CHAPTER 2

Literature review

The literature review in this study will explore the literature related to neck pain and a foundation for understanding change in thickness of the lower trapezius muscle in patients with neck pain. The first sub-section will review the definition of neck pain. The second sub-section will review the prevalence of neck pain. The third sub-section will review contributing factors of neck pain. The forth sub-section will focus on the role of the axioscapular muscles associated with neck pain. The fifth sub-section will review alterations of the trapezius muscle behavior in patients with neck pain and the last section will review the ultrasound imaging and its validity and reliability to measure the lower trapezius.

2.1 Definitions of neck pain

In a review of Misailidou et al (18), definitions of neck pain in the literature have been suggested in different ways based on anatomical location, etiology, severity, and duration of symptoms.

2.1.1 Definitions based on anatomical location of neck pain

The International Association for the Study of Pain (IASP) (19) defines neck pain as pain in the posterior region of the cervical spine, from the superior nuchal line to the first thoracic spinous process. However, it has been argued that the definition of neck pain by the IASP has some limitations, in particular on referred pain areas (19). Recently, The Bone and Joint decade 2000-2010 Task Force on Neck Pain and its Associated Disorders (20) defines neck pain as pain located in the anatomical regions of the neck, which the posterior neck region is located from the superior nuchal line to the spine of the scapular and the side region is down to the superior border of clavicle and the supra sternal notch (Figure 1). Additionally, neck pain may occur with or without radiation to the head, trunk, and upper limbs. Bogduk and McGuirk (21) also suggest that neck pain may be subdivided into upper cervical spinal pain (C0-3) and lower cervical spinal pain (C4-7). Pain from the upper cervical spine is often referred to the head whereas pain from the lower cervical spine is often referred to the scapular region, anterior chest wall, shoulder, or upper limb.

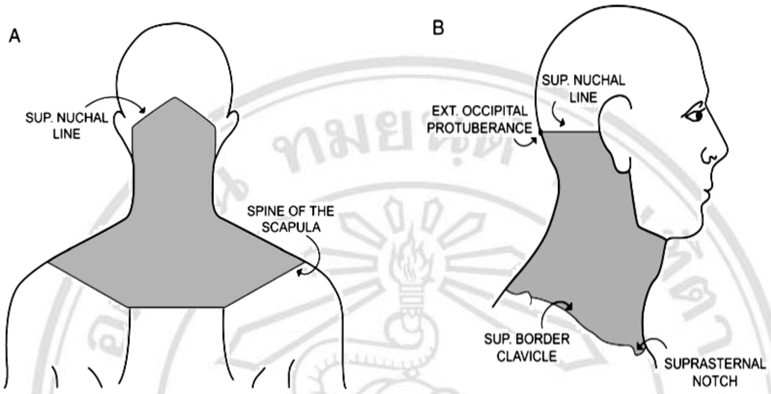

Figure 1 The anatomic region of the neck from the back (A) and the side (B) (20)

2.1.2 Definitions based on etiology of symptoms

Many studies have considered neck pain as a local pathology but some have considered neck pain based on precipitating factors such as whiplash-associated disorders (WAD), occupational neck pain, sports-related neck pain, and non-specific neck pain (22-25). However there is an argument that the causes of common neck pain are not known (21). Thus the recommended term of “idiopathic neck pain” (26) or “cervical spinal pain of unknown origin” (27) is frequently used for patients who have neck pain with unknown cause.

2.1.3 Definitions based on severity of symptoms

The Bone and Joint decade 2000-2010 Task Force on Neck Pain and its Associated Disorders (20) classifies neck pain into four grades, according to severity of pain.

1) Grade I: neck pain with no signs of major pathology and no or little interference with activities of daily living

2) Grade II: neck pain with no signs of major pathology, but interference with activities of daily living
3) Grade III: neck pain with neurologic signs or symptoms (radiculopathy)
4) Grade IV: neck pain with signs of major structural pathology

2.1.4 Definitions based on duration of symptoms

Based on duration of symptoms, The Bone and Joint decade 2000-2010 Task Force on Neck Pain and its Associated Disorders (20) categorizes neck pain into transitory, short-duration and long-duration neck pain. Transitory neck pain lasts less than 7 days whereas short-duration neck pain lasts more than 7 days but less than 3 months and long-duration neck pain lasts 3 months or more.

