Comparison of cervical range of motion in two seated postural conditions in adults 50 or older with cervical pain

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Objectives: The influence of self-selected unsupported seated posture on cervical range of motion (ROM) has not been widely studied. Cervical ROM in habitual (HAB) compared to erect (ER) seated posture in adults 50 or older with cervical pain was investigated.
Methods: Individuals 50 or older with chronic neck pain participated in this within-subject observational study. ROM and posture (sagittal distances from the nose to the occiput, C7, and thoracic width and relative to a projected laser plumb line) were measured with the CROM device in the two postures. Test–retest reliability, standard error of measurement (SEM) and minimum detectable change at the 95% confidence level (MDC_{95}) were calculated.
Results: Total planar ROM values were significantly different between HAB and ER postures. Extension, total rotation and lateral flexion, and R lateral flexion ROM were greater, while flexion decreased significantly in the ER posture. SEM% ranged from 4.0 to 9.5% and MDC_{95} values were lower in ER (5.8–11.6°) compared to HAB (6.6–17.7°). MDC_{95}% was moderately low for both postures (11.2–26.2%).
Discussion: ROM was significantly different between HAB and ER postures. The directions most likely to detect real change in neck mobility were rotation in both postures, and extension as well as total flexion/extension in ER. Flexion and lateral flexion should be regarded cautiously as measures of improvement. Erect posture maximizes available cervical ROM in individuals over 50 with chronic neck pain compared to habitual postures.

Keywords: Cervical pain, Postural assessment, Postural correction, Cervical range of motion, Minimum detectable change

Introduction

Chronic neck pain in adults is extremely common with the prevalence of activity limitations due to neck pain in working adults estimated as 10–15%.[1,2] Static seated postures for computer operation and deskwork are required frequently in work and home environments, potentially contributing to neck pain.[3,4] The incidence of neck pain increases with age and is extremely common in females over 50.[5–7] Cervical range of motion (ROM) limitations have been associated with traumatic and non-traumatic cervical pain,[8–13] resulting in functional limitation and disability.[11] Active range of motion (ROM) is a common clinical outcome measure useful for classifying a patient in the International Classification of Functioning impairment based categories of neck pain with mobility deficits (b7101) and neck pain with headaches (28010).[14] While some studies have used controlled postural positions such as a rigid high backed chair when measuring ROM,[15,16] there is limited information about the influence of self-selected posture in unsupported sitting on cervical ROM particularly in the presence of pain in habitual or erect conditions.

The influence of cervical postural position on the available ROM has been studied using extreme positions which increase tensile loading of ligaments and soft tissue compared to more neutral positions. Maximal flexion, extension, protraction, or retraction result in less cervical rotation range compared to a more neutral position.[17,18] There is some evidence that a 'neutral' head and cervical posture provides a starting point for greater cervical ROM than resting or more passive postures in healthy younger adults.[19] Young adults exhibit significantly less extension[19] and less rotation and right lateral flexion in habitual compared to erect posture. It is unclear whether there are differences in cervical ROM in adults over 50 with pain in these positions. Older individuals with cervical pain are more likely to have pronounced

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ROM deficits,[20,21] as cervical ROM decreases progressively with age (estimated losses of 6° of passive motion[20] and 5° of active motion[21] per decade). Maximizing available range in individuals with chronic pain would therefore be an important goal.[22,23] To our knowledge there has been no investigation of the influence of different seated postural positions such as self-selected habitual and erect postures on cervical ROM for individuals 50 and older with cervical pain.

The purpose of this study was to determine: (1) if there were differences in cervical ROM when tested in two self-selected seated postures (habitual and erect) in individuals over 50 with chronic neck pain and (2) standard error of measurement (SEM) and minimum detectable change at the 95% confidence level (MDC_{95}) for cervical ROM in the two postures in individuals over 50 experiencing chronic neck pain. For the purpose of this study, habitual posture (HAB) was defined as the self-selected seated posture assumed automatically by the participant without any instructions,[24,25] and erect posture (ER)[26] was defined as the self-selected seated posture assumed when participants were instructed to sit in their 'best' posture.

