Reliability of Isometric Muscle Endurance Tests in Subjects With Postural Neck Pain

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Abstract

Objective: The purpose of this study was to determine the reliability of 3 isometric muscle endurance tests in subjects with postural neck pain.

Methods: Twenty-one subjects with chronic postural neck pain performed 3 submaximal muscle tests twice on the first occasion and once at the second session 3 days later. The tests examined isometric neck flexion, neck extension, and scapular muscle endurance.

Results: Reliability was excellent for the neck flexor test (intraclass correlation coefficient [ICC] = 0 93), moderate for the scapular test (ICC = 0.67), and good for the neck extensor test (ICC = 0 88). The standard error of measure for the tests was 6.4, 10.9, and 25.9 seconds, respectively. The minimum change required to represent real change in muscle endurance was 17.8 seconds for the neck flexor test, 30.1 seconds for the scapular test, and 71.3 seconds for the neck extensor test.

Conclusion: This study showed the reliability of 3 cervical spine and shoulder girdle submaximal muscle endurance tests in patients with postural neck pain. (J Manipulative Physiol Ther 2008;31:348-354)

Key Indexing Terms: *Neck Muscles; Isometric Contraction; Posture; Reliability*

Mechanical neck pain is commonly associated with impairments of the primary mechanical functions of the neck, specifically mobility, and postural loading.[1] Postural neck pain is usually associated with sustained static loading of the cervical spine and shoulder girdle during occupational or leisure activities.[2,3] A positive association between neck pain and occupational sitting postures has been described,[4,5] which suggests that factors that influence posture such as postural awareness and muscle function may be deficient in this patient group. Patients with postural neck pain have been found to have an altered perception of 'good' posture, but no deficit in cervico-thoracic kinesthesia, as compared with asymptomatic individuals.[6,7] Impairment of muscle strength or endurance has been shown in patients with neck pain, but not specifically in those with posture-related pain.[8-11] Preliminary evidence suggests that exercises to improve neck and shoulder girdle strength are effective in reducing pain and improving neck function in patients with posture-related neck pain.[12]

To evaluate muscle function in this patient group, it is important to develop clinical tests that are reliable, can be tolerated by the patient, and can be conducted in the clinic without complex instrumentation. Tests of maximal neck and shoulder girdle muscle strength have been described and tested for validity and reliability.[13-15] However, maximal strength tests have limited utility in a clinical population due to the potential for the results to be influenced by pain or fear of pain provocation.[16] Furthermore, maximal muscle strength may have limited relevance in relation to postural neck pain because levels of muscle activity during sitting tasks are typically low.[17]

Maintenance of neck posture is dependent on optimal levels of coactivation of ventral and dorsal neck muscles. It is suggested that these muscles form a 'sleeve' around the cervical spine to support the segments in functional postures

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Short description. Edmondston et al examined the reliability of 3 tests of neck and scapular muscle endurance in subjects with postural neck pain. Reliability coefficients show the tests have good to excellent reliability in this patient group. The levels of change that represent actual change in muscle endurance, in repeated measurements, have been established for each test.

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and movement tasks.[18] Loading of the cervical spine may also be influenced by axioscapula muscle function. Coordinated activation of the trapezius and serratus anterior muscles is important to optimize scapula position and load transfer from the upper limbs to the cervical spine. Changes in axioscapula muscle activity during low-load functional tasks have been shown in patients with chronic neck pain.[19] These findings suggest that the key muscle groups involved in the maintenance of neck posture are the cervical flexor and extensor groups and the muscles that control the position of the scapula.

