Correlation of Neck Pain Severity with Balance in Subjects with Mechanical Neck Pain

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Abstract: ***Background**: Mechanical neck pain (MNP) is the most common cause of neck pain which causes sustained and abnormal loads on the neck and compromises the pain sensitive structures and therefore affects function of the cervical spine. MNP is characterised by reduced mobility, myofascial pain, faulty posture and altered cervical proprioception which can affect the balance of an individual. Hence, this study aimed to correlate pain severity with static and dynamic balance in young adults with MNP. **Method**:42 subjects of age 18 to 35 years with MNP were included in this study. The subjects were asked to rate neck pain severity using Numerical Pain Rating Scale (NPRS) whereas, static and dynamic balance was assessed using Modified Clinical test for Sensory Interaction in Balance (MCTSIB) and Modified Star Excursion Balance Test (MSEBT) respectively. **Results**: The findings demonstrated a significant positive correlation between neck pain severity and static balance when standing on unstable surface with eyes closed (r = 0.3127) and dynamic balance (r= - 0.4534). However, there was no correlation between pain severity and static balance when standing on firm surface with eyes open and closed and on unstable surface with eyes open. **Conclusion**: The study concluded that there is linear relationship between pain severity and balance in challenging condition in patients with MNP.***

Keywords: Mechanical neck pain, static and dynamic balance, MCTSIB, MSEBT

1. 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]. Causes of neck pain can be inflammation, infection, neoplasm, degenerative, mechanical, trauma or stress. Mechanical neck pain (MNP) 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 non-specific neck pain (NSNP) or MNP for many patients [2]. Modern life is predominantly centred around computers, laptops and mobile phones for work as well as leisure activities. Recreational activities also usually include watching T.V. and video games with minimal physical activities. All these factors predispose young adults like office and computer workers, healthcare workers, housewives, students, transit operators, drivers, etc to MNP.

MNP or 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 [3]. The clinical presentation of patients with mechanical neck pain is reduced mobility in either single or multiple segments, myofascial pain, fatigue and faulty posture like forward head posture. A systematic review and meta-analysis conducted by T. R. Stanton et al [4] 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 [5]. The unique morphological features of muscle spindles in deep suboccipital muscles are important for movement precision, proprioception, control of head position and eye-head coordination [5], [6]. Neck afferents are involved in reflexes which influence head orientation, eye movement control and postural stability, namely, the cervicocollic reflex (CCR), the cervico-ocular reflex (COR) and the tonic neck reflex (TNR). These reflexes work in conjunction with other cervical, vestibular and visual reflexes acting on the neck musculature, for coordinated stability of posture as well as head and eye control [7]. Considering cervical muscle spindle characteristics, it's central connections and their role in reflex pathways, it is apparent that the sensory properties of the cervical region are important for somatosensory information and their influence on postural control and eye head coordination [5].Thus, altered cervical afferent due to neck pain may lead to impaired postural control which contributes not only to loss of functional independence but also reduces participation in daily life activities and increases risk of falls.

Researchers have assessed static and dynamic balance in traumatic and chronic neck pain patients, especially adult and elderly age group, using different measurements of balance and reported significant abnormalities in standing vertical postures when compared to subjects with no neck pain [8]-[11]. However, very few researchers have studied the relationship between neck pain severity and balance [12]. Therefore, the objective of this research was to study this relationship with respect to static and dynamic balance in young adults with MNP.

2. Methodology

Institutional ethics committee approval was taken. A crossectional study was conducted in a tertiary health care center, for a period of six months, using consecutive sampling technique. Sample size of 42 was calculated from a pilot study and participants were included in study after screening for inclusion and exclusion criteria. Subjects of age group 18 to 35 years, male or female, with MNP of minimum duration of 3 weeks were included in the study. Any subject with spinal or lower limb fracture, soft tissue injury or surgery, CNS disorder, vertebrobasilar artery insufficiency, vestibular pathologies, dizziness,cervical spinal stenosis, spondylosis or spondylolisthesis, malignancy, systemic inflammatory disease, polymyositis and subjects who regularly participated in moderate physical activities or exercises for the past 6 weeks were excluded.After explaining the study procedure, informed written consent was obtained from individuals participating in the study. Outcome measures used were Numerical Pain Rating Scale (NPRS), Center of Gravity (COG) sway velocity for four conditions of Modified Clinical test for Sensory Interaction in Balance (MCTSIB) and mean composite score of Modified Star Excursion Balance Test (MSEBT).

