MEASUREMENT OF THICKNESS OF THE LOWER TRAPEZIUS MUSCLE USING ULTRASOUND IMAGING IN INDIVIDUALS WITH CHRONIC NECK PAIN

CHALOMJAI PENSRI

MASTER OF SCIENCE
IN MOVEMENT AND EXERCISE SCIENCES

GRADUATE SCHOOL
CHIANG MAI UNIVERSITIY
AUGUST 2014

MEASUREMENT OF THICKNESS OF THE LOWER TRAPEZIUS MUSCLE USING ULTRASOUND IMAGING IN INDIVIDUALS WITH CHRONIC NECK PAIN

CHALOMJAI PENSRI

A THESIS SUBMITTED TO CHIANG MAI UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN MOVEMENT AND EXERCISE SCIENCES

GRADUATE SCHOOL, CHIANG MAI UNIVERSITIY

AUGUST 2014

MEASUREMENT OF THICKNESS OF THE LOWER TRAPEZIUS MUSCLE USING ULTRASOUND IMAGING IN INDIVIDUALS WITH CHRONIC NECK PAIN

CHALOMJAI PENSRI

THIS THESIS HAS BEEN APPROVED TO BE A PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN MOVEMENT AND EXERCISE SCIENCES

Examination Committee:

..................................Chairman
(Assoc. Prof. Dr. Rungthip Puntumetakul)

..................................Member
(Asst. Prof. Dr. Sureeporn Uthaikhup)

..................................Member
(Asst. Prof. Dr. Patraporn Sitilertpisan)

Advisor:

....
(Asst. Prof. Dr. Sureeporn Uthaikhup)

22 August 2014

To

My family,

My advisor,

and

My friends

Without whom none of my success would have been possible

ACKNOWLEDGEMENT

I would like to express my sincere thanks to my thesis advisor, Asst. Prof. Dr. Sureeporn Uthaikhup for her invaluable help, suggestions, encouragement, and support me throughout this thesis study. I am most grateful for her guidance and advice, not only the research methodology but also other aspects associated with work and life. I would not have achieved this far and this thesis would not be completed without all support that I have always received from her.

I am sincerely grateful to Asst. Prof. Dr. Patraporn Sitilertpisan for her helps and suggestions on measurement of ultrasound imaging.

I am very grateful to Miss Kanokon Kowsoiy,my lab-mate for her helps in the experimental setup, data collection and friendship.

I am thankful to all staffs from the Radiologic Technology Clinic and Physical Therapy, Faculty of Associated Medical Sciences, Chiang Mai University for their kindness and allowing me to work in their lab.

I would like to thank all participants for their contributions to the study.

Unforgettably, I would like to thank graduate students and my friends for their love, encouragement and friendship.

Finally, I would like to honestly thank my parents for being the best support, love, and encouragement throughout my study.

Chalomjai Pensri

หัวข้อวิทยานิพนธ์ การวัดความหนาของกล้ามเนื้อทราพีเซียสส่วนล่างโดยใช้ภาพถ่ายอัลตราซาวด์ในผู้ที่มีอาการปวดคอเรื้อรัง

ผู้เขียน นางสาวชโลมใจ เพ็ญศรี

ปริญญา วิทยาศาสตรมหาบัณฑิต (วิทยาศาสตร์การเคลื่อนไหวและการออกกำลังกาย)

อาจารย์ที่ปรึกษา ผู้ช่วยศาสตราจารย์ ดร. สุรีพร อุทัยคุปต์

บทคัดย่อ

ที่มา การเปลี่ยนแปลงลักษณะการทำงานของกล้ามเนื้อทราพีเซียสส่วนล่างถูกพบในผู้ป่วยที่มีอาการปวดคอ แต่อย่างไรก็ตามยังมีการศึกษาจำนวนน้อยที่ศึกษาถึงขนาดของกล้ามเนื้อทราพีเซียสส่วนล่างในขณะพักและขณะหดตัวในผู้ที่มีอาการปวดคอ **วัตถุประสงค์** เพื่อเปรียบเทียบความหนาของกล้ามเนื้อทราพีเซียสส่วนล่างในขณะพักแขนกาง 0° และ 120° และในขณะหดตัวแขนกาง 120° ในผู้ที่มีอาการปวดคอ **วิธีการ** อาสาสมัครที่มีอาการปวดคอเรื้อรังข้างเดียวจำนวน 24 คน และอาสาสมัครที่ไม่มีอาการปวดคอจำนวน 24 คน ใช้เครื่องอัลตราซาวด์ (12 MHz หัวตรวจแบบเรียบ) วัดความหนาของกล้ามเนื้อทราพีเซียสส่วนล่างทั้งสองข้างในท่านอนคว่ำขณะพักแขนกาง 0° และ 120° และขณะหดตัวแขนกาง 120° ที่บริเวณกระดูกสันหลังอกระดับที่ 8 ภาพถ่ายแต่ละภาพถูกนำมาวัดความหนา 2 ครั้งด้วยโปรแกรม Image J **ผลการศึกษา** กลุ่มที่มีอาการปวดคอมีความหนาของกล้ามเนื้อทราพีเซียสส่วนล่างข้างขวาในขณะพักที่แขนกาง 0° น้อยกว่ากลุ่มที่ไม่มีอาการปวดคอ ($p < 0.05$) ไม่พบความแตกต่างของความหนาของกล้ามเนื้อทราพีเซียสส่วนล่างขณะหดตัวระหว่างทั้งสองกลุ่ม ($p > 0.05$) กลุ่มที่มีอาการปวดคอมีความหนาของกล้ามเนื้อทราพีเซียสส่วนล่างใกล้เคียงกันระหว่างข้างขวาและข้างซ้าย กลุ่มควบคุมมีความหนาของกล้ามเนื้อทราพีเซียสส่วนล่างข้างขวา (ข้างที่ถนัด) มากกว่าข้างซ้าย (ข้างที่ไม่ถนัด) ($p < 0.05$) **สรุปผลการศึกษา** เครื่องถ่ายภาพอัลตราซาวด์สามารถใช้วัดความบกพร่องของกล้ามเนื้อทราพีเซียสส่วนล่างในขณะพักแขนกาง 0° ในผู้ทีมีอาการปวดคอได้ แต่การวัดความบกพร่องของกล้ามเนื้อทราพีเซียสส่วนล่างในขณะหดตัวยังไม่ชัดเจนและยังคงต้องการการศึกษาเพิ่มเติม

