Journal of Chemical Health Risks

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JCHR (2024) 14(2), 952-959 | ISSN:2251-6727

"A Corelation Between Craniovertebral (CV) Angle, Cervical Range of Motion and Deep Neck Flexor Muscle Endurance in Young Adults with Neck Pain"

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(Received: 07 January 2024 Revised: 12 February 2024 Accepted: 06 March 2024)

KEYWORDS

Neck Pain, Craniovertebral angle, Forward Head Posture (FHP), Deep Neck Flexor Muscle Endurance (DNF Endurance), Cervical Range of Motion (Cervical ROM)

ABSTRACT

BACKGROUND: By definition neck pain is pain perceived as arising in a region bounded superiorly by the superior nuchal line, laterally by the lateral margins of the neck, and inferiorly by an imaginary transverse line through the T1 spinous process, associated with poor general health status, psychological distress, and previous neck injury, in addition to a range of other factors such as occupational tasks and obesity. Key elements of cervical muscle performance are strength, power, and endurance. If any one or more of these areas of muscle performance is impaired, functional limitations and disability or increased risk of dysfunction may occur. Imbalances in cervical muscles resulting if postural misalignment are prolonged, an excessive load is imposed on the joints and muscle, resulting forward head posture.

AIM: To find out corelation between Craniovertebral (CV) angle, Cervical Range of Motion (ROM) and Deep Neck Flexor muscle (DNF) Endurance in young adults with neck pain.

METHODOLOGY: Total 58 subjects were taken in this study. By photographic method Craniovertebral (CV) angle, by Bubble Goniometer Cervical ROM and by muscle force technique cervical Deep neck flexors endurance are checked. Cervical ROM degrees, Degree of CV angle and time in seconds for DNF endurance are taken as outcome measures.

RESULTS: Data were analysed by SPSS statistics 26.0 software. Normality of the data was checked by Shapiro-wilk test and it showed that data is of non-parametric type. Spearman Correlation test was used to determine the degree of association between deep neck flexors muscle endurance, Cervical ROM and craniovertebral angle. The results revealed that there is low positive ($r = 0.118$) correlation between deep neck flexor muscle endurance and craniovertebral angle. (p value for above results was > 0.05) Craniovertebral angle and cervical rotations have negatively correlated while other cervical range of motions have positively correlated with CV angle. DNF endurance with cervical extension has negatively correlated while other cervical range of motion are positively correlated.

CONCLUSION: It can be concluded from this study that any deviation in craniovertebral angle can affect deep neck flexor muscle endurance as both are low positive correlated with each other in young adults with neck pain. Similarly, DNF Endurance and CV angle changes significantly affects cervical ROM.

1. INTRODUCTION

Neck pain is defined as the pain perceived as arising in a region bounded superiorly by the superior nuchal line, laterally by the lateral margins of the neck, and inferiorly by an imaginary transverse line through the T1 spinous process, associated with poor general health status, psychological distress, and previous neck injury, in addition to a range of other factors such as occupational tasks and obesity.[1,2] Neck pain can result from irritation, injury, inflammation, or even infection of almost any of the contained tissue.[1,2] Neck pain is a common condition affecting as much as two-thirds or more of the general population at one point of time during their life.[3] Prevalence of neck pain in young adults is not the same all over the world. The prevalence of neck pain varies largely between studies with a mean point prevalence of

Journal of Chemical Health Risks

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JCHR (2024) 14(2), 952-959 | ISSN:2251-6727

7.6% and mean lifetime prevalence of 48.5%. The prevalence of neck pain in the overall population ranging between 16.7% to 75.1%.[4] The prevalence was found to be highest in the age group of 21–40 years followed by 41–60 years. More frequent neck ache (and shoulder ache) was found in 15.4% of males and 24.9% of females with age range 20–56 years.[5]