Tests of neck muscle endurance have focused predominantly on the flexor muscles, and these tests have shown reliability in asymptomatic subjects and heterogeneous groups of patients with neck pain.[11,20,21] Neck flexor muscle performance has not been specifically examined in individuals with postural neck pain. Ljungquist et al[22] described a neck extensor endurance test but were unable to show acceptable reliability in patients with spinal pain. Neck extensor endurance has been shown to be lower in patients with neck pain compared with asymptomatic individuals. However, the subjects in the study were not classified as having posture-related pain, and the reliability of the endurance test was not reported.[9] More recently, a loaded neck extensor test has been used to show impairments of muscle endurance in patients with nonspecific neck pain.[23] Reliability coefficients for the test were reported but with no detail in relation to how these were derived.

It is evident that further development of clinical tests of neck and shoulder girdle muscle endurance is required to evaluate muscle function more specifically in patients with postural neck pain. The purpose of this study was to determine the reliability of 3 cervical spine and shoulder girdle submaximal muscle endurance tests in patients with postural neck pain. These tests were chosen as they evaluate the 3 key muscle groups that influence neck and shoulder girdle posture.

Methods

Subjects

Twenty-one subjects (14 women, 7 men) with postural neck pain (mean age = 36 years, SD = 11) completed the study. They were recruited through poster advertising and through a university physical therapy clinic. The symptom duration ranged from 6 to 192 months (mean = 81 months, SD = 67). The inclusion criteria were neck pain that was primarily aggravated by functional activities which required sustained postures and relieved by postural modification, no pain-related restriction of cervicothoracic mobility, symptom duration of greater than 3 months, and age between 20 and 65 years. Subjects were excluded if they had medical conditions affecting cervical mobility, arm pain, upper limb neurological symptoms, or were currently receiving physical treatment for neck pain. Subjects who identified shoulder pain on the body chart or had pain associated with any active movement of the shoulder were also excluded.

Fig 1. *Subject position for the neck flexor muscle endurance test. The examiners hand is positioned to detect changes in the subjects head position.*

All subjects signed an informed consent document after a detailed explanation of the study procedures. Information regarding the occupation and current work status was gathered. Subjects were asked to define the location of their pain using a body chart divided into regions.[24] Neck pain intensity was measured using a 10 cm Visual Analogue Scale (VAS). Patients were asked to record the average pain intensity associated with their pain provocative activity over the week before testing. Pain intensity was also recorded immediately before and after each testing occasion. Further information about the impact of the postural neck pain on physical and psychological function was measured using the Neck Pain and Disability Scale.[25] Approval for the study was obtained from the Human Research Ethics Committee of Curtin University of Technology, Western Australia.

Muscle Endurance Tests

The neck flexor endurance test was based on the test described by Harris et al[21] (Fig 1). The test was performed with the subject in crook-lying on a plinth. The subject's head was positioned in slight upper neck flexion by the examiner who placed their left hand on the table just below the occiput. The subject was asked to gently flex his or her upper neck and lift his or her head off the examiner's hand while retaining the upper neck flexion. Verbal feedback ("tuck your chin in" or "hold your head up") was given to the subject when their head touched the examiner's left hand during the test. The test was terminated if the subject was unable to maintain the position of head off the examiner's hand. The holding time was measured in seconds.

The scapula muscle endurance test was based on a strengthening exercise for the shoulder girdle muscles described by Sahrmann.[26] For this test, the subjects stood