Thesis Title	Measurement of Thickness of the Lower Trapezius Muscle Using Ultrasound Imaging in Individuals with Chronic Neck Pain
Author	Ms. Chalomjai Pensri
Degree	Master of Science (Movement and Exercise Sciences)
Advisor	Asst. Prof. Dr. Sureeporn Uthaikhup

ABSTRACT

Background: Altered behavior of the lower trapezius muscle has been consistently demonstrated in patients with neck pain. However, little has investigated size of the lower trapezius muscle at rest and during contraction in patients with neck pain. **Objective:** To determine thickness of the lower trapezius at rest 0° and 120°, and contraction at 120° of shoulder abduction in patients with neck pain. **Methods:** Twenty-four participants with chronic unilateral neck pain and 24 matched controls were recruited into the study. A real-time ultrasound scanner (12-MHz linear transducer) was used to measure thickness of the lower trapezius muscle in prone at rest 0° and 120°, and contraction at 120° of shoulder abduction bilaterally. Images were taken twice at the spinous process of T8 and measured using Image J program. **Results:** The neck pain group had smaller thickness of the lower trapezius muscle than the control group on the right side at resting at 0° of shoulder abduction condition ($p < 0.05$). There was no significant difference in the lower trapezius muscle thickness during contraction between groups ($p > 0.05$). The neck pain group had similar thickness of the lower trapezius muscle on the right and left sides. The control group had greater thickness of the lower trapezius on the right (dominant) side than the left (non-dominant) side ($p < 0.05$). **Conclusion:** Ultrasound imaging can be used to detect impairment in size of the lower trapezius muscle at rest at 0° of shoulder abduction in patients with neck pain. However investigation of size of the lower trapezius muscle during contraction is still warranted.

CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

LIST OF ABBREVIATIONS

% IEMG	Percent integrated electromyography
BMI	Body mass index
cm	Centimeter
EMG	Electromyography
IASP	International association for the study of pain
kg	Kilogram
MHz	Megahertz
mm	Millimeter
MRI	Magnetic resonance imaging
NDI	Neck disability index
NDI-TH	Neck disability index-thai version
RUSI	Rehabilitative ultrasound imaging
VAS	Visual analog scale
WAD	Whiplash-associated disorders
yrs	Years

CHAPTER 1

Introduction

1.1 Rationale

The lower trapezius muscle, which is one of the axioscapular muscles works together with the upper and middle trapezius and serratus anterior in stabilizing the scapula both in static and during shoulder movement (1). There is evidence that changes in behavior of the lower trapezius contribute to abnormal scapulohumeral rhythm and pain in shoulder (1-4). In addition, it has been suggested that changes in behavior of the lower trapezius can be associated with the initiation or perpetuation of chronic neck pain (5, 6). The association of the lower trapezius and neck pain may be explained by mechanical loading on pain sensitive cervicobrachial structures (7).

Several studies have demonstrated that patients with neck pain have altered activity of the lower trapezius muscle, although such alterations are likely to be dependent on task characteristic and measurement protocol used (5, 6). For example, Wegner et al (5) found decreased EMG activity of the lower trapezius during the typing task in patients with neck pain compared to controls. On the other hand, Zakharova-Luneva et al (6) reported greater EMG activity of the lower trapezius muscle at 20%, 50% and 100% maximum voluntary contraction in patients with chronic neck pain as compared to controls for the abduction and external rotation conditions. In addition, Petersen et al (8) investigating lower trapezius muscle strength in patients with unilateral neck pain demonstrated significantly less lower trapezius muscle strength on the symptomatic side compared to asymptomatic side. However, to date, there have been limited investigations of change in muscle thickness of the lower trapezius muscle in patients with chronic neck pain. The change in muscle thickness may provide objective information about the lower trapezius size, which will be useful for customizing rehabilitation programs.

Ultrasound imaging has been widely used to measure change in muscle thickness (9-12). There is evidence suggesting that ultrasound imaging is reliable and valid for measuring thickness of the lower trapezius muscle (13-15). Recently, Day et al (13) have examined the reliability for measuring scapular muscle thickness and how scapular muscle thickness changes with respect to external load in healthy individuals, using ultrasound imaging. The results showed good inter- and intra- reliability for the lower trapezius muscle (ICC = 0.86-0.99). The results also demonstrated that ultrasound imaging could be used to detect absolute change in thickness from resting to arm lifting (75% and 100% of isometric contraction) conditions but was yet unable to detect difference in lower trapezius muscle thickness between a low and high load placed on shoulder. The authors discussed that ultrasound imaging may not be sensitive enough to detect changes at higher levels of muscle contractility or the lower trapezius muscle may function independently of the demand placed on shoulder. Conversely, O'sullivan et al (16) demonstrated no difference in thickness of the lower trapezius at resting and during contraction at 90° and 120° of shoulder abduction between patients with shoulder pain and healthy controls. It seems that a change in thickness of the lower trapezius muscle may depend on loads, task characteristics as well as pathology. As investigation of thickness of the lower trapezius muscle either at resting or during contraction has not yet been conducted in patients with neck pain, this study was aim to investigate thickness of the lower trapezius at resting and during contraction at 120° of shoulder abduction in patients with neck pain compared to healthy controls. Shoulder in 120° of abduction was chosen as this is a standard position for manual muscle testing as described by Kendall et al (17). All participants in the study were alsoright hand dominant as hand dominance may have an effect on muscle thickness measured (7, 8).

1.2 Aims of the study

1. To compare resting thickness of the lower trapezius at 0° and 120° of shoulder abduction between patients with neck pain and controls
2. To compare thickness of the lower trapezius during contraction at 120° of shoulder abduction between patients with neck pain and controls

1.3 Hypotheses of the study

1. Thickness of the lower trapezius at resting at 0° and 120° of shoulder abduction in patients with neck pain would be less than controls
2. Thickness of the lower trapezius during contraction at 120° of shoulder abduction in patients with neck pain would be less than controls

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.

