Clinical Use of Neck Isometric Strength Measurement in Rehabilitation

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• The purpose of this study was to evaluate for diagnostic purposes the isometric strength of the neck flexor and extensor muscles in 56 patients with neck and shoulder pain and to quantify the effect of a specific rehabilitation program. An isometric measurement protocol was performed at the beginning and at the end of a 3-week rehabilitation program that included physiotherapy, stretching, aerobic exercises, and circuit training to improve arm, shoulder, and neck muscle strength. In the beginning, mean neck flexor muscle isometric strength was 83N (±48 SD) and extensor muscle strength 158N (±76 SD), whereas after rehabilitation the strength measurements were 117N (±43 SD) and 207N (±84 SD) respectively. There was a significant increase in the ability to push forward and backward, which correlated with the lessening of neck pain and disability found at the end of the program ($p < .05$). Isometric strength measurement is a useful and practical method of objectively showing a functional improvement in response to rehabilitation.

Stiff neck and arm pain is reported to occur in 80% of male industrial and forestry workers.[1] In fact, neck pain is an even more common complaint than back pain. Mild neck pain is experienced by nearly everyone at some time in their lives. It is also often accompanied by headache and arm pain. Painful conditions appear in most cases as a result of excessive mental or physical stress. The symptoms usually subside quickly with only a few individuals actually consulting a doctor. In one study,[2] 70% of patients who visited doctors because of neck pain were reported to be well or better within 1 month with or without treatment. There remain many people who frequently develop a recurring or even chronic condition. In the Mini-Finland Health Survey a nationally representative sample of 8,0 persons aged 30 years and over took part in a health survey (participation more than 90%). The results showed that the prevalence of chronic pain in the neck was 15% for women and 6% for men.[3]

Despite its high incidence, neck pain is poorly understood. Traditionally, attention has focused on x-ray findings that, however, do not correlate with the symptoms. Neck muscle functioning is usually accepted as satisfactory, if the gross movements of the neck are normal. Clinically, the actual functioning of the neck muscles is not generally studied. Only a few studies have focused on the strength of neck muscles in patients with neck pain. Silverman et al,[4] using a hand-held dynamometer for testing, reported a significant weakness in the anterior neck flexors among individuals with cervical pain.

Grieger-Morris et al[5] reported that people with frequently occurring neck pain maintain a head forward-leaning posture in which the shoulders are held abnormally forward. Clinical findings also show that a poor forward-leaning posture is associated with weak neck flexor muscles.

The purpose of this study was to verify imbalances in the neck muscles and to evaluate whether improvement could be achieved with a 3-week rehabilitation program. Good results have been obtained from strength exercises and increasing difficulty in treating long-standing back pain conditions. However, with neck pain it has been suspected that intensive exercises produce increased muscle tension and may worsen symptoms. In planning the rehabilitation program special attention was given to strength training.

MATERIALS AND METHODS

The subjects were 56 patients referred for rehabilitation because of persistent neck pain. They were enrolled at the rehabilitation center for 3 weeks of intensive full-day training. The rehabilitation program was paid for by the state health insurance program because the patients' neck problems had interfered with their ability to work or have a normal lifestyle. The sample included 41 women and 15 men of working age (range 29 to 54 years; $\bar{x}$ = 45 years for both sexes with ±5.9 SD for the women and ±7.5 SD for the men). Forty-three patients had been on sick leave because of neck pain in the previous 12 months. Periods of sick leave varied from 1 day to 5 months ($\bar{x}$ = 48 days). Periods of 1 to 2 weeks of inactivity at a time were common. Only two patients were on sick leave from work because of neck pain at the time of admission to the program and two patients were unemployed. Patients' occupations ranged from white collar work to extremely strenuous work such as logging and industrial cleaning (table 1).

