Neck Muscle Endurance, Self-Report, and Range of Motion Data From Subjects With Treated and Untreated Neck Pain

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Abstract

Background: Despite the high prevalence and cost of neck-pain problems, there is currently little data available on the physical characteristics associated with different levels of neck pain.

Objective: To investigate associations between categories of response to neck pain/discomfort and (1) the endurance time of neck muscles, neck range of motion (ROM), and neck and head morphology, (2) sensitization or stretch effects arising from repeating end-of-range measurements, and (3) self-report data from neck pain and disability questionnaires.

Design: A cross-sectional study design.

Methods: Fifty-five Australian volunteers with and without neck pain, who were not taking time off work, were measured for neck muscle endurance, active neck ROM, craniocervical and thoracic posture, neck length, and head circumference and completed questionnaires about any neck pain/discomfort and disability.

Results: Twenty-two subjects reported a level of neck pain/discomfort that had required treatment (treated neck pain), a group of 17 subjects reported experiencing low-level neck pain/discomfort on a recurrent basis for which they had not sought treatment (untreated neck pain), whereas 16 subjects had no experience of neck pain or discomfort (no pain). Neck muscle endurance time was significantly lower for both pain groups. The affective dimension of the Short-Form McGill Pain Questionnaire and neck disability questionnaires were scored significantly higher by subjects who had sought treatment than by those in either of the untreated groups. Both pain groups showed a range decrease for most directions of neck motion at second measurement.

Conclusions: Neck muscle endurance times, repeated end-ROM testing, the Short-Form McGill Pain Questionnaire, and disability questionnaires may distinguish between groups with untreated, treated, and no neck pain. (J Manipulative Physiol Ther 2005;28:25-32)

Key Indexing Terms: *Spine; Active Range of Motion; Articular; Neck Muscles; Physical Endurance; Neck Pain*

Neck pain is common in the general population, with 70% of individuals affected at some time in their lives[1] and 5% to 10% of adults having a disabling neck-pain problem.[1,2] Whiplash is the most common cause of neck injury after motor vehicle accident and is an important cause of chronic disability.[3] However, neck pain can arise from unspecified causes.[4] A recent population-based study suggested that in young adults, approximately one third wake up with neck pain or stiffness once per week.[5] The effects of chronic symptoms and the disability arising from neck-pain problems can have substantial economic consequences. For example, the costs related to chronic neck problems in the Netherlands in 1996 were estimated at US$868 million,[6] and more than US$29 billion per year is spent in the United States on treatment and compensation for whiplash injuries.[7]

Despite the prevalence and cost of neck problems, few studies are available that evaluate the physical characteristics that may be associated with neck pain. Research on the lower limbs of basketball players has found anthropometric measures to be better risk predictors of injury than flexibility,[8] but no information is currently available on pain and structural measures of the head and neck. Some authors have proposed applying categories related to the time course of development of neck-pain problems.[9,10] Grant et al[9] have suggested that there is a group of people who have neck symptoms but who are not yet receiving any treatment. This group is classified as having minor musculoskeletal or subclinical dysfunction. It has been suggested that early

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management of such cases may prevent progression to more serious neck problems.[9,10] This untreated-pain group is of particular interest with respect to the development and progress of pain, as they represent the category intermediate between individuals with no pain and those seeking treatment. For anatomically defined pain symptoms, Von Korff et al[11] have proposed that research is needed to determine the factors that differentiate treated and untreated individuals, where both have painful symptoms. This classification of subjects into treated and untreated groups has been used previously in studies of orofacial pain[12] and temporomandibular joint disorders.[13]

Several authors have postulated an association between measures of posture, range of motion (ROM), muscle strength, and the experience of neck pain and disability. Joint ROM is an important component of assessments of disability.[14] Dall'Alba et al[15] reported that cervical movements in the sagittal plane can be used to discriminate between asymptomatic people and patients with whiplash-associated chronic neck pain. Hanten et al[16] and Jordan et al[17] also found that chronic neck-pain patients had significantly less range in extension, protraction, and retraction than asymptomatic subjects, but it is not clear what relationship exists between neck mobility and different levels of neck pain.

