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Association of head posture with balance in patients with non-specific neck pain

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Abstract
Background and objectives: The aim of the study was to correlate head posture with balance in patients with non-specific neck pain.
Method: This was a cross-sectional study and 76 subjects of age 18 to 35 with non-specific neck pain were included after screening for inclusion and exclusion criteria. The subjects were asked to rate neck pain severity and their head posture, static and dynamic balance was assessed.
Result: Results demonstrated that there was no correlation between CVA and sway velocity in firm surface-eyes open ($r = -0.12$) and eyes closed ($r = 0.005$) or CVA and sway velocity in foam surface-eyes open ($r = -0.05$) and eyes closed ($r = 0.02$).
Conclusion: The present study concludes that there is no relationship between head posture and static and dynamic balance in patients with non-specific neck pain.

Keywords: neck pain, association, head posture, balance

Introduction

Neck pain ranks 4th in terms of disability (in Years Lived by Disability) and 21st in overall burden of disease (in Disability Adjusted Life Years) [1]. One year incidence of neck pain ranges between 10.4% and 21.3%. The point prevalence for neck pain in the general population ranges between 0.4% and 41.5% (mean: 14.4%) while 1-year prevalence ranges between 4.8% and 79.5% (mean: 25.8%) [2].

Bone and Joint Decade 2000– 2010 Task Force on Neck Pain and Its Associated Disorders (Neck Pain Task Force) have described neck pain as pain perceived in area bounded superiorly by superior nuchal line and inferiorly by spine of scapula and laterally by lateral borders of the neck [3]. Neck pain can originate from any of the pain sensitive structures i.e structures that are innervated like muscles, dura, ligaments, facets, capsule, vertebral bones, and nerve roots [4]. Causes of neck pain can be inflammation, infection, neoplasm, degenerative, mechanical, trauma or stress.

Non-specific neck pain (NSNP) is the most common cause of neck pain as in the majority of patients with neck pain, no patho-anatomic diagnosis can be provided, resulting in diagnostic label of NSNP or mechanical neck pain (MNP) for many patients [5]. Bogduk (1988) defined MNP as "having no detectable or specific etiology (such as inflammation and infection) which may be reproduced by provocative stimuli. It is usually located at lower neck region between occiput and first thoracic vertebrae. [6]" NSNP is defined as pain in the neck arising from poor posture, sustained, long term and abnormal physiologic loads on the neck. These loads compromise the pain sensitive structures and therefore affect the function of the cervical spine causing a musculoskeletal imbalance in the upper quarter of the body [7].

Risk factors for NSNP are static postures, repetitive movements with awkward positions, poor work space layouts, high job demands, stress, depression, lack of physical activities, etc [8]. Office and computer workers, healthcare workers, and transit operators have a high incidence of neck disorders.

The common causes of NSNP are sustained muscular tension and faulty posture of the cervical spine. Forward Head Posture (FHP) is often considered to be associated with development and persistence of neck pain. FHP is defined as anterior translation of head to a vertical line through the center of gravity [9]. In FHP, center of gravity of head shifts in anterosuperior direction, increasing the load on neck which causes dysfunction in musculoskeletal, neuronal and vascular systems [10].

Mi Young Lee *et al* [9] have demonstrated that FHP is related to altered joint position sense, and concluded that change in muscle length associated with FHP reduces joint position sense which leads to abnormal cervical proprioception. Similarly, in a systematic review and meta-analysis conducted by T. R. Stanton *et al* [11], they concluded that people with chronic, idiopathic neck pain are worse than asymptomatic controls at head-to-neutral repositioning tests signifying affection of cervical proprioception in chronic idiopathic neck pain patients. Cervical proprioceptive inputs are provided by mechanoreceptors like muscle spindles, golgi tendon organs and paciniform corpuscles present in cervical region [12]. Muscle receptors, specially muscle spindles are found in high densities in upper cervical region, more in deeper sections of suboccipital muscles [13]. In addition to high

density of muscle spindles, the arrangement of muscle spindles in cervical region is unique. Spindles exist as single muscle spindles or are linked in pairs, parallel or in tandem. In cervical region, the tandem arrangement of muscle spindles is more common (35-50%) as compared to leg muscles (10-25%). Muscle spindles in neck are also compartmentalized in series within the muscle which helps in effective tension generation in the muscle.[14] These morphological features of muscle spindles in deep suboccipital muscles are important for movement precision, proprioception, control of head position and eye-head coordination [12]. Also, Suboccipital muscles like obliquus capitis inferior and rectus capitis posterior minor have large numbers of slow-twitch muscle fibres and muscle spindles which play a key role in proprioception [14]. The sensory information from mechanoreceptors in neck conveys information for sensorimotor control [12].

