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Harish S Krishna
Professor, Department of Physiotherapy, Rajiv Gandhi University of Health Sciences, Mangalore, Karnataka, India

Sudeep Shetty
Professor and HOD, Department of Orthopaedics, Rajiv Gandhi University of Health Sciences, Mangalore, Karnataka, India

R Reshma
Post Graduate Student, Department of Physiotherapy, Rajiv Gandhi University of Health Sciences, Mangalore, Karnataka, India

Corresponding Author:
R Reshma
Post Graduate Student, Department of Physiotherapy, Rajiv Gandhi University of Health Sciences, Mangalore, Karnataka, India

Relationship between cervical proprioception and deep neck flexor endurance in subjects with forward head posture: A pilot study

Harish S Krishna, Sudeep Shetty and R Reshma

Abstract
Forward head posture, one of the most common abnormal head postures, is a postural head-on-trunk misalignment, which is defined as a head that is positioned anterior to a vertical line of gravity. It is a common postural variation in people of all ages, from childhood to old age and has been suggested to affect the cervical muscles and restrict neck movement, and impair cervical proprioception. The objective was to find the relationship between cervical joint position sense with deep neck flexor endurance in subjects with Forward Head Posture. 20 subjects with forward head posture (22- 55y old) were included in the study. The forward head posture was assessed by the craniovertebral angle, the error value of the cervical position sense was evaluated using the head repositioning accuracy test, neck flexor endurance test for the endurance functionality of cervical flexors. Karl pearson correlation coefficient was calculated between craniovertebral angle and head repositioning error. A strong negative correlation was found between craniovertebral angle and head repositioning error ($p<0.001$) and a moderate positive correlation between craniovertebral angle and deep neck flexor endurance ($p<0.01$) which was statistically significant. The study concluded that Forward head posture is correlated with greater repositioning error or reduced proprioception and endurance training of deep cervical flexors could improve the forward head posture.

Keywords: forward head posture, cervical proprioception, head repositioning accuracy, cervical joint position sense error, deep neck flexor endurance

1. Introduction

The prevalence of Forward head posture (FHP) is estimated to be about 85.5% of the general population. [1] Its prevalence in children and teenagers is 53.5% and also a significant association is seen between FHP and gender [1]. This malalignment has been suggested to affect the length tension relationship in the cervical muscles, increase muscular activity level, restrict neck movement, and impair cervical proprioception [2]. Several musculoskeletal problems, including neck pain, cervicogenic headache, temporomandibular disorder, and muscular dysfunction were also reported in patients with forward head posture. [3] Consequently, degenerative changes of intervertebral and facet joints are expected. Given that cervical structures consist of a huge amount of mechanoreceptors; it is believed that the neck proprioceptive function is disturbed in individuals with FHP [4].

Whole-body balance, postural awareness, and gait control are all aided by Cervical Joint Position Sense. There are numerous reports in the literature on the effect of various factors on proprioception, such as age, trauma, pain, fatigue, and disease [5]. Proper function of the head-neck system has been shown to rely on proprioception, including joint positioning sense and repositioning sense. These are provided by receptors in the zygapophysial joints and small intrinsic muscles in the neck. Revel *et al.*, who were the first author to report about the affected joint position sense, found that reposition sense in subjects with neck pain was impaired [6].

The deep neck flexor (DNF) muscles, including the longus capitus and the longus colli, function as cervical segmental flexors that dynamically stabilize the neck and contribute to head acceleration control [7]. Muscles are proprioceptive information sources. The deep cervical muscles, being rich in muscle spindles, have been thought to play a relatively more prominent role in sensory motor function of this region [8].

The deep neck flexors is an important muscle for the control and support of the neck, supporting the weight of the head against gravity and stabilizing the head and are responsible for maintenance of cervical lordosis and intersegmental stability during activities of daily living [8, 9]. Improved DNF performance has been shown to reduce neck pain, increase the pressure pain threshold in the cervical region, increase anterior cervical muscle endurance and defatigability, decrease cervical joint position error, improve sensorimotor control, decrease perceived cervical disability, and improve head-shoulder posture [7]. Hence, deep neck flexor muscle dysfunction in terms of increased fatigability may be associated with proprioceptive dysfunction and poor postural control [8]. Although there is evidence for the relevance of both factors to FHP, but no study has yet investigated the association between the endurance capacity and proprioceptive functioning of the deep cervical muscles in Forward head posture subjects. So, the aim of the study is to correlate Cervical proprioception with Deep Neck flexor endurance in subjects with FHP. If this study concludes that Neck flexor endurance is associated with cervical proprioception in FHP subjects, endurance training should be started early in subjects with Forward head posture to improve proprioception.

