CHAPTER 2

Literature Review

This section will explore the literature that is relevant to neck pain and understanding the role of the lower trapezius associated with neck pain. The first two parts will review the prevalence of neck pain and a clinical classification system for patients with neck pain. The third part will review the anatomy and biomechanics of the lower trapezius muscle and its dysfunctions in patients with neck pain. And, the last part will focus on measurement of USI.

2.1 Prevalence of neck pain

Neck pain is a common musculoskeletal complaints that has an impact on physical and mental functions as well as health care system (1). Neck pain can be experienced by people of all age. The prevalence of neck pain varies in available studies with respect to several factors such as the case definition and recall period that is used, the age and sex distributions, and the sample and validation of the instrument used (5, 34-36). However, most studies have demonstrated that the prevalence of neck pain increases with age, peaks in the middle age, and is higher in women than men (2, 3, 37). Between 30-50% of adult population reports having experience of neck pain in the past year (38). In a systematic review conducted by Hoy et al (1), the overall prevalence of neck pain was estimated at 23.1% in the general population (ranging from 0.4 to 86.8%). The mean overall prevalence was 27.2% in females and 17.4% in males. A point prevalence and one-year prevalence were estimated at 14.4% and 25.8%, respectively. In another review of the epidemiology of neck pain, Cote et al (36) reported that the age-standardized lifetime prevalence was 66.7% and the point prevalence was 22.2%. The prevalence of low-intensity and low-disability neck pain was also found to be decreased with age. In Thailand, Kanchanomai et al (6) have investigated 1-year incidence and persistent neck pain in undergraduate students.

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The 1-year incidence of neck pain was high, at 46%, of whom 33% reported persistent neck pain.

It has been suggested that neck pain is associated with several risk factors. A single factor is not sufficient to cause neck pain. Risk factors can be either work-related or nonwork-related risk factor (39). Cote et al (40) have reported in a systematic review of neck pain in workers that neck pain results from complex relationships between individual, work-related and cultural variables. The authors have also reported that age, previous musculoskeletal pain, quantitative job demand, social support at work, job insecurity, low physical capacity, poor computer workstation design, repetitive work and precision are associated with the development of an episode of neck pain. Those risk factors have been organized and classified into two types: those inherent to the worker and those related to workplace. The risk factors inherent to the worker have been grouped into 6 categories: 1) demographic; 2) ethnicity and country of origin; 3) health behaviors; 4) occupation; 5) general health, prior pain and co-morbidities; and 6) individual psychological factors. The risk factors related to the workplace have been grouped into 3 categories: 1) psychosocial workplace exposures; 2) physical workplace exposures; and 3) how the worker copes with stress at work. Similarly, Hogg-Johnson et al (41) have undertaken a best evidence synthesis of the published evidence on the burden and determinants of neck pain and its associated disorders in the general population. They have reported that the risk factors for neck pain include non-modifiable factors (i.e. age, gender, genetic) and modifiable factors (i.e. psychological health, smoking and exposure to tobacco). Disc generation has not been identified as a risk factor.

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Numerous studies have demonstrated that neck pain is associated with cervical musculoskeletal impairments (14, 22, 42, 43). The impairments include reduced cervical range of motion (44-46), palpable symptomatic joint dysfunction (47-49), reduced muscle cervical muscle strength and endurance (50, 51), increased muscle fatigability (52, 53), poor cervical muscle control (11, 54) and greater balance disturbances (55).

In general, evidence suggests that exercise is an effective intervention for neck pain (56) as well as associated with good prognosis (57). Supervised exercise together with education emphasizing self-management and return to normal function is more beneficial than manual therapy, TENS, neck collar for patients with nonspecific neck pain (57). Physical modalities, ergonomic interventions and physical and stress management have not been proven effective for nonspecific neck pain.

2.2 Classification of neck pain

The International Association for the Study of Pain (IASP) in its classification of chronic pain defines cervical spinal pain as pain perceived anywhere in the posterior region of the cervical spine, from the superior nuchal line to the first thoracic spinous process (58). The Bone and Joint Decade 2000-2010 Task Force on Neck pain and Its Associated Disorders describes neck pain as pain located in the anatomical region of the neck with or without radiation to the head, trunk, and upper limbs (59). It defines the posterior neck region from the superior nuchal line to the spine of the scapula and the side region down to the superior border of the clavicle and the suprasternal notch (Figure 1). Neck pain may involve one or more causes from neurovascular and musculoskeletal structures such as nerves, facet joint, intervertebral joints, discs, ligament and muscle (60).