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’ [13]. The subjects were asked to rate current neck pain.

Static balance was assessed by performing MCTSIB on Neurocom Balance Manager® version 8.6. The subjects were asked to stand still on force plate in four conditions – firm surface eyes open (FIEC), firm surface eyes closed (FIEC), foam surface eyes open (FOEO) and foam surface eyes closed (FOEC). Three trials were taken for each condition. The device provided mean COG sway velocity for each condition [7], [14].

Dynamic balance was assessed using MSEBT. The testing grid consisted of 3 lines, each 120 cm in length extending to anterior, posteromedial and posterolateral directions in relation to the stance foot [15]. Subjects were asked to practice four times in each direction as per suggestion by Robinson and Gribble as well as Munro and Herrington who found that performance on the SEBT stabilised after four trials [16]. Subject was made to stand on one leg in the centre of the grid and was asked to reach as far as possible with the reaching limb along the 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. The same process was repeated for the other limb. Three readings of maximum excursion distance were taken for each direction [17]. The reach distances were normalised by dividing it by limb length and multiplying by 100 [18]. Composite score was calculated by averaging the three normalised reach direction scores. Composite score of both sides was averaged to calculate mean composite score.

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. P value less than 0.05 was considered statistically significant.

3. Results

The study sample consisted of 42 subjects of age 18-35 years (22.64 ± 3.28) with mechanical neck pain of which 27 were female and 15 were male and the mean duration of neck pain in these subjects was 5 (± 1.41) months.

Table 1: Descriptive Statistics of Outcome Measures

Outcome Measures	*Mean*	*Median*	*SD*
NPRS	4.98	5	1.62
Sway velocity FIEO (deg/sec)	0.27	0.27	0.07
Sway velocity FIEC (deg/sec)	0.33	0.33	0.08
Sway velocity FOEO (deg/sec)	0.66	0.63	0.15
Sway velocity FOEC (deg/sec)	1.3	1.23	0.28
SEBT COMPOSITE SCORE	83.76	84.95	8.33

Significant positive correlation was found of NPRS with sway velocity in foam surface eyes closed condition (r = 0.31; p = 0.04) and significant negative correlation of NPRS and MSEBT composite score (r = - 0.45; p = 0.0026) in subjects with MNP.

No significant correlation was found of NPRS with sway velocity on stable surface in both eyes open and closed condition and on unstable surface in eyes open condition in subjects with MNP.

Table No. 2: Correlation analysis of outcome measures

Sr. No.	*Correlation*	*r - value*	*p - value*	*Significance*
1.	NPRS and sway velocity (FIEO)	0.13	0.42	Not Significant
2.	NRPS and sway velocity (FIEC)	0.05	0.73	Not Significant
3.	NPRS and sway velocity (FOEO)	0.003	0.98	Not Significant
4.	NPRS and sway velocity (FOEC)	0.31	0.04	**Significant**
5.	NPRS and Composite MSEBT score	- 0.45	0.0026	**Very Significant**

4. Discussion

Static balance requires integrated information from visual, vestibular and proprioceptive inputs to ensure orientation and stability of the body and affection of any of these inputs can result in increased postural sway [19].

MNP causes altered muscle spindle activity and changes in structure and function of cervical muscles [20]. This results in altered cervical proprioceptive inputs [4], [5]. Cervical proprioceptive inputs along with inputs from peripheral vestibular apparatus and visual system are sent to vestibular nuclei. Abberant cervical proprioceptive inputs due to neck pain when sent to vestibular nuclei and CNS, causes mismatch of inputs which directly influences vestibular function like balance [7].

