise 3 times a week for a half hour. If they lacked the time to perform all of the exercises, they were en-

couraged to perform muscle exercises, at a minimum, including specific neck muscle exercises.

Because many of our patients say they are not willing to visit health clubs on a regular basis primarily because of costs, time spent traveling, and time away from family, exercises for both training groups were planned so that they could be performed at home. The participants received written information about the exercises to be practiced at home and were taught to keep a weekly exercise diary throughout the training year. They were encouraged to exercise regularly 3 times a week at home. Exercise intensity and technique were checked at follow-up visits at 2 and 6 months and at the end of the year.

Both training groups also underwent a common multimodal rehabilitation program, including aspects commonly associated with traditional treatment: relaxation training, aerobic training, behavioral support to reduce fear of pain and improve exercise motivation, and lectures and practical exercises in ergonomics. During the rehabilitation course, each patient received 4 sessions of physical therapy, which consisted mainly of massage and mobilization to alleviate neck pain and to enable those with severe neck pain to perform active physical exercises.

Control Group. Each control group of 10 participants was asked to come in for baseline measurements of strength and ROM at 2 monthly intervals between training groups during the same year, according to the recruiting and block randomizing procedure. They spent 3 days at the rehabilitation center and performed recreational activities in addition to the tests. The participants were advised to perform aerobic exercise 3 times a week for a half hour. They received written information about the same stretching exercises that were performed by the training groups, which they were to practice at home for approximately 20 minutes regularly 3 times a week. Each group of participants was trained once in the

proper way to perform these exercises. The participants were not encouraged to perform any exercises to improve muscle strength, and they received no treatments for this. After the 1-year follow-up measurements, they were given the opportunity to participate in the same rehabilitation training course as the active intervention participants, including training and follow-up, which was also financed by the Social Insurance Institution.

Sample Size

The initial sample size for each treatment group was estimated on the assumption that the endurance training group and control group would show

a 15% improvement in pain measured with the visual analog scale and that the active strength training group would have to produce a 50% improvement to be better than either the endurance training group or the control group. To test the null hypothesis of equality of treatment at $\alpha = .05$ with 95% power and assuming a uniform dropout rate of 5%, it was calculated that 60 patients in each group would be sufficient.

Data Analysis

Clinical outcome variables were analyzed by intention to treat. The results are expressed by means and SDs, medians, and interquartile ranges. Statistical comparison among the groups was made using the *t* test, Mann-Whitney

U test, analysis of variance with Tukey honestly significant difference test, and Kruskal-Wallis test. Hommel adjustments were used to correct significance levels for multiple and post hoc testing. Hodges-Lehmann estimate of median difference with 95% confidence intervals was used to show changes in clinical outcome variables. The normality of variables was evaluated by the Shapiro-Wilk statistics. The α level was set at .05 for all tests. Analyses were performed using Stata Statistical Software version 8.0 (Stata Corp, College Station, Tex).

RESULTS

The dropout rate during the year was 1.7%. One patient in the endurance training group was diagnosed as having polymyalgia rheumatica after randomization and was thus excluded from the study. In addition, there was 1 withdrawal from the endurance training group and 1 from the control group (Figure 1). These 2 patients were included in the intention-to-treat analysis.

The distributions of age, anthropometric measures, short depression inventory, grip strength, and oxygen uptake were similar in the 3 groups at the baseline (TABLE 1). The pain and disability indices in the 3 groups were also at the same level (TABLE 2). All these outcome measures were significantly lower in the 2 training groups compared with the control group at the 12-month follow-up visit. There was no statistically discernible difference between the endurance and strength train-

Table 1. Demographic and Clinical Data of the Patients in the Intervention and Control Groups*

