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Cervical Range of Motion Associations with Sub-clinical Neck Pain

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경미한 경부 증상이 있는 대상자의 경추 관절 운동 범위 연구

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<Abstract>

목적: 병원치료가 필요하지 않을 만큼의 경부통증/증상과 관절가동범위, 경흉추의 다각적 면에서 관계를 조사하기 위해서이다.

방법: 연령은 19세에서 42세(평균연령 28세로 실험에 참여하기를 원하는 건강한 성인 40명을 대상으로 하였다. 경흉추의 척추 자세, 경추 능동 관절 가동범위, 경부 분절 길이 등의 다각적인 면을 측정하였다. 모든 측정들은 동일시에 각 대상자에게 서로 다른 측정자에 의해 두 번 실시되었다. 경부 근 지구력은 수정된 Biering-Sorensen 검사법에 의해 측정되었다. 마지막으로 대상자들에게 경부 통증/증상의 재발에 대한 질문을 하였다.

결과: 14명의 대상자들은 경미한 재발성 경부 통증/증상을 보고하였다. 경부 근 지구력 시간($F(1,38) = 6.75$, $p=0.01$)과 좌측 회전 가동 범위($F(1,38) = 4.56$, $p=0.04$)가 경부 통증을 가진 대상자들에서 유의하게 감소하였다. 신전 가동범위가 재 측정에서 특정군 변화 즉, 정상군 증가, 경부 통증/증상군 감소($F(1,38)=4.67$, $p=0.04$)가 보였다. 경부 통증/증상군은 정상군과 비교 시 후인 가동 범위의 증가하였다($F(1,38) = 4.56$, $p=0.04$). 통증 유무에 관계없이 모든 대상자들에서 우측 회전보다 좌측 회전에서 가동범위가 더 크게 나타났고($F(1,38) = 4.34$, $p=0.04$), 반복 측정에서 좌측 측방굴곡 ($F(1,38) = 5.10$, $p=0.03$)과 우측 측방 굴곡 ($F(1,38) = 5.27$, $p=0.03$)의 감소가 나타났다.

결론: 경미한 증상의 경부통증 대상자군과 정상적인 대상자군을 비교할 때 그룹 간 차이는 경부 근 지구력 시간의 감소, 좌측 회전 가동 범위 감소와 특히, 두 번 째 측정에서 신전범위 감소가 나타났으나 후인의 가

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동범위는 증가로 관찰되었다. 이러한 결과들은 경부 통증의 발생과 관련된 초기 가동범위 변화를 제안한다.

중심 단어: cervical spine, active range of motion, neck muscle endurance, neck pain

Ⅰ. Introduction

The problem of neck pain is common in the general population, with 70% of individuals affected at some time in their lives(Cote et al., 1998) and about 510% of adults suffering a disabling neck problem(Bovim et al., 1994; Cote et al., 1998). A recent random population-based study suggested that, in any group of young adults, approximately one-third wake up with neck pain or stiffness once per week(Gordon et al., 2002). Despite the high prevalence of neck problems, very few studies are available indicating any physical associations with the development of neck pain. Accordingly, there is a lack of knowledge concerning early signs of pathology for neck pain, such as which movements are affected when early neck symptoms appear.

It is well understood that cervical structures can be affected by specific causes such as degenerative disease, trauma, and/or inflammatory disorders, and that neck pain can result(Barry & Jenner, 1995; White & Panjabi, 1990). Another group of neck pain cases with mainly mechanical disorders, including those thought to arise from habitual postures and degenerative involvement, have been referred as non-specific neck pain (Bogduk, 1984). However, most cases of non-specific neck pain are similar in presentation to that seen when cervical structures are injured by disease or trauma, even though systemic conditions cannot be found as underlying cause of neck complaints.

It has been proposed by several authors that these non-specific neck pain problems result from poor posture, in terms of sustained, long-term, abnormal physiologic loads on the neck. Both Haughie et al(1995) and Mckenzie (1990) have suggested that these loads compromise pain-sensitive structures, and thereby affect the function of the cervical spine, causing a musculoskeletal imbalance in the upper quarter of the body. For example, a habitual excessively forward head posture has been suggested to be pain provoking, with a consequential reduction in muscle strength (Braun & Amundson, 1989; Griegel-Morris et al., 1992; Janda, 1994).

