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Physical exercises and functional rehabilitation for the management of chronic neck pain

J. YLINEN

Department of Physical and Rehabilitation Medicine Jyväskylä Central Hospital, Jyväskylä, Finland

Despite chronic neck pain being so common in the population, few randomized studies have evaluated exercise methods in treating the neck disorders. The aim of this review was to reassess the effectiveness of different exercise methods in relieving pain and improving disability in patients with chronic nonspecific neck pain. Ten randomized controlled or comparative high-quality trials were included in a more detailed analysis using patient-oriented primary outcome measures (*e.g.*, patient's rated pain and disability) as well as pressure pain threshold and functional outcomes (neck strength and range of motion). Findings revealed moderate evidence supporting the effectiveness of both long-term dynamic as well as isometric resistance exercises of the neck and shoulder musculature for chronic or frequent neck disorders. Findings revealed no evidence supporting the long-term effectiveness of postural and proprioceptive exercises or other very low intensity exercises. Clinicians are encouraged to consider these findings and incorporate them into their practice when planning the treatment of patients with chronic neck disorders.

Key words: **Neck pain - Exercise therapy - Range of Motion, articular.**

Prevalence of chronic neck pain

Chronic neck pain is a common condition. In the Norwegian population, chronic neck pain was found in 17% of women and 14% of men.[1] Guez *et al.*[2] reported a corresponding prevalence of 22% in women and 16% in men in northern Sweden. In Finland, the prevalence of chronic neck pain was found to be 7% in women and 5% in men.[3] Similar prevalences have also been reported also in the UK.[4] In epidemiologic studies, pain has been defined as chronic, if it has lasted more than 3 months,[3] 6 months[1, 2] or 5 years.[4] To date, only the Finnish study included personal interviews, clinical testing and diagnostic criteria for restricted mobility or tenderness of the neck, all factors that increase the reliability of this study. Other studies have relied solely on questionnaires. Among other factors, climate, level of education, means of livelihood and average age of the population may influence the prevalence of pain and account for differences between different countries.

Chronic neck pain is often a widespread sensation with hyperalgesia in the skin, ligaments and muscles on palpation and in both passive and active movements. The exact source and cause of neck pain is rarely revealed by clinical examination or diagnostic imaging.[5-7] In this respect, neck pain is similar to many other painful conditions of the musculoskeletal system.

Cost of chronic neck pain

Treatment of chronic neck pain has also an important economic impact. Patients with chronic neck pain used health care services twice as frequently as the general population and treatment costs on average were estimated to be €240 and costs due to sick leave

Address reprint requests to: J. Ylinen, MD, PhD, Jyväskylä Central Hospital, Head of Department of Physical and Rehabilitation Medicine, Keskussairaalantie 19, 40620 Jyväskylä, Finland.
E-mail: jari.ylinen@ksshp.fi

€ 653 per patient case in 1988.[8] Borghouts *et al.*[9] estimated the total cost of neck pain in the Netherlands in 1996 to be € 686 million. Of these, 50% were disability pensions, with direct medical costs accounting for 23%, or about 1% of the total cost of health care. Some 1.4 million days were estimated to be lost because of neck pain. Diagnostic examinations and therapy play a minor role in comparison with the indirect costs of lost wages, sick leave and disability pensions.[10]

Current treatment recommendations

The problem for the clinician is the plethora of therapies available in a situation where systematic meta-analyses have shown a lack of evidence for the effectiveness of physical therapy and even of multidisciplinary rehabilitation in cases of chronic neck pain.[11, 12] Doctors find themselves in a frustrating situation, as they are taught to adhere to evidence-based forms of therapy, which, however, are not really available, while systematic meta-analyses provide few guidelines for clinical practice. Ergonomic counseling, as well as maintaining physical activity and exercise, is commonly recommended. However, there are no specific guidelines about how exercise should be performed in cases of chronic neck pain.[13] On the other hand, leaving patients without any treatment may lead to an even worse scenario. Patients may feel that their complaints are being minimized and perhaps ascribe this to nonchalance. So there is an urgent need to identify effective forms of therapy for chronic neck pain.

Function and strength of neck muscles

To properly appreciate the role of neck exercises, we need to understand the various interactive functions of neck muscles. The neck muscles have an isometric function, which is to counteract the force of gravity in order to maintain the head and neck in an upright position. The neck muscles also stabilize the head during movements, while the forces of acceleration and deceleration applied to the head, in turn, impose additional stress on the connective tissues of the neck.[14] The neck muscles also have the dynamic function of positioning the cervical spine and head for better utilization of sight, hearing, olfaction and mouth. While moving the body, the neck muscles are used to keep the head in an upright position according to the information received from the balance organs, the eyes and the proprioceptors in the musculoskeletal system.[15] The function of the neck muscles attaching to the ribs, scapula and clavicle is to lift and hold up the shoulders and to assist in deep inspiration by lifting the upper ribs. A large variation in neck muscle strength between healthy individuals has been observed in several studies.[16-18] However, the optimal or even minimum level of strength to maintain required good neck function remains to be established.

Several studies have reported lower neck muscle strength in patients with chronic neck pain than in healthy controls. Barton *et al.*[19] found 50% lower maximal neck flexor muscle strength in patients than in healthy controls. Jordan *et al.*[20] found flexion and extension strength to be over 50% lower in patients with chronic neck pain than in healthy controls. Chiu *et al.*[21] found 28% lower extensor and 24% lower flexor muscle strength in patients than in healthy controls. Ylinen *et al.*[22] found 30% lower flexion and extension and 23% lower rotation forces produced by patients with chronic neck pain compared with healthy matched controls, showing that muscle deficit was not restricted only to certain groups of muscles. These studies were cross-sectional and so do not indicate whether the neck pain was a result of weakness in the neck muscles or whether the lower results in the neck strength tests were due to a long-standing painful condition. Nevertheless, these studies suggest a connection between muscle weakness and neck pain.