The IASP (27) proposes duration of neck symptoms with the same time frames but different terminology. According to the classification of the IASP, acute neck pain is used for transitory, subacute neck pain for short-duration, and chronic neck pain for long-duration.

2.2 Prevalence of neck pain

Neck pain is a common musculoskeletal complaint in general populations worldwide (28, 29). The prevalence of neck pain in general population varies with time. Estimated one-month and one-year prevalence of neck pain ranged from 15.4% to 45.3% and 12.1% to 71.5%, respectively (28). The prevalence of neck pain peaks in middle-age groups (ages 30 to 39 and 40 to 49) (28, 30, 31) and is more common in women than men. Cote et al (32) demonstrated that women were likely to develop more neck pain as well as experienced persistent pain than men (incidence rate ratio = 1.67 and 1.19, respectively). In addition, Gerr et al (33) found that white workers had a higher incidence of neck pain than non-white workers.

Many studies have demonstrated that patients with neck pain had continuous or recurrent symptoms in their life (29, 32). Cote et al (32) investigated the incidence of neck pain in Saskatchewan adult population in Canada and found that 37.3% had persistent problems, 9.9% experienced an aggravation during follow-up, and 22.8% reporteda recurrent episode of neck pain.

2.3 Contributing factors of neck pain

Many factors have been demonstrated to be associated neck pain disorders (30). These include age, gender, marital and family status, occupation, ethnicity, physical capacity, history of musculoskeletal symptoms, headache, smoking, physical risk factors at work and psychological factor (30, 31, 33-35). Additionally, it has been suggested that repetitive and precision work, working with hands above shoulders, poor working posture and heavy physical work increases risk of neck pain (36-38). Ariëns et al (39) demonstrated that persons who were sitting for more than 95% of the working time had a higher risk of neck pain. Johnston et al (40) also suggested that using a computer mouse for more than 6 hours per day was associated with a higher Neck Disability Index (NDI) score. Similarly, Brandt et al (41) reported that the prevalence rate ratio (PRR) for neck pain was 1.7 for mouse use more than 25 hours per week.

Depressive symptom is one of the common psychological problems that has been found to be associated with neck pain (30). Previous studies suggested that persons who had depressive or emotional symptoms and stress at work had a higher risk to develop neck pain (31, 42). In addition, La Touche et al (43) demonstrated moderate correlations between severity of pain and neck pain and disability (NDI) score and between severity of pain and depression score (r = 0.57 and 0.64, respectively, $p < 0.05$). Johnston et al (40) also found associationsof higher NDI score and higher negative affectivity.

2.4 The role of the axioscapular muscles

The trapezius and serratus anterior muscles (Figure 2), the scapular stability muscles, have shown to play an important role to maintain normal orientation of the scapula with arms by sides and also to stabilize/control the scapula during movement of the upper limb. To comprise the muscle balance, these muscles also function in association with the activity and extensibility of the mobility muscles (i.e. pectoral muscles, levator scapulae and rhomboids) (44). It has been suggested that a neutral scapula position with arms by the sides are the mid position of the scapula (between upward and downward rotation, external and internal rotation, and posterior and anterior tilt) (45). There is also a little difference in scapular orientation between dominant and non-dominant side (46). The neutral position of the scapula is maintained by the trapezius and serratus anterior muscles.

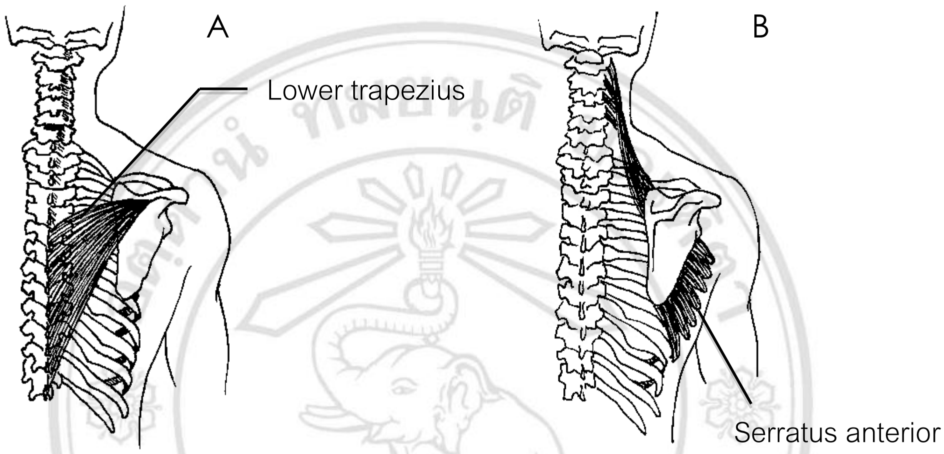

Figure 2 Lower trapezius muscle (A) Serratus anterior muscle (B) modified from Oatis (1)