Associations between cervicothoracic spine physical dimensions and the presence of neck pain/discomfort, however, have not been firmly established. Grimmer(1996) failed to find any relationship between subjects having extreme cervical resting postures and reports of neck pain. There is also a lack of association reported between cervical posture and deep cervical short flexor endurance, as noted in another random population-based study(Grimmer & Trott, 1998). Most postural studies have employed static measurements for calculating spinal angles using X-rays and photographs(Dalton & Coutts, 1994; Raine & Twomey, 1994; Refshauge, 1995; Showfety et al., 1983; Smidt et al., 1984). While forward head posture has been suggested to cause pain and dysfunction, few studies have investigated the relationship between posture and active range of motion. Hanten and colleagues(2000) measured resting head posture and total range between full protraction and retraction in the horizontal plane, in subjects with and without neck pain, and found that the neck pain group had less range than the normal group. Another study by Haughie and colleagues (1995), with office workers who complained of neck pain, also demonstrated a relationship between forward head posture and reduced cervical extension range.

Currently, there are not enough studies available comparing those with non-specific neck pain to the normal population in order to make conclusions about any specific physical dimensions related to non-specific neck pain. In those few available, the severity of neck pain is not well defined, and the techniques used to measure physical dimensions vary between studies, making it difficult to compare results. Therefore, further study is warranted to clarify the relationship between cervicothoracic spine physical dimensions and the presence or absence of sub-clinical neck pain/discomfort.

The purpose of this study, therefore, was to examine physical dimensions of morphology of the neck and head, posture, range of neck motion, and the endurance strength of neck muscles, in order to determine any association between the presence or absence of neck pain/discomfort, and physical dimensions of the cervicothoracic spine. Because none of the subjects were to be receiving any treatment, questions about neck pain were held until the end of all testing to avoid any subconscious reduction in performance due to pain subjects conforming to perceived expectation(Matlin, 1979). A second set of the range of motion tests was included to determine whether there were any sensitization or stretch effects arising from repeated end-of-range measurement.

II. Materials and Methods

A. Subjects

Forty volunteers responded to advertisements placed on notice boards in the Faculty of Health Sciences, University of Sydney. The advertisements sought subjects over 18 years of age, with no experience of neck, upper back or spinal problems that had resulted in a restriction of normal activity or time-off work, and no current neck symptoms, to take part in a measurement study. Subjects who had sought medical attention for neck pain and/or related problems within the last 12 months were excluded from participation in the study, as was anyone with any medical condition likely to affect mobility of the cervical spine(e.g., ankylosing spondylitis). Approval for the study was obtained from the Human Ethics Committee of the University of Sydney, and each subject gave informed consent prior to testing. Twenty male and twenty female subjects, with an age range of 19 to 42 years(mean age for male 30, female, 26), took part. One subject had to leave before the neck muscle endurance test and could not be contacted thereafter; however, the subject reported having no neck pain. Neck muscle endurance data were therefore available for 39 of the 40 subjects.

B. Procedure

Physical dimensions of the cervicothoracic spine were measured with the Dualer(JTech, American Fork, Utah), the Cervical Range of Movement device(CROM) (Performance Attainment Associates, St Paul, Minnesota), and a tape measure, for tests measuring spinal posture, active cervical range of motion, and segment length of the anterior and posterior neck and head circumference, respectively

Table 1. Protocol for spinal posture, cervical range of motion, anthropometric, and neck muscle endurance measurements

