Chapter 1
Introduction
Introduction

1.1. BACKGROUND

Neck pain is a significant contributor to worldwide disability and poses a considerable financial burden to its stakeholders. The prognosis for chronic neck pain is generally poor, and the associated disability seems to be more persistent than low back pain (William et al., 2010). Mechanical neck pain as reported by Côté et al. (2004) is a disabling condition with a course marked by periods of remission and exacerbation. Fejer et al. (2006) and Guez et al. (2002) reported that neck pain is more common in women and its prevalence gradually increases with age. They also stated that certain cervical movements like turning and bending results in unbearable pain, along with crunching sounds and a feel of neck stiffness. Along with neck pain, other disabling features of neck disorders are decrease in range of motion (Armstrong et al., 2005; and Dall’Alba et al., 2001) and altered position sense (Rix and Bagust, 2001).

1.2. PREVALENCE

Neck pain is a common musculoskeletal disorder, with a reported life-time prevalence of 22% to 67% (Walker et al., 2008). Côté et al. (2000) reported that in comparison to low back pain, neck pain has been poorly researched. Cleland et al. (2005) also cited that the prevalence of neck pain varies widely between studies, with a mean point prevalence of 7.6 % (range 5.9- 38.7%) and mean life-time prevalence of 48.5% (range 14.2-71.0%). In a population-based study by Evans et al. (2002), in Canada and Finland, 70% of adults had suffered from neck pain at some stage of their life. They also concluded that 5-10% of such population complained of severe disability and around 14% developed chronic pain. Fejer et al. (2006) reported that neck pain was more common in Scandinavian population as compared to the Europeans and Asians. Côté et al. (2004) reported that each year 0.6% of the population developed disabling neck pain. Furthermore, they also reported that 22.8% of those with prevalent neck pain report episodes of recurrence. A three months epidemiological study by Strine and Hootman (2007) reported that 31% of the population suffered from neck pain in the US.
Furthermore, Côté et al. (2000) stated that neck pain was highly prevalent in the Saskatchewan adult population with 66% of adults having experienced neck pain during their life-time and 54% having experienced it in the previous 6 months. They also documented that, Europeans showed equal prevalence of neck pain and low back pain and it was a common source of disability in the working-age population. However, no significant studies have documented the prevalence of neck pain and its related disability in American population. Côté et al. (2000) and Webb et al. (2003) reported prevalence of neck and back pain in population of UK. They cited that age, female gender (neck pain only), high body mass index, living in an area of raised material deprivation, and south Asian ethnicity were significant predictors of spinal pain with disability.

1.3. ETIOLOGY

Little is known about the etiology of neck pain and its related disability. Because most neck pain has no specific, identifiable cause, it is diagnosed as mechanical neck pain (Bogduk, 1984). Croft et al. (2001) reported that a history of previous neck injury at baseline was a significant risk factor for neck pain. Other independent baseline risk factors stated by them include poor self-assessed health, poor psychological status and a past history of low back pain. Furthermore, Webb et al. (2003) in a population-based study in UK concluded that age, female gender, high body mass index and south Asian ethnicity were significant predictors of both neck & back pain with disability. Côté et al. (2000) reported that neck pain might be associated with lower socio-economic status and with occupational factors, such as repetitive or static work tasks, awkward occupational postures, heavy lifting or physically demanding work. Neck disorders are a significant source of pain and limit activity in workers.

Several studies have reported a strong association between neck pain and the specific occupational activities like computer users (Korhan and Mackieh, 2010; Korhonen et al., 2003; and Smith et al., 2009), office workers (Cagnie et al., 2007; Hogg-Johnston et al., 2010; and Hush et al., 2006), dentists (Hayes et al., 2009), and sand core making workers (Gangopadhyay et al., 2010). Employees in occupations that require repetitive use of the upper extremities such as machine operators, carpenters, and
office workers are more likely to have neck complaints (Tola et al., 1988). Workplace physical exposures like sedentary work position, repetitive work, precision work, awkward work postures, physical work environment, and computer workstation set-up and psycho-social exposures like quantitative job demands and social support at work are the risk factors for neck pain in workers (Côté et al., 2008; Frank et al., 2005; Geertje et al., 2001; Ostergren et al., 2005; and Palmer et al., 2001). However, the effects of such factors have been small and non-specific; a single one of these exposures was unlikely to cause neck pain on its own. Neck pain has a multifactorial etiology and its development is dependent on the presence of more than one risk factor (Côté et al., 2008; and Haldeman et al., 2010).

Hogg-Johnson et al. (2008) classified the risk factors associated with neck pain as non-modifiable (gender, history of neck pain, and genetics) and modifiable (smoking, exposure to tobacco, physical activity, and psychological health) risk factors.

They performed a systematic search and critical review of literature published between 1980 and 2006, and assembled the best evidence on neck pain to know its determinants and burden of neck pain in general population. He summarized that

- Neck pain was common in the adult general population, with typical 12-month prevalence estimates from 30% to 50%.
- Among children and adolescents, 12-month prevalence estimates range from 21% to 42%.
- Neck pain that limits activities was less common, with 12-month prevalence estimates ranging from 2% to 11%.
- There was no evidence to support the assumption that degenerative disc changes are a risk factor for neck pain without radiculopathy.
- Poor psychological health was a risk factor for neck pain and is often associated with it.

