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The relationship between cervical spine range of motion and postural sway in mechanical neck pain: A cross-sectional study

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Background: Impairments in postural sway have been identified in people with mechanical neck pain. The influence of cervical spine range of motion (ROM) on postural sway is unclear in mechanical neck pain (MNP).
Objective: This study investigated the relationship between cervical spine range of motion (ROM) and postural sway in MNP.
Methods: The cervical ROM was measured using the Cervical Range of Motion (CROM) device. Standing postural sway characterised by mean centre of pressure (COP) measurements in the anterior posterior (AP) and medio-lateral direction with eyes closed and feet together condition was recorded on a posturography platform. Pearson product moment correlation coefficient was used to identify the relationship between cervical ROM and postural sway.
Results: Seventy-two MNP individuals (Mean age: 29.9 ± 11.7) of either sex (Male: Female $= 23 : 49$) were recruited. Overall, no statistically significant correlations were identified between cervical spine ROM in sagittal and frontal plane and postural sway (r values ranging from 0.00 to -0.38; p-values > 0.05). However, a weak negative correlation was present between the cervical rotation and AP (r-value $= -0.23$; p-value $= 0.04$) and mediolateral (r-value $= -0.38$; p-value $= 0.01$) COP excursion.

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Conclusion: The cervical spine ROM was found to have a weak relationship with postural sway in individuals with MNP. This suggests the investigation of other mechanisms especially muscle tension which might be responsible for altered postural sway in MNP.

Keywords: Cervical pain; mobility; postural balance.

Background

Neck pain is experienced by 20–70% of the general population at some period of life with high recurrence rates and greater chronicity.[1] The nociceptive sources of the cervical spine include various structures such as intervertebral discs, facet joints, myofascial, and nerve roots.[2] The diagnosis mechanical (MNP) is commonly considered after the exclusion of serious pathology and nerve root involvement due to inadequate diagnostic criteria to identify a single pathoanatomical source of neck pain. Accordingly, the management of MNP involves identification and correction of various physical impairments associated with the pain such as reduced mobility, altered motor control, reduced proprioception, and postural stability.[3]

The cervical spine plays an important role to maintain postural stability due to the presence of abundant mechanoreceptors and its connections with vestibular and visual systems.[4] A systematic review by Ruhe *et al.* identified studies that reported increased postural sway (measured as the centre of pressure (COP) displacement) in non-specific neck pain when compared to healthy controls.[5] The proposed reasons for increased postural sway in neck pain are (1) reduced proprioceptive input from the cervical spine as a result of the structural damage to proprioceptors in whiplash associated disorders[5] or (2) pain interference, where the activation of pain pathways may inhibit the firing of the motor units required to maintain the COP within the physiological limits in non-specific neck pain.[6] A systematic review concluded that postural sway is not consistently increased in idiopathic neck pain when compared to healthy controls.[7]

Normal cervical spine movement stimulates the abundant proprioceptors and mechanoreceptors in the cervical spine. Adequate cervical spine mobility is not only necessary for functional activities (e.g., turning the head while driving a car) but also provides sensory input to maintain postural balance.[8] However, increased muscular stiffness of the spinal column as a protective response to nociception to avoid further movement and re-injury is well documented.[9] Restricted range of motion (ROM) caused due to stiff spine may decrease the sensory input from cervical spine and drive the individuals to adopt destabilising movement patterns while performing functional tasks.

A previous study identified an upper cervical spine ROM restriction and asymmetry being associated with increased postural sway in elderly population with neck pain.[10] Altered afferent input from the cervical spine and mismatch of sensory information between somatosensory, vestibular, and visual systems were reasoned as the mechanisms for the influence of ROM asymmetry on postural sway.[10] Apart from this study, there is inadequate research to ascertain the influence of spinal mobility on postural balance in MNP.[5]

Therefore, this study aims to quantitively examine the relationship between cervical ROM and postural sway in MNP. Such analysis may help to identify the role of cervical spine mobility and cervical spine sensory input to maintain overall postural balance in non-traumatic MNP individuals. We hypothesise that reduced cervical mobility might contribute to increased postural sway.