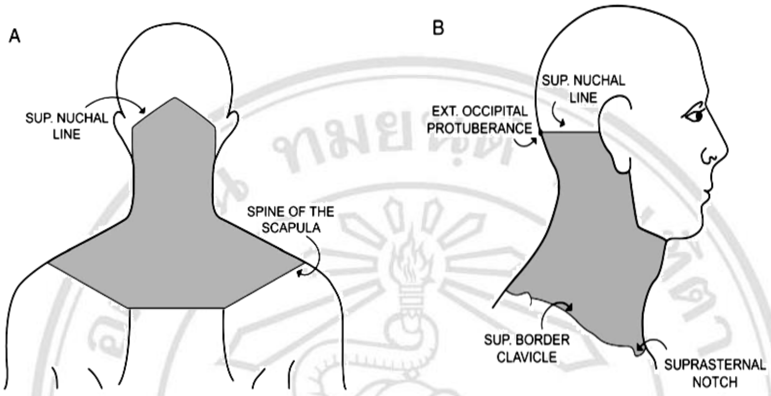

Figure 1 The anatomic region of the neck from the back (A) and the side (B) (20)

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.

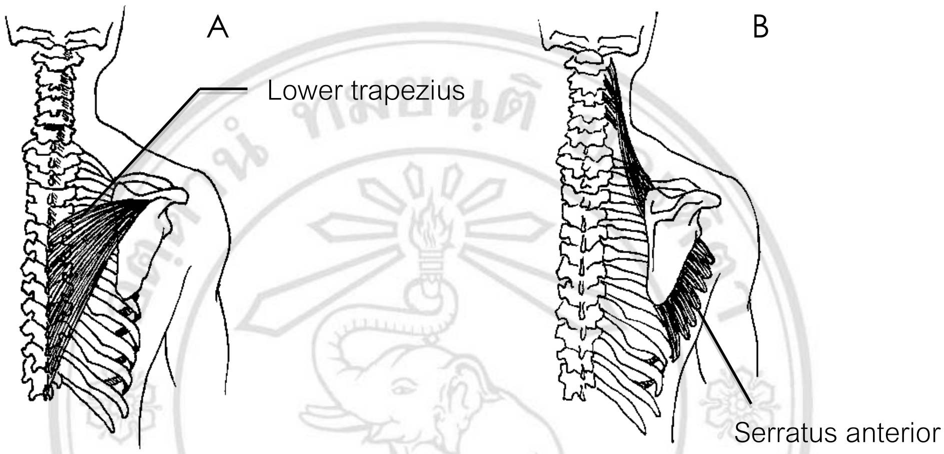

Figure 2 Lower trapezius muscle (A) Serratus anterior muscle (B) modified from Oatis (1)

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).

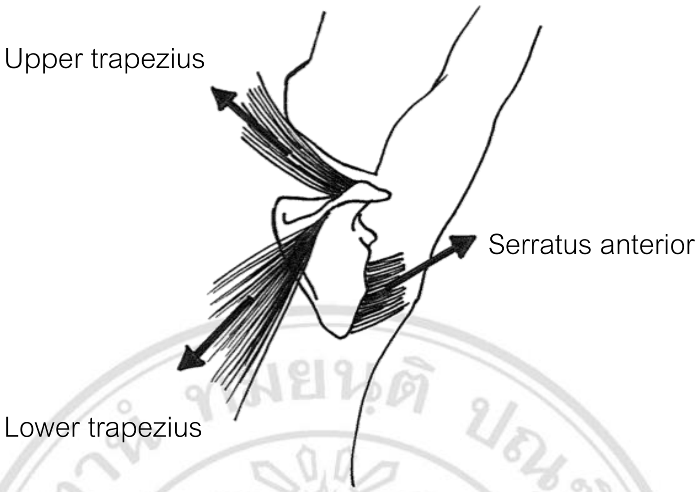

Figure 3 Force couple of the upper trapezius, lower trapezius and serratus anterior muscles modified from Oatis (1)

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.

CHAPTER 3

Methods

3.1 Sample size calculation

Sample size calculation in this study was based on our unpublished data of the lower trapezius thickness conducted in patients with unilateral neck pain (n = 30) and healthy controls (n = 30) utilizing the same ultrasound method at resting condition (0° shoulder abduction). The mean thickness of the lower trapezius muscle for the neck pain and control groups was 2.76 ± 0.66 and 3.28 ± 0.75, respectively. To achieve a power of 80% with a significance level of 0.05 and effect size of 0.74, a total of 48 subjects (the neck pain group = 24 and the control group = 24) were recruited for the study.

3.2 Participants

Twenty-four volunteers with chronic neck pain aged between 18 and 59 years were recruited through advertising in physical therapy clinics, hospitals and community. Twenty-four matched controls of age, gender and body mass index were also sought for the study. Inclusion and exclusion criteria for both groups were as follows.

3.2.1 Inclusion criteria for the neck pain group:

1) Had been suffering from chronic neck pain for at least 3 months
2) Had unilateral (right) idiopathic neck pain Grade I or II
3) Had the Neck Disability Index score of > 10/100
4) Had a dominant right hand which was considered according to Yoshizaki et al's study (56)

3.2.2 Inclusion criteria for the control group:

1) Had no history of neck pain for 12-month period (VAS < 2/10)

2) Had a dominant right hand which was considered according to Yoshizaki et al's study (56)

3.2.3 Exclusion criteria for the neck pain and control groups:

1) Had a history of neck surgery
2) Had a training program involving the scapular muscles in the past 12 months
3) Had fibromyalgia or myofascial pain
4) Had systemic diseases
5) Had neurological disorders
6) Had shoulder/back disorders
7) Had a severe scoliosis

The study was approved by Human Experimental Committee of Faculty of Associated Medical Sciences, Chiang Mai University and the informed consent was obtained from each participant prior to commencement of the study.

3.3 Measurements

3.3.1 Questionnaires

1) A General questionnaire

General questionnaire was developed to include demographic data and neck pain characteristics (i.e. duration, sides and associated symptoms of neck pain). Details of the questionnaire are provided in Appendix D1.

2) Visual Analog scale (VAS)

Visual analog scale (VAS) is commonly used to evaluate pain perception in both research and clinical settings (66) and has shown high reliability and validity (67, 68). It consists of a 100-mm horizontal line (69). Participants were asked to rate their level of pain in their neck from the no pain (0 cm) anchored on the left to the worst pain imaginable (10 cm) anchored on the right. The distance from the ‘‘no pain’’ anchor to this mark was measured by a ruler in millimeters (mm) and used as the overall pain intensity score (70, 71). The overall pain score could range from 0 to 100 (71). Details of this questionnaire are provided in Appendix D2.