Neck pain has been associated with poor general health status, psychological distress, and previous neck injury, in addition to a range of other factors such as occupational tasks and obesity, Which led to clinical symptoms such as pain and stiffness in the neck, headache, dizziness, and radiating pain to shoulders and the upper limbs associated with decreased range of cervical movement, increased fatigability, and decreased pressure pain thresholds of cervical muscles.[6] Co-morbidities such as anxiety, depression, and low back pain may indicate more severe conditions.[7] The structures of the neck-cervical region in the body include seven cervical vertebrae, intervertebral discs, muscles, ligaments, arteries, veins, nerves, lymphatics, glands, hyoid bone, oesophagus and trachea. The Musculature of the human cervical region (neck) has developed in response to two major functional demands. With the development of bipedal gait and upright posture, the position of the skull has moved more directly over the cervical spine. Two major functions of the neck musculature are (a) to stabilize the head during external perturbations or body movements and (b) to provide orienting or voluntary head movements. Stability implies support and is related to the stiffness of the supporting structure. In the vertebral column, muscular and ligamentous connections provide this stiffness.[8] Muscles of neck run from the base of skull to the back & are divided into categories of anterior & posterior cervical muscles; cervical flexors (superficial & deep) & extensor muscles. Out of these, deep cervical neck flexor muscles are considered to be an important stabilizer of the head-on-neck posture.[9]

Deep Cervical Neck Flexor (DNF) muscles (longus colli, longus capitis, rectus capitis anterior and rectus capitis lateralis)[2] lying on the anterior of the cervical spine and occiput act to support the cervical lordosis, to flex the occiput on the atlas, and are postulated to assist in cervical segmental stability during gross movements of the neck initiated by the more superficial flexors.[2] Location of deep cervical neck flexors suggest that they potentially play an important role in stabilizing the cervical spine.[9,10] It has been demonstrated & proved in various studies that DNF muscles are increasingly active during cranio-cervical flexion (chin tuck) and individuals who have weak or compromised DNF are more prone to experience neck pain in near future.[9] When muscle performance is impaired, the balance between the stabilizers on the posterior aspect of the neck and the DNF will be disrupted, resulting in loss of proper alignment and posture, which is then likely to contribute to cervical impairment.[10] Sustained postural loading during occupational and recreational tasks is increasingly being recognized as an important etiological factor for mechanical neck and upper back pain.[11]

The factor which is an important determinant of postural control and magnitude of cervical spinal loading is the level of muscle activity associated with the neck posture. Impairments of muscle function which appear most relevant to neck pain are muscle endurance and fatigue. Sustained postural loading of the cervical spine during work or recreational tasks in young adults are likely to contribute to the development of neck pain. Deviations in Craniovertebral (CV) angle suggest the alignment of cervical spine & which muscles appear to be elongated or shortened associated with neck posture. Poor endurance of deep neck flexor muscle may lead to neck disability as these muscles play major role in head and neck posture. Thus, the need of the study is to identify the specific elements of poor posture and need to identify appropriate strategy for patient who present with poor deep neck flexor muscle endurance. Thus, the purpose of the study is to identify corelation between deep neck flexor (DNF) muscle endurance, Cervical Range of Motion (ROM) and Craniovertebral (CV) angle.

There are many instruments to assess head posture, including the Rocabado Posture Gauge, the Cervical Range of Motion Instrument, the Plumb Line and Photographic Imaging.[12] One Objective method of assessing head posture is through measuring the Craniovertebral (CV) angle. The Craniovertebral (CV) angle is a commonly used research measure for expressing head-on-neck posture.[13] A horizontal line passes through the spinous process of C7 and a line from spinous process of C7 through the tragus of the ear forming the CV angle. CV angle appears to be a representative measurement of a combination of an anterior or posterior position of the lower cervical spine and the associated upper cervical flexion or extension. It is imperative that the instrument and method chosen to assess head posture clinically are reliable, objective,

Journal of Chemical Health Risks

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JCHR (2024) 14(2), 952-959 | ISSN:2251-6727

easy to use and produce immediate results when assessing a patient's condition as well as measuring the progress of the patient after therapeutic intervention.[12] The motions permitted by the cervical spine are flexion, extension, lateral flexion and rotation. Cervical ROM can be examined with the use of bubble inclinometer which provides accurate measurements as well as good reliability.[25]

2. OBJECTIVES

Aim of study is to find out corelation between Craniovertebral (CV) angle, Cervical range of Motion (ROM) and Deep Neck Flexor Muscle Endurance in young adults with neck pain.