Methods

Participants

Individuals 50 and older were recruited by flyers and email postings from an urban research university and suburban community fitness centers as part of a larger study investigating the efficacy of therapeutic exercise interventions for chronic neck pain. Individuals reporting cervical pain between 2/10 and 8/10 for more than 3 months were included in the study. The participants' pain severity was evaluated using an 11 point numeric rating scale (0/10 to 10/10).[27] Participants completed the neck disability index (NDI),[27] and provided a medical history after signing an informed consent document. Exclusion criteria included history of cervical neurological compression symptoms such as numbness, tingling or weakness, cervical stenosis, spinal surgery, osteoporosis, or other serious medical conditions. The study was approved by Wayne State University Human Investigation Committee.

Procedures

Testing was conducted by five examiners to accommodate testing in three locations of an urban metropolitan area. For each individual participant a single examiner conducted all testing. Examiners completed 15 hours of training prior to the study trials to become familiarized with the testing procedures. A within-subject test–retest single session observational design was utilized with three trials of cervical ROM conducted in each of two seated postural conditions — HAB followed by ER.

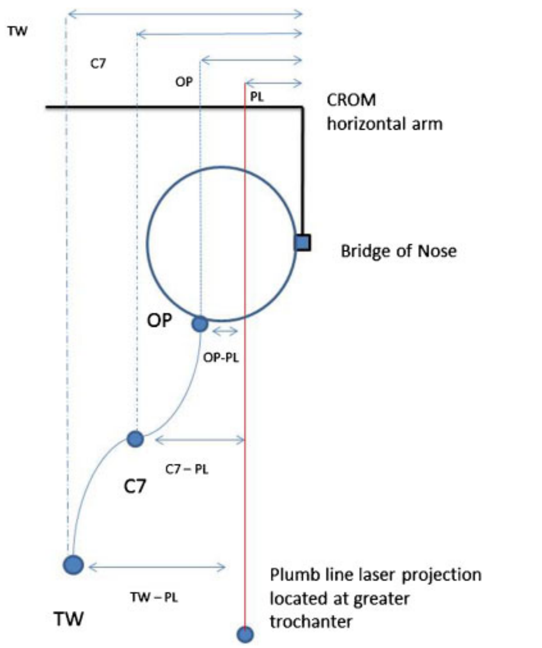

Figure 1 Mean sagittal distances from bridge of CROM to OP, C7, TW and relative distances to PL (habitual posture).

Cervical ROM

The Cervical Range of Motion device (CROM) (Performance Attainment Associates) was used to record active cervical ROM for each half cycle from the starting position with the participant looking straight ahead in each of the two seated postural conditions. ROM measurement with the CROM device has shown good intra- and inter-rater reliability for individuals with neck pain [intraclass correlation coefficient (ICC): 0.76–0.98],[28] and the instrument has produced comparable results to three-dimensional digital measurement.[30] Procedures used for recording ROM with the CROM are described by Audette[29] and Fletcher.[15] The CROM device was secured with the velcro strap immediately below the occipital protuberance and positioned on the bridge of the nose and over the ears similar to wearing glasses. The position of the subject was established by setting the magnetic reference to north to provide a zero starting point for measurement using the rotation inclinometer. Trials were completed in the same order — flexion, extension, right rotation, left rotation, right side flexion, left side flexion. Each set of ROM trials was repeated in the HAB followed by ER postures three times to establish test–retest reliability.