Fig 2. *Subject position for the scapular muscle endurance test.*

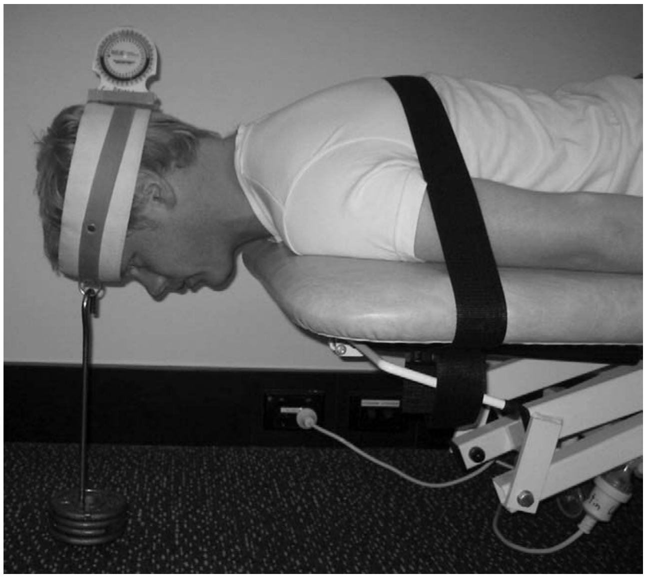

Fig 3. *Subject position for the neck extensor muscle endurance test. The inclinometer on the subjects head is used to monitor the head position during the test.*

facing the wall, with their shoulders and elbows flexed to 90°. There was no contact between the subject's arms and the wall (Fig 2). A digital dynamometer was held between the subject's hands. The scapulae were positioned in a neutral position, and an adjustable spacer was positioned between the subject's elbows to maintain the test position. The subject was then instructed to externally rotate shoulders to achieve a 1-kg load and to maintain this force, which was displayed on the dynamometer. The end point of the test was defined as when the subject was unable to maintain the set resistance, dropped the adjustable spacer, or failed to maintain 90° of shoulder flexion. External rotation of the shoulder in the test position has been shown to produce coactivation of the trapezius and serratus anterior muscles, which have been suggested to be important in the control of scapula orientation and posture.[27,28]

The neck extensor test was based on a test described by Ljungquist et al,[22] which was adapted from the Biering-Sorensen lumbar extensor test.[29] The subject was positioned in prone lying on a plinth with their arms at their side and head over the end of the plinth, supported by the examiner (Fig 3). A strap was placed at the level of T6 to support the upper thoracic spine. A Velcro band was fixed around the head with a fluid inclinometer attached to the band over the occiput. A 2-kg weight was suspended from the headband so that the weight was located just short of the floor. The subject's head was positioned in neutral sagittal plane position and the test begun when the examiner removed the support of the subject's head. The subject was required to hold the cervical spine horizontal with the chin retracted. The test was terminated if the weight returned to the floor or if the neck position changed by more than 5° from the horizontal, as measured by the inclinometer. The holding time was measured in seconds.

Testing Procedures

The testing was conducted in a musculoskeletal research laboratory. The order of testing was randomly assigned for each subject and remained the same for the follow-up testing sessions. The subjects completed each test twice on the first day of testing. Each subject had a 3-minute rest between tests and a 20-minute rest between the 2 sets of tests. The subjects were retested 3 days after the initial session, but each test was only performed once on the second testing occasion. The same investigator supervised each muscle endurance test for all subjects and at each testing occasion. To eliminate recall bias, the timing was performed by a second investigator who was not watching the test. The supervising investigator indicated when the test started and stopped.

Before testing, all subjects were given a detailed explanation of the testing procedures, and were then positioned in the start position to assist familiarization with the test. All subjects were given verbal and tactile feedback during the tests to help maintain the test position. Because visual feedback was difficult, this feedback helped prevent a premature end to the tests and assisted the subjects to achieve a test end point that was a true reflection of their muscle endurance. Tests were terminated if the subject experienced an unacceptable increase in discomfort. At the completion of the first testing session,

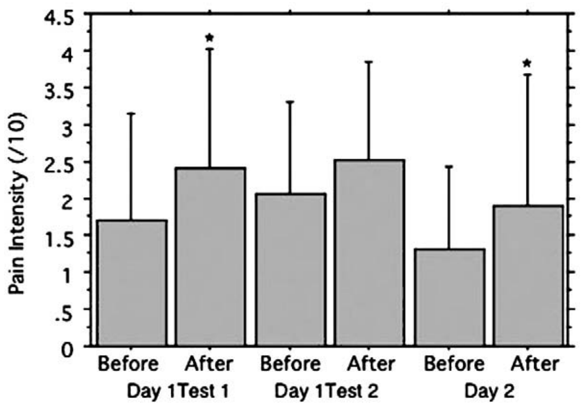

Fig 4. *Pain intensity scores (VAS) measured before and after each test occasion. *Significant change in pain intensity following the test (P <.05).*

subjects were asked to maintain their normal levels of physical activity until after the second test occasion.

