COMPARISON OF NECK LENGTH WITH THE INCIDENCE OF CERVICAL SPONDYLOSIS

BY

DR SYEDA BUSHRA AHMED
MBBS

A thesis presented to Bahria University, Islamabad
In partial fulfillment of the requirement for the degree of
Master of Philosophy in Anatomy

DEPARTMENT OF ANATOMY
BAHRIA UNIVERSITY MEDICAL & DENTAL COLLEGE

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DEDICATION

To my parents, my husband and my daughter

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LIST OF ABBREVIATIONS

S.No	Abbreviations	Stands for
1.	ANOVA	Analysis of Variance
2.	ASPN	Asporin
3.	AAI	Atlantoaxial instability
4.	BUMDC	Bahria University Medical and Dental College
5.	BMI	Body Mass Index
6.	CODA	Cartesian Optoelectronic Dynamic Anthropometer
7.	CDA	Cervical Disc Arthroplasty
8.	COL11A1	Collagen Type XI Alpha 1
9.	CR	Computed Radiography
10.	CT	Computed Tomography
11.	CMS	Cooper Myelopathy Scale
12.	CABG	Coronary Artery Bypass Grafting
13.	DTI	Diffusion Tensor Imaging
14.	EMS	European Myelopathy Score
15.	GDF5	Growth Differentiation Factor 5
16.	HILT	High-Intensity Laser Therapy
17.	IVD	Intervertebral Disc
18.	kVp	Kilo Voltage peak
19.	LNL	Lateral Neck Length
20.	MRI	Magnetic Resonance Imaging
21.	MMP9	Matrix Metalloproteinase 9
22.	MPa	Mega Pascal
23.	MNL	Midline Neck Length
24.	mAs	milli Ampere second
25.	mSv	millisievert
26.	mJOA score	modified Japanese Orthopedic Association Score
27.	MDCT	Multidetector-Row Computed Tomography
28.	MSUS	Muscloskeletal Ultrasound
29.	RNIIG	Neck Circumference/Inter-Incisor Gap Ratio
30.	NDI	Neck Disability Index
31.	OPD	Out Patient Department
32.	RVAO	Rotational Vertebral Artery Vertigo
33.	SPSS	Statistical Package for Social Sciences
34.	THBS2	Thrombospondin 2
35.	ULTT	Upper Limb Tension Test
36.	WHO	World Health Organization

ABSTRACT

BACKGROUND

Cervical spondylosis is a disc degenerative disease commonly presenting in the middle aged to ageing population. It manifests as a syndrome causing degeneration of intervertebral discs and vertebral bodies leading to compression of spinal cord, its vessels and spinal nerve roots. It has been considered as an epidemic by World Health Organization. The disease has an insidious onset, progresses stealthily and causes syndromes of radiculopathy, myelopathy and axial joint pain.

OBJECTIVES

The objectives of the study were to correlate short neck length with the increased incidence of cervical spondylosis, and to compare neck length, relative neck length, height and weight with incidence of cervical spondylosis and evaluate the demographics, patient characteristics as well as radiographic changes in the subjects of cervical spondylosis.

SUBJECTS, MATERIALS AND METHODS

It was a comparative study conducted at Patel hospital, Karachi after obtaining approval of synopsis (Appendix A) and ethical approval from BUMDC and Patel hospital (Appendix B). It enrolled 88 cases and 88 controls using convenient sampling technique. The cases were recruited from the Orthopedic outpatient department (OPD) and Radiology Department, on the basis of history and physical examination while controls were enrolled from hospital premises, as healthy individuals accompanying the patients. Those individuals who met the inclusion criteria and signed the informed consent (Appendix C) were included in the research project. These participants were subjected to cervical spine radiography (lateral view) with the help of Agfa Fuji CR 35-X system. The neck length was measured on a software Synapse, as a perpendicular distance from the external occipital protuberance to the C7 spinous process. The height and weight of the cases were measured with the help of stadiometer. The relative neck length was calculated by dividing the neck length with the height of the individual. Their history, height, weight, demographics and other characteristics were recorded in a subject evaluation form (Appendix D).

RESULTS

A total of 176 subjects were evaluated and it was established that the disease was prevalent in the middle age to elderly population ranging from 40 to 60 years. The neck length and relative neck length of the cases showed insignificant decrease with the disease while the short height had a significant association with the disease. The neck length, height and weight also showed significant differences with respect to the disease within males and females. The disease was found to be more prevalent in the pre-obese and obese cases. It showed significant association with the occupation, being most frequent in the female home makers and male outdoor workers having a working duration of more than 8 hours. The disease had increased incidence in mobile users of more than 4-hour duration. The degenerative radiographic changes observed were also severe in relation to the increase in age demonstrating significant association of degenerative changes with respect to the age.

CONCLUSION

The present study concluded that the prevalence of cervical spondylosis was more in middle aged to elderly population. There was a significant association of height which showed that the short height individuals were more prone to develop cervical spondylosis. The Body Mass Index (BMI), occupation, working hours and mobile use were also significant risk factors. The results delineated the parameters and factors involved in the disease process. These results should be considered by health care providers while assessing the disease. Short height individuals must adapt good posture and healthy lifestyle factors to prevent the disease.

KEYWORDS: Cervical spondylosis, Epidemic, Syndrome, Cervical myelopathy, Cervical radiculopathy, Short neck length, Relative neck length, Height

CHAPTER 1

INTRODUCTION

The vertebral column is a characteristic feature of vertebrates. The vertebral column is an array made of repeated series of bones known as the vertebrae. The vertebra has a body which surrounds the spinal cord. The vertebral column provides strength, and protects the spinal cord, and related vascular and neural components (Fleming, Kishida, Kimmel & Keynes, 2015).

The curvature of the vertebral column is kyphotic in the fetal period which continues in the thoracic region till adulthood. The secondary curvatures develop in the cervical and lumbar regions during infancy. The lordotic curve is achieved in the cervical region as a result of keeping the head upright and in the lumbar region as a result of sitting and standing posture respectively (Kaplan, Spivak & Bendo, 2005). The lordotic curve is vital as it allows head and neck movement, helps in transmitting axial load, maintains horizontal gaze and protects neurovascular components. Any deformity in the cervical spine can deteriorate a patient's quality of life. A most common deformity of the cervical spine is kyphosis. The support to the vertebral column is augmented by the interaction between the muscular system and the central nervous system; even the spine cannot bear weight more than 10 kgs. The gravitational force places a paramount impact on the posture (Hawes & Brien, 2006).

Sexual dimorphism is present in the cervical spine as newborn girls have smaller vertebrae as compared to the boys concerning height and weight, and it is attributed to the genetic, endocrinal and environmental factors. Therefore, spinal deformities and vertebral fractures are common in girls and older women. Women also extend their spine during gestation and walk upright to compensate the heavy gravid uterus and therefore even lumbar lordotic curve aggravates this way (Gilsanz, Wren, Ponrartana, Mora & Rosen, 2018).

The timing and nature of fetal muscle activity are essential influences on the normal development of the spine. The growth of the spine is dependent on genetic, mechanical, postural and occupational factors. It can be easily disrupted by skeletal deformities, and storage and endocrinological diseases (Remes, Heinänen, Kinnunen & Marttinen, 2000).

1.1 CURVATURES

The vertebral column displays four curves; the thoracic and sacral kyphoses present as primary curvatures which are the anterior concavities while secondary curvatures are cervical and lumbar lordoses, which are the posterior concavities. Sacral kyphosis in women is reduced so that coccyx protrudes less into pelvic outlet (Moore, Dalley & Agur, 2013).

1.2 IMPORTANCE OF LORDOTIC CURVE

Cervical lordosis helps in carrying out normal physiological processes like breathing, gaze, vocalization, mastication, and shock absorption while walking or running. The lordotic curvature develops due to the increased growth of vertebrae and intervertebral discs at the anterior side relative to the posterior side. It helps in bearing compression forces at the vertebral endplates, and the rest is done by the anterior column (Guo et al., 2018). The cervical components are also affected by day to day activities since neck is used many times in a day (Sayıt, Aghdasi, Daubs & Wang, 2015).

1.3 NECK PAIN AND ITS PREVALENCE

Neck pain is the chief cause of morbidity worldwide. It is the fourth leading cause of disability around the globe with more than 30% annual prevalence (Cohen, 2015). In the Netherlands, it ranks third, after respiratory infections and low back pain as the cause of morbidity in ages of 15 to 25 years. The Royal Dutch Society of Physical Therapy has chosen Neck Disability Index (NDI) as a standard outcome measure of neck pain. It is a self-reporting questionnaire including relevant questions related to pain intensity, headache, concentration, self-care, loading of heavy items, reading, driving, sleep and leisure activities (Beurskens, Swinkels, Pool, Batterham, Osborne & de Vet, 2016).

In Canada and Saskatchewan, around two-thirds of the general population suffers from neck pain. It has been found to be associated with female sex, obesity, and smoking (Lee et al., 2018). In Denmark, neck pain has been reported to be the second leading cause of disability-adjusted life years with one-year prevalence of 25% (Hoy, Protani, De & Buchbinder, 2011).

1.4 ANATOMY OF CERVICAL SPINE

The human spine consists of 7 cervical, 12 thoracic, and 5 lumbar vertebrae and the sacrum and coccyx (Rolfe et al., 2017). The cervical spine comprises of seven vertebrae designated as C1-C7 and six intervertebral discs. It extends from the base of the skull to the top of the trunk. It supports and cushions the head and neck, allows rotational movements, and protects the spinal cord and adjacent vascular and neural elements (Frost, Camarero & Foster, 2019).

Out of the seven cervical vertebrae, first, second and seventh show some atypical features, therefore called as atypical cervical vertebrae while rest of them are the typical cervical vertebrae. The cervical vertebrae are largest anteriorly while posteriorly, it is formed by pedicles and laminae resulting in a vertebral arch. Transverse processes arise at the junction of pedicles and laminae. Other processes include midline spinous process posteriorly and articular processes on either side of a vertebral body. Intervertebral discs act as a shock absorber and are lodged in between two vertebrae (Moore, Dalley & Agur, 2013).

The first cervical vertebra is called Atlas; it has been named after a Greek Titan who was punished to support the globe of the universe on his head just similar to the first cervical vertebra supporting head (Rajani, 2014). It has a characteristic ring form. The dry weight of the Atlas accounts for approximately 10 to 20 g and can carry 3 to 5 kg weight of the head (Laiho, Kauppi & Konttinen, 2004). It has neither body nor spinous process. The second cervical vertebra is called axis because it rotates around the odontoid process. It has a body and an odontoid process supported by the transverse ligament. The first two cervical vertebrae are significantly different from the rest. The cervical vertebrae possess vertebral body, and uncovertebral joints (Figure 1) (Kim, Souza, Ho, Pendharkar & Sussman, 2018). The cervical spine contains 24 joints. There are six intervertebral joints, two atlanto-occipital joints, two lateral atlantoaxial joints, 12 facet joints, one central atlantoaxial joint, and one joint between the dens and the transverse ligament. The atlanto-occipital joint allows 50% of the head's flexion and extension movement, while the atlantoaxial joint allows 50% of the neck's rotation. The rest of the vertebrae (C3–C7) have significantly reduced mobility, enabling support for the weight bearing of the head and other loads applied onto the neck (Swartz, Floyd & Cendoma, 2005). The cervical spine allows a diverse range of movement including 90º flexion, 70º extension, 20-45º lateral bending, 90º axial rotation, and anterior and posterior translational movements. The atlanto-occipital joint is a firm synovial condylar joint formed by the articulation between the occipital condyle and superior articular facet of the Atlas, reinforced by the strong joint capsule, allowing flexion and extension and little movement in lateral bending or axial rotation. The atlantoaxial joint involves articulation between the four synovial joint interfaces as an anterior arch of C1, odontoid process, transverse ligament, and the paired C1-2 facet joints. It allows a substantial degree of axial rotation (Tan, Riew & Traynelis, 2017). Rest of the cervical vertebrae from third to seventh are typical. They are smaller than vertebrae of the thoracic and lumbar region. The vertebral body is more or less rectangular in shape, and disc material is also less. Two lips are present on the superior surface of vertebral body which interlock with vertebra above it. The spinous process of the seventh cervical vertebra is the longest of all, called vertebra prominence (Zhou, Guo, Zhang & Tang, 2010). The intervertebral discs are located between adjacent vertebrae, composed of three distinct parts. The middle part of the disc is nucleus pulposus surrounded by the annulus fibrosis. The outer region of each disc is attached to adjacent vertebrae by the end plates (Choi, Lee & Harfe 2012).

1.5 DEVELOPMENTAL ANATOMY OF CERVICAL SPINE

The ossification centers are vital as they help in assessing the fetal stages and anomalies. Three ossification centers are present in the Atlas, one in the anterior arch and rest two each in a posterior arch. Axis has four ossification centers, one in body, one in dens and remaining in either arch. There are three ossification centers in cervical vertebra C3-C7, one in the body and the remaining two in either neural arches. First vertebral ossification center appears in the 8^{th} week in axis, at week 10^{th} in the lower thoracic vertebrae and the first lumbar vertebra (Baumgart et al, 2016a). The ossification process advances in both directions cranially and caudally with the cranial one being more thorough (Baumgart et al, 2016b). The width, length, and volume of the ossification centers are maximum in the cervical region, which reduce gradually in the lower segments. The reason behind this is that, the ossification starts from the cervical spine, and neural processes are supported by nuchal muscles attributing to the head extension, i.e., the gasp reflex.

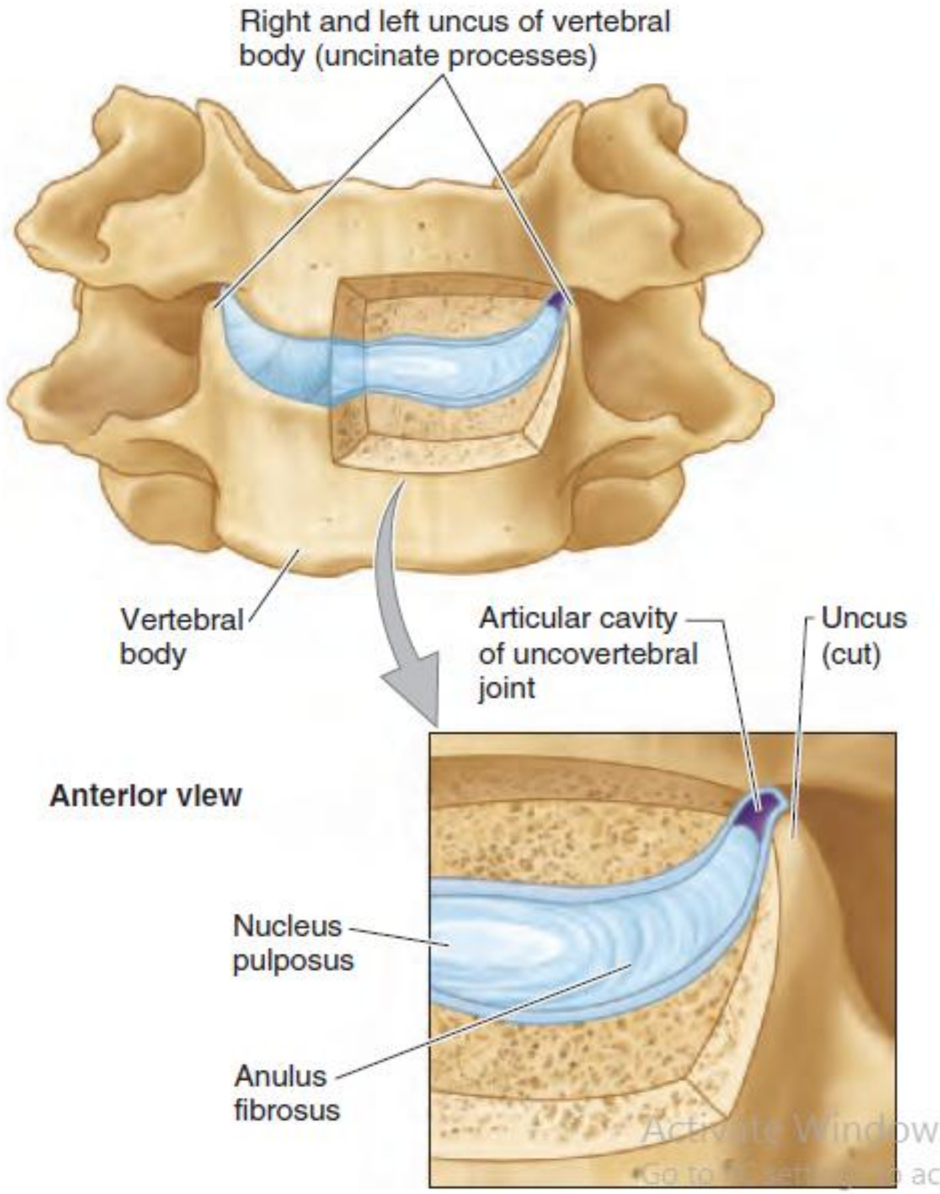


Figure 1: Uncovertebral Joints
(Moore, Dalley, & Agur, 2013)

The decrease in sacral ossification center is due to the delayed appearance of the ossification centers (Baumgart, Szpinda & Szpinda, 2013). The C3- C7 act as the same unit, they follow the same ossification pattern as one in body and the remainder two in neural arches. Secondary ossification centers also appear in transverse processes and spinous process. They can also appear at superior and inferior aspects of cervical vertebral bodies which remain unfused until adulthood. The typical cervical vertebra is half the height of lumbar and two-thirds of the height of the thoracic vertebrae respectively. Three ossification pathways have been proposed, first starting from the thoraco-lumbar region, cervico-thoracic and superior cervical region, followed by ossification in the mid-thoracic and superior cervical region (Szpinda, Baumgart, Szpinda, Woźniak, & Mila-Kierzenkowska, 2013)

Neurocentral synchondroses separate the anterior and posterior ossification centers which fuse between 5 and 8 years of age, while posterior ossification centers are separated by the posterior synchondroses which fuse around 3 to 5 years of age (Junewick, Chin, Meesa, Ghori, Boynton & Luttenton, 2011).

The vertebral column starts to develop in the 3rd week of development. The first and second cervical vertebrae display exceptional origin and function. The first cervical vertebra and dens is derived from the first cervical sclerotome, while the remaining of second cervical vertebra is formed from second sclerotome. The fetal spine is best imaged at 12th week of gestation as ossification centers also develop in 10th to 11th weeks of gestation (Henderson et al., 2016). The vertebral column is derived from the somites which are the primary segments derived from paraxial mesoderm during the process of somitogenesis. These somites undergo epithelial to mesenchymal transition and form mesenchymal sclerotome ventrally and dermamyotome dorsally. The dermomyotome gives rise to dermis of the back and the myotomal trunk muscles. The sclerotome is divided into a ventral, central, dorsal and lateral compartment. The ventral sclerotome forms the vertebral body. The central forms the pedicles of the vertebral arch, the transverse process, the head and neck of the ribs and costovertebral joints. The lateral sclerotome forms the distal part of the ribs, and the dorsal sclerotome forms the lamina and spinous process of the vertebral arch. The dense and loose mesenchyme in perinotochordal sheath gives rise to the vertebral bodies and intervertebral disc (IVD) annulus fibrosus respectively. The notochord degenerates and persist at the level of the IVD to form the nucleus pulposus (Scaal, 2016).

1.6 DEGENERATIVE DISORDERS OF SPINE

Neurodegenerative disorders are common and a severe problem worldwide due to various reasons like lifestyle, environmental and genetic factors. Around 50% of the middle-aged population suffer from spondylosis as degeneration of vertebral column commonly appears in men around 20 years and women around 30 years of life. Genetic variations in the components of the intervertebral disc like proteins, vitamin D receptors and proteoglycans are also considered as factors causing degeneration. Clinical diagnosis and treatment are complicated since the disease occurs as a diverse array in terms of pain, neurological deficits or gait presentation. The degenerative disease must be studied along with the whole spine suspecting the upper spinal lesions too, so that the diagnosis of cervical spondylosis cannot be missed (Morishita, Buser, Oro, Shiba & Wang, 2018).

Loss of lordotic curve is one of the degenerative changes that occur in the cervical spine and acknowledged as the cause of neck pain. Kyphotic deformity of around 4º is also seen in 17% asymptomatic population, and 23% symptomatic people in at least one segment of the cervical spine. The average kyphotic angle is of 6.5º in the patients presenting with pain, and 6.3º in asymptomatic group. Degenerative changes reduce the height at the anterior and posterior column. Loss of lordotic curve leads to disruption in kinematics and biomechanics of the cervical spine (Xiong et al., 2017). The prevalence of neck pain is around 20% over the age of 40 years. The lordotic curve is the primary physiological form of the cervical spine. It is most significant in normal healthy controls and lowest in patients. The loss of lordotic curve is also a predisposing factor for lower back pain (Grob, Frauefelder & Mannion, 2007).

1.7 TERMS SIMILAR TO SPONDYLOSIS; SPONDYLOLISTHESIS, SPONDYLOLYSIS, AND SPONDYLITIS

Spondylolisthesis is the disease of ageing most commonly found in women as compared to men, due to the ligamentous laxity and hormonal influences. The word has been derived from Greek “spondylos”, the vertebra and olisthesis, “slip forward” by the Newman and Stone. This degenerative process results in slippage of a vertebral body causing spinal stenosis and a classic presentation of neurogenic claudication. The clinical presentation involves lower extremity pain, paresthesia, and weakness on walking or standing, painful extended spine position, and radicular pain pattern. The diagnosis is made on standing lateral radiographs (Koreckij & Fischgrund, 2015).

There is an ethnic predisposition with a prevalence of 54% in adult Inuit and 2% in the black population. Spondylolisthesis is common in high-intensity sports which include hyperextension of the trunk like swimming, diving, rowing, wrestling, weight lifting, gymnastics, etc. It is prevalent around 43% in divers. Exaggeration of lumbar lordosis during sports causes increased stress on pars intercularis leading to fatigue fracture (Tsirikos & Garrido, 2010).

Spondylolysis is the defect in the pars interarticularis due to excessive hyperextension and rotation. It is most common in the lumbar spine, L5 level and present in adolescents as low back pain. The pars interarticularis is a small isthmus of bone between the superior and inferior articular facets of the spinal vertebra. Spondylolysis has been reported to occur twice as often in males as in females (Lawrence, Elser & Stromberg, 2016). It affects 6% and 8% in the pediatric and adolescent population respectively (Sousa et al., 2017).

Spondylitis denotes spinal infection. The classification of spinal infection depends on the etiology like pyogenic, granulomatous, or parasitic and regarding anatomical point of view; it includes vertebral osteomyelitis, discitis, and epidural abscess. Pyogenic and tuberculous variety are the most common cause and are difficult to differentiate; the diagnosis must be done in relation with blood and tissue cultures, radiological findings and clinical presentation (Lee, 2014).

Cervical pyogenic spondylitis can even cause paralysis, therefore prompt diagnosis and surgical intervention are indicated if neurological deficits appear (Miyazaki, Yoshiiwa, Kodera & Tsumura, 2011).

1.8 CERVICAL SPONDYLOSIS:

1.8.1 Definition

Cervical spondylosis is defined as "A spinal disorder characterized by degeneration of vertebral bodies, intervertebral discs, facet joints, and ligaments resulting in osteophytes or myelopathy" (Ellingson, Salamon, Grinstead & Holly, 2014). It is more common in middle and elderly aged population, around 80% in the total population (Woodworth, Holly, Salamon & Ellingson, 2018). It presents as the most common non-traumatic spinal cord injury and cord dysfunction in the elderly (Chanpimol, Seamon, Hernandez, Harris-love & Blackman, 2017). Cervical spondylosis is a chronic degenerative disease presenting with neck stiffness and back pain as the most initial symptom. It is a pathological condition affecting the cervical spine, known to cause significant disability. It has a high prevalence and insidious onset; and, with unsatisfactory treatment, it is very burdensome and major public health concern (Shi et al, 2015).

1.8.2 Prevalence

Cervical spondylosis is a common occurrence in the middle-aged population. Its prevalence is around 3.3 cases per 1000 people (Rudy et al., 2015).

1.8.3 Symptoms

Around two-thirds of the population suffer from neck pain which is prevalent in middle-aged population affecting employers and health care providers. Many treatment plans of mobilization, manipulation and exercises help alleviate neck pain. Moderate evidence has been conceived at the cost of systemic reviews that exercises based on coordination, strengthening and endurance are more effective than pharmacological treatment (Binder, 2007).

1.8.4 Text Neck Syndrome

Text neck syndrome is the neck pain caused by the forward head posture with the usage of mobile and electronic devices. A recent survey in Hong Kong revealed that the prevalence of neck pain with mobile phone usage is around 17.3% to 67.8%. Forward head posture is the leading cause behind the concept of text neck syndrome. As the neck flexes forward, it imparts heavy load of the head on the neck, around 27 pounds at 15º flexion, and 60 pounds at 60º flexion. Moreover, children have a bigger head size relative to their body. Thus they are at increased risk of developing Text neck syndrome (Neupane, Ali, & Mathew, 2017).

Other studies also support neck pain and its association with forward head posture and decreased muscle strength, and considered as an essential entity in children who use computers or suffer from whiplash trauma (Ormos, 2016). Obesity is also linked to cause neck pain, ranking after ischemic heart disease, ischemic stroke, diabetes and low back pain in high middle and high socio-demographic index countries (Kyu et al., 2018).

1.8.5 Atypical Symptoms of Cervical Spondylosis

Some atypical manifestations of cervical spondylosis include vertigo, headache, palpitation, nausea, abdominal discomfort, tinnitus, blurred vision, and amnesia. Barré and liéou first reported these in 1926 as “Barré and liéou syndrome” (Li, Jiang, Wang, Yuan, Liang &Wang, 2016).

The cause of cervical spondylosis mainly involves either herniation of the cervical disc or the ossification of the ligaments of the cervical spine, i.e., posterior longitudinal ligament or ligament flavum and narrowing of the cervical spinal canal (Sun, Muheremu & Tian, 2018).

1.8.6 Factors Contributing to Cervical Spondylosis

Factors contributing to the disease are congenital cervical canal stenosis, poor posture, anxiety, depression, neck strain, and sporting activities like soccer, rugby or horse riding (Sun, Yue & Zhang, 2013) and occupational influences (Yalamanchili, Vives & Chaudhary, 2012).

1.8.7 Classification and Clinical Manifestations

Cervical spondylosis is a broader term that encompasses all degenerative changes that occur over time with the process of senescence or as a result of any extrinsic factor like trauma or disease. It is a clear fact that the majority of asymptomatic elderly show degenerative changes over radiography; therefore, clinical correlation with radiography is recommended and not every elderly can be labelled to have cervical spondylosis.

Cervical spondylosis presents as three syndromes that are;

1. Cervical Radiculopathy
2. Cervical Myelopathy
3. Axial joint pain

The syndromes are explained as follows:

1.8.7.1 Cervical Radiculopathy

It is an inflammatory condition compressing cervical nerve roots by either protrusion of the soft or hard disc or hypertrophied facet joints. It is a straight forward syndrome to be diagnosed by clinicians. The incidence rate of cervical radiculopathy is around 107.3 per 100,000 men and 63.5 per 100,000 women. It is prevalent in the fourth and fifth decade of life (Childress & Becker,2016). It ranks second in spinal radiculopathies with a prevalence of 36%, following lumbar radiculopathy (Abdul-latif, 2011).