3) Neck Disability Index-Thai version (NDI-TH)

The Neck Disability Index (NDI) is a self-reporting of neck disability questionnaire (68). It includes 10 items: pain intensity, personal care, lifting, reading, headaches, concentration, work, driving, sleeping, and recreation. Each item is scored out of 5 with a maximum total score of 50 (72). The interpretation of the NDI score is as follows: 0-4 = none; 5-14 = mild disability; 15-24 = moderate disability; 25-34 = severe disability; over 34 = complete disability. The NDI-TH has been translated from the original English versions of the NDI and shown to be valid and reliable for measure neck disability in Thai patients with neck pain (73). Details of this questionnaire are provided in Appendix D3.

3.3.2 Ultrasound imaging

A real-time ultrasound scanner (Toshiba Famio 8, Tokyo, Japan) with a 12-MHz linear transducer was used to image the lower trapezius muscle, according to the procedure described by O'Sullivan et al (16). The lower trapezius muscle was imaged at the spinous process of T8. The transducer was placed centrally and moved laterally over the inferior edge of the T8 spinous process to image the lower trapezius muscle. The echogenic bone of the T9 spinous process was identified and maintained as a consistent landmark to capture the muscle. The transducer might be angled slightly caudad or cephalad to capture the best images. The images of the lower trapezius muscle were measured twice both sides.

The thickness of the lower trapezius was measured by a blinded investigator using Image J software (available for free download at http://rsb.info.nih.gov/ij/docs/index.html). The cursor was placed on the inside edge of the muscle border and the measurement was made at 3 cm lateral to the lateral edge of the spinous process (Figure 4).

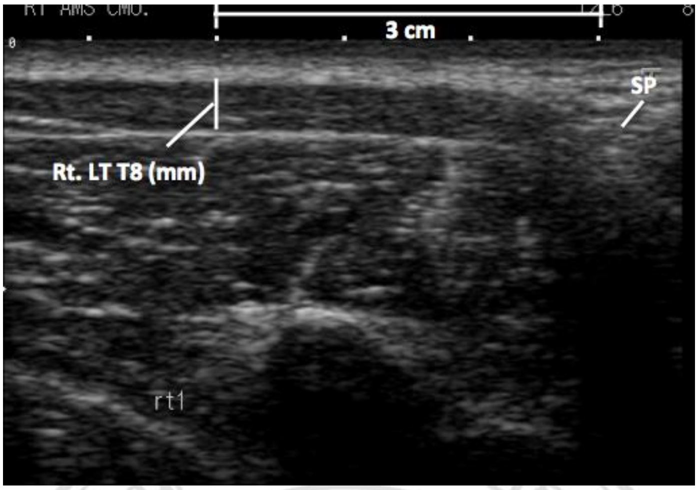

Figure 4 Measurement of the thickness of the lower trapezius muscle

The reliability of the measurement of the lower trapezius thickness in this study had been shown to be good to excellent ($ICC_{3, 1}$ for intra-reliability = 0.86 and $ICC_{2, 1}$ for inter-reliability = 0.92). Details of the inter- and intra-reliability are provided in Appendix E1 and E2.

3.4 Procedures

On the testing day, all participants completed a consent form and general questionnaire. Participants with neck pain also completed the neck disability index-TH version (NDI-TH) (68) and visual analogue scale (VAS). Participants were then positioned prone on a treatment plinth with the head in midline, the arms close to the side and the palms facing the ceiling (14-16). An investigator who was blinded to the participant's condition palpated the spinous process of T8 and marked with a non-permanent marker as a reference line for imaging the lower trapezius muscle. The ultrasound imaging measurement of the lower trapezius muscle was performed both sides under a standard set of conditions: (1) at rest at 0° shoulder abduction; (2) at rest at 120° shoulder abduction and; (3) during contraction at 120° shoulder abduction. For the first condition, participants were instructed to completely relax with their arms remaining at their side. For the second condition, participant's arm was positioned at 120° abduction measured by a goniometer (16). This position was relevant to the line of the lower trapezius muscle fibers and recommended as a standard position for manual muscle testing (17). Participants were then asked to maintain the position and relax as much as possible. For the last condition, participants were asked to lift their arm straight up without any compensation. The height that participants could lift without compensation was set as a reference point, using an adjustable bar. To prevent compensation during the test, the other investigator stood at the side test and stabilized the contralateral scapula (8, 17, 48) (Figure 5). The side measured for all conditions was performed in a random order. Each condition was captured two times with a 30-60 second rest between images and each image captured was measured twice using Image J software. The mean values of each side for each condition were used for further analysis. A flow chart of the study is shown in Figure 6.

Figure 5 The ultrasound imaging measurement of the lower trapezius muscle during contraction at 120° shoulder abduction

