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A Randomized Controlled Trial on the Efficacy of Exercise for Patients With Chronic Neck Pain

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Study Design. A randomized controlled trial with single-blind outcome assessments.

Objective. To evaluate the efficacy of a neck exercise program in patients with chronic neck pain.

Summary of Background Data. The effect of exercise for patients with chronic neck pain has been investigated in a number of studies. The efficacy is, however, questionable.

Methods. A total of 145 patients were randomly allocated into an exercise (n = 67) and a nonexercise (control) group (n = 78). Patients in the control group were given infrared irradiation and neck care advice. In addition to infrared irradiation and advice, patients in the exercise group had undergone an exercise program with activation of the deep neck muscles and dynamic strengthening of the neck muscles for 6 weeks. Subjective pain and disability and isometric neck muscle strength were measured at baseline, 6 weeks, and 6 months. Analysis was by intention-to-treat.

Results. At week 6, the exercise group had a significantly better improvement in disability score ($P = 0.03$), subjective report of pain ($P = 0.01$), and in isometric neck muscle strength ($P = 0.57–0.00$) in most of the directions than the control group. However, significant differences between the two groups were found only in the subjective report of pain and patient satisfaction at the 6-month follow-up.

Conclusions. At week 6, patients with chronic neck pain can benefit from the neck exercise program with significant improvement in disability, pain, and isometric neck muscle strength in different directions. However, the effect of exercise was less favorable at 6 months.

Key words: efficacy, exercise, neck pain, randomized controlled trial. **Spine 2005;30:E1–E7**

Neck pain is a common musculoskeletal disorder in the general population. In Saskatchewan, Canada, Cote *et al*[1] reported the age-standardized lifetime prevalence of neck pain was 66.7% and the point prevalence was 22.2%. It is costly in terms of treatment, individual suffering, and time lost due to work absentee.[2]

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It is generally accepted that muscles play an important role in the support and protection of joints. Criso and Panjabi[3] suggested that muscles that have direct attachments to the vertebrae are responsible for the segmental stability through the control of the neutral zone.[4] The deep muscles of the neck, which act like dynamic ligaments, play an important role in maintaining the stability of the cervical spine.[5] Several studies[6–9] demonstrated that neck muscle atrophy is strongly correlated with neck pain. However, the causal association between neck muscle atrophy and neck pain still remains unexplained. In the past decade, several researchers[10–12] reported that dynamic strengthening of the neck muscles for 6 to 11 weeks in patients with chronic neck pain resulted in reduced neck pain, increase in isometric neck muscle strength, and decrease in disability. However, the efficacy of active strengthening exercises for management of chronic neck pain has been uncertain in the previous studies. In some studies, only minor or short-term improvements were induced with active exercise, and most of the studies did not have control groups.[10–13] Moreover, the relatively small number of patients and the lack of long-term, objective changes did not allow firm conclusions to be made on the overall efficacy of the treatment programs.[14] There is a lack of well-designed randomized controlled trials to investigate the efficacy of rehabilitation, especially in the management of chronic neck pain.[15] The current study aimed at evaluating the efficacy of a specific exercise program for the management of patients with chronic neck pain. The efficacy of the exercise program was assessed subjectively by an adapted Chinese version of neck disability score, verbal numeric pain scale, and objectively by isometric muscle strength measured by a multicervical rehabilitation unit.

Materials and Methods

Subjects. Patients with neck pain were recruited from two physiotherapy outpatient departments in different regions of Hong Kong. The inclusion criteria were: patients with chronic neck pain (of various intensity of pain) that had lasted longer than 3 months, age 20 to 70 years, and able to read Chinese. Both genders were included. Patients were excluded if they had a previous history of injury to the neck or upper back from T1–T6, an inflammation condition, *e.g.*, rheumatoid arthritis, previous surgery to the neck, a history of malignancy, congenital abnormality of the spine, been receiving concurrent treatment, *e.g.*, chiropractor or bone setting, contraindication for infrared irradiation, *e.g.*, lost of skin sensation, neurologic signs and symptoms, *e.g.*, muscle weakness or changes in spinal reflex jerks, other musculoskeletal problems at the same time, acute neck pain with no freedom of movement, received physiotherapy manipulation, or training because of neck pain in the

6 months before examination, or work-related injuries. A full description of the study, including the randomization process, was explained to each patient. Documented consent was obtained from each patient, and the project was approved by the Polytechnic University's Review Board for Health Sciences Research involving Human Subjects.

Randomization. Patients were randomly allocated to the exercise or the nonexercise group by using computer-generated minimization method[16] taking into account age, gender, and degree of disability resulting from neck pain. A computer program for randomization was installed in a notebook computer, after the senior physiotherapist keyed in the patients' particulars the program automatically allocated the grouping of the patient as according to the minimization theory that yielded the smallest imbalance between the two groups. Moreover, computer-based randomization also helps to establish allocation concealment, which is an essential part of a randomized trial

Outcome Measures. The primary outcome measure of this study was the disability scores as measured by the Chinese version of the Northwick Park Neck Pain Questionnaire (NPQ)[17] validated by us (scale: 0 = no disability to 4 = the worst). Secondary outcomes included the verbal numerical pain scale (VNPS)[18] (scale: 0 = no pain to 10 = worst pain), the peak isometric strength (PIS) of neck muscles in different directions as measured by the Multi Cervical Rehabilitation Unit (MCRU)[19]: medication, sick leave, and patient satisfaction.