NSNP results in change in mechanoreceptors morphology and motor control of neck muscles [15]. Information from mechanoreceptors in the structures of neck is crucial for interpreting vestibular information and controlling motor tasks [16]. Aberrant cervical afferent inputs to vestibular nuclei and CNS due to neck pain may lead to impaired postural control. Studies comparing balance in subjects with and without neck pain have been conducted and established that neck pain has an effect on balance [17]. Alexander Ruhe *et al* [18] studied correlation of postural sway with pain severity in subjects with nonspecific low back pain and found that there is positive correlation between them. A similar correlation study has been conducted in nonspecific neck pain patients which concluded that pain severity is related to postural sway [19].

FHP induced mechanical stress on neck causes muscle imbalance where some muscles are inhibited and weakened and other muscles tend to become tight [20]. This muscle imbalance leads to a vicious cycle that includes protracted and elevated shoulders and abnormal scapular posture. This causes muscle below the neck such as Rhomboids, Serratus Anterior and lower Trapezius to weaken and antagonist muscles such as Pectoralis major, upper Trapezius and Levator Scapulae to stiffen [21].

Altered COG due to forward head posture leads to mechanical modifications related to postural control in the torso and other joint which can alter balance control mechanisms. Joon-Hee Lee [22] compared balance control between subjects with and without FHP and found increased sway in subjects with FHP than control group.

Researchers have assessed static and dynamic balance in chronic neck pain patients using different measurements of balance showing significant abnormalities in standing vertical postures [17, 23]. Studies have also reported affection of balance in subjects with FHP [22]. Previous studies have shown that both neck pain and forward head posture may have an effect on balance [22]. However, most of the studies were done on elders, computer or office workers and in patients with traumatic and chronic neck pain. Also, very few researchers have studied the relation between head posture with static and dynamic balance [19]. Thus, this study aimed to correlate head posture with static and dynamic balance in patients with non specific neck pain.

Aims and Objective

Aim

To study correlation of head posture with static and dynamic balance in patients with non-specific neck pain.

Objectives

- To correlate head posture with static balance in patients with non-specific neck pain.
- To correlate head posture with dynamic balance in patients with non-specific neck pain.

Hypothesis

Null Hypothesis

There is no significant correlation between head posture and balance in patients with non-specific neck pain.

Experimental Hypothesis

There is significant correlation between head posture and balance in patients with non-specific neck pain.

Methodology

- **Study Design:** Correlational study
- **Duration of Study:** 6 months
- **Sampling Technique:** Convenient sampling
- **Sample Size:** 76

- **Inclusion Criteria**
  - Age- 18 to 30 years
  - Sex- Either male or female
  - Non-specific neck pain of minimum duration of 3 weeks
  - Subjects who are willing to participate and have given consent for the same

- **Exclusion Criteria**
  - Any spinal or lower limb fracture, soft tissue injury or surgery
  - Neck injury/fracture/surgery

- Any red flag or yellow flag for neck pain
- Low back, hip, knee or ankle pain
- Congenital or bony abnormality of spine or lower limb
- CNS disorder, vertebrobasilar artery insufficiency, vestibular pathologies, dizziness
- Signs of nerve root involvement (diminished myotomal strength, sensation or reflexes)
- Diagnosis of cervical spinal stenosis, spondylosis or spondylolisthesis
- Malignancy, systematic inflammatory disease or polymyositis
- Subjects who don't wish to have their pictures taken.
- Subjects who regularly participated in moderate physical activities or exercises for the past 6 weeks.

Procedure

- Participants were included in study after screening for inclusion and exclusion criteria.
- The purpose of study and study procedure was explained to these individuals.
- A prior written consent was taken from the participants stating their voluntary participation in this project.
- Collection of demographic data, pain and balance assessment of the participants was documented in case record sheet and carried out as follows:

1. **Demographic data**: Name, Age, Gender, occupation, no. of working hours and posture attained while working, no. of hours spent on mobile phones and computers was recorded.