Variable	Control Group (n = 60)	Training Groups	
		Endurance (n = 59)	Strength (n = 60)
Demographics			
Age, y	46 (5)	46 (6)	45 (6)
Height, cm	164 (5)	165 (6)	165 (5)
Weight, kg	69 (12)	68 (10)	67 (11)
Body mass index†	26 (4)	25 (3)	25 (3)
Clinical			
Duration of neck pain, y	8 (5)	9 (6)	8 (6)
Short depression inventory score‡	6 (3)	6 (4)	5 (3)
Grip strength, right hand, N§	293 (54)	299 (50)	299 (54)
Grip strength, left hand, N§	266 (46)	270 (53)	286 (52)
Maximum oxygen uptake, mL/kg per min	31 (5)	32 (4)	33 (5)
Smoking, No. (%)	10 (17)	12 (20)	10 (17)

Abbreviation: N, Newton, which is a measure of force.

*Data are presented as mean (SD) unless otherwise indicated.

†Body mass index is calculated as weight in kilograms divided by the square of height in meters.

‡Mood is assessed on a theoretical range of 1 to 21, with a lower score indicating a better mood.

§Grip strength was measured using a hand-held Jamar grip-strength device while the participant was in a seated position and the elbow supported in a right angle.

Table 2. Disability and Pain Ratings of Patients at Baseline and Changes at 12-Month Follow-up*

Variable	Baseline, Median (IQR)			Change After 12 Months, Median (95% CI)†			P Value Between Groups (Multiple Comparisons)‡
	Training Group			Training Group			
	Controls	Endurance	Strength	Controls	Endurance	Strength	
Neck pain as measured on VAS	58 (42-74)	57 (43-74)	58 (43-72)	-16 (-22 to -9)	-35 (-42 to -28)	-40 (-48 to -32)	<.001 (E vs C and S vs C)
Neck and shoulder pain and disability index	38 (26-49)	36 (28-46)	35 (24-45)	-12 (-15 to -8)	-22 (-26 to -19)	-23 (-27 to -20)	<.001 (E vs C and S vs C)
Vernon neck disability index	22 (16-31)	22 (16-28)	21 (16-26)	-3 (-6 to 0)	-8 (-11 to -6)	-9 (-11 to -7)	<.001 (E vs C and S vs C)

Abbreviations: C, control group; CI, confidence interval; E, endurance group; IQR, interquartile range; S, strength group; VAS, visual analog scale.

*See "Methods" section for definition of scoring.

†Hodges-Lehmann estimates of median difference.

‡Mann-Whitney test and P value is adjusted using the Hommel method.

ing groups. Considerable or complete relief from pain was obtained by 73% of participants in the strength training group, 59% in the endurance training group, and 21% in the control group. Only 3% in all groups felt that their pain had become worse due to the training.

Neck strength showed a significant increase in the directions tested in all groups at the 12-month follow-up visit compared with baseline (FIGURE 2). In the strength training group, maximal isometric neck strength increased in flexion by 110%, in rotation by 76%, and in extension by 69%. The results in the endurance training group improved by 28%, 29%, and 16% and in the control group by 10%, 10%, and 7%, respectively. The strength increases were significantly different among all 3 groups ($P < .001$). Transient neck pain was sometimes reported throughout the few days succeeding the isometric maximal neck strength tests, but all patients were able to continue with the training without interruption. No major complications occurred.

All groups achieved a statistically significant increase in ROM in the sagittal plane (flexion-extension) and frontal plane (lateral flexion) at the 12-month follow-up visit compared with baseline (TABLE 3). However, only the training groups achieved a statistically significant increase in rotation. The increase in ROM in the strength training group was statistically significant in all directions when compared with the control group. Between the endurance and control groups, a statistically significant discernible difference emerged only in the measurements of rotation. No statistically significant changes in mean grip strength were observed in any groups at the 12-month follow-up visit compared with baseline. There were also no significant changes in maximal oxygen uptake.

According to their exercise diaries, the patients continued the training throughout the year; the mean (SD) training frequency was 2.0 (0.8) times a week in the endurance training group and 1.7 (0.6) times a week in the strength training group. Stretching ex-

ercises were performed 2.0 (0.8) times a week by both groups.