Patients were assessed at baseline, 6 week, and at 6-month follow-up by an independent assessor who was blinded to the grouping.

Sample Size Calculation. The rationale for calculating sample size was as follows: From a related study[17] (N = 90) using the same questionnaire (NPQ), it was found that the mean and standard deviation of the neck pain score were 13.99 and 5.823, respectively. Assuming that the intervention group would improve by 50% and the control group would improve by 25%. Assuming a 0.5 correlation between the pre and post measurement, and the standard deviations in the pre and post intervention measurement would be about the same, the standard deviation for their difference would be about the same as that of the original measurement (or smaller if the correlation is higher). Using 5% alpha, 90% power, 2-sided alternative test on the difference between pre and post measurement, it was estimated that 60 subjects should be required for each group.

Exercise Program. The exercise program began with one set (10 minutes) of activation of the deep neck muscles to enhance its ability for active stabilization of the cervical spine.[20] Then the patient was asked to perform 15 repetitions of flexion and extension of the neck using the MCRU as a warming up exercise for the superficial torque producing muscles. The resistance used during the warm-up was set at approximately 20% of the PIS. After the warm-up, dynamic training started, which consisted of three sets of variable resistance load allowing 8 to 12 repetitions[11,21–23] of full flexion and extension within pain tolerance. A 5-minute rest between sessions was given. For the initial training session, the dynamic weight load used for each subject was calculated from about 30% of the PIS.[11] The weight load was increased by approximately 5% when a set of 12 or more repetitions had been achieved.[24] There were two training sessions per week for a period of 6 weeks. [11,25]

Activation of the Deep Neck Muscles. The patient lay down in the supine position with the weight of the head and the cervical spine supported by towels under the occiput in a neutral position. The patient was also requested to place the tongue on the roof of the mouth, to keep lips together and teeth slightly apart to discourage activity of the jaw depressors. An air-filled pressure sensor (Stablizer, Chattanooga South Pacific, Australia) was used to monitor the subtle flatting of the cervical lordosis that was expected to occur with the contraction of the deep neck flexors. The sensor was placed suboccipitally behind the neck and inflated to 20 mm Hg, which was sufficient to fill the space between the testing surface and the neck without pushing the neck into lordosis. Guided by an experienced physiotherapist, the patient was instructed to slowly nod the head in an action indicating "yes," so that the pressure level rose. The pressure that could be achieved and held in a steady manner for 10 seconds was called the activation score.[20] The patient was asked to practice a 10-second hold at that activation score with the visual feedback of the pressure sensor for 10 minutes with 15 seconds' break between each hold, or until the patient felt tired and was unable to control the contraction. Loss of control of the contraction was reflected in a loss of pressure as demonstrated by the air-filled pressure sensor.

Dynamic Strengthening of the Neck Muscles. The patient sat upright in the adjustable chair with his or her trunk secured by the trunk restraint system. The seat height was adjusted until the lower portion of the flexion pad (or the Velcro strap, which was secured to the extension pad, for training toward the direction of extension) met the upper portion of the patient's eyebrow. Then the operator adjusted the flexion or extension pads forward or backward so that the patient's cervical spine was aligned with the side bar of the outer head brace. The amount of resistance used during the warming-up and the strengthening period was adjusted by inserting the pin into the appropriate hole between the stack of metal weights located at the back of the chair. The operator instructed the patient to flex or extend his head as far as possible against the resistance, producing movement only through the cervical spine. The patient was asked to perform 15 repetitions of flexion and extension of the neck using the MCRU as a warming up exercise. After the warm-up, dynamic training started, which consisted of three sets of variable resistance load, allowing 8 to 12 repetitions of full flexion and extension within pain tolerance.

Infrared Irradiation. Infrared irradiation was given to both the exercise group (before the exercise program) and the control group (twice a week for 6 weeks). The patient with the back of his neck exposed was arranged in a sitting position with his head supported comfortably over the pillows on top of a small table. The position of the infrared lamp (Hanovia, Model 10, United Kingdom) was adjusted so that the center of the emission coil was directly above and behind the spineous process of the fourth cervical vertebra. The distance between the patient and the lamp was adjusted so that the patient reported mild comfortable warmth over the back of his neck. The irradiation time was 20 minutes. As infrared irradiation gives only superficial heating (almost all energy is absorbed at a depth of 2.5 mm) and the effect is not long lasting, so it is suitable as a control intervention.