Measurement	Position for measurement	Measuring instrument
Thoracic kyphosis in comfortable standing	Standing comfortably on the floor	Dualer digital inclinometer
Thoracic kyphosis in comfortable sitting	Sitting comfortably on a chair, looking straight ahead, arms resting on the lap, and feet flat on the floor	Dualer digital inclinometer
Forward head posture in comfortable sitting	Sitting comfortably on a chair, looking straight ahead, arms resting on the lap, and feet flat on t he floor	CROM
Forward head posture in upright sitting	Sitting upright on a chair, looking straight ahead, arms resting on the lap, and feet flat on the floor	CROM
Protraction	Starting with head and neck upright, taking head forward maximally in the horizontal plane (poke chin out)	CROM
Retraction	Starting with head and neck upright, taking head backward maximally in the horizontal plane (tuck chin in)	CROM
Flexion	Starting with head and neck upright, bending head forward maximally (chin to chest)	CROM
Extension	Starting with head and neck upright, bending head backward maximally (face toward ceiling)	CROM
Side flexion	Starting with head and neck upright, tilting head over shoulder maximally to each side	CROM
Rotation	Starting with head and neck upright, rotating head over shoulder maximally to each side	CROM
Anterior neck length	From the gnathion (tip of the chin) to the suprasternale (the sternal notch)	Tape measure
Posterior neck length	From the inion (the prominence of the external occipital protuberance) to the cervicale (the tip of 7th spinous process of the cervical spine)	Tape measure
Cranial circumference	From the median point on the glabella horizontally around cranium to the most prominent point on the back of the cranium	Tape measure
neck circumference	Around neck column at the level of the C5 spinous process and just below the crichoid cartilage	Tape measure
Neck muscle endurance	Lying prone holding hte chin retracted and the cervical spine in a horizontal position over the end of the plinth	Modified Biering-Sorensen test

(Table 1). A modified Biering-Sorensen test(Biering-Sorensen, 1984) was used for the neck muscle endurance test. All measurements, except the neck muscle endurance test, were taken twice from each subject, by two different testers on the same day. Subjects were not informed of the results of the tests. The testers were always two of the three authors, with the pairing determined by availability.

Thoracic kyphosis was measured by the Dualer digital inclinometer during both comfortable standing and sitting. Marks were made on the skin at T12 and T1 spinous processes to be used by both testers. With the subject in quiet standing, the Dualer inclinometer was placed at 12th spinous process of the thoracic spine and the sensor was set to 0. It was then repositioned at the 1st spinous process of the thoracic spine, with the resulting measure determining the degrees of the thoracic kyphosis. For protraction and retraction, the CROM device was used. Sagittal rotation was held at 0 using the sagittal inclinometer of the CROM, thus standardizing the head position for the test. A vertebra locator and a forward head arm were used in the measure of protraction and retraction. The bottom tip of the vertebra locator was placed on the 7th spinous process of cervical spine, 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 subjects head to keep the sagittal inclinometer at zero. The vertebra locator and forward head arm intersect at a right angle, allowing a measure of protraction and retraction in centimeters to be taken from the horizontal arm. While in neutral flexion/extension, subjects were asked to take their head backward and forward as far as possible, for retraction and protraction respectively, and the measurements at the junction of the forward head arm and the vertebra locator were recorded.

For neck endurance testing, subjects were asked to prone lie on a therapy table with their head and cervical spine supported over the end of the plinth. Arms were positioned alongside the trunk with hands at the hips. To counter-support the upper thoracic spine, a strap was used across the T2 level. For objective determination of endurance failure, the following equipment configuration was employed. A Velcro strap was positioned around the skull with the lower edge of the

Fig. 1. Cervical Biering-Sorensen test for neck muscle endurance. A subject is strapped to the plinth across the T2 level to counter-support the upper thoracic spine. A Myrin goniometer and a pendulum from the subjects head are used to monitor the head position during the test.

strap made level with the top of the ears. Next, a Myrin goniometer was placed on the Velcro strap immediately above the superior-most tip of the helix 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 subjects glabella, with the tape measure case hanging just short of the floor, in pendulum fashion. Endurance was measured by removing the support, then requiring the subject to hold their head steady in a position with the chin retracted and the cervical spine horizontal (see Fig 1). The test was discontinued if the subject could not hold their head horizontal any longer due to fatigue or pain, if the subject lost more than 5 degrees of upper cervical spine retraction for more than 5 seconds as measured with the Myrin goniometer, or if the subject could not maintain the extended position (the tape measure case touching the floor for longer than 5 seconds or on more than 5 occasions). The hold time was recorded in seconds. Although 600 seconds was the target time given for the test, if subjects could continue to hold for a longer time than 600 seconds, they were encouraged to do so, and what they achieved was recorded as their holding time.