It is not enough that individuals have sufficient muscle strength to cope with everyday tasks; there has to be reserve capacity sufficient to perform tasks that require more effort at work and during recreational activities. If an individual's muscle strength does not cover these ranges of function, this may lead to exhaustion or trauma, and pain is a common sign of these conditions. Even though there may be sufficient muscle strength in normal circumstances, pain may reduce muscle strength, leading to insufficient function during high load situations. Patients with chronic neck pain and osteoarthritis of the cervical spine have been shown to exhibit greater fatigue of both the anterior and posterior neck muscles at high force levels compared with healthy subjects at electromyography.[23] Falla *et al.*[24] found neck flexor fatigue on the painful side in patients with neck pain. She also showed in a randomized study that active training of neck muscles was effective in reducing myoelectric manifestations of neck muscle fatigue in patients with chronic neck pain.[25]

Neck training studies

Neck training in this context refers to neck muscle exercises that directly involve the head or neck, *i.e.*, intentional acceleration, deceleration, pushing or pulling forces directed at these structures. Shoulder and upper extremity training refers to exercises involving the hands in lifting, pushing or pulling.

Randomized studies

A summary of training studies concerning chronic neck pain is presented in Table I.[26-41] Only randomized studies presenting data on primary outcome measures and a control group receiving either no treatment or passive treatment have been included. The results of different studies seem to be quite consistent, despite differences in study design and patient population.

Pain has most commonly been measured in randomized studies by continuous visual analogue scale scores (0-10), which allows for the use of nonparametric tests in the statistical analysis. However, several studies have used numerical scales (from 0, no pain, to 10, maximal pain). Continuous and categorized scales cannot be directly compared, as the range of these two types of scales may be understood differently.

The same problem exists when comparing studies where neck disability is assessed on continuous and categorized scales. Moreover, the variety of different question items makes its difficult to directly compare the degree of change in disability between different studies. Therefore, changes are expressed in per cent in Table I and Figure 1.[26-41]

Jordan *et al.*[28] compared the effects of three treatment methods in patients with chronic neck pain: active training, passive physiotherapy and manual therapy. Training started with warm-up on a stationary bicycle for 5 min and stretching for 10 min. Neck exercises were performed with a Follo® machine using a load of 30% of measured maximal isometric neck strength. Twelve repetitions in one series were performed in flexion and 3 series each in extension and lateral flexion. Strength tests were performed every 2 weeks and the load was adjusted according to the results. Dumbbells and a pull-down machine were used in exercises for the shoulder, scapular and chest muscles. Total training time was about 60-75 min. Passive physiotherapy included hot packs, massage, ultrasound, traction and mobilization of the cervical spine and proprioceptive neuromuscular facilitation for muscle tension. The total time spent on the treatments was about 30 min. Manual therapy consisted of manipulation, manual traction, massage and manual treatment of trigger points; the treatment lasted 15-20 min. Two treatment or training sessions per week were arranged for a total period of 6 weeks. All three groups were instructed to perform the same home exercises, including light resistance exercises using dumbbells (1-2 kg), isometric anti-gravity exercises for the cervical muscles in all directors and stretching exercises for the neck and shoulder muscles. Pain was reduced by about 50% in all groups after the intervention period and remained at the same level at the 12-month follow-up. There was no significant difference in pain and maximal isometric neck strength between the three groups. Despite its stated purpose, the study did not compare active exercises with passive therapies, as the home training may have been effective, while the passive treatments did not have any additional effect.

Bronfort *et al.*[34] and Evans *et al.*[35] compared the effects of three treatment methods: neck muscle training combined with manual therapy, neck muscle training and spinal manipulation in patients with chronic nonspecific neck pain. The fist group received massage and cervical spinal manipulation treatments and performed progressive neck strength exercises with a pulley (1-10 pounds) and headgear while lying down. Upper body exercises were performed with dumbbells and push-ups for 45 min. Training was supervised and patients performed 2 sets of 15-30 repetitions with weights varying from 2-10 pounds. The second group performed neck extension and rotation exercises on a machine (MedX®) with progressive load, upper body strengthening and stretching exercises. The third group received massage and spinal manipulation treatments plus sham microcurrent therapy. All groups attended 20 sessions over 11 weeks. All groups performed the same home exercise program for the neck flexor, extensor and rotator muscles with a rubberized tubing device. After the intervention, pain was reduced by about 50% from baseline level in both exercise groups, while the pure home training group showed somewhat less improvement. No

TABLE I.—*Randomized studies on training in chronic neck pain. Changes are compared to baseline. Pain is commonly asked during the past week.*