Data Analysis. Statistical analysis was based on the intention-to-treat approach. Statistical significance was set at the 5% level. A 20% improvement from the baseline values was considered to be clinically relevant.[26] The exercise group was compared with the control group at the baseline by two-sample unpaired *t* test. After the intervention, statistical analysis for the difference (*i.e.*, difference between the pre and post measurement) in neck disability score, verbal numerical pain scale, and isometric neck muscle strength of the exercise and the control groups were compared using the repeated-measure analysis of variance. The mean difference and their 95% confidence interval (CI) were calculated. Moreover, repeated-measures analysis of variance was used to investigate whether there was any change in muscle strength, neck disability score, and pain scale after the intervention within each patient group, the mean percentage difference and their 95% CI were also calculated. χ^2 tests and McNemar tests were used for nominal data comparison.

Imputation of Missing Values. The main cause of the missing data were due to those subjects who defaulted from the follow-up measurement. All these subjects were contacted again by phone calls to find out the reasons for default and the treatment effect. The present study used the following methods to impute the missing values:

1. For those subjects who defaulted from the follow-up because of dissatisfaction of the treatment effect or worsening of symptoms after treatment: a mean percentage of worsening was calculated from all the observed subjects (both the exercise and the control group) whose condition got worse and the missing value was replaced by the product of the mean percentage and the baseline measurement.
2. For those subjects whose condition was improving but unable to come because of time constraint: a mean percentage of improvement was calculated from all the observed subjects (both the exercise and the control group) whose condition got better, and the missing value was replaced by the product of the mean percentage and the baseline measurement.
3. For those subjects whose treatment effect was unknown: the baseline value was used for imputation.

■ Results

A total of 145 patients were recruited and follow-up between September 2000 and March 2002. Patient recruitment, participation, and attrition during the trial are summarized in Figure 1. The reasons for the withdrawals included insufficient time, dissatisfaction worsening of symptoms, and other reasons (Figure 1). No complications occurred because of either of the treatments. No differences were noted between those who finished the intervention and the withdrawals in neck disability scores ($P = 0.52$), pain intensity ($P = 0.85$), and isometric neck muscle strength ($P = 0.37$–0.92).

Baseline characteristics of the subjects were described in Table 1, and the mean values of the outcome measures for disability, pain, and neck isometric muscle strength in the follow-up periods were presented at Table 2.

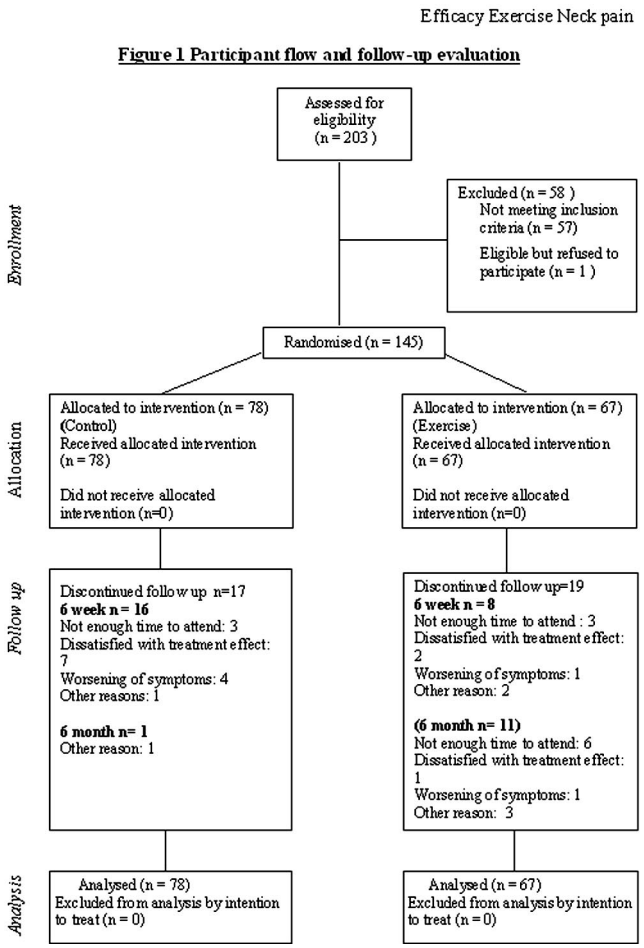

Figure 1. Participant flow and follow-up evaluation.

Group Differences at Baseline

No statistically significant differences were observed between the exercise group and the control group in neck disability scores ($P = 0.86$), pain intensity ($P = 0.28$), and isometric neck muscle strength ($P = 0.10$–0.98) before the intervention. Baseline clinical characteristics of the subjects in the exercise and the control group are shown in Table 1. More than 50% of the subjects in this study had a history of neck pain for more than 12 months. The subjects had moderate neck pain (pain intensity: 4.3 and 4.6 of 10) and a mean disability score of 1.4 of 4 (Table 1).

