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CORRELATION BETWEEN CRANIOVERTEBRAL ANGLE, DEEP NECK FLEXOR ENDURANCE AND POSTURAL SWAY IN COMPUTER USERS WITH FORWARD HEAD POSTURE.

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ABSTRACT

Introduction: Due to work from home, the duration of exposure to the screen has increased hence forward head posture can be commonly present. Due to forward head posture, the deep cervical flexors are weakened and proprioceptive afferent input from neck muscles can affect the postural control. This study was undertaken to find the interplay between the craniovertebral angle, deep neck flexor endurance and postural sway in forward head posture. **Aim:** To correlate the craniovertebral angle, deep neck flexor endurance and postural sway in computer users with forward head posture. **Setting and design:** 86 computer users were screened for forward head posture from tertiary healthcare center's offices by purposive sampling. Craniovertebral angle was assessed using photographic method and deep neck flexor endurance was assessed using deep cervical flexor endurance test and postural sway was measured using modified- clinical test for sensory interaction in balance test. **Results:** Statistical analysis was done using the Pearson's correlation test after checking for normal distribution. The correlation test between craniovertebral angle with deep neck flexor endurance and postural sway indicated that there was negative correlation coefficient with a p value of more than 0.05 which was statistically insignificant. The correlation test between deep neck flexor endurance and postural sway indicated that there was positive correlation coefficient with a p value of less than 0.05 which was statistically significant. **Conclusion:** There was negative correlation of craniovertebral angle with deep neck flexor endurance and postural sway in computer users with forward head posture and a positive correlation between deep neck flexor endurance and postural sway in computer users with forward head posture.

KEYWORDS :

INTRODUCTION

In India, 66% of the population use computers for doing office work and 59% have reported that they had experienced some form of musculoskeletal health symptoms, out of which 30% of the IT professionals have most frequently experienced neck pain [1]. The percentage of the population that use a personal computer or smartphone has increased as work from home and use of advanced technology is implemented in all fields. Body posture is defined as a state of alignment of the body for a specific amount of time and ideal posture describes a state of maintaining balance in the body using minimal musculoskeletal activity without causing any pain or discomfort[2]. Majority of laptops are designed with the screen joined to the keyboard, making it impossible to adjust the two separately in terms of screen height and distance.[3]. Due to long working hours and improper position of the chair and screen the users find it difficult to maintain optimal posture. This has caused changes in the alignment of the spine, leading to improper posture causing forward head posture [1,2].

The forward head posture is characterized by a dorso extension of the head together with the upper cervical spine (C1-C3), accompanied by a flexion of the lower cervical spine (C4-C7) due to which the cervical curvature is increased causing a condition called hyper lordosis [4]. Forward head posture is identified by craniovertebral angle which is defined as the angle measured at the juncture of a line drawn from spinous process of C7 to the tragus of the ear and a horizontal line that passes through C7.[3,4]

Forward head posture increases the length of the external moment (the arm) by moving the gravitational centre (the head) ahead of the load bearing axis thereby increasing the load on posterior neck muscles [5]. This biomechanical strain, in the presence of reduced strength of the core stabilizing neck musculature, if prolonged, is the predominant explanation for symptoms associated with this posture. The deep neck flexors (longus coli and longus capitis) are located inside the neck and placed laterally at the upper vertebral column. Inappropriate load due to sitting for long period and abnormal pattern of posture can cause a permanent contraction of the cervical spine extensors. This may not be balanced by the deep neck flexors in the long term and can affect the deep neck flexor endurance [7]. The deep neck flexor muscles play an important role in stabilizing the cervical spine and maintaining the lordosis of the neck during cervical movement[8,9].