In MCTSIB, when standing on foam surface with eyes closed, postural control is maintained with vestibular inputs alone [7], [19]. In this study, there was significant positive correlation of neck pain severity with sway velocity when standing on foam surface with eyes closed in subjects with MNP. This suggests altered vestibular inputs, which may have resulted in increased sway in the absence of visual and somatosensory cues.

Previous studies [8]-[10], [21] 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. A systematic review conducted by Ruhe et al [9], 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 Center Of Pressure (COP) excursions irrespective of the COP parameter chosen.

Varied results have been obtained for association of balance and neck pain severity owing to differences in conditions for assessing static balance, study population and outcome measures. Further, some studies included subjects with lower pain intensity and some with higher pain intensity. Hence, not considering pain severity may have acted as a confounding factor and impacted their study results.

Alexander Ruhe et al [22], studied relationship of postural sway with pain severity in subjects with nonspecific low back pain and found a positive correlation between them. Another correlation study was conducted by Ruhe et al [12], in nonspecific neck pain patients which reported significant correlation between neck pain severity and postural sway. In the above study [12], sway velocity was measured only in eyes closed firm surface condition with a narrow base of support, which is a more challenging task than that used in the present study. This might be a reason for not getting significant correlation between neck pain severity and sway velocity in eyes closed, firm surface but comfortable stance condition in the present study. Thus, insignificant results of the current study can be attributed to less challenging static test.

Static as well as dynamic balance is essential for postural control. Dynamic balance tests are more challenging and sensitive to appreciate postural control deficits [23]. 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 [24].

In this study, significant correlation was also found between neck pain severity and dynamic balance. MSEBT involves self initiating movement of lower limb which needs anticipatory control i.e pre-programming of force by CNS in anticipation of the required task. 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 center of mass (COM) motion that occurs due to pertubations or movements prior to gait initiation or whole body reaching movements [25], [26]. Head stability i.e head posture with respect to trunk, during whole body actions is important, in order to ensure a reliable reference frame, which is brought about by APA of neck muscles [27]. 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 [27].

Altered motor control of neck muscles has been associated in patients with neck pain [20]. 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 [5]. EMG studies have demonstrated inhibition of deep cervical flexors and increased activation of superficial muscles in patients with neck pain. This reorganisation of motor strategy was reported during neck flexion movement, isometric cervical flexion and during task involving dynamic movement of upper limb [5], [28], [29]. Also, delay in onset of the neck muscles activation exceeding the criteria (i.e within 50ms of deltoid contraction) for feedforward contraction during arm movements has been reported in neck pain subjects [29]. This indicates significant deficit in the automatic feedforward control of cervical spine or delayed APA of neck muscles. When performing MSEBT, subject has to stand on one leg and reach out with the other leg. This requires head stability which is brought about by APA of neck muscles 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.

A study conducted by Saadat M et al [23], 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 MSEBT which is a clinical test. The mean score obtained was correlated with pain severity. Significant positive correlation was found between them which can be attributed to altered cervical proprioceptive inputs and motor control of neck muscles due to neck pain.

It is debatable whether pain results in altered motor control or whether change in motor control results in pain. However, some changes in motor control seen in neck pain patients have also been reported in healthy subjects when induced with neck pain experimentally, suggesting pain may trigger initial motor control changes [5].

Limitation of this study is that randomised sampling technique was not used when recruiting participants for the study. Future studies correlating neck pain and balance should assess balance using tests which includes more complex sensory conditions like tandem stance or narrow stance.

5. Conclusion

The findings of the study conclude that,neck pain severity is related to balance affection in MNP patients. However, significant correlation was found only when balance was assessed in a challenging condition like standing on unstable surface with eyes closed and while performing dynamic balance test like MSEBT.

Clinical Implication: It is imperative to assess balance in subjects with severe MNP, as severe neck pain is related to balance affection and can lead to imbalance while performing challenging tasks. Along with pain relief, managing effects of pain like, altered motor control of neck muscles which affects cervical proprioception, should be included in treatment protocol of patients with MNP.

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