Following collection of all physical measures, background information was obtained by structured interview. This included questions about: work-related posture and activities, recreation and fitness activities, any previous history of neck trauma and related treatment, as well as post-treatment functional level, and lastly, any recurrent neck pain (see Appendix).

C. Analysis

2 X 2 ANOVAs were employed to analyse differences between groups (pain/no pain) and across repeats (occasion 1/occasion 2) for the set of physical measures. Independent-samples t-tests, with a Type I error rate set at 0.05, were used to determine whether there were any differences between groups in terms of demographic data and structural measurement data. Neck muscle endurance times for the two groups were examined using a Mann-Whitney U test. Confidence intervals were calculated for the difference in the means of each measure, on each of the separate occasions. The intraclass correlation coefficient (ICC (1,1), as described by Shrout and Fleiss (1979), was the reliability statistic calculated for each of the ROM and forward head posture measures, across the two measurement occasions, to assess the inter-tester reliability of ROM measurements and forward head posture.

Ⅲ. Results

Fourteen subjects reported having neck pain/discomfort on a recurring basis. The rate of recurrent neck pain ranged from weekly, and also depended on sports activities and the nature of daily activities. Long periods of sitting in one position, awkward sleeping positions, and changes in training for their regular sports were common reasons given for recurrent neck pain/discomfort. Duration of the symptoms ranged from ½ hour to 48 hours at each recurrence. Subjects with recurrent neck pain/discomfort are hereafter referred to as the sub-clinical neck pain group, and the rest as the normal group. None of these subjects reported any previous neck trauma or neck treatment. The groups did not differ on any of the measured demographic and structural variables, when