The number of patients taking analgesics at the 12-month follow-up visit had decreased in all groups although this decline was more evident in the training groups than in the control group (TABLE 4). Visits to a physician and use of therapies due to neck pain also decreased during the follow-up year compared with the previous year in all groups. The change was more marked in the training groups. The therapies most commonly used were massage and stretching (65%). Hot and ice packs, electrotherapy, acupunc-

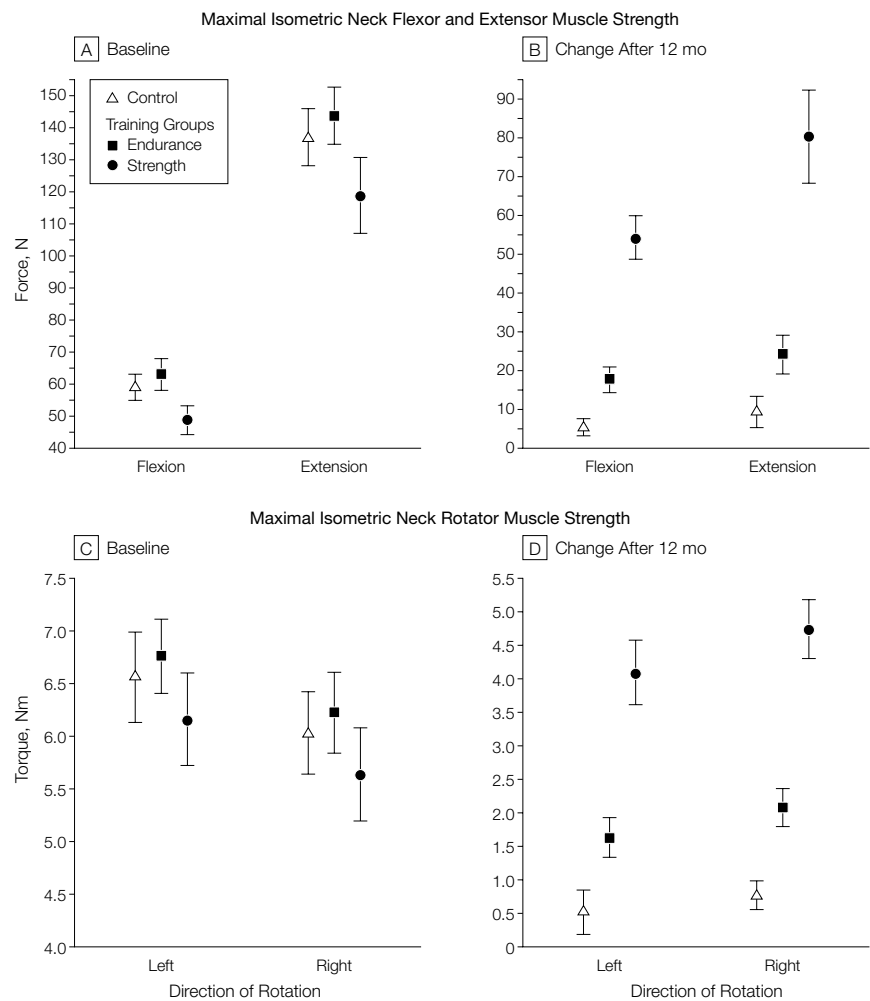
ture, traction, and zone therapy each accounted for between 5% and 7%.

COMMENT

Our study showed that participation in 1-year endurance and strength training programs led to a considerable reduction in average neck pain and disability compared with the control group. Neck function, including neck strength and ROM, was improved significantly in both training groups compared with the control group.

Previous randomized studies²⁴⁻³¹ have not shown active training to be effective or the results have been short-

Figure 2. Twelve-Month Comparison of Change in Neck Muscle Strength Among Patients in the Neck Strength and Endurance Training Groups and Control Group



N indicates Newton, which is a measure of force; and Nm, Newton meter, which is a measure of torque. Error bars indicate 95% confidence intervals.