Change in Disability Score

After 6 weeks of treatment, both the exercise (28.8%, 95% CI, 9.0–48.6, $P < 0.001$) and the control group (18.4%, 95% CI, 5.7–31.1, $P < 0.001$) had significant improvement in the disability score (NPQ) (Table 3). The exercise group had a significantly better (mean difference: 0.2, 95% CI, 0.0–0.4, $P = 0.03$) improvement in disability score than the control group. Follow-up assessment at 6 months demonstrated that the significant improvement was maintained in both groups. The exercise group maintained 26.5% (95% CI, 8.3–44.8) improvement while 14.62% (95% CI, 3.6–25.7) improvement was observed in the control group. However, the

Table 1. Baseline Characteristics of Patients: Age, Gender, Height, Weight, Pain History, Education, and Exertion for the Randomized Controlled Trial

	Control	Exercise	P*
n	78	67	
Age (yr)			
Mean/SD	44.3/9.8	43.3/9.7	0.52
Range	21–64	23–59	
Gender (%)			
Male	33.3	28.4	0.30
Female	66.7	71.6	0.69
Height (cm)			
Mean/SD	159.6/8.9	159.2/11.6	0.85
Range	123–180	120–185	
Weight (kg)			
Mean/SD	59.1/9.1	59.3/11.1	0.91
Range	37.7–80	40–98	
Pain history (%)			
3–6 months	17.9	18.2	0.68
>6–12 months	16.5	25.8	0.35
>12 months	66.6	56.0	0.11
Education (%)			
Primary	28.2	23.8	0.33
Secondary	57.7	55.2	0.38
Tertiary	14.1	21.0	0.55
Exertion (%)			
Static work	16.7	26.9	0.37
Minimal	44.9	41.8	0.38
Moderate	26.9	19.9	0.48
Heavy	6.4	7.4	1.00
N/A	5.1	4.0	1.00
Verbal numerical pain scale†			
Mean/SD	4.3/2.1	4.6/1.9	0.28
Disability score‡			
Mean/SD	1.4/0.5	1.4/0.6	0.86
Strength (in 6 different directions)			
Mean/SD	7.2–11.5/ 4.0–5.8	7.5–11.5/ 4.2–6.1	0.10–0.98

* *P* values of comparison of baseline characteristics.
† Verbal numerical pain scale: 0 (no pain) to 10 (worst pain).
‡ Disability score was measured by the Chinese version of Northwrick Park Neck pain Questionnaire: 0 (no disability) to 4 (worst).

difference between the two groups was statistically not significant at 6 months (Table 4).

Change in Verbal Numeric Pain Scale

The average score of the VNPS reduced by 34.9% (95% CI, 14.6–55.2, $P < 0.01$) after the 6 weeks' treatment in the exercise group. However, there was no significant change in the control group (11.7%, 95% CI, −0.6–24.0, $P = 0.06$). There was significantly more improvement (mean difference: 1.0, 95% CI, 0.2–1.7, $P = 0.01$) in pain in the exercise group than the control group (Table 3). Follow-up assessment at 6 months demonstrated that significant improvement in pain was maintained in the exercise group (33.7%, 95% CI, 14.1–53.2, $P < 0.001$) and no significant change ($P = 0.20$) was found in the control group. Again, patients in the exercise group had better improvement of pain (mean difference: 1.2, 95% CI, 0.4–2.0, $P < 0.01$) at 6 months than those in the control group (Table 4).

Change in Isometric Neck Muscle Strength

Significant improvement (26.1%–45.7%, $P < 0.001$) in isometric neck muscle strength in all six different directions was observed in the exercise group after 6 weeks of training and there was significantly better improvement (mean difference, 0.4–2.2 lb, $P = 0.57$–0.00) in muscle strength in the exercise than in the control group in most of the directions (Table 3). However, the difference between the two groups was statistically not significant at month 6 (Table 4).

Sick Leave Because of Neck Pain

There was a significant decrease from the baseline to 6-month follow-up in the percentage of subjects who had taken sick leave because of neck pain for the past 3 weeks in the exercise group (from 16.4% to 3%, $P = 0.01$) but not in the control group (from 16.7% to 9.0%, $P = 0.08$). However, no significant difference was found between groups ($P = 0.22$) (Table 5).

Medication for Neck Pain

Self-reported medication usage for the past 2 weeks decreased from baseline to 6-month follow-up in both groups (from 31.3% to 17.9% in the exercise group and from 30.8% to 26.9% in the control group) (Table 5), and no significant differences were found either within group ($P = 0.06$ for the exercise group and $P = 0.21$ for the control group) or between groups ($P = 0.69$).

Perceived Satisfaction

The mean score of patient's perceived satisfaction at 6 week follow-up was 5.3 (11-point scale: 0 = very disappointed, 10 = very satisfied) in the control group and 6.3 in the exercise group. A significant difference was found between the two groups ($P = 0.04$), which was maintained at the 6-month follow-up (control = 5, exercise group = 6.3, $P = 0.02$).

