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ORIGINAL RESEARCH

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Analysis of posture and balance impairments in individuals with chronic nonspecific neck pain—an observational study

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Abstract

Background: Neck pain is one of the most burdensome chronic musculoskeletal problems globally. Impaired proprioception is associated with Chronic Nonspecific neck pain as the structures of the cervical spine are crucial for proprioception and balance. There is a paucity of literature examining objective measures of balance and postural sway in patients with Nonspecific neck pain.

Methods: This study was observational and consisted of 126 samples (63 cases and 63 controls who were recruited using convenience sampling. The demographics of the samples were collected and the postural and balance impairment was assessed using Biodex Balance SD. Mean, Median, and SD were obtained and the inferential analysis was done using the Whitney U Test and the level of significance was accepted at $p < 0.05$.

Results: The subjects with neck pain showed had a lower static stability index, static sway index, static stability index- forward backward and static sway index lateral scores than the normal counterparts. There are significant differences in the overall static stability index, ($p < 0.001$). There was a significant difference in static sway index($p = 0.003$), and static stability index lateral ($p = 0.004$). There was no significant difference for static sway index forward and backward ($p = 0.550$) and lateral sway index ($p = 0.711$).

Conclusion: Subjects with neck pain showed had a lower static stability index, static sway index, static stability index- forward backward and static sway index lateral scores than the normal counterparts and there was a significant difference between the static sway and static stability index in forward and backward directions as well as in lateral direction. These findings may help to assess the specific balance parameters and address the underlying causes of balance issues in patients with neck pain and also provide a comprehensive care to the patients.

Clinical Trial Registration: The trial was registered with CTRI India with registration number: CTRI/2022/07/044222.

KEYWORDS

balance, chronic pain, neck pain, posture, stability index, sway index

1 | INTRODUCTION

Neck pain is a prevalent musculoskeletal condition that affects people of all ages[1] and is one of the most burdensome chronic musculoskeletal problems globally. There are many potential pathological conditions that may contribute to neck pain, but the cause often remains elusive Harvie et al.[2] Individuals may exhibit as being Nonspecific or mechanical Gómez et al.[3] Nonspecific neck pain is defined "as pain in the posterior and lateral aspect of the neck between the superior nuchal line and the spinous process of the first thoracic vertebra with no signs or symptoms of major structural pathology or neurological signs and specific pathologies; such as traumatic sprain and fracture, tumour, infectious or inflammatory cervical spondylolysis, etc" Hidalgo et al.[4]

Chronic neck pain is described as "an often-widespread sensation with palpation and pain in passive and active neck movements." Chronic nonspecific neck pain is associated with disability, deficits in muscular strength, decreased range of motion, increased pain sensitivity and impaired proprioception Misailidou et al.[5] Literatures has identified that structures of the cervical spine is crucial for proprioception and balance as the inputs from the cervical spine have direct access to the central nervous system for balance. Eythor Kristjansson & Treleaven[6] Studies has shown that patients with neck pain often experience somatosensory deficits potentially due to multiple causes including sensitivity of receptors, alteration of cortical representation and modulation of cervical afferent inputs Thunberg et al.[7,8] Also, muscles of cervical region include high muscle spindle density in the suboccipital and deep flexor muscles which assists with neck proprioception which may impact postural sway Jull.[9–11]

Studies; Treleaven et al.[12]) have shown that neck pain associated with whiplash injuries and idiopathic neck pain has an impact on balance and proprioception. Also, a systematic review[13] examining standing balance in people with idiopathic neck pain and whiplash injuries has found balance deficits when compared to asymptomatic individuals. Postural control may be impaired as a result of whiplash-induced injuries to the central nervous system's vestibular and neck sensors. Cruz[13] Contrary to whiplash injuries there is no inciting trauma in idiopathic neck pain, where the suggested mechanism is likely to be impaired peripheral mechanoreceptors, but a much more precise mechanism to be attributed to this can be proprioceptive dysfunction from spinal and supraspinal causes Stanton et al.[10] A recent study has found that balance and proprioception were impaired in elderly individuals with chronic neck pain,[14] while a study on healthy individuals found that there was no correlation between balance and cervical proprioception Anıl Ozudogru.[15] Despite the utilization of these measurement tools in recent studies, a comparative analysis between individuals with and without neck pain is notably lacking. Existing literatures have consistently highlighted the impact of neck pain on balance in individuals. However, there remains a notable gap in research regarding the objective outcomes that is capable of accurately assessing balance and postural sway parameters. This indicates a significant gap in current research and hence warrants a further investigation. Hence, this study aims to examine balance and postural sway in individuals with nonspecific neck pain, utilizing validated methods. Through the application of rigorous methodologies, the goal is to explore existing gaps in knowledge and contribute new insights to address balance and postural issues in patients with neck pain.