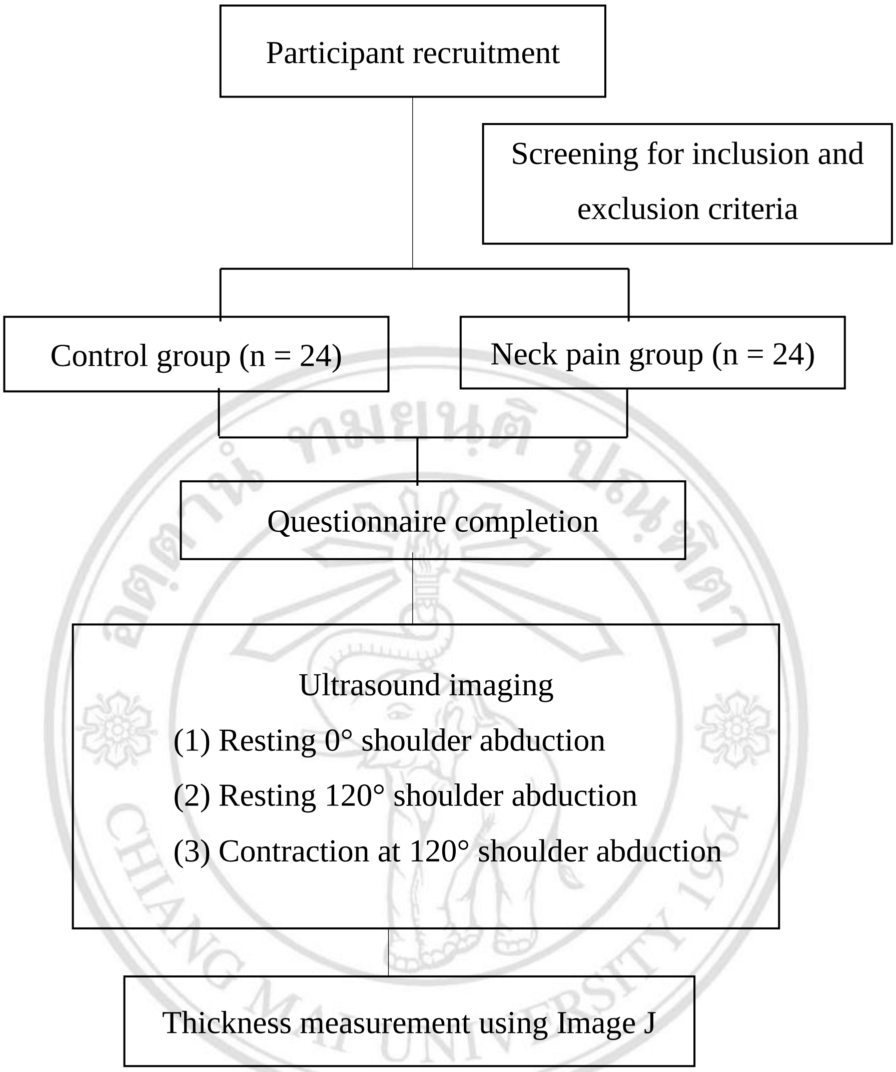

Figure 6 Flow chart of the study procedure

3.5 Independent and dependent variables

3.5.1 Independent variable

Subject group (patients with neck pain and controls)

3.5.2 Dependent variable

The average thickness of the lower trapezius muscle

3.6 Statistical analysis

Kolmogorov-Smirnov test was used to test normality of the variables. Independent *t*-test was then used to determine differences in demographic data and the thickness of the lower trapezius in each condition between the neck pain and control groups. Dependent t-test was further used to determine differences in the muscle thickness between sides for each group. A significance level was set at 0.05. All statistical analyses were analyzed by SPSS (version 16.0).

3.7 Location

The study was conducted at the Radiologic Technology Clinic and Department of Physical Therapy, Faculty of Associated Medical Sciences, Chiang Mai University.

CHAPTER 4

Results

4.1 Demographics of participants

Demographic data for participants in the neck pain and control groups are shown in Table 1. Two outliers (one neck pain and one control) were excluded from the analysis. There were no significant differences in age, weight, height and BMI between the neck pain and control groups (all $p > 0.05$), except for the VAS and NDI scores ($p < 0.05$).

Table 1 Demographic data of the participants

Variables	(mean ± sd)		*p*-value
	Neck pain (n = 23)	Control (n = 23)	
Gender			
Male : Female (n)	2 : 21	2 : 21	-
Age (yrs)	27.52 ± 5.33	27.00 ± 5.46	0.75
Weight (kg)	54.52 ± 7.50	53.28 ± 7.84	0.59
Height (cm)	160.57 ± 6.93	161.09 ± 5.96	0.79
BMI (kg/m^2)	21.17 ± 2.76	20.48 ± 2.32	0.37
VAS (0-10)	5.16 ± 1.95	0.53 ± 0.84	<0.01
NDI (0-100)	22.35 ± 8.15	3.39 ± 3.22	<0.01

Values represent mean ± sd

BMI = Body Mass Index, VAS = Visual Analog Scale, NDI = Neck Disability Index

4.2 Thickness of the lower trapezius

Table 2 shows the mean values and standard deviations for the left and right sides of the lower trapezius thickness between the neck pain and control groups. The results of Independent *t*-test revealed no significant differences between groups in the thickness of the lower trapezius both sides in all conditions (all $p > 0.05$), except for that on the right side at resting at 0° of shoulder abduction condition, which the neck pain group had smaller thickness than the control group ($p < 0.05$).

The results of dependent *t*-test revealed no differences in the thickness of the lower trapezius between the left and right sides in all conditions in the neck pain group (all $p > 0.05$). In the control group, the thickness of the lower trapezius on the right side was greater than that on the left side in all condition (all $p < 0.05$).

Table 2 Thickness of the lower trapezius muscle in the neck pain and control groups

	Thickness (mm)	
	Neck pain group (n = 23)	Control group (n = 23)
At rest 0°		
Left	2.38 ± 0.94	2.54 ± 0.91
Right	2.55 ± 0.66 [a]	2.96 ± 0.98 [b]
At rest 120°		
Left	2.88 ± 1.14	2.99 ± 0.95
Right	3.14 ± 0.90	3.32 ± 1.02 [b]
At contraction 120°		
Left	4.37 ± 2.58	4.44 ± 1.98
Right	4.57 ± 1.94	5.28 ± 2.39 [b]
Difference in thickness at 120°		
Left	1.49 ± 1.89	1.45 ± 1.32
Right	1.43 ± 1.46	1.96 ± 1.70 [b]

Values are presented as mean ± SD

[a] $p < 0.05$ compared between neck pain and control groups

[b] $p < 0.05$ compared between the left and right sides

CHAPTER 5

Discussion

This study has investigated thickness of the lower trapezius muscle at rest at 0° and 120° and during contraction at 120° of shoulder abduction using ultrasound imaging in patients with neck pain compared to healthy controls. The results partially support our hypotheses. The first hypothesis of this study was that thickness of the lower trapezius at rest at 0° and 120° of shoulder abduction would be less in patients with neck pain than controls. Our findings found that the neck pain group had smaller thickness of the lower trapezius muscle than the control group on the right side at rest at 0° of shoulder abduction only. There were no differences in the thickness at rest at 120° of shoulder abduction and during contraction. The second hypothesis was that thickness of the lower trapezius during contraction at 120° of shoulder abduction would be less in patients with neck pain compared to controls. The results demonstrated no differences in thickness of the lower trapezius muscle during contraction between the neck pain and control groups. Furthermore, the results of this study found symmetry in the lower trapezius muscle thickness between the left and right sides in all conditions in patients with neck pain but bilateral asymmetry in healthy controls.