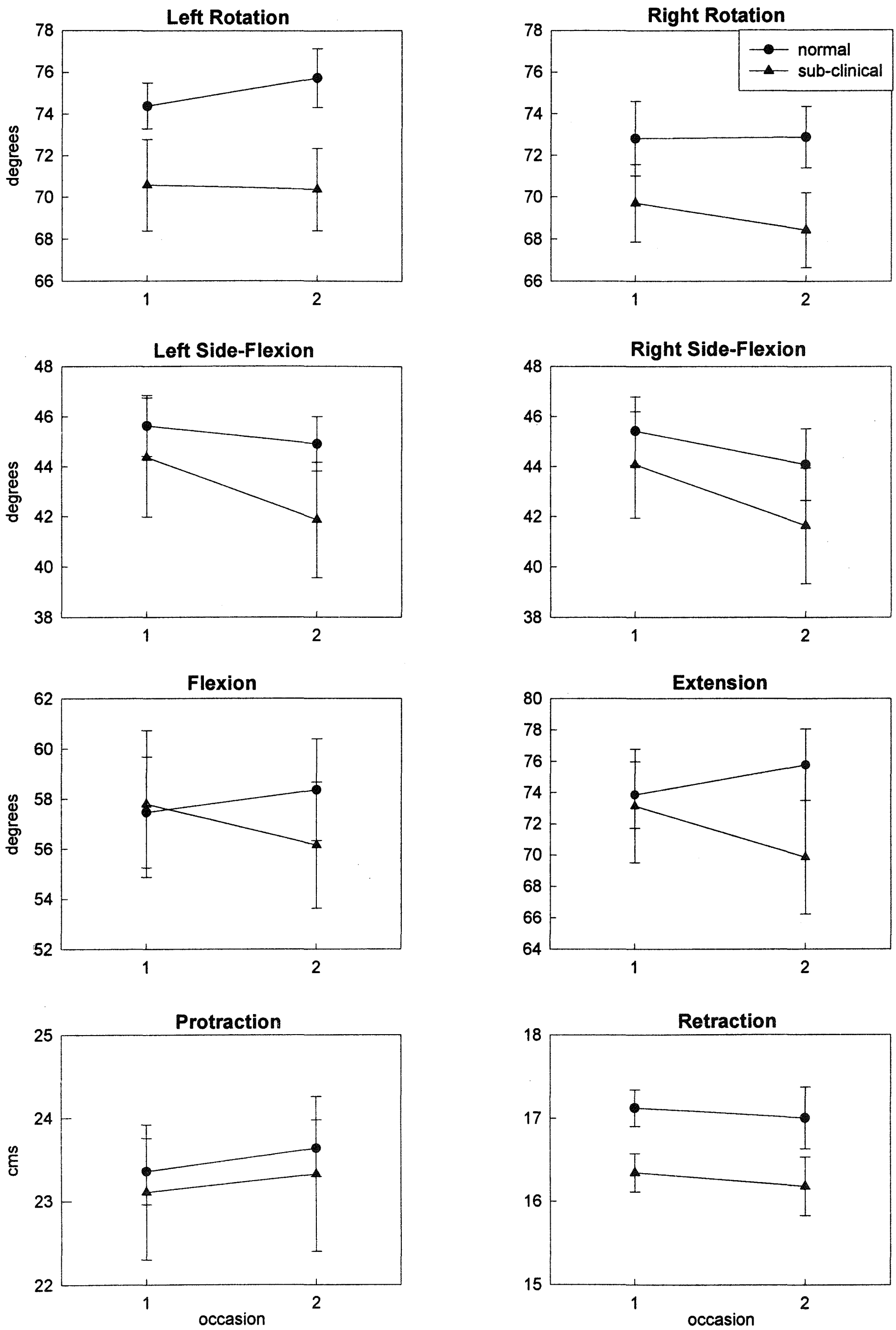

Fig. 2. Mean range values for each cervical range of motion. Note that the smaller values indicate greater range of retraction, whereas greater value indicate greater range of protraction.

analyzed by independent-samples t-tests. Means, standard deviations, and p-values for the tests are presented in Table 2.

Neck muscle endurance time, as assessed using the outcome of the modified Biering-Sorensen test, was significantly reduced in the sub-clinical neck pain group (Z=2.58, p=0.01). The average length of time for this test was 531.4 seconds for the sub-clinical group (SD=142.5; 95% CI=449-614; range 241-690 seconds), whereas for the normals it was 610.4 seconds (SD=42.2; 95% CI=592-627; range 446-690 seconds). The most common complaint at termination of the test was pain in the lower cervical and upper thoracic spine area, which was a similar site to the sub-clinical pain subjects recurrent neck pain/ discomfort. Of the 39 subjects tested, only 6 subjects could not achieve at least 600 seconds holding time. Five of these six subjects were in the sub-clinical neck pain group, with the test provoking symptoms and preventing them from maintaining the required position. There was considerable overlap in holding time between groups. However, the three subjects with lowest holding time were in the sub-clinical pain group. Only one subject in the normal group ceased the test due to fatigue, failing to hold their head in the required horizontal position. Those subjects who could not hold their head in the test position longer than 600 seconds lost the vertical height of their head, as monitored by the pendulum, rather than altering cervical lordosis from the testing position, which was monitored by the Myrin goniometer. In general, with this endurance test, most subjects tended to first lose the ability to hold their head in the testing position in terms of vertical distance from the

Table 2. The mean (standard deviation) and p-values of subjects demographic and structural variables. There is no significant differences between groups when analysed by independent samples t test within and between groups.