Several studies have reported that anxiety and depression are risk factors of neck pain (Côté et al., 2008; Hogg-Johnson et al., 2008; and Young et al., 2009). Also, there are few studies reporting that neck pain leads to anxiety (Carroll et al., 2009; Main and Watson, 1999; Narita et al., 2006; Poleshuck et al., 2009; Reichborn-Kjennerud et al.,
Thus, along with pain and range of motion, anxiety is also taken as an outcome measure in this study.

Although, disability associated with neck pain varies from less to highly severe (Côté et al., 1998) yet its incidence in the general population is very common (Ahn et al., 2007; Ghaffari et al., 2006; Guez et al., 2002; Hakala et al., 2002; Haldeman et al., 2010; Hogg-Johnson et al., 2008; Hoving et al., 2002; Mäkelä et al., 1991; and Nygren et al., 1995) and results in a considerable economic burden (Bot et al., 2005; Cassidy and Côté, 2008; Cleland et al., 2005; and Naheed et al., 2006). MaCaulay et al. (2007) reported that neck pain has personal (pain and stiffness), social (disability) and health system costs. A significant proportion of health care cost has been associated with neck pain, which includes visits to health care providers, sick leave, and the related loss of productive capacity (Borghouts et al., 1999; Ingeborg et al., 2003; and Lidgren, 2008). Hence, personal sufferings and lost work productivity have been some of the reasons that require effective management of this condition.

1.4. RELEVANT CLINICAL ANATOMY

A large number of conservative treatment options are reported in the literature for treating mechanical neck pain. There has been a mixed response available regarding their efficacy. Therapies involving manual therapy and exercise were more effective than alternative strategies for patients with neck pain (Hurwitz et al., 2009). Increasing inclination towards manual therapy was seen in a U.S. survey in which 54% of total patients sought treatment from manual therapist (Wolsko et al., 2003). Several studies also have confirmed that immediate changes do occur following manual therapy of the cervical spine (Cassidy et al., 1992a, 1992b & Whittingham and Nilsson, 2001). Mulligan’s approach is frequently used in clinical practice for reducing pain and improving functional abilities of neck pain sufferers (Vicenzino et al., 2007). The concept has its foundation built on Kaltenborn’s principles (Kaltenborn et al., 1999) of restoring the accessory component of physiological joint movement. Passive oscillatory movements called NAGs and sustained glides with active movements are the mainstay of Mulligan’s spinal treatment concept (Mulligan, 1999). NAGs are predominantly useful in restoring painful loss of active cervical
motion (Wilson, 2001). Moreover, NAGs are much less likely to provoke latent pain than other spinal techniques. Hoving et al. (2002) reported in a high quality randomized clinical trial that manual therapy consisting of mobilization performed by a physiotherapist was more effective in improving outcomes and more cost effective (Korthals et al., 2003), than a physical therapy intervention that did not incorporate a manual therapy approach.

In order to appreciate the magnitude of morbidity attributable to cervical spine injuries and degenerative changes, it would be necessary to understand the anatomy and pathophysiology of cervical spine. In case of cervical spine, relatively little morbid and microscopic anatomy has been done in comparison with lumbar spine, presumably due to difficulty in obtaining whole specimens of human cervical spines for evaluation (Giles and Singer, 2002). The portion of spine encompassing neck region forms cervical spine. The cervical spine is specialized for mobility. While holding the head up, it also directs gaze up to 180 degree in horizontal plane and 120 degree in vertical plane (Huelke and Nusholz, 1986). Handicap posed by neck stiffness as in cases of anklyosing spondylitis illustrates the need of rapid and wide movement ranges (e.g., driving a car). The unique first two vertebrae and their synovial joints provide more than half of axial rotation and 1/3 of flexion-extension. Remainder of spine is more slender and mobile than its lumbar counterparts (Penning and Wilmink, 1987). Collectively, cervical joint provide 90 degree sagittal range and it has much wider axial rotation, which is restricted in lumbar spine (Taylor and Twomey, 1980; and White and Panjabi, 1990) that can be advocated through differences in facet shape and orientation with addition of uncinate process on cervical vertebrae.

The cervical spine is made up of the first seven vertebrae in the spine, which are named as C1 to C7. Anatomically, a cervical spine starts where the top vertebra (C1) connects to the bottom of the skull and it ends when C7 joins with first thoracic vertebra (T1). The cervical spine has a backward "C" shape (lordotic curve with convexity on anterior aspect) and is much more mobile than either of the thoracic or lumbar regions of the spine. Neural foramina of cervical spine allows for exit of cervical spinal nerves, which are eight in number and are named as C1 to C8. Cervical
spine, besides providing protection to the spinal cord, supports the head and allows for a significant amount of range of motion (Bogduk and Mercer, 2000; and Panjabi et al., 1993). While carrying the thickest spinal cord part in spinal canal and blood vessels of brain through transverse process neck injury can be fatal, still injury to these arteries remains rare complication of manipulation of cervical spine (Fast et al., 1987); however, this may reduce further in case of mobilization.