Postural sway is defined as the **horizontal movement around the centre of gravity.** The cervical vertebrae contribute to proprioceptive sense input[12]. The proprioceptive sensing of the cervical vertebrae can transmit information to correct malalignment and can play an important role in postural control. It reacts sensitively to the fine movement of the head by acting in coordination with sensory input coming from the vestibular system, somatosensory and visual system. People who use computer for longer duration have relatively protruded heads which causes their COG to shift anteriorly to maintain balance. In quantification of their balancing abilities, these individuals had posture imbalance and relatively reduced motor control ability [4,13]Hence, we need to study the interplay of relationship between the craniovertebral angle, deep neck flexor endurance and postural sway in computer users with forward head posture.

AIM

To correlate between craniovertebral angle, deep neck flexor endurance and postural sway in computer users with forward head posture.

OBJECTIVES

1. To measure
   (a) the craniovertebral angle by using photographic method.
   (b) deep neck flexor endurance by deep neck flexor endurance test.
   (c) the postural sway by modified clinical test for sensory organization.
2. To correlate the craniovertebral angle with postural sway in computer users with forward head posture.
3. To correlate the craniovertebral angle with deep neck flexor endurance in computer users with forward head posture.
4. To correlate the deep neck flexor endurance and postural sway in computer users with forward head posture.

METHODOLOGY

Type of study:- Correlational study.

Place of Study: Tertiary healthcare centre.

Duration of Study: 1 year.

Sample size:-86.

Sampling method: Purposive sampling.

Inclusion criteria:

1) Participants were included if they were asymptomatic and age between 30 and 50 years old with craniovertebral angle of 50° or lesser as measured by the photographic method [3]; and had not sought medical/health care for neck, shoulder pain over the past month.
2) Computer users who have been using a computer for a duration of greater than or equal to 6 hours/day and have been using the computer for more than a year were included in the study[3,9].

Exclusion criteria[24]

1. Neck pain due to all conditions.
2. Computer users who do not have forward head posture.
3. Previous neck and upper limb surgery.

Methodology:

- After receiving approval from the Institution's Ethics Committee, subjects who were fitting into the inclusion criteria were recruited.
- An informed written consent was taken prior to screening and recruiting the patients in the study.
- Computer users underwent screening for forward head posture by photographic method. The craniovertebral angle was calculated and if the angle was 50 degrees or lesser the participants were included for further assessment in the study[3]

Assessment Of Craniovertebral Angle[5,17,25,26,27]

1. Each subject was asked to stand relaxed on a mark over the floor at 1.5 m from the camera during the assessment.
2. The examiner identified the cutaneous bony points and placed the coloured adhesive tapes to mark the C7 spinous process.
3. The C7 spinous was identified by palpating the lower cervical spine, while flexing or extending the cervical spine.
4. A picture of the sagittal view of the right upper body was taken using the camera.
5. The captured image was subsequently processed digitally using Windows Microsoft Paint application.

Image processing in Microsoft Paint:

- The angle was drawn manually using “angle” tools in the Microsoft's Paint for the Windows 10 operating system.
- These triangles were made by connecting the anatomical reference points (tragus, C7 spine) in order to enhance the accuracy of angle measurement using WPD software.

Image processing in WPD software[25]:

- The captured image was uploaded into the WPD software, and the angle of forward head posture was measured using “angles measure” function.

Craniovertebral angle:

- The craniovertebral angle was measured between the line connecting 7th cervical spine (C7), the middle part of tragus of the ear and the horizontal line passing through it (C7-tragus-horizontal)[4,6].
- A decrease in angle measured indicates a more forward neck posture.

For Assessing Deep Neck Flexor Endurance Test:[28,29,30,31]

1) The patient was made to lie supine in crook lying.
2) The chin was made to maximally retracted by the patients and maintained while the patient lifts the head and neck until the head is approximately 2 to 5cm (1inch) above the examining table.
3) The examiner placed a hand on the table under the patients table (occiput).
4) The examiner watched the skin folds resulting from the chin tuck and neck flexion. As soon as the skin folds separate (due to loss of the chin tuck) or the patient's head touches the examiner's hand, the test was terminated.
5) Normal people should be able to hold for 39 +/- 26 second without any complaints of pain.