Objectives of study:

• To evaluate Craniovertebral (CV) angle in young adults with neck pain.
• To evaluate Cervical range of Motion (ROM) in young adults with neck pain.
• To evaluate Deep Neck Flexor Muscle Endurance in young adults with neck pain.
• To find corelation between Craniovertebral (CV) angle, Cervical range of Motion (ROM) and Deep Neck Flexor Muscle Endurance in young adults with neck pain.

3. METHODS

STUDY DESIGN: A correlation study.
SOURCE OF DATA: Subjects were selected from Physiotherapy OPD in and around physiotherapy centres, Rajkot.
STUDY POPULATION: Young Males and Females with neck pain.
SAMPLING METHOD: Purposive sampling.
SAMPLE SIZE: Total 58 subjects.
STUDY DURATION: One time study.
The materials used for the study are Consent form, assessment form, Goniometer, Stop watch, Measurement tape, Plinth, 40cm height stepper, Camera, Tripod, Elastic Velcro strap, Baseline Bubble Inclinometer, Laptop. Subjects of both the gender (male & female) were selected from Physiotherapy OPD centres, Rajkot. Prior to participation; the purpose of the study was explained to each participant and written informed consent was taken from all participants. The physiotherapy assessment was taken of all participants and based upon criteria of selection; participants have been included within the study.

The criteria of participants included within the study are;
INCLUSION CRITERIA:
• Age between 20 to 30 years.
• Both male and female.
• Neck pain in the cervical region, possibly with referred in the occiput, nuchal muscles, shoulders with more than 1 month of duration.
• Having signs and symptoms of with and without radiating pain in the shoulders and /or arms and /or hands.
EXCLUSION CRITERIA:
• Having a history of trauma in region of the neck, shoulder and head.
• Having a history of cervical surgery.
• Tumour in cervical region.
DNF ENDURANCE TEST:[14,15]
Test was performed with subject in crook lying positions and hands resting on the abdomen in the beginning. The chin was maximally retracted by the subject and maintained. Subject lifted the head and neck until the head was approximately 2 to 5 cm above the examination table. The examiner placed one hand on the table under the subject's head (occiput). The examiner watched a skin fold resulting from the chin tuck and neck flexion. Time recording was started when the subject raised head and terminated when one of the following four criteria was met.[18] [1] Loss of skin fold as chin tuck position lost. [2] Subject's head rest on the therapist's hand for more than 1 second. [3] Therapist noted that subjects had not raise head above the normal level. [4] Subject was not able to continue the test position.[14,15]

Figure 3.1(a): Position for Deep Neck Flexor Muscle Testing.

The subject was tested twice, with a five-minute break between tests to allow muscular recovery. During this time, the subject was instructed to remain supine and turn the neck from side to side through a pain-free range of motion as the subject felt warranted, without raising

Journal of Chemical Health Risks

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JCHR (2024) 14(2), 952-959 | ISSN:2251-6727

the head from the table. The two-time scores were averaged, and the result was recorded.[14,15]

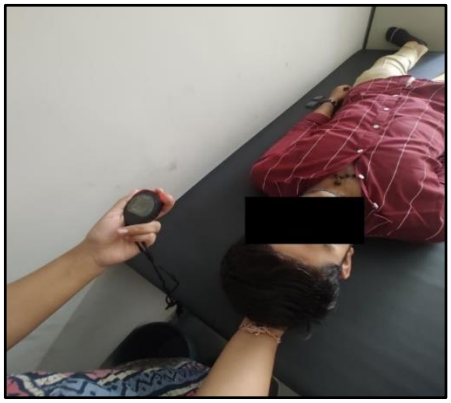

Figure 3.1(b): Therapist's hand placement for Deep Neck Flexor Muscle Testing.

CERVICAL RANGE OF MOTION (ROM) MEASUREMENT:[25]

The range of motions of the cervical spine are flexion, extension, lateral flexion and rotation were examined with the use of bubble inclinometer which provides accurate measurements as well as good reliability.[25]

CRANIOVERTEBRAL (CV) ANGLE MEASUREMENT:[12,13,16,17]

The objective method of assessing head posture is through measuring the craniovertebral (CV) angle. It is the angle between a horizontal line passes through the spinous process of C7 and a line from spinous process of C7 through the tragus of the ear.