McKenzie[18] and Haughie et al[19] have proposed that nonspecific neck pain results from poor posture, arising through the sustained, long-term, abnormal physiological loads that such postures impose on the neck,[20,21] with a consequent reduction in neck muscle strength.[22] Currently, associations between neck pain, neck posture, and neck muscle endurance have not been firmly established. Grimmer[23] did not find any relationship between extreme neck postures and reports of neck pain. Jull et al[24] showed that craniocervical angle did not change with treatment of cervicogenic headaches, thus change in symptoms was not accompanied by a change in posture. Other studies have also disagreed on the association between neck posture and the presence of neck pain.[16,25-27]

Muscle strength assessment is frequently used in clinical trials to evaluate treatment progress, and furthermore, muscle strength exercises are used as treatment for neck pain.[24,28-30] Weakness of neck muscles has been proposed to contribute to persistent neck pain.[22,31] However, there is conflicting evidence for the proposed causative relationship between neck pain and neck muscle strength. Grimmer and Trott [32] failed to show an association between deep short flexor endurance of the neck and neck pain in their population-based study, but Grant et al,[9] using a different measurement protocol, reported an association. Some authors have reported reduced neck muscle strength in neck-pain patients who sought treatment, compared with matched healthy controls.[17,33] It remains unclear whether lack of strength is a cause or a consequence of neck pain. A test of neck muscle endurance is needed to determine whether neck extensor muscle impairment can aid in distinguishing between groups with no pain, and untreated and treated neck pain. Such a test needs to be combined with other available measures to find which are the most clinically useful and to ascertain which are the most sensitive to early onset of neck pain/dysfunction.

The purpose of this study was to compare the endurance time of neck extensor muscles, self-reported pain and disability, neck ROM, and morphology of the neck and head in groups with no pain, and untreated and treated neck pain.

Methods

Subjects

Fifty-five volunteers were recruited by advertisements placed on notice boards in the Faculty of Health Sciences, University of Sydney, seeking participants both with and without neck pain. For inclusion in the study, all subjects were to be older than 18 years and to have no medical condition likely to affect mobility of the cervical spine (eg, ankylosing spondylitis). Neck-pain subjects were to have pain/discomfort with certain activities or postures but not to have taken time off from work. Subjects without neck pain were to have no experience of any neck, upper body, or spinal problems that had resulted in a restriction of normal activity or time off work. Volunteers were excluded from the study if they had current neck pain or had been under treatment for neck pain within the previous 6 months. Approval for the study was obtained from the Human Ethics Committee of the University of Sydney, and each subject gave informed consent before testing. Twenty men and 35 women with an age range of 19 to 72 (mean age: men, 42; women, 38) years volunteered.

Procedure

Anthropometrics and neck ROM measures were taken, followed by an interview to gather demographic data and any history of neck pain and any treatment. Next, a second application of all ROM tests was carried out to elicit any sensitization or stretch effects arising from repeating end-of-range measurements. After this, a neck muscle endurance test was performed, and lastly, pain and disability data were collected using the Short-Form McGill Pain Questionnaire (SFMPQ),[34] the Neck Pain and Disability Questionnaire (NPDQ),[35] and the Functional Rating Index (FRI).[36] These instruments were administered to subjects regardless of whether they experienced any neck pain.

The Cervical Range of Movement device (CROM) (Performance Attainment Associates, St Paul, Minn), the Dualer digital inclinometer (Jtech American Fork, Utah), and a tape measure were used for tests of (1) active cervical ROM, (2) spinal posture, and (3) segment length of the neck and head circumference, respectively.