2 | METHODOLOGY

This observational design study was conducted at the Physiotherapy Outpatient's Department, Manipal Hospitals, Bangalore between August 2022 and August 2023 in subjects with chronic nonspecific neck pain. The ethical approval was obtained from the Ethics Committee, Manipal Hospitals, Bangalore, and the study was registered under CTRI with Register Number: CTRI/2022/07/044222 Individuals aged 18–55, with pain, isolated to the neck/cervical region, and nonspecific neck pain were eligible to participate. Patients with serious neck pathologies, a history of Cervicogenic headache, radiculopathy symptoms, recent Trauma to the upper extremity or neck including a history of whiplash, and previous surgery to the neck or shoulder were excluded. Sample Size estimation was performed using G Power 3 software. To detect a moderate effect (0.5) between two groups (cases and controls) at 80% power and 5% level of significance a minimum of 63 subjects per group (63 cases and 63 controls) was needed. The study was conducted according to the Code of Ethics of World Medical Association- Declaration of Helsinki. The study adhered to the STROBE guidelines for reporting observational studies von Elm et al.[16]

2.1 | Study procedure

The subjects were recruited using convenience sampling from Physiotherapy Outpatient's Department, Manipal Hospitals, Bangalore. All subjects participating in this study provided informed consent before participation. The subjects were then recruited based on the eligibility criteria. The measurements were taken by an experienced physiotherapist who was blinded to the study population.

Postural control and balance were assessed with the Biodex Balance System®. Biodex Balance SD ® is an instrument used to quantify the balance and postural sway in individuals with a high reliability of 0.94 for the Overall Stability Index. The Biodex Balance SD® is a specialized equipment that provides insight into several aspects of balance that may not be able to perceive with the naked eye, such as the magnitude of a stability index or the degree of postural sway Nicole Dawson.[17] It is an instrument equipped with a circular platform that measures both static and dynamic balance. The platform is capable of moving in all four directions and adopting 12 static positions and the ability to move in 20 degrees in each direction makes it capable of measuring the Antero-Posterior Stability Index, Medio-Lateral Stability Index and Overall Stability Index Measurement of these indices will quantify the balance and postural sway which will provide a better insight to the dynamic and static balance issues in patients with neck pain.[18–20] The participants were asked to stand on the Biodex Balance System® to assess both static and dynamic stability. The testing involved a three-set, 30-second test of static test and each of the system's 12 resistances. If the subjects lose balance during the test, they were permitted to briefly toe touch or grasp

the handrails to regain balance. These indices were computed based on the platform's oscillation level. These indices were measured in anteroposterior, and mediolateral directions and overall. Low values suggested that the subject has a higher stability Eftekhar-Sadat et al.[21] Postural sway is defined as the constant swaying motion that the human body undergoes in erect standing. Sway index was calculated using the position of CoP and the higher score indicated more sway Kelsey Evans.[22]

2.2 | Statistical analysis

Mean, median, and standard deviations were used to summarize the central tendency and dispersion of the data. Levene's Test was utilized to assess the homogeneity of variances across groups, ensuring the validity of subsequent parametric tests. Independent *t*-tests were then conducted to compare mean differences between groups for parametric data, while the Mann–Whitney U test was employed for nonparametric data to account for violations of normality or small sample sizes. A significance level of $p < 0.05$ was adopted.

3 | RESULTS

The study screened 234 subjects of which 126 were found to be eligible and participated in the study (63 with neck pain and 63 without neck pain), with 18 males and 108 females. The mean age of the participants was 31.63 ± 6.2. The specific characteristics of the subjects are given in Table 1 and the group-wise characteristics are given in Table 2.

The subjects with neck pain showed higher values in static stability index, static sway index, static stability index- forward backward and static sway index lateral than the normal counterpartsThe difference in the mean scores are represented in Figures 1–4. There significant difference in the overall static stability index, dynamic stability index, dynamic sway index, dynamic stability index forward and backward, dynamic sway index forward and backward, dynamiclateral stability index

TABLE 1 Showing the characteristics of the subjects participated.