5.1 Thickness of the lower trapezius muscle

This study demonstrated decreased thickness of the lower trapezius muscle at rest (0° shoulder abduction) on the painful side in patients with neck pain compared to controls. There was no difference in the lower trapezius muscle thickness at rest and during contraction of 120° shoulder abduction between the neck pain and control groups. However, the average of the lower trapezius muscle thickness on the painful side during contraction were likely to be less in patients with neck pain, but the difference between groups did not reach a statistical significance. These results are partially supported by a previous study conducted by O'sullivan et al (16). They investigated percentage thickness change of the lower trapezius muscle during isometric contraction between patients with and without shoulder pain, and between painful and non-painful sides. They demonstrated no differences between sides and groups in resting and contracted muscle thickness at 0°, 90°, and 120° of shoulder abduction in patients with unilateral shoulder pain. The percentage thickness changes during contraction at 120° were higher in the painful side than the non-painful side however the difference was not statistically significant. The discrepancy between O'sullivan et al's and our results may be due to variations between individuals and tasks. Recently, Hodges and Tucker (74) have proposed a new theory to explain the motor change in pain. Responses of muscle activity are likely to vary according to muscles and tasks. There are also various options of the nervous system to achieve the protection from pain or injury. Thus decrease or increased muscle activity can be associated with pain. The decreased thickness of the lower trapezius muscle on the painful side in this study may be due to changes in muscle activity with pain (75). Alternatively, it has been suggested that impaired function of the scapular control can produce compressive force on the cervical spine (50). Thus the thickness that decreased in the painful side may be associated with poor scapular control.

On the other hand, the results of this study are consistent to previous studies which demonstrated impairment of the lower trapezius muscle using EMG in patients with neck pain (5, 6). Wegner et al (5) reported decrease in EMG activity of the lower trapezius muscle in patients with neck pain during the typing task compared to controls. Zakharova-Luneva et al (6) also found that patients with neck pain had greater EMG activity of the lower trapezius muscle at 20%, 50% and 100% maximum voluntary contraction (MVC) than controls for the abduction and external rotation conditions.

As mentioned earlier, activity of muscle can vary between tasks. Thus this may be one reason for no difference in the lower trapezius thickness during contraction but at rest at 0° of shoulder abduction in this study. Another reason may be associated with level of muscle contraction tested in this study. Hodges et al (57) investigated thickness of several human muscles using ultrasound imaging during isometric contraction (0-100% maximum voluntary contraction) and found that only low levels of muscle activity (< 30% MVC) could be detected by ultrasound imaging. Ultrasound measure of thickness could not differentiate between moderated to strong contraction. In this study, participant's arm was placed at abduction angle of 120° and then we asked the participant to lift his/her arm off the bed and hold for 5-10 seconds. This may exceed low level of muscle contraction. However, force and EMG muscle activity were not measured, which is a study limitation. In addition, lifting arm at abduction angle of 120° activated not only the lower part of the trapezius muscle but also the upper and middle parts (76). Thus, different patterns of muscle activation may be another possible factor. Increase in thickness during contraction may indicate muscle contraction which is useful for clinicians training lower trapezius muscle. Although there was no significant difference in thickness during contraction between groups, it was noted that the neck pain group had a reduction in muscle contraction of the lower trapezius muscle in the right side but not the left side compared to the control. This may suggest that the lower trapezius muscle contraction is influenced by pain in the neck.

Decrease in the lower trapezius thickness during contraction was observed in some cases, particularly in the control group. We have noticed on the screen during contraction that muscle in those was pulled medially. The imaging site (3 cm lateral to spinous process at T8) may be relatively far from the spinous process, accounting for a thinner portion of the thickness measured. Furthermore, only thickness was imaged in this study. Hides et al (77) previously found lateral sliding of muscle-fascia junction of transverses abdominis (TrA) muscle in healthy controls using ultrasound imaging during a drawing-in of the abdominal wall. Gildea et al (78) also reported that small degree of TrA lateral sliding in patients with low back pain compared to controls but there was no difference in TrA thickness between the two groups. Thus, sliding patterns of muscle-fascia junction may also be associated with changes in thickness of the lower trapezius muscle between the neck pain and control group. Further research in this area is still required.

In addition, the results of this study demonstrated identical thickness of the lower trapezius muscle between the right (painful) side and left (non-painful side) side in patients with neck pain whereas the control group had a greater thickness in the dominant side than the non-dominant side. These results support other (79) and our previous findings (unpublished data). Wannaprom et al (79) investigated thickness of the lower trapezius muscle between the dominant and non-dominant arms in healthy controls and found thickness of the dominant arm was greater than the non-dominant-arm. Likewise, Yoshizaki et al (56) reported that dominant arm had a greater percent integrated electromyography (%IEMG) of the lower trapezius than non-dominant arm in healthy controls. The lower trapezius muscle identical in size in patients with unilateral neck pain may be due to atrophy of muscle on the side ipsilateral to pain.

From the results of this study, it may indicate that ultrasound imaging can be used to detect thickness of the lower trapezius muscle at rest (0° of shoulder abduction) in patients with neck pain. To detect impairment of the lower trapezius muscle using ultrasound during isometric contraction, further research is warranted.

5.2 Clinical implications and limitations

The study confirms impairment of the lower trapezius muscle in patients with neck pain. It also provides further information about the use of ultrasound imaging to detect thickness of the lower trapezius in patients with neck pain. The results suggest atrophy of the lower trapezius muscle in patients with neck pain. However, the evidence of decreased thickness of the lower trapezius muscle was observed at rest but not during contraction. Evaluation of thickness of the lower trapezius muscle using ultrasound may assist clinicians to determine dysfunction of the lower trapezius muscle associated with neck pain in clinics. Also, clinicians should also be aware that size of muscle is not necessary to be symmetrical. It may depend on several factors such as pain side, hand dominance and functional characteristics of muscles.

There are some limitations in this study. The sample size of this study was small. The statistical power levels of the non-significant results (at rest and during contraction at 120° conditions) were less than 0.8, indicating inadequate power to detect statistical significance. Only the lower part of the trapezius muscle was measured as one transducer could be used at one time. Simultaneous recording of muscle activity and force were also not made. Moreover, it was not possible to control scapula during contraction between individuals. There may also be different patterns of muscle activation. Additionally, the task for muscle contraction was tested according to anatomical structure but not be part of functional activity. Muscle fatigue may also be occurred during contraction test. Patients with neck pain in this study had mild intensity and disability of pain and pain on the dominant side. Thus the results may not be directly applied to those with higher level of pain and/or having pain on the non-dominant side.