White race, smoking, former lumbar radiculopathy, lifting heavy load, vibration at workplaces or sports activities like diving and playing golf have been included as risk factors. It presents with a broad spectrum of clinical signs and symptoms which entails pain, sensory and motor deficits and diminished reflexes. The most common cervical nerve roots to be affected are the sixth, seventh and eighth. Accurate history accounts most in diagnosis; furthermore it is characterized by the unilateral pain (Pohl et al., 2018). The provocative tests which are helpful in the diagnosis of cervical radiculopathy comprise of the Spurling test, the shoulder abduction test, Valsalva maneuver, Neck distraction, and Elveys upper limb tension test (ULTT) (Rubinstein, Tulder, Riphagen & Vet, 2007). The radiculopathy involves the neurological dysfunction occurring at the level of cervical nerve roots while radicular pain is the inflammation of cervical nerve roots; they often coexist. The physical tests for ULTT and the assessment of cervical radiculopathy are tendon reflexes, physical examination of the bulk and power of muscles, sensory supply, and movement. The ULTT provided high sensitivity and low specificity for diagnosing cervical radiculopathy. It is advised to have a combination of tests including Spurling’s test (Figure 2), axial traction test, and arm squeeze test. A negative arm squeeze test can help exclude the diagnosis (Thoomes et al., 2018). ULTT can also be used for screening purposes in patients with neck and arm pain to diagnose cervical radiculopathy.

1.8.7.2 Cervical Myelopathy

It is the consequence of impingement of spinal cord due to the degenerative changes and the resultant dysfunction of upper motor neurons (Figure 3). It is the most common primary diagnosis for patients over 64 years and imposes as a great challenge in the field of neurosurgery (Salamon et al., 2013). Congenital cervical spine stenosis is a significant predisposing factor for Cervical Myelopathy. It is common with short pedicles. Canal stenosis can be assessed with radiography by Torg Pavlov ratio, i.e. dividing the canal diameter with the vertebral body diameter (Bakhsheshian, Mehta & Liu, 2017). The characteristic symptoms range from acute to chronic and neurological involvement including instability of gait, loss of fine motor control of the upper limbs, weakness, and neck pain with reduced range of movement in this region, and urinary incontinence. The diagnosis depends on clinical examination and imaging studies showing spinal cord compression. The average space of the spinal canal range is from 13 to 20 mm. The space less than 12 mm is a characteristic finding in myelopathy (Vilaça et al., 2016). Gait disturbance was the most common sign while the loss of sensation in the upper extremities was the second most common finding. Several scores have been devised to diagnose Cervical myelopathy like the Nurick score, modified Japanese Orthopedic Association score (mJOA score), Cooper Myelopathy Scale (CMS), Prolo-score, and European Myelopathy Score (EMS). They are commonly applied in researches. They have limited application in clinical practice due to the fact that they are self-assessment questionnaires employed by the patients regarding their daily activities which lack imitation of neurologic examination and substantial interpretation.

There is a dire need for strict radiographic criteria for diagnosing the disease and to be used for comparison (Amenta et al., 2014). The symptoms encountered are that of neuropathic pain, weakness in upper extremities, spasticity in lower extremities, gait disturbances and autonomic symptoms such as bowel and bladder incontinence. The clinical signs used to evaluate the extent of neurological injury involve corticospinal tract signs, i.e. upper and lower limb spasticity and hyperreflexia, positive plantar response, ataxia of gait and Hoffmann's reflex. Gait disturbances have a wide array presenting florid spastic paraparesis as the most severe clinical presentation (Iyer, Azad & Tharin, 2016).

Figure 2: Spurling maneuver. Lateral flexion and extension of the neck with axial compression (Childress & Becker, 2016).

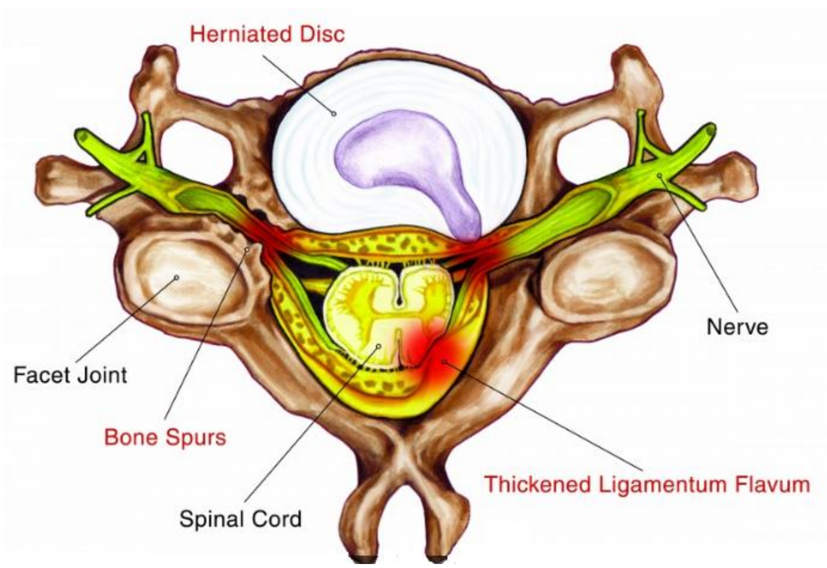


Figure 3: Example of spinal nerve compression (viewed from above)

(Stewart, 2019)

The incidence of patients with Cervical Myelopathy has been reported to be 1.6 per 100,000 individuals yearly (Boogaarts & Bartels, 2015). Physical tests include tandem walking, heel walking, toe walking, and Romberg's sign. Tests of hand include 15 sec grip and release and finger escape sign. Cervical range of motion should also be assessed in flexion,extension,lateral bending, and axial rotation range of movements (Lebl, Hughes, Cammisa & Leary, 2011).

1.8.7.3 Axial Joint Pain

It is a common clinical condition identified by pain radiating to the medial scapula, chest wall, shoulder, and head. It is often misdiagnosed as a cervical sprain or strain. Headaches are generated in the occipital region due to cervical muscle spasms. Pain radiating to the medial border of the scapula is a characteristic feature which can be relieved by rest and immobilization (Voorhies,2001). There is no neurological involvement in this syndrome. Several factors related to the ligamentous and bony elements of cervical spine predispose to this condition; they include poor posture, muscle fatigue, occupational factors, and prior neck injury. A study after chemical analysis of trapezius muscle revealing decreased levels of high energy phosphates and increased adenosine monophosphate and creatine concluded that the pain is generated due to the muscle. Chronic suboccipital pain is a characteristic feature denoting atlanto-occipital and atlantoaxial degeneration (Kelly, Groarke, Butler, Poynton & Byrne, 2012).

1.9 PATHOGENESIS

Cervical spondylosis is initiated by a series of physiological and biochemical changes occurring over time. Desiccation of the discs is caused by an increased ratio of keratin sulfate to chondroitin sulfate which reduces the disc size and elasticity of nucleus pulposus; dorsal annular fibers also get compromised and ligaments leading to kyphosis of the cervical spine. With advancing kyphosis, the annular and Sharpey’s fibers separate from the vertebral endplates forming osteophytes at the devoid areas. Osteophytes are developed as a protective phenomenon to compensate for the load-bearing effect on the margins of the cervical spine and canal simultaneously impinging on the neural and vascular structures within the spinal cord. The disrupted neutral axis of the cervical spine is no more efficient to bear axial load, distributing weight to the uncovertebral and facet joints augmenting formation of osteophytes and ventral angulation of cervical spine (Ferrara, 2012).

1.10 RADIOGRAPHIC CHANGES

The frequent radiographic changes observed involve disc space narrowing, osteophytes formation, vertebral endplate sclerosis, ossification of ligaments, sagittal alignment of cervical spine and abnormalities at neurocentral and zygoapophyseal joints (Moon, Yoon, Park & Park, 2016).

1.11 ADVERSE EFFECTS OF CERVICAL SPONDYLOSIS

1.11.1 Stroke

Posterior circulation ischemic stroke is due to the internal or external compression of the vertebrobasilar system, most commonly caused by atherosclerotic changes or emboli. Cervical spondylosis is a risk factor, 1.46 times for posterior circulation ischemic stroke. Vertebral artery transmitting through transverse foramina of C3-C6 vertebrae can be compressed due to osteophytes and narrowing of foramina (Chen, Chung, Lee, Chang, Tang & Pei 2015). Most predilected sites are C4-C5, C5-C6, and C6-C7 cervical vertebrae. The increased sympathetic tone in hypertension can also be a risk factor for stroke (Lin et al., 2018).

1.11.2 Dysphagia

Dysphagia has been reported in several patients having a cervical spinal deformity or cervical spondylosis (Unlu, Orguc, Eskiizmir, Aslan & Bayindir, 2008). The deep cervical flexor muscles, longus coli and longus capitis maintain lordotic curve. Dysfunction of these muscles and anterior cervical osteophytes cause dysphagia. Dysphagia is more severe for solids than liquids while aspiration is more due to liquids rather than solids. Cervical spondylotic patients display rigid spines with limited range of movement due to which safe deglutition positions can not be adopted making the situation worse (Papadopoulou, Exarchakos, Beris & Ploumis, 2013).

1.11.3 Hypertension

Cervical spondylosis is also believed to be the cause of secondary hypertension owing to the stimulation of sympathetic reflex causing vertigo and hypertension (Peng, Pang, Li & Yang, 2015).

1.11.4 Tinnitus

Tinnitus is also associated with cervical spondylosis attributing to the vertebrobasilar insufficiency. Compression of the vertebrobasilar artery leads to ischemia in internal ear and tinnitus (Zhang, Wu & Chen, 2013).

1.11.5 Neuromyelitis Optica Spectrum Disorder

Neuromyelitis Optica Spectrum Disorder showed lesions with longitudinally extensive transverse myelitis (more than three vertebrae) mainly located in the cervical and thoracic spinal cord. It is easily misdiagnosed as cervical spondylosis; therefore, prompt diagnosis is essential. It should be evaluated clinically with imaging techniques, and detection of serum AQP-4 antibody can help in its diagnosis (Zhou, Zhu, Cheng & Lin, 2015).

1.11.6 Vertigo

Vertigo is defined as an unpleasant disturbance of spatial orientation. It involves dysfunction in ear, nose and throat, central nervous system, cardiovascular system, and benign paroxysmal vertigo (Peng.,2018). There are different hypothesis related to cervical region explaining the process, and they include Barré-Lieou syndrome, cervical proprioceptive vertigo, Rotational Vertebral Artery Vertigo (RVAO), and migraine-associated cervicogenic vertigo. Each has different pathophysiology, diagnostic characteristics, and optimal treatment. Diagnosis depends on correlating patient’s symptoms with neck pain etiology excluding other vestibular disorders (Attry et al., 2016).

1.12 TREATMENT

1.12.1 Conservative Treatment

The incidence of the disease is getting prevalent in younger population affecting around 10-15% of patients. A variety of treatment options have been devised which include medications, physiotherapy, chiropractic, acupuncture, tuina, and High-Intensity Laser Therapy (HILT) (Fan, 2018). Loss of lordotic curve is significant in patients with cervical spondylosis. Acupuncture which involves insertion of filiform needles at acupoints and tuina is a muscle relaxation achieved through manipulation techniques, these both have been reported to alleviate pain, restore standard lordotic curve, muscle spasm and allow a cervical range of motion (Wang & Long, 2017). The reason behind the efficacy of acupuncture is that it has been found to release endogenous morphine-like substances which relieve pain, relax muscles and increase the local blood circulation (Yang, 2008).

Cervical spondylosis is the disease common in elderly, so the conservative treatment is preferred. The use of complementary and alternative medicine has also been encouraged in the United States of America due to lesser side effects. Pharmacopuncture is used in East Asia, employing the use of herbal medicine at the acupuncture reflex points. It is also being practiced in Korea (Lee et al., 2018).

1.12.2 Surgical Treatment

Conservative treatment is indicated first, but if it fails to relieve pain, then surgery is considered. Decompression is achieved through anterior and posterior techniques as discovered by Robinson and Smith and Cloward (Faldini et al., 2010).

Surgery has been reported to alleviate disease symptoms more quickly than conservative treatment. Surgical intervention has much potential to eradicate the disease in the ageing population.

Cervical Disc Arthroplasty (CDA) or Total disc replacement has also emerged as a better technique in treating cervical spondylosis and its syndromes, preserving mobility at multiple levels and reducing adjacent segment disease in the last two decades. It has been proved to be safe and efficient as anterior cervical discectomy and fusion, which has been practiced earlier. Effective decompression is achieved through CDA; it has been associated with less adverse effects. It promises to be a better choice for treating cervical stenosis caused by different etiology in future (Chang, Huang, Wu & Mummaneni, 2018).

1.13 IMAGING METHODS

Several imaging modalities have been used to diagnose cervical spondylosis. They include X-rays, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), spinal angiography, and vertebral artery angiography.

1.13.1 Plain Radiography

X-rays are readily available, and cost-effective modality with less radiation dose; it seems to be the most commonly used in our clinical practice. They are the first imaging technique widely employed to examine cervical spine (Saraiva, Silva & Grande, 2016). X-rays can quickly identify vertebral dislocation, curvature, space between intervertebral discs, intervertebral foramen, sclerosis, osteophytes, calcification of ligaments, and abnormal position change. On the other hand, MRI which is also used for evaluation of pathological changes in the spine, is not preferred due to the weak correlation between the findings and the clinical presentation (Yu & Xiang, 2014).

1.13.2 Magnetic Resonance Imaging (MRI)

MRI can easily detect type 1 and type 2 Modic changes, disc degeneration, herniation, bulge, compression of roots, foraminal stenosis, central stenosis, and arthrosis at facet joints, and uncovertebral joints. Foraminal stenosis also appears in asymptomatic patients which concludes the fact that pathoanatomical changes can also appear in healthy individuals. The degenerative findings are common in between the ages of 18 and 40 years which is of significant concern (Jensen et al., 2019).

MRI is the preferred imaging modality for detecting the severity of cervical myelopathy as it demonstrates canal stenosis and degree of compression. Disadvantages of MRI include chemical shift, truncation, cerebrospinal fluid flow, and motion artifacts. These disadvantages are offset by a newer modality, i.e. dynamic MRI (Karpova et al., 2013).

1.13.3 Dynamic Magnetic Resonance Imaging

Diffusion Tensor Imaging (DTI) is an MRI technique. It is a sensitive imaging modality for patients with functional dysfunction in advanced stages of cervical spondylosis. It easily detects micro-structural changes in cervical spondylosis cases at the cervical cord, compression of the disc, disc protrusions, osteophytes at marginal endplates, ossification of ligaments, secondary cord ischemia, cavitation, demyelination as well as cord infarction. DTI can evaluate neural integrity on the disc lesion even at contralateral side concerning the patient's presentation; therefore, it has an edge over conventional MRI. Therapeutic measuresare dependent on early and accurate diagnosis (Ibrahim & Saleh, 2018).

Dynamic MRI detects pathological changes and micro-structural changes with respect to the distribution of white matter/tracts effectively in patients of cervical spondylosis and would serve as a better aid in future (Schatlo et al., 2018).

Cervical spine disorders deteriorate normal alignment of the cervical spine inducing changes in the curvature which leads to the fatigue, pain and unnecessary increased muscular force. Dimensional CT scans are being used to evaluate cervical and thoracic sagittal alignment parameters exposing patients to repeated dosing of ionizing radiations which is hazardous as well. MRI does not involve radiation and provides greater vertebral visibility; it is used to detect cervical and thoracic sagittal alignment parameters in cervical spondylotic patients when X-rays don't show anatomical sites due to the overlapping of soft and bony tissues (Cheng et al., 2019).

1.13.4 Computed Tomography (CT)

Contrast-enhanced CT and CT myelography are imaging tools used for the cases of cervical radiculopathy, but they possess hazards of nephrotoxicity and anaphylactic reactions. The non-contrast CT has some disadvantages which include lack of soft tissue contrast, radiation exposure, more time for formatting sections, beam hardening artifacts in lower cervical spine and motion artifacts. The multidetector-row computed tomography (MDCT) has a few seconds scan acquisition time, sufficient spatial resolution, enhanced multi-planar reconstructions and fewer motion artifacts. It is employed as a practical and cost-effective approach for evaluating disc lesions, spondylosis or in individuals where MRI is contraindicated (Yi, Cha, Han & Kim, 2015).

1.14 HYPOTHESIS

Null Hypothesis

Short neck length is not associated with an increased incidence of cervical spondylosis.

Alternate Hypothesis

Short neck length is associated with an increased incidence of cervical spondylosis.

1.15 OBJECTIVES OF STUDY

The objectives of the study were to

- Compare neck length, relative neck length, and height with the incidence of cervical spondylosis.
- Compare demographics and baseline patient's characteristics between subjects and healthy population.
- Compare demographics and baseline patient's characteristics within subjects with respect to the incidence of cervical spondylosis.
- Compare demographics and baseline patient's characteristics within subjects with respect to the radiographic changes observed in the subjects of cervical spondylosis.

1.16 PROBLEM STATEMENT

Cervical spondylosis is the most common problem encountered in the orthopedic outpatient department. This disease has been a target of diverse fields including neurology, neurosurgery, radiology, physiotherapy, and orthopedics. It has an insidious onset and progress stealthily deteriorating quality of life. It has been observed that it is more common in short stature individuals. As short stature is prevalent in our population on the account of factors like undernutrition, lack of exercises, and probably some genetic predisposition, we wanted to evaluate short neck length, relative neck length, and height with respect to the incidence of cervical spondylosis.

1.17 SIGNIFICANCE OF STUDY

The condition is prevalent in our society in ageing population. Through this study, we wanted to find the association of neck length, relative neck length, and height with the incidence of cervical spondylosis. We wanted to evaluate demographics, patient's characteristics and radiographic changes to assess their association with the disease. This study was also important due to the fact that short stature people were more affected by the cervical spondylosis and its resultant complications. Multiple measures can be simply adopted for the prevention of cervical spondylosis. A physician or physiotherapist can educate the general population with short neck length to have a good neck posture, massage, and advice of neck exercises and other non-operative measures as a guideline.

1.18 OPERATIONAL DEFINITIONS

Spondylosis:

Spondylosis is defined as "vertebral osteophytosis secondary to non-inflammatory disc degeneration, it is a normal ageing process" (Shedid and Benzel, 2007)

Cervical Spondylosis:

Cervical spondylosis is defined as "the degeneration of the cervical spine that occurs during the normal course of ageing. This degeneration leads to herniated intervertebral discs, osteophytes, and ligament hypertrophy, which may eventually cause compression of the nerve roots and spinal cord" (Xiong and Guan, 2015)

Cervical myelopathy:

Cervical myelopathy is defined as "the dysfunction of the spinal cord with sensory and motor deficits, loss of dexterity and poor coordination" (Harrop, Naroji, Maltenfort, Anderson, Albert and Ratliff, 2010)

Cervical radiculopathy:

Cervical radiculopathy is defined as "the disorder of cervical spinal nerve causing inflammation or compression. It is caused by the disc herniation or any space occupying lesion" (Wainner, Fritz, Irrgang, Boninger, Delitto and Allison, 2003)

Disc degeneration:

It is "a cell-mediated response to progressive structural failure. A degenerative disc is a structural failure combined with accelerated or advanced signs of aging" (Adams and Roughley, 2006)

Neck length:

It is the "linear distance between two fixed bony points, the external occipital protuberance and the spinous process of the C7 vertebra with the patient standing upright and neck held in a neutral position" (Mahajan and Bharucha, 1994)

CHAPTER 2

LITERATURE REVIEW

There have been a rising trend in cervical disease and spinal surgeries. The lack of human cadavers and its related ethical concerns paved a way in modern science which involves the use of cervical vertebra from animals like sheep, calves, dogs, deer, and baboons to substitue human cervical vertebra. The seventh cervical vertebra of the calf have also been found to bear much resemblance to that of humans (Sheng et al., 2016).

Significant differences exist between the genders with respect to the morphology of the cervical vertebrae which become most evident after puberty. The vertebral body in males is larger than that of females. The reason being the enhanced growth of the male over the females, which also continues for a longer period, i.e., 19 to 20 years. In contrast, females are believed to complete growth around the age of 17-18 years. These parameters for measurement are helpful as references in assessing medical intervention. The cervical vertebrae of both genders show same growth in super-inferior depth while males show more growth in anteroposterior plane. These developmental changes occur as the child starts to hold neck and bear the weight of the head on adopting an erect posture in the initial two decades. In short, the differences in morphometry of cervical spine account for the growth rate, its duration and the biochemical needs of cervical spine like controlling head, nuchal muscle development, bipedal movement and shifting of line of gravity (Miller, Hwang, Cotter & Vorperian, 2019). There has been a predisposition of cervical spondylosis in the patients of Down Syndrome. It is due to Atlantoaxial instability (AAI) which is defined as the increased mobility of C2 in relation to C1 occurring frequently in patients with Down syndrome due to the laxity of the ligaments. Ten to twenty percent of individuals with AAI were suffering from Down syndrome. The study reported that half of the patients with AAI had cervical spondylosis (Ali, Al-Bustan, Al-Busairi, Al-Mulla & Esbaita, 2006).

The cervical spine is a delicate mobile structure, more prone to injuries and pain, and its treatment is also difficult and require extra care (Haładaj, Pingot & Topol, 2017).

Cervical spine injuries in children are common in the upper cervical spine, as the fulcrum of motion is at C2-C3 level as compared to C5-C6 in adults. Moreover, the pediatric cervical spine is lax and shallow having angled facet joints, underdeveloped spinous process, and anterior wedging of vertebral bodies. Large head, weak muscles and incomplete ossification at dens are other factors (Lustrin et al., 2003). Spondylosis is a degenerative cascade involving wear and tear of vertebrae, intervertebral disc, facets, joints and ligaments with age. It is the most prevalent disease in the aged individuals with the mean age of 70.2 years. Cervical spondylosis accounts for the degenerative changes in 95% of asymptomatic men and 89% of women respectively. It involves multiple spinal levels and can present with neck and regional pain (Toledano & Bartleson, 2013).

The cervical spondylosis was first time defined in 1948 as the degeneration of the cervical spine with respect to ageing which leads to herniated intervertebral discs, development of osteophytes, and ligament hypertrophy resulting in compression of the nerve roots and spinal cord (Brain, Knight & Bull,1948).

Procedures like thyroidectomy, parathyroidectomy, dental extraction, Coronary Artery Bypass Grafting (CABG), and long term hemodialysis involve hyperextension of the neck which narrow the spinal canal and cause compression of the spinal cord (Xiong & Guan, 2015).

Difficult laryngoscopy is also observed in cases with cervical spondylosis (16.4%). A ratio known as Neck Circumference/Inter-Incisor Gap Ratio (RNIIG) was believed to predict difficult laryngoscopy in the spondylotic patients, as it is difficult to expose glottis in such patients. A value of RNIIG of ≥ 9.5 predicted difficult laryngoscopy in cervical spondylotic patients (Han et al., 2017).

Cervical radiculopathy presents with an incidence of 83.2 per 100,000, and a prevalence of 3.5 per 1,000 population. Surgery is indicated with the progression of symptoms like gait changes or autonomic symptoms like bladder and bowel incontinence (Kavanagh, Butler, Byrne & Poynton, 2012). The compression in cervical radiculopathy leads to intraneural edema, or ischemia (Chung, Yim, Seo, Kim & Cho, 2012). The involved roots are affected along with their dermatomal and myotomal distribution and present with associated sensory and motor changes respectively. The C4-5, C5-6, and C6-7 roots level are commonly involved. They present with weakness of intrinsic hand muscles supplied by the median and ulnar nerves (Sadeh & Dabby, 2017).

A new screening test, “Neck tornado test” has been proposed to screen cervical radiculopathy. It involves compression at all angles while rotating neck and has high sensitivity and moderate to high specificity as compared to other provocative tests (Park et al., 2017).

Cervical Myelopathy has been defined by 8 weeks of clinical presentation. It is the most common cause of spinal dysfunction in the elderly. Its etiology involves multiple factors like genetic and environmental factors. The pathogenesis involves chronic inflammatory response, apoptosis of neurons and oligodendrocytes, and hypoxic ischemic injury (Lebl & Bono,2015). A study suggested surgical decompression as an effective way to arrest disease progression and boost quality of life, functional activity and neurological status (Badhiwala & Wilson, 2018).

Cervical canal stenosis causes myelopathy due to the compression against bony spinal canal (Dong et al., 2013). The compression can also be due to several other factor like trauma,inflammation, infection or degenerative changes. Prompt diagnosis and intervention can effectively delay the progress (Wheeler et al., 2014). The individuals with narrow spinal canal are at increased risk of developing myelopathy, as high prevalence is seen in North America, Japan, Europe, Australia and Africa (Gibson et al., 2018).

Cervical canal stenosis can be detected by a ratio known as Torg-Pavlov ratio. It is measured by dividing the anteroposterior diameter of the cervical canal with the anteroposterior diameter of the vertebral body. A Torg-Pavlov ratio having value ≤0.80 represent significant stenosis (Morales et al,. 2018). The assessment of cervical myelopathy is mostly done by MRI. With the advances in technology, a new technique known as Diffusion Tensor Imaging has emerged as a better biomarker for delineating anatomical disruption and functional impairment in spondylotic patients (Ellingson et al,. 2014).

Axial neck pain is attributed to stress, posture and muscle fatigue related to muscular and ligamentous factors. The peripheral portion of intervertebral disc is supplied by sinuvertebral nerve which supplies the vertebral body, disc, ligaments, and epidural veins, and is responsible for pain perception (Hirpara, Butler, Dolan, Byrne & Poynton, 2012).

Several imaging modalities like X-rays, MRI and CT scans have been used for the diagnosis of the cervical spondylosis and to differentiate between its syndromes of radiculopathy, myelopathy and axial joint pain. These modalities localize the lesion, its level and the severity which is of utmost important if surgical intervention is required. Apart from modernization in imaging techniques, X-ray still remains a useful, inexpensive and easily accessible modality for the assessment of cervical spine. X-rays can be taken in different views like lateral, oblique and anteroposterior as well (Green, Butler, Eustace, Poynton & Byrne, 2012).

Senescence is a normal ageing process. The difference between senescence and degenerative changes is not clear up to date. The imaging findings which are predictive of degenerative changes include instability, disc herniation, annular fissure, end plate changes, marrow changes and canal stenosis (Kushchayev et al., 2018).

The cervical spinal range of movement decreases in cervical spondylosis,it is also reduced in relation to the age and the severity of the degeneration. It can be easily assessed by Kinetic MRI which can evaluate subaxial cervical spinal movement (Hayashi et al., 2016). A motion system known as Cartesian Optoelectronic Dynamic Anthropometer (CODA) motion system is also being used to measure cervical range of motion. As cervical spondylotic patients suffer from limited cervical mobility and acquired disability in daily activities, it is a better parameter to indicate disease progression (Gao et al., 2017).

Vertigo is the hallucination of movement, commonly encountered in the elderly. It is due to the dysfunction in either sensory input regions like visual, vestibular, proprioceptive or central centers. There are abundant mechanoreceptors in the deep cervical muscles and free nerve endings in the intervertebral disc which are responsible for neck pain (Yang etal., 2017).