Meaure	Normal Group N=26 (13 male, 13 female)	Sub-clinical Group N=14 (7 male, 7 female)	*p*-value
Age (years)	26.62 (6.65)	29.50 (7.29)	0.21
Height (cms)	169.13 (8.10)	168.49 (11.53)	0.84
Weight (kgs)	67.86 (11.70)	65.73 (13.60)	0.61
Kyphosis in standing (°)	35.79 (7.78)	36.64 (8.82)	0.75
Kyphosis in sitting (°)	31.52 (8.47)	29.79 (9.12)	0.55
Forward head posture in comfortable sitting (cms)	19.96 (1.62)	19.26 (1.88)	0.25
Forward head posture in upright sitting (cms)	18.69 (1.34)	17.89 (1.39)	0.09
Anterior neck segment length (cms)	14.67 (1.24)	14.76 (1.37)	0.84
Posterior neck segment length (cms)	15.47 (1.53)	15.82 (2.72)	0.60
Cranial circumference (cms)	57.09 (1.54)	56.90 (1.80)	0.73
Neck circumference (cms)	35.76 (3.18)	35.82 (3.34)	0.96

Table 3. The result of repeated-measures ANOVA for cervical range of motion, giving the F-ratios and associated p-values for the main effects between pain/no pain groups and the two measurement occasions, and for the groups occasions interaction, on eight cervicothoracic range measurements.

Measure	Groups difference	*p*-value	Occasions difference	*p*-value	Interaction	*p*-value
Left rotation (°)	4.60	0.04*	0.57	0.51	1.55	0.36
Right rotation (°)	3.78	0.13	-0.60	0.54	1.36	0.49
Left flexion (°)	2.15	0.34	-0.61	0.02*	1.77	0.20
Right flexion (°)	1.90	0.44	-1.89	0.02*	1.09	0.47
Extension (°)	3.31	0.39	-0.68	0.58	5.20	0.04*
Flexion (°)	0.94	0.78	-0.38	0.70	2.54	0.21
Retraction (cm)	0.80	0.04*	-0.14	0.62	0.04	0.94
Protraction (cm)	0.28	0.71	0.25	0.39	0.06	0.91

* statistically significant at the level of $p < 0.05$

floor, and a retracted chin followed.

The mean for each measure of cervical range of motion is presented in Figure 2. A groups by repeated-measures ANOVA was employed to compare ranges both within and between groups. Those results are presented in Table 3. Left rotation was found to be significantly worse in the sub-clinical neck pain group ($F(1,38) = 4.56$, $p=0.04$). Extension ($F(1,38)=4.67$, $p=0.04$) showed a significant interaction with measurement occasion, with a reduction in range (sensitization) for those reporting pain, but an improvement (stretch) for other subjects. Over both groups, irrespective of pain classification, both left ($F(1,38) = 5.10$, $p=0.03$) and right ($F(1,38) = 5.27$, $p=0.03$) side flexion measures sensitized with repeated measurement. Overall, subjects also demonstrated greater range of left rotation than right rotation ($F(1,38) = 4.34$, $p=0.04$). Finally, retraction showed significantly greater range with the sub-clinical group ($F(1,38) = 4.56$, $p=0.04$). Retraction and protraction are both measured as the distance between the vertebrae arm, placed vertically on the C7 spinous process of the cervical vertebrae, and the point of the nose-bridge of the CROM device, located on the subjects nose. The more retracted the head is, the shorter distance which results, as the closer the back of the head comes to the vertical arm of the device. Therefore, smaller values indicate greater range of retraction, whereas greater values indicate greater range of protraction, as shown in Fig 2.

For cervical ROM and forward head posture using the CROM device, six of the obtained values of the ICC (1,1) reliability statistic were excellent, three fair to good and one poor according to the criteria used by Fleiss (1986). The poor value was for the retraction measure, which did not show any sensitization effect. The acceptable reliability of the other measures indicates the significant sensitization findings in those measures can be regarded as systematic effects, and not due to error. The resulting ICC(1,1) values with 95% CIs are presented in Table 4.

Ⅳ. Discussion

Upon questioning, 35% of otherwise healthy

Table 4. Reliability as ICC (1,1) values of each measurements, and associated 95% CIs.