For Assessing The Postural Sway[32,33]

- Modified clinical test for sensory integration balance test(m-CTSIB) – It measures subject's postural stability, how much they are swaying forward or backward from the center of gravity, while they maintain a standing posture for 30 seconds under each of 4 conditions, with a fixed/swaying force platform, open/closed eyes.
- Condition 1 was a fixed force platform, with open eyes;
- Condition 2 was a fixed force platform, with closed eyes;
- Condition 3 was a swaying force platform, with open eyes;
- Condition 4 was a swaying force platform, with closed eyes;

There is a clinical test for sensory interaction in balance (CTSIB): By, Shumway-Cook and Horak.

Time in balance and increased sway or loss of balance are recorded. Each condition is scored on an ordinal scale based on performance in time and sway 0 to 3 (0 = unable, 1 =<30 seconds, 2 = 30 seconds unstable, 3 = 30 seconds stable).

RESULTS

120 Computer users were assessed for screening of the forward head posture. Out of which 86 computer users were recruited after taking a written informed consent. Forward head posture was assessed by calculating the craniovertebral angle. Craniovertebral angle was measured using photographic technique, reading was recorded in degrees. Deep cervical neck flexor endurance was calculated using deep cervical neck flexor endurance test, readings were recorded in seconds. Postural sway was measured using modified - clinical test for sensory integration for balance where the time in balance was recorded in seconds and sway was graded from 0 to 3 in all 4 positions.

- All the data analysis was performed using IBM SPSS statistical software (version 26).
- Results were analyzed keeping 95 % confidence interval and significance at p value of 0.05.
- The mean and median of the baseline data was calculated and represented in a tabular form.
- The data was distributed in normal distribution.
- Hence the data was analyzed using Pearson's Correlation test for all the 3 variables.

Descriptive Analysis

Table 1: Showing Characteristics Of All Subjects

	Count	Minimum	Maximum	Percentile 25	Median	Percentile 75	Mean	Standard Deviation
AGE	86	30.00	56.00	31.00	34.00	38.00	36.15	6.88
CVA	86	34.00	50.00	42.00	46.00	47.00	47.31	2.34
DNF E	86	5.00	33.00	11.00	15.00	20.00	15.79	6.08
Time in balance (a)	86	20.00	30.00	27.00	30.00	30.00	28.45	2.51
Time in balance (b)	86	10.00	30.00	20.00	24.00	27.00	23.97	4.21
Time in balance (c)	86	10.00	30.00	15.00	20.00	24.00	19.28	4.65
Time in balance (d)	86	4.00	28.00	9.00	12.00	18.00	12.79	5.63

- CVA- Craniovertebral angle
- DNF E – Deep Neck flexor endurance
- Time in balance was recorded in seconds and it was an indicator of postural sway.
- The greater is the time in balance lesser is the postural sway.

The table shows percentage of subjects having mild, moderate and severe degree of forward head posture.

65 %	Mild degree of forward head posture
22%	Moderate degree of forward head posture
13%	Severe degree of forward head posture

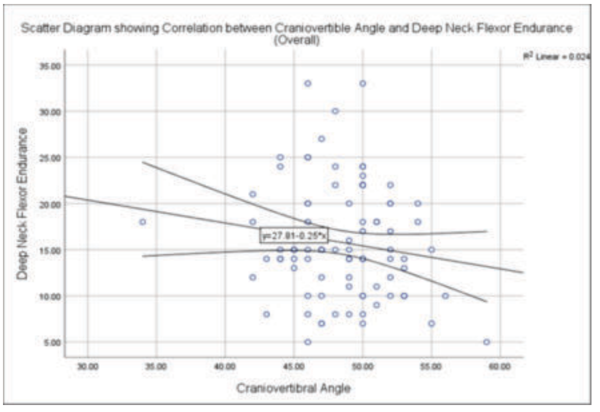
Quantitative Analysis

Correlation Test:

(1) Craniovertebral Angle With Deep Neck Flexor Endurance: (All Subjects)

Table 2. Correlation Of Craniovertebral Angle With Deep Neck Flexor Endurance.