Cervical vertigo is a very disputable term among various causes of vertigo. The development of osteophytes at Luschka’s joints is responsible for causing it. These joints exist as an uncinate process situated on the upper surface of the vertebral body from the lateral to the posterior side with corresponding recess on the inferolateral surface of the upper vertebral body from third to seventh cervical vertebrae. It protects intervertebral foramen and gives stability and mobility to the cervical spine. There was no method for diagnosing cervical vertigo previously. However, the Musculoskeletal Ultrasound (MSUS) is a non-invasive technique to scan Lusckha joint and vertebral artery in the real time. It promises an excellent diagnostic approach for cervical vertigo (Yin et al., 2016).

Many diseases are associated with ageing. Among one of them is depression which was associated with poor health outcomes. Therefore, it is regarded as a risk for cervical spondylosis. Depressed individuals adopt improper posture which leads to stiff muscles and disrupted anatomy of the cervical spine, hence deteriorating the cervical spine progressively. The patients should be offered postural training and orthopedic therapy to eradicate the disease (Lin, Sung, Lin, Chou, Hsu & Kao, 2018).

The migraine is another debilitating condition common in the cases of cervical spondylosis occurring with a prevalence of 15.9%. It affects majority of population, compromising health and quality of life. The release of vasoactive neuropeptides in the trigeminovascular system is responsible for the perception of pain (Lin, Huang, Chuang, Lin & Kao, 2018).

Cervical spondylosis is also associated with the increased sympathetic activity of the heart causing arrhythmia. It is responsible for compression of spinal canal and autonomic nervous system; therefore, it increases risk of arrhythmia by three-fold, and leads to other atypical symptoms such as dizziness, headache and palpitation. Therefore physicians should consider it and recommend anticoagulants in the ageing population to protect them from fatal consequences of the disease (Lin et al., 2018).

Cervical spondylosis has been regarded as an epidemic by the World Health Organization (WHO). Neck pain ranks second after back pain as the common musculoskeletal problem. The prevalence of chronic neck pain is around 10-24%. Vertebrobasilar insufficiency, bad posture, trauma, hormonal and emotional disorders, and intervertebral disc degeneration are responsible for the compression and pain (Kolu, Buyukavci, Akturk, Eren & Ersoy 2018).

With mechanized lifestyle as adopted by our society, one spends more than 8 hours a day while sitting, and this sitting posture leads to musculoskeletal problems affecting 25–51% of office workers. Sitting posture increases the load and pressure at intervertebral disc more as compared to standing posture (Kwon, Kim, Heo, Jeon, Choi & Eom, 2018).

Static postures involve contraction of the head and neck muscles in several occupations. The head makes up about 6% of the total body weight supported by the cervical spine, muscles and joints. Normal posture is defined by an imaginary line i.e., line of gravity passing from the external auditory meatus, bodies of cervical spine, and acromion, and passes anterior to the thoracic spine. Malalignment in spine entails failure of head to align in vertical axis which leads to round shoulders and thoracic kyphosis to compensate for the altered line of gravity. Examples of such posture include slouched or slumped posture. Forward head posture is related to the computer and mobile use, carrying heavy back packs, breathing by mouth and shoulder overuse. Neck muscles are also shortened in it like levator scapulae, sternocleidomastoid, trapezius and suboccipital muscles (Singla& Veqar, 2017).

Disc degenerative disorders also have genetic influence of around 75%. It was observed in familial aggregations and heritability estimates. Some genes, such as, collagen type XI alpha 1 (COL11A1), asporin (ASPN), and thrombospondin 2 (THBS2) have structural roles, with the matrix metalloproteinase 9 (MMP9) involved in the structural degradation. Growth differentiation factor 5 (GDF5) have a role in development of the ligament and tendon and the growth of the nucleus pulposus. The heritability estimates has been 75% in women of United Kingdom and Australia while Finnish men had an estimate of 30-55% (Näkki, Battié & Kaprio, 2014). The degenerative disc disorder leads to segmental instability which increases the load on the facet joints. Degenerative process starts from the intervertebral disc with the increased predilection for increasing age, female sex and increased BMI as the risk factors. Osteoarthritis on the other hand, is the structural and functional failure of the synovial joints indicated by the inflammatory changes, damage to the articular tissue and the subchondral bone, and overgrowth of the bone and cartilage. It is commonly observed in knee, hands and hips. The radiographic features are different in degenerative process and osteoarthritis (Goode, Carey & Jordan, 2014).

Intervertebral disc degeneration is a loss of matrix molecules, which affects tissue biochemical contents and disrupts normal alignment of the cervical spine resulting in the degeneration. MRI is a common non-invasive modality used to assess soft tissue structures. The evolution of kinetic MRI has improved efficiency of imaging technique (Xiong et al., 2017).

The intervertebral disc allows mobility, flexibility and tolerance to the weight bearing of the spine. The degenerative disc disorders account for the disability adjusted life years as they cause pain, neurological deficits and disability. More than 52 million patients in United States are affected by it. The intervertebral disc includes soft tissue in between two vertebral bodies and fibro cartilaginous part of the facet joints. It is able to bear pressures of 0.1 to 3 Mega Pascal (MPa). The deterioration in the intervertebral structure can affect the alignment, flexibility and anatomy of the nerves, or osteophyte formation corresponding to the ageing process (Bowles& Setton, 2017).

The disc degeneration leads to prostaglandin leakage in the intervertebral disc and causes ingrowth of free endings of a sinuvertebral nerve from the ventral ramus and the sympathetic chain in to the intervertebral disc, while in the normal disc, it penetrates only the outer lamella (Eloqayli, 2018).

Cervical spondylosis causes spinal instability which is of prime concern. With increasing prevalence of cervical spondylosis, some modality should be developed for measuring cervical instability. For this purpose, a radiographic index method was developed which employs the use of radiograph of cervical spine in neutral, flexion and extension views. The radiographic index is measured by horizontal displacement and angular displacement of cervical vertebral body on the lateral view. The height in between anterior and posterior intervertebral space was divided by the height of inferior vertebral body to yield cervical curvature index. It determines the morphometry of the cervical spine, the difference in the vertebral bodies, the cervical curvature and the flexion extension range of motion (Alizada, Li & Hayatullah, 2018).

The degenerative changes of cervical spine are widespread in asymptomatic population. A study had 1211 asymptomatic volunteers ranging from18 to 69 years, which displayed significant disc bulge (87.6%) and the compression of the spinal cord (5.3%) in Japanese population (Tetreault et al., 2015).

The cervical spine possesses lordotic curve. It is the ideal posture assumed by the neck with respect to the biomechanics of the cervical spine. If cervical curvature is lost, it leads to cascade of degenerative process. Loss of curvature is associated with pain in the neck, shoulders, upper thoracic region and headache. The vertebral arteries pass in the transverse foramen of each cervical vertebra. Loss of lordosis affects vertebral artery also altering its hemodynamics. Loss of lordotic curve is also associated with the severe compressive forces exacerbating the degenerative process. It is also associated with tension of neck muscles (Bulut et al,.2016).

A study attempted to determine the lordotic curve in healthy subjects, and its change in the patients of the cervical spondylosis presenting with non specific pain after spinal manipulation therapy, as the lordotic curve can change either due to the trauma or the degenerative process. The reduced lordotic curve is also associated with neck pain which affects health severely. It is also believed by some researchers that the decreased lordotic curvature is a normal variant and is not responsible for causing neck pain. The study reported no association of lordotic curvature between patients and healthy subjects. Further there was no change in lordotic curve after spinal manipulation therapy (Shilton, Branney, Vries & Breen, 2015).

The compression of vertebral artery against osteophytes at Luschka's joint is responsible for causing vertigo and sympathetic symptoms. Apart from that, the sympathetic nerves present in posterior longitudinal ligament are also responsible. Previous studies demonstrated that the anastomosis between the cervical sympathetic ganglia and the sinuvertebral nerves caused vertigo. However, it was further studied and it was found that the sympathetic nerves in posterior longitudinal ligament were also responsible for causing sympathetic symptoms. The sinuvertebral nerve can be compressed directly, by the osteophytes, due to the release of chemical mediators or, instability to the cervical spine can irritate sympathetic nerves in the posterior longitudinal ligament causing sympathetic symptoms (Li et al., 2014).

CHAPTER 3

METHODOLOGY

3.1 STUDY DESIGN

Case control study

3.2 ETHICAL APPROVAL

This study was approved by the ethical review committee and faculty research committee of the Bahria University Medical and Dental College (Appendix A). It was also approved by the ethical review committee of the Bahria University Medical and Dental College and Patel hospital (Appendix B).

3.3 SETTING

The study was conducted in the Orthopedic outpatient department and Radiology department of the Patel Hospital.

3.4 INCLUSION CRITERIA

(a) For cases

- Age between 18 to 75 years
- Diagnosed cases of cervical spondylosis on clinical grounds referred from outpatient departments of orthopedic surgeon
- Provided written informed consent
- Any previous investigation confirming diagnosis of cervical spondylosis (X-ray, MRI or CT scan)

(b) For controls

- Age between 18 to 75 years
- Healthy individuals
- No complaint of neck pain
- Provided written informed consent
- Previous radiographic records of neck if any, excluding cervical spondylosis

3.5 EXCLUSION CRITERIA

- History of trauma to the neck

- Cervical ribs, cervical tumors and previous surgeries like cervical laminectomy
- Congenital vertebral anomalies (scoliosis, block, or hemivertebra)
- Individuals with thyroid and parathyroiddiseases
- Neuromuscular disease
- Systemic disease involving cervical spine
- Systemic disease of bone
- Pregnant or lactating women
- Individuals under the age of 18years and over the age of 75 years

3.6 DURATION OF STUDY:

a) Individual study period: 2 hours
b) Total period of study: 6 months

3.7 SAMPLE SIZE CALCULATION:

It was estimated using sample size for comparing two means on the software G power 3.1.9.2 with the mean and standard deviation of 112.36±2.19 patient group and 98.51±3.22 control group (Taha et al., 2014). Margin of error was kept 5%, and confidence interval was 95%. The minimum sample size in each group was 88, making a total of 176 subjects.

3.8 SAMPLING TECHNIQUE:

The sample technique used was non-probability convenient sampling.

3.9 HUMAN SUBJECTS AND CONSENT:

Patients aged between 18 to 75 years presenting with the complaints of neck pain, arm pain, vertigo, and headache were assessed in the orthopedic outpatient department where detailed history was taken by the orthopedic surgeon which was followed by the clinical examination. Then the subjects were advised X-ray of cervical spine to confirm the diagnosis. They were also asked to sign an informed consent form and were accompanied by the principal investigator to the radiology department for lateral radiographs of neck through Agfa Fuji Computed Radiography system CR-35 X to verify the findings of cervical spondylosis, and to assess further complications caused by it. The controls were recruited from the healthy attendants accompanying the patients. They did not complain of neck pain or any symptoms related to the cervical etiology.

3.10 MATERIALS:

The demographics like age, gender and patient's personal characteristics such as presenting complaint, symptom duration and lifestyle factors were asked at the time of history in the orthopedic outpatient department and were recorded by the principal investigator in the subject evaluation form (Appendix D).

3.10.1 Stadiometer

The weight and height were measured by a stadiometer (Body Weight & Health Scale ZT-120) at orthopedic out patients department (Figure 4). The BMI was calculated by dividing weight in kilograms with the square of height in meters using the formula;

$$\text{weight (Kg)/ height } (m^2)$$

The BMI cut-off points were classified into following categories as Underweight, healthy, pre-obese, obese class I , obese class II and obese class III (Who, 2004).

Underweight:

The underweight was further divided into mild, moderate and severe category. These categories are mentioned as follows; severe underweight <16 kg/m^2, moderate underweight 16·0–16·9 kg/m^2 and mild underweight 17·0–18·49 kg/m^2.

Healthy:

The healthy range was within the BMI range of 18·5–24·9 kg/m^2.

Pre-obese:

The BMI range within 25–29·9 $kg/m^2$was delineated as the pre-obese.

Obese:

The obesity was further categorized into 3 groups as obese class I, obese class II and obese class III. The obese class I had a BMI range of 30–34.9 kg/m^2, the obese class II fall within range of 35–39·9 kg/m^2 and the obese class III was over the range of ≥40 kg/m^2.

3.10.2 Agfa Fuji Computerized Radiography System, CR-35X

The X-ray was taken in lateral view through Agfa Fuji Computerized Radiography system, CR-35X (Figure 5). The absolute neck length was measured on a software Synapse (Fujifilm Medical Systems, Tokyo, Japan). Synapse is a digital image management system used worldwide for its high image quality. The effective dose given at the time of exposure was 0.1mSv (millisievert) (Watson and Jones, 2018) which was very less as compared to the annual radiation exposure by the environment. With Computed Radiography system, radiographic technique was better, and images were sought at higher kVp (kiloVoltage peak) and lower mAs (milliampere second) which lead to the potential reduction in the patient radiation dose. Moreover, the CR system was also automatic and imaging plates were reusable. It also had low radiation dose as compared to MRI.

3.11 PARAMETERS OF STUDY

The parameters were divided into three categories i.e., demographics, personal characteristics and lifestyle factors. The demographics of the patients included age and gender. The personal characteristics included the measurements such as absolute neck length, relative neck length, height, weight, BMI, presenting complaint, and symptom duration. The lifestyle factors included occupation, working hours, usage of computer and mobile.

3.12 PROTOCOL OF STUDY

Patients presenting with the signs and symptoms of cervical spondylosis were advised lateral X-ray of the cervical spine as part of the initial investigation for the assessment and management of the disease. Such patients were told about the research and were asked to sign an informed consent form (Appendix C). It was made sure that they understood the procedure. The radiographs were taken by the same technician. They were then evaluated for the measurement of absolute neck length by a radiologist who was blinded to the patient’s details. The calculation of the relative neck length was done by the principal investigator in relation to the height of the subject. Those results were further cross checked by the expert radiologist and then documented in subject evaluation form by the principal investigator.

Figure 4: Stadiometer, Body Weight & Health Scale ZT-120 (Orthopedic outpatient dept, Patel hospital, Karachi, 2018- 2019)

Figure 5: Agfa Fuji Computerized Radiography System, CR-35X showing foot print digitizer, Central Processing Unit and monitor (Radiology dept, Patel hospital, Karachi, 2018- 2019)

The absolute neck length was measured on software Synapse by marking a point at the external occipital protuberance. Then the perpendicular distance was measured between the external occipital protuberance to the tip of the seventh cervical vertebra spinous process (Figure 6; Taha, Jafari, Kashyar & Asad, 2014). In order to remove the variation of the neck length with the height of the individual, relative neck length was calculated (Mahajan & Bharucha, 1994), by dividing the absolute neck length with the height of the subject and then multiplying it by 100 using the formula

$$\text{Relative neck length} = \frac{\text{Absolute neck length}}{\text{Height of individual}} \times 100$$

3.12.1 Positioning of the Patient

The X-ray of cervical spine was taken in erect lateral position. The patient was standing with each shoulder against the CR cassette, looking straight ahead with mouth closed. The shoulders were adjusted so that they were in horizontal plane. The median sagittal plane was also adjusted to make it parallel to the plane of CR cassette. The head was slightly extended and chin elevated to avoid superimposition of upper cervical vertebrae by angle of the mandible and of posterior arch of atlas by the occipital condyles, (Whitley, Sloane, Hoadley, Moore & Alsop, 2005).

The patient was asked to relax and depress shoulders before radiation exposure for demonstration of lower cervical vertebra. In obese cases, they were asked to carry 2 kg weight in each hand for proper visualization of the lower cervical spine. The immobilization was augmented by asking the patient to stand with feet apart and standing against cassette stand. The X-ray beam was directed towards a point vertically below the mastoid process at the level of prominence of thyroid cartilage with focus to film distance of 100cm. The exposure was given at the time of arrested expiration. The lateral x-ray of the cervical spine was evaluated by the adequate demonstration from atlanto-occipital joint to the top of first thoracic vertebra.

3.12.2 Radiographic Image Evaluation

The diagnosis of cervical spondylosis was confirmed on observation of radiological changes in the X-ray of the cervical spine (lateral view). The radiological changes were evaluated on the grading criteria developed by Kellgren and Lawrence, known as Kellgren Lawrence grading scale. This scale was used to assess the degenerative changes like the presence of osteophytes, disc height narrowing, and vertebral endplate sclerosis. It ranges from grade 0 to grade 4 (Table 1).

Grade 0	No sign of degenerative disc disease
Grade 1	Minimal anterior osteophytes
Grade 2	Definite anterior osteophytes with possible narrowing of the disc space and some sclerosis of vertebral plates
Grade 3	Moderate narrowing of the disc space with definite sclerosis of vertebral plates and osteophytes
Grade 4	Severe narrowing of the disc space with definite sclerosis of vertebral plates and multiple large osteophytes

Table 1: Kellgren Lawrence Grading Scale (Rudy et al, 2015)

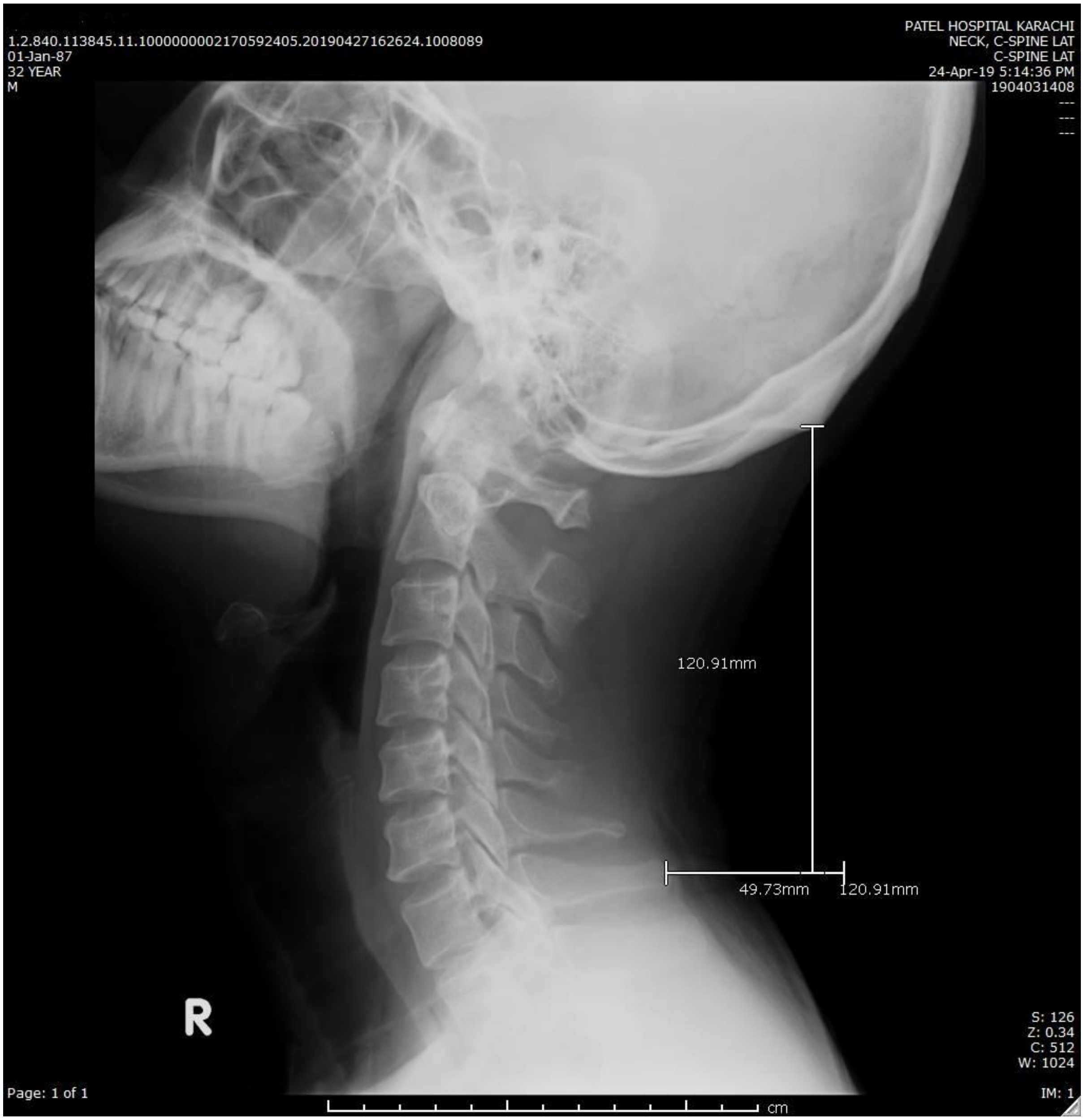
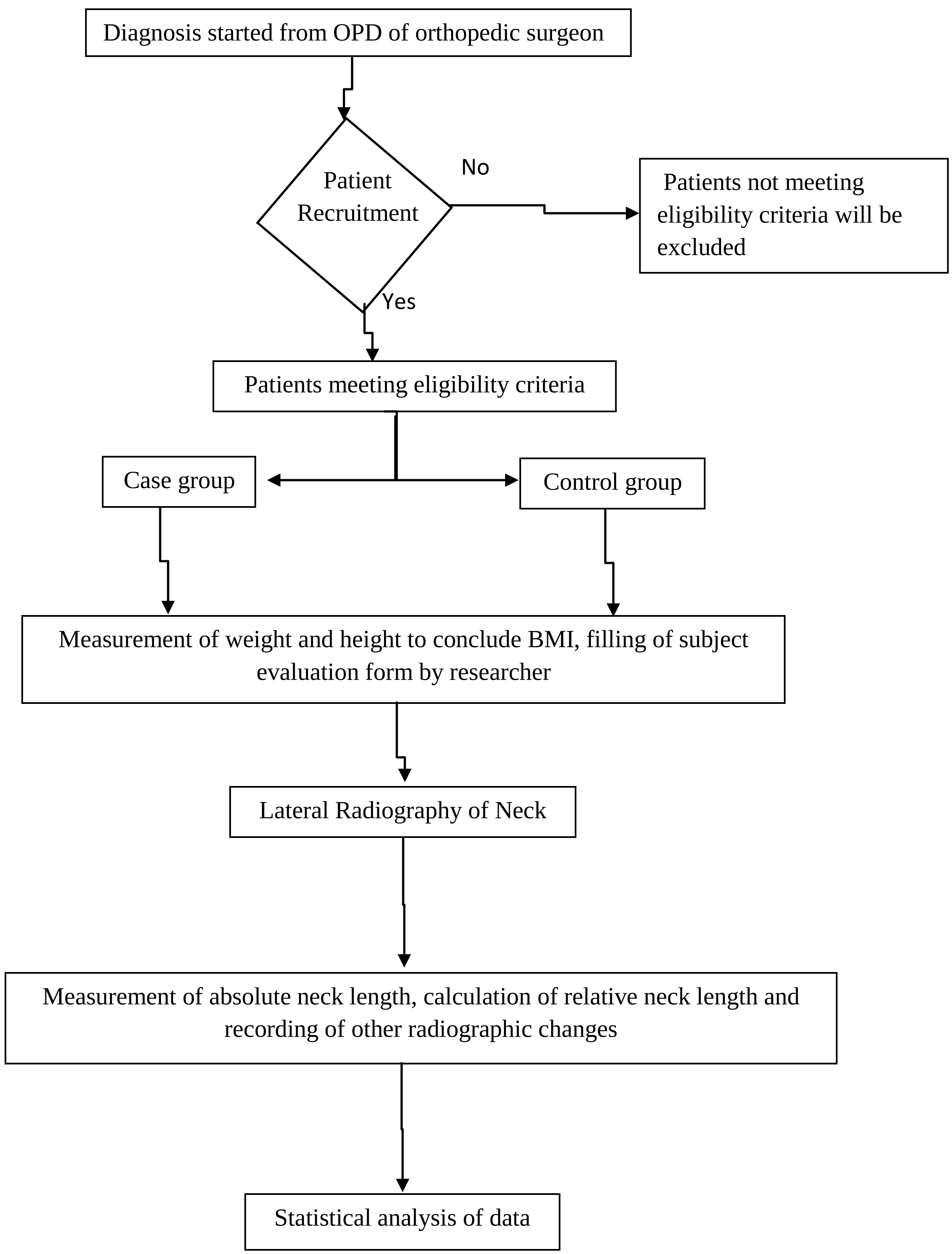


Figure 6: Radiographic Image showing measurement of Neck length using software "SYNAPSE" (Radiology dept, Patel hospital, Karachi, (2018-2019)

3.13 ALGORITHM OF STUDY



3.14 STATISTICAL ANALYSIS

The statistical analysis was done using software SPSS (Statistical Package for Social Sciences) version 23.0. The continuous variables were presented as mean and standard deviation. The categorical variables were presented as frequency and percentage. The data was checked for normality via Histogram with normal curve. A chi-square test and Fisher exact test was applied to find the association between the two categorical variables. For comparison of the two groups, independent sample T-test was applied. For comparison of more than two groups, one-way ANOVA (Analysis of Variance) was used. The p-value ≤ 0.05 was considered as a statistically significant difference.

CHAPTER 4

RESULTS

This study was designed to compare neck length, relative neck length and height in the cervical spondylotic patients with healthy controls and to evaluate patient's demographics, characteristics, and lifestyle factors with the incidence of cervical spondylosis. For this study, the data was statistically analyzed and all the results were plotted in the form of tables with their graphical representations.

4.1 COMPARISON OF NECK LENGTH, RELATIVE NECK LENGTH, HEIGHT AND WEIGHT BETWEEN CASES AND CONTROLS

The value of mean neck length in cases and controls was 104.15±18.9mm and 106.98±19.0mm respectively. There was an insignificantly shorter neck length in cases as compared to controls with a p-value of 0.326 (Table 2, figure 7a).

Statistically insignificant shorter relative neck length (6.90±0.89mm) was observed as compared to the controls (6.93±0.87mm) with a p-value of 0.823 (Table 2, figure 7b).

The value of mean height in cases and controls was 163.31±9.88cm and 166.22±9.07cm respectively. A statistically significant shorter height was determined in cases when compared to controls, with a p-value $\leq$0.05 (Table 2, figure 7c).

Statistically insignificant increase in weight of cases (69.62±11.2kg) was observed as compared to controls (66.64±12.44 kg) with a p-value of 0.097 (Table 2, figure 7d).

4.2 COMPARISON OF NECK LENGTH, RELATIVE NECK LENGTH, HEIGHT AND WEIGHT WITHIN CASES VERSUS GENDER

The value of mean neck length in males and females was 109.08±16.94mm and 100.42±19.78 mm respectively. There was statistically significant shorter neck length in females as compared to the males with a p-value of 0.033 (Table 3, Figure 8a).

Statistically insignificant longer relative neck length (7.01±0.90) was observed in males as compared to females (6.82±0.90) with a p-value of 0.317(Table 3, Figure 8b).

The mean value of height in males and females was 168.81±8.42cm and 159.14±8.88cm respectively. The females had a significantly shorter height as compared to the males with a p-value of 0.000 (Table 3, Figure 8c).

The mean value of weight in males and females was 73.94±11.93 kg and 66.34±9.49 kg. The males were significantly heavier as compared to females with a p-value of 0.001 (Table 3, Figure 8d).