2. Materials and Methods

A pilot study was conducted on 20 forward head posture subjects aged 20 to 55-year-old in a period of 3 months. A convenience sampling technique was used to include the participants in the study. Ethical clearance was obtained from the ethics committee. Participants who are willing to take part in the study were screened for inclusion and exclusion criteria, after seeking their written consent, and the subjects falling within the inclusion criteria were recruited for the study. Participants with CVA angle less than 49 degrees, no history of neuromuscular disorder, no history of fracture and moderate to severe scoliosis were included in the study. Participants were excluded if they had history of trauma or surgery on the spine, Congenital deformities, Inflammatory diseases or Vestibular impairment. The CVA was measured between the line passing C7 and the midpoint of the ear tragus with the horizontal line with a goniometer. CVA less than 49 degrees was considered as Forward Head Posture. This study involved minimal equipment such as a head strap with laser pointer, chair, target, stopwatch, inch tape, plinth, pen/pencil, paper, marker.

2.1 Procedure

At first, informed consent was obtained from the participants. A brief introduction to the procedure was explained to all the subjects. Participants were recruited on basis of the inclusion and exclusion criteria. After the recruitment, an initial examination including demographic data, craniovertebral angle was carried out before the study.

2.2 Outcome Measure

To assess cervical joint position sense error by Head Repositioning Accuracy Test and to assess deep neck flexor endurance by Neck Flexor Endurance Test.

2.2.1 Head Repositioning Accuracy Test

The Participants were requested to sit upright on a chair with a backrest, in a neutral but comfortable head position (NHP) with hips and knees flexed at 90° at a fixed distance of 90 cm to a target, wearing a headlight laser pointer on the head. A circular graduated target (40cm diameter with concentric circles every centimetre) was divided into 4 quadrants separated by 2 axes intersecting at 0. The target will be placed on the wall in front of the subject and adjusted to align with the subject's reference head position. Opaque goggle was used to occlude the vision during the test. The subjects, vision occluded, was instructed to adopt the self-determined neutral head neck position, defined as the reference position. Then, the target was placed so that the laser pointer on top of the head strap pointed to the target's centre. For each trail, the subject was instructed to memorize the initial reference point, then to perform a maximal cervical rotation (horizontal plane) for about 2 secs and to accurately return to the reference position without any speed constraint. The error in head repositioning after an angular head displacement, the cm measurements on the target was converted to degrees from the centre of rotation. The Arc tangent of the distance between the reference and target points divided by the distance between reference point and the laser pointer was considered as Head Repositioning Error. Each participant performed 3 trials. The average amount of three HRE was used for data analysis. No complication or discomfort was reported by participants after HRE test.

2.2.2 Cervical deep neck flexor endurance test:

The participants in the "crook lying" position with the arms alongside the body was asked to raise their head approximately 2cm of the plinth while keeping their chins tucked in (craniocervical flexion posture). Losing the chin tucked posture, having the head back in contact with the plinth for more than 1 second, or reluctance to continue for any reason led to test termination. The test duration was measured in seconds with a stopwatch. The examiner visually monitored the cervical posture during the test.

2.3 Statistical analysis

SPSS, version 20.0 was used for data analysis. The obtained data were collected and statistically analysed using descriptive statistic. Karl pearson correlation coefficient was used to find the relationship between craniovertebral angle (CVA) and head repositioning error (HRE), CVA and deep neck flexor endurance (DNFE). p value <0.05 was considered significant

3. Results

The study consists of 20 Forward head subjects. [Table 1] shows the description statistics age of the age, craniovertebral angle, head repositioning accuracy and deep neck flexor endurance. In the studied population, 75% subjects were males and 25% subjects were females.