2. **Pain assessment [24]:** Location and duration of pain was documented. Numerical pain rating scale (NPRS) was used to measure neck pain severity. It consists of 11 points from 0 –10 with 0 being 'no pain' at all and 10 being 'worst pain imaginable'. The subject was asked to rate current neck pain on activities or movement.

3. **Craniovertebral angle [25]:**

- CVA was assessed by taking lateral view photograph of the subjects in their usual standing posture.
- Spinous process of 7th cervical vertebra (C7) was palpated after performing neck flexion.
- Adhesive markers were put on the C7 spinous process and tragus of the ear to identify it.
- The subject was asked to look straight ahead with a comfortable stance.
- A Sony digital camera was fitted on a tripod stand placed on the right side of the subject at a distance of 120 cm from the subject.
- The tripod had a leveling system to ensure proper positioning of the camera relative to the horizontal plane. It was adjusted such that the axis of the lens was perpendicular to the sagittal plane and at the height of subject's shoulder.
- Subjects were asked to flex and extend the neck three times and then maintain the head in a comfortable position prior to taking photograph. After the photograph was taken, CVA was measured by using MB Ruler software from the digital photograph.

4. **Balance assessment [26]**: Static balance was assessed by performing MCTSIB on Neurocom Balance Manager® version 8.6 whereas dynamic balance was assessed using modified star excursion balance test.

Modified CTSIB

- Here the subjects were asked to stand barefoot on the force plate of Neurocom Balance Manager® version 8.6.
- The force plate has markings for foot placement according to the height (S- Short, M-Medium and T-Tall). The subject was asked to place lateral calcaneum medial to the height line indicated by the system depending on the height of the subject.
- The subjects were asked to stand still on force plate in these four conditions – eyes open stable surface, eyes closed stable surface, eyes open foam surface and eyes closed foam surface. Three trials were taken for each condition.
- The device quantifies sway velocity after the "start" cue for each trial and provides mean COG sway velocity for each condition and composite sway velocity.

Modified SEBT

- In this study, three directions including anterior, posteromedial and posterolateral direction were used.
- The testing grid consisted of 3 lines, each 120 cm in length extending to anterior, posteromedial and posterolateral in relation to the stance foot.
- Subjects received verbal instruction and demonstration of the test by the examiner before performing the test.
- Subjects were asked to practice the test four times for each direction to minimize learning effect.
- Subject was made to stand on one leg in the centre of the grid. While maintaining single leg stance, the subject was asked to reach as far as possible with the reaching limb along the reaching line of the prescribed

direction, lightly touch the line with the most distal portion of the reaching foot without shifting weight to or coming to rest on this foot and then return back to the centre of the grid. If failed, the test was discarded and then repeated. The same process was repeated for other limb.

Statistical Analysis

- The data was entered using Microsoft Office 2010 and analysed using Graph Pad Instat version 3.1 software.
- The numerical data was analysed for normality using the one-sample Kolmogorov Smirnov test.
- Parametric test (Pearson's test) was used for the data passing normality test, non-parametric test (Spearman's test) was used for data not passing normality test.

Results

- The study sample consisted of 76 patient of age 18-35 years (22.64 ± 3.28) with non-specific neck pain.
- The mean NPRS for the subjects was 4.98 (± 1.62) and the mean duration of neck pain in these subjects was 5 (± 1.41) months.
- There is no significant correlation of head posture with static and dynamic balance in patients with non-specific neck pain.