Table 3. Range of Motion at Baseline and Changes at 12-Month Follow-up

Variables	Baseline Range of Motion, Mean (SD), Degrees			Change in Range of Motion After 12 Months, Mean (95% CI), Degrees			P Value Between Groups (Multiple Comparisons)
	Control Patients	Training Group		Control Patients	Training Group		
		Endurance	Strength		Endurance	Strength	
Flexion to extension	122 (11)	128 (14)	123 (16)	6 (3 to 9)	8 (5 to 11)	12 (9 to 15)	.007 (S vs C)
Lateral flexion	82 (11)	85 (11)	83 (14)	12 (9 to 15)	15 (12 to 18)	18 (15 to 21)	.02 (S vs C)
Rotation	160 (14)	161 (16)	159 (18)	1 (-3 to 4)	7 (3 to 10)	12 (9 to 15)	<.001 (E vs C and S vs C)

Abbreviations: C, control group; CI, confidence interval; E, endurance group; S, strength group.

*Between-group comparison by analysis of variance. Multiple pairwise comparisons were calculated using the honestly significant difference Tukey test ($P < .05$).

Table 4. Use of Analgesics, Visits to Physician, and Therapies Received Due to Neck Pain*

Variable	Control Group (n = 60)	Training Groups	
		Endurance (n = 59)	Strength (n = 60)
Use of analgesics at baseline, No. (%)			
None	11 (18)	13 (22)	10 (17)
Occasionally	41 (68)	37 (63)	41 (68)
Daily	8 (13)	9 (15)	9 (15)
Use of analgesics at 12-month follow-up, No. (%)†			
None	27 (46)	33 (56)	39 (65)
Occasionally	28 (47)	22 (37)	20 (33)
Daily	4 (7)	4 (7)	1 (2)
Visits to physician due to neck pain up to 12-month follow-up			
No. (%) of patients	20 (33)	15 (25)	12 (20)
Total No. of visits	45	24	25
Therapies for neck pain during 12 months before the study			
No. (%) of users	49 (82)	37 (63)	43 (72)
Total No. of therapies	489	394	433
Therapies up to 12-month follow-up			
No. (%) of patients	48 (80)	29 (49)	34 (57)
Total No. of therapies	425	310	283

*Percentages may not sum to 100 due to rounding.

†Patients were asked how often they had taken analgesics in the past month.

lived and have disappeared within a few months. Similarly, multidisciplinary rehabilitation has not been shown to be better at reducing pain and disability than the more commonly used methods of care, despite the fact that the former requires substantial staffing and financial resources.³² This raises the question of why previous intervention studies have failed to produce any significant long-term change. There are several possible reasons for this.

Selecting the Study Population

In many studies the inclusion and, especially, exclusion criteria have not been well defined, which may be critical in studies with smaller numbers of participants; several other conditions

may act as confounding factors. Epidemiologic studies have shown that women experience chronic neck pain more often than men, and thus study populations have commonly consisted of women. It should be recognized that a considerable number of working-aged women experience fibromyalgia, the prevalence of which was reported to be 10.5% in Norway.³³ The prevalence may be even higher among women with chronic neck pain. Fibromyalgia has not been an exclusion criteria in previous studies although it is a major confounding factor in treating painful conditions in women. In addition, patients with neck and shoulder pain are often combined into a single group. However, ail-

ments in the shoulder joint are distinctly different and should be differentiated from neck pain. There are also several other conditions that cause neck pain, which should be treated by means other than special neck exercises. In our study, we tried to exclude these diseases as much as possible.