		Deep Neck Flexor Endurance
Craniovertebral Angle	Pearson Correlation	-.154
	Sig. (2-tailed)	.151
	N	86



Graph 1. Showing Correlation Between Craniovertebral Angle And Deep Neck Flexor Endurance

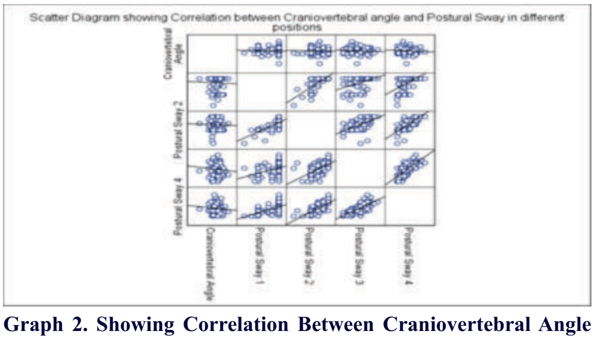
Interpretation:
There is a negative correlation between craniovertebral angle and deep neck flexor endurance and p value is 0.151 which is not less than 0.05 hence it is not statistically significant.

2. Craniovertebral Angle With Postural Sway: (All Positions)
Time in balance was recorded in seconds and it was an indicator of postural sway.

The greater is the time in balance lesser is the postural sway.

Table 3. Correlation of craniovertebral angle with postural sway. (Time in balance)

		Postural Sway Time In Balance 1	Postural Sway Time In Balance 2	Postural Sway Time In Balance 3	Postural Sway Time In BalANCE 4
Craniovertebral Angle	Pearson Correlation	-.032	-.030	-.083	-.087
	Sig. (2-tailed)	.768	.781	.441	.417
	N	86	86	86	86



Graph 2. Showing Correlation Between Craniovertebral Angle And Postural Sway (time In Balance) In Different Positions

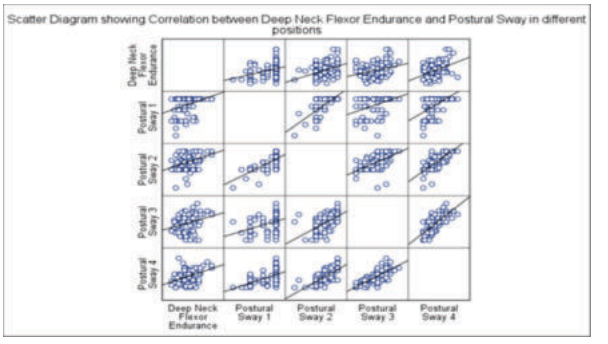
Interpretation:
There is a negative correlation between craniovertebral angle and postural sway (time in balance) in all positions with a p value more than 0.05 hence it is statistically insignificant.

3. Deep Neck Flexor Endurance And Postural Sway: (all Subjects)
Time in balance was recorded in seconds and it was an indicator of postural sway.

The greater is the time in balance lesser is the postural sway.

Table 4. Correlation Of Deep Neck Flexor Endurance And Postural Sway. (time In Balance)

		Postural Sway Time In Balance 1	Postural Sway Time In Balance 2	Postural Sway Time In Balance 3	Postural Sway Time In Balance 4
Deep Neck Flexor Endurance	Pearson Correlation	.329**	.377**	.291**	.421**
	Sig. (2-tailed)	.002	.000	.006	.000
	N	86	86	86	86



Graph 3. Showing Correlation Between Deep Flexor Endurance And Postural Sway (time In Balance)

Interpretation:
There is a weak positive correlation coefficient with a p value less than 0.05 that means the test is statistically significant in first 3 positions and with a moderate positive correlation coefficient with a p value less than 0.05 that means the test is statistically significant in 4th position.

Hence there is a correlation between deep neck flexor endurance and postural sway (time in balance) in all 4 positions.