Cervical flexion, extension, rotation, and lateral flexion ranges of motion were measured with the CROM device, as described by Youdas et al.[37] For the measurement of

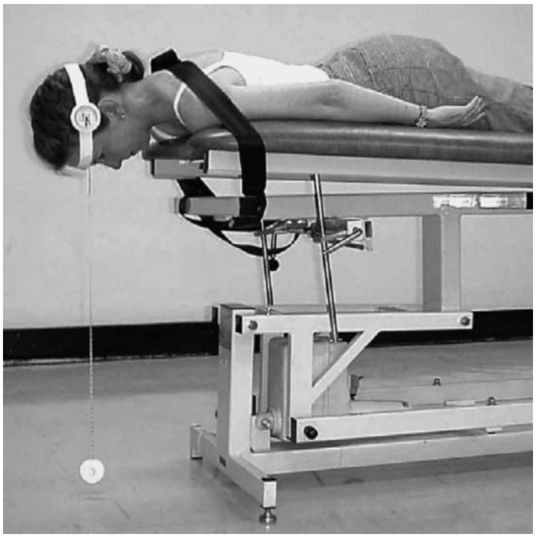

Fig 1. *Neck muscle endurance test. A Myrin goniometer and a pendulum from the subject's head are used to monitor the head position during the test.*

protraction and retraction, the vertebra locator and the forward head arm of the CROM device were used. The starting position was neutral sitting with the sagittal inclinometer of the CROM set at zero to standardize the head position. The bottom tip of the vertebra locator was placed on the subject's C7 spinous process and positioned vertically by adjusting the spirit level on top of the locator. The forward head arm, marked in half centimeters along the horizontal distance, was maintained horizontally during the test by adjusting the subject's head to keep the sagittal inclinometer at zero. The vertebra locator and forward head arm are intersected at a right angle to allow a measure of protraction or retraction in centimeters to be taken. Then, the subject was asked to move his head horizontally backward or forward as far as possible from the starting position, for retraction and protraction, respectively.

Thoracic kyphosis was measured using the Dualer digital inclinometer, during both comfortable standing and sitting. Locating marks were made on the skin at the T12 and T1 spinous processes, employing the protocol described by Maitland.[38] With the subject standing comfortably, the Dualer inclinometer was placed at the T12 spinous process and the sensor set to zero, then repositioned at the T1 spinous process, with the resulting measure determining degree of thoracic kyphosis. The Garrett et al[39] protocol was used to measure craniocervical posture using the CROM device.

With a tape measure, posterior neck length was measured from the external prominence of occipital protuberance to the C7 spinous process, and anterior neck length was measured from the outermost tip of the mandible to the sternal notch.[40] Head circumference was measured around the cranium horizontally at the level of the point between eyebrows.[40]

The neck extensor endurance test used was based on the low-back extensor test described by Biering-Sorensen[41] and the neck extensor endurance test.[43] Subjects were asked to lie prone on a plinth, with their head and neck initially supported over the end and arms alongside their trunk. To counter-support the upper thoracic spine, a strap was placed across the T2 level. A Velcro strap was fixed around the skull, level with the top of the ears. A Myrin goniometer (LIC rehab vardrum, Solna, Sweden) was placed on the Velcro strap immediately above the superiormost tip of the left ear and was used as gravity inclinometer in the sagittal plane. An extendable tape measure was attached to the Velcro strap at the point between subject's eyebrows, with the case hanging just short of the floor, pendulum fashion. Endurance was measured by removing the support, then requiring the subject to hold the head steady in a position with the chin retracted and the cervical spine horizontal (Fig 1). For the neck extensor endurance test, the discontinuation criteria of the low back Biering-Sorensen test[41] were adapted, so the test was discontinued if the subject terminated it because of fatigue or pain, or if they could not hold their head horizontal any longer, such that the suspended tape measure case touched the floor for longer than 5 seconds or on more than 5 occasions. The test was also terminated if the subject lost more than 5° of upper cervical spine retraction for more than 5 seconds, as measured with the Myrin goniometer. Holding time was recorded in seconds. Although 600 seconds was the target time given to all subjects for the test, if anyone could continue to hold for longer, they were encouraged to do so, and this was recorded as their holding time.