Researchers	Subjects	Intervention	Outcome measures and main results	Comments
Revel *et al.*[26]	N=60 Mean age: 48 years (SD 14) Pain >3 months G1: F=22, M=8 G2: F=29, M=1	G1: proprioceptive exercises G2: control; no treatment G1: trained twice a week for 8 weeks	Mean (SD) neck pain on VAS Baseline at 10 wk G1: 50 (22) - 40% G2: 46 (26) - 9%	Pain decreased more significantly in G1 than in G2
Takala *et al.*[27]	N=44 Mean age: 44 years (IQR 38, 49) G1: F=22 G2: F=22	G1: stretching, aerobic dynamic and relaxation exercises G2: control; no treatment Part 1: G1 trained once a week for 10 weeks Part 2: G2 trained once a week for 10 weeks and G1 served as a control group	Median (IQR) neck pain on VAS. Baseline 10 wk G1: 40 (18-66) - 22% G2: 50 (16-66) - 16% Cross-over design: in the second part of the study there was no significant change after the training intervention	Pain decreased in both groups; there was no significant difference between groups
Jordan *et al.*[28]	N=119 Mean age: 35 years Pain >3 months G1: F=30, M=10 G2: F=29, M=10 G3: F=29, M=11 Drop-out: 14%	G1: stretching, training of neck and shoulder muscles G2: physiotherapy; hot packs, US, massage, mobilization and traction. G3: chiropractic manipulation, massage, manual therapy of trigger points and manual traction G1-3: training or treatment sessions twice a week for 6 weeks G1-3: home exercises consisting of 3 stretching and 5 strengthening exercises for neck and shoulder muscles	Neck pain in 11-point scale; 0=no pain to 10=worst pain during the past 14 days. Three scales: present + average + worst pain, max 30 points/3: median (90% CI) Baseline 6 wk 12 mo G1: 4 (3-5) - 50% - 50% G2: 4 (3-5) - 50% - 25% G3: 4 (3-5) - 50% - 50% Disability scale with 15 items (0-2) max 30 points: Baseline 6 wk 12 mo G1: 8 (7-10) - 37% - 37% G2: 9 (8-11) - 44% - 67% G3: 8 (7-10) - 50% - 37%	Pain and disability were significantly reduced in all groups; there was a significant difference between groups
Lundblad *et al.*[29]	N=97 Mean age: 33 years (SD 9) Average 5 years G1: F=32 G2: F=33 G3: F=32 Drop-out: 40%	G1: stretching, coordination, endurance, ergonomics and posture exercises G2: Feldenkreis intervention; coordination and body awareness exercises G3: control; no treatment G1 and G2: supervised training for 50 min twice a week for 16 weeks	Mean (SD) neck pain during previous week in VAS. Baseline 16 wk G1: usually 12 (10) - 25% worst 41 (20) - 1% G2: usually 15 (10) - 80% worst 44 (25) - 25% G3: usually 20 (14) - 45% worst 55 (28) - 13%	Pain usually was significantly reduced after the intervention in G2 and G3 No significant difference between groups in pain and disability
Taimela *et al.*[30]	N=76 Mean age: 44 years (SD 11) Pain >3 months Average 8 years G1: F=17, M=8 G2: F=19, M=6 G3: F=18, M=8 Drop out: 20%	G1: cervicothoracic stabilization and proprioceptive training, eye fixation and dynamic training with neck machines, seated wobble board training, and relaxation exercises. G2: neck lecture and home exercises G3: control; neck lecture and written information about neck exer-	Mean (SD) neck pain during previous 6 weeks in VAS (SD) Baseline 3mo 12mo G1-3: 51 (21) - 35% G1: - 57% G2: - 55% G3: - 23%	Pain in G1 and G2 was significantly lower than in G3 after the intervention No significant difference in pain between groups at 12 months Disability scores decreased significantly after the intervention, but

(To be continued)

TABLE I.—*Randomized studies on training in chronic neck pain. Changes are compared to baseline. Pain is commonly asked during the past week (Continued)*

Researchers	Subjects	Intervention	Outcome measures and main results	Comments
		cises applied at home and at workplace G1: supervised training twice a week for 12 weeks G2: supervised training for home exercises twice with a 1-week interval		there was no significant difference between groups
Waling *et al.*[31] Ahlgren *et al.*[32] Waling *et al.*[33]	N=126 Mean age: 38 years (SD 6) Pain >12 months Average 7 years G1: F=34 G2: F=34 G3: F=31 G4: F=27 Drop-out: 5%	G1: strength training; rowing, triceps press, shoulder press and pulldown with air machines G2: endurance training; arm cycling alternating with rubber expanders, abdominal and back exercises G3: coordination training; body awareness training to more relaxed movement patterns G4: control; stress management. G1-3: supervised training 3 times per week for 10 weeks G4: 2-hour session once a week for 10 weeks	Mean (SD) neck pain in VAS Baseline 10 wk 3 y G1: present 26 (21) +19% general 39 (18) -18% worst 74 (16) - 24% - 20% G2: present 28 (20) -21% general 40 (21) - 27% worst 70 (17) - 11% -17% G3: present 33 (21) - 18% general 41 (17) - 29% worst 77 (13) - 12% - 26% G4: present 37 (24) - 57% general 43 (19) - 65% worst 75 (21) 0% -23%	Only VAS-worst was significantly decreased in G1 versus G4 after the intervention No significant difference at 10-week and 3-year follow-ups When all exercise groups were taken together, VAS-worst and VAS-general decreased significantly versus G4 at 10 weeks
Bronfort *et al.*[34] Evans *et al.*[35]	N=191 Mean age 44 years (SD 11) Pain >3 months Average 8 years G1: F=38, M=26 G2: F=38, M=25 G3: F=37, M=27 Drop out: 9%	G1: manipulation and massage for 15 min. Stretching and dynamic exercises for neck and upper extremities G2: stretching and dynamic exercises with neck extension and rotation machine G3: spinal manipulation and sham micro-current therapy G1–2: supervised training twice a week for 11 weeks G1–3: performed home exercises for neck muscles	Mean (SD) neck pain (11-point scale): Baseline 11wk 12mo 24mo G1: 5.6 (1.5) -57% -46% -39% G2: 5.6 (1.5) -59% -48% -39% G3: 5.6 (1.4) - 48% -37% -30% Northwick Park Neck Pain Questionnaire (short form-36) Baseline 11 wk 12mo 24mo G1: 26 (8) -46% -42% -38% G2: 26 (10) -54% -42% -35% G3: 28 (10) -46% -32% -28%	Pain and disability after the intervention were significantly reduced in all groups No significant differences between groups
Viljanen *et al.*[36]	N=393 Mean age: 44 years (SD 7) Pain >3 months Average 11 years G1: F=135 G2: F=128 G3: F=130 Drop out: 13%	G1: stretching and dynamic exercises for shoulders and upper extremities G2: relaxation training G3: control; no treatment G1 and G2 had supervised training 3 times a week for 12 weeks and for 1 week after 6 months G1 and G2 were instructed home exercises	Mean (SD) neck pain (11-point scale): Baseline 3mo 12mo G1: 4.8 (2.3) - 39% - 35% G2: 4.8 (2.3) - 39% - 31% G3: 4.1 (2.2) - 34% - 22% Mean neck disability index: Baseline 3mo 12mo G1: 29 (15) - 48% - 34% G2: 29 (14) - 52% - 34% G3: 26 (14) - 46% - 35%	Pain and disability after the intervention were significantly reduced in all groups No significant differences between groups
Ylinen *et al.*[37-39]	N=180 Mean age: 46 years (SD6)	G1: isometric neck muscle exercises and dynamic exercises for muscles of shoulders and upper extremities and stretching.	Median (SD) neck pain during previous week in VAS:	Pain and disability decreased significantly more in G1 and G2 *versus* controls