■ Discussion

The present study was performed as far as practicable in accordance with previous recommendations,[20,24,25] to

Table 2. Mean (SD) Values of Disability (NPQ), Pain (VNPS), and Isometric Neck Muscle Strength (Strength) at 6-Week and 6-Month Follow-up

	Control		Exercise	
Outcome Measure	6 Weeks	6 Months	6 Weeks	6 Months
NPQ	1.1 (0.6)	1.2 (0.7)	1.0 (0.5)	1.0 (0.5)
VNPS	3.8 (2.3)	3.9 (2.4)	3.0 (2.3)	3.1 (2.4)
Strength (in 6 different directions)	8.5–12.2 (4.9–6.5)	8.2–12.1 (4.1–6.4)	9.2–14.6 (5.0–7.7)	9.0–13.9 (4.0–6.9)

Table 3. Percentage Improvement Within Each Group and Mean Difference Between Groups in Disability (NPQ), Pain (VNPS) and Isometric Neck Muscle Strength* at 6-Week Follow-up

Outcome Measure	Mean Percentage Improvement (95% CI) (*P* of within-group comparison)		Mean Difference (95% CI) *P* (between-group comparison by ANOVA) (control *vs* exercise)
	Control	Exercise	
NPQ mean	18.4 (5.7 to 31.1) (0.00)†	28.8 (9.0 to 48.6) (0.00)†	0.2 (0.0 to 0.4) 0.03†
VNPS	11.7 (−0.6 to 24.0) (0.06)	34.9 (14.6 to 55.2) (0.00)†	1.0 (0.2 to 1.7) 0.01†
Flex0	15.3 (3.7 to 27.0) (0.01)†	35.5 (14.9 to 56.1) (0.00)†	1.8 (0.6 to 3.1) 0.00†
Flex20	15.5 (−13.0 to 44.0) (0.28)	30.2 (9.4 to 51.0) (0.00)†	1.8 (0.5 to 3.0) 0.00†
Flex40	19.5 (−8.7 to 47.8) (0.17)	30.2 (9.4 to 51.0) (0.00)†	1.8 (0.4 to 3.2) 0.01†
Ext0	19.8 (1.9 to 37.7) (0.03)†	42.6 (17.8 to 67.3) (0.00)†	2.1 (0.3 to 4.0) 0.02†
Ext20	15.8 (−4.3 to 36.0) (0.12)	45.65 (19.1 to 72.2) (0.00)†	2.2 (0.3 to 4.1) 0.02†
Ext40	16.4 (−2.7 to 35.5) (0.09)	36.9 (15.5 to 58.3) (0.00)†	2.2 (0.2 to 4.1) 0.03†
Latl0	15.2 (−1.4 to 31.9) (0.07)	37.2 (15.6 to 58.9) (0.00)†	1.3 (0.2 to 2.5) 0.02†
Latl20	15.1 (−21.4 to 51.6) (0.41)	41.4 (17.4 to 65.5) (0.00)†	0.6 (−0.5 to 1.7) 0.29
Latr0	25.5 (7.8 to 43.1) (0.00)†	34.1 (10.6 to 57.5) (0.00)†	1.3 (−0.0 to 2.6) 0.05
Latr20	24.1 (5.8 to 42.3) (0.01)†	26.1 (8.6 to 43.6) (0.00)†	0.4 (−1.0 to 1.8) 0.57
Protract	17.3 (−3.5 to 38.0) (0.10)	39.7 (18.4 to 61.0) (0.00)†	1.6 (0.1 to 3.9) 0.03†
Retract	19.2 (−0.3 to 38.6) (0.052)	42.8 (17.9 to 67.7) (0.00)†	2.1 (0.5 to 3.7) 0.01†

Flex 0 = flexion at 0°; Flex 20 = flexion at 20°; Flex 40 = flexion at 40°; Ext 0 = extension at 0°; Ext 20 = extension at 20°; Ext 40 = extension at 40°; Latl 0 = left lateral flexion at 0°; Latl 20 = left lateral flexion at 20°; Latr 0 = right lateral flexion at 0°; Latr 20 = right lateral flexion at 20°; Protract = protraction; Retract = retraction.
* Isometric neck muscle strength was measured in lbs.
† $P < 0.05$.

Table 4. Percentage Improvement Within Each Group and Mean Difference Between Groups in Disability (NPQ), Pain (VNPS), and Isometric Neck Muscle Strength* at 6-Month Follow up