	N	Mean	SD
Age (years)	126	31.635	6.297
Height (cms)	126	10.331	36.096
Weight (kgs)	126	61.111	8.580
Stability Index Static (Overall)	126	1.165	0.352
Sway Index Static (Overall)	126	1.215	0.345
Stability Index Dynamic (Overall)	126	3.044	1.873
Sway Index Dynamic (Overall)	126	4.066	1.545
Stability Index Static Forward backward	126	0.792	0.357
Sway Index Static Forward backward	126	0.981	0.298
Stability Index Dynamic Forward backward	126	2.138	1.441
Sway Index Dynamic Forward backward	126	2.577	1.264
Stability Index Static Lateral	126	0.474	0.298
Sway Index Static Lateral	126	0.578	0.302
Stability Index Dynamic Lateral	126	1.575	0.921
Sway Index Dynamic Lateral	126	2.684	1.158

TABLE 2 Showing the group wise characteristics of both the groups.

	Group	N	Mean	SD
Age (years)	Case	63	33.172	5.9457
	Control	63	30.048	6.3023
Height (cms)	Case	63	1.632	0.0812
	Control	63	19.321	50.0824
Weight (kgs)	Case	63	61.125	9.0018
	Control	63	61.097	8.1958
Stability index static	Case	63	1.279	0.3215
	Control	63	1.047	0.3461
Sway index static	Case	63	1.303	0.2977
	Control	63	1.125	0.3692
Stability index dynamic	Case	63	1.783	0.9939
	Control	63	4.345	1.6675
Sway index dynamic	Case	63	3.480	1.0098
	Control	63	4.671	1.7637
Stability index static forward backward	Case	63	0.930	0.3239
	Control	63	0.650	0.3347
Sway index static forward backward	Case	63	0.965	0.2815
	Control	63	0.997	0.3154
Stability index dynamic forward backward	Case	63	1.224	0.7948
	Control	63	3.082	1.3486
Sway index dynamic forward backward	Case	63	1.959	0.8428
	Control	63	3.214	1.3137
Stability index static Lateral	Case	63	0.400	0.2748
	Control	63	0.551	0.3040
Sway index static Lateral	Case	63	0.568	0.2740
	Control	63	0.588	0.3302
Stability index dynamic Lateral	Case	63	1.099	0.5935
	Control	63	2.067	0.9437
Sway index dynamic Lateral	Case	63	2.394	0.7896
	Control	63	2.983	1.3872

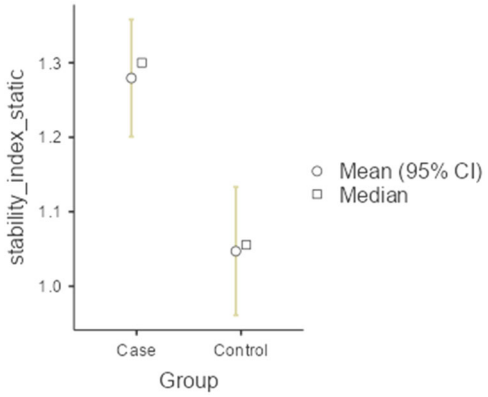

FIGURE 1 Difference in the mean static stability index between the groups.

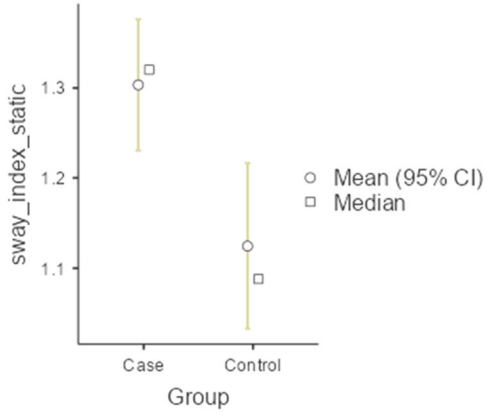

FIGURE 2 Difference in the mean static sway index between the groups.

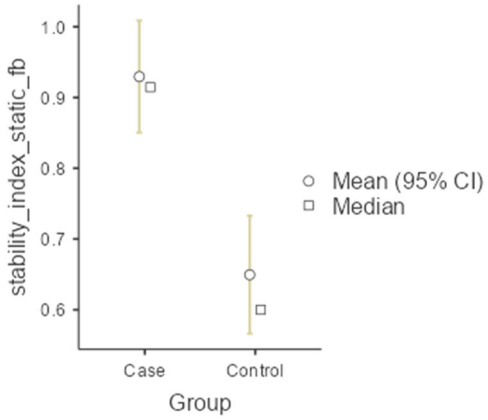

FIGURE 3 Difference in the mean static stability index forward backward between the groups.