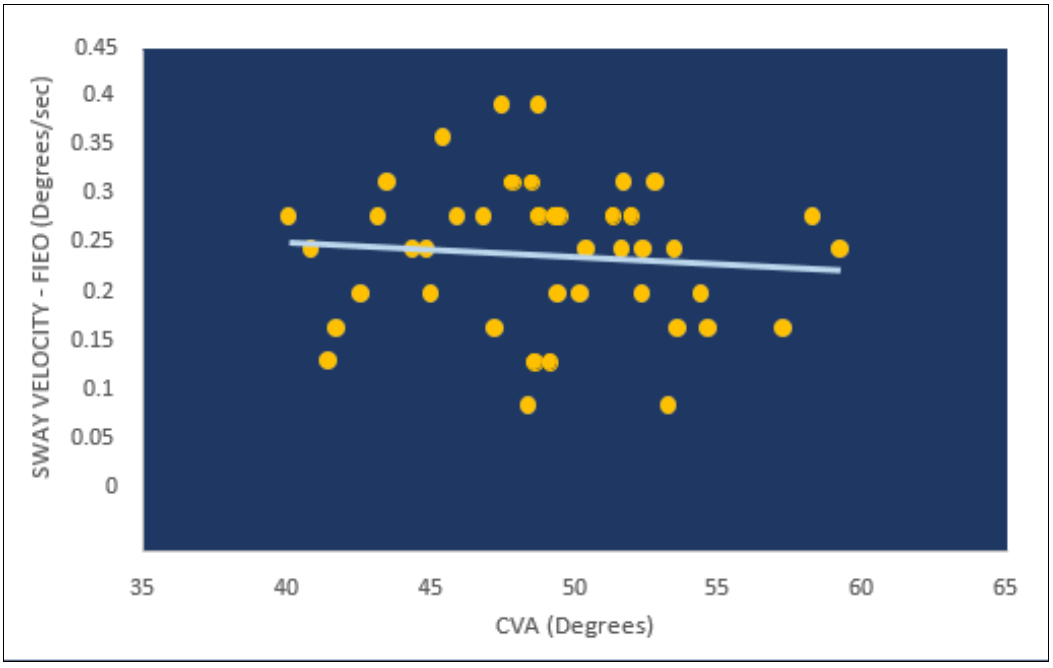
Table 1: Descriptive Statistics of Outcome Measures

Variables	Min	Max	Mean	Median	SD
NPRS	2	8	4.98	5	1.62
CVA	40.06	59.19	48.97	48.92	4.681
FIEO	0.13	0.4	0.27	0.27	0.07
FIEC	0.2	0.6	0.33	0.33	0.08
FOEO	0.43	1.13	0.66	0.63	0.15
FOEC	0.8	1.97	1.3	1.23	0.28
SEBT COMPOSITE SCORE	59.81	96.35	83.76	84.95	8.33

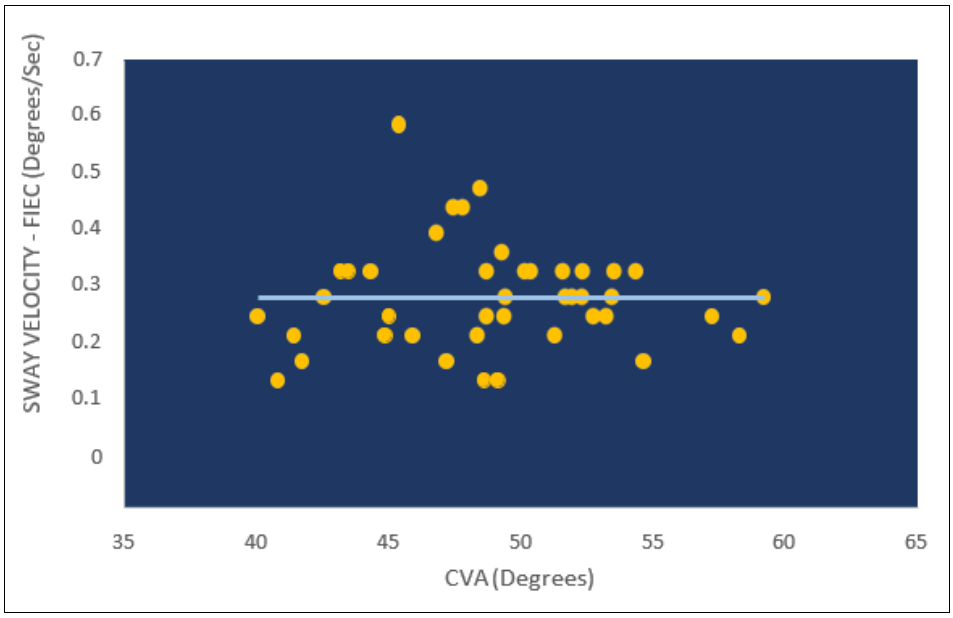
Table 3: Correlation between head posture and Balance

Variables	Correlation Coefficient (r)	p value
CVA and sway velocity in firm surface-eyes open	−0.12	0.44
CVA and sway velocity in firm surface-eyes closed	0.005	0.7
CVA and sway velocity in foam surface-eyes open	−0.05	0.77
CVA and sway velocity in foam surface-eyes closed	0.02	0.92
CVA and SEBT composite score	0.12	0.44