Outcome Measure	Mean Percentage Improvement (95% CI) (*P* of within-group comparison)		Mean Difference (95% CI) *P* (between-group comparison by ANOVA) (control *vs* exercise)
	Control	Exercise	
NPQ mean	14.6 (3.6 to 25.7) (0.01)†	26.5 (8.3 to 44.8) (0.00)†	0.2 (−0.0 to 0.4) 0.08
VNPS	10.1 (−5.5 to 25.7) (0.20)	33.7 (14.1 to 53.2) (0.00)†	1.2 (0.4 to 2.0) 0.00*
Flex0	12.6 (−1.6 to 26.7) (0.08)	24.9 (7.8 to 42.1) (0.00)†	2.1 (−0.7 to 5.0) 0.14
Flex20	11.3 (−1.4 to 24.0) (0.08)	20.3 (6.3 to 34.3) (0.00)†	1.0 (−0.5 to 2.4) 0.17
Flex40	6.9 (−3.3 to 17.2) (0.18)	16.3 (5.1 to 27.5) (0.00)†	1.2 (−0.3 to 2.7) 0.12
Ext0	12.0 (−0.1 to 24.1) (0.050)	21.2 (6.6 to 35.7) (0.00)†	1.2 (−0.7 to 3.0) 0.20
Ext20	14.7 (0.2 to 29.3) (0.046)†	18.7 (5.8 to 31.6) (0.00)†	1.3 (−0.6 to 3.2) 0.17
Ext40	1.8 (−0.5 to 4.1) (0.12)	21.4 (6.6 to 36.1) (0.00)†	0.1 (−1.7 to 2.0) 0.90
Latl0	14.3 (−14.9 to 43.4) (0.33)	20.9 (6.5 to 35.3) (0.00)†	0.5 (−0.8 to 1.7) 0.45
Latl20	6.2 (−18.7 to 31.1) (0.62)	14.8 (4.6 to 25.0) (0.00)†	1.0 (−0.3 to 2.2) 0.12
Latr0	14.9 (2.4 to 27.5) (0.02)†	19.3 (6.0 to 32.7) (0.00)†	0.1 (−1.1 to 1.4) 0.85
Latr20	11.9 (−1.5 to 25.3) (0.08)	13.4 (−1.3 to 28.1) (0.072)	0.4 (−1.0 to 1.8) 0.56
Protract	17.1 (−6.4 to 40.6) (0.15)	16.3 (4.0 to 28.6) (0.01)†	0.3 (−1.2 to 1.8) 0.65
Retract	16.9 (−0.8 to 34.6) (0.06)	23.1 (7.2 to 39.0) (0.00)†	1.2 (−0.6 to 3.0) 0.19

Flex 0 = flexion at 0°; Flex 20 = flexion at 20°; Flex 40 = flexion at 40°; Ext 0 = extension at 0°; Ext 20 = extension at 20°; Ext 40 = extension at 40°; Latl 0 = left lateral flexion at 0°; Latl 20 = left lateral flexion at 20°; Latr 0 = right lateral flexion at 0°; Latr 20 = right lateral flexion at 20°; Protract = protraction; Retract = retraction.
* Isometric neck muscle strength was measured in lbs.
† $P < 0.05$.

ensure that it was scientifically sound and that the findings were statistically and clinically relevant. Patients came from different workplaces (office workers and manual laborers) and from two typical physiotherapy outpatient departments from two different regions of Hong Kong, and should be a reasonably representative sample of patients with chronic neck pain. They displayed pain and disability comparable to those of typical patients with chronic neck problems described in many previous studies.[27,28] Therefore, results of this study should be generalizable to those patients with chronic neck pain. As almost all eligible patients (99.3%) agreed to participate, nonresponse bias should be small.

Improvement in the Disability Score

A number of studies[11,26] demonstrated similar within-group improvement in the disability score. In a randomized clinical trial, Bronfort *et al*[12] compared the relative efficacy of rehabilitative neck exercise and spinal manipulation for the management of patients with chronic pain. Substantial improvement in the Neck Disability Index was observed in different groups of patients, and no significant between-groups difference was reported ($P = 0.45$). As all inferences for effectiveness should be based only on the results of contrast between the intervention and the control group, the present study demonstrated that the exercise group had a short-term significantly better improvement in disability score than the control group after 6 weeks of treatment. Previous studies did not report the reasons for this improvement. We suggested that as the disability score aims to assess different aspects of the clinical symptoms of neck pain (which consist of pain intensity, daily activities, work, and social activities[29]), the improvement in disability score might be due to the combined effects of reduction in neck pain, improvement in neck muscle strength and to certain extent improvement in activities of daily living.

Improvement in Verbal Numeric Pain Scale

Several studies[10–12,26,30] also demonstrated that intensive training of the neck muscles for 6 to 12 weeks re-

Table 5. Percentage of Patients Taken Sick Leaves and Using Medication Because of Neck Pain

	Control			Exercise			
	Week 0	Week 6	Month 6	Week 0	Week 6	Month 6	*P**
% of subjects taken sick leaves for the past 3 weeks	16.7% (13)	6.4% (5)	9.0% (7) p = 0.08*	16.4% (11)	1.5% (1)	3.0% (2) p = 0.01*†	0.22‡
% of subjects using medication for the past 2 weeks	30.8% (24)	23.1% (18)	26.9% (21) p = 0.21*	31.3% (21)	19.4% (13)	17.9% (12) p = 0.06*	0.69‡

Values in parentheses are no. of patients.
* *P* value of within-group difference between month 6 and week 0.
† $P < 0.05$.
‡ *P* value of between-group difference at month 6.

sulted in significant reduction of self-reported neck pain. However, as there was no control group in these studies, the reduction in pain could be a result of the exercise program or simply a result of spontaneous changes in the course of the problem. Recently, Ylinen *et al*[28] reported significant decrease in pain in patients after 12 months of active neck muscle training as compared with the control group. However, our neck muscle strengthening program was more specific and of shorter duration than those in previous studies.[11–12,28,31] More studies are indicated to compare the effects of different exercise programs in pain reduction.