5.3 Future directions in research

The results of this study demonstrated decreased thickness of the lower trapezius muscle at 0° of shoulder abduction in patients who had unilateral neck pain on the same side as their dominant hand. Future research using different ways to detect dysfunction of the lower trapezius muscle during contraction is required. Sliding pattern of muscle should also be addressed. Investigation of simultaneous ultrasound imaging, EMG activity and force would help to provide better understanding of relationships between thickness, muscle activation and strength of the lower trapezius muscle. Testing position should also be addressed. Further research should investigate level of the cervical joint that effect on thickness of the lower trapezius muscle. Additionally, future research should investigate thickness of the lower trapezius muscle in relative to other muscles as well as during functional tasks. Moreover, a clinical trial study investigating the effectiveness of specific exercise training on the lower trapezius muscle in patients with neck pain would also assist in supporting the contribution of the lower trapezius muscle to pain in the cervical spine.

5.4 Conclusion

The results of this study demonstrated that patients with neck pain had smaller thickness of the lower trapezius muscle at rest 0° of shoulder abduction on the painful side compared to control but not at rest and during contraction of 120° shoulder abduction. This suggests that impairment of the lower trapezius muscle at rest 0° of shoulder abduction can be detected by ultrasound imaging. However investigation of size of the lower trapezius muscle during contraction is still warranted. Future research is also required to identify pattern of the lower trapezius muscle during functional activity in patients with neck pain. This will provide better understanding of the association of the lower trapezius muscle and neck pain.

REFERENCES

1. Oatis CA. Kinesiology: the mechanics and pathomechanics of human movement. Philadelphia: Lippincott Williams and Wilkins; 2004.

2. Ludewig PM, Cook TM. Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. Phys Ther. 2000;80:276-91.

3. Matias R, Pascoal AG. The unstable shoulder in arm elevation: a three-dimensional and electromyographic study in subjects with glenohumeral instability. Clin Biomech. 2006;21:52-8.

4. Lin JJ, Wu YT, Wang SF, Chen SY. Trapezius muscle imbalance in individuals suffering from frozen shoulder syndrome. Clini Rheumatol. 2005;24:569-75.

5. Wegner S, Jull G, O'Leary S, Johnston V. The effect of a scapular postural correction strategy on trapezius activity in patients with neck pain. Man Ther. 2010;15:562-6.

6. Zakharova-Luneva E, Jull G, Johnston V, O'Leary S. Altered trapezius muscle behavior in individuals with neck pain and clinical signs of scapular dysfunction. J Manipulative Physiol Ther. 2012;35:346-53.

7. Behrsin JF, Maguire K. Levator scapulae action during shoulder movement: a possible mechanism of shoulder pain of cervical origin. Aust J Physiother. 1986;32:101-6.

8. Petersen SM, Wyatt SN. Lower trapezius muscle strength in individuals with unilateral neck pain. J Orthop Sports Phys Ther. 2011;41:260-5.

9. Critchley DJ, Coutts FJ. Abdominal muscle function in chronic low back pain patients: measurement with real-time ultrasound scanning. Phys Ther. 2002;88:322-32.

10. McMeeken JM, Beith ID, Newham DJ, Milligan P, Critchley DJ. The relationship between EMG and change in thickness of transversus abdominis. Clin Biomech. 2004;19:337-42.

11. Young A, Stokes M, Crowe M. Size and strength of the quadriceps muscles of old and young women. Eur J Clin Invest. 1984;14:282-7.

12. Teyhen DS, Bluemle LN, Dolbeer JA, Baker SE, Molloy JM, Whittaker J, et al. Changes in lateral abdominal muscle thickness during the abdominal drawing-in maneuver in those with lumbopelvic pain. J Orthop Sports Phys Ther. 2009;39:791-8.

13. Day JM, Uhl T. Thickness of the lower trapezius and serratus anterior using ultrasound imaging during a repeated arm lifting task. Man Ther. 2013;18:588-93.

14. O'Sullivan C, Bentman S, Bennett K, Stokes M. Rehabilitative ultrasound imaging of the lower trapezius muscle: technical description and reliability. J Orthop Sports Phys Ther. 2007;37:620-6.

15. O'Sullivan C, Meaney J, Boyle G, Gormley J, Stokes M. The validity of rehabilitative ultrasound imaging for measurement of trapezius muscle thickness. Man Ther. 2009;14:572-8.

16. O'Sullivan C, McCarthy Persson U, Blake C, Stokes M. Rehabilitative ultrasound measurement of trapezius muscle contractile states in people with mild shoulder pain. Man Ther. 2012;17:139-44.

17. Kendall FP, McCreary EK, Provance PG. Muscles testing and function. 4th ed. Philadelphia: Lippincott Williams and Wilkins; 1993.

18. Misailidou V, Malliou P, Beneka A, Karagiannidis A, Godolias G. Assessment of patients with neck pain: a review of definitions, selection criteria, and measurement tools J Chiropr Med. 2010;9:49-59.

19. Merskey H, Bogduk N, editors. Classification of chronic pain. Descriptions of chronic pain syndromes and definitions of pain terms. 2nd ed. Seattle: IASP Press; 1994:11.

20. Guzman J, Hurwitz EL, Carroll LJ, Haldeman S, Côté P, Carragee EJ, et al. A new conceptual model of neck pain: linking onset, course, and care: the bone and joint decade 2000-2010 task force on neck pain and its associated disorders. J Manipulative Physiol Ther. 2009;32:17-28.

21. Bogduk N, McGuirk B. Management of acute and chronic neck pain: an evidence based approach. Pain research and clinical management. Philadelphia: Elsevier; 2006.

22. Spitzer WO, Skovron ML, Salmi LR, Cassidy JD, Duranceau J, Suissa S, et al. Scientific monograph of the quebec task force on whiplash-associated disorders: redefining "whiplash" and its management. Spine. 1995;20:1-73.

23. Bongers PM, Ijmker S, van den Heuvel S, Blatter BM. Epidemiology of work related neck and upper limb problems: psychosocial and personal risk factors (part I) and effective interventions from a bio behavioural perspective (part II). J Occup Rehabil. 2006;16:279-302.

24. Dorshimer GW, Kelly M. Cervical pain in the athlete: common conditions and treatment. Prim Care 2005;32:231-43.

25. Borghouts JA, Koes BW, Bouter LM. The clinical course and prognostic factors of non-specific neck pain: a systematic review. Pain. 1998;77:1-13.

26. Australian Acute Musculoskeletal Pain Guidelines Group. Evidence-based management of acute musculoskeletal pain: a guide for clinicians.Brisbane:Australian Academic Press; 2004; Available from: http://www.nhmrc.gov.au.

27. International Association for the Study of Pain (IASP). IASP Task Force for Taxonomy. Pain Terminology. Seattle: IASP; 2004.