Postural measurement

Postural conditions were attained for the HAB posture without specific instruction, while instruction for the ER posture was to 'sit in your best posture'. Postural measurements for HAB and ER postures were conducted in sitting with feet on the floor and

the hip angle at 90° while looking straight ahead (Fig. 1). Procedures used for measurement of forward head position (FHP) using the CROM device and the sagittal measurement arm are described in detail by Garrett.[16] The FHP distance from C7 to the nose measured with the CROM has shown excellent reliability (ICCs: intra-rater, 0.93; inter-rater, 0.83).[16] The measurements of the occipital position (OP) were taken from the base of occiput at the junction of C0/1, forward head posture from the C7 spinous process (FHP), and thoracic width (TW) from the maximal thoracic curvature. Measurement of cervical and thoracic sagittal distance was recorded from the intersection of the vertebral locator component (OP, FHP), and with a yardstick (TW) with the sagittal FHP arm of the CROM device. Both the CROM vertebral locator and the yardstick were oriented using a bubble inclinometer to ensure that the instrument extended vertically to the intersection with the CROM horizontal FHP arm. The sagittal distance was measured in centimeter to the nearest 0.5 cm. The measurement divisions of the FHP arm are offset by 5 cm to account for a 5-cm addition on the vertebral locator to avoid interference of the back of the head with the vertebral locator. An additional 5 cm was therefore added to the TW measurement with the yardstick to account for the adjusted scale built into the CROM sagittal arm. A sagittal plumb line (PL) was projected onto the participant using a commercially available optical laser (Skil model 8201-CL) mounted on a self-leveling tripod and centered at the midpoint of the anterior and posterior iliac spines of the pelvis vertically through the greater trochanter. The intersection of the laser with the FHP measurement arm was recorded and distances to the plumb line were calculated by subtracting the plumb line sagittal distance from the OP, C7 and TW distances to the nose. The calculated distance to the plumb line were used to reflect distances to a central gravitational reference to provide a base for measurement which accounted for alterations in position created through lumbar motion or overall body position in space.

Data analysis

Descriptive statistics were computed for ROM and postural variables. Paired *t*-tests were conducted using means of the three trials to examine differences for ROM and postural variables between HAB and ER postures. Intraclass correlation coefficients ($ICC_{2,1}$)[30] were calculated from the three trials to determine test–retest reliability for CROM. SEM for ROM was computed as $\sqrt{MSE}$, where MSE is the mean square error term from the ANOVA tables generated in the ICC computations. The MDC_{95} for ROM was calculated using the formula: $MDC_{95}=Z\times SEM\times\sqrt{2}$, where $Z=1.96$, the score associated with the 95% confidence interval, and $\sqrt{2}$ is a multiplier to account for added uncertainty when repeated assessments are taken. SEM and MDC_{95} were expressed in absolute units as well as the percentage of the mean of the ROM variables (SEM% and MDC_{95}%). Significance was set at $P<0.05$.

Results

Thirty-six participants with an average age of 59 (SD: 5.6; range: 50–70) completed testing ($F=32$). On the day of testing participants reported an average pain level of 4.7 (SD: 1.7; range: 2/10–8/10). Mean neck disability index was 12.6 (SD: 6; range: 2/50–27/50).

Postural measurements in habitual compared to erect postures

The means and standard deviations for postural variables in HAB compared to ER postures are presented in Table 1. To establish that cervical ROM was measured under different conditions, postural variables were compared between HAB and ER postures. The mean distance of the plumb line was closest to the bridge of the CROM in both the HAB and the ER postures with the OP, C7, and TW points

Table 1 Postural measurement (cm) in habitual versus erect posture (N=36)

Measurement	Habitual mean (SD)	Erect mean (SD)	*P* value
Distance from bridge of nose			
PL	8.0 (4.0)	7.4 (3.4)	0.198
OP (N=35)	17.2 (2.6)	16.3 (2.2)	0.013*
C7	19.0 (3.4)	17.7 (2.8)	0.001**
TW	26.7 (4.2)	24.1 (3.4)	0.000**
Difference in sagittal plane from bridge of nose minus distance from bridge of nose to plumb line			
OP–PL (N=35)	9.2 (3.5)	8.9 (2.9)	0.728
C7–PL	11.0 (3.3)	10.3 (3.3)	0.150
TW–PL	18.7 (4.0)	16.7 (3.0)	0.004**

Note: PL: plumb line; OP: occipital position; C7: spinous process of C7; TW: maximum thoracic width.
*Mean values were significantly different at the P,0.05 level using paired *t*-tests.
**Mean values were significantly different at the P,0.01 level using paired *t*-tests.
N=36 for all variables except for OP and OP–PL (N=35).