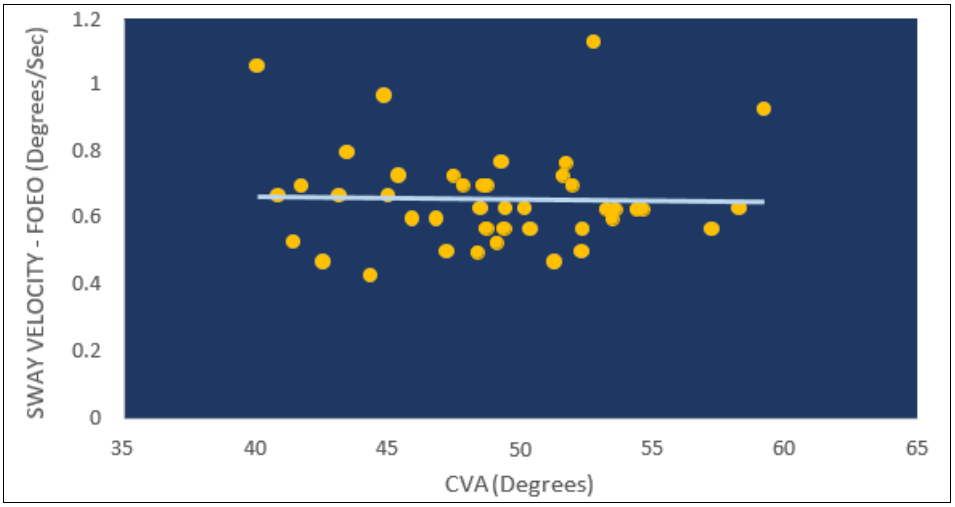
*Correlation is significant at $p<0.05$



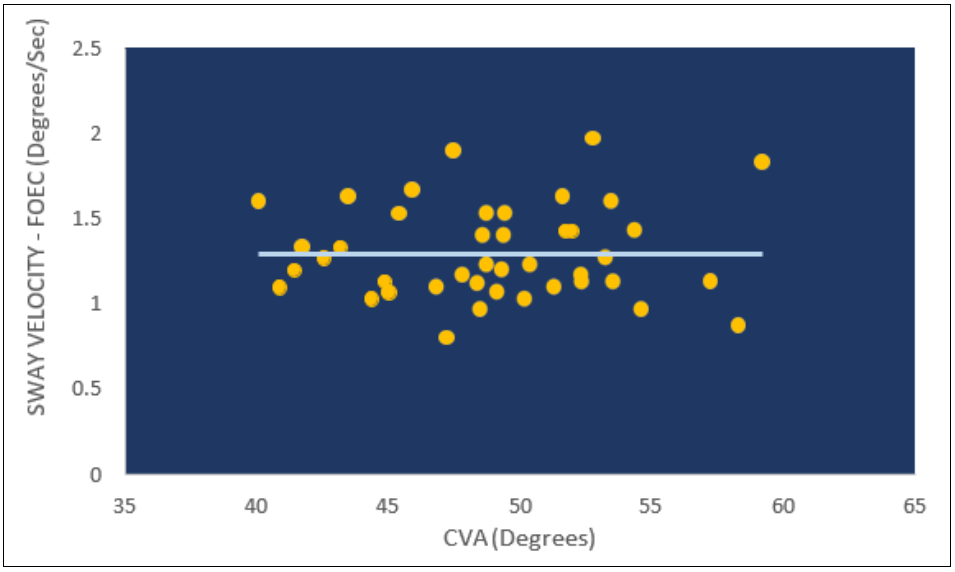
Graph 1: Scatter Plot representing the correlation between CVA and sway velocity in firm surface-eyes open condition



Graph 2: Scatter Plot representing the correlation between CVA and sway velocity in firm surface-eyes closed condition



Graph 3: Scatter Plot representing the correlation between CVA and sway velocity in foam surface-eyes open condition



Graph 4: Scatter Plot representing the correlation between CVA and sway velocity in foam surface-eyes closed condition.

Discussion

The study sample consisted of 76 subjects of age 18-35 years (22.64 ± 3.28) with non-specific neck pain. Degenerative changes in cervical spine starts from forth decade of life and its incidence increases exponentially from 4th decade [27]. Studies have shown that age related degenerative changes can reduce cervical proprioception [28]. Also, postural sway increases with age. This has been attributed to reduced muscle mass and ability to generate force from the age of 40-60 [29]. Thus, in the present study age group of 18-35 were included to reduce bias caused by degenerative changes in spine and balance issues due to age.