Analysis

Independent-samples *t* tests, with a type I error rate set at 0.05, were used to evaluate any differences between groups in terms of neck muscle endurance time, demographic data, and structural measurements. Pain and disability data were also compared between groups. On each neck ROM variable, groups by repeated-measures analyses of variance were conducted using 2 orthogonal between-groups contrasts, comparing groups with and without pain, then pain groups with and without treatment. Associations between the measured variables were examined using the Pearson correlation coefficient.

Results

All 55 subjects were placed into 1 of 3 categories based on their care-seeking behavior, with these categories being no pain, untreated neck pain, or treated pain. Twenty-two subjects reported a level of neck pain/discomfort which had required treatment (treated neck pain), a group of 17 subjects reported experiencing low-level neck pain/ discomfort on a recurrent basis which had not required

Table 1. *Demographic and anthropometric data with between-group test outcomes*

	No pain (n = 16), mean values (SD)	Pain/no pain test, *P* value	Untreated pain (n = 17), mean values (SD)	Treated pain (n = 22), mean values (SD)	Pain-type test, *P* value
Age (y)	40.5 (15.1)	.554	38.4 (15.3)	37.9 (12.1)	.920
Height (cm)	167.5 (11.4)	.631	168.1 (9.7)	164.5 (9.4)	.249
Weight (kg)	68.8 (16.0)	.989	70.8 (10.7)	67.20 (12.2)	.346
Head circumference (cm)	56.2 (2.6)	.486	56.4 (1.8)	55.4 (1.9)	.093
Posterior segment length of the neck (cm)	14.4 (1.1)	.551	14.1 (2.1)	14.1 (1.7)	.937
Anterior segment length of the neck (cm)	14.8 (1.4)	.397	14.8 (0.9)	14.2 (1.4)	.201