Taylor and Twomey (2002) studied the cervical spine in two parts, the Occipito-atlanto-axial joint complex and the sub-axial spine. Occipito-atlanto-axial joint complex also called craniovertebral junction forms the upper cervical spine, and consists of occiput, C1 (atlas) and C2 (axis), (Todd, 2001). Taylor (2002) also found that these joints are well preserved in older subjects in contrast to age changes in sub-axial joints.

Cervical vertebrae have the smallest body and largest foramina and it is shaped like a seat with uncinate process as side supports. The facets are flat and form synovial zygapophyseal joints. These lateral articular bilateral columns bear significant proposition of axial loading (Pal and Sherk, 1988).
Figure 1.2: Typical Cervical Vertebrae.
Source: Taken from power-point presentation of Professor J. R. Taylor with permission via email, dated October 19, 2010

The transverse and anterior-posterior diameters increase from C2-C7 with a significant increase in both diameters in the upper end plate of C7 (Panjabi et al., 1991c). The lateral margins of the upper surfaces of the cervical vertebral bodies from C3-C7 support uncinate processes that give the upper surfaces of these vertebrae a saddle shaped form (Bland and Boushey, 1990; and Levangie and Norkin, 2005). In the typical cervical spine, the spinous processes are bifid and projected more horizontally. Development of nucleus pulposus, uncinate process and formation of uncovertebral joints, disc fissuring and facet orientation are some of the special features of lower cervical spine.

Between each vertebra in the cervical spine are discs, which act as cushions or shock absorbers and also permit some movement between the vertebral bodies. They are made up of a strong outer ring of fibres called the annulus fibrosis, and a soft centre called the nucleus pulposus. The outer layer (annulus) helps keep the disc's inner layer intact. The annulus is made up of very strong fibres that connect each vertebra together. The nucleus of the disc has a very high water content making it very moist. Amount of proteoglycan and water respond to extent of load bearing as weight bearing is lesser in cervical spine; the lumbar spine is assigned with bearing loads (Scott et al., 1994). It has relatively brief existence up to young adulthood but with
passage of time soft matter may become masked in plentiful collagen meshwork. Cervical disc material is likely to travel backward into spinal canal than to slip laterally into intervertebral canals. However, in middle aged or elderly spines, a bar like posterior ridge is evident as a protrusion mostly usual for already fissured cervical annulus.

Ageing in cervical discs: 1) uncus formation in childhood; 2) unco-vertebral cleft formation at puberty; 3) spread of transverse fissures through disc in early adult life.

It occurs due to effect of shearing forces in medial extension of horizontal fissures into nucleus and posterior annulus. It is more evident as transverse fissures in the posterior part of disc between two uncovertebral joints by the age of late thirties. Only anterior annuluses with anterior ligaments are left untouched (Taylor and Twomey, 2000; and Taylor and Taylor, 1996). This in turn converts the disc into a bipartite disc, which permits several millimeter of translation both forward and backward during neck movements. Cervical motion segments, for their stability are now highly dependent on posterior ligaments and muscles and the integrity of zygapophyseal joints. Further loading of uncovertebral joints, loss of nucleus material and disc collapse lead to lateral osteophytosis into the intervertebral canal compressing the anterior part of cord (Bohlman and Emory, 1988; and Clark, 1988). Taylor (1996) reported that in other spinal regions, age related fissuring generally occurs in middle
life or in old age. In the cervical spine age related clefts in the discs begin as uncovertbral (UV) clefts at puberty and extensive transverse fissuring across the posterior disc follows in early adult life. This early change results from the shearing forces produced in the discs by the typical wide range cervical movements, which include both rotation and translation in each segment. The fissuring begins in the UV clefts, which is the thinnest part of the disc.

The extent of disc fissuring is variable as seen in coronal sections of discs from adults of 30–40 years

**Figure 1.4: Showing Disc Fissuring in an Adult Disc.**
**Source:** Taken from power-point presentation of Professor J. R. Taylor with permission via email, dated October 19, 2010

In addition to the intervertebral discs, special joints between each of the vertebral bodies, called facet joints, allow the individual bones of the spine to move and rotate with respect to each other. The facets connect the bony arches of each of the vertebral bodies. There are two facet joints between each pair of vertebrae, one on each side. Facet joints connect each vertebra with the next vertebra above and below. These joints are important because they can be a source of pain if they become arthritic (Panjabi et al., 1991a). Vascular, fat-filled synovial folds projects between articular surface as meniscoid inclusion, and are prone to bruising or rupture in injuries forming joint hemarthroses (Taylor and Taylor, 1996). Facet orientation and uncovertbral joint contribute to shearing and posterior fissuring in adult discs, which is seen as price paid in reducing stability for cervical mobility.
Facet Joints: Sagittal Sections from 35 year male;

Figure 1.5: Facet Joint Shown in a Sagittal View.
Source: Taken from power-point presentation of Professor J. R. Taylor with permission via email, dated October 19, 2010