(To be continued)

TABLE I.—*Randomized studies on training in chronic neck pain. Changes are compared to baseline. Pain is commonly asked during the past week (Continued)*

Researchers	Subjects	Intervention	Outcome measures and main results	Comments
	Pain >6 months Average 8 years G1: F=60 G2: F=59 G3: F=60 Drop out: 1%	G2: dynamic exercises for muscles of neck, shoulders and upper extremities and stretching G3: control; stretching exercises. G1–3: were instructed to perform exercises 3 times a week at home	Baseline 12mo G1: 58 (43-72) - 70% G2: 57 (43-74) - 61% G3: 58 (42-74) - 27% Median (SD) neck and shoulder pain and disability index Baseline 12mo G1: 35 (24-45) - 66% G2: 36 (28-46) - 61% G3: 38 (26-49) - 42%	No significant difference between G1 and G2
Chiu *et al.*[40, 41]	N=218 Pain >3 months 67% had pain >12 months G1: F=48, M=19 G2: F=49, M=24 G3: F=52, M=26 Drop out: 16%	G1: dynamic flexion and extension exercise with neck exercise machine, isometric neck flexor exercises in supine and infrared radiation G2: TENS (30 min) and infrared radiation G3: control group: infrared radiation G1-3: treatment twice a week for 6 weeks	Mean (SD) neck pain (11-point scale): Baseline 6 wk 6 mo G1: 4.6 (1.9) -35% - 33% G2: 4.7 (1.8) - 6% - 28% G3: 4.3 (2.1) - 7% - 16% Mean (SD) disability: Northwick Park Neck Pain Questionnaire (0=no disability to 4=the worst) Baseline 6 wk 6 mo G1: 1.4 (0.5) - 28% - 28% G2: 1.5 (0.4) - 20% - 20% G3: 1.4 (0.5) -21% - 14%	Neck pain was significantly reduced in G1 and G2 versus baseline Disability decreased significantly in all groups No significant difference between the groups

N: number; F: female; M: male; G: treatment group; SD: standard deviation; IQR: interquartile range; VAS: visual analog scale; TENS: transcutaneous electrical nerve stimulation.

significant differences in pain were found between the groups at the 12-month follow-up. Both supervised exercise groups showed greater gains in neck strength and range of motion. The study did not, in fact, compare passive therapies with active exercises. The home training may have been effective, while the additional treatments, such as manipulation or training with MedX®, did not have any additional effect on the primary outcomes.

Randomized controlled studies

Revel *et al.*[26] evaluated slow motion proprioceptive exercise in patients with chronic neck pain. The exercises were mainly concerned with eye-neck coordination. There were two training sessions per week for 8 weeks. Neck pain was reduced significantly more in the training group compared to the control group at the 10-week follow-up. The patients in the control group were given the opportunity to start rehabilitation after the follow-up. No long-term follow-up was applied.

Takala *et al.*[27] conducted a cross-over study in which group gymnastics were assessed during working hours in women with neck pain. The physiobic, the so-called training program, included stepping and dynamic exercises of the muscles of the trunk and extremities for 35 min. Stretching and relaxation was done for 10 min. There were no exercises aimed specifically at the neck area. Training was performed in supervised groups once a week for 10 weeks, after which the groups were reversed. No significant difference was found between the training and the control group after either training period.

Lundblad *et al.*[29] evaluated the effects of active physiotherapy and Feldenkreis intervention in women with chronic neck pain. The physiotherapy program consisted of coordination, endurance, ergonomics, flexibility and posture exercises. The Feldenkreis therapy had an emphasis on posture, relaxation and movement patterns. The physiotherapy group exercised twice a week for 16 weeks and the Feldenkreis group 12 times after 4 sessions of individual guidance. The subjects had only minor neck pain at baseline and no significant difference in neck pain was found between the groups after 12 months.