DISCUSSION
The study was conducted at the tertiary healthcare center's offices. The mean age of the population was 36.15 years with age group between 30 to 50 years as explained in table 1. It is observed that there was no effect of age on craniovertebral angle and deep neck flexor endurance although it is evident that there is an increase in postural sway with increase in age. This can be attributed to age related increase in postural sway with center of pressure displacement ranges as reported in previous studies by Norris, Marsh et al., 2005.

Craniovertebral angle is used to assess the forward head posture. The mean craniovertebral angle is 47.31 degrees with standard deviation of 2.34 degrees. Craniovertebral angle varies from 34 to 50 degrees for our study population. The smaller is the craniovertebral angle greater is the degree of forward head posture. The degrees of forward head posture are as follows: 47 to 50 degrees is mild degree of forward head, 44 to 46 degrees is moderate degree of forward head, less than 44 degrees is considered as severe forward head posture. [30] According to our study, 65% of the subjects were having mild degree of forward head posture and 22% of the subjects were having moderate degree of forward head posture,13% of the subjects were having severe degree of forward head posture.

The cervical flexors, essentially the deep neck flexors help in stabilizing the cervical spine during neck movement. According to table 1, for this study participants, mean deep neck flexor endurance is 15.79 secs with standard deviation of 6.08 secs. Deep neck flexor endurance in our study varies from 5 to 33 secs. Normal values of deep neck flexor endurance are ranging from 26 to 39 secs. This indicates that there is slight decrease in the deep neck flexor endurance values. Forward head posture puts biomechanical stress on deep neck flexors due to change in the alignment of the head in the anterior direction.[5,17]

Postural sway is defined as the horizontal movement around the center of gravity.[34,36] Time in balance was recorded in seconds and decrease in time in balance indicates increase in postural sway. According to table 1, mean time in balance in position 1 was 28.45 secs. In position 1, subject stands on stable surface and with eyes open so here all 3 systems are giving feedback to the body. For study participants, mean time in balance in position 2 was 23.97 secs with standard deviation of 4.21 secs. In position 2 of postural sway, the subject stands on fixed platform with eyes closed. Here the visual feedback is blocked so subject relies on the somatosensory and vestibular systems for sensory perception. For study participants, mean time in balance in position 3 was 19.28 secs with standard deviation of 4.65 secs. In position 3, the subject was asked to stand on unstable surface with eyes open, here the somatosensory system is challenged so body has to rely on visual and vestibular feedback to maintain balance. Postural sway is greatly increased in this position. For study participants, mean time in balance in position 4 was 12.79 secs with standard deviation of 5.63 secs. In position 4, subject was asked to stand on unstable surface with eyes closed so here both somatosensory and visual systems are challenged. In forward head posture alignment, the center of gravity of the head is altered which can affect the proprioception leading to postural sway. [19,20,41] In this study there was increase in postural sway because the time in balance was decreased.

According to table 2 and graph 1, there is negative correlation coefficient (-.154), and p value is > 0.05 indicating that it is not statistically significant. There was slight decrease in deep neck flexor endurance test values. Contrary to what was expected, there is decrease in the deep nec k flexor endurance with decrease in craniovertebral angle. The reason for this study findings can be attributed to 65% of subjects having mild degree of forward head posture hence the change in the muscle endurance was probably not evident.

Due to the forward head posture, there is a change in the alignment of head on neck, that is., increase in the sagittal vertical alignment (SVA). As seen in the figure 1, the Sagittal vertical alignment represents the horizontal offset between two cervical spine bones as seen between the head centre of mass (approximated by the external auditory meatus) and the superior posterior margin of T1.. Now the greater is the degree of forward head posture greater is the sagittal vertical alignment measurement[29,30].