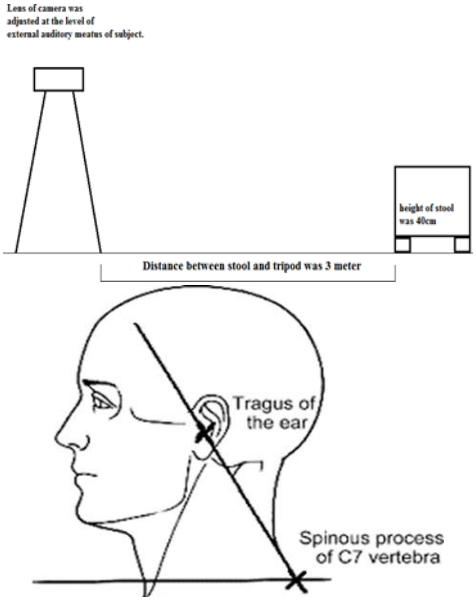

Figure 3.2 (a)&(b): Measurement of craniovertebral angle & Landmarks for Photographs.

All landmarks were placed on the floor to ensure the same positioning of all subject. Distance between stool and tripod was 3-meter,16 height of stool was 40cm.[12] Lens of camera was adjusted at the level of external auditory meatus by adjusting the height of camera tripod. Photo was taken in Canon SX 500 IS in auto mode with 1.4-meter optical zoom.

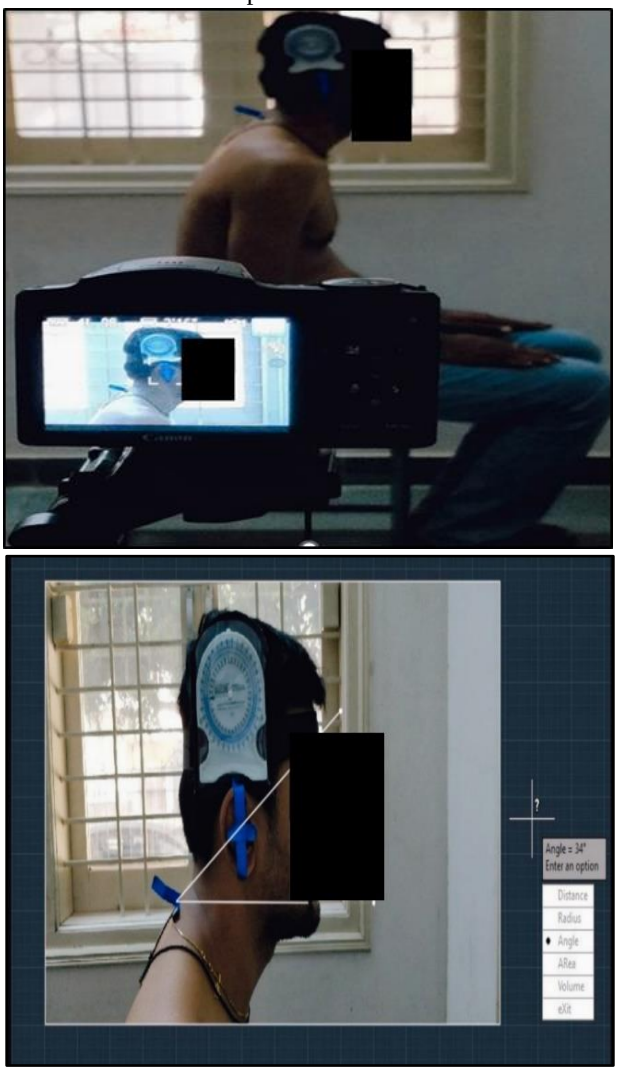

Figure 3.3 (a)&(b): Measurement of craniovertebral angle & Landmarks for Photographs.