Direction	ICC (1,1)	95% CI
Forward head posture in comfortable sitting	0.73	0.55-0.85
Forward head posture in upright sitting	0.64	0.42-0.79
Protraction	0.76	0.59-0.86
Retraction	0.33	0.03-0.58
Flexion	0.84	0.72-0.91
Extension	0.81	0.67-0.89
Left flexion	0.81	0.68-0.90
Right flexion	0.81	0.66-0.89
Left rotation	0.76	0.59-0.86
Right rotation	0.74	0.56-0.85

subjects in this study reported that they experienced neck pain/discomfort on a recurrent basis, a proportion similar to that observed in a recent population-based study (Gordon et al., 2002). The point in time at which self-classification as to having sub-clinical neck pain takes place (i.e., before or after physical testing) has important implications for research with this group. If, after responding to an advertisement requesting subjects without neck problems or current pain, individuals undertake physical tests and perceive themselves to have performed badly, upon questioning about pain they may be prompted to recall pain events which explain their poor performance, whereas good or adequate performers do not experience such prompting. Alternatively, if individuals respond to an advertisement requesting subjects experiencing neck problems, upon entering the research laboratory they may perceive a demand on them to behave in ways that they think are expected of pain subjects. Demand characteristics are experimental cues that influence subjects to respond in ways that validate the experimental hypothesis (Orne, 1962), which in pain research might involve restricting range or effort. Because demand characteristics have been shown to affect responding to pain questionnaires (Fernandez, 1994), it was considered important to control these by not questioning subjects about any neck pain until after all physical testing. Further, the subjects in the current study were kept unaware of their results on the range of movement tests so that they were unable to evaluate themselves in relation to others. For the sub-clinical pain group there was no general sensitisation effect from repeated testing, with only one direction (extension) showing a group-specific sensitisation effect. Here there was on average 3 degrees (out of 70 degrees) difference between testing occasions in the sub-clinical group, and it is unlikely that subjects would be able to produce a difference of this magnitude over the range. On the neck muscle strength test, the endurance holding for the sub-clinical group ranged fro 241 to 690 seconds. If performing poorly was a prompt to identifying themselves as suffering recurrent pain, it might be expected that the holding time for all these subjects would be low. However, only three out of fourteen subjects in the sub-clinical group had a lower holding time than the worst performer in the no pain group, and even the worst performing sub-clinical pain subject achieved over 4 minutes. Accordingly, we have interpreted the ROM and strength differences between the physically-similar subjects with and without neck pain as reflecting their group status, rather than determining it.

Neck muscle endurance time was found to be significantly less with subjects in the sub-clinical neck pain group than with subjects in the normal group, when tested by a modified version of the Biering-Sorensen test. Decreased neck muscle strength has been found when clinical neck pain groups are compared to normal groups by several authors (Jordan & Mehlsen, 1993; Jordan et al., 1997; Silverman et al., 1991). However, there is only limited evidence that neck muscle exercise is effective for management of neck pain, from studies with both short and/or long-term follow-up periods (Johnson, 1998; Takala et al., 1994; Bronfort et al., 2001). It is possible that neck muscle dysfunction is a long standing problem for severe neck pain patients, and that it cannot be improved by short-term treatment. Therefore, it may be that management techniques should be evaluated at the sub-clinical stage, to determine methods of preventing the problem from progressing to become severe neck pain.

Simple physical measures of active cervical ROM, employed in the current study, discriminated between subjects having and not having neck pain or discomfort on a recurring basis, although no general effect on range tests was observed. Two of the range of motion tests found to be significantly different in the sub-clinical neck pain subjects were left rotation and extension. Other available data have reported rotation as the most affected direction of movement in the cervical spine, and found it to differ between the normal and neck pain subjects (Jordan & Mehlsen, 1993; Hagen et al., 1997). Extension showed a significant interaction with a reduction in range (sensitization) for those reporting pain, but an improvement (stretch) for other subjects. Various authors have reported this direction of movement for the cervical spine to be commonly reduced in neck pain patients (Haughie et al., 1995; Jordan & Mehlsen, 1993; Dvorak et al., 1992).