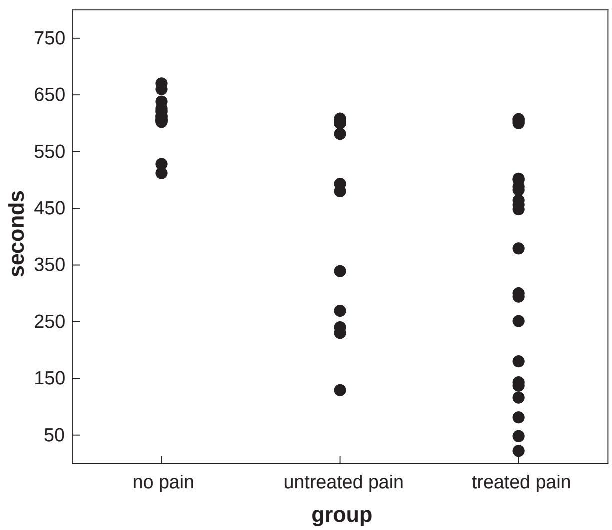

Fig 2. *Individual neck muscle endurance holding times.*

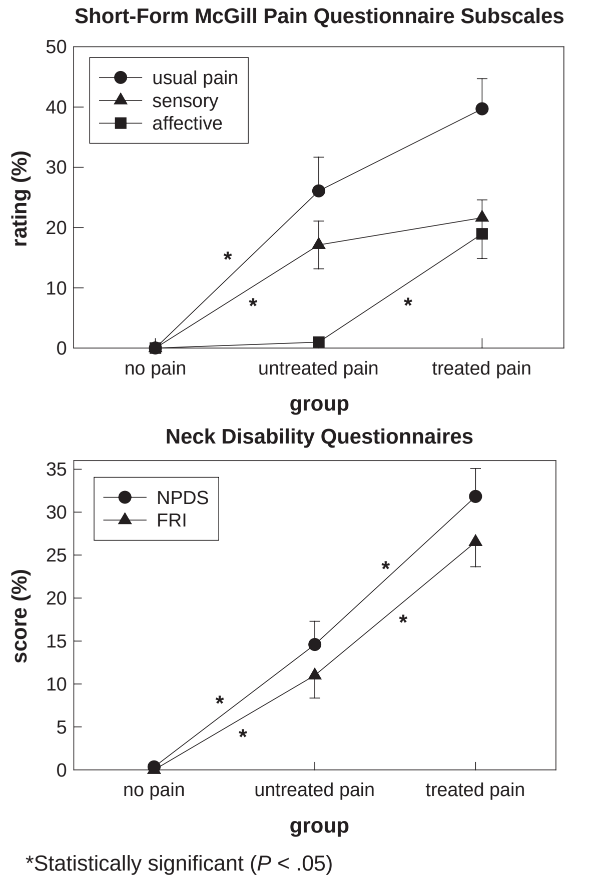

Fig 3. *Mean scores for the 3 groups on the SFMPQ subscales, the NPDQ and FRI.*

treatment (untreated neck pain), whereas a further 16 subjects reported no experience of neck pain or discomfort (no pain). The groups did not differ on any of the measured demographic and anthropometric variables. Mean values, SDs, and *P* values for the *t* tests are presented in Table 1.

All subjects were at least able to commence the neck muscle endurance test, but success at the test with a 10-minute goal varied between groups. Individual holding times are shown in Fig 2. Mean holding times were 350.4 seconds for the treated-pain group (SD, 199.3; 95% CI, 262.0-438.8), 480.8 seconds for the untreated-pain group (SD, 167.8; 95% CI, 394.5-567.1), and 608.3 seconds for subjects without pain (SD, 39.9; 95% CI, 587.0-629.6). Neck muscle endurance times were significantly lower in both treated and untreated neck-pain groups when compared with the no-pain group ($F_{1,52} = 25.87$, $P < .001$; $F_{1,52} = 8.76$, $P = .006$, respectively), and the treated-pain group's time was significantly less than the holding time achieved by untreated-pain subjects ($F_{1,52} = 4.70$, $P = .037$).

Summary self-report results from the SFMPQ, NPDQ, and FRI questionnaires are presented in Fig 3. When scoring the NPDQ, only 19 questions were used, as the last question regarding pain medication was not applicable for all subjects. For the NPDQ and FRI, untreated subjects scored higher than subjects with no pain ($F_{1,52} = 25.50$, $P < .001$; $F_{1,52} = 16.13$, $P < .001$), and those with treated pain scored significantly higher than those with untreated pain ($F_{1,52} = 15.29$, $P < .001$; $F_{1,52} = 14.84$, $P < .001$). With the SFMPQ,