Subject was asked to expose neck area and therapist palpated C7 spinous process where with help of double tape place small markers were placed over the midpoint of most prominent part of C7 and tragus of ear. Then baseline bubble inclinometer was placed on subjects' head with elastic strap on side of dominant hand to maintain head in neutral position and avoid excessive movement in sagittal plane. Subject was asked to seat perpendicular to the camera on a stool with feet flat on

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(2), 952-959 | ISSN:2251-6727

the floor and arms resting comfortably on their thighs. During sitting position arrow of Baseline Bubble Inclinometer was maintained on zero degree. Photo of the subject in this position was captured.

Data of photo was transferred to a computer running software AutoCAD 201627, inside a drawing of area, where one vertical and horizontal line was present called graphic cursor. On command these graphic cursors joined the anatomical markers and gave the degree of craniovertebral angle.[12,13,16,17]

4. RESULTS

The study included a total of 58 young adults with neck pain [28 Males(48%) & 30 Females(52%)] having mean age of subjects i.e. 24.13 ± 4.32 (SD) years.

Statistical software: All statistical analysis was done by SPSS statistics version 26.0 for windows software. Microsoft excel and word were used to generate graphs and tables.

Statistical test: Normality of the data was checked by Shapiro-wilk test and it showed that data is of non-parametric type. Mean and Standard Deviation (SD) were calculated as a measure of central tendency and measure of dispersion respectively for deep neck flexors muscle endurance and craniovertebral angle. Spearman Correlation test was used to determine the degree of association between deep neck flexors muscle endurance and Neck ROM with craniovertebral angle.

Table 4.1: Mean (in degree) and SD of Craniovertebral (CV) angle.

Number of Subjects	Mean (Degree)	SD
58	42.77	6.37

Interpretation: The above table shows the mean of craniovertebral angle in subjects i.e. 42.77 ± 6.37 (SD) degree.

Table 4.2: Result of Spearman's Corelation test between DNF muscle endurance and CV angle. (N=Number of Subjects)

Variables	Spearman r value	P value	N
DNF AND CV ANGLE	0.128	0.26	58

Interpretation: Spearman correlation coefficient is r = 0.128 which shows low positive corelation between DNF muscle endurance and CV angle.

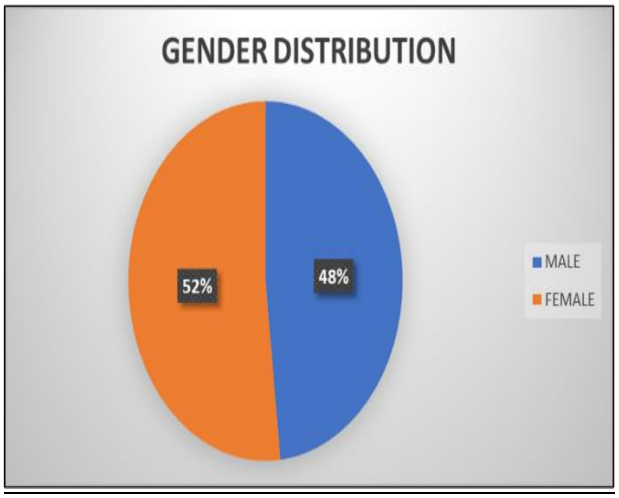

Figure 4.1: Gender wise distribution of total 58 subjects.

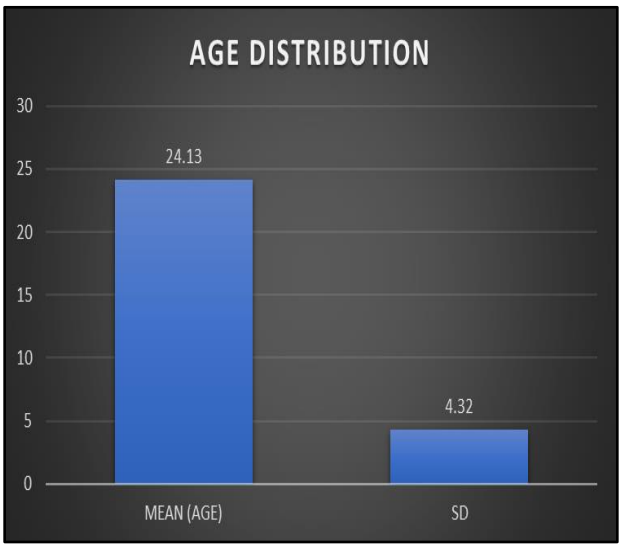

Figure 4.2: The mean age of subjects i.e. 24.13 ± 4.32 (SD) years.