Table 2 CROM (°) in habitual versus erect posture (N=36)

Measurement	Habitual mean (SD)	Erect mean (SD)	P value
Total flexion/extension	89.8 (21.8)	86.0 (23.0)	0.031*
Flexion	46.5 (15.0)	39.1 (14.2)	0.000**
Extension	43.3 (12.1)	46.9 (13.6)	0.000**
Total rotation	96.8 (20.2)	100.0 (21.9)	0.017*
R rotation	49.4 (11.7)	51.0 (11.1)	0.153
L rotation	47.4 (10.5)	49.0 (13.1)	0.130
Total lateral flexion	56.6 (13.4)	59.9 (15.8)	0.027*
R lateral flexion	26.2 (8.3)	28.9 (8.5)	0.004**
L lateral flexion	30.4 (7.3)	31.0 (8.7)	0.497

Note:*Mean values were significantly different at the $P<0.05$ level using paired t-tests.
**Mean values were significantly different at the $P<0.01$ level using paired t-tests.

being progressively further from the bridge of the nose (see Fig. 1 and Table 1). These results reflect an average FHP with OP anterior to both C7 and TW in both the HAB and ER positions. Distances between the bridge of the nose and OP, C7 and TW decreased significantly (OP: 0.9, C7 1.3; TW: 2.6 cm) from the more passive HAB to the more active ER posture ($P<0.05$). The position of the plumb line was not significantly different between the two postures. However, when the distance to the plumb line was calculated for the ER posture, only TW was significantly closer to PL (TW–PL: 2.0 cm, $P<0.01$) indicating a less kyphotic position in the erect posture. The two postures were therefore distinct with the major alterations occurring in the thoracic rather than the cervical regions compared to a central plumb line.

Cervical ROM in habitual compared to erect postures

The means and standard deviations of ROM variables in the two postures are presented in Table 2. The major ROM differences between the two postures were in the sagittal plane. Extension increased significantly by 3.6° ($P<0.001$) in ER posture, while flexion decreased by 7.4° ($P<0.001$), with a decrease in total flexion/extension of 3.8° ($P<0.05$). Total rotation increased significantly by 3.2° ($P<0.05$), total lateral flexion increased by 3.3° ($P<0.05$), and right lateral flexion increased by 2.7° ($P<0.01$) in the ER posture. (Table 2)

Reliability and minimum detectable change of cervical ROM

Test–retest reliability for all CROM measurements (calculated from three consecutive trials in each postural condition) was excellent with ICCs ranging from 0.87 to 0.96 in the HAB posture and 0.88 to 0.96 in the ER posture (Table 3). SEM ranged from 2.4 to 6.4° in the HAB posture and 2.1 to 4.2° in the ER posture. In both postures, the largest half cycle error values were observed for flexion (4.4° HAB, 3.5° ER). SEM% ranged from 4.0 to 9.5% for ROM assessed in the HAB posture and from 4.2 to 9.0% in the ER posture. MDC_{95} values ranged from 6.6 to 17.7° in the HAB posture and from 5.8 to 11.6° in the ER posture. MDC_{95}% was moderately low for both HAB (11.2–26.2%) and for ER (11.6–24.8%) postures.