Increase in Isometric Neck Muscle Strength

Previous studies[10–12,30]also demonstrated significant improvements in neck muscle strength after exercise training of various durations. However, as all the previous studies did not include a control group, the authors found it difficult to attribute the improved strength to the effect of the exercise training. In contrast to the previous studies, we included a control group and therefore can attribute the significant improvement in strength to our 6 weeks' training program. It is interesting to note that patients in the control group also had some improvement in their isometric neck muscle strength. Other studies have also demonstrated strength increase in the cervical musculature even after passive treatment.[11,28,32] Jordan *et al*[11] suggested that the gain in strength in these subjects was likely a result of increased confidence. Ylinen *et al*[28] explained that the strength increase in the control group was probably due to biologic variation and learning effect due to repeated testing. Similarly Al-Obaidi *et al*[33] suggested that an improvement in the cognitive perception of pain, and the fear-avoidance belief about physical activities, might contribute to the improvement of isometric muscle strength in patients with chronic back pain. Future trials investigating the effect of fear avoidance behavior in patients with neck pain is indicated.

Sick Leave

There was a significant decrease in the percentage of subjects who had taken sick leave due to neck pain in the exercise group, but there was no significant difference between the two groups. No study data were reported in previous studies. Exercise training might have some benefits on reducing absenteeism due to neck pain. However, Deyo *et al*[34] and Hazard *et al*[35] suggested that return to work and absenteeism are strongly influenced by factors unrelated to patient's health and treatment. Further study is needed to investigate the validity and sensitivity of return to work and absenteeism as an outcome measure in the rehabilitation of patients with neck pain.

Reduction in Using Medication Because of Neck Pain

Self-reported medication usage for the past 2 weeks decreased in both groups, but the differences were not statistically significant.

This could be due to the insufficient sample size and lack of statistical power to detect the difference. Previous studies[11–12,26,28] also reported that decreased medication usage in the exercise group, but no significant difference was found between groups. Comparing the results of different studies is problematic because the baseline disabilities were different. The disagreement in results between the nonsignificant reduction in medication and significant improvement in self-report of pain in the present study suggested that the usage of pain relieving medication is under multiple influences in addition to the relieving of neck pain.

Perceived Satisfaction

Patients in the exercise group were significantly more satisfied with their condition of neck pain than those in the control group. Several studies[11–12,31] documented similar findings.

Limitations of the Present Study

Because only patients with chronic neck pain (more than 3 months' history of neck pain) were recruited in this study, the findings could only be applicable to patients within this category.

The exercise program of this trial consisted of two parts: the activation of the deep neck muscles and dynamic strengthening of the neck muscles with the MCRU. It was not possible to identify the effects of each individual part on patients with chronic pain.

The sample size of the present study did not allow subgroup analysis of the effects of the neck exercise train-

ing program on patients of different genders and of different age groups. There is also a lack of findings on these aspects.

It should also be noted that the time spent in the exercise training and the cost of investment in the cervical rehabilitation unit was higher in the exercise group. The cost effectiveness of the exercise program needs to be evaluated in future studies. The cost of the cervical rehabilitation unit is high at present, which may limit the uptake of this method of treatment.

■ Conclusion

The results showed that after a 6 weeks' training program, patients in the exercise group were significantly better in disability scores, subjective report of pain, isometric neck muscle strength in most of the different directions, and satisfaction than those in the control group at week 6. However, at the 6-month follow-up, a statistically significant difference was found only in the subjective report of pain and patient satisfaction but not in disability between the two groups. The effect of exercise was less favorable at 6 months.

■ Key Points

- A randomized controlled trial to investigate the efficacy of a 6-week neck exercise program has been completed in patients with chronic neck pain.
- At week 6, patients with chronic neck pain can benefit from the neck exercise program. However, the effect of exercise was less favorable at 6 months.