($p < 0.001$). There was a significant difference in static sway index ($p = 0.003$), and static stability index lateral ($p = 0.004$). There was no significant difference for static sway index forward and backward ($p = 0.550$) and lateral sway index ($p = 0.711$). The data is shown in Table 3.

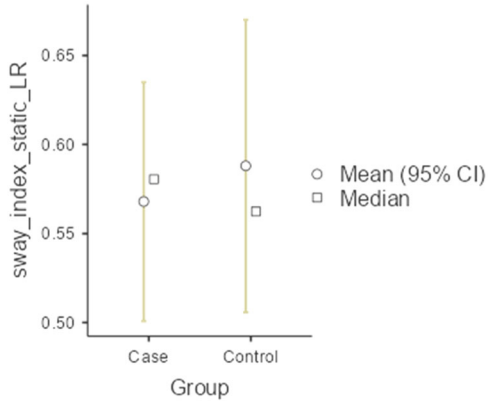

FIGURE 4 Difference in the mean static sway index-lateral between the groups.

TABLE 3 Inferential analysis of difference between the groups.

Parameter	*P* value
Stability Index static	<0.001
Sway Index static	0.003
stability Index Dynamic	<0.001
Sway Index Dynamic	<0.001
Stability Index static forward backward	<0.001
Sway Index static forward backward	0.550
stability Index Dynamic forward backward	<0.001
Sway Index Dynamic forward backward	<0.001
Stability Index static Lateral	0.004
Sway Index static Lateral	0.711
stability Index Dynamic Lateral	<0.001
Sway Index Dynamic Lateral	<0.001

4 | DISCUSSION

This study analyzed balance and postural impairments in subjects with chronic neck pain compared to asymptomatic subjects. The results of our study demonstrated that. the subjects with neck pain showed lower static stability index, static sway index, static stability index- forward backward and static sway index lateral than the normal counterparts and there was a significant difference between the static sway and static stability index in forward and backward directions as well as in lateral direction.

The results of the static stability index parameters (forward-backward, lateral, and overall) of our study were found to be in line with the findings of Ozudogru[15] but the findings differed in the dynamic stability index parameters. The reason for this could be due to the difference in the age group in both the study. Age is considered a significant factor that influences the balance and higher degrees of postural imbalances are observed in higher age groups. It

is observed that a greater amount of hip strategy is used to maintain the balance on swaying support Mei-Yun Liaw.[23] This could be the reason that the results were aligned with the static parameters and a higher difference in the dynamic parameters.

When compared with the findings of the previous studies, the results of our study are in line with the findings of Maryam Saadat[24] and Marie B Jorgensen[25] conducted a cross-sectional study to examine neck pain and postural balance among workers with high postural demands. The researchers found that postural balance was impaired among workers who had neck pain and also had an impact on the postural sway while maintaining erect posture Maryam Sadat[24] compared the postural stability in patients with neck pain to asymptomatic individuals and found that there was poor balance and stability in patients with neck pains. However, the results of Per J Palmgren[26] are controversial to the current findings. They found a statistically significant difference in one of the six global repositioning errors yet no impaired balance. Although the studies employed similar methodologies while assessing the balance impairments in subjects with neck pain, these studies have studied the balance parameters in various assessment positions including tandem stance, eyes closed and eyes open. These factors could have led to the differences in the study results. The similarity in the results could be due to the age group selected as well as the homogeneity in the condition studied. The reason for the impaired balance in subjects with neck pain can be attributed to various entities.

Balance is a complex component in human motor control and function. Being a complex entity, it receives inputs from the vestibular systems, visual inputs, proprioception, muscular imbalances and postural changes, fatigue and fear of movement, and avoidance behavior John & Buckley.[27] Altered vestibular inputs can cause cervical dizziness which is characterized by imbalance, reduced neck range of motion, unsteadiness, and neck pain. This can arise due to degenerative as well as mechanical dysfunction of the cervical spine Alexander & Reiley.[28,29] The studies highlighted that faulty cervical proprioceptive input as well as the inaccurate perception of head and neck orientation in space is caused by interference with the afferent impulses from the upper cervical proprioceptors to the vestibular nucleus Karlberg et al.[30,31] Pain is also considered a contributing factor to the altered inputs to the spine Kristjansson & Treleavan.[6]