Taimela *et al.*[30] evaluated the effects of supervised resistance training and a home regimen in women with chronic nonspecific neck pain. Low load resistance exercises of neck muscles in flexion and rotation were performed in combination with eye fixation exercises using a neck exercise machine. Shoulder blade adduction, arm extension and curl exercises, stretching, relaxation and seated wobble-board exercises were also applied. There were two supervised sessions per week, each lasting 45 min, for 12 weeks. The home group heard a lecture and had two practical sessions separated by a one-week interval. The home regimen consisted of stretching and strengthening exercises. The control group attended one lecture about neck pain and received written information about neck exercises to be applied at home and at the workplace. After the intervention, pain was reduced by about 50% in both training groups; it was significantly lower in both training groups than in the control group; there was no significant difference between two training groups. At the 12-month follow-up, no significant difference was found in neck pain between the groups.

Waling *et al.* and Ahlgren *et al.*[31-33] evaluated the effects of three dynamic training programs in women with chronic neck and shoulder pain. The strength training group performed shoulder and upper extremity muscle exercises with air machines set to allow 12 repetition maximum (RM). The endurance training group exercised with an armergometer or rubber expanders allowing a 30-35 RM. The coordination training group performed body awareness exercises with an emphasis on balanced movement with controlled breathing. Supervised strength and endurance training was conducted 3 times weekly and coordination training once a week for 10 weeks. After the intervention, when all exercise groups were added together, pain in the neck and shoulder area decreased significantly more in the exercise groups than in the control group, but the number of patients was too small to reveal any differences between the individual groups. No statistically significant difference was found between the groups at either the 8-month or 3-year follow-up.

Viljanen *et al.*[36] evaluated the effects of dynamic mus-

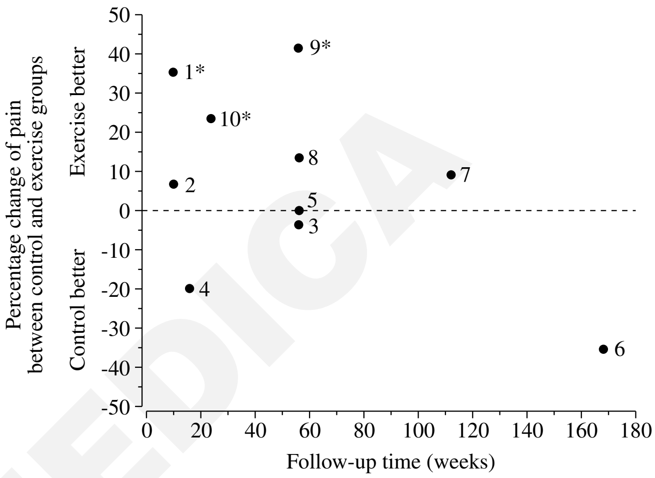

Figure 1.—Outcomes of randomized neck exercise studies in the treatment of chronic nonspecific neck pain. *Significantly greater pain reduction in the exercise group versus the control/passive treatment group. 1: Revel *et al.*;[26] 2: Takala *et al.*;[27] 3: Jordan *et al.*;[28] 4: Lundblad *et al.*;[29] 5: Taimela *et al.*;[30] 6: Waling *et al.*,[31] Ahlgren *et al.*,[32] and Waling *et al.*;[33] 7: Bronfort *et al.*,[34] and Evans *et al.*;[35] 8: Viljanen *et al.*;[36] 9: Ylinen *et al.*;[37-39] 10: Chiu *et al.*[40, 41]

cle training and relaxation training for chronic nonspecific neck pain in women. All the exercises of the training group were done with dumbbells and stretching immediately after each exercise. Relaxation training comprised various techniques based on the progressive relaxation method, autogenic training, functional relaxation, and systematic desensitization. Both intervention groups had 3 supervised exercise sessions per week over 12 weeks followed by one week reinforcement training, 6 months after baseline assessment. The control group was instructed not to change their physical activity or means of relaxation. Neck pain was significantly reduced in all groups, but no statistically discernible difference emerged between the groups after the intervention or at the 12-month follow-up.

Ylinen *et al.*[37, 38] evaluated whether intensive strength training or lighter endurance training of neck muscles, or stretching exercises performed by a control group, reduces pain and disability in women with chronic neck pain. The two muscle training groups started with a 12-day institutional program at a rehabilitation center, during which a supervised exercise session was performed daily and, thereafter, continued at home up to the 12-month follow-up. The strength training group performed isometric neck strengthening and stabilization exercises with an elastic band in the sitting position with 80% load of maximal strength measured at baseline. The endurance training group performed dynamic neck exercises, which included lifting the head from the supine and prone positions. Both groups performed dynamic exercises with dumbbells. The control group received only instructions on stretching exercises, which were also given to the muscle training groups. All patients were encouraged to exercise regularly 3 times a week at home. Exercise intensity and the technique used by those in the two muscle training groups were checked at follow-up visits at 2 and 6 months. In both training groups, the greatest decrease in neck pain and disability was achieved during the first 2 months; however, improvement continued up to 12 months. At the 12-month follow-up, neck pain and disability indexes had significantly decreased in both the strength and endurance training groups compared with the controls. Moreover, after the study intervention the control group initiated high intensity strength training and achieved similar decreases in neck pain and disability indices at the 24-month follow-up.[39]

Chiu *et al.*[40, 41] evaluated the effects of neck exercise and transcutaneous electrical nerve stimulation (TENS) in chronic neck pain patients. A resistance training program of the exercise group consisted of a warm-up session of isometric neck exercises with Stabilizer® for 10 s with 15-s breaks between holds for 10 min in the supine position, 15 repetitions of dynamic flexion and 15 repetitions of flexion and extension of the neck using the Multi Cervical Rehabilitation Unit® with resistance set at 20% of the subject's peak isometric strength. The warm-up was followed by 3 series each with 8 to 12 repetitions. The initial resistance was about 30% of the subject's peak isometric neck strength and was increased by 5% when a set of 12 repetitions had been achieved. The therapy group received advice on neck care, infrared irradiation for 20 min and TENS to the neck region for 30 min. The control group received only infrared irradiation for 20 min. Two treatment sessions per week were held over a period of 6 weeks. The exercise and therapy group showed significantly improved pain and disability scores after the intervention and at the 6-month follow-up. However, no significant difference was found among the three groups.