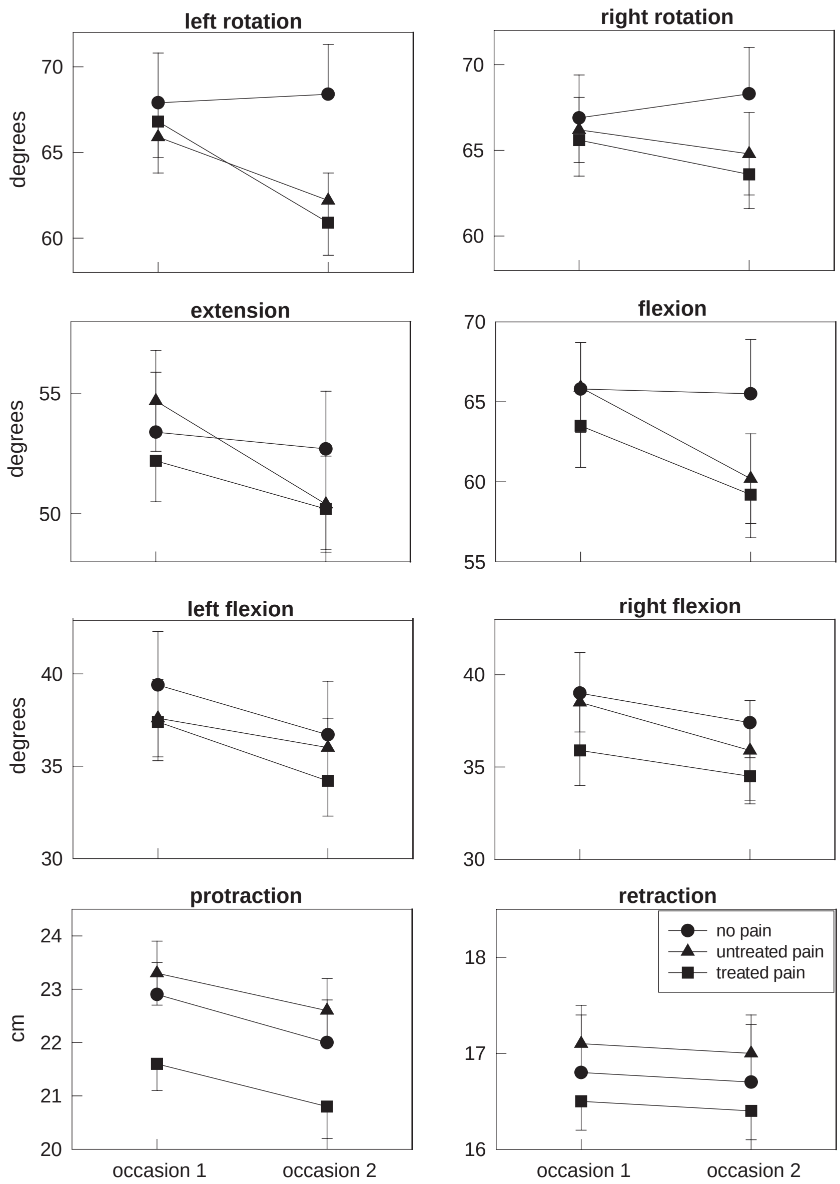

Fig 4. *Mean values and SE for cervical ROM tested on 2 occasions. The second end-of-range test can be considered to be a provocation test.*

the pattern was different. Usual pain was rated on a 100-mm Visual Analogue Scale. The sensory dimension subscale has 11 descriptors (throbbing, shooting, stabbing, sharp, cramping, gnawing, hot-burning, aching, heavy, tender, and splitting). The affective subscale has 4 descriptors (tiring-exhausting, sickening, fearful, and punishing-cruel). On the 'sensory' and 'usual pain' subscales, subjects with untreated or treated pain did not differ, but both pain groups rated significantly higher than the no-pain group ($F_{1,52}$ = 31.27, P < .001; $F_{1,52}$ = 27.39, P < .001). On the affective subscale, scores were greater for those with treated pain than those with untreated pain ($F_{1,52}$ = 14.70, P < .001), but subjects with untreated pain were not significantly different from those with no pain.

At the first set of ROM measures, only protraction range showed a significant difference between the treated-pain and untreated-pain groups ($F_{1,52}$ = 4.81, P = .035). At the second test, when the no-pain and neck-pain groups were compared (Fig 4), left rotation, right rotation, and extension showed a group-specific change, with ROM not changing for subjects with no pain but decreasing (sensitizing) for those with neck pain ($F_{1,52}$ = 16.04, P < .001; $F_{1,52}$ = 6.75, P = .022; and $F_{1,52}$ = 6.44, P = .014, respectively). This pattern was similar, although not significant, for flexion ($F_{1,52}$ = 2.55, P = .116). There were no significant differences between the 2 pain groups in the extent of sensitization on any measure. Side flexion movements to the left and right and protraction showed general sensitization