Data Analysis

Descriptive statistics (mean and SD) were calculated for each test on each testing occasion. A repeated measures analysis of variance was used to test for significant differences in muscle endurance between test occasions. Paired-sample t tests (2-tailed) were conducted for each of the 3 tests, comparing session 1 with session 3 within each test. This was done to test for a difference over time between the first and last sessions of the study, without the 'blurring' effect of the intermediate session.

Intraclass correlation coefficients ($ICC_{3,1}$) and 95% confidence intervals (CIs) were calculated using muscle endurance scores from the 3 test occasions. The ICC values were interpreted according to the criterion of Portney and Watkins[30] (poor $r < 0.50$, moderate $0.50 < r < 0.70$, good $0.70 < r < 0.90$, and excellent $r > 0.90$). The standard error of measurement (SEM) was calculated using the ICC with the formula SEM = $Z_\alpha \times SD \times \sqrt{(1 - ICC)}$, where Z_α is the z-score for the 95% CI of the true score about the observed score, that is, $Z_\alpha = 1.96$, and SD is the test's SD.[15] Finally, the minimal detectable change (MDC) was calculated using the formula $1.95 \times \sqrt{2} \times$ SEM. This score represents the smallest change that exceeds error in the measurement and represents real change.[31] Test of normality was performed on all variables using the Kolmogorov-Smirnov test statistic. The P values for the Kolmogorov-Smirnov statistic for the 9 variables ranged from 0.006 to well above 0.200. No transformations were performed on the data. For each test, linear regression analysis was used to examine the relationship between patient age, symptom duration, pain intensity, and level of disability on muscle endurance. We used SPSS 10.1 (SPSS Inc, Chicago, Ill) and Excel 2000 (Microsoft Corporation, Redmond, Wash) to perform all statistical analyses, and the criteria for statistical significance were set at $\alpha < .05$.

Table 1. *Mean holding time[a] for each muscle endurance test at each testing session*

	Day 1		Day 2
	Test 1	Test 2	Test 3
Neck flexor test	46.9	50.5	54.1
SD	22.7	25.6	26.3
Range	19-105	21-118	25-142
Scapular test	52.7	53.4	56.5
SD	20.5	18.6	18.5
Range	27-116	25-92	27-107
Neck extensor test	151.5	149.2	125.0
SD	71.4	87.1	65.9
Range	38-279	27-355	38-292

[a] All times recorded in seconds.

Table 2. *Statistical indices of reliability*

	Neck flexor test	Scapular test	Neck extensor test
$ICC_{3,1}$ (95% CI)	0.93 (0.86-0.97)	0.67 (0.31-0.85)	0.88 (0.75-0.95)
SEM (s)	6.4	10.9	25.8
MDC (s)	17.8	30.1	71.3

Results

All subjects were able to complete the 2 test sessions, and all results were included in the analysis. All subjects reported pain in their neck during the pain aggravating activity. A total of 4 subjects also complained of pain in their shoulder girdle, 4 had pain in the thoracic spine, and 1 subject reported headache. The mean pain intensity during the aggravating activity over the previous week measured using the VAS was 4.5 (SD = 1.8). The mean Neck Pain and Disability Scale score was 32.4% (SD = 16). The pain intensity scores before and after each test occasion are shown in Figure 4. The baseline pain intensity on day 1 was significantly higher than that on day 2 ($P < .01$). There were small but significant increases in pain intensity after the first set of tests on day 1 ($P < .01$) and after testing on day 2 ($P < .05$). For all tests, there was no significant association between holding time and patient-related factors such as age, symptom duration, pain intensity, or level of disability.