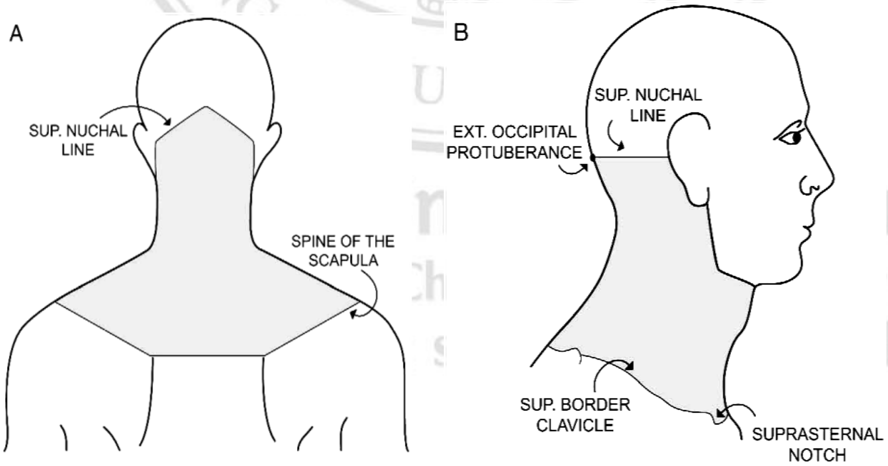

Figure 1 The anatomic region of the neck from the back (A) and the side (B) (59)

Neck pain can also be classified based on duration of neck pain. According to IASP (58), acute pain usually lasts less than 7 days, sub-acute lasts more than 7 days but less than 3 months, and chronic neck pain lasts greater or equal to 3 months. Additionally, neck pain can be categorized based on precipitating factors such as whiplash associated disorder (WAD), sports-related neck pain, occupational neck pain and nonspecific neck pain (61, 62). However, it has been argued that the causes of common neck pain are not known (63). Thus neck pain of unknown origin is then termed "idiopathic neck pain" (64).

In addition, Bone and joint decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders describes a clinical classification of neck pain in 4 grades according to severity of pain (65). The clinical classification of neck pain is provided in Table 1.

Table 1 A clinical classification of neck pain (65)

Grade	Description	Symptoms/Signs	Severity
I	Neck pain with no signs or symptoms of major structural pathology and no or minor interference with activities of daily living	- stiffness, tenderness, but no significant neurological complaints - no signs and symptoms of major structural pathology (e.g. fracture, dislocation, infection, etc.)	- low disability - low intensity
II	Neck pain with no signs or symptoms of major structural pathology, but major interference with activities of daily living	- neck pain interference with daily activities - no signs and symptoms of major structural pathology or root compression	- low disability - high intensity

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Table 1 A clinical classification of neck pain (continued)

Grade	Description	Symptoms/Signs	Severity
III	Neck pain with no signs or symptoms of major structural pathology, but with neurologic signs of nerve compression	- complaints of neck pain associated with significant neurologic signs (e.g. decreased deep tendon reflexes, weakness, sensory deficits) - these complaints suggest malfunction of spinal nerves or the spinal cord	- high disability - moderately limiting
IV	Neck pain with signs or symptoms of major structural pathology	- complaints of neck pain and/or its associated disorders along with signs or symptoms of major structural pathology, detected by clinician - be aware of red flags for fractures, myelopathy, infection, neoplasm, other destructive lesions or systemic diseases	- high disability - severely limiting

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2.3 Lower trapezius muscle and its dysfunctions

2.3.1 Anatomy and biomechanics of lower trapezius muscle

Lower trapezius muscle is the scapular stabilizer which has an important role in normal scapulohumeral rhythm. The lower trapezius muscle arises from the spinous processes T5 - T12 and inserts into the medial end of the spine of the scapula (66) (Figure 2). However, there is also evidence suggesting that the lower trapezius muscle originates from T6-T12 (67). Its functions are to medially rotate and depress the scapular as well as to provide spcapulo-thoracic stability (68).