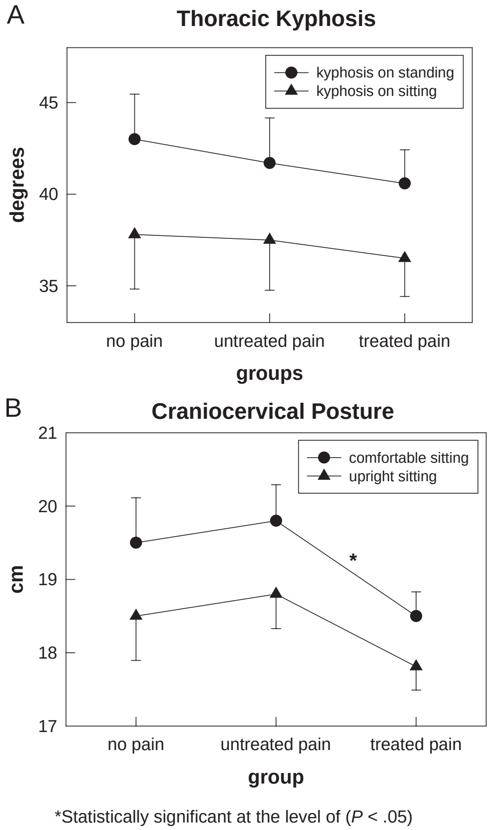

Fig 5. *A, Thoracic kyphosis angle measured by the Dualer digital inclinometer. There is no significant difference between groups on their comfortable standing and sitting spinal posture. B, Craniocervical posture measured in comfortable sitting and upright sitting using the CROM device. Greater values indicate a more forward head posture. The group with pain and treatment experience had a significantly more upright posture than the group with pain but no treatment experience.*

effects for all subjects at second measurement ($F_{1,52}$ = 16.32, $P < .001$; $F_{1,52}$ = 11.03, $P = .002$; and $F_{1,52}$ = 8.95, $P = .004$, respectively). Only retraction showed no between-group differences or effects of repeated testing.

With respect to posture measurements, thoracic kyphosis angle (Fig 5*A*) was significantly greater in standing than in sitting ($F_{1,52}$ = 39.07, $P < .001$), but there were no differences between groups. As expected, craniocervical posture (Fig 5*B*) was more retracted in upright sitting than in comfortable sitting ($F_{1,52}$ = 80.58, $P < .001$). On this measure, however, treated-pain subjects showed significantly more retraction than untreated neck-pain subjects in comfortable sitting ($F_{1,52}$ = 4.82, $P = .035$), although not in upright sitting ($F_{1,52}$ = 3.07, $P = .88$).

Correlations were evaluated between measures of physical structure and neck muscle endurance time (Table 2). By assuming the shape of human head to be spherical and its density 1.11 g/cm3, an approximation to the torque acting on the neck during the endurance test was obtained.[42] Calculated torque is greatest for the combination of large head and long neck, and less for a small head combined with a short neck. The relationship between torque and holding time was positive, indicating that it was subjects with greater torque at the neck who achieved longer holding times (r = 0.28, P = .04). Thus, a small but significant proportion of variance in holding time could be predicted from the size of the head and neck.

Discussion

People with neck pain who had never sought treatment and people with neck pain who had sought treatment but who had not taken time off work showed similar ROM measures. However, each group differed with respect to endurance time, pain, and their disability questionnaire responses.

Few studies have compared neck strength for symptomatic and asymptomatic subjects,[17-43] and the comparison has required the use of expensive equipment.[24,29] In the current study, a simple and inexpensive test was used, using a modified version of the Biering-Sorensen low-back extensor test,[41] and significantly lower endurance times were found for pain subjects. Most pain-free subjects achieved the allocated goal of 10 minutes, whereas most subjects with pain could not. Subjects in the untreated-pain group who could not reach the target time tended to cease the test because of muscle fatigue, whereas treated-pain group subjects tended to cease because of pain. Other researchers have reported similar results, ie, a significant reduction of neck muscle strength in neck-pain subjects.[17,33,44]