The cervical spine is designed for a relatively large amount of mobility. The neck moves around 600 times every hour whether we are awake or asleep (Bland and Boushey, 1990). The main movements of the neck are flexion, extension, lateral flexion and rotation. These movements are accompanied by translations that increase in magnitude from C_2-C_7. The atlanto-occipital joint permits primarily a nodding motion of the head, i.e., flexion-extension in the sagittal plane around a coronal axis (Basmajian, 1976). The combined range of motion for flexion-extension reportedly ranges from 10-30 degrees. The movements at the atlantoaxial joint include rotation, lateral flexion, flexion and extension. Approximately, 55 to 58% of the total rotation of the cervical region occurs at the atlantoaxial joint (Dumas _et al_. 1993). The atlas pivots about 45 degrees to either side, summing up of 90 degrees of total rotation. Lateral flexion and rotation movements are coupled below the level of C_2 due to the configuration of the zygoapophyseal articulating facets. The shape of the zygoapophyseal joints and the inter-body joints dictates the motion at the lower cervical segments. Pure anterior translation does not occur, because it would cause the zygoapophyseal joints to abut one another. Flexion of these segments must include anterior tilt of the cranial vertebral body coupled with anterior translation. Given the 45 degree slope, tilt of the vertebral body, in addition to anterior translation, is necessary to get full motion from these joints (Figure 1.6).
Extension includes posterior tilt of the cranial vertebral body, coupled with posterior translation (Levangie and Norkin, 2005). Lateral bending is a combination of upward movement on one side and downward movement on the other side. Thus, lateral bending to the right is coupled with rotation to the right and vice versa (Panjabi et al., 1991b).

The articulating surfaces of the inferior and superior intervertebral joints resemble a saddle joint, maintaining anterior, posterior, medially and laterally directed concavities (Penning and Wilmink, 1986). This orientation of the cervical bodies of the mid to lower cervical column allows for rotation and flexion movements but is resistant to lateral flexion. Lateral flexion is possible as a combined movement in the cervical column but only due to coupled rotational movement in each segment to that side (Penning and Wilmink, 1986). Lateral flexion is coupled with ipsilateral rotation, and rotation is coupled with ipsilateral lateral flexion. These motions also involve a combination of vertebral tilt to the ipsilateral side and translations at the zygoapophyseal joints (Bogduk and Mercer, 2000; and Panjabi et al., 2001).

Lower cervical segments generally favour flexion and extension ROM; however, there is great variability in reported ranges of motion in the individual cervical segments. In general, the range for flexion and extension increases from the C₂/C₃ segment to the C₅/C₆ segment, and decreases again at the C₆/C₇ segment (Oatis, 2004; Marina et al., 2010; and Van Mameren et al., 1990 & 1992).
Table 1.1: Segmental Range of Motion of the Cervical Spine in Young Adults.  
(Adapted from Penning, 1977)

<table>
<thead>
<tr>
<th>Vertebral Joint</th>
<th>Flexion-Extension</th>
<th>Side Flexion Left / Right</th>
<th>Rotation Left / Right</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Range</td>
<td></td>
</tr>
<tr>
<td>C0-C1</td>
<td>30</td>
<td>25-45</td>
<td>10</td>
</tr>
<tr>
<td>C1-C2</td>
<td>30</td>
<td>25-45</td>
<td>10</td>
</tr>
<tr>
<td>C2-C3</td>
<td>12</td>
<td>5-16</td>
<td>70</td>
</tr>
<tr>
<td>C3-C4</td>
<td>18</td>
<td>13-26</td>
<td></td>
</tr>
<tr>
<td>C4-C5</td>
<td>20</td>
<td>15-29</td>
<td>70</td>
</tr>
<tr>
<td>C5-C6</td>
<td>20</td>
<td>16-29</td>
<td></td>
</tr>
<tr>
<td>C6-C7</td>
<td>15</td>
<td>6-25</td>
<td></td>
</tr>
</tbody>
</table>

Table 1.2: Total ROM at Cervical Spine by Different Methods of Measuring.  
(Adapted from Reese and Bandy, 2002)

<table>
<thead>
<tr>
<th>Motion</th>
<th>Tape measure*</th>
<th>Goniometer^</th>
<th>Inclinometer#</th>
<th>CROM+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>1-4cm</td>
<td>45°</td>
<td>50°</td>
<td>50°</td>
</tr>
<tr>
<td>Extension</td>
<td>20cm</td>
<td>45°</td>
<td>60°</td>
<td>75°</td>
</tr>
<tr>
<td>Lateral flexion</td>
<td>15cm</td>
<td>45°</td>
<td>45°</td>
<td>45°</td>
</tr>
<tr>
<td>Rotation</td>
<td>10cm</td>
<td>-</td>
<td>80°</td>
<td>70°</td>
</tr>
</tbody>
</table>

* Derived from data by Balogun et al. (1989); and Hseih and Yeung (1986)
^ Provided by the American Medical Association. AMA Guides 2nd edition (1987)
+ Derived from means of male and female data from 20-40 age years according to Youdas et al. (1992)
The zygoapophyseal joint capsules and the ligaments, in addition to the shape of the joints, dictate motions at all of the cervical segments. The zygoapophyseal joint capsules are generally lax in the cervical region, which contributes to the large amount of motion available here. The height in relation to the diameter of the disks also plays an important role in determining the amount of motion available in the cervical spine. The height is large in comparison to the anteroposterior and transverse diameters of the cervical disks. Therefore, a large amount of flexion, extension, and lateral flexion may occur at each segment, especially in young persons, when there is a large amount of water in the disks (Levangie and Norkin, 2005).