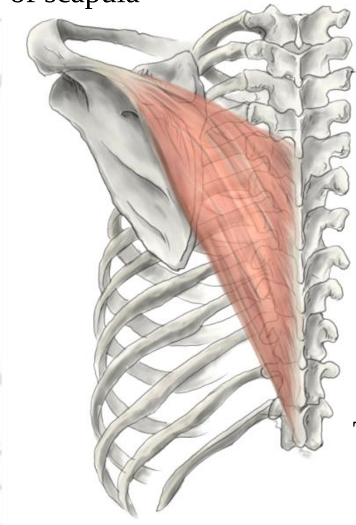

Figure 2 The origin and insertion of the lower trapezius muscle

To retain normal scapulohumeral rhythm, the couple force of trapezius (upper and lower parts) and serratus anterior muscles are required to upwardly rotate the scapular (17, 69). It has been suggested that the lower trapezius muscle force is essential for maintaining vertical and horizontal equilibrium of the scapula during humeral elevation. During active humeral elevation, the serratus anterior muscle initially performs upward rotation of the scapula. The lower trapezius muscle helps to stabilize the scapula against lateral displacement produced by serratus anterior muscle and shoulder elevation produced by the levator scapula. The serratus anterior and upper trapezius muscles can then exert upward rotation about the scapula (17). The lower trapezius is particularly active during the later phase of shoulder abduction. Ekstrom et al (70) reported that the lower trapezius muscle performed the maximum activity when

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arm is overheaded in the line with its muscle fibers. McCabe et al (71) demonstrated marked EMG activity of both the lower and upper trapezius and moderate EMG activity of the middle trapezius during scapular retraction. Moderate lower trapezius EMG activity was also found during shoulder external rotation and scapular depression.

In addition, Kinney et al (72) investigated the activation pattern of the middle and lower trapezius muscle in 32 healthy volunteers using surface EMG during horizontal arm abduction exercise (the glenohumeral joint positioned at 75^{o}, 90^{o}, 125^{o}, and 160^{o} abduction). The results found that the middle and lower trapezius muscle had significantly greater recruitment at 90^{o} and 125^{o} compared to 160^{o}. Besides, Youshizaki et al (73) found difference in EMG activity of the lower trapezius between the dominant and non-dominant shoulders.

2.3.2 Dysfunctions of the lower trapezius muscle and neck pain

Impairment of one or more scapular rotators can cause imbalance of the muscle force couples around the scapula, leading to abnormal kinematics. It has been well documented that abnormality of scapular function is associated with shoulder pathologies (such as impingement syndrome, instability) (69, 74-76). However, recent studies have also demonstrated that dysfunction of scapular rotators including the lower trapezius can be associated with neck pain (10, 15, 16). Wegner et al (15) have investigated the activity of the three portions of the trapezius muscle in patients with neck pain with poor scapular posture compared to those without neck pain during the performance of a functional typing task. They demonstrated that patients with neck pain had greater EMG activity in the middle trapezius and lesser EMG activity in the lower trapezius than the control group. There was also a trend toward lesser activity of the upper trapezius in the neck pain group. Zakharova-Luneva et al (10) found significantly greater EMG activity of the lower trapezius muscle in patients with mechanical neck pain who had clinical signs of scapular dysfunction. Increased or decreased EMG activity may depend on task and individuals. Petersen et al (16) also demonstrated that individuals with unilateral with neck pain exhibited significantly less lower trapezius muscle strength on side of neck pain when compared with contralateral side using handheld dynamometer. In Petersen et al’s study, the maximum force of lower trapezius muscle was tested in prone position, with arm overhead in line with the

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fiber of lower trapezius muscle. Moreover, Helgadottir et al (77) also suggested that altered dynamic stability of the scapula was different between patients with idiopathic neck pain and whiplash-associated disorder (WAD).

Furthermore, there is evidence suggesting that abnormality of cervical alignment affects performance of the scapular rotators. Weon et al (78) have investigated the effects of forward head posture in the sitting position on the activity of the scapular upward rotators during loaded isometric shoulder in sagittal plane. The result showed that increased EMG activity of upper and lower trapezius muscle and decreased EMG activity of the serratus anterior during loaded isometric shoulder flexion with forward head posture. Thus, Weon et al (78) suggested that maintaining neutral head posture can help to reduce the upper and lower trapezius muscle activity and increase serratus anterior muscle activity.