Methods

Participants

Individuals with MNP of any pain duration and intensity were requested to take part in a cross-sectional assessment study procedure. Those with MNP aged between 20 and 60 years of either sex referred to the physiotherapy outpatient unit of a tertiary care hospital in India were screened and recruited for the study during the period from August 2016 to March 2017. MNP for this study is defined as the neck pain with or without referral to the upper extremity that is provoked with cervical spine movement or sustained postures.

Participants with cervical radiculopathy (evaluated by dermatome and myotome testing), complaints of numbness or paresthesia, pain in other regions of the spine, neurological conditions affecting postural control, a recent history of trauma, and whiplash disorders were excluded from the study. The Institutional Research Committee approved the study protocol, and ethical clearance was obtained from the Institutional Ethics Committee, Kasturba Hospital, Manipal, India. On recruitment, the participants were provided with a detailed description of the procedure and signed a written informed consent.

Pain and range of motion measurement

Participant's demographics including age, gender, and duration of symptoms were recorded. For all the participants, the current pain intensity was recorded on an 11-point numerical pain rating scale with zero as no pain and 10 as the worst imaginable pain. The ROM of the cervical spine in the sagittal, coronal, and transverse planes was recorded in degrees using CROM device, which was found to be valid and reliable.[11–13] The placement of the device was done as per the standard guidelines.[12,13] Before the measurement, the tester demonstrated the six cervical movements to each participant. The measurements were performed by the participants, seated on a chair in an upright posture with the lower back and thoracic spine in contact with the backrest, feet on the floor and shoulders relaxed. The participants were cued manually and verbally to actively move their neck into the flexion, extension, bilateral lateral flexion, and rotation up to the maximum possible range. The compensations from the thoracic spine were prevented either by manual stabilisation of the torso or verbal instruction by the outcome assessor as required. The sequence of cervical movements was kept same for all the participants as follows: flexion, extension, lateral flexion to the left then right, rotation to the left and then right. Each movement was performed for three times and a 5 s rest period was given between the movements. The reading in degrees on the CROM device at the neutral head position and after the completion of maximum range in every direction was recorded by the same assessor for every participant. The difference of readings between the end position and the neutral position was calculated. After recording the ROM in each direction, the tester instructed the participants to move the cervical spine back to the neutral position. When the participants could not perform the movement accurately, further trials were given with adequate instructions.

Postural control assessment

Postural control assessments were performed on a static posturography platform (Metitur, GB02, Finland) following standard procedures.[10,14] The postural sway signals were recorded at 100 Hz and converted to digital. The participants were made to stand barefoot with arms at their sides on the posturography platform. The postural sway was recorded with eyes closed, and feet together, while the participant was instructed to stand upright on the platform as still as possible. For all the participants, a foam surface (10-cm thick high-density rubber) was placed under the participant's feet, above the posturography platform and the balance was assessed for 30 s. COP excursion (cm) in the AP and medio lateral (ML) directions was recorded for data analysis as in previous studies on spinal pain.[10] This study measured COP excursion in cm because of its affluent understandability and clinical inference. In addition, sway velocity moment in eyes closed and feet together condition is also reported.

Statistical analysis

Statistical analysis was performed with SPSS version 16. The level of statistical significance criterion was set at p-value < 0.05. The sample size was estimated expecting a minimum correlation coefficient of 0.40 at 80% power and determined to be 72. The demographic details (mean age, duration, and intensity of symptoms) outcome measure values (cervical spine ROM in three planes and postural sway in AP and ML directions) of the participants were summarised using descriptive statistics. Shapiro–Wilk test was used to identify the normal distribution of the data, which was found to be in normal distribution. Pearson's product–moment correlation was used to examine the correlation between cervical spine ROM in the sagittal, frontal, and horizontal planes and postural sway in AP and ML directions. The Pearson correlation coefficient (r value) is used to classify the significance and strength of the correlation analysis.

Results

Seventy-two MNP individuals with a mean age of 29.9 ± 11.7 years and symptom duration of 4.8 ± 9.4 months participated in the study. The other demographic details and mean outcome measure values were indicated in Table 1. The mean (SD) cervical spine ROM values are as follows: Flexion: 51.7° (11.3°), Extension: 50.2° (11.5°), Lateral flexion (R): 41.1° (7.7°); Lateral flexion (L): 42.1° (7.8°); Rotation (R): 63.8° (12.1°); Rotation (L): 63.6° (12.3°). The ROM was categorised into the sagittal plane (addition of flexion and extension), frontal plane (addition of lateral flexion to left and right), and the horizontal plane (addition of rotation to left and right). The mean COP values of the participants in the AP and ML distances and sway velocities are summarised in Table 1.