The [Table 2] shows the Pearson correlation analysis of the variables craniovertebral angle with Head Repositioning Error and Deep Neck Flexor Endurance. The results of the present study suggested that a strong negative correlation was noted between CVA and HRE (p<0.001) Moderate positive correlation was noted between CVA and DNFE. However, the correlation was found to be statistically significant (p<0.01)

Table 1: Demographic data of the study

Age (yr) Mean ± SD	CVA (%) Mean ± SD	HRE Mean ± SD	DNFE (secs) Mean ± SD
24.6±0.98	41.5±2.3	7.3±0.34	32.2±3.42

Table 2: Correlation of Craniovertebral angle, Head repositioning error, and deep neck flexor endurance.

Correlations	r value	p value
CVA & HRE	-.786	.000
CVA & DNFE	.635	.003

4. Discussion

This study explored the association between HRE and deep neck flexor endurance in participants with forward head posture. Nowadays, the use of visual display terminals (VDT) of computers and smartphones in almost all homes and organizations is very common. Excessive use of VDTs causes musculoskeletal disorders. FHP is one of the most common disorders among these. FHP is distinguished by upper cervical extension as well as lower cervical flexion. These changes in the cervical region may result in musculoskeletal dysfunction, such as a "upper crossed syndrome," as a result of maintaining a poor head position for an extended period of time. Furthermore, patients with FHP frequently complain of neck and shoulder pain. These pains cause a reduction of joint sense which influences abnormal proprioception and poor postural balance. The present study examined the position-reposition error of the cervical region in order to investigate whether FHP affects joint position sense. Higher error rates were shown by subjects with increased FHP. This result suggests that FHP affects joint position sense.

There was a strong negative relationship between CVA and HRE, which agrees with the findings of a previous study by *Lee et al.* who found an inverse correlation between the craniovertebral angle and error value of the joint position sense [10] As a result, the worse the HRE, the more severe the FHP. This could be explained by the fact that FHP changes the alignment of the cervical spine and the length of the neck muscles. FHP also adds extra loads to facet joints and the posterior capsule [11]. Therefore, as a result of altering mechanical loads to the articular and muscular structures, muscle spindles and other mechanoreceptors afferent signals are negatively affected [5].

The present study also showed a moderate positive relationship between CVA and deep neck flexor endurance. Deep, local slow-twitch muscles are believed to be responsible for the posture maintenance task manifested as the endurance score. Because the same group of muscles have been proposed to be rich in muscle spindles providing proprioceptive afferent to the CNS, these two functions should be correlated, but the hypothesis was rejected. Possible reason would be that it should be noted that these findings are all based on the clinical cervical endurance test for the flexor group of muscles. The validity of this test in determining the true flexor endurance capacity of the cervical spine may be called into question. With this test, it is impossible to distinguish between the deep and superficial flexor muscles of the neck. *Jull et al.* found no acceptable validity for the clinical flexor endurance test when they compared its results to electromyographic indices [12]. although it has been proposed that there is a differential involvement in the superficial and deep cervical muscles in the presence of CNP [13]. This may highlight the importance of using clinical tests capable of distinguishing between the deep and superficial groups of cervical flexor muscles when assessing patients, and it may have implications for the prescription of exercises to address endurance in these patients.

The findings of the present study should be interpreted with the following limitations in mind, First, because our participants were drawn from a young population, we were unable to assess the effects of ageing on HRE. Future studies on a larger population are encouraged to look into different age groups. The second limitation of the current study was that we did not include a healthy control group to see how much the HRE differed in the normal population. Endurance was measured by the participants' inability to maintain the desired position, regardless of what caused them to lose it. The lack of a relationship between proprioceptive function and endurance as measured by the clinical flexion endurance test calls for more research into the validity and relevance of these commonly used assessment tools in cervical spine evaluation.

5. Conclusion

On the basis of the data in this study, our findings suggest that there is a positive association between the FHP severity and the HRE in individuals with FHP and also the clinical cervical flexor endurance test, ignoring the relative contribution of the deep and superficial muscle groups, may not adequately characterise FHP subjects. This highlights the importance of assessing and possibly rehabilitating the endurance capacity of the two muscle groups in FHP subjects.

6. Acknowledgments

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