According to the previous studies, it can be concluded that there is altered activity of the lower trapezius in patients with neck pain compared those who do not have neck pain, suggesting that assessment and management of the lower trapezius function should be considered by clinicians. However, it is noting that the lower trapezius muscle dysfunction in the previous studies was investigated during shoulder movements and/or isometric contraction. There is a call for further study to provide information concerning the contribution of the scapular muscle in maintaining normal scapular orientation, with arm by the side in patients with cervical pain. Thus in this study we are interested to investigate the thickness of the lower trapezius at rest with arm by the side in patients with neck pain using ultrasound imaging as this has not been conducted previously.

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2.4 Ultrasound Imaging (USI)

USI has been used in the rehabilitation setting since the mid 1950s (79). It allows clinicians to assess muscle morphology and behavior which can then be used for muscle retraining. USI is an inexpensive-cost, safe and noninvasive method when compared with magnetic resonance imaging (MRI) and computed tomography (CT). Thus USI has become commonly used to determine changes in muscle activation and thickness in research and clinical practice. A decrease in muscle thickness measured by USI has been found to be associated with various pathologies or dysfunction (21, 22, 80). Yet, there has been no research investigation the thickness of the lower trapezius muscle using USI in patients with neck pain. The following sections will review the measurement of ultrasound imaging and its reliability and validity. This will form the basis for assessing the thickness of the lower trapezius muscle in this study.

2.4.1 Ultrasound imaging measurement

Ultrasound imaging is a procedure that uses high frequency sound wave to produce images of body structures. It consists of a transducer (probe) attached to the main body of the machine via cord. There are two basic modes commonly used: B-mode and M-mode (81, 82). B-mode is a brightness or grayscale mode which the returning echo is displayed as shades of gray while M-mode is a motion mode used to display moving structure. B-mode can be viewed into as a two dimensions image (2Ds) on screen. The brightness of the pixel depends on the strength of the returning echo and the position of the pixel in the image is due to the depth of the reflecting surface (83). Large reflective interfaces (such as bone and muscle) will appear brighter on the screen compared to less reflective interfaces which appear darker (84). B-mode is frequently used in most previous studies to measure changes in muscle thickness (21, 29, 82). Thus the thickness of the lower trapezius muscle in this study was also be measured using B-mode.

Ultrasound wave is produced by a transducer (probe). There are two standard type transducers; linear array and curvilinear array. For linear transducer array, the ultrasound beam is perpendicular to the transducer surface and produces rectangular images. The linear array is generally high frequency (5-13 MHz), which provides better resolution and less penetration. It often uses for imaging superficial structures and vessels. Curvilinear transducer is low frequency (1-8 MHz), which allows greater penetration but less resolution. The curvilinear probe has a wide field of view and is often used for deeper structures. Thus, to image musculoskeletal structures such as tendons, ligaments, muscles, high resolution scanning is recommended (84).

To have good ultrasound images, it depends on several factors as well as there are many factors errors that can occur if protocols are not developed and followed strictly. The associated factors and errors are discussed below.

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- Factors associated with a transducer selection

Selection of proper transducer including frequency and type is necessary for good ultrasound images. As discussed earlier, B-mode is commonly used to measure muscle thickness (24, 29, 85) and identify the bony landmarks while M-mode is used to visualize things that are physically moving. A linear array is high frequency that is generally used for superficial structures (30, 31, 86) whereas a curvilinear array, low frequency provides a wild view and is often used for deeper muscles (87-89). Thus it is noting that the ultrasound wavelength depends on the frequency. Choosing an appropriate transducer is necessary for assessing musculoskeletal features.

- Measurement errors

There are several errors that can occur when measuring USI. These include angle of transducer, pressure of transducer, and placement of ultrasound transducer (85, 88, 90). A clear image depends on a strict measurement and protocol as slightly angulations of the probe and the probe pressure exerted on the underlying muscle have influence on the image produced (23). Thoris and English (85) suggested that to achieve the clear and shape images the transducer should be slightly flattened with the minimum pressure and perpendicularly held on the skin (85). Whittaker et al (90) suggested that angular motion of the transducer should be between 5° and 10° and inward/outward motion should be minimized to less than 8 mm. Large amount of the transducer motion may distort the images and make measurement errors. Likewise, Dupont et al (88) suggested that the transducer should be held with no muscle compression and using generous amount of gel.