In general, the upper trapezius assists in scapular elevation and upward rotation. The middle trapezius is to stabilize and adduct scapula and the lower trapezius helps adduct scapula and rotate scapular upward to lift the arm overhead (1). Coupling of the three portions of the trapezius with the serratus anterior result in force couples, which is important for normal scapula orientation and control.

During arm elevation, it has been suggested that the upper trapezius contributes to scapula upward rotation and also scapula elevation however this is still unclear. The lower trapezius externally rotates the scapular and assists in scapular upward rotation and posterior tilt whereas the middle trapezius helps to stabilize the scapula against action of the serratus anterior and levator scapulae. The serratus anterior is a prime muscle in scapula upward rotation in particular during a completion of active arm elevation (Figure 3). It also helps to abduct, posteriorly tilt and externally rotate the scapula holding it flat against the thoracic cage during arm movement (1, 47).

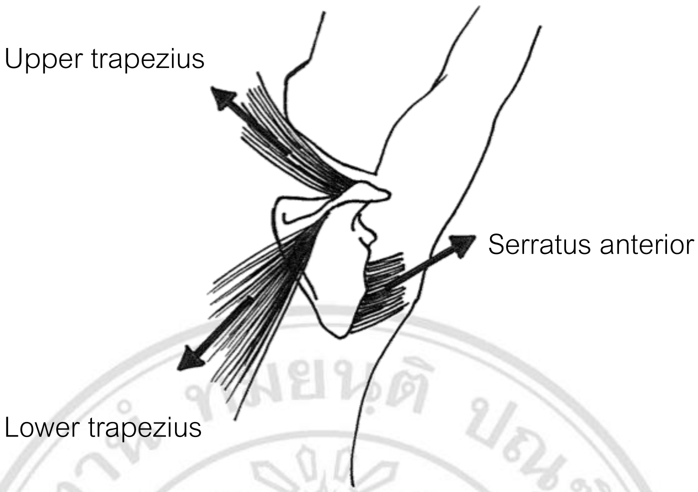

Figure 3 Force couple of the upper trapezius, lower trapezius and serratus anterior muscles modified from Oatis (1)

A study of Ekstrom et al (48) investigated EMG activity of the trapezius muscle (upper, middle and lower parts) and the serratus anterior muscle during nine manual muscle testing positions performed with maximum voluntary contraction in healthy individuals. The results showed that the greatest EMG activity in the upper trapezius was with resistance applied at about 90° of shoulder abduction with the neck side-bent to the same side, rotated to the opposite side, and extended whereas the greatest EMG activity in the middle and lower trapezius was produced when the shoulder was horizontally abducted with external rotation and when the arm was raised above the head in line with the lower part of the trapezius in the prone position, respectively. In the serratus anterior the maximum amount of EMG activity was generated with resistance given to upward rotation of the scapula with 125° of shoulder flexion.

There is evidence that the presence of pain can be associated with delayed activation of the muscles that control joint stability (49). Thus altered activity of the scapular stability muscles: the trapezius and serratus anterior muscles may result in shoulder and neck pain. Impaired function of the scapular stability muscle and increased activity of the mobility muscles (e.g. the levator scapulae) may induce load or compressive forces on the cervical spine (50). Additionally, abnormal scapular orientation (i.e. a reduction in retraction of the clavicle, scapular upward rotation, scapular posterior tilt as well as an increase in clavicle elevation) has been found to be associated with alteration in balance forces of the serratus anterior and trapezius muscles (2, 47).