G. Stenberg *et al* [30] examined similarities and differences in problem areas reported by women and men with back or neck pain and found that more women reported stress, pain and low support at work and more men reported a lower domestic workload which explains why women report more pain in neck and back than men. In this study also, a greater number of females reported with non-specific neck pain than males. This matches with the incidence of neck pain in general population [31]. This could also be due to difference in pain perception in both.

In this study, modified CTSIB has been used to assess static balance on balance master for measuring sway velocity. When standing on firm surface with eyes open, balance is maintained by inputs from all systems. With eyes closed there is absent visual inputs and body relies on the other two system to maintain balance. When standing on foam surface with eyes open, there is alteration of incoming somatosensory information for postural orientation and thus body relies on visual and vestibular inputs for postural control. Whereas, with eyes closed posture control is maintained with vestibular inputs alone. Alteration in inputs from any of the system will result in increased sway in the respective conditions [16].

Previous studies have demonstrated altered static balance in subjects with chronic neck pain which has been attributed to altered proprioceptive inputs from cervical region due to neck pain [17, 23]. A systematic review was conducted by Ruhe *et al* [32] studied postural sway in non-specific neck pain (NSNP) and whiplash associated disorder (WAD). They concluded that patients with neck pain either NSNP or due to WAD, exhibited greater postural instability than healthy controls, signified by greater COP excursions irrespective of the COP parameter chosen. Static as well as dynamic balance is essential for postural control. Dynamic balance tests are more challenging and sensitive to appreciate postural control deficits [33]. Studies have concluded that there is no significant correlation between static and dynamic balance measures signifying that assessing static balance alone does not represent stability [34]. In this study, dynamic balance was assessed using SEBT. Anticipatory balance control is pre-programming of force by CNS in anticipation of the required task [35]. Anticipatory postural adjustments (APA) in the muscles of trunk and limbs takes place prior to limb movement in order to produce shifts of COP so as to reduce COM motion that occurs due to pertubations or movements prior to gait initiation or whole body reaching movements [36]. The organisation of postural muscle activity preceding voluntary movement depends on characteristics of the demands of both the postural and voluntary movement task. Thus, anticipatory postural muscle activity increases as support to the body reduces or when task load increases [35].

Head stability i.e head posture with respect to trunk during whole body actions is important in order to ensure a reliable reference of frame. This is brought about by neck muscles APA [37]. Two patterns of APA are seen in neck muscles – reciprocal activation and co-activation. Reciprocal activation of neck flexor and extensor muscles occurs when pertubations are applied directly to the head in order to minimize its effects on head posture. Co-activation of neck muscles occurs when pertubations are applied to trunk in order to increase apparent neck stiffness [37].

When performing SEBT, subject has to stand on one leg and reach out with the other leg. This requires head stability which is brought about by neck muscles APA's prior to lifting the leg. If this is affected, subject will limit himself from reaching out far with the other leg in order to maintain balance while standing on one leg.m Reduced strength and endurance of neck muscles is one of the factors associated with neck pain. Deficit in isometric strength and endurance in cervical flexors specifically craniocervical flexors and cervical extensor muscles have been demonstrated in neck pain patients [15]. Deficits in craniocervical flexors have been demonstrated at 50% and 20% MVC (maximal voluntary contraction). Also, poor steadiness of contraction at low load (20% MVC) has been seen in neck pain patients which may manifest as muscle fatigue and is detrimental to cervical spine stability [12].

A study conducted by Saadat M, *et al* [33] compared dynamic balance in chronic neck pain patients with healthy individuals which recorded significant differences. However, dynamic balance was assessed using tilting platform. In the current study, dynamic balance was assessed with modified SEBT which is a clinical test. Forward Head Posture is often considered to be associated with development and persistence of neck pain. It has been associated with altered cervical proprioception due to muscular imbalance which can affect balance. Kang JH *et al* [38] reported that heavy computer users had more protruded head than controls and that anterior translation of head was significantly correlated with balancing abilities. Head posture was significantly correlated with balance when standing on swaying platform with eyes closed which is contradictory to the findings of this study. The head posture assessment was done while operating computers whereas in the current study it was assessed during comfortable stance. In the above study [38], significant correlation between the two parameters was also found when standing on swaying platform with eyes open and a moving screen in front. This was more challenging compared to conditions used in the current study. Also, outcome measures used in both studies were different.