4.3 COMPARISON OF NECK LENGTH, RELATIVE NECK LENGTH, HEIGHT AND WEIGHT WITHIN CASES VERSUS RADIOGRAPHIC CHANGES

The mean value of neck length with moderate narrowing, definite sclerosis and osteophytes (Grade 3) was 98.86 ±18.61mm; the mean value of neck length with definite anterior osteophytes, mild narrowing and sclerosis (Grade 2) was 106.52±17.36mm, whereas, neck length with minimal changes (Grade 1) was 103.11±21.05mm. Thus, most extensive degenerative changes were observed with shortest neck length (p-value = 0.435), showing strong association of short neck length with increased severity of cervical spondylosis (Table 4, Figure 9a).

The mean value of relative neck length with Grade 3 radiographic changes was 6.69±0.74mm. The mean value of relative neck length with Grade 2 changes was 6.85±0.89mm and neck length with minimal anterior osteophytes (Grade 1) was 7.04±0.96mm. The relative neck length with Grade 3 radiographic changes was insignificantly shorter as compared to other radiographic changes with a p-value of 0.451 (Table 4, Figure 9b).

The mean value of height with Grade 3, Grade 2 and Grade 1 radiographic changes was 161.67±0.74cm, 163.49±11.27cm and 163.69±9.06mm respectively. Thus, most exaggerated degenerative changes (Grade 3) were observed with shortest height (p-value =0.824), showing increased occurrence of cervical spondylosis in short height subjects, and also confirming results of neck length (Table 4, Figure 9c).

The mean values of weight with Grade 3, Grade 2 and Grade 1 radiographic changes were 69.72 ±7.68 kg, 71.53±12.85 kg and 67.24±9.79kg respectively. When comparison was performed between the groups, it was observed that Grade 2 changes (definite anterior osteophytes, mild narrowing and sclerosis) were seen with increased weight, that is 71.53±12.85 kg with a p-value of 0.824 (Table 4, Figure 9d).

4.4 DEMOGRAPHICS AND CHARACTERISTICS IN CASES AND CONTROLS

The present study was conducted at a multidisciplinary private hospital. The data revealed a statistically insignificant increase in number of females (50) as compared to male subjects (38) with a p-value of 0.76 among the cases of cervical spondylosis (Table 5).

When disease process was compared between the different age groups, highest number of cases (22) were found in the age range of 51-60 years, followed by the age range of 41-50 years (21). These finding showed statistically significant enhancement of the disease in the middle age group with a p-value of 0.000 when compared with controls (Table 5).

The BMI was measured in the cases and controls, based on WHO categorization (undernutrition, healthy, pre obese, obese class I, II and III). The highest number of cases and controls were seen in the pre- obese range (41) and (27) followed by cases (14) and controls (7) in the obese class I range respectively. The preponderance of statistically significant pre-obese and obese class I cases indicated a significant difference with other BMI ranges (p- value of 0.003) (Table 5).

In the present study, the occupations were divided in five categories as home makers, outdoor workers, manual laborers, retired personnel and students. The number of cases and controls in the outdoor occupation were 39 and 48. The number of cases and controls as homemakers were 38 and 21, whereas as manual laborers were 3 and 1 respectively. The number of cases and controls as retired personnel were 8 and 1. No student reported with the symptoms of cervical spondylosis. More than half of the cases were outdoor workers and home makers. Hence, the prevalence of outdoor workers and homemakers was statistically significantly higher in comparison to other occupations with a p-value of 0.002 (Table 5).

4.5 LIFESTYLE FACTORS IN CASES AND CONTROLS

When working hours were compared between the cases and controls, it was ascertained that the cases (65) had a duration of more than 8 working hours, whereas the control group (65) had a working duration of less than 8 hours. The results showed statistically significant association of disease with the increase in working hours (p-value of 0.000) (Table 6).

The use of computer was evaluated between the cases of cervical spondylosis and healthy controls. A statistically significantly increased incidence of the disease (18) was seen in the cases with the use of the computer for less than 4 hours when compared with controls (42) with a p-value of 0.030, whereas statistically insignificant number of cases (17) were found with computer use of more than 4 hours when compared to controls (16)(Table 6).

The results of the present study ascertained a significantly increased number of cases (52) with the use of mobile phone for more than 4 hour duration, as compared to controls (28). The extended use of mobile for more than 4 hours indicated statistically significant difference with a p-value of 0.000. Thus, it can be determined that the mobile usage for longer time period was a leading contributing factor to the increased incidence of the disease (Table 6).

4.6 DEMOGRAPHICS AND CHARACTERISTICS OF CASES IN BETWEEN MALES AND FEMALES

The study subjects included 50 female and 38 male patients. There were (12) males and (9) females within age range of 41-50 years. There were (17) females and (5) males in the age range of 51-60 years. There were (9) females and (7) males in the age range of 60-70 years. There were (7) males and (4) females in the age range of 71-75 years The data showed that the increased ages were more susceptible for the disease although the results were statistically insignificant (Table 7).

There were 23 females and 18 males in the pre-obese range. There were more pre-obese and obese subjects (55) as compared to (32) healthy subjects. The results suggested that there was increased prevalence of pre-obesity and obesity, although statistically insignificant, in pathogenesis of disease with a p-value of 0.738 (Table 7).

There were 24 females and 18 males who had definite anterior osteophytes, narrowing and mild sclerosis (Grade 2), followed by minimal osteophytes (Grade 1) in 19 females and 15 male subjects. The results indicated a surge in the Grade 2 degenerative changes which was statistically insignificant in comparison to Grade 3 and Grade 1 radiographic changes (p-value=0.987) (Table 7).

4.7 LIFESTYLE FACTORS IN CASES BETWEEN MALES AND FEMALES

There were 27 male and 12 female outdoor workers in comparison to 37 female and 1 male home maker. The retired personnel and manual laborers were 8 and 3 respectively. These results confirmed the increased prevalence of disease in outdoor workers and homemakers which was statistically significant with a p-value of 0.000 (Table 8).

There were 38 females and 27 males who were working for more than 8 hours, whereas 12 females and 11 males had a working duration of less than 8 hours, thus indicating that more than half of the cases had a working duration of more than 8 hours. Thus, it was established that the increased working hours were strongly associated with escalated prevalence of disease, although the results were statistically insignificant with a p-value of 0.601 (Table 8).

The results of this study showed 12 males and 5 females who were using computer for more than 4 hours, whereas 10 males and 8 females were using computers for less than 8 hours. The number of non-users was highest with 37 females and 16 males. Thus, our results showed highest number of non-users with a highly significantly p value (Table 8).

There were 27 females and 25 males who used mobile for more than 4 hours as compared to 11 females and 7 males with the mobile use for less than 4 hours. It is ascertained that the increased mobile use hours were a provocative factor in the development of the disease, with a p-value of 0.508 (Table 8).

4.8 DEMOGRAPHICS AND CHARACTERISTICS OF CASES VERSUS RADIOGRAPHIC CHANGES

There were 24 females and 18males cases who presented with Grade 2 radiographic changes in comparison to the 19 female and 15 male participants who had Grade 1 radiographic changes. The results showed increased prevalence of Grade 2 degenerative changes, although they were statistically insignificant (Table 9a, figure 10a).

The results of the present study reported 12 cases in the age group 41-50 years, followed by 11 respondents in 51-60 years, and 8 cases in the age range of 61-70 years with Grade

2 degenerative changes respectively. These results confirmed the presence of statistically significant evidence of Grade 2 changes with increasing ages (p-value of 0.000) (Table 9a, figure 10b).

There were 23 cases with Grade 2 radiographic changes in the pre-obesity range as compared to 11 cases with Grade 1 changes. Similarly, there were 7cases with Grade 2 and 4 cases with Grade 1 in the obese range. These results demonstrated evidence of Grade 1 and Grade 2 degenerative changes in relation to increased BMI with a p-value of 0.143 (Table 9b, figure 10c).

The results demonstrated that 18 cases with Grade 2 radiographic changes and 15 cases with Grade 1 changes presented with pain in the cervical region indicating it to be the most common presenting complaint (p-value=0.796) (Table 9b, figure 10d).

4.9 LIFESTYLE FACTORS OF CASES VERSUS RADIOGRAPHIC CHANGES

Our study included 19 outdoor workers, 17 home makers, 4 retired personnel and 2 manual laborers who presented with Grade 2 radiographic changes accounting for half (42) of the cases in comparison to 34 cases of Grade 1 changes. The results confirmed the presence of Grade 2 changes most prevailing in outdoor workers and home makers with a p-value=0.879 (Table 10, figure 11a). The results showed 30 cases with Grade 2 radiographic changes who worked for more than 8 hours followed by 28 cases with Grade 1 changes. The results suggested the preponderance of Grade 1 and Grade 2 degenerative changes with extended working hour duration, with a p-value of 0.235 (Table 10, figure 11b).

The results also determined 10 cases with Grade 2 radiographic changes as compared to 7 respondents with Grade 1 changes who used computers for less than 4 hours. The numbers of extended computer users (more than 4 hours) were 10 cases with grade 1, and 7 cases with Grade 2 degenerative radiographic changes (Table 10, figure 11c). The study reported 27 subjects with Grade 2 degenerative radiographic changes with the mobile use of more than 4 hours, as compared to the non-users and those respondents using mobile phone for less than 4 hours. Thus the Grade 2 radiographic changes were seen in frequent mobile users (p-value=0.095) (Table 10, figure 11d).

Table 2
Comparison of Neck Length, Relative Neck Length, Height and Weight In Between Cases and Controls
(N=176)

Parameters	Cases Mean±S.D	Controls Mean±S.D	p-value
Neck Length (mm)	104.15±18.9	106.98±19.0	0.326¥
Relative Neck length (mm)	6.90±0.89	6.93±0.87	0.823¥
Height (cm)	163.31±9.88	166.22±9.07	0.044*¥
Weight (kg)	69.62±11.2	66.64±12.44	0.097¥

p-value ≤ 0.05* considered as statistically significant difference
Test applied: Independent sample T-test¥

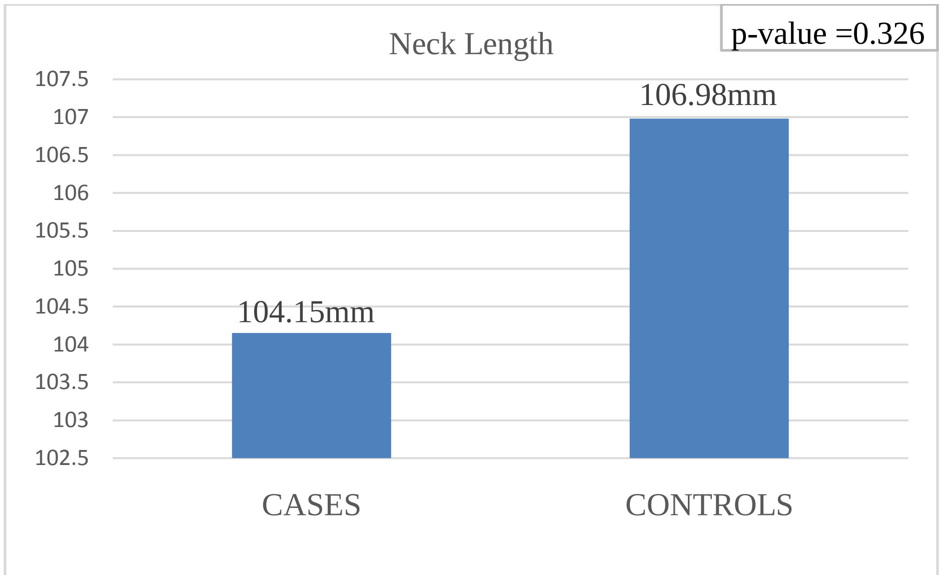


Figure 7a: Bar Chart demonstrating comparison of neck length between cases and controls

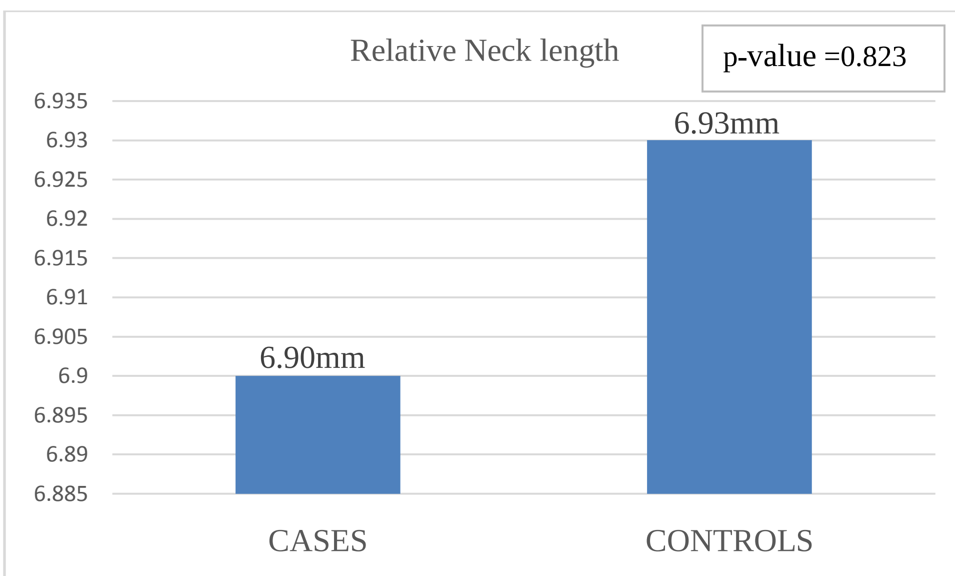


Figure 7b: Bar chart demonstrating comparison of relative neck length between cases and controls

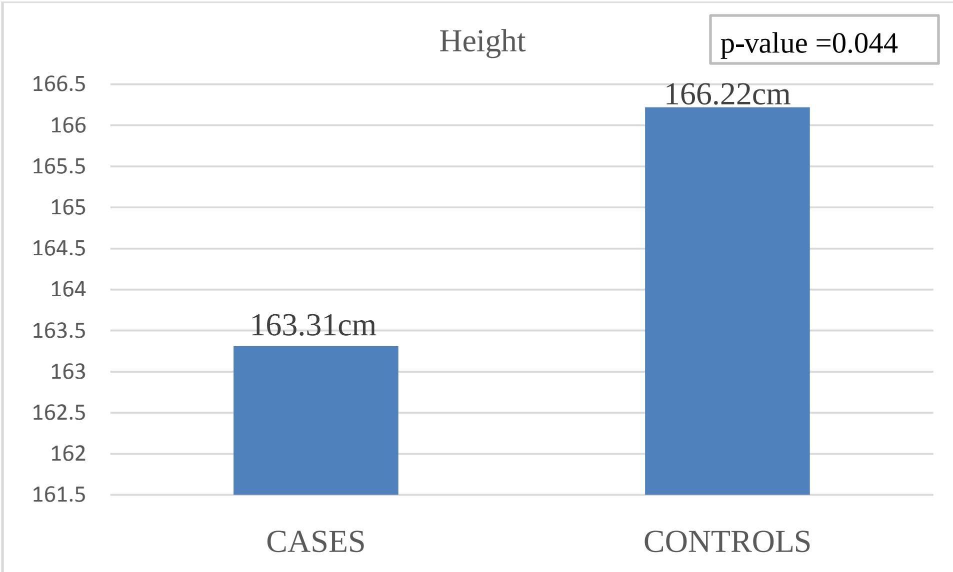


Figure 7c: Bar Chart demonstrating comparison of height between cases and controls

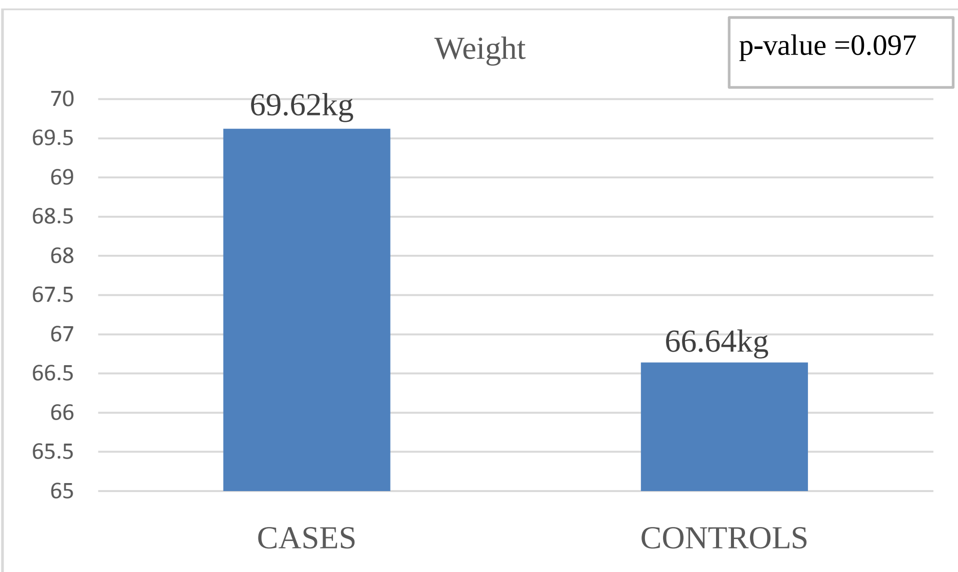


Figure7d: Bar chart demonstrating comparison of weight between cases and control

Table 3
Comparison of Neck Length, Relative Neck Length, Height and Weight within cases Vs gender
(N=176)

Parameters	**Male Mean±S.D**	**Female Mean±S.D**	**p-value**
Neck Length (mm)	109.08±16.94	100.42±19.78	0.033*¥
Relative Neck length (mm)	7.01±0.90	6.82±0.90	0.317¥
Height (cm)	168.81±8.42	159.14±8.88	0.000*¥
Weight (kg)	73.94±11.93	66.34±9.49	0.001*¥

p-value ≤ 0.05* considered as statistically significant difference
Test applied: Independent sample T-test¥

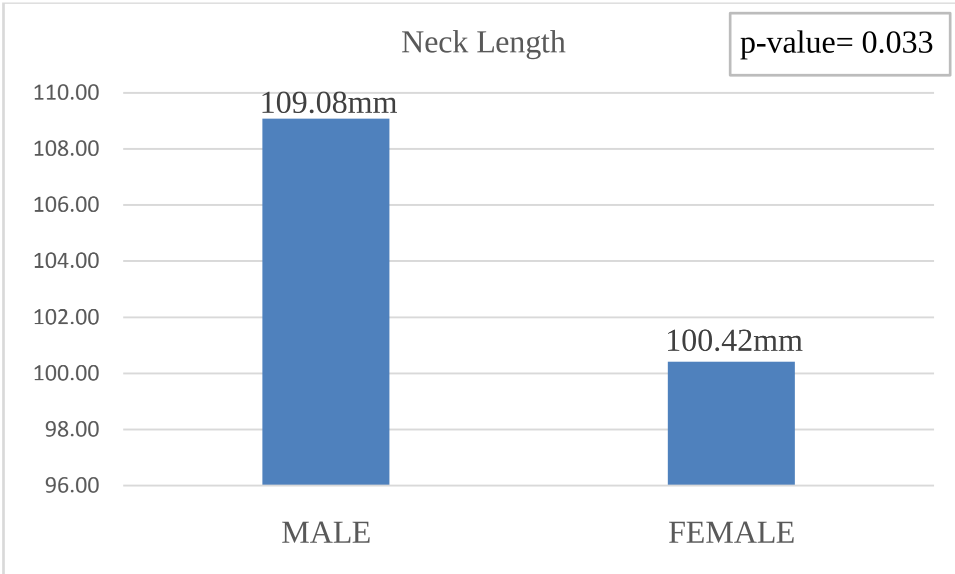


Figure 8a: Bar chart demonstrating comparison of neck length between males and females

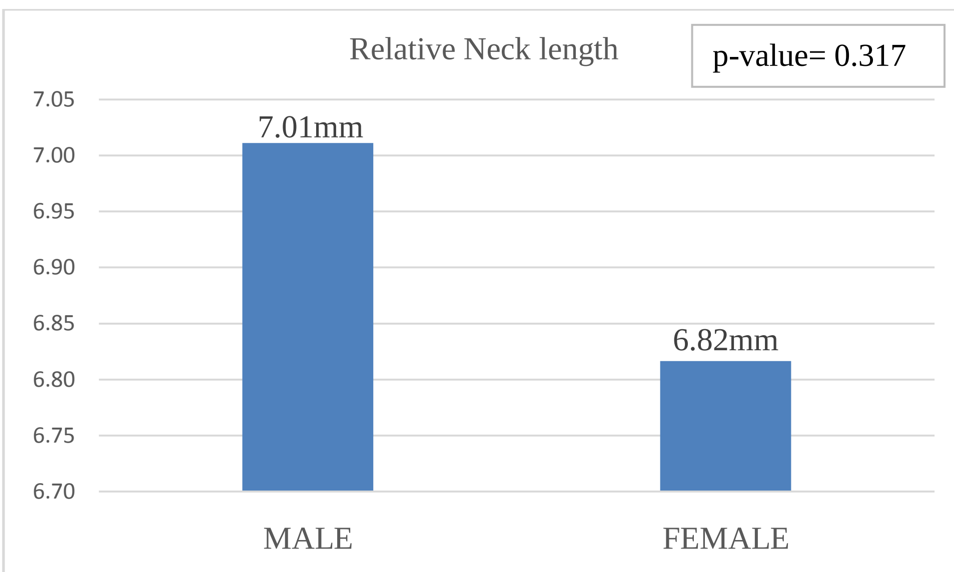


Figure 8b: Bar chart demonstrating comparison of relative neck length between males and females

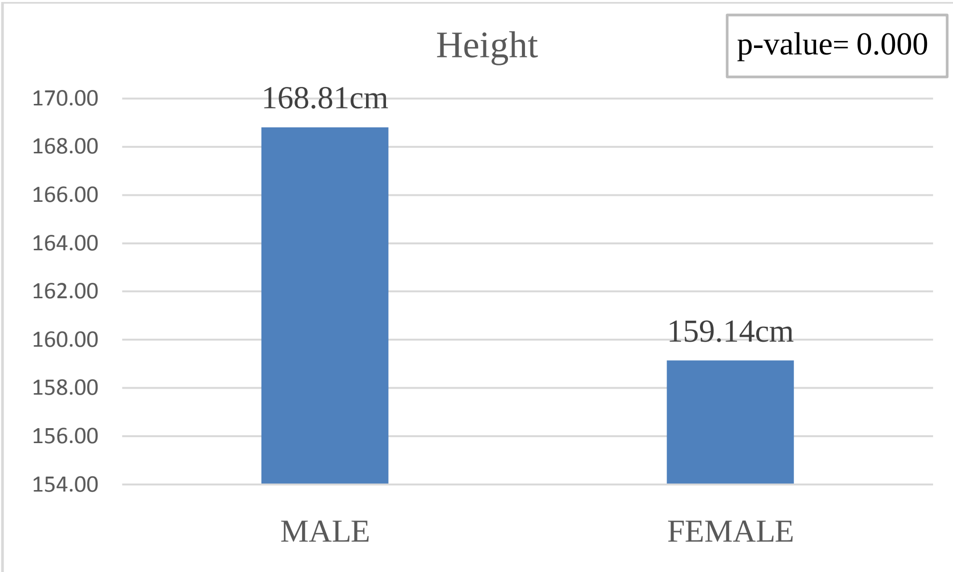


Figure 8c: Bar chart demonstrating comparison of height between males and females

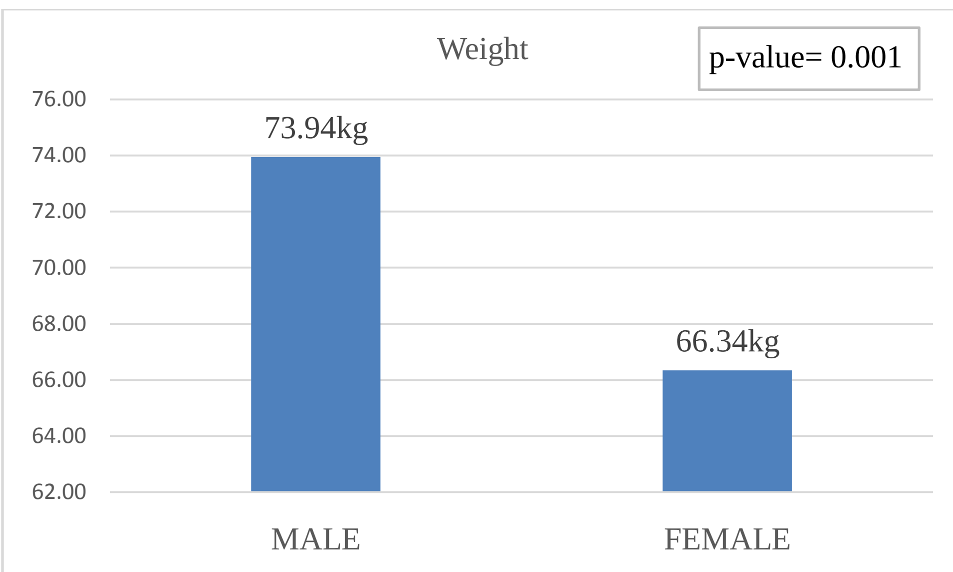


Figure 8d: Bar chart demonstrating comparison of weight between males and females

Table 4
Comparison Between Neck Length, Relative Neck Length, Height and Weight Within Cases Vs Radiographic Changes
(N=88)

Radiographic Changes Observed				
Parameters	**Grade 1 degenerative changes Mean±S.D**	**Grade 2 degenerative changes Mean±S.D**	**Grade 3 degenerative changes Mean±S.D**	**p-value**
Neck Length (mm)	103.11±21.05	106.52± 17.36	98.86±18.61	0.435€
Relative Neck Length (mm)	7.04±0.96	6.85±0.89	6.69± 0.74	0.451€
Height (cm)	163.69±9.06	163.49±11.27	161.67±7.08	0.824€
Weight (kg)	67.24±9.79	71.53±12.85	69.72±7.68	0.255€

p-value ≤ 0.05* considered as statistically significant difference
Test applied: One-way ANOVA €
Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

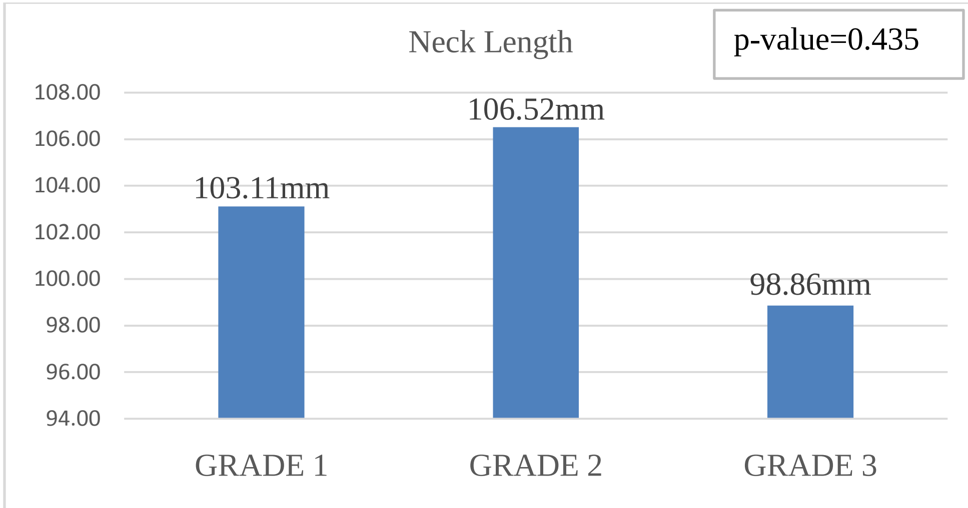


Figure 9a: Bar chart demonstrating comparison of neck length and radiographic changes
Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