Descriptive statistics for each test by session are presented in Table 1. There was no significant difference in the mean holding time between test occasions for any of the tests. Reliability statistics for each test are presented in Table 2. Reliability was excellent for the neck flexor test ($ICC_{3,1} = 0.93$), moderate for the scapula test ($ICC_{3,1} = 0.67$), and good for the neck extensor test ($ICC_{3,1} = 0.88$). The corresponding SEM values were 6.4, 10.9, and 25.8 seconds, respectively.

Discussion

There has been little evaluation of tests for muscle endurance in the neck and scapulothoracic region in individuals with postural neck pain. The purpose of this study was to test the reliability of a series of tests of submaximal muscle endurance in subjects with postural neck pain, which may then be used in clinical practice or in further research. Within this patient group, the tests were found to have moderate to excellent reliability based on the interpretation of the ICC values, and MDC values have been established. These tests require little equipment, are easy to apply, and therefore have the potential to be used in clinical practice or future research in this patient group.

The subjects in this study had moderate neck pain intensity (mean = 4.5) and disability (mean neck pain and disability scale = 32.4) at baseline, and all subjects were able to complete the 3 tests on each testing occasion. There were small but significant increases in the reported pain intensity after each testing occasion compared with pretest baseline measures. This increase in pain intensity may have affected performance. However, in the most cases, the test was terminated due to muscle fatigue rather than an increase in pain intensity. In addition, the pretest pain intensity decreased between the first (VAS = 1.7) and third (VAS = 1.3) series of tests. This shows that the tests can be performed safely with a minimal risk of an increase in symptoms over time.

The neck flexor muscle endurance test showed excellent reliability (ICC = 0.93, SEM = 6.44 seconds). In this patient group, a change of greater than 17 seconds (MDC) would be required in repeated tests for the clinician to be confident that the change is something other than measurement variability. In a previous study, Grimmer[32] reported excellent intrarater reliability (ICC = 0.92-0.93) of a similar test in subjects without previous trauma or degenerative pathology in the cervical spine, but with no reference to proportion of subjects with neck pain. Harris et al[21] examined both symptomatic and asymptomatic subjects and reported moderate interrater reliability for the neck flexor endurance test in the symptomatic group (ICC = 0.67). The interrater reliability of the test in the asymptomatic group was moderate to good (ICC = 0.67-0.78), and the intrarater reliability was good to excellent (ICC = 0.82-0.91). The mean test duration in the present study was greater than those reported in previous studies, which could be explained by differences in the test end point and the subject groups. In the present study, maintaining the head position and upper neck flexion was assisted using verbal and tactile feedback. This feedback may help reduce problems with kinesthetic awareness and provide a more accurate measure of endurance capacity. Subject age, pain intensity, and disability level were not associated with test performance in the present study, but these factors have not been reported in full in previous studies.[20,21]

The scapular muscle endurance test showed moderate reliability (ICC = 0.67, SEM = 10.87 seconds), although the wide CI for the ICC may suggest that this estimate may not be particularly precise. The MDC value indicates that changes of greater than 30 seconds between repeated tests would be required to reflect real change in muscle endurance. This test was based on an exercise described by Sahrmann[26] designed to improve performance of the serratus anterior and trapezius muscles and has not previously been tested for reliability. Using surface electromyography analysis, Ekstrom et al[28] found high serratus anterior activation with coactivation of all parts of trapezius during a similar exercise. Impaired function in these axioscapular muscles may lead to altered patterns of load transfer in the cervical spine, which may be important in the etiology of postural neck pain.[27] In this test, the muscle force was measured using a digital dynamometer, and subjects were instructed to maintain a static force of 1 kg. The reliability of the test may have been influenced by the ability of the subject to maintain the load at a constant level. Modification of the dynamometer to ensure that the force is maintained at the required level may help improve the reliability of the test.