In the present study, the results depict that there is no significant correlation of balance with head posture. Chris Ho Ting Yip, *et al* [39] concluded that there was no significant correlation between head posture and pain severity when age is taken into consideration. Hence, it may be assumed that there would not be a significant correlation between head posture and balance which is in accordance with the result of the current study.

Change in head posture has been said to alter the proprioceptive inputs from the muscles and joints which results in change in orientation of the head with respect to body [9]. These altered inputs to vestibular system can give rise to postural instability. However, in theory, CNS is capable of adapting altered somatosensory and vestibular inputs and abate the symptom of instability even though the underlying dysfunction remains [16]. Hence, even though there is FHP in neck pain patients, adaptation of the altered inputs could prevent the postural instability, which would otherwise be expected. This may be the reason for the insignificant correlation of head posture with balance found in this study.

Conclusion

The findings of the study conclude that there is no correlation between head posture and static and dynamic balance in patients with non-specific neck pain.

References

1. Vassilaki M, Hurwitz EL. Perspectives on pain in the low back and neck: Global Burden, Epidemiology, and Management. Hawaii J Med Public Health,2014:75(4):122-6.
2. Hoy DG, Protani M, De R, Buchbinder R. The epidemiology of neck pain. Best Pract Res Clin Rheumatol,2010:24(6):783-92.
3. Guzman J, Hurwitz EL, Carroll LJ, Haldeman S, Coˆte´ P, Carragee EJ, *et al*. A New Conceptual Model of Neck Pain: Linking Onset, Course, and Care: The Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders. Spine,2008:33(4 suppl):S14-S23.
4. Calliet R. Neck and Arm Pain. 3rd edition. New Delhi: Jaypee,1991:73:130:165.
5. Fernández-De-Las-Peñas C, Cleland JA, Huijbregts P, Palomeque-Del-Cerro L, González-Iglesias J. Repeated Applications of Thoracic Spine Thrust Manipulation do not Lead to Tolerance in Patients Presenting with Acute Mechanical Neck Pain: A Secondary Analysis. J Man Manip Ther,2009:17(3):154-62.
6. Bogduk N. Neck pain: an update. Aust Fam Physician,1988:17:75-80.
7. Lee H, Nicholson LL, Adams RD. Cervical range of motion associations with subclinical neck pain. Spine (Phila Pa 1976),2004:29(1):33-40.
8. Keyserling WM, Brouwer M, Silverstein. A checklist for evaluating ergonomic risk factors resulting from awkward postures of leg, trunk and neck. International Journal of Industrial Ergonomics,1992:9:283-301.
9. Lee MY, Lee HY, Yong HS. Characteristics of cervical position sense in subjects with forward head posture. J Phys Ther Sci,2014:26(11):1741-3.
10. Harrison DE, Harrison DD, Betz JJ, *et al*.: Increasing the cervical lordosis with chiropractic biophysics seated combined extension-compression and transverse load cervical traction with cervical manipulation: nonrandomized clinical control trial. J Manipulative Physiol Ther,2003:26:139–151.
11. Stanton TR, Leake HB, Chalmers KJ, Moseley GL. Evidence of Impaired Proprioception in Chronic, Idiopathic Neck Pain: Systematic Review and Meta- Analysis. Phys Ther,2016:96:876–887.
12. Jull G, Sterling M, Falla D, Treleaven J, O'Leary S. Whiplash, Headache, and Neck Pain. Research based directions for physical therapies. China: Elsevier; 2008, 42-64.
13. Kulkarni V, Chandy M, Babu K. Quantitaive study of muscle spindles in suboccipital muscles of human foetuses. Neurol India,2001:49:355-359.
14. Liu J, Thornell L, Pedrosa-Domello F. Muscle spindles in the deep muscles of the human neck: a morphological and immunocytochemical study. J Histochem Cytochem,2003:51:175-186.
15. Mario DM, Carla V, Paolo P, Antonio R. Structural and Functional Changes of Cervical Neuromuscular System Associated with Insidious Onset Mechanical Neck Pain: A literature Review. Int J Phys Ther Rehab,2015:1:103-108
16. Herdman SJ, Clendaniel RA. Vestibular rehabilitation. 1st Indian edition. New Delhi: Jaypee Brothers Medical Publishers, 2014, 29-33.
17. Field S, Treleaven J, Jull G. Standing balance: a comparison between idiopathic and whiplash-induced neck pain. Man Ther,2008:13(3):183-91.
18. Ruhe A, Fejer R, Walker B. Is there a relationship between pain intensity and postural sway in patients with non-specific low back pain? BMC Musculoskeletal Disorders,2011:12:162
19. Ruhe A, Fejer R, Walker B. On the relationship between pain intensity and postural sway in patients with non-specific neck pain. J Back Musculoskelet Rehabil,2013:26(4):401-409.
20. Waris P. Occupational cervicobrachial syndromes. A review. Scand J Work Environ Health,1979:5:3-14.
21. Gu SY, Hwangbo G, Lee JH, *et al*. Relationship between position sense and reposition errors according to the degree of upper cross syndrome. J. Phys. Sci,2016:28(2):438-441.
22. Lee JH. Effects of forward head posture on static and dynamic balance control. J Phys Ther Sci,2016:28:274–277.