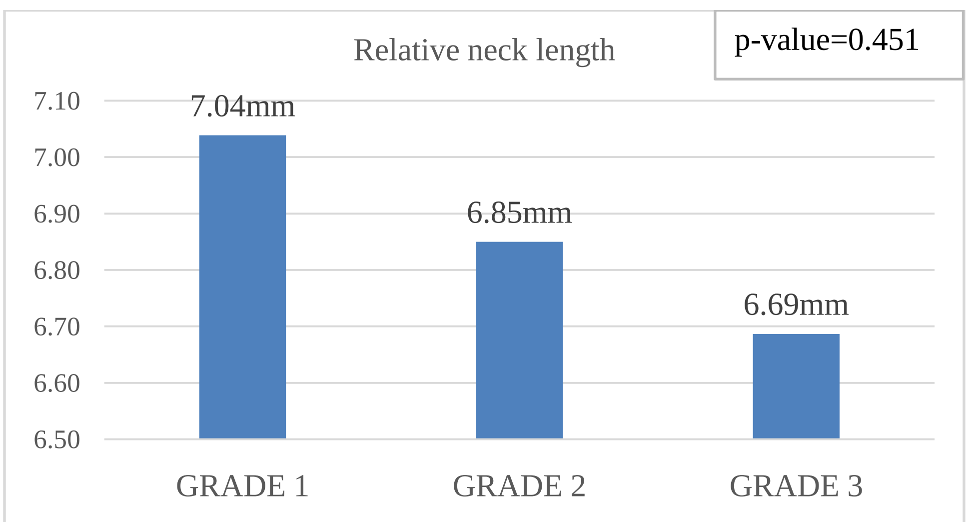


Figure 9b: Bar chart demonstrating comparison of relative neck length and radiographic changes
Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

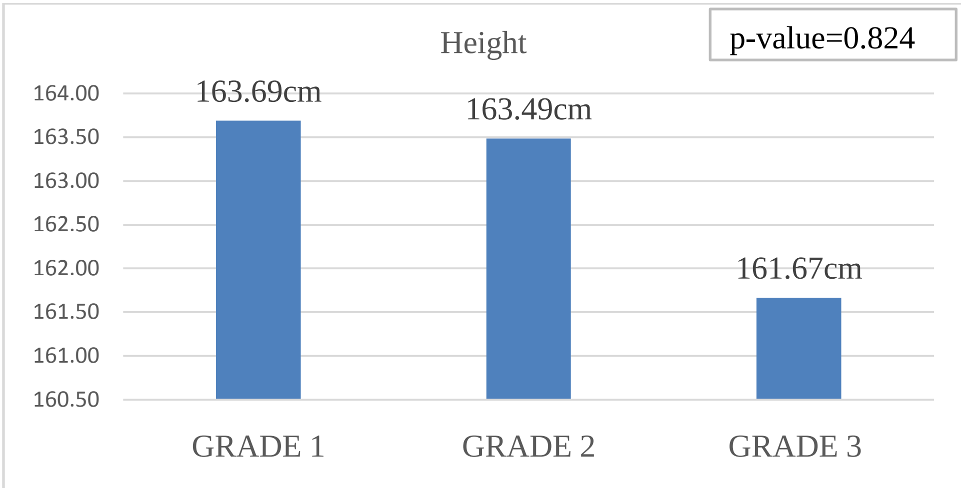


Figure 9c: Bar chart demonstrating comparison of height and radiographic changes
Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

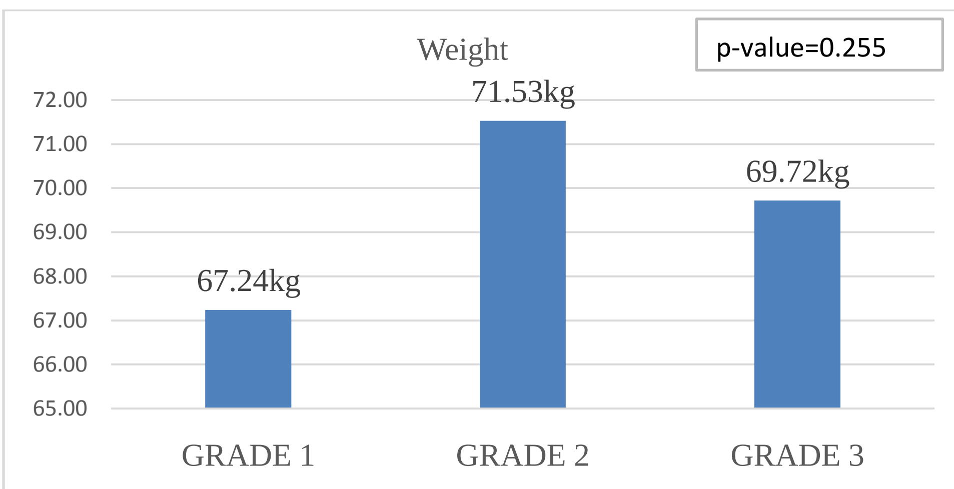


Figure 9d: Bar chart demonstrating comparison of weight and radiographic changes
Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

Table 5
Demographics and Characteristics in Cases and Controls
(N=176)

Gender	**Cases**	**Controls**	**p-value**
Male	38(43.2%)	35(39.8%)	0.76¥
Female	50(56.8%)	53(60.2%)	
Age (years)			
<=30	4(4.5%)	40(45.5%)	0.000*€
31-40	14(15.9%)	22(25.0%)	
41-50	21(23.9%)	15(17.0%)	
51-60	22(25.0%)	8(9.1%)	
61-70	16(18.2%)	3(3.4%)	
71-75	11(12.5%)	0(0.0%)	
BMI (kg/m^2)			
Underweight	1 (1.1%)	5 (5.7%)	0.003*€
Healthy range	32 (36.4%)	49 (55.7%)	
Pre obese	41 (46.6%)	27 (30.7%)	
Obese class I	14 (15.9%)	6 (6.8%)	
Obese class II	0 (0.0%)	1 (1.1%)	
Occupation			
Homemaker	38 (43.2%)	21 (23.9%)	0.002*€
Outdoor workers	39 (44.3%)	48 (54.5%)	
Manual Labors	3 (3.4%)	1 (1.1%)	
Retired Personnel	8(9.1%)	1 (1.1%)	
Student	0 (0.0%)	17 (19.3%)	

p-value ≤ 0.05* considered as statistically significant difference
Test applied: Fisher exact test €, T-independent test ¥
BMI:Underweight <18.49 kg/m^2, healthy 18·5–24·9 kg/m^2, pre-obese 25–29·9 kg/m^2, obese class I 30–34.9 kg/m^2, obese class II 35–39·9 kg/m^2 and obese class III ≥40 kg/m^2(Who, 2004)

Table 6
Lifestyle Factors in Cases and Controls
(N=176)

Work hours	**Cases**	**Controls**	**p-value**
Less than 8 hours	23 (26.1%)	65 (73.9%)	0.000*£
More than 8 hours	65 (73.9%)	23 (26.1%)	
Computer use			
No use	53 (60.2%)	30 (34.1%)	0.030*£
Less than 4 hours	18 (20.5%)	42 (47.7%)	
More than 4 hours	17 (19.3%)	16 (18.2%)	
Mobile use			
No use	18 (20.5%)	11 (12.5%)	0.000*£
Less than 4 hours	18 (20.5%)	49 (55.7%)	
More than 4 hours	52 (59.1%)	28 (31.8%)	

p-value ≤ 0.05* considered as statistically significant difference
Test applied: Chi square test£

Table 7
Demographics And Characteristics Of Cases In Between Males And Females (N=88)

Age (years)	Gender		p-value
	Male (n=38)	Female (n=50)	
<=30	0 (0.0%)	4 (8%)	0.057∞
31-40	7 (18.4%)	7 (14%)	
41-50	12 (31.6%)	9 (18%)	
51-60	5 (13.2%)	17 (34%)	
61-70	7 (18.4%)	9 (18%)	
71-75	7 (18.4%)	4 (8%)	
BMI (kg/m^2)			
Under weight	0 (0.0%)	1 (2.0%)	0.738∞
Healthy range	15 (39.5%)	17 (34.0%)	
Pre obese	18 (47.4%)	23 (46.0%)	
Obese class I	5 (13.2%)	9 (18.0%)	
Radiographic changes			
Grade 1 degenerative changes	15 (39.5%)	19 (38.0%)	0.987£
Grade 2 degenerative changes	18 (47.4%)	24 (48%)	
Grade 3 degenerative changes	5 (13.2%)	7 (14.0%)	

p-value ≤ 0.05* considered as statistically significant difference
Test applied: Fisher exact test∞ and Chi square test£
BMI:Underweight <18.49 kg/m^2, healthy 18·5–24·9 kg/m^2, pre-obese 25–29·9 kg/m^2, obese class I 30–34.9 kg/m^2, obese class II 35–39·9 kg/m^2 and obese class III ≥40 kg/m^2(Who, 2004)
Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

Table 8
Lifestyle Factors of Cases Between Males and Females
(N=88)

Occupation	**Gender**		**p-value**
	Male (n=38)	**Female (n=50)**	
Homemaker	1 (2.6%)	37 (74.0%)	0.000*£
Outdoor workers	27 (71.1%)	12 (24.0%)	
Manual Laborer	2 (5.3%)	1 (2.0%)	
Retired Personnel	8 (21.1%)	0 (0.0%)	
Work hours			
Less than 8 hours	11 (28.9%)	12 (24.0%)	0.601£
More than 8 hours	27 (71.1%)	38 (76.0%)	
Computer use			
No use	16 (42.1%)	37 (74.0%)	0.007*£
Less than 4 hours	10 (26.3%)	8 (16.0%)	
More than 4 hours	12 (31.6%)	5 (10.0%)	
Mobile use			
No use	6 (15.8%)	12 (24.0%)	0.508£
Less than 4 hours	7 (18.4%)	11 (22.0%)	
More than 4 hours	25 (65.8%)	27 (54.0%)	

p-value ≤ 0.05* considered as statistically significant difference
Test applied: Chi square test£

Table 9(a)
Demographics and Characteristics of Cases Versus Radiographic Changes (N=88)

Gender	Radiographic Changes			p-value
	Grade 1 degenerative changes	Grade 2 degenerative changes	Grade3 degenerative changes	
Male	15 (44.1%)	18 (42.9%)	5 (41.7%)	0.987£
Female	19 (55.9%)	24 (57.1%)	7 (58.3%)	
Age (years)				
< 30	1 (2.9%)	3 (7.10%)	0 (0.00%)	0.000*
31-40	10 (29.4%)	4 (9.50 %)	0 (0.00%)	
41-50	8 (23.5%)	12 (28.6%)	1 (8.3%)	
51-60	8 (23.5%)	11 (26.2%)	3 (25%)	
61-70	5 (14.7%)	8 (19.0%)	3 (25%)	
71-75	2 (5.90%)	4 (9.50%)	5 (41.7%)	

p-value ≤ 0.05* considered as statistically significant difference
Test applied: Fisher exact test∞ and Chi square test£
Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

Table 9(b)
Demographics and Characteristics of Cases Versus Radiographic Changes (N=88)

BMI (kg/m^2)	Radiographic Changes			p-value
	Grade1 degenerative changes	Grade 2 degenerative changes	Grade3 degenerative changes	
Underweight	1 (2.9%)	0 (0.0%)	0 (0.0%)	0.143$^{\infty}$
Healthy range	18 (52.9 %)	12 (28.6%)	2 (16.7%)	
Pre obese	11 (32.4%)	23 (54.8%)	7 (58.3%)	
Obese class I	4 (11.8%)	7 (16.7%)	3 (25.0%)	
Presenting Complaint				
Pain in cervical region	15 (44.1%)	18 (42.9%)	6 (50.0%)	0.796$^{\infty}$
Pain in arms and hands	15 (44.1%)	15 (35.7%)	6 (50.0%)	
Headache	0 (0.0%)	1 (2.4%)	0 (0.0%)	
Vertigo	1 (2.9%)	3 (7.1%)	0 (0.0%)	
Pain in arms, hands and vertigo	3 (8.8%)	5 (11.9%)	0 (0.0%)	

p-value ≤ 0.05* considered as statistically significant difference
Test applied: Fisher exact test∞ and Chi square test£
BMI:Underweight <18.49 kg/m^2, healthy 18·5–24·9 kg/m^2, pre-obese 25–29·9 kg/m^2, obese class I 30–34.9 kg/m^2, obese class II 35–39·9 kg/m^2 and obese class III ≥40 kg/m^2(Who, 2004)
Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

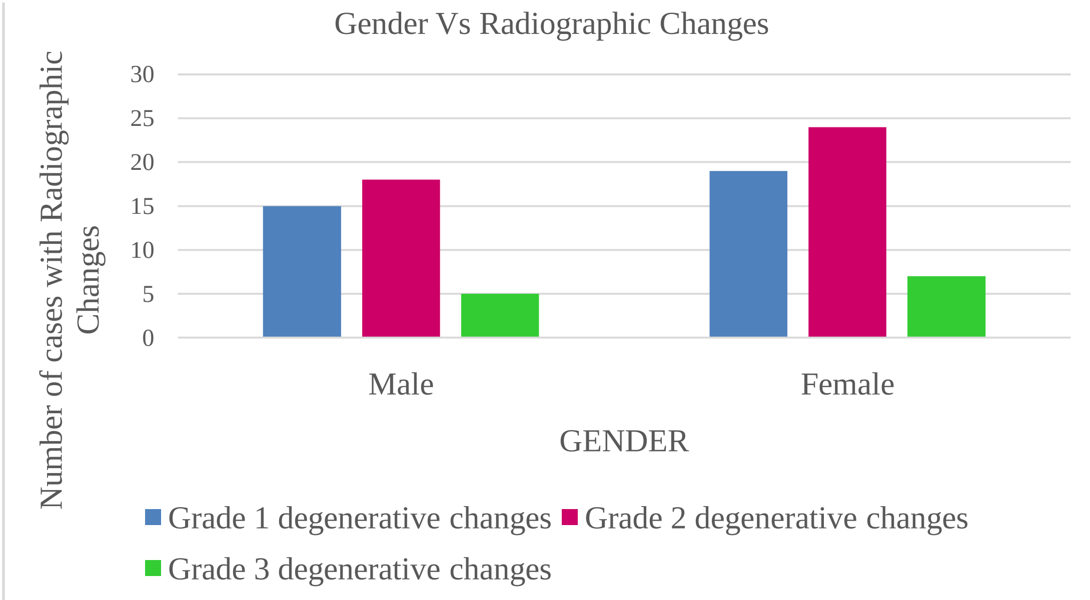


Figure 10a: Bar chart demonstrating radiographic changes in both genders

Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

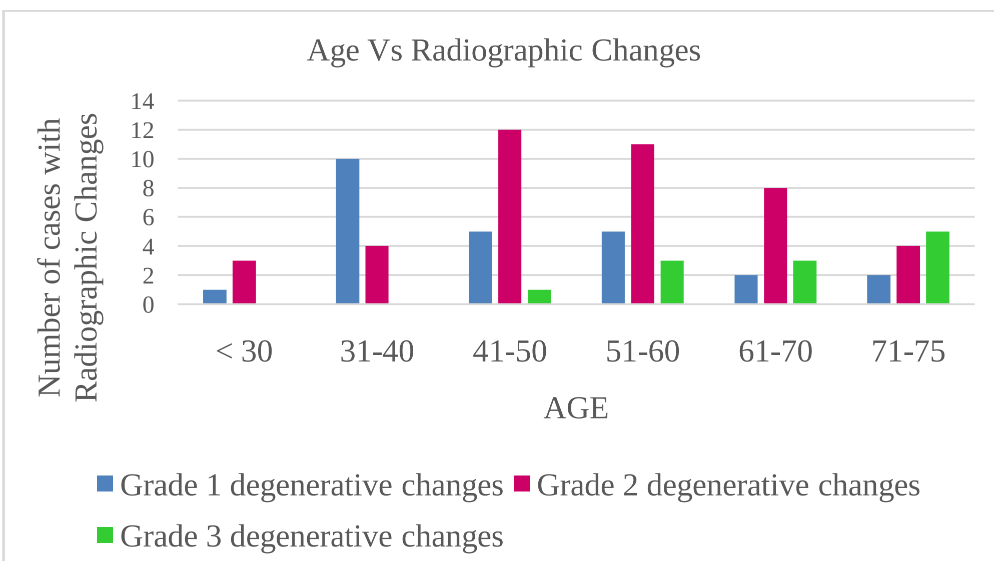


Figure 10b: Bar chart demonstrating radiographic changes in different age groups

Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

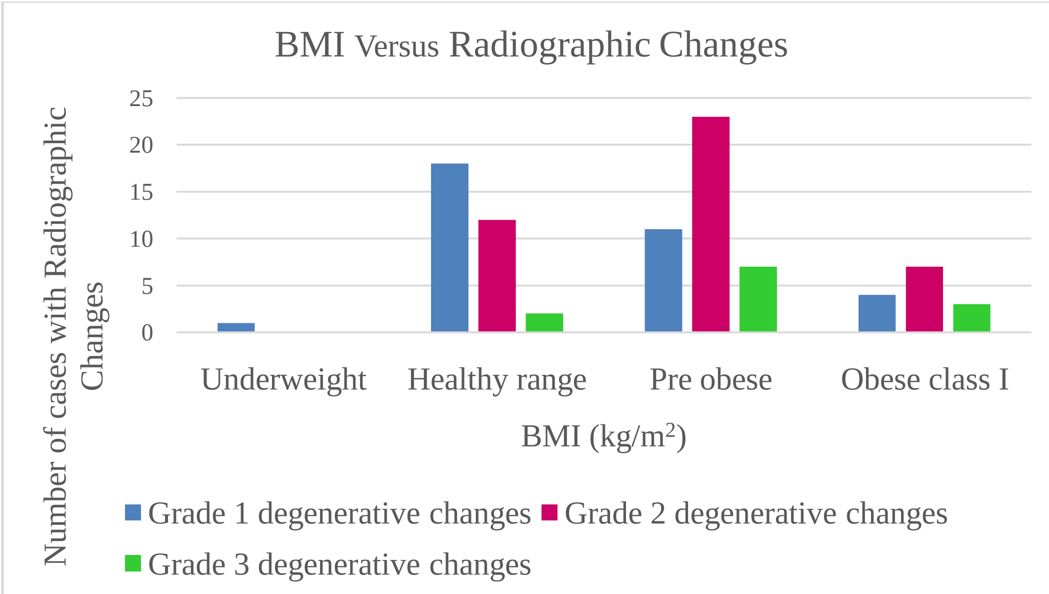


Figure 10c: Bar chart demonstrating radiographic changes with different BMI ranges

BMI:Underweight <18.49 kg/m^2, healthy 18·5–24·9 kg/m^2, pre-obese 25–29·9 kg/m^2, obese class I 30–34.9 kg/m^2, obese class II 35–39·9 kg/m^2 and obese class III ≥40 kg/m^2(Who, 2004)

Kellgren Lawrence Grading scale:

Grade 1: Minimal anterior osteophytes

Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis

Grade 3: Moderate narrowing with definite sclerosis and osteophytes

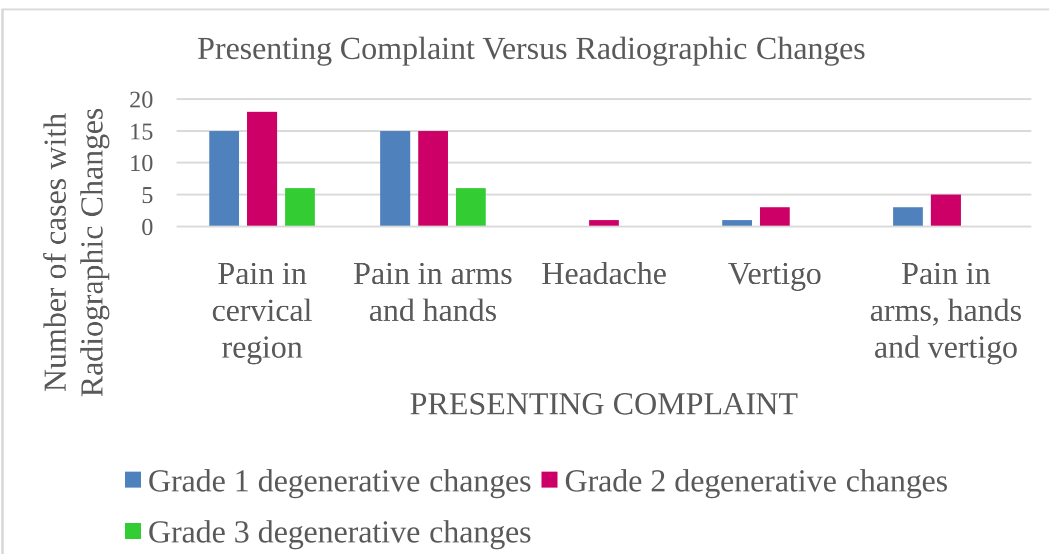


Figure 10d: Bar chart demonstrating radiographic changes with varied presenting complaints

Kellgren Lawrence Grading scale:

Grade 1: Minimal anterior osteophytes

Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis

Grade 3: Moderate narrowing with definite sclerosis and osteophytes

Table 10
Lifestyle Factors of Patients Versus Radiographic Changes
(N=88)

Occupation	**Radiographic Changes**			**p-value**
	Grade 1 degenerative changes	**Grade 2 degenerative changes**	**Grade 3 degenerative changes**	
Homemaker	15 (44.1%)	17 (40.5%)	6 (50.0%)	0.879$^{\infty}$
Outdoor workers	16 (47.1%)	19 (45.2%)	4 (33.3%)	
Manual Laborer	1 (2.9%)	2 (4.8%)	0 (0.0%)	
Retired Personnel	2 (5.9%)	4 (9.5%)	2 (16.7%)	
Work Hours				
Less than 8 hours	6(17.6%)	12(28.6%)	5(41.7%)	0.235$^{£}$
More than 8 hours	28(82.4%)	30(71.4%)	7(58.3%)	
Computer Use				
No use	17 (50.0%)	25 (59.5%)	11 (91.7%)	0.095$^{£}$
Less than 4 hours	7 (20.6%)	10 (23.8%)	1 (8.3%)	
More than 4 hours	10 (29.4%)	7 (16.7%)	0 (0.0%)	
Mobile Use				
No use	5 (14.7%)	7 (16.7%)	6 (50.0%)	0.098$^{£}$
Less than 4 hours	8 (23.5%)	8 (19.0%)	2 (16.7%)	
More than 4 hours	21 (61.8%)	27 (64.3%)	4 (33.3%)	

p-value ≤ 0.05* considered to be statistically significant
Test applied: Fisher exact test∞ and Chi square test£
Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

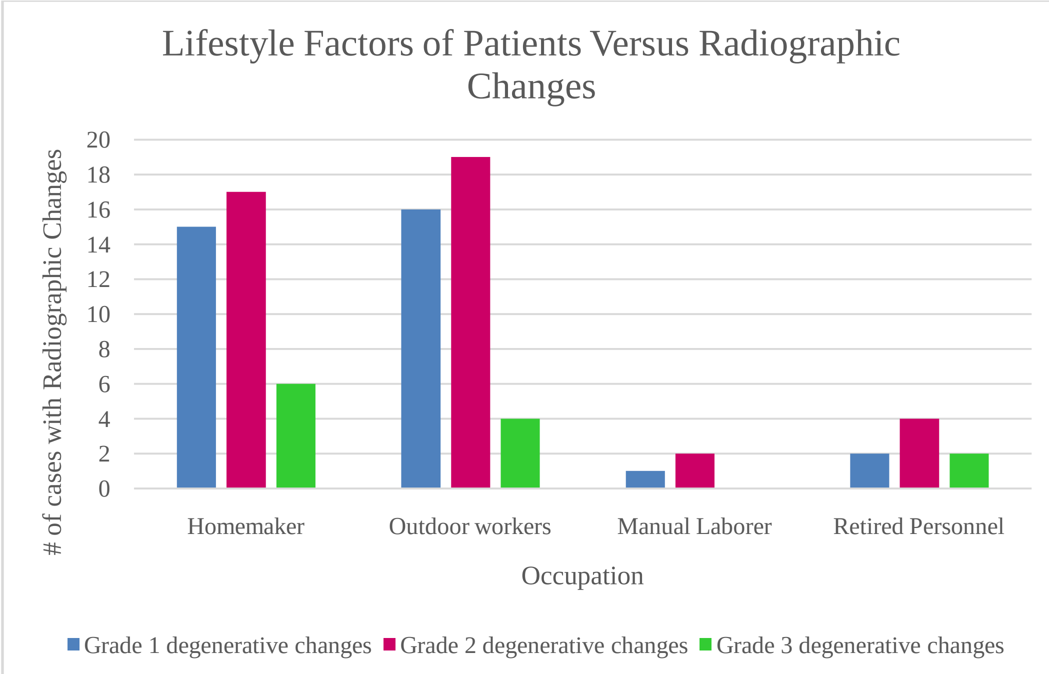


Figure 11a: Bar chart demonstrating radiographic changes in different occupations

Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

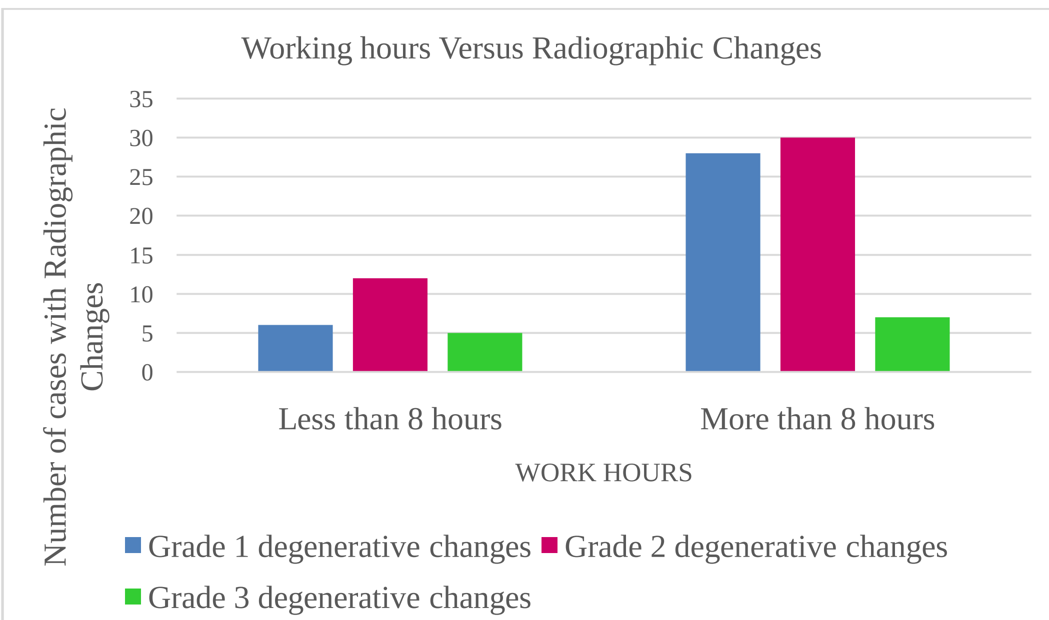


Figure 11b: Bar chart demonstrating radiographic changes with different working hours

Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

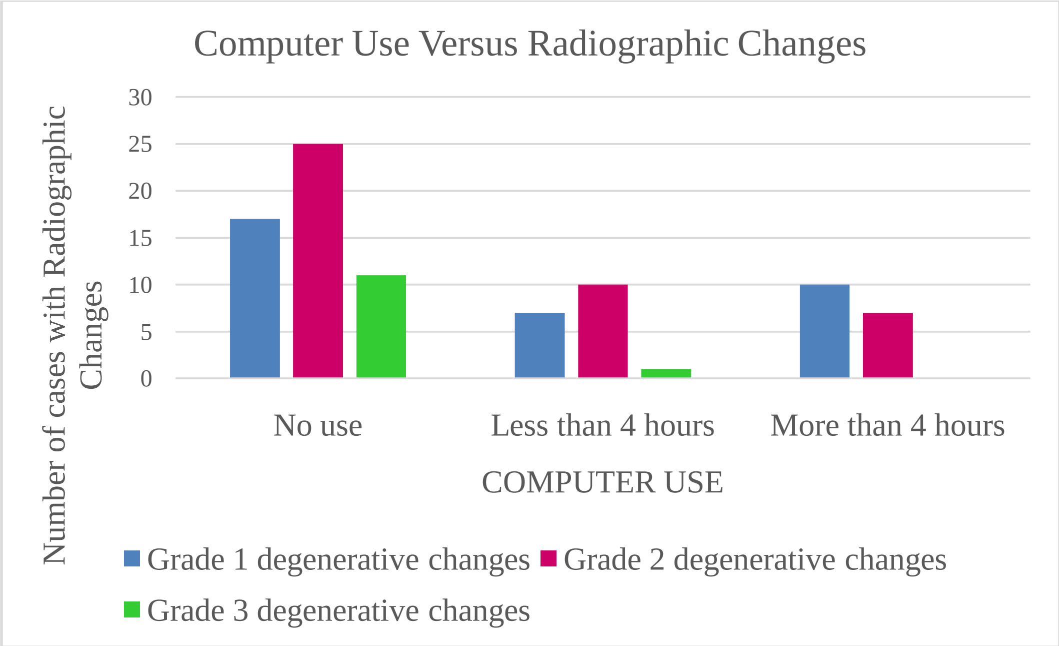


Figure 11c: Bar chart demonstrating radiographic changes with computer usage

Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

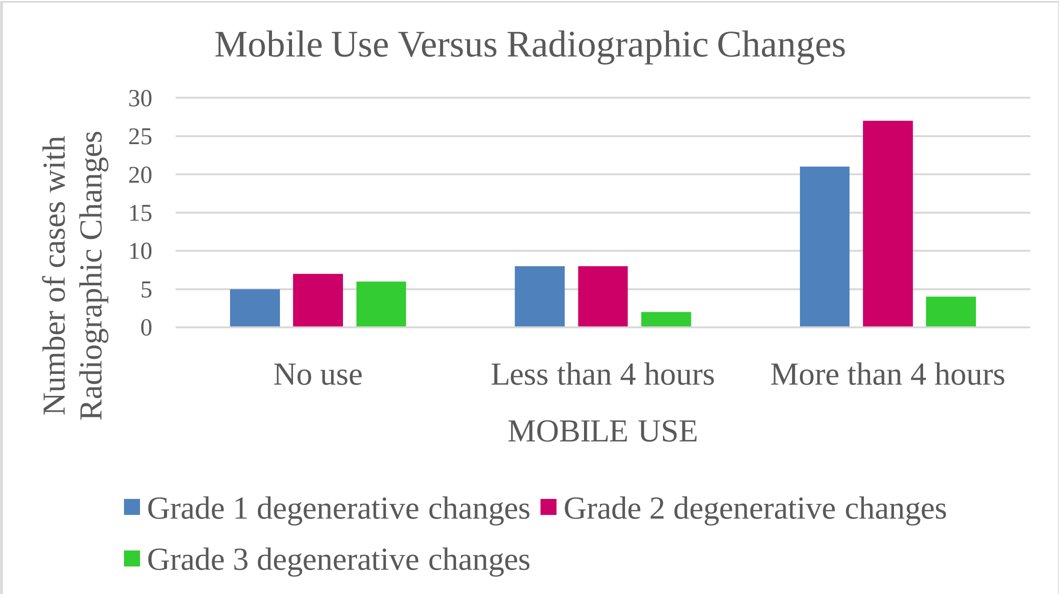


Figure 11d: Bar chart demonstrating radiographic changes with mobile use

Kellgren Lawrence Grading scale:
Grade 1: Minimal anterior osteophytes
Grade 2: Definite anterior osteophytes, narrowing and mild sclerosis
Grade 3: Moderate narrowing with definite sclerosis and osteophytes

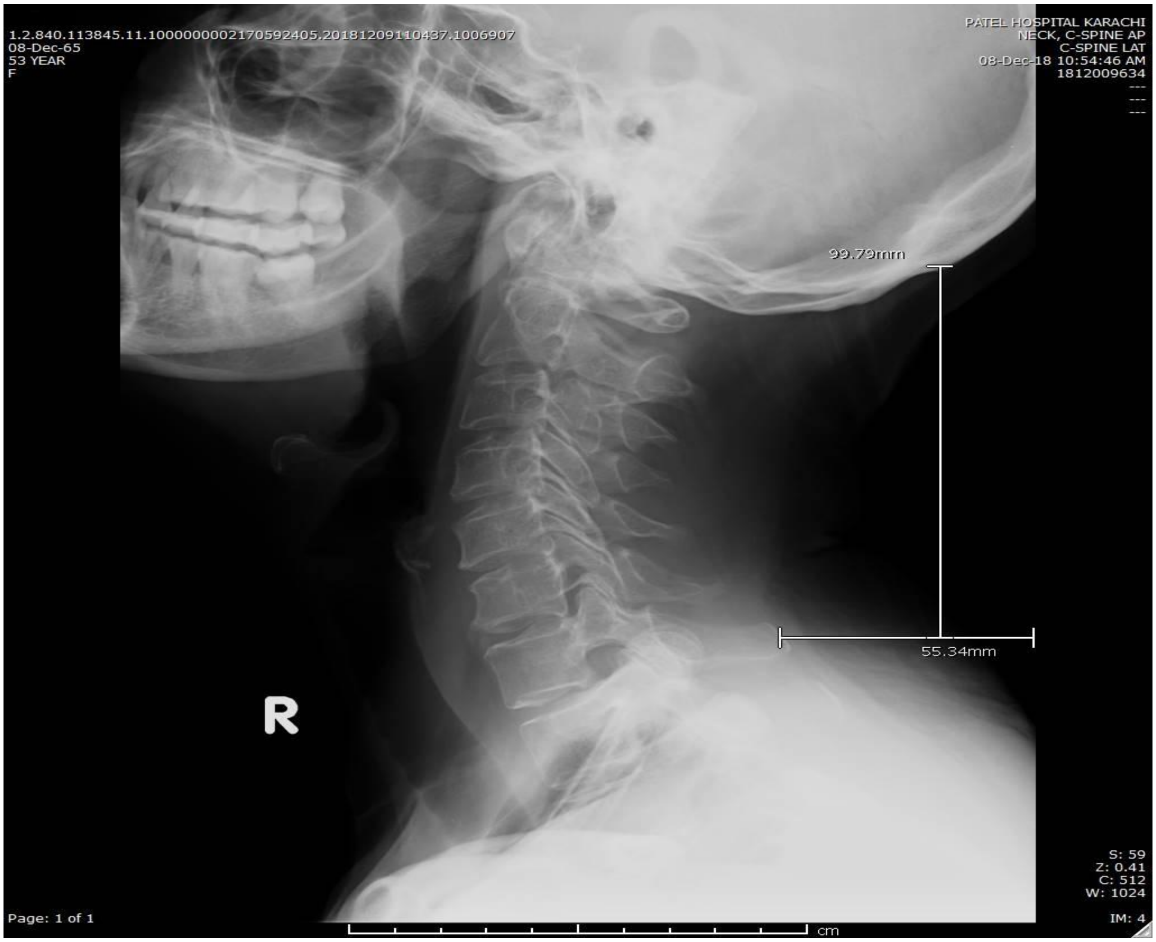


Figure 12: Radiograph of case showing Grade 2degenerative changes at Radiology Department, Patel Hospital, Karachi (2018-2019).

Gender: Female
Age: 53 years
Height: 150cm
Weight: 59kg
Neck Length: 99.79mm
Grade according to Kellgren Lawrence Scale: Grade 2 degenerative changes
Lifestyle factors:
Occupation: Outdoor Worker
Working hours: More than 8 hours
Computer use: No use
Mobile use: More than 4 hours

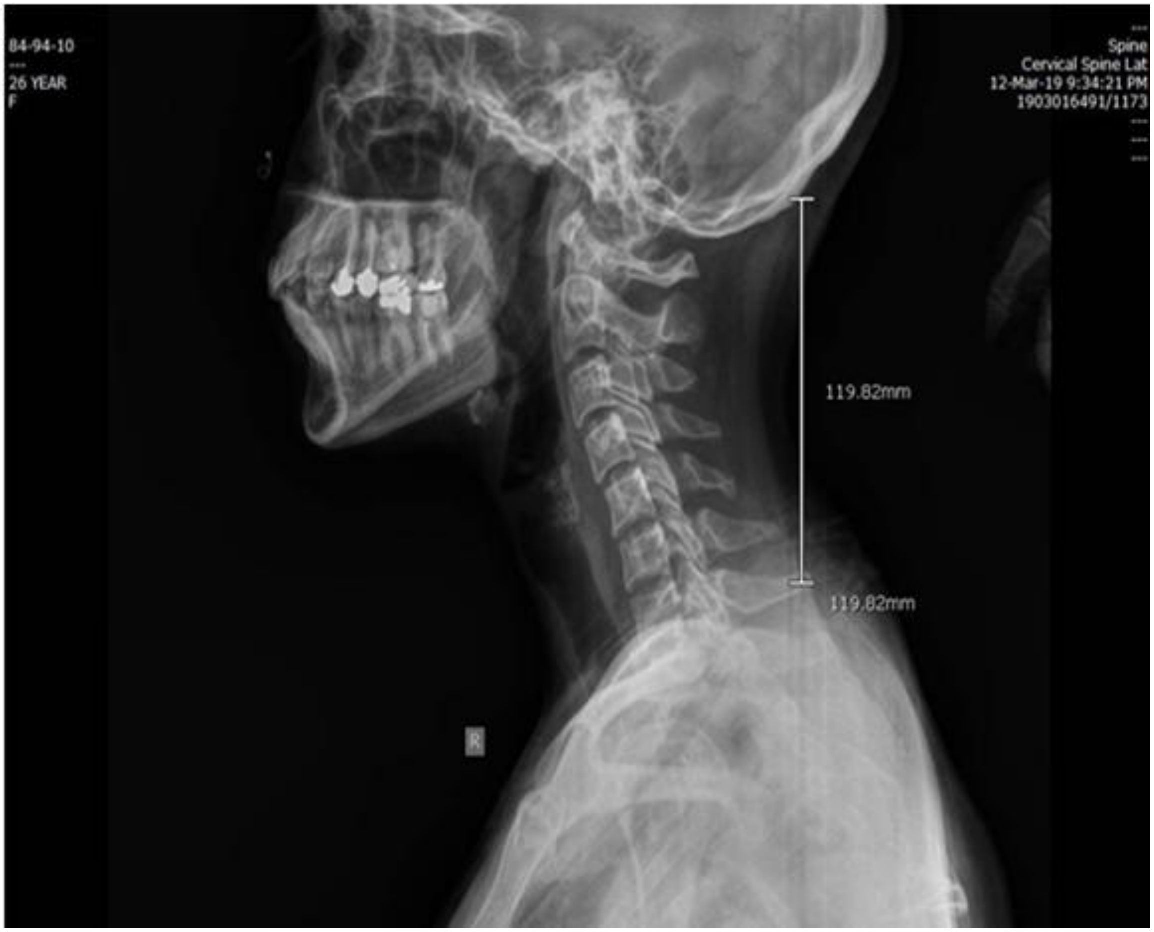


Figure 13: Radiograph of control showing no degenerative changes at Radiology Department, Patel Hospital, Karachi (2018-2019).

Gender: Female
Age: 26 years
Height: 160cm
Weight: 53kg
Neck Length: 119.82mm
Grade according to Kellgren Lawrence Scale: No degenerative changes
Lifestyle factors:
Occupation: Outdoor Worker
Working hours: Less than 8 hours
Computer use: No use
Mobile use: Less than 4 hours

CHAPTER 5

DISCUSSION

The present study was designed to observe the effect of neck length, relative neck length, height and weight with the incidence of cervical spondylosis, and to evaluate whether there was any association with these parameters. This was a pioneer study in Pakistan, in which these parameters were measured and their association with cervical spondylosis was determined.

In the present study, the neck length was measured by X-ray of cervical spine, taking a lateral radiograph of the neck with the help of computerized radiography system on a software Synapse. First, a point was marked at the external occipital protuberance, and then a perpendicular distance was measured from the protuberance to the tip of the seventh cervical vertebral spinous process, as done by Taha et al (2014).

However, different studies have measured neck length in different ways. Han et al (2015) measured midline and lateral neck length in both genders and observed its association with sleep and cardiovascular risk factors. He measured midline neck length (MNL) as the distance between the hyoid bone to the jugular notch, and lateral neck length (LNL) as the distance from the mandibular angle to the middle portion of the clavicle of the same side. His study determined a positive correlation between shorter lateral neck length and metabolic syndromes in males while in women, shorter midline neck length was associated with snoring and cardiovascular risk factors. Tabaee et al (2005) tried to observe the effect of neck length and its importance in percutaneous and surgical tracheotomy. He measured neck length as a cricosternal distance from the cricoid cartilage to the sternum, but there was no significant association of neck length and its role in both procedures.

This study found an insignificant decrease in the neck length in the cases of the cervical spondylosis as compared to controls. The reason for this finding was most likely that the subjects with short height mostly had a short neck, and due to improper posture and strain at the neck, they had a higher incidence of the disease. In contrast to our results, Martin-Vaquero and da Costa (2015) observed the effect of neck length in the breed of Great

Danes dogs in cases of cervical spondylomyelopathy and found no significant association of neck length on the disease.

This study demonstrated an insignificant decrease in relative neck length in the cases of cervical spondylosis as compared to control. The relative neck length was calculated as was done in the study by Mahajan & Bharucha (1994) where neck length was measured as the percentage of standing and sitting height to provide reference values for the evidence of short neck in children and early adolescence, although they did not correlate it with any disease.

Height plays a crucial role in the development of personality as it has been related to leadership, better academics, occupation, and dominant personality. Normal stature is the result of a coordinated complex processes involving nutrition, genetics, ethnicity and endocrine status. It is a part of the normal distribution curve as the 3rd and 97th percentile. Short and tall stature are just variations of height between different populations (Bramswig, 2007).

The results of the present study reported that there was a significant positive association of the short stature with the incidence of the cervical spondylosis, that is, the cases had a shorter height as compared to the controls. These results were in accordance with the study by Singh, Kumar, and Kumar (2014) who also demonstrated a shorter height in cases of cervical spondylosis as compared to controls. The short height and its association with cervical spondylosis were most likely due to the fact that the transverse area of the spinal cord, transverse area of the dural tube, and the spinal canal area were directly related to the height, leading to the predisposition of short stature subjects to the exaggerated incidence of cervical spondylosis. The decreased area of the spinal canal also led to the compression of the spinal cord as observed by Ulbrich et al (2014).

This study also determined a significant decrease in neck length in females as compared to the males. It was in agreement to our another result, that males were significantly taller than the females, when height was compared in genders. This also demonstrated that neck length was directly proportional to the height. This observation of taller height in the males was in agreement with the study done by Nagata et al (2014), who also observed height, weight, and BMI to be significantly higher in the men as compared to the women. Based on these results, we can assume that the focus of prevention should specifically be females as they were of short height. Our study also discovered greater number of female cases as compared to the male cases. The present study also correlated weight within genders, and it revealed that the males were significantly heavier than females. The relative neck length was shorter in females as compared to the males although results were statistically insignificant.

Our study also correlated parameters like neck length, relative neck length, height, and weight with radiographic changes. It was observed that the degenerative changes were most severe radiologically in the cases with shortest neck length, whereas moderate narrowing of cervical spinal canal with definite sclerosis and osteophytes (Grade 2) were determined in cases with medium neck length. The cases which had longer neck length demonstrated minimal osteophytes (Grade 1) on radiography. This result clearly asserted that short neck length was associated with severe degenerative changes.

The results of the present study demonstrated the significant prevalence of the disease in the middle age population ranging from 40 to 50 years and 60 to 70 years in the elderly which was consistent with the findings of another study by Moon et al (2016), who determined that the incidence of the disease increased and became more severe with respect to increasing age. Alshami (2015) reported the prevalence of the disease was more (30%) in population younger than 30 years, 11.6%, above the age of 30 years and 38.5%, above the age of 70 years which did not coincide with the results of present study, as the younger population (i.e., less than 30 years) of our population were healthy subjects. Another study by Wang, Tian, Zhou, He, & Cai (2016) also found disease prevalence in younger population rather than the elderly. The increased prevalence of the disease in middle-age and elderly in our set up was most likely due to the reason that they already had natural disc degeneration due to the normal aging process. The compensatory development of osteophytes at facet joints and Luschka joints further complicated it to counteract the instability at the cervical spine, causing disc space narrowing and thus resulting in spondylosis.

In the present study, comparison of BMI within cases and control was also conducted. This indicated that the cases of cervical spondylosis had a BMI range of pre-obesity and class 1 obesity. This result was consistent with the findings demonstrated by Cook et al (2010) who reported preponderance of disease in the obese population. The results could be attributed to the fact that the weight was increased due to the obesity, placing more axial load on the cervical spine, thus aggravating the degeneration process. The result of the present study was in disagreement to that by Mesas et al (2014) who reported that obesity had no role in the degenerative disc disorders. Another survey by Kumagai et al (2014) reported a statistically significant mean BMI of males and females within healthy range, which did not correlate with the present study.

The present study compared occupations such as outdoor workers, homemakers, retired personnel, students, manual laborer, and head load carriers within cases and controls. A statistically significant incidence of the disease was found in female homemakers and male outdoor workers. In contrast, Mahbub et al (2006) and Echarri & Forriol (2002) reported increased incidence of disease in porters and wood carriers (on head) respectively emphasizing that carrying heavy loads at the head was a significant risk factor in causing disease. Oguntona (2014) also displayed exaggerated disease in farmers of Southwest Nigeria. However, these studies were not in conformity with the findings of the present study. The difference was most likely due to the decreased number of heavy load carriers and manual laborers as subjects in our research. As the research was conducted in a private hospital, so load carriers or manual laborers probably could not afford medical treatment at such hospitals.

On comparison of working hours within cases and controls, it was ascertained that statistically significant number of cases had working duration of more than 8 hours as compared to controls. It was also in accordance with the study done by Yang et al (2015), who determined that there was an increased preponderance of neck pain with increased working hours (46-59, as compared to 8-39 hours) per week.

The results of the present study indicated that the majority of the cases were non-computer users. Our results do not support computer use as a major contributing factor with the association of the disease, the reason being the significantly less number of computers using subjects as compared to non-users.When the cases using computer for less than 4 hours were compared with controls, there was a significant decrease.

However, when the cases using computer for more than 4 hours were compared with controls, there was an insignificant increase. Thus, our results demonstrated that computer use had no significant impact on development of the disease. The results were in dissension with the research done by Aziz & Al-Bustany (2009), and Karic-Skrijelj et al (2008), who found a significant preponderance of disease in the computer users as compared to non-users.

The text neck syndrome is used to denote technical disease caused by the usage of handheld devices such as mobiles and tablets. This causes increased flexion of the neck due to the forward head posture, which intermittently increases compressive forces at the cervical spine and deteriorates anatomical structure of the cervical spine. The use of mobile phones has expanded worldwide and is known to cause pain in the neck, shoulder, and thumb. The present study analyzed the effect of mobile use and its relation to the disease. It was established that mobile use for more than 4 hour had a significant association with the disease process. The results of our study were consistent with the study by Jung et al (2016), which determined that the improper posture and breathing problems were caused in mobile users. These results were most likely due to the fact that mobile users spent more than 4 hours on the screen by flexing their neck, adopting forward head posture, resulting in increased axial forces at the cervical spine, which could also disrupt the normal lordotic curve of cervical spine resulting in the enhancement of the degenerative process.

The present study also compared genders within cases and control. It was ascertained that predilection of females was associated with the disease. This result was in disagreement with parallel researches conducted by Miao, Qiang, & Jin (2018) who reported no association of gender with the disease.

On comparison of gender with demographics and characteristics, the results of the present study revealed an insignificant increase in the prevalence of disease in females. This finding was in dissonance with the research done by RoseBist et al (2018), who reported augmented incidence of disease in the male population. The results of the present study were most likely due to that fact that the males had increased height, thus had wider spinal canal diameters as compared to the females. The small spinal canal predisposed females to an enhanced occurrence of stenosis, which could eventually lead to the cervical myelopathic syndrome of cervical spondylosis. This was also seen in a research done by Zadbuke, Wade, & Panjwani (2016) correlating the spinal canal with compression.

On comparing age ranges within cases among males and females, the result showed insignificant increase of male gender within age range of 41-50 years and prevalence of females within age range of 51-60 years. The predisposition of cervical spondylosis in females within this age range of 51-60 was attributed to menopause, and it was linked with degenerative processes, as submitted by Lou et al (2014).

Our results indicated the increased prevalence of pre-obese and obese class 1 females with the disease as compared to males in the pre-obese and healthy range. This was most likely because majority females suffered from unhealthy eating habits, had a sedentary lifestyle, and lacked exercise in their daily routine. Thus, keeping weight within the normal BMI range can also be a preventive factor.

The present study compared the cases and their lifestyle factors within males and females, and it was found that the majority of diseased subjects were the female homemakers followed by male outdoor workers. This result was pursuing the study by Lv et al (2018) who also found housework intensity to be an associated factor for cervical spondylosis. The results of the present study also implied that there was an insignificant increase of female homemakers followed by outdoor workers indicating daily house activities as a risk factor for the development of disease. These results were in disagreement with the study by Zejda and Stasiow, 2003 who found the prevalence of the disease more in coal miners. Another study by Khan et al (2018) demonstrated an increased incidence of disease in railway porters.

Moreover, on comparison of radiographic changes among gender, there was female preponderance. The Grade 2 disc degenerative radiographic changes ranked first followed by Grade 1 degenerative changes. Our study also observed an insignificant increase of Grade 2 cervical spondylosis in females as compared to males. Further there was an insignificant increase in cases with Grade 2 degenerative changes in the pre-obese range, which were followed by Grade 1 with a healthy BMI range. These results suggested that even minimal anterior osteophytes can develop in individuals with healthy BMI, denoting osteophytes as a compensatory response to counteract the compressive forces and instability in the cervical spine.

There was an insignificant increase in male computer users (more than 4 hours as well as less than 4 hours duration) as compared to the females. However, the number of female cases were more in the study which were non-computer users. Tiric-Campara et al (2014) demonstrated that cervical syndrome was a technological disease caused due to the increased use of computers for long hours and improper posture. This was most likely the reason for developing the disease in our cases also. Our results were contradictory to the study by Karic-skrijelj et al (2008), who reported an increased prevalence of the disease in female computer users. Aziz (2009) also declared to have more cases of cervical spondylosis in computer users and with longer hours of usage. The reason for this contradiction was most likely less number of computer users in our study.

The present study indicated a positive correlation between radiographic changes concerning the age. An insignificantly increased prevalence of minimal anterior osteophytes was seen in the age range of 31-40years, depicting minimal degeneration. The cases in the age range of 40-50 years followed by 50-60 years and 61-70 years, displayed definite osteophytes with possible narrowing and some sclerosis, severity of the disease increasing with the increase in the age. These findings were in accordance with the study by Rudy et al (2015), who observed significant positive relation between age and disc degeneration according to the Kellgren Lawrence scale. It indicated that the grade of disc degeneration increases by 1 for every 16.7 years, as the person ages.

The present study also reported an insignificant increase of pain in the cervical region as the presenting complaint with the Grade 2 degenerative changes. The presenting complaint of pain in arms and hands was presented with minimal anterior osteophytes.

CHAPTER 6

CONCLUSION

This study presented with the most intriguing fact that the disease was more prevalent in short stature individuals who also had shorter neck length and relative neck length. The study population had increased number of females. It was predominantly found in the middle aged and elderly population. The age ranges of 41-50 and 51-60 years had the predilection for the disease.

Our study concluded many risk factors based on patient's demographics and lifestyle factors. They included increased BMI, homemakers and outdoor activities, extended duration of working hours and usage of computers and mobiles. Considering the above facts, it is suggested that this knowledge should be spread to the clinicians so they can advise short height individuals, specially females to take precautions before the onset of the disease, and to guide them to avoid those factors which can contribute to its progression.

6.1 RECOMMENDATIONS

1. The study should be done in multiple hospitals, including tertiary care to get a better idea about prevalence in different ethnic groups and to include subjects with different occupations.
2. MRI can be used as an alternative imaging modality for evaluating the relationship between dimensions of vertebral body and spinal canal with the incidence of cervical spondylosis.
3. The lordotic curve and the loss of lordotic curve must be assessed for the incidence of the disease.
4. Treatment options and their efficacy in the treatment of disease needs to be explored.

6.2 STRENGTHS OF STUDY

1. This study is pioneer in Pakistan to evaluate neck length, relative neck length and height with the incidence of cervical spondylosis.
2. The study evaluated the demographics and lifestyle factors and correlated them with disease.

3. The results of the study should be disseminated so that it can help physicians to identify target population and educate them about its prevention

6.3 LIMITATIONS

1. Our study enrolled patients on the basis of history, physical examination and radiographic findings. Some cases may be missed due to asymptomatic presentation apart from evident radiographic findings.
2. Need a larger cohort-based study to know the associations of factor with cervical spondylosis.
3. The ethnicity and occupation should have been equal matched for the proper presentation of variables

CHAPTER 7

7.1 REFERENCES

Abdul-Latif, A. A. (2011). Dropped shoulder syndrome: a cause of lower cervical radiculopathy. *Journal of Clinical Neurology, 7*(2), 85-89.

Adams, M. A., & Roughley, P. J. (2006). What is intervertebral disc degeneration, and what causes it?. *Spine*, *31*(18), 2151-2161.doi:10.1097/01.brs.0000231761.73859.2c

Ali, F. E., Al-Bustan, M. A., Al-Busairi, W. A., Al-Mulla, F. A., & Esbaita, E. Y. (2006). Cervical spine abnormalities associated with Down syndrome. *International orthopaedics*, *30*(4), 284-289.doi. 10.1007/s00264-005-0070-y

Alizada, M., Li, R. R., & Hayatullah, G. (2018). Cervical instability in cervical spondylosis patients. *Der Orthopäde*, *47*(12), 977-984.doi: 10.1007/s00132-018-3635-3

Alshami, A. M. (2015). Prevalence of spinal disorders and their relationships with age and gender. *Saudi medical journal*, *36*(6), 725.