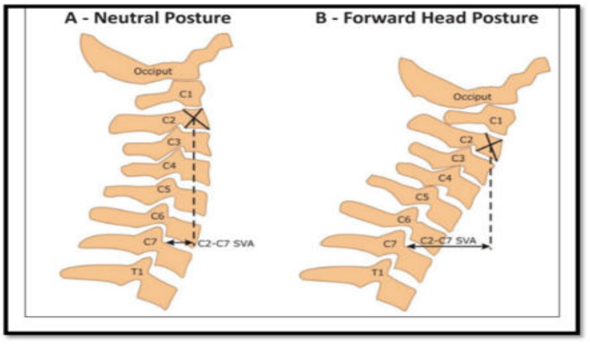


Figure 1. Change in Sagittal vertical alignment in forward head posture.[43]

Morphological factors such as muscle length, sarcomere length, muscle thickness does affect the endurance of the muscles. The muscle length is inversely related to the muscle endurance. Endurance is the function of internal muscle force. [48] Deep, local slow-twitch muscles are believed to be responsible for the posture maintenance task hence endurance can get affected.

Previous studies support the finding that the muscle thickness of deep cervical flexors can affect the endurance. [50] The muscle volume will get altered which can affect the contractility of the muscle hence indirectly it can affect the endurance of the muscle. For endurance to get affected, the muscle morphological changes occur as a late consequence due to exposure to forward head posture.

According to table 3 and graph 2, there is a negative correlation between craniovertebral angle and postural sway in all four positions in computer users with forward head posture. In our study, there was decrease in craniovertebral angle with increase in postural sway. The time in balance was recorded and from our study there was a decrease in this balance time hence we got an increase in postural sway.

One of the reasons was anticipatory postural adjustments which are used in a proactive manner, to stabilize the body before making a voluntary movement. Literature suggests that there is increased muscle co-contraction throughout the body in exaggerated forward head posture condition to avoid falling.[9]

According to normal postural control mechanism, central nervous system must activate synergistic muscles at mechanically related joints to ensure that forces generated at one joint for balance control do not produce instability elsewhere in the body [54,55]. The specific movement patterns used to recover stability following displacement of the center of mass in the sagittal plane are selected by the central nervous system based on a number of factors, including characteristics of the perturbation (e.g., direction and magnitude), and biomechanical constraints, including musculoskeletal geometry and intersegmental dynamics of the individual's body. Hence with decrease in craniovertebral angle in forward head posture, the change in center of gravity due to shift in the alignment can probably affect the postural sway.

Neck muscles have a high spindle density because the muscles in eye/head coordination are used for reaching out for objects and move about in the environment. Hence, neck position plays important role in proprioception. Inputs of cervical proprioception give significant somatosensory feedback hence affection of postural stability can be seen in forward head posture[9,14,20,23].

Sensory information has a vital role in modulating the output of movement that results from the activity of pattern generators in the spinal cord . Due to forward head posture, the sensory feedback probably gets altered hence indirectly affecting postural control.

Hence the factors mentioned above cause changes that occur in the postural control, the degree of forward head, the duration of exposure to the screen as discussed earlier, alignment of center of gravity plays an important role in determining the anticipatory postural adjustments that are done by the body when the sensory systems are challenged due to change in posture.

According to table 4 and graph 3, there is a positive correlation of the deep neck flexor endurance and postural sway in computer users with forward head posture. There was slight decrease in deep neck flexor endurance test values. There is decrease in the deep neck flexor endurance with decrease in the time in balance. Forward head posture can put a biomechanical stress on deep neck flexors and cause an imbalance in the muscles which can put pressure on neck-extensor muscles and can cause neck-flexor muscle weakness. Exhaustion and fatigued muscles influence both power and position of head and coordination while maintaining the posture.

Whenever there is a voluntary contraction, there is coactivation of both alpha (activating the main muscle, i.e., the extrafusal muscle fibre) and gamma (activating the spindle muscle, i.e., the intrafusal fibre) motor neurons. The sensory deficits seen in forward head posture can be one of the probable reasons of this positive correlation.

Hence, there is an interplay between the craniovertebral angle, deep neck flexor endurance and postural sway in computer users with forward head posture.

CONCLUSION

There is a negative correlation of craniovertebral angle with deep neck flexor endurance and with postural sway in computer users with forward head posture and a positive correlation of deep neck flexor endurance with postural sway in computer users with forward head posture.

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