1.5. PATHOPHYSIOLOGY OF MECHANICAL NECK PAIN

Bogduk (2003) and Whitten et al. (2005) classified neck pain as nociceptive, neuropathic or idiopathic in origin, out of which nociceptive pain appears most often. Further, Spitzer et al. (1987) suggested that the pain is often of nociceptive origin in the acute phase, but when it progresses towards the chronic phase, the influence of psychological and social factors become more marked. Along with neck pain, other disabling features of neck disorders are decrease in range of motion (Armstrong et al., 2005; and Dall’Alba et al., 2001), and altered position sense (Rix and Bagust, 2001).
According to Côté et al. (2000), main causes of mechanical neck pain include minor injuries or sprains to muscles and ligaments in the neck and malalignment of facet joints. So many studies into the common complaint of chronic neck pain have focused on its anatomical origin, identifying especially the cervical zygoapophyseal joints (Bogduk et al., 1988; Rachel and Cohen, 1998; and Yin and Bogduk, 2006) as the main cause of mechanical neck pain. However, the pathophysiology of chronic neck pain remains poorly understood. They also reported that psycho-social factors are also related with neck pain. Moreover, they also reported that it is associated with lower socio-economic status and with occupational factors such as repetitive or static work tasks, awkward occupational postures, heavy lifting, or physically demanding work.

In a recent research by Yip et al. (2008) to evaluate the relationship between head posture and neck pain, they concluded that craniovertebral (CV) angle in subjects with neck pain is significantly smaller than that in normal subjects. Smaller the CV angle more is the forward head posture leading to more disability. In another study to diagnose the relation between cervical lordosis and neck complaints, McAviney et al. (2005) found that lordosis of less than 20° leads to cervical pain. Work related complaints in neck pain are commonly attributed to excessive loading of the shoulder muscles (Winkel and Westgard, 1992). Poor motor control of postural muscles or previous injury to neck or shoulder might also cause work related neck pain (Edwards, 1988).

Bogduk (2003) and Cailliet (1996) suggested that isometric muscle contraction creates intra muscular pressure, which might lead to tear of muscle fibers contributing to neck pain in the adolescents. They also suggested that inadequate arterial circulation leads to inadequate oxygen supply, which is followed by accumulation of lactic acid and CO\textsubscript{2} activating nociceptors. Local decreases of pH and pO\textsubscript{2}, k+ leakage from inflamed cells and substance P have also been reported as the factors that may modulate the excitability of nociceptors in muscle pain (Lundeberg, 1995).

Hagberg (1984 & 1987) suggested that possible pathophysiological routes for muscle pain related to physical load are:

1. Mechanical Failure: It leads to muscle pain 24-48 hours after heavy physical exertion.
2. Local Ischemia: It is caused by repeated muscle injuries or static muscle contraction. It causes accumulation of muscles metabolites, which cause pain.

3. Disturbances of Energy Metabolism: It results in muscular pain when intramuscular demands for energy exceed the production.

Outcome studies have shown that usually neck pain is not a self-limiting condition; it can be a long-term problem (Côté et al., 2000; Gross et al., 2002; and Evans et al., 2002). In acute cases, prognosis is good. But in chronic and/or persistent cases, the patient develops the tendency to wax and wane with flare ups from time to time (Gross et al., 2002).

Cervical spondylosis is the most common progressive disorder in the ageing cervical spine (Hoff and Wilson, 1977; Irvine et al., 1965; and Rao et al., 2008). It results from the process of degeneration of the intervertebral discs and facet joints of the cervical spine.

Biomechanically, the disc and the facets are the connecting structures between the vertebrae for the transmission of external forces. They also smoothen the progress of cervical spine mobility. Thus, its degeneration impairs the cervical spine function, mobility and cause pain (Shedid and Edward, 2007).

Bogduk et al. (1988) in their experimental study, found a strong connection between the facet joints and mechanical neck pain as anesthesia applied to them completely eliminates the pain. The other conditions, which are commonly incriminated for neck pain, are degenerative disc disease with or without disc herniation and degenerative arthritis of zygoapophyseal joints (Côté et al., 2000). Specific conditions that are not well understood are post-traumatic neck pain syndrome, commonly known as whiplash injuries and pain, following repetitive activities in an occupational setting (Côté et al., 2000; and Gore, 1998). They also reported that psycho-social factors are also related with neck pain.

There may be abnormal growths or "spurs" on the bones of the spine (vertebrae). These may compress the nerve roots or in severe cases spinal cord causing neurological symptoms (McCormack and Weinstein, 1996; and Parke 1988).
Neck pain should never be confused with cervical radicular pain. Neck pain is perceived in the neck, and its causes, mechanisms, investigation, and treatment are different from those of cervical radicular pain. Reciprocally, cervical radicular pain is perceived in the upper limb, and its causes, mechanisms, investigation, and treatment are different from those of neck pain (Bogduk, 2003).