Discussion

The primary purpose of this study was to determine if cervical ROM was different between HAB and ER postures in individuals over 50 with cervical pain. Total ROM was significantly different as well as flexion, extension, and right lateral flexion measured in HAB compared to ER seated posture. These results indicate the need to utilize consistent instructions for seated posture when testing cervical ROM with the CROM device. As the ER posture resulted in significantly greater ROM for the majority of directions, the ER posture is likely to maximize the amount of available range for cervical ROM

Table 3 Reliability and minimum detectable change values for ROM in habitual versus erect seated posture

	Habitual					Erect				
	$ICC_{2,1}$	SEM (°)	SEM%	MDC_{95} (°)	MDC_{95}%	$ICC_{2,1}$	SEM (°)	SEM%	MDC_{95} (°)	MDC_{95}%
Total flexion/extension	0.92	6.4	7.1%	17.7	19.7%	0.96	4.2	4.9%	11.6	13.5%
Flexion	0.92	4.4	9.5%	12.2	26.2%	0.93	3.5	9.0%	9.7	24.8%
Extension	0.92	3.5	8.1%	9.7	22.6%	0.96	2.7	5.8%	7.5	16.0%
Total rotation	0.96	3.9	4.0%	10.8	11.2%	0.96	4.2	4.2%	11.6	11.6%
R rotation	0.94	2.8	5.7%	7.7	15.6%	0.94	2.8	5.5%	7.7	15.1%
L rotation	0.94	2.7	5.7%	7.5	15.8%	0.96	2.8	5.7%	7.7	15.7%
Total lateral flexion	0.91	3.7	6.5%	10.2	18.0%	0.92	3.9	6.5%	10.8	18.0%
R lateral flexion	0.91	2.4	9.2%	6.6	25.2%	0.92	2.1	7.3%	5.8	20.1%
L lateral flexion	0.87	2.6	8.6%	7.2	23.7%	0.88	2.8	9.0%	7.7	24.8%

measurements in this population. This finding may have implications for therapeutic exercise or function requiring extremes of range.

Cervical extension, total rotation, total lateral flexion, and right lateral flexion ROM increased in the ER posture. Flexion decreased in the active ER posture. This may have been related to an altered starting position with a midpoint segmental axis of motion contributing to the available range with less restriction of motion from compressed facet joints or stretched soft tissue. Based on studies by Canerio *et al.*[31] and Edmonston *et al.*,[25] it is plausible that positioning the head closer to the plumb line through thoracic movement might require less cervical extensor muscle activity required to counterbalance the head weight, permitting increased ROM rather than requiring muscle activity to support the head. In young asymptomatic individuals the cervical extensors have been found to be less active in standardized thoracic upright postures similar to ER postures, compared to lumbopelvic neutral or slumped sitting.[25,31] However, the exact mechanism of altered CROM between these two postures cannot be concluded from this study. The ability to alter position of the thoracic spine to maximize cervical ROM requires further investigation.

To our knowledge, this is the first study using a projected plumb line and the CROM to measure sagittal plane distances from the nose in the cervicothoracic region relative to the center of overall spinal alignment. The reliability and validity of this method will need to be investigated further. The use of the CROM and a projected plumb line would be less time consuming than sophisticated motion analysis or photogammetry to document changes in thoracic position in patients with cervical pain.

Similar to other reliability studies for cervical ROM[15,29] and FHP[16] using healthy younger subjects,[28,29] participants with cervical pain,[15,16,32] and similar mean age,[33,34] test–retest reliability for all directions was excellent ($ICC_{2,1}$: 0.87–0.96). SEM (2.1–6.4°) and SEM% (4–9.5%) indicated low measurement error and good absolute reliability for ROM measured with the CROM device. These values are similar to SEM reported by Fletcher[15] for younger subjects with neck pain (2.5–4.1°), while Audette[29] reported lower values for young subjects without neck pain (1.6–2.8°). Most reliability studies using the CROM device for ROM or postural measurements have not provided details on postural instructions used for testing or have used standardized seating arrangements such as support of the thoracic spine against a high backed chair.[15,16]