Résumé **of training studies**

Neck pain and disability

Chronic neck pain was once thought to be due to overexertion, so passive physical therapies and rest have been as the mainstay of treatment. Stressful exercises are avoided in the belief that they worsen the condition. Several follow-up studies without a control group have evaluated specific neck strength training and shown that increased strength is associated with a decrease in chronic neck pain.[42-45] These results suggest that training programs should place emphasis specifically on the strength training of neck muscles.

The randomized studies by Takala *et al.*[27] and Viljanen *et al.*[36] showed that a training program without specific neck muscle exercises produced no significant effect on chronic neck pain in the training group *versus* the control group. Light exercises to improve neck proprioception have been shown to decrease neck pain effectively, immediately after intervention,[26] while the long-term effectiveness of exercises in which the head is turned in different directions without resistance and pure postural straightening exercises has not been demonstrated.[29-31] Several randomized studies with different training programs have been shown to decrease chronic neck pain immediately after the intervention in training groups *versus* controls, although the improvement was not maintained at follow-up.[30, 31] There is a clear physiological explanation for this, in that training in these studies lasted only from 8 to 12 weeks. Short-term training interventions mainly induce neural adaptation, while tissue changes require much longer.[46, 47]

The studies show that resistance-type exercise methods, when training frequency and loading is appropriate, can reduce neck pain.[37, 40] Combining information from training physiology and clinical studies produces strong evidence for the effectiveness of exercise therapy for chronic neck pain, as well as the disability it causes. Resistance training has also been shown to improve neck strength and range of motion in a time-dependent fashion, as a more extensive exercise period leads to better results.[37]

Pressure pain threshold

A lower pressure pain threshold (PPT) in neck muscles has been found in patients with neck pain than in healthy controls.[48, 49] Significantly elevated in PPT has been observed during and after isometric exercise on the arms and legs of healthy subjects.[50, 51] However, several randomized studies on active training have not found a positive effect on the PPTs

TABLE II.—*Change in maximal isometric neck strength after training intervention compared to the baseline.*

Researchers	Subjects	Intervention	Outcome measures and main results	Comments
Jordan *et al.*[28]	G1: n=40 G2: n=39 G3: n=40	G1: neck flexion (1x12) and extension (3x12) exercises with the load 30% of maximum twice a week for 6 weeks. G1 and G2: no supervised exercising. G1-3: home exercises including also exercises for neck muscles.	Neck strength gains after 6 weeks: Flexion Extension G1: -7% 11% G2: 6% 33% G3: 15% 24%	There was no significant increase in flexor strength, but extensor strength improved significantly in all groups versus baseline. There was no significant difference between groups.
Bronfort *et al.*[34] Evans *et al.*[35]	G1: n=64 G2: n=63 G3: n=64	G1: progressive dynamic exercises for neck with pulley in extension, flexion and rotation; shoulder and upper extremity exercises with dumbbells and push-ups. G2: progressive, dynamic neck exercises with MedX® in extension and rotation. G3: no supervised exercising. G1–2: supervised training twice a week for 11 weeks. G1-3: home exercises for neck flexor, extensor and rotator muscles with rubberized tubing device.	Neck strength gains after 11 weeks: Flexion Extension Rotation G1: 52% 41% 49% G2: 33% 35% 19% G3: 21% 11% 13% (NS)	G1 showed greater gains in all strength measures, but G2 only in extension versus G3.
Ylinen *et al.*[37-39]	G1: n=60 G2: n=59 G3: n=60	G1: progressive, isometric neck strength exercises in flexion and extension and dumbbell exercises for muscles of shoulders and upper extremities. G2: neck flexion in supine and dumbbell exercises for muscles of shoulders and upper extremities. G3: control (no strength exercises). G1 and G2 supervised training 5 times a week for 2 weeks and G3 one instruction session. All groups were instructed to perform exercises 3 times a week at home.	Neck strength gains after 12 months: Flexion Extension Rotation G1: 110% 69% 76% G2: 28% 16% 29% G3: 8% 7% 10%	G1 showed significantly greater gains versus G2, which, in turn, had greater gains versus G1 in all directions.
Chiu *et al.*[40, 41]	G1: n=67 G3: n=78	G1: neck strengthening exercises with Stabilizer® and dynamic exercises in flexion and extension with Multi Cervical Rehabilitation Unit. G3: control (no exercises). G1: supervised training twice a week for 6 weeks.	Neck strength gains: 6 wk 6 mo Flexion Extension Flexion Extension G1: 36% 43% 25% 21% G3: 15% 20% 13% 12%	G1 had significantly greater strength gains versus G2 at 6-weeks, but no longer at 6 months.

of neck muscles in patients with chronic neck pain *versus* controls.[30, 31, 52, 53] The reason may be that training intensity was low and that the training intervention had lasted only up to 12 weeks in these studies, which may be too short to produce clinically significant tissue changes. Ylinen *et al.*[54] found a significant increase of 2 to 3 kp in PPT in the neck strength training group and an increase of 1.5 to 2.5 kp in the neck endurance training group, compared to 0 to 1 kp in the stretching group. Both neck muscle training groups continued exercising up to 12 months. Also, exercise intensity affected the results and was shown to have a major impact on the rise in PPT, as passive stretching did not increase PPT as much as dynamic and isometric muscle exercises did. Appropriate neck and shoulder muscle training not only reduces pain but can also increase tolerance to local mechanical pressure.