The subjects were clinically examined and x-rays were taken where the diagnosis was unclear or where x-rays had not previously been made. The diagnoses were cervical spondyloarthrosis (30 patients) and neck tension (26). Associated diagnoses were tendinitis of the supraspinatus muscle

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Table 1: Patients' Occupation

	Women	Men	Total
Occupation			
Office work	7	1	8
Sedentary industrial work	1		1
Light standing work	11	2	13
Medium industrial work	14	4	18
Heavy industrial work or farming	6	3	9
Extremely heavy work	2	5	7
Total	41	15	56

(6) and thoracic outlet syndrome (4). Patients could seldom give the exact date when they had begun to feel neck pain. It had commonly started several years earlier and had become increasingly bothersome in the last 1 to 2 years. Cervical pain and stiffness was often associated with headache, shoulder, and arm pain. Numbness in the upper extremities was a common symptom, but actual entrapments were not diagnosed. Neck pain was thought to be caused by either muscle spasm or myofascial pain or as a result of a tense scalene muscle that induces compression of the brachial plexus (thoracic outlet syndrome).

Before and after the rehabilitation program, the patients completed a form to measure pain according to the visual analogy scale (VAS) from 0 to 10cm and the Oswestry index (0 to 100) to see how their neck pain and associated symptoms affected their everyday lives compared with the life of a healthy person. Oswestrys questionnaire was used because it reproduces well and, because it is not related to the symptoms of any specific body part, it allows different painful conditions and disabilities to be compared.[6-8]

After the physical examination and isometric strength tests of the neck muscles were completed, individual physiotherapy programs were planned for all patients. Programs included various combinations of massage, stretching, cold packs, hot packs, ultrasound, electrotherapy, acupuncture, articulation, manipulation, and traction depending on the patient's condition and experience concerning pain relief and tolerance to the various methods.

All patients were started on an aerobic exercise program with stretching exercises to improve general fitness. The program varyingly consisted of fast walking for 30 minutes two to three times a week, light jogging on soft ground, bicycle ergometer exercise, or step aerobics. Lectures were given on ergonomics, correct posture, and basics of exercise. Stabilizing neck exercises were performed twice a week in various working conditions according to the patients' occupations.

Circuit training was done three times a week in the gym using equipment chosen to suit the exercise therapy. Arms, shoulders, trunks, and legs were trained by dynamic exercises. However, the training program was specially designed to improve neck muscle strength. Neck muscles are classified as postural muscles and they continuously work isometrically to stabilize the position of the head during bodily movement. Consequently the exercises were mainly isometric, eg, pulling an elastic bandage or weight. The weakest subjects had to first exercise by slowly lifting their head upward about 5cm and then maintaining this position for a few seconds while lying first supine and then prone on a training bench. They thus performed exercises that were partly dynamic to be able to continue doing the exercises for a longer period.

In the prone position, patients had a soft-weighted bag attached to the back of their head. They lifted then head about 20° upward, and then lowered the head to about 20° below horizontal level.

The pulling exercises on the neck machine were also partly dynamic as the head and neck always move slightly during performance (fig 1). A weight allowing 15 to 20 repetitions was normally used. However, weaker patients did a shorter series, with 5 to 10 repetitions, with the lowest weight, 2.5kg. Elastic bandages were used for training, especially when the home training program was introduced. Bandages with different elasticity were used to allow the body about 10cm movement during exercise (fig 2). Resistance increases progressively with pulling and, in the case of muscular insufficiency, any tendency for the upper cervical area to bend backwards should be prohibited, while exercising the flexor muscles of the neck. The tendency for the midcervical area to become kyphotic with bigger loads or as the muscles become tired should be monitored and the therapist should intervene and immediately correct faulty postures, while exercising the extensor muscles of the neck. Similarly, in the weight training, 15 to 20 repetitions and three series were usually performed. These neck exercises teach patients the correct posture and stabilization of the neck and head, not only in the relaxed normal standing position, but also during conditions of strain in excess of what they experience at work.