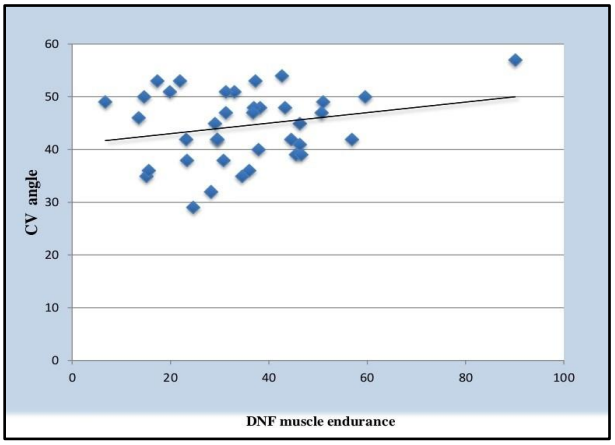

Figure 4.3: Spearman's Corelation Between DNF muscles endurance and CV Angle.

Journal of Chemical Health Risks

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JCHR (2024) 14(2), 952-959 | ISSN:2251-6727

Table 4.3: Result of Spearman's Corelation Test between CV angle and cervical Range Of Motion(ROM).

Variables	Spearman r value	P value
CV angle and Cervical Flexion	0.194	0.267
CV angle and Cervical Extension	0.299	0.112
CV angle and Cervical Right-Side Flexion	0.134	0.262
CV angle and Cervical Left-Side Flexion	0.232	0.327
CV angle and Cervical Right Rotation	-0.014	0.482
CV angle and Cervical Left Rotation	-0.022	0.443

Interpretation: Result suggest that CV angle and cervical rotations are negatively correlated and other cervical Range Of Motion(ROM) with CV angle are positively correlated.

Table 4.4: Result Of Spearman's Corelation Test between DNF muscle endurance and cervical Range Of Motion(ROM).

Variables	Spearman r value	P value
DNF and Cervical Flexion	0.395	0.068
DNF and Cervical Extension	-0.069	0.218
DNF and Cervical Right-Side Flexion	0.336	0.144
DNF and Cervical Left-Side Flexion	0.264	0.182
DNF and Cervical Right Rotation	0.145	0.124
DNF and Cervical Left Rotation	0.127	0.166

Interpretation: Result suggest that DNF endurance with cervical extension negatively correlated while other cervical Range Of Motion(ROM) are positively correlated.

5. DISCUSSION

The intent of the study was to find a co-relation between deep neck flexors muscle endurance and craniovertebral angle in young individuals with neck pain. In this study it was found that there is low positive correlation between deep neck flexors (DNF) muscle endurance and craniovertebral (CV) angle in neck pain subjects. Considering Range of motion of cervical spine; CV angle and cervical rotations have negatively correlated while all other cervical range of motions have positively correlated with CV angle. Similarly, DNF endurance with cervical extension has negatively correlated while all other cervical range of motion have positively correlated with DNF endurance.

Neck pain occurs commonly throughout the world and causes substantial disability and economic cost. The pain and disability associated with neck pain have a large impact on individuals and their families, communities, healthcare systems and businesses.[18] Chronic neck pain is widely prevalent and a common source of disability in the working-age population. In this study woman are more prone than man. And there are no age boundaries, either they are young or old subjects, according Rodrigo M. Ruivo et al., (2014) forward head and protracted shoulder are common postural disorders in adolescents, especially in girls.[19]

Researches indicate that individuals with a history of cervical spine pain demonstrate a delay in DNF activation when associated with use of the arm, which indicates a significant deficit in the DNF automatic feed forward control of the cervical spine. This compromise in DNF control may lead to cervical spinal dysfunction, where a cycle of pain and weakness is established.[14,20]