In their NPDQ and FRI responses, subjects with untreated neck pain were intermediate between the treated-pain and no-pain groups. On the SFMPQ, untreated-pain subjects scored similarly to those with treated pain on the sensory subscales (aching, throbbing, stabbing, shooting, etc) but on the affective scale rated their pain as no more frightening, punishing, or sickening than those without pain. This suggests that at the point when people come to interpret their neck pain as frightening, punishing, or sickening, they tend to seek treatment. Consistent with this, Leclerc et al [45] reported that a high level of psychological distress was associated in neck-pain subjects with either seeking treatment or visiting a health care professional. Likewise, Von Korff et al[11] found that patients with temporomandibular pain with high levels of psychological distress were more likely to seek health care.

Range of motion in both directions of rotation, and extension, showed a group-specific interaction effect, whereby they did not change at second measurement for subjects without pain but decreased for those with neck pain. Thus, the second ROM test can be considered a provocation test, in that it was only at second testing that between-groups differences emerged. Therefore, it seems that these directions of motion are ones that maximally stress painful cervical structures.

All second measurements were taken within a 10-minute period after the first. The experience of going to end of

Table 2. *Correlation between cervical muscle endurance time and cervical anthropometrics (N = 55)*

		Endurance time	Ant seg neck length	Post seg neck length	Head weight	Torque A	Torque P
Endurance time	Correlation	1.000	0.276*	0.261	0.168	0.263	0.280*
	Sig (2-tailed)		0.042	0.054	0.220	0.052	0.038
Ant seg neck length	Correlation		1.000	0.347*	0.348*	0.771*	0.445*
	Sig (2-tailed)			0.009	0.009	<0.001	0.001
Post seg neck length	Correlation			1.000	0.162	0.292*	0.783*
	Sig (2-tailed)				0.237	0.030	0.001
Head weight	Correlation				1.000	0.862*	0.737*
	Sig (2-tailed)					0.001	0.001
Torque A	Correlation					1.000	0.736*
	Sig (2-tailed)						0.001
Torque P	Correlation						1.000
	Sig (2-tailed)						

Torque A is obtained from head weight times anterior segment length of neck. Torque P is obtained from head weight times posterior segment length of neck. *Ant*, Anterior; *Post*, posterior; *Seg*, segment; *Sig*, significance.
* Statistically significant at the level of $P < .05$.

range twice within this time affected some of the measured values in all subjects. Both left and right side flexion and protraction ranges were significantly reduced on the second measurement regardless of group, thereby showing a general sensitization effect. It is possible that these movements place stress on pain-sensitive structures, and limiting range at second measurement may protect against such stress. There were no significant differences between the 2 pain groups in the extent of sensitization on any measure. Therefore, it seems that impairments of neck ROM may develop at the early stage of neck pain.

Of all the range measures, the one with the greatest apparent resilience was retraction. End-of-range tests of this movement were not altered by repeated measurement, nor were there any differences between groups. Furthermore, from the data, it may be suggested that in upright sitting, treated-pain subjects used a greater degree of retraction as an unloading technique. This may be antalgic, or because they had been taught to, because performing retraction is a common treatment technique.[18] The findings of the current study suggest that retraction is the only nonprovocative direction of neck movement.

Paradoxically, there was a small but significant positive relationship between the magnitude of the torque experienced at the neck in prone and endurance time. This can be interpreted as a use effect, whereby those with larger heads and longer necks may have developed greater neck muscle endurance capability as a consequence of daily activity. One implication of this finding is that resisted exercise may have a role in neck-pain rehabilitation.

Conclusion

In a comparison of groups with different levels of neck pain, differences observed were (1) lower neck muscle endurance time with pain groups, (2) higher score in the affective dimension of SFMPQ and both disability questionnaires for the group with treated pain, and (3) increased left and right rotations in the no-pain group but decreased in both pain groups at second measurement. These data suggested that neck muscle endurance, SFMPQ and neck disability questionnaires, and both ranges of rotation may be useful measurements to distinguish between groups with different levels of neck pain.

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