The isometric strength of the neck muscles was measured at the beginning of the training program. The testing device was a commercially available isometric system[a] comprising a strain gauge attached to a sturdy metal stand mounted on the wall. To ensure a similar position for the different measurements, the patients were harnessed securely at shoulder level. They were also supported above knee level to

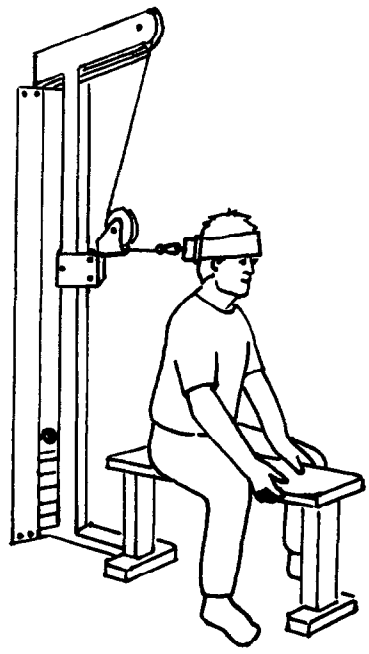

Fig 1—Exercising the flexor muscles of the neck. The patient pulls forward with the strap around the head while sitting on the training bench; the extensor muscles are exercised in the same manner with the patient sitting facing the machine.

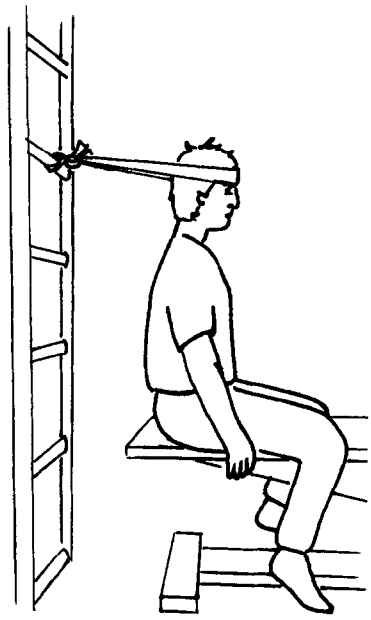

Fig 2—Exercising the flexor muscles of the neck using an elastic bandage. The patient pulls forward; extensor muscles are exercised by pulling the bandage backward by bending at the hip joints as the trunk and neck are held straight.

hinder movement of the trunk during intense pulling. The patient pulled the measurement gauge while in a standing position with the strap placed firmly around his/her head above the level of the eyebrows. The strain gauge was connected to a computer programmed to record the force curve (fig 3). Patients were instructed to hold their necks and trunks in a neutral position and then to perform three practice pulls to become familiar with the neutral position and to learn the way and direction they had to pull. Thereafter, they were encouraged to do three consecutive steady pulls as hard as they could, with 2 minutes rest between pulls. The best result was recorded. The test was repeated after 3 weeks. The VAS forms and the Oswestry questionnaire were completed once again. Statistical analyses of measurements and indices from questionnaires were performed using Student's test.

RESULTS

The mean Oswestry index was 21 (SEM 1.3) and the mean neck pain measured by VAS was 7.1cm (SEM 0.3) at the beginning of the rehabilitation program. Both the women and men had very weak cervical muscles, especially on the flexor side. A strength value below 50N means that these people cannot hold their heads up in a horizontal position for more than a few seconds. Most patients progressed from this lowest strength class after 3 weeks (tables 2,3).

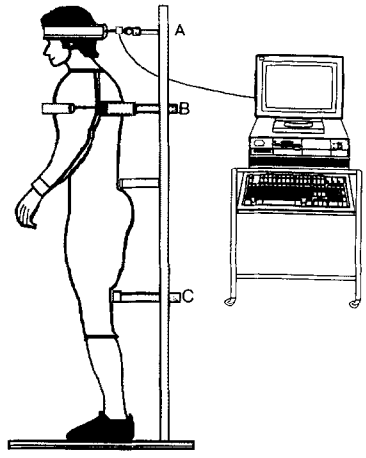

Fig 3—Hardware of the isometric strength measurement system. (A) Head strap with the force measurement device; (B) Upper back support (level of the lower end of the scapula); (C) Leg support (level of upper border of the patella).