Cervical impairment describes as any cervical pain, loss of range of motion, or decreased strength. Where strength defined as the force-generating capacity of a muscle or endurance of the neck musculature, including, but not limited to, the sternocleidomastoid, trapezius, and Deep Neck Flexor (DNF) muscle strength reduction has been found in up to 70% of people with headaches.[10] Continuous imbalance between the superficial and deep neck muscles causes the head to position further forward from the body limiting the range of motions.[2,20]

In this study, the low positive corelation of deep neck flexor endurance and craniovertebral angle suggest that any negative deviation in both variable results in shortening of posterior cervical muscles and weakening of anterior cervical flexor muscles leads to alteration in length tension relationship and leads to myofascial neck pains.[20]

Posture refers to the alignment of body parts in relation to each other,[14] and it is a frequently cited risk factor leading to musculoskeletal disorders. Inadequate posture consists of poor interrelations between parts of the body

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These imperfect interrelations cause muscle tension and shortening, which makes appropriate joint movements more difficult to achieve and may cause pain.[19,20,21] According to F P Kendall et al (2005) the lack of mobility, which is not apparent as an alignment fault but which is detected in tests for flexibility and muscle length, may be the more significant factor for any postural pain.[22]

Abnormalities in head posture are often considered to be associated with the development and persistence of neck pain, and some clinicians emphasize its importance during examination. Forward head posture can occur because of an anterior translation of the head, lower cervical flexion, or both, and it is claimed to be associated with an increase in upper-cervical extension.[20] Forward head posture leads to an increase in the compressive forces on the cervical apophyseal joints and posterior part of the vertebra and to changes in connective tissue length and strength resulting in pain.[20] supported by Chris Ho Ting Yip et al (2006) where study concluded that CV angle was negatively correlated with Neck Pain Questionnaire (NPQ) and Numeric Pain Rating Scale (NPRS).[12] While Kwok Tung Lau et al (2009) find negatively correlation between CV angle of cervical spine with neck pain and moderately correlated with disability in subjects of neck pain.[23]

As the result of the present study concludes that there's is low positive corelation in between DNF endurance and CV angle in subjects with neck pain. Similarly, CV angle and all cervical range of motions shows positive correlation except cervical rotations and DNF endurance with all cervical range of motion shows positive correlation except extension. The study alerts physiotherapist to address the head posture as well as cervical ROM along with conventional treatment in subjects with neck pain. Since muscle function is an important factor in understanding neck pain, by having strong deep neck flexors endurance can actually prevent future occurrences and can contribute in preventing various neck related pathologies.[9,11] Jin Young Kim et al (2015) demonstrate clinical effects deep cervical flexor muscle activation in patients with chronic neck pain and concluded that deep cervical flexors activation exercise was effective to alleviate pain, recover functions, and correct for- ward head posture in the patients with neck pain. Hence, it might be recommended in the rehabilitation of patients with chronic neck pain.[24]

The limitations of the study include that measurement Setup cannot be utilized in outfield. Further studies can be done using larger sample size and along with Head Posture Spinal Curvature Instrument (HPSCI) particularly for measurement of craniovertebral angle.[21]