Currently, few studies have investigated retraction and protraction in non-specific neck pain/discomfort subjects. In the present study, the sub-clinical neck pain group showed greater range of retraction than the normal, suggesting that the former use a retraction movement for relief. Retraction is comprised of maximum flexion at the upper cervical spine, from occiput to C2, and extension at the lower cervical spine, C6-C7, whereas protraction results in maximum extension at upper cervical spine and lower cervical flexion (Ordway et al., 1999). Thus, subjects in the sub-clinical group may tend to use more movement in the lower cervical spine to get retraction of their cervical spine.

Both right and left side flexion range scores were significantly reduced upon re-testing, for both groups in the current study. All second measurements were taken within a ten-minute period after the first. It is possible that both groups of subjects in the present study were unfamiliar with moving into the end range in lateral flexion, and that these are movements which might place stress on pain sensitive structures. Decreasing range in the second measurement of this movement may protect against stress on those structures and decrease discomfort.

Because the tester combination for a given subject was determined by availability, the reliability of the measurements was determined for the ROM measurement protocols using the ICC (1,1) (Shrout & Fleiss, 1976) as the statistic appropriate for this mixed raters design(Protney & Watkins, 1993). The ICC reflects the proportion of the total variance which is true score variance (Fleiss, 1986) and except for retraction, all directions of neck ROM and posture using the CROM device in our study demonstrated fair to excellent reliability. Other authors have also reported difficulty in the measurement of retraction range with the CROM device (Henten et al., 2000) and advised that the retraction range measure might have poor reliability(Garrett et al., 1993). Although subjects within groups tended not to maintain their relative rankings on the second retraction measure, a between groups difference was detected on the first measure. However, the amount of error in this measure may have made it less sensitive to any differences between occasions.

One side-specific effect was also observed in both groups, in that left rotation showed a greater range than right rotation. Differences between sides were found when examining other studies conducted in different countries (Dall'Alba et al., 2001; Dvir et al., 2001; Youdas et al., 1991). It is possible that this asymmetry arises from directional head turning to end of range during driving. Where the driving position is on the right of the vehicle, end-of-range head turning to the left is needed for reversing, and vice versa. Thus, further range should be available in left cervical rotation for adult subjects in UK, Australia and Japan, and in right cervical rotation for subjects in the USA and South Korea, which seems to be the case based on current data.

Finally, postural measures of thoracic kyphosis angle and extent of forward head posture did not differ between the sub-clinical pain and the normal group. A recent study by Johnson (1998) showed that pain was not confined to subjects with relatively low craniovertebral values indicative of a forward head posture, and this finding is consistent with data from the present study. Therefore, it can be suggested that extreme resting postures are not necessarily an indicator of neck symptoms.

Symptoms in our sub-clinical neck pain group were of a benign and transient nature, so that self-management was employed rather than professional consultation sought. Self-management for this sub-clinical neck pain group consisted of changing the postures(i.e., retracting) which they felt caused neck pain/discomfort, ignoring symptoms and keeping up usual activities despite discomfort. Data for the neck pain group showing significantly greater retraction range, and a trend toward a more retracted head posture in quiet sitting, are consistent with this. It is possible that this active self-management may be sufficient to prevent the development of severe neck pain. However, prospective longitudinal studies are needed to determine whether this is indeed a valid method for managing neck pain in the general population.

Although their pain was sub-clinical, the neck pain group in the current study

showed important impairment signs, notably in neck muscle endurance, rotation, and extension, and these findings give direction to future study of the clinical neck pain population.

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Appendix

Name: ______________________________ Date: _______/_______/_______

Date of birth: _______/_______/________ Gender: male ☐ female ☐

1. Occupation:
   What posture/activities are involved in your work?
   What would be average hours per day of sitting?

2. Recreation:
   What are your recreation activities?
   How many hours per week for each activity?

3. Do you have any previous history of neck trauma? Yes ☐ No ☐
   If yes, when did it happen?
   Please list all past treatment related to your neck trauma, if you had any.

   Were you able to get back to your normal level of function afterwards?
   Yes ☐ No ☐

4. Do you get any recurring neck pain? Yes ☐ No ☐
   If yes, how often do you get neck pain?
   How long do you get neck pain for on each occasion?