TABLE III.—*Change in range of motion compared to the baseline.*

Researchers	Subjects	Intervention	Outcome measures and main results	Comments
Bronfort *et al.*[34] Evans *et al.*[35]	G1: n=64 G2: n=63 G3: n=6	G1: progressive dynamic neck exercises in extension, flexion and rotation and stretching. G2: progressive, dynamic neck exercises in extension and rotation and stretching. G3: spinal manipulation.	Mean (95% CI) changes in cervical ROM after 11 weeks Flexion/extension; Rotation; Lateral flexion G1: 8° (5° to 11°); 11° (8° to 14°); 8° (5° to 10°) G2: 7° (4° to 10°); 8° (5° to 11°); 5° (2° to 8°) G3: 2° (-1° to 4°); 6° (3° to 8°); 2° (-0° to 5°)	G1 showed greater gains in all ROM measures, but G2 only in flexion-extension ROM versus G3.
Ylinen *et al.*[37-39]	G1: n=60 G2: n=59 G3: n=60 Drop out: 1%	G1: isometric strength exercises for neck and stretching. G2: dynamic endurance exercises for neck, and stretching. G3: control (stretching only).	Mean (95% CI) changes in cervical ROM after 12 months Flexion/extension; Rotation; Lateral flexion G1: 12° (9° to 15°); 12° (9° to 15°); 18° (15° to 21°) G2: 8° (5° to 11°); 7° (3° to 10°); 15° (12° to 18°) G3: 6° (3° to 9°); 1° (-3° to 4°); 12° (9° to 15°)	G1 showed significantly greater gains in all ROM measures, but G2 only in rotation versus G3.

ROM: range of motion.

Neck strength

Within the first couple of months after the start of regular strength training, strength increases mainly because of neural adaptation.[46, 47] Response to exercise is greater in weak muscles and less in trained muscles.[55, 56] However, Jordan *et al.*[28] found only minor strength gains in response to training intervention due to low training intensity[28, 34, 35, 37-41] (Table II). Several studies have named the intervention "intensive training" or "strength training" to differentiate it from other therapies. However, if no strength gains >10% are observed with repeated testing, then these studies should be classified as low intensity training methods in a systematic review analysis.[22] The problem, however, is that the results of strength tests are not given in most studies. Increases in neck strength took place following short-term neck muscle training in studies by Bronfort *et al.*[34] and Chiu *et al.*[21] and after long-term neck strength and endurance training in a study by Ylinen *et al.*[37] Even a relatively low load, such as weight of the head, was shown to produce significant strength gains.[37] This suggests that, in everyday life, the gravitational load and acceleratory movements imposed by the head on these muscles are modest. Exercise intensity was shown to be important in reducting neck pain and disability. If training frequency is low, the results remain unsatisfactory even in long-term training. Nikander *et al.*[57] showed that although several subjects benefited from training performed 2 times a week, practically all subjects performing high intensity strength training 3 times a week showed reduced neck pain and disability. What can be recommended is that if low intensity training a few times a week does not produce results, training should be intensified and resistance training should be performed 3 times a week.

Neck range of motion

Most studies have not shown any significant increase in neck range of motion, which may be related to low training load or short training period.[26, 28, 30, 36] Bronfort *et al.*[34] found that the group receiving cervical manipulation combined with neck exercise had greater gains in range of motion compared to passive manipulation alone (Table III). Even greater strength gains were observed with long-term strength training alone by Ylinen *et al.*[37]

Methodological issues

The quality of randomized clinical studies of physiotherapy has been criticized in several reviews; accordingly, recommendations have been made to improve the methodology of future studies. However, even the reviews suffer from limitations. When rating studies according to the Jadad, Oxman, PEDro or van Tulder criteria, major methodological issues have been addressed.[11-13] But there are a number of other equally important factors. Staunch adherence to certain criteria may bias what is expected from a high quality training study.

Minor neck pain

Some studies have evaluated the effectiveness of neck muscle exercises in patients with minor pain, *i.e.* pain ≤3 on the visual analog scale.[28, 29, 31] This gives rise to the question of ceiling effect. When the initial pain level is low, the amount of treatment effect will inevitably be small as well. So it may become difficult to show a statistically significant change in the treatment *versus* the control group, even when the treatment is effective. The second issue is that subjects with minor neck pain often do not seek help from their health care system; if they do, their symptoms can be easily treated with advice and recommendations for exercises. This population differs from that of patients with severe neck pain, which places a considerable financial burden not only on medical services but on society at large in terms sick leave and disability pensions, to name just two.[9, 10] Rehabilitation research therefore needs to be targeted at the right patient population.

Spontaneous recovery

Chronic neck pain has been considered to be more persistent compared than back pain.[58] However, the level of neck pain can vary greatly also in subjects with chronic neck pain.[59] If patients are entered into a study only on the basis of severe current neck pain, many may experience spontaneous relief from their symptoms over the course of the study, as has been observed in the considerable changes control groups were noted to have in several randomized studies.[29, 30, 36, 40] This places importance on the methodology of patient selection.