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For the placement of transducer, variable placements of the ultrasound transducer can lead to misinterpretation of different parts or thickness of the muscles measured. The resolution of the image and measurement using a caliper tool can also be a potential source of errors. Kristjansson et al (23) suggested that investigators must have a thorough knowledge of cross-sectional anatomy as the image is not as good as measured by CT and MRI. In addition, errors are likely to occur when an investigator is not familiar or experienced with technique and has insufficient training. Kristjansson et al (23) also suggested that marking the boundaries of the muscle with the cursor is dependent on the investigator's level of training. Koppenhaver et al (87) discussed the limitation of their study that the clinicians who had minimal USI experience less than 16 hours of ultrasound training had less reliable than the other examiners in the study. Thus, the investigator should be trained in the specific USI measurement at least 16 hours beforehand. Also, for best measurement a transducer may need to be adjusted and angled sharpen the images when necessary. The pressure placed on the transducer also needs to be consistent.

- Factors associated with individuals

There is evidence suggesting that changes in water and fat content may increase or decrease the echogenity of muscles. Position taken has also found to be associated with the ultrasound images. Muscle thickness taken from different positions can be varied. Thoirs and English (85) found influence of body position on ultrasound measures of muscle thickness. Muscle thickness in recumbent measures was significantly smaller than those taken when participants were standing. There was no difference in measures between length of time which participants spent time lying down, indicating that any changes in intra-muscular fluid is not related to the time spent recumbent. In addition, the beam penetration is also compounded by subcutaneous and intraperitoneal fat. Uppot et al (91) demonstrated that increased thickness of body parts in obese patients resulted in poor penetration of the ultrasound beam beyond the focal depth.

2.4.2 Reliability and validity of ultrasound imaging

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USI has been widely used to measure appearance of muscle features such as cross-sectional area (CSA), muscle thickness and muscle volume in many studies (28-30). Numerous studies have shown that ultrasound imaging is a valid and reliable method to measure muscle morphology (29, 92-94). Inter-intra-rater reliability of ultrasound imaging were performed in many muscles (87, 92, 95) including cervical muscles (29) and lower trapezius muscle (31). Janvanshir et al (29) have assessed the reliability of longus colli muscle in relaxed position using a real time ultrasonography in 10 patients with chronic neck pain and 15 controls. They found that USI was a reliable tool to measure the muscle thickness of longus colli in both healthy and patient with chronic neck pain (ICCs of CSA ranged between 0.82 - 0.93 in healthy control and 0.76 - 0.86 in patient with chronic neck pain). O'Sullivan et al (31) have investigated a procedure for assessing lower trapezius muscle thickness and reliability within and among investigators. The results demonstrated that inter-reliability and intra-reliability of lower trapezius muscle thickness were moderate to high (ICC ranged from 0.70 - 0.99). The study suggested that thickness of the lower trapezius muscle can be measured reliably with ultrasound imaging.

USI has also been reported to be a valid tool for measuring the muscle morphology when compared with gold standard measurement (MRI and CT) (32, 94), Dupont et al (88) demonstrated that real-time sonography is valid for measuring supraspinatus and deltoid muscle thickness in healthy subjects when compared with CT and MRI (r = 0.98 and r = 0.88-0.99, respectively). A recent study has determined the validity of rehabilitative ultrasound imaging (RUSI) against MRI for measuring trapezius muscle thickness (32). The results demonstrated good agreement between MRI and RUSI measurements of the lower trapezius muscle at T8 (r = 0.77) and moderate agreement at T5 (r = 0.62). However, there was poor agreement for the middle and upper trapezius which may be resulted from difference in both positioning and imaging plane. From the results, the authors concluded that RUSI is a valid method of measuring lower trapezius muscle thickness, but upper and middle trapezius. On the other hand, Cagnie et al (33) evaluated the validity of ultrasound for measuring CSA of the longus colli muscle as compared to MRI in asymptomatic subjects. The results that the validity of USI of the longus colli muscle were doubtful. The author discussed that this may be due to both anatomical characteristics and methodological limitations.

Although ultrasound imaging of the lower trapezius muscle has been reported to be reliable and valid, potential variability of the measurement using ultrasound must be considered. Causes of errors can arise from technical and investigator factors. Thus, inter-and intra-rater reliability is still necessary to be conducted prior to a main study.

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