1.6. CONVENTIONAL PHYSIOTHERAPY OPTIONS FOR MECHANICAL NECK PAIN

Manual therapies are commonly used in the treatment of sub-acute and chronic neck pain (Groeneweg et al., 2010; Koes et al., 1991; and Michael et al., 2008) and there are numerous systematic reviews of the treatment of neck pain by manual therapy (Bergmann, 1995; Bronfort et al., 2004; Gross et al., 2004, 2005 and 2007; and Hooper 2004). Spinal mobilization may be described as a non-thrust form of manipulation directed at joint dysfunction (Gross et al., 1996; and Hurwitz et al., 1996).

A large number of conservative treatment options are reported in the literature for the mechanical neck pain. There has been a mixed response available regarding their efficacy. However, none of the studies mentions about their long-term effectiveness in the neck pain. Aker et al. (1996) did a systematic review of the conservative management of mechanical neck pain. They concluded that there is little information available from clinical trials to support many of the treatments for mechanical neck pain.

In another randomized clinical trial, Chiu et al. (2005) investigated the efficacy of TENS and exercise for patients with chronic neck pain. After the six weeks of treatment, patients in the exercise group had a better and clinically relevant improvement in disability, isometric neck muscle strength and pain. All the improvements in the intervention groups were maintained at the six-month follow-up.

In a randomized controlled trial, Irnich et al. (2001) compared the efficacy of acupuncture and massage in chronic neck pain and concluded that acupuncture is an effective short-term treatment for patients with chronic neck pain, but there is only
limited evidence for long-term effects after five treatments. Furthermore, in another similar study, Vickers (2001) reported that the efficacy of acupuncture is superior to massage due to its placebo effect.

Gross et al. (2007) in their systematic review stated that there is little support for the use of electromagnetic therapy and against the use of Low-level laser therapy (LLLT) with respect to pain reduction. LLLT is widely used in the treatment of musculoskeletal conditions. However, there is controversy over its true efficacy. Özdemir et al. (2001) compared the analgesic efficacy of low-power laser with placebo laser in neck pain patients and reported improvement in paravertebral muscle spasm, loss of lordosis and neck ROM in the low-power laser group. Functional activities were also improved. Further in a systematic review, Gross et al. (2007) also stated that the low-level laser therapy is effective for neck pain. However, Chow et al. (2009) & Gross et al. (2007) suggested that further research is required to confirm the efficacy of laser in the treatment of neck pain.

Regarding the efficacy of cervical traction in neck pain, Swezey et al. (1999) reported that traction in both supine and sitting position is effective in treating neck pain. Graham et al. (2006) also suggested the use of intermittent traction for mechanical neck disorders. However, Kjellman et al. (1999) & Lucas et al. (2001) reported that traction and acupuncture had either no effect or negative outcome on neck pain.

A few studies also compared the manual therapy with physical modalities and found that in comparison to electrotherapy, exercises are much more effective in treating neck pain. Kjellman et al. (1999) & Lucas et al. (2001) in their randomized clinical trials investigated the efficacy of physiotherapy treatment techniques in neck pain patients. They reported positive outcomes for electromagnetic therapy, manipulation and active physiotherapy. Taimela et al. (2000) in their randomized study divided the subjects with non-specific chronic neck pain in three groups. They concluded that the multimodal treatment in the active group was more efficacious than activated home exercises that were further more efficacious than just advising in the control group. They suggested that multimodal treatment including postural exercises; relaxation and
Introduction

psycho-social behavioural support result in earlier return to work and better emotional response.

Hurwitz et al. (1996) performed a structured search of four computerized bibliographic databases to identify articles on the efficacy and complications of cervical spine manual therapy. Two of the three RCTs showed a short-term benefit for cervical mobilization in patients with acute neck pain. The authors concluded that cervical manipulative therapy and mobilization probably provide at least some short-term benefits for some patients with neck pain and headaches. The study carried out by Mc Kinney et al. (1989) found that groups treated with mobilization and exercises had greater improvement in range of motion and pain. Stronger evidence suggests a multi-modal management strategy using mobilization or manipulation plus exercise is beneficial for relief of mechanical neck pain (Gross et al., 2002).

In general, conservative interventions have not been studied in enough detail to assess efficacy in mechanical neck pain adequately.

1.7. MULLIGAN CONCEPT

Brian Mulligan, New Zealand, developed mulligan concept in 1960. Exelby (2002) documented that the Mulligan concept is an integral component of many manual physiotherapists’ clinical practices around the world. These techniques are widely used for joint dysfunction by growing number of therapists and are an important addition to the field of Manual Therapy. It aims towards the restoration of normal biomechanics of the motion segment and is based on the positional fault theory (Exelby, 2002). Mulligan (2004) proposed that positional faults of articular surfaces might arise either from prolonged micro traumas or by a macro trauma at an instant. In support to this, Lewit (1985) also stated that this mechanical block caused by the inert structures within a joint could also lead to reduce joint mobility. All the treatment techniques are directed towards correcting this fault. Mulligan (1999) suggested that technique restores the normal movement option to the joint, which may have both mechanical and neurological components. According to him whatever be the mechanism, the clinical result of the approach can be quite gratifying.
Unbeaten applicability of Mulligan techniques depends on certain specific guiding principles, like passive accessory glides should never reproduce pain/symptoms. No joint compression should be there. Essentially, all the glides should be along the treatment plane. This necessitates the Mulligan practitioner to be well familiar with joint anatomy more precisely direction of all spinal joints. Another imperative fact is that all the spinal mobilizations and Mobilisation with Movements (MWMs) are done in weight bearing. Mulligan (2004) says that in non-weight bearing technique, improvements gained are lost when the patient resumes an erect posture.