Conflict of Interest: None

Source of Funding: Self

References

1. Rene Cailliet. Neck and arm pain, pain series: 2nd edition. F. A. Davis company Philadelphia; 1981.
2. Nikolai Bogduk. The anatomy and pathophysiology of neck pain. Physical Medicine Rehabiitation Clinics of north America. 2003;14: 455–472.
3. Rene F, Jan H. Neck pain and disability due to neck pain: what is the relation?. Eur Spine J. 2008;7: 80–88.
4. Genebra, C. V., Maciel, N. M., Bento, T. P., Simeão, S. F., & Vitta, A. D. (2017). Prevalence and factors associated with Neck Pain: A population-based study. Brazilian Journal of Physical Therapy. 2017; 21(4), 274–280.
5. Sjaastad O, Wang H, Bakketeig LS. Neck pain and associated head pain: persistent neck complaint with subsequent, transient, posterior headache. Acta neurologica scandinavica. 2006; 114: 392–399.
6. Peter RC, Martyn Lewis, Ann CP, Elaine T, Malcolm I.V, Grey JM, Alan JS. Risk factors for neck pain: a longitudinal study in the general population. International association for the study of pain. 2001; 93: 317–25.
7. Trilok NM, Martin G. Pain management in rehabilitation. Demos Medical Publishing New York; 2002.
8. Carol A. Oatis. Kinesiology the mechanics and pathomechanics of human movement. 2nd edition. Lippincott Williams & Wilkins; 2009.
9. Alka P, Vikram Y, Shabnam J, Taruna V. Deep neck flexor endurance: a normative data score in normal healthy indian population. Indian journal of applied research. 2015;5(8): 217–20.
10. Harris KD, Heer DM, Roy TC, Santos DM, Whitman JM, Wainner RS. Reliability of a measurement of neck flexor muscle endurance. physical therapy. 2005;85(12): 1349– 55.
11. Stephen E, Guony B, Thorvaldur P, Hege S, Kasper U, Garry A. Endurance and fatigue characteristics of the neck fl exor and extensor muscles during

isometric tests in patients with postural neck pain. Manual Therapy. 2011;16(4): 332–38.

12. Chris TY, Thomas Tw, Anthony TK. The relationship between head posture and severity and disability of patients with neck pain. Manual Therapy. 2008;13: 148–50.
13. Karen G, Pat T. The association between cervical excursion angles and cervical short flexor muscle endurance. Australian Physiotherapy. 1998;44(3): 201-207.
14. Manuel AD, Phil SS, Gregory SD, Michael K.M, Jean-Michel B. The deep neck flexor endurance test: normative data scores in healthy adults. The American Academy of Physical Medicine And Rehabilitation. 2011;3: 105-110.
15. David J Magee. Orthopedic physical assessment: 6th edition.Saunders elsevier ; 2014.
16. Eslam B, Aslan K, Zahra M,Saleh B. An innovative software method for measuring lumbar lordosis. Scholars Research Library Annals of Biological Research. 2012; 3 (1): 204-213.
17. Elizabeth AF, Marcos D,Edison PM,Ana AB ,Amélia PM. Quantitative assessment of postural alignment in young adults based on photographs of anterior, posterior, and lateral views. Journal of Manipulative and Physiological Therapeutics. 2011;34(6): 371–80.
18. Hoy D, March L, Woolf A, Blyth F, Brooks P, Smith E. The global burden of neck pain: estimates from the global burden of disease 2010 study. Ann Rheum Dis. 2014;73: 1309–1315.
19. Ruivo RM, Pezarat-correia P, Carita AI. Cervical and shoulder postural assessment of adolescents between 15 and 17 years old and association with upper quadrant pain. Braz J Phys Ther. 2014;18(4): 364-371.
20. Anabela GS, David P, Paul S, Vilas B, Mark IJ. Head posture and neck pain of chronic nontraumatic origin: a comparison between patients and pain-free persons. Arch Phys Med Rehabil. 2009;90(4): 669–74.
21. Arun VS. Measurement of craniovertebral angle by the modified head posture spinal curvature instrument: a reliability and validity study measurement of craniovertebral angle by the modified head posture spinal curvature instrument: a reliability and validity study. Physiotherapy theory and practice. 2016;3985: 0–9.
22. Kendall FP, Elizabeth KM, Patricia GP, Mary MC, William AR. Muscles testing and function with posture and pain.: 5th Edition. Lippincott Williams & Wilkins; 2005.
23. Kwok TL, Ka YC, Kwok BC, Man HC, King Y, Thomas T. Relationships between sagittal postures of thoracic and cervical spine, presence of neck pain, neck pain severity and disability. Manual Therapy. 2010;15(5): 457–62.
24. Jin YK, Kwang I K. Clinical effects of deep cervical flexor muscle activation in patients with chronic neck pain. J. Physical Therapy Science. 2016;28: 269–73.
25. Sukari AA, Singh S, Bohari MH, Idris Z, Ghani AR, Jafri MA. Examining the range of motion of the cervical spine: Using Different Bedside Instruments. Malays j Med sci. 2021;28(2): 100-105.