Improvements in cervical ROM of 10° of flexion, 8° of extension, 8° of rotation, and 6° of lateral flexion are required when tested in an erect seated posture to reflect change beyond measurement error in individuals older than 50 with chronic neck pain. In this study, half cycle ROM MDC_{95} values ranged from 6.6 to 12.2° in HAB posture with lower values in ER posture (5.8–9.7°). Fletcher's[15] half cycle MDC_{95} results (5.9–9.6°) for young participants with cervical pain tested using a high backed chair were comparable to the MDC_{95} values obtained in this study using a self-selected ER posture. The similar measurement error in the two age range cohorts experiencing cervical pain suggest that either external or muscular support of the lumbothoracic position is likely to result in less measurement error when assessing ROM in individuals with cervical pain. However, the MDC_{95} values in both postural positions were higher than those reported for normal younger individuals by Audette[29] (3.6–6.5°).

The MDC_{95} can be expressed as a percentage of the mean to provide an indication of the ability of the measurement to reflect change. MDC_{95}% was moderately low for both postural conditions (ranging from 11 to 26%) suggesting that ROM measurement using the CROM device maybe sufficiently sensitive to detect real change in both postures for older individuals with neck pain. The directions most likely to detect real change in neck mobility were rotation in both postures (11% total, 15–16% half cycles), and extension (16%) as well as total flexion/extension (14%) in the erect posture. As both rotation and extension are often limited in individuals with cervical dysfunction,[35] the lower measurement error in these directions imply that these directions are useful for evaluating clinical progress. Flexion and lateral flexion SEM% and MDC_{95}% were larger than for other half cycle directions, a finding consistent with those reported by Fletcher.[15] Changes in flexion and lateral flexion range should therefore be regarded more cautiously.

There are limitations of this study. We did not investigate the position or ROM available with 'ideal' posture and further studies comparing the ER posture to those attained with therapist assisted corrections are indicated. A guided or instructed fully slumped position rather than the self-selected HAB posture may have resulted in different results and a comparison of these positions would be useful. ROM might be limited by osteoarthritic and soft tissue restrictions in this age group, and findings may not be the same for younger individuals. We did not provide comparative results to asymptomatic adults over 50 and the findings were limited to observations in a single testing session. The contributions from the upper and lower cervical regions to overall ROM were also not separated. Future studies should also investigate muscular activity using EMG as well as the postural patterns in the lumbopelvic and thoracic

regions in order to be able to determine the self-selected spinal postural patterns used by patients with chronic neck pain and resultant influence on cervical ROM.

Conclusions

In this study, there were cervical ROM differences between HAB and ER posture in individuals over the age of 50 with cervical pain. Extension, total rotation, total lateral flexion, and right lateral flexion ROM increased significantly when measured in the ER compared to the HAB posture, while flexion decreased significantly. The ER posture resulted in decreased sagittal distances for the cervical and thoracic regions compared to the HAB posture, with only TW reflecting significant changes relative to the plumb line position. Thoracic spine position is therefore important to consider for older individuals with cervical pain when testing ROM and for postural correction. These results indicate the need to document the seated posture used when testing cervical ROM with the CROM device for accurate outcome measurements, as well as taking self-selected posture into consideration for functional movement requiring maximal ROM.

Although the MDC_{95}% was moderately low for both positions, the ER posture resulted in slightly decreased MDC_{95}% for total flexion/extension, extension, and R lateral flexion. Rotation in both postures as well as extension and total flexion/extension (14%) in ER posture, are likely to be the most sensitive ROM directions to detecting real change for patients over 50 with chronic neck pain, while flexion and lateral flexion improvements should be regarded cautiously. Improvements in half cycle cervical ranges of motion of 6 to 10° are required when tested in seated ER posture to reflect change beyond measurement error in individuals older than 50 with chronic neck pain. Utilization of a consistent postural position when testing cervical ROM is important for older individuals with neck pain.

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