Table 2: Cervical Flexor Muscle Strength Pretraining and Posttraining

Flexion Strength

	Women (n = 41)		Mean (n = 15)		Total (n = 56)	
F	Pre	Post	Pre	Post	Pre	Post
0-50	11	2	2		13	2
50-100	25	22	3	1	28	23
100-150	5	15	6	6	11	21
150-200		1	3	6	3	7
200-250		1	1	2	1	3

Mean maximal neck flexor muscle isometric strength was 83N (SEM 6.4) and mean extensor muscle strength was 158N (SEM 10.2). After the training period, flexor muscle strength was 117N (SEM 5.8) and extensor muscle strength was 207N (SEM 11.2). There was nearly twice as much power in the cervical extensor muscles compared with the flexor side, and this difference remained after rehabilitation (fig 4). A significant increase in both flexor and extensor muscle strength was observed ($p < .05$). The increase in strength was similarly attained by both the women and men, although the latter showed a significant difference in the amount of force measured (figs 5,6). The Oswestry index declined significantly ($p < .05$) to 14 (SEM 1.3) by the end of rehabilitation program and pain also declined significantly with a reduction in VAS values to 2.7cm (SEM 0.4). (figs 7,8). Both the Oswestry index and VAS were slightly higher for the men at the beginning and end of the rehabilitation program. At the start the Oswestry index was 22 (SEM 3.0) for the men compared with 20 (SEM 1.5) for the women and VAS was 7.7 (SEM 0.6) for the men and 7.0 (SEM 0.4) for the women. The differences in the results between the sexes were not significant. At the end of the rehabilitation program the Oswestry results were 16 (SEM 2.6) and 13 (SEM 1.5) and VAS were 4.1 (SEM 0.8) and 2.2 (SEM 0.4) for the men and the women respectively. The difference between the Oswestry indexes increased, but it was still not statistically significant. However, pain decreased more for women, and men had significantly higher VAS at the end of the rehabilitation period ($p < .05$).

DISCUSSION

A significant improvement in the isometric strength of the cervical extensor muscles after 8 weeks of clinical training using a cervical extension machine was reported by Highland et al.[9] A significant reduction in pain and increase in motion were observed. The results of the strength measurements in their study cannot be directly compared with our results because their results were expressed in Nm and the lever arm was not stated. However, the increase in strength seems to be somewhat less than in our rehabilitation group, although the training period was much longer. This may be caused by differences in patient groups and/or rehabilitation

Table 3: Cervical Extensory Muscle Strength Pretraining and Posttraining

Extension strength	Women (n = 41)		Mean (n = 15)		Total (n = 56)	
F	Pre	Post	Pre	Post	Pre	Post
0-50	2		1	1	3	1
50-100	7	4	2	2	9	6
100-150	15	9	3	1	18	10
150-200	11	10	1	1	12	11
200-250	6	11	2	1	8	12
250-300		6	2	2	2	8
300-350		1	2	3	2	4
>350			2	4	2	4

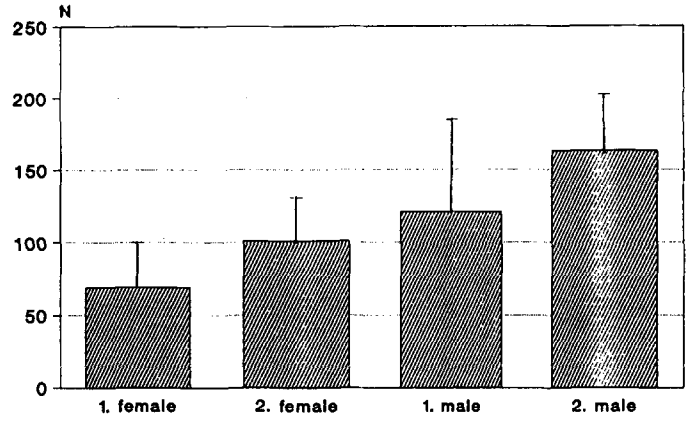

Fig 5—Mean flexor isometric muscle strength with standard deviations separately for women and men measured before and after the 3-week training period. (1, prerehabilitation; 2, postrehabilitation).

programs; the training methods were different and we ran an inpatient rehabilitation program that included physiotherapy. Our results indicate that there is weakness in the neck muscles, especially on the flexor side, in patients with chronic neck pain. Gogia et al[10] reported a significantly lower muscle torque in both anterior and posterior neck muscles in patients with osteoarthritis of the cervical spine when compared with normal subjects.