The clinical acceptance (convention) of the cervical NAGs is evinced by the fact that it formed an integral component of approximately 200 continuing education courses in three continents in 1998 (Claassen 1999), in addition to its description in an increasing number of clinical texts (Grieve, 1991; Boyling and Palastanga, 1994; Petty and Moore, 1998). Nevertheless, literature on efficacy of the Mulligan’s techniques is lacking and mainly dominated by descriptive or case report publications (Exelby, 1995, 1996 & 2001; Hetherington, 1996; Lincoln, 2000; Miller, 2000; O’Brien and Vicenzino, 1998; Vicenzino and Wright, 1995; and Wilson 1994, 1997 & 2001). Recently, however, research measuring the neurophysiological or mechanical effects has been conducted (Abbott et al., 2001a, Hall et al., 2000; Kavanagh, 1999; and Vicenzino et al., 2000).

Folk (2001) concluded that the Mulligan concept uses abolition of pain to identify dysfunctional structure and determine the appropriate therapeutic accessory movements. According to him, the abolition of pain tells the therapist that the dysfunction has been reduced making it clear that the appropriate technique is being used. Sustaining the joint repositioning can also be reinforced with the use of tape, for a couple of days to enhance the mobilization with movement therapy (Mulligan 1993, 1996).

Mechanical neck pain is usually associated with zygoapophyseal joint maltracking and Mulligan (1999) suggested various treatment options including: Mobilization with movement (MWM), Natural Apophyseal Glides (NAGs) and Sustained Natural
Apophyseal Glides (SNAGs). However, passive oscillatory movements called NAGs and sustained glides with active movements are the mainstay of Mulligan’s spinal treatment concept (Mulligan, 1999).

**Natural Apophyseal Glides (NAGs)**

NAGs being the mainstay of this concept will be used to treat subjects in experimental groups. NAGs are oscillatory accessory movements in Anteriocranial direction, gliding one spinal facet upon its neighbor, and are performed passively on a patient (Exelby, 1995). Wilson (2001) in his study mentioned that depending upon the patient's presentation; NAGs are carried out in mid to end range; and are used to treat movement problems originating from C₂-T₃. He further added that it could be applied centrally or unilaterally with the patient's cervical spine in neutral or positioned in the direction of movement limitation. Direction of the glide is upwards and forwards, towards the patient’s eyes. However, the anatomical configuration of the upper 2 joints of the cervical spine (C₀, C₁ and C₂) necessitates a glide in more horizontal plane (Exelby, 1995). They are performed with the patient seated.

![Figure 1.8: Position of Therapist and Patient while Delivering NAGs.](image-url)
Figure 1.8 describes the position of both the patient and therapist while performing NAGs. The patient is seated erect on armless stool or chair, and the therapist is in walk standing position. One hand cradles the head of patient for stabilization and little finger of same hand is placed on spinous process while other hand performs the glide.

![Position of Therapist and Hand Placement while Delivering NAGs.](image)

Figure 1.9: Position of Therapist and Hand Placement while Delivering NAGs.

The Figure 1.9 presents a closer view showing the precise hand positioning. Little finger of the hand stabilizing the head is kept on desired spinous process and other hand’s radial border of thumb applies the force in required direction. Note that therapist is using his trunk (with pillow) to stabilize the shoulder and avoid thoracic rotation.

In his descriptive study, Wilson (2001) explained that NAGs are predominantly useful in restoring painful loss of active cervical motion. Moreover, NAGS are much less likely to provoke latent pain than other spinal techniques, so NAGs are the treatment of choice for irritable patients and also if multiple joints of the cervical spine are implicated then NAGs are preferable (Wilson, 2001). Mulligan (2004, 2010) also reported that adding a small degree of traction is often very beneficial in painful condition. He stated that some palpation or pressure pain is accepted, but technique should not reproduce any symptom that the patient was complaining of. Indeed, these symptoms should be eliminated. The technique was abandoned as unsuitable if symptoms recur and if provoked immediately, reverse NAGs should be tried (Mulligan, 1999).
Figure 1.10: Position of Therapist and Hand Placement while doing NAGs on Spine Model.

Placement of hands on spine model is illustrated in Figure 1.10 (b), which shows that finger is on inferior aspect of spinous process, while Figure 1.10 (c) depicts the area of thumb that comes in contact with little finger. Note the alignment of forearm in Figure 1.10 (a). It enables to force the glide in cranio-ventral direction.