Table 1. Demographic characteristics of the participants.

Mean Age (in years)	30.1 ± 11.7
Mean duration of symptoms (months)	4.8 ± 9.4
Male:Female	23:49
Mean intensity of pain (NPRS)	4.9 ± 2.0
Cervical ROM (Sagittal plane) in degrees	102.2 ± 18
Cervical ROM (Frontal plane) in degrees	83.2 ± 14.8
Cervical ROM (Horizontal plane) in degrees	125.3 ± 24.5
Mean sway velocity moment	130.8 ± 97.3
Mean COP excursion (cm) AP (EC, Foam S, FT)	0.61 ± 0.18
Mean COP excursion ML (cm) (EC, Foam S, FT)	0.59 ± 0.22

Notes: NPRS: Numeric pain rating scale; ROM: Range of motion; COP: Centre of Pressure; AP: Anteroposterior; ML: Mediolateral; EC: Eyes closed; S: Surface; FT: Feet Together.

Overall, the correlation analysis identified no statistically significant correlation between postural sway (in standing; eyes closed position) and cervical spine ROM in various directions (Table 2). There is a no correlation between the cervical spine ROM in frontal and sagittal plane and postural sway in AP and ML directions (Table 2). However, a weak negative correlation was found between cervical spine ROM in the horizontal plane and COP excursion in AP ($r = -0.2$; $p = 0.04$) and ML direction ($r = -0.3$; $p = 0.01$). Similarly, a weak negative correlation was found between cervical rotation ROM and sway velocity moment (Table 3). As there were no significant correlations, regression analyses were not performed.

A subgroup analysis was performed in participants with pain scores more than 5/10 ($n = 25$), which showed similar results. No significant correlation was found between cervical spine ROM

Table 2. Correlation between cervical spine ROM and postural sway.

ROM	Postural sway	*r*-value	*p*-value
Sagittal plane	COP excursion AP (EC, Foam S, FT)	−0.07	0.52
	COP excursion ML (EC, Foam S, FT)	0.00	0.98
Frontal plane	COP excursion AP (EC, Foam S, FT)	−0.14	0.22
	COP excursion ML (EC, Foam S, FT)	−0.07	0.53
Horizontal plane	COP excursion AP (EC, Foam S, FT)	**−0.23**	**0.04**
	COP excursion ML (EC, Foam S, FT)	**−0.38**	**0.01**

Notes: COP: Centre of pressure; AP: Anteroposterior; ML: Mediolateral; EC: Eyes closed; S: Surface; FT: Feet together.

Table 3. Correlation between cervical spine ROM and postural sway.

ROM		*r*-value	*p*-value
Sagittal plane	Sway velocity moment (EC; FT)	0.06	0.57
Frontal plane	Sway velocity moment (EC; FT)	−0.06	0.58
Horizontal plane	Sway velocity moment (EC: FT)	**−0.30**	**0.007**

Notes: EC: Eyes closed; FT: Feet together.

Table 4. Correlation between cervical spine ROM and postural sway in participants (n=25) with severe neck pain.

ROM	Postural sway	r-value	p-value
Sagittal plane	COP excursion AP (EC, Foam S, FT)	0.04	0.81
	COP excursion ML (EC, Foam S, FT)	0.07	0.72
Frontal plane	COP excursion AP (EC, Foam S, FT)	−0.24	0.22
	COP excursion ML (EC, Foam S, FT)	−0.17	0.62
Horizontal plane	COP excursion AP (EC, Foam S, FT)	**−0.35**	**0.02**
	COP excursion ML (EC, Foam S, FT)	**−0.41**	**0.01**

Notes: COP: Centre of pressure; AP: Anteroposterior; ML: Mediolateral; EC: Eyes closed; S: Surface; FT: Feet together.

and postural sway in these participants as well (Table 4).

Discussion

The principal finding of this study is that there was no significant relationship between cervical spine ROM (frontal, sagittal) and postural sway (AP and ML) and sway velocity moment in our neck pain cohort. However, a weak negative relationship between cervical spine ROM in horizontal plane and postural sway and velocity moment was noticed. These results differ with our hypothesis that a significant relationship may exist between neck mobility and postural sway in MNP. As previous research showed that postural sway increases linearly with the intensity of pain in neck pain,[6] a sub-group analysis was performed in high pain group individuals. The subgroups analysis revealed no statistical relationship between the variables.