The high VAS at the beginning of the rehabilitation program showed that the patients had severe neck pain. The Oswestry index was also high. Although it is common to see higher figures associated with back pain, neck pain can also be disabling. The increase in isometric strength seemed to be related to the amelioration of neck pain and disability as measured at the end of the program. After the rehabilitation program there was a clear difference in the results between men and women. Perhaps men did heavier work and had more severe problems or they sought help for neck problems only in the more severe cases. The difference in the results between the sexes may also be explained by error because of the small sample of men, indicating a need for further research.

There was a significant improvement in cervical strength. The rehabilitation program lasted only 3 weeks and, as is well known from training physiology, increased output in tests cannot be caused by muscular hypertrophy. The increased strength is presumed to be caused by general exercise and physiotherapy, both of which were included in the rehabilitation program. The rehabilitation programs commonly used emphasize individuals' own activity together with intensive physical training. Earlier training methods have concentrated mainly on the trunk and extremities, therefore any significant increase in the strength of the neck muscles in measurements after rehabilitation could not have been observed. Pure physiotherapy and the training of the arms and shoulders does not seem to improve neck muscle force or increase tolerance to push against resistance. Thus, nonspecific training does not increase neck tolerance to physical exertion. On the contrary, intense training may cause isometric contraction in nonspecific muscles, irritation to tissues and stiffening of muscles that may even lead to termination of training. However, physiotherapy usually relieves pain, when a person is at rest, at least temporarily, and relaxes the muscles, which is necessary to avoid worsened symptoms. We believe that physiotherapy is an essential part of

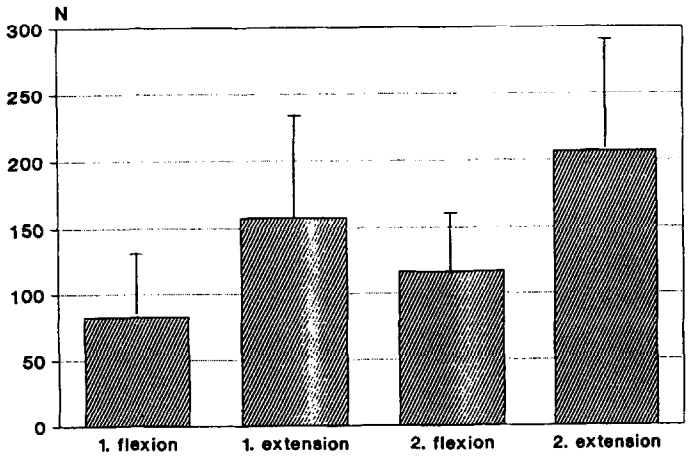

Fig 4—Mean flexor and extensor isometric muscle strength with standard deviations measured before and after the 3-week training period. (1, prerehabilitation; 2, postrehabilitation).

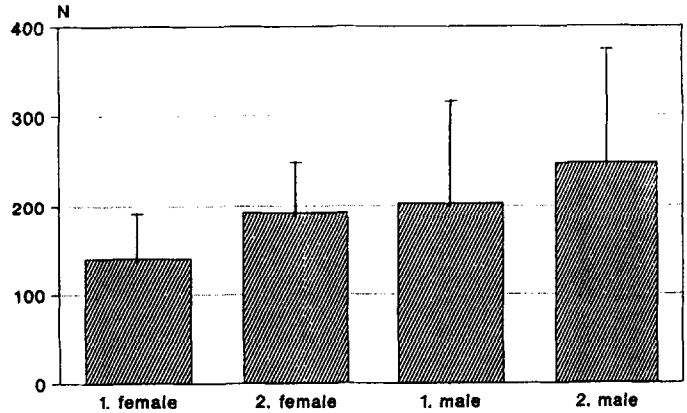

Fig 6—Mean extensor isometric muscle strength with standard deviations separately for women and men measured before and after the 3-week training period. (1, prerehabilitation; 2, postrehabilitation).

any rehabilitation program for patients with severe neck pain. Aerobic exercises aid general relaxation and may also help to speed the recovery process, because they help to increase circulation. However, it appears that the improved strength in the neck resulted from the specific neck exercises, added to an existing neck rehabilitation program. Control of neck muscles and an increased pain threshold—not only at rest, but also during maximal strain—are major factors contributing to increased cervical muscle strength.