Visual disturbances have also been reported in individuals with neck pain and dizziness, the potential reason behind this may be related to the mismatch of afferent information from the vestibular and visual systems Hölzl.[32,33] Evidence supports that visual abnormalities in asymptomatic people following experimentally disrupting the cervical afferents.[34,35] According to these findings, those with neck discomfort experience visual sensations more frequently and more severely than asymptomatic subjects. It has been reported that these symptoms are similar to those previously related to neck pain and possibly caused by aberrant cervical afferents Treleaven & Takasaki.[36]

Cervical muscular imbalances and forward neck posture are also causing of balance and postural impairments in individuals with neck pain Schieppati et al.[37] has reported that a mechanism related to fatigue-induced afferent input and prolonged bilateral contraction of the dorsal neck muscles can affect balance control. Also, recent research has identified that sustained, strong neck muscular contractions can result in postural deviations Duclos et al.[38,39] The findings of Lee JH also suggest that forward neck posture has a significant effect on static balance Lee.[40] Cervical range of motion might also have an impact on neck pain and balance. A study conducted by Gottfert et al.[41] identified that balance was improved with increases in the range of motion.

These all could be possible factors for the significant differences in balance in patients with neck pain when compared to asymptomatic individuals. This study has only analysed the difference in balance and posture in people with and without neck pain. The limitations of this study is that confounding factors such as gender, muscular strength, range of motion, endurance, and joint position sense error were not studied. Also, the balance and posture scores were from the average of three sets of measurements in the static and dynamic conditions, so the subjects would have learned the strategy to maintain the balance as the monitor provided the feedback for the centre of pressure. This study has used convenience sampling as the sampling method as the study sample was homogenous and the study intended to explore the impact of neck pain on balance, but this sampling is not a statistically rigorous one and hence has its own limitations. Future studies on balance and postural sway in subjects with neck pain should address the effect of age, gender, chronicity, and associate the effect of muscle strength, range of motion and joint position sense to get a clear insight of how these factors might affect the balance in subjects with neck pain. Also, future studies that compares the balance and postural impairments in subjects with and without neck pain on males and females should be done to find the impact of gender on balance as most of the studies done till date are with a female predominance.

Hence this study concludes that there was a significant difference between the sway and stability index in static and dynamic conditions in overall, forward-backward, and lateral directions, except sway index forward-backward and sway index lateral in static conditions.

5 | IMPLICATIONS ON PHYSIOTHERAPY PRACTICE

Balance is affected in individuals with neck pain. Few recent literatures[42–45] have found similar results that static as well as dynamic balance is affected in patients with neck pain when compared to their asymptomatic controls. All these studies have employed various outcome measures to evaluate balance, yet future research could benefit from prioritizing tools that offer specificity in assessing balance. This approach would enhance the comparability of results in a more consistent and standardized manner. The findings of this study will help understand how the individual parameters of

postural control are affected in subjects with neck pain when compared to their normal counterparts. In the current physiotherapy practice the component of balance assessment and interventions is not done in individuals with neck pain even though evidence suggest that the balance is affected. Hence the findings of this study will help to understand the importance of specific balance parameters and its assessments in patients with neck pain. This will help the Physiotherapists to address the underlying causes of balance issues in patients with neck pain if any and hence provide a comprehensive care to the patients. As the current study is a cross sectional study, the results cannot be generalized, but based on the results of this study a randomized controlled trial which finds the effectiveness of balance training in individuals with neck pain can be done in the future.

AUTHOR CONTRIBUTIONS

Nithin Prakash: Conceptualization; data curation; investigation; project administration; writing—original draft. **Joshua Cleland**: Conceptualization; methodology; project administration; supervision; writing—review and editing. **Hemant K Kalyan**: Project administration; writing—review and editing. **Ajit Kumar Roy**: Project administration; writing—review and editing. **Naveen Mathew Jose**: Project administration; writing—review and editing. **Karvannan Harikesavan**: Conceptualization; methodology; project administration; supervision; writing—review and editing.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data available upon reasonable request from the corresponding author.

ETHICS STATEMENT

Ethical approval was obtained from the Ethics Committee for Manipal Hospitals, Bangalore. Informed consent was taken from all the subjects prior to before their participation in the study.

TRANSPARENCY STATEMENT

The lead author Karvannan Harikesavan affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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