Exercise description

Description of training method, *i.e.* the name of an exercise or its proper description if not a commonly used one, as well as repetitions, series, load and frequency are essential to be able to understand the intensity of training. These parameters are as essential as knowing the name and dose of the study compound in drug evaluations. No journal would publish studies without these data. In several randomized studies evaluating exercises for treating neck pain, however, this basic information is partly missing.[27, 28, 30, 34, 36] While primary intervention exercises are described, proper explanation of the home training program is commonly omitted. Different training methods should be analyzed separately, as done in comparing different drugs. Lack of information about the study objective makes adequate meta-analysis, where this is based entirely on information derived from the publications included, practically impossible.[13]

Combined treatments

A researcher who uses combined treatments runs additional risk. If several treatments are effective, the net result is not necessarily additive or multiplicative. In the studies by Jordan *et al.*[28] and Bronfort *et al.*,[34] manipulation and supervised exercise were combined with home exercises. It seems that the researchers underestimated the value of the latter and so paid them scant attention, focusing on manipulation and supervised exercise therapy instead. However, even home exercises alone may well explain the similar outcome of a 50% reduction in pain across all groups.[37] Where there is no group without home training, differentiating the effects of therapy interventions is impossible.

Adjunct therapies

Hemmila[59] reported that 70% of the patients in one treatment group and all the patients in the other treatment group had had other therapies up to the 12-month follow-up after the 5-week treatment period. This raises the question: what do exercise studies claiming to report long-term follow-up results of the intervention—but fail to report possible contaminating therapies—actually report? It is unclear to what extent the results are due to the effects of exercise and to what extent they are due to the effect of treatment received between the intervention and the follow-up.[28-31, 34, 36, 40]

Pain relieving mechanisms of neck muscle exercises

There are several possible mechanisms by which it is possible to decrease pain and to increase load tolerance through active training. Patients with chronic neck pain may suffer from sensorimotor impairment, like those with chronic low back pain.[60, 61] When proprioception is impaired, the timing of the eccentric contraction of the neck muscles is delayed and, because neck stability in performing activities is insufficient, this is thought to lead to excessive strain and microtrauma. Special exercises may improve neuromuscular function and restore sensorimotor control of the normal movement patterns of the neck.

Resistance training has been hypothesized to lead to increased sensitivity of the muscle spindles, Golgi tendon organs, and proprioceptors of joints.[62] According to the gate control theory of segmental pain, stimulation of these mechanoreceptors around the joints due to training induces increased afferent nerve activity, which, in turn, may inhibit the activity of the small diameter pain nerves.[63] Pain inhibitory mechanisms are not limited to dorsal horns but occur supraspinally. Pain perception is affected by the descending pathways from the central nervous system, especially from the midbrain thalamus, basal ganglia and periaqueductal grey region.[64] The prefrontal and posterior parietal cortex are important areas for the modulation of pain perception.[65] Recent neurological evidence has revealed that the adult brain is capable of substantial plastic change in the primary somatosensory cortex. Cortical plasticity related to chronic pain can be modified by behavioral interventions that provide feedback to brain areas that have been altered by somatosensory pain memories.[66] Training often includes cognitive therapy that may show the patient that loading the affected structures not only causes no harm, but actually improves their function, which may have been restricted due to the pain.

Strong muscle contractions activate muscle stretch receptors. The afferents from the receptors cause the release of endogenous opioids and stimulate the release of endorphin from the pituitary.[67] The increase in endorphin levels that occurs after training is thought to reduce both peripheral and central pain and form a part of the central desensitization process. High intensity exercise has been shown to produce statistically significant increases in both plasma b-endorphin and serum cortisol. However, a low-volume resistive exercise protocol did not alter their concentration, although elevated lactate concentrations were observed.[68, 69]

In patients with chronic neck pain, histopathologic investigations have detected atrophic muscle fibers, mitochondrial damage and a decreased concentration of adenosine diphosphate, triphosphate and Na^+-K^+-pumps in trapezius muscle cells, which may be relevant in the development of muscular fatigue and pain.[70-74] Patients with chronic neck pain have been found to have significantly lower trapezius muscle blood flow at low contraction intensities on the more painful than the less painful side.[73, 75] Both endurance and strength training increase Na^+-K^+-pump concentration and increase the number of capillaries in the trapezius muscles.[76, 77] Myonuclear numbers decrease and protein turnover becomes negative, *i.e.* catabolic, due to decreased loading or immobility. This can result from either decreased synthesis or increased degradation or both.[78] Deterioration may occur in protein turnover also in isolated muscles in otherwise healthy subjects should they use these specific muscles at low intensities, but also if they overload them. Resistance training aims to improve metabolism and to induce an anabolic response in muscles, resulting in increased protein synthesis.

In women, resistance exercises cause transient hormonal changes of only a small increase in testosterone, but a greater increase in growth hormone levels and insulin-like growth factor, which are important in the regulation of muscle hypertrophy.[79, 80] Pain may be relieved due to modification in the environment of peripheral nociceptors following increased metabolism, healing and strengthening of the tissues in which the pain receptors lie. A sufficient stimulus for muscles, such as that obtained from resistance training, is needed to switch from catabolic to anabolic metabolism, and it has to be repeated at regular intervals to maintain this change.

It remains controversial which neck exercise-related mechanisms are the most important in reducing pain and hyperalgesia in neck muscles. The relevance of different factors may vary individually and, presumably, several factors may act in concert.

Conclusions

Specific moderate and high-intensity neck muscle training can reduce neck pain. A decrease in neck pain is associated with reduced pressure pain sensitivity in neck muscles. Intensive regular training will increase neck muscle strength and range of motion, leading to improved function and less disability in patients with chronic neck pain. Training for a few months is commonly recommended, but it has been shown to produce only transitory improvements. Long-term progressive resistance training for neck and shoulder muscles is therefore recommended. Moreover, effective training can be performed at home with low-cost training equipment.

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