Amenta, P. S., Ghobrial, G. M., Krespan, K., Nguyen, P., Ali, M., & Harrop, J. S. (2014). Cervical spondylotic myelopathy in the young adult: a review of the literature and clinical diagnostic criteria in an uncommon demographic. *Clinical neurology and neurosurgery*, *120*, 68-72.doi: 10.1016/j.clineuro.2014.02.019

Attry, S., Gupta, V. K., Marwah, K., Bhargav, S., Gupta, E., & Vashisth, N. (2016). Cervical Vertigo-Pathophysiology and Management: An Update. *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), 1*(15), 98-107. doi:10.9790/0853-1507698107

Aziz, Z. A., & Al-Bustany, D. A. (2009). Cervical Spondylosis among Group of Computer Users in Erbil City. *Zanco Journal of Medical Sciences, 13*(2), 28-36.

Badhiwala, J. H., & Wilson, J. R. (2018). The natural history of degenerative cervical myelopathy. *Neurosurgery Clinics, 29*(1), 21-32. doi: 10.1016/j.nec.2017.09.002

Bakhsheshian, J., Mehta, V. A., & Liu, J. C. (2017). Current diagnosis and management of cervical spondylotic myelopathy. *Global spine journal, 7*(6), 572-586. doi:10.1177/2192568217699208

Baumgart, M., Szpinda, M., & Szpinda, A. (2013). New anatomical data on the growing C4 vertebra and its three ossification centers in human fetuses. *Surgical and Radiologic Anatomy*, *35*(3), 191-203.doi:10.1007/s00276-012-1022-z

Baumgart, M., Wiśniewski, M., Grzonkowska, M., Małkowski, B., Badura, M., Dąbrowska, M., & Szpinda, M. (2016). Digital image analysis of ossification centers in the axial dens and body in the human fetus. *Surgical and Radiologic Anatomy*, *38*(10), 1195-1203.doi:10.1007/s00276-016-1679-9

Baumgart, M., Wiśniewski, M., Grzonkowska, M., Małkowski, B., Badura, M., & Szpinda, M. (2016). Morphometric study of the neural ossification centers of the atlas and axis in the human fetus. *Surgical and Radiologic Anatomy*, *38*(10), 1205-1215.doi:10.1007/s00276-016-1681-2

Beurskens, A. J., Swinkels, R. A., Pool, J. J., Batterham, R. W., Osborne, R. H., & de Vet, H. C. (2016). The burden of neck pain: its meaning for persons with neck pain and healthcare providers, explored by concept mapping. *Quality of Life Research, 25*(5), 1219-1225.

Binder, A. I. (2007). Cervical spondylosis and neck pain. *Bmj*, *334*(7592), 527-531.doi:10.1136/bmj.39127.608299.80

Boogaarts, H. D., & Bartels, R. H. (2015). Prevalence of cervical spondylotic myelopathy. *European Spine Journal*, *24*(2), 139-141. doi:10.1007/s00586-013-2781-x

Bowles, R. D., & Setton, L. A. (2017). Biomaterials for intervertebral disc regeneration and repair. *Biomaterials*, *129*, 54-67.doi: 10.1016/j.biomaterials.2017.03.013

Bramswig, J. H. (2007). Short and tall stature. *Annales Nestlé (English ed.)*, *65*(3), 117-127.doi:10.1159/000112234

Brain, W. R., Knight, G. C., & Bull, J. W. (1948). Discussion of rupture of the intervertebral disc in the cervical region. *Proceedings of the Royal Society of Medicine*, *41*(8), 509-516.

Bulut, M. D., Alpayci, M., Şenköy, E., Bora, A., Yazmalar, L., Yavuz, A., &Gülşen, İ. (2016). Decreased vertebral artery hemodynamics in patients with loss of cervical lordosis. *Medical science monitor: international medical journal of experimental and clinical research*, *22*, 495.doi:10.12659/MSM.897500

Chang, C. C., Huang, W. C., Wu, J. C., & Mummaneni, P. V. (2018). The option of motion preservation in cervical spondylosis: cervical disc arthroplasty update. *Neurospine*, *15*(4), 296.

Chanpimol, S., Seamon, B., Hernandez, H., Harris-Love, M., & Blackman, M. R. (2017). Using Xbox kinetic motion capture technology to improve clinical rehabilitation outcomes for balance and cardiovascular health in an individual with chronic TBI. *Archives of physiotherapy*, *7*(1), 6. doi: 10.1186/s40945-017-0033-9

Chen, C. C., Chung, C. Y., Lee, T. H., Chang, W. H., Tang, S. F., & Pei, Y. C. (2015). Increased risk of posterior circulation infarcts among ischemic stroke patients with cervical spondylosis. *Neuropsychiatric disease and treatment*, *11*, 273.

Cheng, J., Liu, P., Sun, D., Ma, Z., Liu, J., Wang, Z., & Mou, J. (2019). Correlation of cervical and thoracic inlet sagittal parameters by MRI and radiography in patients with cervical spondylosis. *Medicine*, *98*(7).

Childress, M. A., & Becker, B. A. (2016). Nonoperative management of cervical radiculopathy. *Am Fam Physician, 93*(9), 746-754.

Choi, K. S., Lee, C., & Harfe, B. D. (2012). Sonic hedgehog in the notochord is sufficient for patterning of the intervertebral discs. *Mechanisms of development*, *129*(9-12), 255-262. doi:10.1016/j.mod.2012.07.003

Chung, J. Y., Yim, J. H., Seo, H. Y., Kim, S. K., & Cho, K. J. (2012). The efficacy and persistence of selective nerve root block under fluoroscopic guidance for cervical radiculopathy. *Asian spine journal*, *6*(4), 227. doi:10.4184/asj.2012.6.4.227

Cohen, S. P. (2015). Epidemiology, diagnosis, and treatment of neck pain. In *Mayo Clinic Proceedings, 90*(2),284-299.doi:10.1016/j.mayocp.2014.09.008

Cook, C., Brown, C., Isaacs, R., Roman, M., Davis, S., & Richardson, W. (2010). Clustered clinical findings for diagnosis of cervical spine myelopathy. *Journal of Manual & Manipulative Therapy*, *18*(4), 175-180. doi: 10.1179/106698110X12804993427045

Dong, F., Shen, C., Jiang, S., Zhang, R., Song, P., Yu, Y., ... & Ding, C. (2013). Measurement of volume-occupying rate of cervical spinal canal and its role in cervical spondylotic myelopathy. *European Spine Journal*, *22*(5), 1152-1157. doi:10.1007/s00586-012-2622-3

Echarri, J., & Forriol, F. (2002). Effect of axial load on the cervical spine: a study of Congolese woodbearers. *International orthopaedics, 26*(3), 141-144.doi: 10.1007/s00264-002-0336-6

Ellingson, B. M., Salamon, N., Grinstead, J. W., & Holly, L. T. (2014). Diffusion tensor imaging predicts functional impairment in mild-to-moderate cervical spondylotic myelopathy. *The Spine Journal, 14*(11), 2589-2597. doi: 10.1016/j.spinee.2014.02.027

Eloqayli, H. (2018). Clinical decision-making in chronic spine pain: dilemma of image-based diagnosis of degenerative spine and generation mechanisms for nociceptive, radicular, and referred pain. *BioMed research international, 2018*.1-6. doi:10.1155/2018/8793843

Faldini, C., Leonetti, D., Nanni, M., Di Martino, A., Denaro, L., Denaro, V., & Giannini, S. (2010). Cervical disc herniation and cervical spondylosis surgically treated by Cloward procedure: a 10-year-minimum follow-up study. *Journal of Orthopaedics and Traumatology, 11*(2), 99-103. doi:10.1007/s10195-010-0093-z

Fan, S. T. (2018). Clinical observation on cervical chiropractic for cervical spondylosis of vertebral artery type. *Journal of Acupuncture and Tuina Science, 2*(16), 115-119.

Ferrara, L. A. (2012). The biomechanics of cervical spondylosis. *Advances in orthopedics, 2012*.1-5. doi:10.1155/2012/493605

Fleming, A., Kishida, M. G., Kimmel, C. B., & Keynes, R. J. (2015). Building the backbone: the development and evolution of vertebral patterning. *Development*, *142*(10), 1733-1744.

Frost, B. A., Camarero-Espinosa, S., & Foster, E. J. (2019). Materials for the Spine: Anatomy, Problems, and Solutions. *Materials, 12*(2), 253. doi:10.3390/ma12020253

Gao, Z., Song, H., Ren, F., Li, Y., Wang, D., & He, X. (2017). Reliability and validity of CODA motion analysis system for measuring cervical range of motion in patients with cervical spondylosis and anterior cervical fusion. *Experimental and therapeutic medicine*, *14*(6), 5371-5378. doi:10.3892/etm.2017.5239

Gibson, J., Nouri, A., Krueger, B., Lakomkin, N., Nasser, R., Gimbel, D., & Cheng, J. (2018). Focus: Sensory Biology and Pain: Degenerative Cervical Myelopathy: A Clinical Review. *The Yale journal of biology and medicine*, *91*(1), 43–48.

Gilsanz, V., Wren, T. A., Ponrartana, S., Mora, S., & Rosen, C. J. (2018). Sexual Dimorphism and the Origins of Human Spinal Health. *Endocrine reviews*, *39*(2), 221-239. doi:10.1210/er.2017-00147

Goode, A. P., Carey, T. S., & Jordan, J. M. (2013). Low back pain and lumbar spine osteoarthritis: how are they related? *Current rheumatology reports*, *15*(2), 1–13. doi: 10.1007/s11926-012-0305-z.

Grob, D., Frauefelder,H., & Mannion, A.F. (2007). The association between cervical spine curvature and neck pain. *European Spine Journal*, *16*(5), 669–678. doi:10.1007/s00586-006-0254-1

Green, C., Butler, J., Eustace, S., Poynton, A., & O'Byrne, J. M. (2011). Imaging modalities for cervical spondylotic stenosis and myelopathy. *Advances in orthopedics*, *2012*.1-4. doi:10.4061/2012/908324

Guo, G. M., Li, J., Diao, Q. X., Zhu, T. H., Song, Z. X., Guo, Y. Y., & Gao, Y. Z. (2018). Cervical lordosis in asymptomatic individuals: a meta-analysis. *Journal of orthopaedic surgery and research*, *13*(1), 147.

Haładaj, R., Pingot, M., & Topol, M. (2017). The effectiveness of cervical spondylosis therapy with Saunders traction device and high-intensity laser therapy: a randomized controlled trial. *Medical science monitor: international medical journal of experimental and clinical research*, *23*, 335–342. doi:10.12659/MSM.899454

Han, T. S., Oh, M. K., Kim, S. M., Yang, H. J., Lee, B. S., Park, S. Y., & Lee, W. J. (2015). Relationship between neck length, sleep, and cardiovascular risk factors. *Korean journal of family medicine*, *36*(1), 10. doi: 10.4082/kjfm.2015.36.1.10

Han, Y. Z., Tian, Y., Xu, M., Ni, C., Li, M., Wang, J., & Guo, X. Y. (2017). Neck circumference to inter-incisor gap ratio: a new predictor of difficult laryngoscopy in cervical spondylosis patients. *BMC anesthesiology*, *17*(1), 55. doi: 10.1186/s12871-017-0346-y

Harrop, J. S., Naroji, S., Maltenfort, M., Anderson, D. G., Albert, T., Ratliff, J. K., ... & Sharan, A. D. (2010). Cervical myelopathy: a clinical and radiographic evaluation and correlation to cervical spondylotic myelopathy. *Spine*, *35*(6), 620-624.

Hawes, M. C., & O'Brien, J. P. (2006). The transformation of spinal curvature into spinal deformity: pathological processes and implications for treatment. *Scoliosis*, *1*(1), 3. doi:10.1186/1748-7161-1-3

Hayashi, T., Daubs, M. D., Suzuki, A., Scott, T. P., Phan, K., Aghdasi, B., ... & Shiba, K. (2016). The compensatory relationship of upper and subaxial cervical motion in the presence of cervical spondylosis. *Clinical spine surgery*, *29*(4), 196-200. doi:10.1097/BSD.0b013e3182aab240

Henderson, P., Desai, I. P., Pettit, K., Benke, S., Brouha, S. S., Romine, L. E.& Pretorius, D. H. (2016). Evaluation of fetal first and second cervical vertebrae: normal or abnormal? *Journal of Ultrasound in Medicine,* *35*(3), 527-536. doi:10.7863/ultra.14.12044

Hirpara, K. M., Butler, J. S., Dolan, R. T., O'Byrne, J. M., & Poynton, A. R. (2012). Nonoperative modalities to treat symptomatic cervical spondylosis. *Advances in orthopedics, 2012*. doi:10.1155/2012/294857

Hoy, D. G., Protani, M., De, R., & Buchbinder, R. (2010). The epidemiology of neck pain. *Best Practice & Research Clinical Rheumatology, 24*(6), 783-792. doi:10.1016/j.berh.2011.01.019

Ibrahim, H. I. A., & Saleh, A. (2018). Role of DTI in cases of cervical spondylosis presented with compression myelopathy: Could it explain the clinical radiological mismatch?!.*The Egyptian Journal of Radiology and Nuclear Medicine*, *49*(2), 441-446. doi: 10.1016/j.ejrnm.2017.12.014

Iyer, A., Azad, T. D., & Tharin, S. (2016). Cervical spondylotic myelopathy. *Clinical spine surgery, 29*(10), 408-414. doi:10.1097/BSD.0000000000000397

Jensen, R. K., Jensen, T. S., Grøn, S., Frafjord, E., Bundgaard, U., Damsgaard, A. L., ...& Kjaer, P. (2019). Prevalence of MRI findings in the cervical spine in patients with persistent neck pain based on quantification of narrative MRI reports. *Chiropractic & manual therapies*, *27*(1), 13.

Junewick, J. J., Chin, M. S., Meesa, I. R., Ghori, S., Boynton, S. J., & Luttenton, C. R. (2011). Ossification patterns of the atlas vertebra. *American Journal of Roentgenology*, *197*(5), 1229-1234. doi:10.2214/AJR.10.5403

Jung, S. I., Lee, N. K., Kang, K. W., Kim, K., & Do, Y. L. (2016). The effect of smartphone usage time on posture and respiratory function. *Journal of physical therapy science, 28*(1), 186-189.

Kaplan, K. M., Spivak, J. M., & Bendo, J. A. (2005). Embryology of the spine and associated congenital abnormalities. *The Spine Journal*, *5*(5), 564-576. .doi:10.1016/j.spinee.2004.10.044

Karic-Skrijelj, M., Talic, A., Masic, I., Vavra-Hadziahmetovic, N., Pandza, H., & Suljic-Mehmedika, E. (2008). Cervical pain syndrome as consequence of computer use in daily practice. *ActaInformaticaMedica, 16*(1), 25. doi:10.5455/aim.2008.16.25-28

Karpova, A., Arun, R., Davis, A. M., Kulkarni, A. V.,Mikulis, D. J., Sooyong, C., & George, J. (2013). Reliability of quantitative magnetic resonance imaging methods in the assessment of spinal canal stenosis and cord compression in cervical myelopathy. *Spine, 38*(3), 245-252. doi:10.1097/BRS.0b013e3182672307

Kavanagh, R. G., Butler, J. S., O'Byrne, J. M., & Poynton, A. R. (2012). Operative techniques for cervical radiculopathy and myelopathy. *Advances in orthopedics, 2012*. 1-5. doi:10.1155/2012/794087

Kelly, J. C., Groarke, P. J., Butler, J. S., Poynton, A. R., & O'Byrne, J. M. (2012). The natural history and clinical syndromes of degenerative cervical spondylosis. *Advances in orthopedics, 2012*. 1-5. doi:10.1155/2012/393642

Khan, M. R., & Singh, N. K. (2018). Prevalence of musculoskeletal disorders among Indian railway sahayaks. *International journal of occupational and environmental health, 24*(1-2), 27-37. doi:10.1080/10773525.2018.1507187

Kim, L. H., D'Souza, M., Ho, A. L., Pendharkar, A. V., Sussman, E. S., Rezaii, P., & Desai, A. (2018). Anterior Techniques in Managing Cervical Disc Disease. *Cureus, 10*(8). doi:10.7759/cureus.3146

Kolu, E., Buyukavci, R., Akturk, S., Eren, F., & Ersoy, Y. (2018). Comparison of high-intensity laser therapy and combination of transcutaneous nerve stimulation and ultrasound treatment in patients with chronic lumbar radiculopathy: A randomized single-blind study. *Pakistan journal of medical sciences*, *34*(3), 530-534. doi: 10.12669/pjms.343.14345

Koreckij, T. D., & Fischgrund, J. S. (2015). Degenerative spondylolisthesis. *Clinical Spine Surgery*, *28*(7), 236-241.

Kumagai, G., Ono, A., Numasawa, T., Wada, K., Inoue, R., Iwasaki, H., ... & Nakaji, S. (2014). Association between roentgenographic findings of the cervical spine and neck symptoms in a Japanese community population. *Journal of Orthopaedic Science, 19*(3), 390-397.doi: 10.1007/s00776-014-0549-8

Kushchayev, S. V., Glushko, T., Jarraya, M., Schuleri, K. H., Preul, M. C., Brooks, M. L., & Teytelboym, O. M. (2018). ABCs of the degenerative spine. *Insights into imaging*, *9*(2),253–274. doi: 10.1007/s13244-017-0584-z

Kwon, Y., Kim, J. W., Heo, J. H., Jeon, H. M., Choi, E. B., & Eom, G. M. (2018). The effect of sitting posture on the loads at cervico-thoracic and lumbosacral joints. *Technology and Health Care*, *26*,409-418. doi: 10.3233/THC-174717

Kyu, H. H., Abate, D., Abate, K. H., Abay, S. M., Abbafati, C., Abbasi, N., ...& Abdollahpour, I. (2018). Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet, 392*(10159), 1859-1922.doi:10.1016/S0140-6736(18)32335-3

Laiho, K., Kauppi, M., & Konttinen, Y. T. (2005). Why atlas, why not heracles: reflections on the rheumatoid cervical spine. *In Seminars in arthritis and rheumatism,34*(4), 637-641.doi: 10.1016/j.semarthrit.2004.07.012

Lawrence, K. J., Else, T., & Stromberg, R. (2016). Lumbar spondylolysis in the adolescent athlete. *Physical Therapy in Sport, 20*, 56-60. doi: 10.1016/j.ptsp.2016.04.003

Lebl, D. R., & Bono, C. M. (2015). Update on the diagnosis and management of cervical spondylotic myelopathy. *JAAOS-Journal of the American Academy of Orthopaedic*Surgeons, 23(11), 648-660.

Lebl, D. R., Hughes, A., Cammisa, F. P., & O'Leary, P. F. (2011). Cervical spondylotic myelopathy: pathophysiology, clinical presentation, and treatment. *The HSS Journal*, *7*(2), 170-178. doi:10.1007/s11420-011-9208-1

Lee, K. Y. (2014). Comparison of pyogenic spondylitis and tuberculous spondylitis. *Asian spine journal, 8*(2), 216.

Lee, S., Shin, J. S., Lee, J., Ha, I. H., Kim, M. R., Koh, W., ... & Jang, B. H. (2018). Effectiveness of pharmacopuncture for cervical spondylosis: A systematic review and meta-analysis. *European Journal of Integrative Medicine, 20,* 154-164.doi: 10.1016/j.eujim.2018.05.010

Li, J., Gu, T., Yang, H., Liang, L., Jiang, D. J., Wang, Z. C., ... & Wang, X. W. (2014). Sympathetic nerve innervation in cervical posterior longitudinal ligament as a potential causative factor in cervical spondylosis with sympathetic symptoms and preliminary evidence. *Medical hypotheses, 82*(5), 631-635. doi: 10.1016/j.mehy.2014.02.029

Li, J., Jiang, D. J., Wang, X. W., Yuan, W., Liang, L., & Wang, Z. C. (2016). Mid-term outcomes of anterior cervical fusion for cervical spondylosis with sympathetic symptoms. *Clinical spine surgery*, *29*(6), 255-260.

Lin, S. Y., Hsu, W. H., Lin, C. C., Lin, C. L., Tsai, C. H., Lin, C. H., ... & Kao, C. H. (2018). Association of Arrhythmia in Patients with Cervical Spondylosis: A Nationwide Population-Based Cohort Study. *Journal of clinical medicine, 7*(9), 236. doi: 10.3390/jcm7090236.

Lin, S. Y., Lin, C. L., Chen, D. C., Lee, H. C., Chen, H. T., Lin, T. C., ... & Kao, C. H. (2018). Risk of posterior circulation stroke in patients with cervical spondylosis: A nationwide, population-based study. *Atherosclerosis, 277*, 42-46. doi: 10.1016/j.atherosclerosis.2018.08.006

Lin, S. Y., Sung, F. C., Lin, C. L., Chou, L. W., Hsu, C. Y., & Kao, C. H. (2018). Association of Depression and Cervical Spondylosis: A Nationwide Retrospective Propensity Score-Matched Cohort Study. *Journal of clinical medicine, 7*(11), 387. doi:10.3390/jcm7110387

Lin, W. S., Huang, T. F., Chuang, T. Y., Lin, C. L., & Kao, C. H. (2018). Association between cervical spondylosis and migraine: a nationwide retrospective cohort study. *International journal of environmental research and public health, 15*(4), 587. doi:10.3390/ijerph15040587

Lou, C., Chen, H. L., Feng, X. Z., Xiang, G. H., Zhu, S. P., Tian, N. F., ... & Xu, H. Z. (2014). Menopause is associated with lumbar disc degeneration: a review of 4230 intervertebral discs. *Climacteric, 17*(6), 700-704. doi: 10.3109/13697137.2014.933409

Lustrin, E. S., Karakas, S. P., Ortiz, A. O., Cinnamon, J., Castillo, M., Vaheesan, K., ...& Singh, S. (2003). Pediatric cervical spine: normal anatomy, variants, and trauma. *Radiographics, 23*(3), 539-560. doi:10.1148/rg.233025121

Lv, Y., Tian, W., Chen, D., Liu, Y., Wang, L., & Duan, F. (2018). The prevalence and associated factors of symptomatic cervical Spondylosis in Chinese adults: a community-based cross-sectional study. *BMC musculoskeletal disorders, 19*(1), 325.

Mahajan, P. V, & Bharucha, B. A. (1994). Evaluation of short neck: new neck length percentiles and linear correlations with height and sitting height. *Indian Pediatr, 31*(10), 1193–1203. doi: 10.1016/j.devcel.2013.07.014

Mahbub, M. H., Laskar, M. S., Seikh, F. A., Altaf, M. H., Inoue, M., Yokoyama, K., ... & Harada, N. (2006). Prevalence of cervical spondylosis and musculoskeletal symptoms among coolies in a city of Bangladesh. *Journal of occupational health, 48*(1), 69-73. doi:10.1539/joh.48.69

Martin-Vaquero, P., & da Costa, R. C. (2015). Body conformation in great Danes with and without clinical signs of cervical spondylomyelopathy. *The Veterinary Journal, 203*(2), 219-222. doi: 10.1016/j.tvjl.2014.12.003

Mesas, A. E., González, A. D., Mesas, C. E., de Andrade, S. M., Magro, I. S., & del Llano, J. (2014). The association of chronic neck pain, low back pain, and migraine with absenteeism due to health problems in Spanish workers. *Spine, 39*(15), 1243-1253. doi: 10.1097/BRS.0000000000000387

Miao, Q., Qiang, J. H., & Jin, Y. L. (2018). Effectiveness of percutaneous neuromuscular electrical stimulation for neck pain relief in patients with cervical spondylosis. *Medicine, 97*(26). doi: 10.1097/MD.0000000000011080

Miller, C. A., Hwang, S. J., Cotter, M. M., & Vorperian, H. K. (2019). Cervical vertebral body growth and emergence of sexual dimorphism: a developmental study using computed tomography. *Journal of anatomy*.doi: 10.1111/joa.12976

Miyazaki, M., Yoshiiwa, T., Kodera, R., & Tsumura, H. (2011). Clinical features of cervical pyogenic spondylitis and intraspinal abscess. *Clinical Spine Surgery, 24*(7), E57-E61.

Moon, M. S., Yoon, M. G., Park, B. K., & Park, M. S. (2016). Age-related incidence of cervical spondylosis in residents of Jeju Island. *Asian spine journal*, *10*(5), 857. doi:10.4184/asj.2016.10.5.857

Moore, K. L., Dalley, A. F., & Agur, A. M. (2014). Clinically oriented anatomy (7th ed.).Philadelphia, USA: Lippincott Williams & Wilkins.

Morales-Avalos, R., Martinez-Gonzalez, B., Villarreal-Garcia, F. I., Requena-Araujo, P. M., Martínez-Gutiérrez, O. A., Reyes-Fernández, P. M., ... & Elizondo-Omana, R. E. (2018). Variations in the Torg-Pavlov Cervical Ratio with Regard to Age and Sex. A Comprehensive Anatomical and Morphometric Study on Contemporary Cadaveric Specimens. *International Journal of Morphology, 36*(2), 598–607. doi:10.4067/S0717-95022018000200598

Morishita, Y., Buser, Z., D'Oro, A., Shiba, K., & Wang, J. C. (2018). Clinical relationship of degenerative changes between the cervical and lumbar spine. *Asian spine journal*, *12*(2), 343.

Nagata, K., Yoshimura, N., Hashizume, H., Muraki, S., Ishimoto, Y., Yamada, H., ... & Kawaguchi, H. (2014). The prevalence of cervical myelopathy among subjects with narrow cervical spinal canal in a population-based magnetic resonance imaging study: the Wakayama Spine Study. *The Spine Journal*, *14*(12), 2811-2817.

Näkki, A., Battié, M. C., & Kaprio, J. (2014). Genetics of disc-related disorders: current findings and lessons from other complex diseases. *European Spine Journal, 23*(3), 354-363. doi:10.1007/s00586-013-2878-2

Neupane, S., Ali, U., & Mathew, A. (2017). Text Neck Syndrome-Systematic Review. *Imperial J Interdiscipl Res*, 3(7), 141-8.

Oguntona, S. A. (2014). Cervical spondylosis in South West Nigerian farmers and female traders. Annals of African medicine, 13(2), 61-64. doi: 10.4103/1596-3519.129857.

Ormos, G. (2016). Survey of neck posture, mobility and muscle strength among schoolchildren. *ManuelleMedizin, 54*(3), 156-162. doi:10.1007/s00337-016-0133-8

Papadopoulou, S., Exarchakos, G., Beris, A., & Ploumis, A. (2013). Dysphagia associated with cervical spine and postural disorders. *Dysphagia, 28*(4), 469-480. doi:10.1007/s00455-013-9484-7

Park, J., Park, W. Y., Hong, S., An, J., Koh, J. C., Lee, Y. W., ... & Choi, J. B. (2017). Diagnostic Accuracy of the Neck Tornado Test as a New Screening Test in Cervical Radiculopathy. *International journal of medical sciences, 14*(7), 662.