References

1. Cote P, Cassidy DJ, Carroll L. The Saskatchewan health and back pain survey: the prevalence of neck pain and related disability in Saskatchewan adults. *Spine* 1998;23:1689–98.
2. Rempel DM, Harrison R J Barnhart S. Work related cumulative trauma disorders of the upper extremity. *JAMA* 1992;267:838–42.
3. Criso JJ III, Panjabi MM. Postural biomechanical stability and gross muscular architecture in the spine. In: Winters JM, Woo SLY, eds. *Multiple Muscle System*. New York: Springer-Verlag, 1990:438–50.
4. Panjabi MM. The Stabilizing system of the spine: II. Function dysfunction, adaptation and enhancement. *J Spinal Disord* 1992;5:390–7.
5. Mayoux-Benhamou MA, Revel M, Vallee C, et al. Longus colli has postural function on cervical curvature. *Surg Radiol Anat* 1994;16:367–71.
6. Hallgren RC, Greenman PE, Rechtien JJ. Atrophy of suboccipital muscles in patients with chronic pain: a pilot study. *J Am Osteopath Assoc* 1994;94: 1032–8.
7. McPartland JM, Brodeur RR. Rectus capitis posterior minor: a small but important suboccipital muscle. *J Bodywork Movement Ther* 1999;3:30–5.
8. Franco JL, Herzog A. A comparative assessment of neck muscle strength and vertebral stability. *J Orthop Sports Phys Ther* 1987;8:351–5.
9. Peck D, Buxton DF, Nitz A. A comparison of spindle concentrations in large and small muscles acting in parallel combinations. *J Morphol* 1984;180: 243–52.
10. Highland TR, Dreisinger TE, Laura LV, et al. Changes in isometric strength and range of motion of the isolated cervical spine after eight weeks of clinical rehabilitation. *Spine* 1992;17(suppl):77–82.
11. Jordan A, Bendix T, Nielsen H, et al. Intensive training, physiotherapy, or manipulation for patients with chronic neck pain: a prospective, single-blinded, randomized clinical trial. *Spine* 1998;23:311–9.
12. Bronfort G, Nelson B, Aker PD, et al. A randomized clinical trial of exercise and spinal manipulation for subjects with chronic neck pain. *Spine* 2001;26: 788–7.
13. Koes BW, Bouter LM, van Mameren H. Randomization clinical trial of manipulative therapy and physiotherapy for persistent back and neck complaints: results of one year follow-up. *Br Med J* 1992;304:601–5.
14. Beeton K, Jull GA. Effectiveness of manipulative physiotherapy in the management of cervicogenic headache: a single case study. *Physiotherapy* 1994; 80:417–23.
15. Philadelphia Panel. Philadelphia Panel evidence-based clinical practice guidelines on selected rehabilitation interventions for neck pain. *Phys Ther* 2001;81:1701–16.
16. Jensen CV. A computer program for randomization patients with near-even distribution of important parameters. *Comput Biomed Res* 1991;24:429.
17. Chiu TW, Lam TH, Hedley AJ. Subjective health measure used on Chinese patients with neck pain in Hong Kong. *Spine* 2001;26:1884–9.
18. Murphy DF, McDonald A, Power C, et al. Measurement of pain: a comparison of the visual analogue with a nonvisual analogue scale. *Clin J Pain* 1988;3:197–9.
19. Chiu TTW, Lo SK. Evaluation of cervical range of motion and isometric neck muscle strength: reliability and validity. *Clin Rehabil* 2002;16:851–8.
20. Jull GA, Barrett C, Magee R, et al. Further clarification of musculoskeletal dysfunction in cervical headache. *Cephalalgia* 1999;19:179–85.
21. Graves JE, Pollock ML, Foster DN, et al. Effect of training frequency and specificity on isometric lumbar extension strength. *Spine* 1990;15:504–9.
22. Risch SV, Norvell NK, Pollock ML, et al. Lumbar strengthening in chronic low back pain patients: physiological and psychological benefits. *Spine* 1993; 18:232–8.
23. Leggett SH, Graves JE, Pollock ML, et al. Quantitative assessment and training of isometric cervical extension strength. *Am J Sports Med* 1991;19: 653–9.
24. Pollock ML, Graves JE, Bamman MM, et al. Frequency and volume of resistance training: effect on cervical extension strength. *Arch Phys Med Rehabil* 1993;74:1080–6.
25. Koes BW, Hoving JL. The value of the randomized clinical trial in the field of physiotherapy. *Man Ther* 1998;3:179–86.
26. Randlov A, Ostergaard M, Manniche C, et al. Intensive dynamic training for females with chronic neck/shoulder pain: a randomised controlled trial. *Clin Rehabil* 1998;12:200–10.
27. Borghouts JAJ, Koes BW, Bouter LM. The clinical course and prognostic factors of non-specific neck pain: a systemic review. *Pain* 1998;77:1–13.
28. Ylinen J, Takala EP, Nykanen M, et al. Active neck muscle training in the treatment of chronic neck pain in women: a randomized controlled trial. *JAMA* 2003;289:2509–16.
29. Leak AM, Cooper J, Dyer S, et al. The Northwick Park neck pain questionnaire, devised to measure neck pain and disability. *Br J Rheumatol* 1994;33: 469–74.
30. Berg HE, Berggren G, Tesch PA. Dynamic neck strength training effect on pain and function. *Arch Phys Med Rehabil* 1994;75:661–5.
31. Taimela S, Takala EP, Asklof T, et al. Active treatment of chronic neck pain: a prospective randomized intervention. *Spine* 2000;25:1021–7.
32. Levoska S, Keinanen-Kiukaannieni S. Active or passive physiotherapy for occupational cervicobrachial disorders? A comparison of two treatment methods with a 1-year follow-up. *Arch Phys Med Rehabil* 1993;74:425–30.
33. Al-Obaidi SM, Nelson RM, Al-Awadhi S, et al. The role of anticipation and fear of pain in the persistence of avoidance behavior in patients with chronic low back pain. *Spine* 2000;25:1126–31.
34. Deyo RA, Adnersson G, Bombardier C. Outcome measures for studying patients with low back pain. *Spine* 1994;19(suppl):2032–6.
35. Hazard RG, Haugh LD, Green PA, et al. Chronic low back pain: the relationship between patient satisfaction and impairment, and disability outcomes. *Spine* 1994;19:881–7.