1.8. SIGNIFICANCE OF THE STUDY

It is reported by Côté et al. (2000) that neck problems are very disabling, painful and costly. William et al. (2010) stated that neck pain is a significant contributor to worldwide disability and poses a considerable financial burden to its stakeholders. The prognosis for chronic neck pain is generally poor, and the associated disability seems to be more persistent than low back pain. As per Borghouts et al. (1999), the prevalence of neck pain in the general population ranges from 10 to 15%. The complaints can result in substantial medical consumption, absenteeism from work and disability. Further, they investigated the costs of neck pain in the Netherlands in 1996 to assess the financial burden to society. The total cost of neck pain in The Netherlands in 1996 was estimated to be US $686 million. The share of these costs was about 1% of total health care expenditures and 0.1 % of the Gross Domestic Product (GDP) in 1996. Direct costs were $160 million (23%). Paramedical care accounted for largest proportion of direct costs (84%). The total number of sick days related to neck pain was estimated to be 1.4 million with a total cost of $185.4 million in 1996. Disability for neck pain accounted for the largest proportion (50%) of the
Introduction

total costs related to neck pain in 1996 ($341). The costs related to neck pain in 1996 in The Netherlands were substantial. This cost may be different in India due to its socio-economic and high population status, however, no relevant study was found there. These costs are not short-term and the financial burden of pain and stiffness continues for months to years. There are indirect costs to society as well, such as disability payments and lost productivity. It has been estimated that pain and stiffness is responsible for over 500 million dollars in lost wages each year, and people with pain and stiffness lose an average of two and one-half work days each month (Evans et al., 2002; and Gross et al., 2002). Hence, personal sufferings and lost work productivity have been some of the reasons that require effective management of this condition. It has been suggested by William et al. (2010) that the goals of a rehabilitation programme are to maximize return to function, limit progression of degenerative changes, and prevent further injury.

Exelby (2002) mentioned that the studies with regard to the Mulligan concept are not widely reported; yet a number of therapists throughout the world use this technique. A limited number of papers including case examples by Mulligan (1999); case studies by Kavanagh (1999), O’Brien and Vicenzino (1998) & Vicenzino and Wright (1995); and randomized controlled studies by Abbott et al. (2000a & 2000b), Vicenzino (2001) and Vicenzino et al. (2000) have documented the rapid reductions in pain and improvements in function that are frequently witnessed clinically. There are not many reports on the efficacy of Mulligan’s technique and dominated by the descriptive or case report publication from Exelby (1995, 1996 & 2001), Hetherington (1996), Lincoln (2000), Miller (2000), O’Brien and Vicenzino (1998), Vicenzino and Wright (1995) & Wilson (1994, 1997& 2001). However, research measuring the mechanical and neurophysiological effects has also been conducted by Abbott et al. (2001a & b), Hall et al. (2000), Kavanagh (1999) and Vicenzino et al. (2000). The only study that used MRI to explore the mechanism of positional fault hypothesis was given by Hsieh et al. (2002). The above mentioned evidence showed the effectiveness of Mulligan technique in the spinal articular pain and in the peripheral joint problems, but all this evidence pointed towards short-term effectiveness of the concept. Moreover, there is scarcity of literature on the efficacy of Mulligan techniques in the mechanical cervical pain and stiffness.
Regardless of discrete and conflicting evidence available, as suggested by previously published reviews, which are discussed above, Mulligan’s approach is frequently used in clinical practice for reducing pain and improving functional abilities of neck pain sufferers (Vicenzino et al., 2007). This eventually reflects to an extent that either the results are not interpreted appropriately or the practicing clinicians find these interventions effective to an extent greater than what is informed through published reviews.

1.9. THE MAIN PROBLEMS OF THE PRESENT RESEARCH

- Is NAGs more effective treatment for cervical spine pain in comparison to the available conventional treatments?
- Is NAGs more effective treatment for stiffness of cervical spine in comparison to the available conventional treatments?

Some other related issues are:

- Do NAGs reduce pain immediately?
- Do NAGs have a long-term effect in pain management?
- Do NAGs reduce joint stiffness immediately?
- Do NAGs have a long-term effect in maintaining range of motion?
- Do NAGs reduce pain and increase range of motion simultaneously?
- Do NAGs improve activities of daily living immediately in comparison to available conventional methods treatment?
- Do the reduction in pain and increased joint range of motion improves the quality of daily living?
- Do NAGs have a long term effect on activities of daily living?
- Is there any relationship between neck pain and anxiety?

This research work is the outcome of non-availability of any evidence in the existing literature showing the effectiveness of Mulligan technique (NAGs) in the cervical spine and improving its range of motion, thus, recuperating the patients to have their daily activities in a normal way.
This study, therefore, aims to provide an integrated source of evidence-based information, which can be used to bridge the gap between research and the best practice. This may eventually lead to better clinical results and improved quality of patient care. This research work is an endeavour to provide a scientific evidence base to use Mulligan technique (NAGs) for pain relief and joint stiffness in mechanical neck pain.

1.10. AIMS AND OBJECTIVES OF THE STUDY

The specific objectives of the study are as under:

1. To evaluate the efficacy of Mulligan concept (NAGs) for pain relief and joint stiffness in mechanical neck pain.
2. To study the long-term effect of Mulligan concept (NAGs) in mechanical neck pain.
3. To study the long-term effect of Mulligan concept (NAGs) in terms of certain activity of daily living.
4. To study the relationship between neck pain and anxiety.
5. To establish a scientific evidence to use Mulligan concept (NAGs) for the benefit of patients.
6. To establish a scientific base for future research on Mulligan concept (NAGs).