2.5 Alterations of the trapezius muscle behavior in patients with neck pain

Alterations of the trapezius muscle behavior in patients with neck pain have been suggested in many studies (6, 51, 52). Wegner et al (5) investigated alterations in three portions of the trapezius muscle activity as well as the effect of a scapular postural correction strategy on the trapezius activity in patients with neck pain compared to healthy controls. The results showed significantly increased EMG activity in the middle trapezius ($p = 0.02$) and decreased EMG activity in the lower trapezius ($p = 0.03$) during the typing task in patients with neck pain compared to healthycontrols. There was a trend towards decrease in EMG activity of the upper trapezius in patients with neck pain. Also, after correction of the scapular position, there were no significant differences in activity in the middle and lower trapeziusbetween the two groups ($p > 0.05$). On the contrary, Falla et al (51) investigated the effect of experimental unilateral upper trapezius muscle pain on the relative activation of the three portions of the trapezius muscle and found decreased EMG amplitude in the upper trapezius muscle and increased EMG amplitude in the lower trapezius muscle during repetitive movement of the upper limb in patients with neck pain (51). This result is similar to Zakharova-Luneva et al’s result which demonstrated significantly greater EMG activity of the lower trapezius muscle for the abduction and external rotation conditions at 20%, 50% and maximum voluntary contraction (MVC) in patients with neck pain compared to controls (6). Discrepancies between results of behavior of the lower trapezius activity may be dependent on specific upper limb tasks. Moreover, it may be due to task characteristics (such as mode, direction, level of elevation, intensity and repetitiveness) and side of pain.

Recently, Petersen et al (8) also investigated the lower trapezius muscle strength in patients with unilateral neck pain using hand-held dynamometer and found significantly decreased strength of the lower trapezius on the symptomatic side compared to the asymptomatic side. This result may suggest that patients with neck pain have lower trapezius muscle weakness.

It has been documented that many factors can affect muscle activity. These include age, gender and dominance side of the extremity and activity (11, 53-56). There is evidence of decline in muscle strength with age (11, 54). Muscle strength is also generally greater in men than women (53). Muscle activity on dominance side is reported to be greater than non-dominant side (55, 56). Yoshizaki et al (56) demonstrated that dominant arm had a higher percent integrated electromyography (% IEMG) of the lower trapezius than non-dominant arm ($p < 0.05$). Similarly, McCreesh et al (55) investigated the effect of limb dominance and sports-specific activity on the anterior tibial muscle thickness in footballers and non-football playing controls using ultrasound imaging. They demonstrated that the anterior tibial muscle group thickness on dominant leg was greater than non-dominant leg in the footballers.

Ultrasound imaging has been frequently used to evaluate function of the abdominal muscle in patients with back pain (9, 57). It has also been used to evaluate the lower trapezius dysfunction in patients with shoulder pain. However there is yet no study investigating dysfunction of the lower trapezius muscle using ultrasound imaging in patients with neck pain. O'Sullivan et al (16) investigated changes in thickness of the trapezius muscle during isometric contraction in patients with shoulder pain compared to healthy controls using rehabilitative ultrasound imaging. Thickness of the trapezius muscles (upper, middle and lower parts) was measured bilaterally at resting at 0°, 90° and 120° of shoulder abduction and during isometric contraction at 90° and 120°. A real-time ultrasound scanner with a 7-MHz linear transducer was used to take muscle images of the upper trapezius at C5, middle trapezius at T1 and lower trapezius at T5 and T8. The results showed no significant differences between groups or sides in any part of the trapezius muscle thickness at resting and during isometric contraction at 0°, 90° and 120° of shoulder abduction. The authors discussed that patients with mild shoulder pain might not have impairment of the trapezius muscle assessed using ultrasound imaging. It has been suggested that patients with neck pain have alteration of EMG activity and decrease in strength of the lower trapezius muscle. Measurement of thickness of the lower trapezius muscle using ultrasound imaging may potentially be used as an indirect measure of muscle strength and also an objective tool to evaluate rehabilitation strategies (O'sullivan 2007). However, no published studies have determined thickness of this muscle in individuals with neck pain. Thus, further research in this area is still required.

2.6 Ultrasound imaging and its validity and reliability for measurement of the lower trapezius

2.6.1 Ultrasound imaging

Ultrasound imaging is a non-invasive tool which provides images in real time and free of radiation risk (58-60). It is also easy, rapid and reliable for the use of measuring dysfunction of muscle thickness either during resting and contraction (9, 10, 57).