Controlling Seasonal Variation in Symptoms

Chronic neck pain symptoms are known to exhibit seasonal variation, worsening in the autumn and decreasing in the spring.³⁴ Our study was performed so that both training groups started at regular intervals throughout the year, and control groups were tested between these intervals to avoid effects due to seasonal variation. In addition, the baseline and final follow-up measurements were performed at the same time of the year to exclude seasonal effect.

Specific Neck Training

Type of exercise, frequency, and intensity of training are key factors in the effectiveness of training. Intensive muscle training at a fitness center, which excludes specific neck exercises, does not increase neck muscle strength.³⁵ The conventional stretching and aerobic exercises the control group were advised to perform had a poor effect on the functional parameters of the neck, and they had only a weak effect on chronic neck pain and disability. However, one fifth of the patients in the control group reported feeling better, which may be the result of endurance training, stretching exercises, periodic variation of symptoms, or spontaneous recovery,

which has been observed to occur in patients with chronic neck pain.³⁶

The results of several previous randomized studies²⁴⁻³¹ do not fully elucidate the effect of the exercise used in inducing change in neck function because the descriptions given are poor and functional measures have not been included or the improvement in function has been minor. However, it is well established that patients with chronic, nonspecific neck pain can tolerate intensive neck strength training and that training performed 2 times a week produces significant changes in functional measures in these participants.^{23,37} The goal of the training programs in our study was to improve neck function by the use of a regular exercise program, which could be performed at home. In our study, all the neck strength and ROM measures improved considerably in the strength training group. A significant improvement in neck strength also occurred in the endurance training group. This is not surprising, since the initial strength values of several patients were so low that lifting their heads when performing dynamic exercises in flexion caused them a great deal of effort. Thus, they were in fact performing strength training. Several women had difficulty lifting their heads from a supine position while doing neck flexion exercises or sit-ups. Thus, the weight of their heads initially provided enough resistance for neck strength training. The small strength increase in the control group was probably due to biological variation and learning effect due to repeated testing.¹⁹

These results cannot necessarily be applied to men; women attain approximately 50% to 80% of the neck strength that men attain.^{23,38-40} It is not certain that the endurance training, in which intensity was lighter and remained unchanged during the follow-up year, would produce a significant change in men even though it was effective among women.

Maintaining Exercise

It has been well established by previous studies⁴¹ that the results achieved

by strength training soon disappear if training is performed for a few months only. In our study, the patients were encouraged to adhere to their training program, which was designed to continue throughout the year. The importance of adherence was emphasized to the training groups initially and at the intermediate follow-up visits in the rehabilitation center.

In our study, the exercise diaries were examined at the intervening follow-up visits, and the supervision may be an important factor in maintaining a high level of compliance. Exercise diaries have not commonly been used in previous randomized studies. Only Taimela et al³⁰ have monitored the training frequency of the intensive group after supervised training and compared this to the frequency of the home training group, which received instructions at a few meetings only. Surprisingly, in this study exercising was far more frequent in the home training group.

Pain often accompanies the start of intensive exercise. Difficulty coping with this pain may cause a patient to stop exercising. The institutional rehabilitation program was planned to enable patients to overcome fear, which might prevent them from performing stressful exercises. The etiology of nonspecific neck pain and the effects of exercising were discussed in detail with the rehabilitation groups. The same physical therapist met with the group every day, giving instructions and leading the group in exercises. The patients received physical therapy during the institutional rehabilitation period to better enable them to cope with the initial stage of intensive training. However, the main aim of the rehabilitation unit staff was to enhance the idea of self-care and increase adherence to training.

In conclusion, both isometric strength training and dynamic endurance training effectively decreased pain and disability in women with chronic neck pain during the 1-year follow-up period. An important practical observation was that long-term benefits could be obtained by training as infrequently as twice a week.

Aerobic and stretching exercises proved to be much less effective than controlled endurance and strength training of the neck muscles.

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If a man will begin with certainties, he shall end in doubts; but if he will be content to begin with doubts, he shall end in certainties.

—Francis Bacon (1561-1626)