23. Poole E, *et al*. the influence of neck pain on balance and gait parameters in community dwelling elders. Manual Therapy, 2007.
24. Young IA, Dunning J, Butts R, Mourad F, Cleland JA. Reliability, construct validity, and responsiveness of the neck disability index and numeric pain rating scale in patients with mechanical neck pain without upper extremity symptoms. Physiother Theory Pract.
25. Dimitriadis Z, Podogyros G, Polyviou D, Tasopoulos I, Passa K. The reliability of lateral photography for the assessment of the forward head posture through four different angle-based analysis methods in healthy individuals. Musculoskeletal care.,2015:13(3):179-86.
26. Naylor ME, Romani WA. Test-Retest Reliability of Three Dynamic Tests Obtained from Active Females Using the Neurocom Balance Master, Journal of Sport Rehabilitation,2006:15(4):326-337. Retrieved Nov 14, 2022
27. Moon MS, Yoon MG, Park BK, Park MS. Age-Related Incidence of Cervical Spondylosis in Residents of Jeju Island. Asian Spine J,2016:10(5):857-868.
28. Khalid A, Alahmari, Ravi Shankar Reddy, Paul S. Silvian, Irshad Ahmad, Venkata Nagaraj Kakaraparthi, and Mohammed Mehtab Alam. Association of age on cervical joint position error. J Adv Res,2017:8(3):201–207.
29. Roman-Liu D. Age-related changes in the range and velocity of postural sway. Arch Gerontol Geriatr,2018:77:68-80.
30. Stenberg G, Lundquist A, Fjellman-Wiklund A, Ahlgren C. Patterns of reported problems in women and men with back and neck pain: similarities and differences. J Rehabil Med,2014:46(7):668-75.
31. Fejer R, Kyvik KO, Hartvigsen J. The prevalence of neck pain in the world population: a systematic critical review of the literature. Eur Spine J,2006:15:834–848.
32. Ruhe A, Fejer R, Walker B. Altered postural sway in patients suffering from non-specific neck pain and whiplash associated disorder - A systematic review of the literature. Chiropr Man Therap,2011:19:13.
33. Saadat M, Salehi R, Negahban H, Shaterzadeh MJ, Mehravar M, Hessam M. Postural stability in patients with non-specific chronic neck pain: A comparative study with healthy people. Med J Islam Repub Iran,2018:23:32:33.
34. Karimi MT, Solomonidis S. The relationship between parameters of static and dynamic stability tests. J Res Med Sci,2011:16(4):530-5.
35. Shummway-Cook A, Woollacott MH, Motor Control- Translating research into clinical practice. 5th edition. Philadelphia: Wolters Kluwer; 2017, 110.
36. Wang D, Mahe G, Fang J, Piscione J, Couvet S, *et al*. Inconsistent anticipatory postural adjustments (APAs) in rugby players: a source of injuries? BMJ Open Sport Exerc Med. 2018;4:e000303. doi:10.1136/bmjsem-2017-000303.
37. Santos AD, Degani AM, Latash ML. Anticipatory Control of Head Posture. Clin Neurophysiol,2007:118(8):1802–1814.
38. Kang JH, Park RY, Lee SJ, Kim JY, Yoon SR, Jung KI. The effect of the forward head posture on postural balance in long time computer based worker. Ann Rehabil Med,2012:36:98-104.
39. Yip CH, Chiu TT, Poon AT. The relationship between head posture and severity and disability of patients with neck pain. Man Ther,2008:13(2):148-54.