The endurance of the neck extensor muscles has been shown to be significantly lower in individuals with neck pain as compared with asymptomatic subjects.[9,23] The neck extensor endurance test has been described previously, both with and without the addition of external load.[9,22,23] The advantage of the loaded test is the decrease in test duration. In the present study, the mean holding time was 141.9 seconds in comparison to between 350 and 480 seconds for subjects with neck pain using an unloaded test.[9] In subjects with postural neck pain, good reliability (ICC = 0.88, SEM = 25.8 seconds) was achieved in the present study. This may have been assisted by the inclusion of a relatively homogeneous subject group. In contrast, previous studies have reported both poor and good reliability for the weighted neck extensor test in heterogeneous groups of patients with neck pain.[22,23] Differences in the methods of statistical analysis, criterion for acceptable reliability, and the duration between tests may have all contributed to the differences between the results of previous investigations and those of the present study. Importantly, the MDC value established in the present study indicates that changes in test performance of greater than 70 seconds would be required in repeated testing to be confident that real change in muscle endurance had occurred.

In making an assessment about the reliability of a clinical test, it is important to consider the context in which the measurement technique will be used. A measurement technique that is able to detect differences between individuals or groups requires a high level of reliability that is reflected in the ICC.[33] Based on the results of this study, the neck flexor and extensor endurance tests would be suitable for this purpose given the high ICC values. In contrast, the moderate reliability of the scapular endurance test (ICC = 0.67) would make it a less useful discriminative test, unless the difference between groups was relatively large. Where the test is used to evaluate change over time, the measurement error should be as small as possible, and in this context, the SEM indicates the level of agreement between repeated measures.[33] The more critical measure in this context is the MDC, which reflects the level of change required in the result to be considered greater than measurement variability. The MDC scores in the present study were 17.8, 30.1, and 71.3 for the neck flexor, scapula, and neck extensor tests, respectively. These values seem acceptable given the range of factors that may influence subject performance in a submaximal muscle endurance test.

Interrater reliability was not examined in the present study because the intent was to simulate the common pattern of clinical practice in which patients are treated by the same therapist over time. The emphasis on intrarater rather than interrater reliability in a clinical population is consistent with previous recommendations[21] and appears appropriate for standardized tests for which time is the dependent variable. All subjects in this study had postural neck pain, and we did not assess the reliability of these tests in asymptomatic subjects. However, previous studies have shown that neck muscle endurance tests have better reliability in asymptomatic subjects than in patients with neck pain.[21,22] Another factor that may impact on performance in muscle endurance tests is the subject's level of effort or exertion. The Borg scale has been used in previous studies as a subjective measurement of exertion.[34,35] Including a measure of effort in the tests would have helped ensure that each subject's level of effort was consistent over the 3 test occasions. A measure of subject effort would be a useful modification to the current test procedures in future studies. Finally, the tests evaluated in this study appear to have face validity, but further studies using electromyographic analysis are required to establish the construct validity.

Conclusion

The purpose of the study was to test the reliability of 3 tests of submaximal muscle endurance in subjects with postural neck pain. The ICC values suggest that the neck flexor and extensor tests would be suitable for use in studies comparing individuals or patient groups. The ICC for the scapula muscle test suggests that it would be less useful for this purpose. The MDC scores established in this study provide a useful guide as to the level of change required in longitudinal assessments to be confident that there has been a real change in test performance. These tests can be performed safely without the risk of a prolonged increase in symptoms, require little equipment, are easy to apply, and therefore have the potential to be used in clinical practice or further research.

Practical Applications

- In this group of subjects with postural neck pain, good to excellent reliability of three tests of neck and shoulder girdle muscle endurance was demonstrated.
- The minimum changes required to represent change beyond measurement variability ranged from 17 to 71 seconds.

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