Peng, B. (2018). Cervical vertigo: historical reviews and advances. *World neurosurgery, 109*, 347-350. doi: 10.1016/j.wneu.2017.10.063

Peng, B., Pang, X., Li, D., & Yang, H. (2015). Cervical spondylosis and hypertension: a clinical study of 2 cases. *Medicine, 94*(10). doi:10.1097/MD.0000000000000618

Pohl, M., Back, T., Leimert, M., Seifert, J., Stoffel, M., Amelung, R. I., ...& Mokrusch, T. (2018). Cervical Radiculopathy.*AktuelleNeurologie, 45*(5), 349–369. doi:10.1055/a-0575-7066

Rajani, S. (2014). Is variant anatomy of atlas clinically important? A review. *Basic Sciences of Medicine*, *3*(1), 1-7. doi: 10.5923/j.medicine.20140301.01

Remes, V. M., Heinänen, M. T., Kinnunen, J. S., & Marttinen, E. J. (2000). Reference values for radiological evaluation of cervical vertebral body shape and spinal canal. *Pediatric radiology, 30*(3), 190-195.

Rolfe, R. A., Bezer, J. H., Kim, T., Zaidon, A. Z., Oyen, M. L., Iatridis, J. C., & Nowlan, N. C. (2017). Abnormal fetal muscle forces result in defects in spinal curvature and alterations in vertebral segmentation and shape. *Journal of Orthopaedic Research*, *35*(10), 2135-2144. doi: 10.1002/jor.23518

RoseBist, P. K., Peethambaran, A. K., & Peethambar, G. A. (2018). Cervical spondylosis: analysis of clinical and radiological correlation. *International Surgery Journal*, *5*(2), 491-495.

Rubinstein, S. M., Pool, J. J., van Tulder, M. W., Riphagen, I. I., & de Vet, H. C. (2007). A systematic review of the diagnostic accuracy of provocative tests of the neck for diagnosing cervical radiculopathy. *European spine journal*, *16*(3), 307-319. doi:10.1007/s00586-006-0225-6

Rudy, I. S., Poulos, A., Owen, L., Batters, A., Kieliszek, K., Willox, J., & Jenkins, H. (2015). The correlation of radiographic findings and patient symptomatology in cervical degenerative joint disease: a cross-sectional study. *Chiropractic & manual therapies*, *23*(1), 9. doi:10.1186/s12998-015-0052-0

Sadeh, M., & Dabby, R. (2018). Apparent C8-T1 radiculopathy with hand weakness due to mid-cervical spondylosis. *Journal of Clinical Neuroscience*, *47*, 111-115. doi:10.1016/j.jocn.2017.10.071

Salamon, N., Ellingson, B. M., Nagarajan, R., Gebara, N., Thomas, A., & Holly, L. T. (2013). Proton magnetic resonance spectroscopy of human cervical spondylosis at 3T. *Spinal cord*, *51*(7), 558. doi: 10.1038/sc.2013.31

Saraiva, C. B. J., Silva, L. D., & Grande, J. B. P. (2016). Accessory articulation of elongated anterior transverse process : a rare anatomical variant of the cervical spine depicted with CT and post-processing techniques. *Surgical and Radiologic Anatomy*, *38*(2), 269–271. doi:10.1007/s00276-015-1535-3

Sayıt, E., Aghdasi, B., Daubs, M. D., & Wang, J. C. (2015). The occupancy of the components in the cervical spine and their changes with extension and flexion. *Global spine journal*, *5*(05), 396-405.

Scaal, M. (2016). Early development of the vertebral column. *In Seminars in cell & developmental biology*, *49*, 83-91.

Schatlo, B., Remonda, L., Gruber, P., Fandino, J., Rohde, V., Fathi, A. R., & Berberat, J. (2018). Cervical Spine Prospective Feasibility Study: Dynamic Flexion-Extension Diffusion-Tensor Weighted Magnetic Resonance Imaging. *Clinical neuroradiology*. doi:10.1007/s00062-018-0686-0

Shedid, D., & Benzel, E. C. (2007). Cervical spondylosis anatomy: pathophysiology and biomechanics. *Neurosurgery*, *60*(1),1-7.doi:10.1227/01.NEU.0000215430.86569.C4

Sheng, S. R., Xu, H. Z., Wang, Y. L., Zhu, Q. A., Mao, F. M., Lin, Y., & Wang, X. Y. (2016). Comparison of cervical spine anatomy in calves, pigs and humans. *PloS one*, *11*(2), e0148610. doi: 10.1371/journal.pone.0148610

Shi, J. S., Lin, B., Xue, C., Zhang, H. S., Chen, Z. D., & Zhao, Z. S. (2015). Clinical and radiological outcomes following hybrid surgery in the treatment of multi-level cervical spondylosis: over a 2-year follow-up. *Journal of orthopaedic surgery and research, 10*(1), 185. doi:10.1186/s13018-015-0330-5

Shilton, M., Branney, J., de Vries, B. P., & Breen, A. C. (2015). Does cervical lordosis change after spinal manipulation for non-specific neck pain? A prospective cohort study. *Chiropractic & manual therapies*, *23*(1), 33. doi:10.1186/s12998-015-0078-3

Singh, S., Kumar, D., & Kumar, S. (2014). Risk factors in cervical spondylosis. *Journal of clinical orthopaedics and trauma*, *5*(4), 221-226.doi: 10.1016/j.jcot.2014.07.007

Singla, D., & Veqar, Z. (2017). Association between forward head, rounded shoulders, and increased thoracic kyphosis: a review of the literature. *Journal of chiropractic medicine, 16*(3), 220-229. doi:10.1016/j.jcm.2017.03.004

Sousa, T., Skaggs, D. L., Chan, P., Yamaguchi Jr, K. T., Borgella, J., Lee, C., ...& Hresko, M. T. (2017). Benign Natural History of Spondylolysis in Adolescence with Midterm Follow-Up. *Spine deformity*, *5*(2), 134-138. doi: 10.1016/j.jspd.2016.10.005

Stewart, G.E.(2019). Spinal nerve disorders. Retrieved on 7th July 2019 from www.spineuniverse.com/conditions/spondylosis

Sun, Y., Muheremu, A., & Tian, W. (2018). Atypical symptoms in patients with cervical spondylosis: Comparison of the treatment effect of different surgical approaches. *Medicine, 97*(20).

Sun, Z. R., Yue, J. H., & Zhang, Q. H. (2013). Electroacupuncture at Jing-jiaji points for neck pain caused by cervical spondylosis: a study protocol for a randomized controlled pilot trial. *Trials, 14*(1), 360. doi:10.1186/1745-6215-14-360

Swartz, E. E., Floyd, R. T., & Cendoma, M. (2005). Cervical spine functional anatomy and the biomechanics of injury due to compressive loading. *Journal of athletic training*, *40*(3), 155-161.

Szpinda, M., Baumgart, M., Szpinda, A., Woźniak, A., & Mila-Kierzenkowska, C. (2013). Cross-sectional study of the neural ossification centers of vertebrae C1–S5 in the human fetus. *Surgical and Radiologic Anatomy*, *35*(8), 701-711. doi:10.1007/s00276-013-1093-5

Tabaee, A., Geng, E., Lin, J., Kakoullis, S., McDonald, B., Rodriguez, H., & Chong, D. (2005). Impact of neck length on the safety of percutaneous and surgical tracheotomy: a prospective, randomized study. *The Laryngoscope*, *115*(9), 1685-1690.doi: 10.1097/01.MLG.0000175539.25182.2A

Taha, M., Jafari, F. H., Kashyar, P., & Asad, M. R. (2014). Analysis of Neck Length and its Incidence for Cervical Spondylosis in Young Adults. *Journal of Rawalpindi Medical College*, 18(1), 3–6

Tan, L. A., Riew, K. D., & Traynelis, V. C. (2017). Cervical spine deformity-part 1: biomechanics, radiographic parameters, and classification. *Neurosurgery*, *81*(2), 197-203. doi:10.1093/neuros/nyx249

Tetreault, L., Goldstein, C. L., Arnold, P., Harrop, J., Hilibrand, A., Nouri, A., & Fehlings, M. G. (2015). Degenerative cervical myelopathy: a spectrum of related disorders affecting the aging spine. *Neurosurgery*, *77*(S1), 51-67. doi:10.1227/NEU.0000000000000951

Thoomes, E. J., Geest, S. Van, Windt, D. A. Van Der, Falla, D., Verhagen, A. P., Koes, B. W., … Vleggeert-lankamp, C. L. (2018). Value of physical tests in diagnosing cervical radiculopathy : a systematic review. *The Spine Journal*, *18*(1), 179–189. doi:10.1016/j.spinee.2017.08.241

Tiric-Campara, M., Krupic, F., Biscevic, M., Spahic, E., Maglajlija, K., Masic, Z., ... & Masic, I. (2014). Occupational overuse syndrome (technological diseases): carpal tunnel syndrome, a mouse shoulder, cervical pain syndrome. *ActaInformaticaMedica*, *22*(5), 333.doi: 10.5455/aim.2014.22.333-340

Toledano, M., & Bartleson, J. D. (2013). Cervical spondylotic myelopathy. *Neurologic clinics*, *31*(1), 287-305. doi: 10.1016/j.ncl.2012.09.003

Tsirikos, A. I., & Garrido, E. G. (2010). Spondylolysis and spondylolisthesis in children and adolescents. *The Journal of bone and joint surgery. British volume*, *92*(6), 751-759. doi:10.1302/0301-620X.92B6.23014

Ulbrich, E. J., Schraner, C., Boesch, C., Hodler, J., Busato, A., Anderson, S. E., ... & Sturzenegger, M. (2014). Normative MR cervical spinal canal dimensions. *Radiology*, *271*(1), 172-182. doi: 10.1148/radiol.13120370

Unlu, Z., Orguc, S., Eskiizmir, G., Aslan, A., & Bayindir, P. (2008). Elongated styloid process and cervical spondylosis. *Clinical medicine: case reports*, *1*, CCRep-S792.

Vilaça, C. D. O., Orsini, M., Leite, M. A. A., Freitas, M. R. G. De, Davidovich, E., Fiorelli, R., … Pessoa, B. L. (2016). Cervical spondyloticmyelopathy : what the neurologist should know.*Neurology international*, 8(4), 69–73. doi:10.4081/ni.2016.6330

Voorhies, R. M. (2001). Cervical spondylosis: recognition, differential diagnosis, and management. *Ochsner Journal*, *3*(2), 78-84.

Wainner, R. S., Fritz, J. M., Irrgang, J. J., Boninger, M. L., Delitto, A., & Allison, S. (2003). Reliability and diagnostic accuracy of the clinical examination and patient self-report measures for cervical radiculopathy. *Spine, 28*(1), 52-62. doi:10.1097/01.BRS.0000038873.01855.50

Wang, C., Tian, F., Zhou, Y., He, W., & Cai, Z. (2016). The incidence of cervical spondylosis decreases with aging in the elderly, and increases with aging in the young and adult population: a hospital-based clinical analysis. *Clinical interventions in aging, 11*, 47-53. doi: 10.2147/CIA.S93118

Wang, G., & Long, X.Yu. (2017). Traditional Chinese medicine treatment selection for straightened cervical curvature and therapeutic observation. *Journal of Acupuncture and Tuina Science, 15*(2), 136–140. doi:10.1007/s11726-017-0990-2

Watson, N.,& Jones, H.(2017) CHAPMAN & NAKIELNY'S GUIDE TO RADIOLOGICAL PROCEDURES (7th ed.).U.K: Elsevier.

Wheeler-Kingshott, C. A., Stroman, P. W., Schwab, J. M., Bacon, M., Bosma, R., Brooks, J., ... & Curt, A. (2014). The current state-of-the-art of spinal cord imaging: applications. *Neuroimage, 84*, 1082-1093.

Whitley, A. S., Sloane, C., Hoadley, G., Moore, A. D., & Alsop, C. W. (2005). Clark's positioning in radiography (12th ed.). UK: Hodder Arnold.

Who, E. C. (2004). Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*, *363*(9403), 157.

Woodworth, D. C., Holly, L. T., Salamon, N., & Ellingson, B. M. (2018). Resting-State Functional Magnetic Resonance Imaging Connectivity of the Brain Is Associated with Altered Sensorimotor Function in Patients with Cervical Spondylosis. *World neurosurgery, 119*, 740-749. doi: 10.1016/j.wneu.2018.07.257

Xiong, C., Daubs, M. D., Scott, T. P., Phan, K. H., Suzuki, A., Ruangchainikom, M., ...& Wang, J. C. (2017). Dynamic evaluation of the cervical spine and the spinal cord of symptomatic patients using a kinetic magnetic resonance imaging technique. *Clinical spine surgery, 30*(8), 1149-1155.

Xiong, W., Li, F., & Guan, H. (2015). Tetraplegia after thyroidectomy in a patient with cervical spondylosis: a case report and literature review. *Medicine, 94*(6). 1–5. doi:10.1097/MD.0000000000000524

Yalamanchili, P. K., Vives, M. J., & Chaudhary, S. B. (2012). Cervical spondylotic myelopathy: factors in choosing the surgical approach. *Advances in orthopedics, 2012*. doi:10.1155/2012/783762

Yang, C. (2008). Therapeutic effect of acupuncture plus tuina on cervical spondylosis. *Journal of Acupuncture and Tuina Science, 6*(6), 344–346. doi:10.1007/s11726-008-0344-1

Yang, H., Haldeman, S., Nakata, A., Choi, B., Delp, L., & Baker, D. (2015). Work-related risk factors for neck pain in the US working population. *Spine, 40*(3), 184-192.

Yang, L., Yang, C., Pang, X., Li, D., Yang, H., Zhang, X., ... & Peng, B. (2017). Mechanoreceptors in diseased cervical intervertebral disc and vertigo. *Spine, 42*(8), 540-546. doi:10.1097/BRS.0000000000001801

Yi, J. S., Cha, J. G., Han, J. K., & Kim, H. J. (2015). Imaging of herniated discs of the cervical spine: inter-modality differences between 64-slice multidetector CT and 1.5-T MRI. *Korean journal of radiology, 16*(4), 881-888.

Yin, Y., Qin, X., Huang, R., Xu, J., Li, Y., & Yu, L. (2016). Musculoskeletal Ultrasound: A Novel Approach for Luschka's Joint and Vertebral Artery. *Medical science monitor:*

international medical journal of experimental and clinical research, 22, 99. doi: 10.12659/MSM.896242

Yu, X., & Xiang, L. (2014). Classifying cervical spondylosis based on fuzzy calculation. *In Abstract and Applied Analysis, 2014*. doi:10.1155/2014/182956

Zadbuke, Y., Wade, R, & Panjwani, T. (2016).Morphometric Analysis of Spinal Canal Diameter of Cervical Spine in Indian Population Using Radiographs and Computerised Tomography. *International Journal of Scientific Research,*5(9), 52–53.

Zejda, J. E., & Stasiow, B(2003). Cervical spine degenerative changes (narrowed intervertebral disc spaces and osteophytes) in coal miners. *International journal of occupational medicine and environmental health, 16*(1), 49-53.

Zhang, S. H., Wu, Y. C., & Chen, J. (2013). Clinical observation on Dong's extraordinary points for tinnitus due to cervical spondylosis. *Journal of Acupuncture and Tuina Science, 11*(5), 300-302.

Zhou, S. W., Guo, L. X., Zhang, S. Q., & Tang, C. Y. (2010). Study on cervical spine injuries in vehicle side impact. *The Open Mechanical Engineering Journal, 4*, 29-35.

Zhou, Y., Zhu, L., Cheng, H. L., & Lin, Y. X. (2015). NeuromyelitisOptica Spectrum Disorder Associated with Cervical Spondylosis. *Chinese medical journal, 128*(22), 3112. doi:10.4103/0366-6999.169110

7.2 APPENDICES

(A) FRC Approval Letter

FACULTY RESEARCH COMMITTEE
BAHRIA UNIVERSITY MEDICAL & DENTAL COLLEGE

LETTER OF APPROVAL

Ref No: FRC-BUMDC -01/ 2018-008

Date: 15th October 2018

To,
Dr. Syeda Bushra Ahmed
M.Phil. Student
Department Of Anatomy
BUMDC-Karachi

Subject: **APPROVAL OF SYNOPSIS**

The Faculty Research Committee has approved the synopsis of below mentioned student with modification in title of thesis as per suggestions of reviewer.

Student Name: **Dr. Syeda Bushra Ahmed**

Title of Study: **"Comparison of neck length with incidence of cervical spondylosis".**

Further this letter is recommended and referred to ERC for approval on ethical grounds.

Regards

Assist Prof. Dr. Mehreen Lateef,
CO- CHAIRPERSON FRC-BUMDC

Cc:

FRC Record
PG Secretariat

Faculty Research Committee, Bahria University Medical College
Sailor's Street, Adjacent PNS-SHIFA DHA
Webmail: rrc-bumdc@bahria.edu.pk

(B) ERC Approval Letter

BAHRIA UNIVERSITY MEDICAL AND DENTAL COLLEGE

Defence phase II, Sailor Street, adjacent to PNS Shifa, Karachi. Tel: 021-35319491-9

ETHICAL REVIEW COMMITTEE

LETTER OF APPROVAL

Date: 17.10.18

PATRON
Prof. Asad Ullah Khan
Principal & Dean
Health Sciences(BU)

CHAIRPERSON
Prof. Ambreen Usmani

SECRETARY
Prof Reza H Syed

MEMBERS
Prof M Alamgir
Prof Anis Jafarey
Ms Nighat Huda
Surg Cdre Amir Ejaz
Ms Shabina Arif
Mr M Amir Sultan
Surg Lt Cdr Farah
Surg Lt Cdr Sadia

Dr. Syeda Bushra Ahmed
M.Phil Student
Department of Anatomy
BUMDC-Karachi

Subject: Institutional Approval of research study

Title of Study: Comparison of Neck Length with Incidence of Cervical Spondylosis

Principal Investigator: Dr. Syeda Bushra Ahmed, M.Phil Student Department of Anatomy, Bahria University Medical and Dental College.

Reference No: ERC 45/2018

Dear Dr. Syed Bushra Ahmed

Thank you for submitting the above mentioned study proposal. ERC Bahria University has reviewed this project in the meeting held on 24th-Sep-2018 and gives approval. Kindly notify us when the research is complete.

Regards,

PROF DR AMBREEN USMANI
Chairperson
BUMDC

Cc:
DG-BUMDC
Principal BUMDC
Chairperson ERC

PATEL HOSPITAL
A Project of Patel Foundation

ETHICS COMMITTEE

APPROVAL FORM NO: 57

Name of principal investigator: Dr. Syeda Bushra Ahmed, M.Phil student, Anatomy, Bahria University Medical and Dental College.

Co-Investigators: Prof. Dr. Aisha Qamar, Professor, Anatomy, Bahria University Medical and Dental College; Dr. Muhammad Imran, Head of Department, Radiology, Patel Hospital.

Title: "Comparison of Neck Length with Incidence of Cervical Spondylosis"

Documents Reviewed:

1. ERC Application from
2. Study proposal/synopsis
3. Questionnaire
4. Informed Consent

Your study proposal and your answers to the raised ethical concerns have also been reviewed. We are pleased to inform you that approval from HEC is granted.

Chairperson

Ms. Shabana Tabassum

Signature ________ Date 18/10/18

Dr. Shahmoona Faisal (Coordinator)

Members:

Dr. Nida Wahid

Dr. Mazhar Nizam

Dr. Kamran Dawood

Dr. Asad Akram Farooqui

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(C) Consent Form English version

INFORMED CONSENT FORM FOR PATIENT

I am giving my consent to participate voluntarily and at my own will in this research "COMPARISON OF NECK LENGTH WITH INCIDENCE OF CERVICAL SPONDYLOSIS" project that aims to know the association of neck length with the incidence of cervical spondylosis.

PROCEDURE: After signing this written consent, you will be asked questions related to presenting complaint. Your weight and height will be recorded. All of your identifying information will be kept confidential. You will be asked to have an x-ray of lateral view of neck. In case of any query you can contact at the above address. You must be at least 25 years old to participate.

COMPLICATIONS: There are no known complications for this study.

ADVERSE EFFECTS: There are no known risks for this study. Adverse effects of x-ray are low. They x-ray can cause mutations that can lead to cancer but the chances of it are very low. The benefits of x-rays outweigh negative outcomes. The study will aid in evaluation of disease and its association with neck length, demographic factors and radiographic changes.

CONSENT: I have been explained in detail the nature and significance of participating in the project and I understand the provided explanation.

I have been told that findings of my disease and my data will be kept strictly confidential and will be used only for the benefit of community, publications and paper presentations.

I also agree to give all relevant information needed, in full and to the best of my knowledge to the researcher. It is clarified to me that no incentive will be provided to me for participating in the study except the cost of lab investigation by the researcher whereas I do have the right to withdraw from the study at any time.

I am advised to contact Dr. Syeda Bushra Ahmed on mobile no: 03323282181 or visit BUMDC in case of any query related to my disease.

Name of patient: _________________________ W/O______________________

Signature/Thumb impression of Patient: _________________________________

Name of Researcher: ____

Signature of Researcher: ____

Date: ____

Urdu version

مریض کے لئے رضامندی فارم

میں رضاکارانہ طور پر حصہ لینے کے لئے اپنی رضامندی پیش کر رہا / کر رہی ہوں۔ اس تحقیق میں گردن اسپنڈیلیسیس کی بیماری کے ساتھ گردن کی لمبائی کا موازنہ کیا جائے گا۔ "اس منصوبے کا مقصد گردن کی لمبائی کے متعلق جاننا ہے۔

طریقہ کار: اس تحریری رضامندی پر دستخط کرنے کے بعد، آپ کو شکایت پیش کرنے سے متعلق سوالات پوچھے جا ئیں گا. آپ کا وزن اور اونچائی درج کی جائے گی. آپ کی شناختی معلومات بھی خفیہ رکھی جائے گی. آپ کو گردن کے پس منظر کے نقطہ نظر کے ایکس رے کرنے کے لئے کہا جائے گا. کسی بھی سوال کے معاملے میں آپ مندرجہ بالا ایڈریس پر رابطہ کرسکتے ہیں. شرکت کرنے کیلئے آپ کو کم سے کم 25 سال کی عمر کا ہونا ضروری ہے.

پیچیدگیاں: اس مطالعہ کی کوئی معروف پیچیدگیاں نہیں ہیں۔

منفی اثرات :اس مطالعہ کے لئے کوئی معروف خطرہ نہیں ہے. ایکس رے کے خراب اثرات کم ہیں۔ ایکس رے کی وجہ سے مفاہمت پیدا ہوسکتی ہے اور یہ کینسر کی قیادت کرسکتا ہے لیکن اس کے امکانات بہت کم ہیں. ایکس رے کے فوائد منفی نتائج سے کہیں زیادہ ہیں۔ مطالعہ سے بیماری کی تشخیص میں مدد ملے گی جس میں گردن کی لمبائی، آبادیاتی عوامل اور تابکاری سے تبدیلیاں شامل ہیں۔

رضامندی: مجھے اس منصوبے میں حصہ لینے کی اہمیت کے بارے میں تفصیل سے بیان کیا گیا ہے۔ اور میں فراہم شدہ وضاحت سمجھتا / سمجھتی ہوں. مجھے بتایا گیا ہے کہ میری بیماری کے نتائج اور میرے اعداد و شمار کو سختی سے خفیہ رکھا جائے گا اور صرف کمیونٹی، اشاعت اور کاغذ کے پیشکشوں کے فائدہ کے لئے استعمال کیا جائے گا.

میں اس سے بھی اتفاق کرتا ہوں کہ تمام متعلقہ ضروری معلومات جو بہتر طور سے میرے علم میں ہے محققین کو دوں گا۔ یہ مجھے واضح ہے کہ محققین کی طرف سے لیب کی تحقیقات کی لاگت کے علاوہ اس مطالعہ میں حصہ لینے کے لئے مجھے کوئی بھی حوصلہ افزائی نہیں کی جائے گی. جبکہ مجھے کسی بھی وقت مطالعہ سے نکلنے کا حق ہے.

مجھے مشورہ دیا گیا ہے کہ ڈاکٹر سیدہ بشریٰ احمد سے موبائل نمبر: 03323282181 پریا بحریہ یونیورسٹی میڈیکل اور ڈینٹل کالج سے میری بیماری سے متعلق کسی بھی سوال کے معاملے میں رابطہ کروں

مریض کا نام: ____

مریض کے دستخط / انگوٹھے کا تاثر: ____________________________________

محقق کا نام: ____

محقق کا دستخط: ____

تاریخ: ____

(D) Subject Evaluation Form

SUBJECT EVALUATION FORM

Date: ______________

Patient Id: ________________________________ Ethnicity: ___________________________

Age: _____________________________________Gender: ____________________________

Height: ___________________ Weight: ___________________ BMI: _________________

Neck length: ____________________________ Relative Neck length: _________________

Occupation:

Home maker	YES	☐	NO	☐
Outdoor worker	YES	☐	NO	☐
Manual laborer	YES	☐	NO	☐
Head load carrier	YES	☐	NO	☐
Student	YES	☐	NO	☐

Presenting complaint: ____

Duration of the symptoms: ____

Past Medical History: ____

History of cervical trauma: YES ☐ NO ☐

Social History:

Smoking: YES ☐ NO ☐

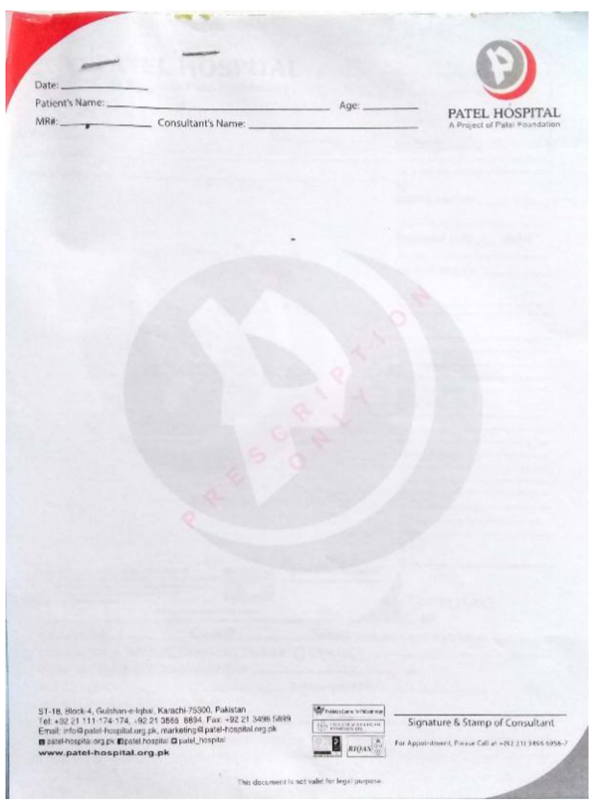
Radiographic changes observed:

osteophyte formation:	YES	☐	NO	☐
intervertebral disc height narrowing:	YES	☐	NO	☐
vertebral end-plate sclerosis:	YES	☐	NO	☐

Grade according to Kellgren Lawrence grading scale: _____________________________

Daily working hours:	< 8 hours	☐	8 hours	☐	>8 hours	☐
Duration of computer use:	no use	☐	<4 hours	☐	>4 hours	☐
Duration of mobile use:	no use	☐	<4 hours	☐	> 4 hours	☐

(E) Hospital Card



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