Identification of the physical impairments associated with altered postural control would enable the clinicians to employ targeted management strategies to normalise postural sway in MNP. Factors such as the intensity of pain and magnitude of proprioceptive deficits were found to cause postural instability in neck pain.[5] As this study identified no significant relationship between cervical spine mobility and postural sway, improving cervical spine ROM might not influence the postural sway in MNP.

The possible reason for not achieving statistical correlation could be that the cervical spine ROM of most of the participants in the study was close to the normative values.[15] These participants could move to maximum cervical spine ROM along with pain and have not shown a significant reduction in cervical spine ROM. A larger variation in the cervical range of motion might have revealed a significant relationship. However, these results are identical to those of an earlier study on low back pain individuals that identified no relationship between the lumbar spine range of motion and increased postural sway.[16]

Participants with reduced cervical rotation were found to have greater postural sway in the AP and ML directions as indicated by the negative correlation (Table 2). The influence of upper cervical rotation asymmetry on postural control is documented in earlier research as well.[10] As cervical rotation is mainly executed at upper cervical spine, the sensory role of this segment in maintenance of postural stability could be a reason for this finding.[10]

The mean AP and ML sway distances in our cohort were higher than the values reported by Quek *et al.* ($AP = 0.45$ cm and $ML = 0.20$), indicating that our sample had greater postural instability. This study measured postural sway in eyes closed condition in contrast to the previous study by Quek *et al.*, which measured postural sway in eyes open condition. The measurement of postural sway in eyes closed position could be the reason for greater postural sway. However, the upper cervical spine ROM asymmetry had a considerable influence on postural sway in their study on older adults. Contrastingly, in our study no significant relationship was found between entire cervical spine ROM and postural sway. Furthermore, the relationship between neck pain and postural balance is still uncertain as there is no consistent evidence from the previous systematic reviews.[7]

Neck pain subjects exhibit a stiffer movement pattern with a reduction in cervical spine ROM.[17]

This stiffening pattern may alter the length–tension relationships of the muscles leading to early fatigue and alter the proprioceptive input from the muscles. Various studies revealed that both the neck flexor and neck extensor muscle fatigue could contribute to increased postural sway.[18,19] Therefore, the complex relationship between reduced neck flexibility and increased muscle fatigue to postural sway qualifies for further research.

Limitations and future research

Though this is one of the few studies that analysed the relationship between the cervical range of motion and postural sway in MNP, it has the following limitations: (1) Measurement of CROM up to the maximum pain (P2) rather than first onset of pain (P1) might have possibly led to no significant relationship with postural sway. (2) The inclusion of pain-free control group could have established whether the postural sway was abnormal in our cohort. The control group was not included based on the current literature that suggested an abnormal postural control in neck pain.[5,20] Furthermore, the mean postural sway in our study population was larger than the normative values in some of the studies in healthy population as described in a previous review.[7] However, postural sway is much increased in neck pain cases with trauma (e.g., whiplash-associated disorder) than those of non-traumatic neck pain.[21] Future studies may attempt to investigate the contribution of cervical spine ROM to sensorimotor control in a specific subgroup of MNP with associated complaints of whiplash, dizziness, and unsteadiness (i.e., cervical dizziness) using robust outcome measures. It would be significant to measure the postural sway simultaneously while performing neck movements and examine the relationship between these clinical characteristics.

Conclusion

This cross-sectional study identified a weak relationship between cervical range of motion and postural sway in MNP. The above findings may suggest a limited role for cervical range of motion in MNP to maintain overall postural balance, which is a complex, multifaceted phenomenon. Further research must investigate other factors that might be responsible for increased postural sway in MNP population.

Ethical Approval

Ethical approval is done by the Institutional Ethics Committee, Kasturba Hospital, Manipal, India.

Conflict of Interest

Authors declare no conflict of interest.

Disclosure

No author has any financial interest or received any financial benefit from this research.

Author Contributions

KV and YVR conceptualised and designed the work. Data collection was carried out by AK and TH. Data analysis, drafting the paper, and critical revisions were carried out by VHB, YVR, and KV. All the authors read and approved the final paper.

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