Isometric tests seem to be a safe mechanism with which to measure patients' maximal strength. It is important to exclude patients with unsuitable conditions such as cervical disc prolapse. Some patients reported minor soft tissue discomfort after tests. No serious complications were noted. The risk of complications may be considerable where experience with the correct testing technique is lacking. Patients should maintain a good posture throughout the test to avoid neck sprain or disc prolapse. Testing personnel should be aware of these problems. There have been several unpublished reports of patients fainting during isometric neck strength tests. This may happen if the patient holds his/her breath during intense pulling. Because of the Valsalva effect there may be a sudden drop in blood pressure when the effort is stopped. To avoid the Valsalva effect, patients were instructed to breath out slowly and steadily during the push/pull effort.

CONCLUSIONS

It is essential to examine the functioning of the cervical muscles in planning an effective rehabilitation program for patients suffering chronic neck pain. In this study, training that focused directly on the cervical muscles significantly improved the isometric strength of both flexor and extensor muscles. Isometric neck strength measurement is a valuable, safe method for diagnosing muscle inadequacy and monitoring rehabilitation progress of a patient.

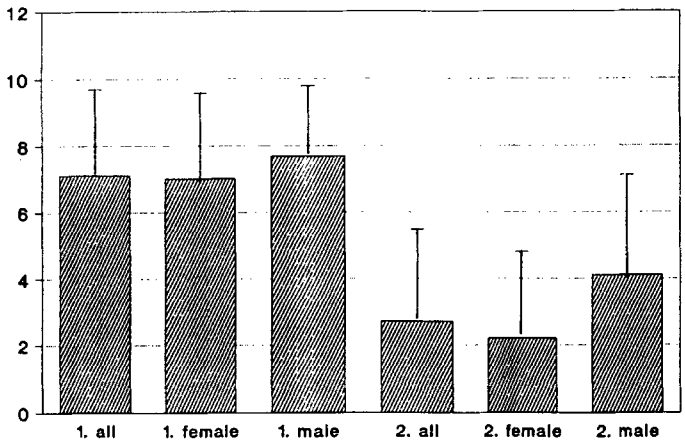

Fig 7—Pain measured in VAS before and after the 3-week training period. Means and standard deviations are shown. (1, prerehabilitation; 2, postrehabilitation).

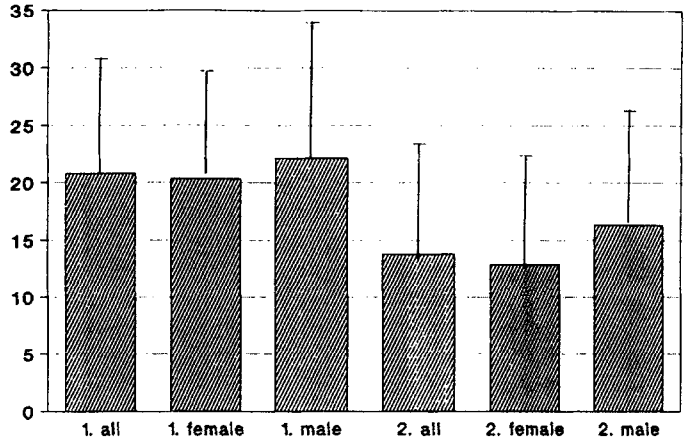

Fig 8—Disability measured by Oswestry index before and after the 3-week training period. Means and standard deviations are shown. (1, prerehabilitation; 2, postrehabilitation).

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Supplier

a. Isometric strain gauge system, Newtest Incorporated, Kiviharjuntie 11, 90220 Oulu, Finland.