Ultrasound imaging uses sound waves in the range of 1-20 MHz, which behave according to the wave propagation processes (61). Ultrasound device consists of transducer (probe) and imaging system. The transducer is responsible for generating ultrasound waves and converting the ultrasound echoes from the tissues into electrical signals whereas the imaging system processes the electrical signals, which are then displayed as a digital image. The ultrasound transducer housing an array of crystals can be linear or curved. A linear transducer is suitable to image small superficial structures as is the high-frequency transducer (7.5-15 MHz). A curved transducer and low-frequency (2-5 MHz) is more suitable for deep structures. There are several modes available to display the ultrasound echo however B-mode (brightness) is commonly used to measure the static architectural features of a muscle such as length, depth and cross-sectional area (12, 62, 63). In addition, there are other factors that can affect ultrasound images. These include an examiner's ultrasound experience, transducer pressure and position and muscle location and condition (53, 59, 64, 65). The examiner needs to be trained in use of ultrasound (64). An ultrasound transducer should be pressed as light as possible to avoid distortion of the underlying tissues (53). A good ultrasound image is obtained by consistence of transducer position (64, 65). Suitability of the angle of the transducer can help to visualize sharpness of the muscle borders. Thus the ultrasound transducer may be slightly angled in either cephalad or caudad direction (59, 64).

2.6.2 Validity and reliability for measurement of the lower trapezius muscle

Ultrasound imaging has been shown to be valid and reliable for measuring the thickness of several muscles including the lower trapezius muscle (14, 15). In 2007, O'Sullivan et al (14) developed a technique for measuring the lower trapezius muscle thickness using ultrasound imaging and investigated intrarater and interrater reliability of measurements in healthy controls. In this study only the left lower trapezius was scanned. To measure the lower trapezius muscle, inferior angle of the left scapula and the vertebra at the same level was used as reference for imaging the lower trapezius muscle. Scanning was performed with the subject positioned in prone with the head and neck in neutral alignment. A real-time ultrasound scanner with an 8-MHz linear transducer and Image J software was used to measure thickness of the lower trapezius muscle at 3 cm lateral to the lateral edge of the spinous process. Linear measurement of the lower trapezius was measured at the inside edge of the muscle border. The results showed high reliability of intra- and inter rater reliability for ultrasound measurements of the lower trapezius muscle (ICC = 0.89-0.99 and 0.88, respectively). The authors concluded that thickness of the lower trapezius muscle could be reliably measured by ultrasound imaging and the vertebral level suggested for measurement was T8. However, validity of the ultrasound measurement was yet to be conducted in the study. Thus in 2009, O'Sullivan et al (15) again described protocols for measuring lower trapezius muscle at T5 and T8, middle trapezius at T1 and upper trapezius at T1 as well as compared measurements of trapezius muscle thickness taken from MRI scan as the gold standard with ultrasound scans. The results showed good and moderate correlations between MRI and rehabilitative ultrasound imaging (RUSI) measurements of the lower trapezius muscle at T8 and T5 (r = 0.77 and 0.62, respectively, $p < 0.001$). There were poor correlations of measurements of the upper trapezius muscle at C6 (r = 0.52, $p = 0.001$) and middle trapezius at T1 (r = -0.22-0.25, $p > 0.05$). The mean of the lower trapezius thickness on RUSI at T8 in this study was 3.6 mm, which is consistent with their previous study (14). From O'Sullivan et al's studies, it may imply that RUSI is a valid method of measuring the lower trapezius muscle thickness.

2.7 Summary statement

Neck pain is a common problem in the general population. Lower trapezius muscle, one of the axioscapular muscles has an important role in maintaining normal orientation of the scapula with arms by sides and controlling the scapula during movement of the upper limb. It has been suggested that patients with neck pain have altered behavior of the lower trapezius muscles at resting and during muscle contraction assessed using EMG and dynamometer. It is questioned whether there is also decrease in muscle size of the lower trapezius in patients with neck pain. To date, there has no study investigating muscle size (thickness) of the lower trapezius muscle in patients with neck pain. A study has demonstrated that ultrasound imaging is a reliable and valid method for measuring the lower trapezius muscle. Thus, this study aims to evaluate thickness of the lower trapezius muscle in patients with neck pain compared to healthy controls using ultrasound imaging. As alteration in muscle thickness may be related to scapular orientation and muscle activity, the thickness of the lower trapezius in the study will be measured at different conditions (resting at 0° and 120° shoulder abduction and during contraction at 120° shoulder abduction). The shoulder in 120° of abduction is chosen according to functional anatomy of the lower trapezius. The result of this study will be of importance for a better understanding of changes in muscle thickness of the lower trapezius in patients with chronic neck pain. Furthermore, it may also provide useful information for assessment and management in patients with neck pain.