28. Hogg-Johnson S, van der Velde G, Carroll LJ, Holm LW, Cassidy JD, Guzman J, et al. The burden and determinants of neck pain in the general population: results of the bone and joint decade 2000-2010 task force on neck pain and its associated disorders. J Manipulative Physiol Ther. 2009;32:46-60.

29. Picavet HS, Schouten JS. Musculoskeletal pain in the Netherlands: prevalences, consequences and risk groups, the DMC3-study. Pain. 2003;102:167-78.

30. Côté P, van der Velde G, Cassidy JD, Carroll LJ, Hogg-Johnson S, Holm LW, et al. The burden and determinants of neck pain in workers: results of the bone and joint decade 2000-2010 task force on neck pain and its associated disorders. J Manipulative Physiol Ther. 2009;32:70-86.

31. Cassou B, Derriennic F, Monfort C, Norton J, Touranchet A. Chronic neck and shoulder pain, age, and working conditions: longitudinal results from a large random sample in France. Occup Environ Med. 2002;59:537-44.

32. Côté P, Carroll LJ, Kristman V. The annual incidence and course of neck pain in the general population: a population-based cohort study. Pain. 2004;112:267-73.

33. Gerr F, Marcus M, Ensor C, Kleinbaum D, Cohen S, Edwards A, et al. A prospective study of computer users: I. Study design and incidence of musculoskeletal symptoms and disorders. Am J Ind Med. 2002;41:221-35.

34. Hamberg-van Reenen HH, Ariens GA, Blatter BM, Twisk JW, van Mechelen W, Bongers PM. Physical capacity in relation to low back, neck, or shoulder pain in a working population. Occup Environ Med. 2006;63:371-7.

35. Ostergren PO, Hanson BS, Balogh I, Ektor-Andersen J, Isacsson A, Orbaek P, et al. Incidence of shoulder and neck pain in a working population: effect modification between mechanical and psychosocial exposures at work? results from a one year follow up of the malmo shoulder and neck study cohort. J Epidemiol Community Health. 2005;59:721-8.

36. Wahlstrom J, M Hagberg M, Toomingas A, Tornqvist EW. Perceived muscular tension, job strain, physical exposure, and associations with neck pain among VDU users; a prospective cohort study. Occup Environ Med. 2004;61:523-8.

37. Luime JJ, Kuiper JI, Koes BW, Verhaar JA, Miedema HS, Burdorf A. Work-related risk factors for the incidence and recurrence of shoulder and neck complaints among nursing-home and elderly-care workers. Scand J Work Environ Health. 2004;30:279-86.

38. Smedley J, Inskip H, Trevelyan F, Buckle P, Cooper C, Coggon D. Risk factors for incident neck and shoulder pain in hospital nurses. Occup Environ Med. 2003;60:864-9.

39. Ariëns GAM, Bongers PM, Douwes M, Miedema MC, Hoogendoorn WE, van der Wal G, et al. Are neck flexion, neck rotation, and sitting at work risk factors for neck pain? results of a prospective cohort study. Occup Environ Med. 2001;58:200-7.

40. Johnston V, Souvlis T, Jimmieson NL, Jull G. Associations between individual and workplace risk factors for self-reported neck pain and disability among female office workers. Appl Ergon. 2008;39:171-82.

41. Brandt LPA, Andersen JH, Lassen CF, Kryger A, Overgaard E, Vilstrup I, et al. Neck and shoulder symptoms and disorders among Danish computer workers. Scand J Work Environ Health. 2004;30:399-409.

42. Eriksen W, Natvig B, Knardahl S, Bruusgaard D. Job characteristics as predictors of neck pain: a 4-year prospective study. J Occup Environ Med. 1999;41:893-902.

43. La Touche R, Fernández-de-las-Peñas C, Fernández-Carnero J, Díaz-Parreño S, Paris-Alemany A, Arendt-Nielsen L. Bilateral mechanical-pain sensitivity over the trigeminal region in patients with chronic mechanical neck pain. J Pain. 2010;11:256-63.

44. Sahrmann SA. Diagnosis and treatment of movement impairment syndromes. St. Louis: Mosby; 2002.

45. Mottram SL, Woledge RC, Morrissey D. Motion analysis study of a scapular orientation exercise and subjects' ability to learn the exercise. Man Ther. 2009;14:13-8.

46. Sobush DC, Simoneau GG, Dietz KE, Levene JA, Grossman RE, Smith WB. The lennie test for measuring scapular position in healthy young adult females: a reliability and validity study. J Orthop Sports Phys Ther. 1996;23:39-50.

47. Ludewig PM, Reynolds JR. The association of scapular kinematics and glenohumeral joint pathologies. J Orthop Sports Phys Ther. 2009;39:90-104.

48. Ekstrom RA, Soderberg GL, Donatelli RA. Normalization procedures using maximum voluntary isometric contractions for the serratus anterior and trapezius muscles during surface EMG analysis. J Electromyogr Kinesiol. 2005;15:418-28.

49. Hodges PW, Richardson CA. Inefficient muscular stabilization of the lumbar spine associated with low back pain: a motor control evaluation of transversus abdominis. Spine. 1996;21:2640-50.

50. Janda V. Muscles and motor control in cervicogenic disorder: assessment and management. In: Grant R, editor. Physical therapy of the cervical and thoracic spine. 2nd ed. New York: Churchill Livingstone; 1994. p. 195-215.

51. Falla D, Farina D, Graven-Nielsen T. Experimental muscle pain results in reorganization of coordination among trapezius muscle subdivisions during repetitive shoulder flexion. Exp Brain Res. 2007;178:385-93.

52. Falla D, Bilenkij G, Jull G. Patients with chronic neck pain demonstrate altered patterns of muscle activation during performance of a functional upper limb task. Spine. 2004;29:1436-40.

53. Freilich RJ, Kirsner RLG, Byrne E. Isometric strength and thickness relationships in human quadriceps muscle. Neuromuscul Disord. 1995;5:415-22.

54. Lindle RS, Metter EJ, Lynch NA, Fleg JL, Fozard JL, Tobin J, et al. Age and gender comparisons of muscle strength in 654 women and men aged 20-93 yr. J Appl Physiol. 1997;83:1581-7.

55. McCreesh K, Egan S. Ultrasound measurement of the size of the anterior tibial muscle group: the effect of exercise and leg dominance. Sports Med Arthrosc Rehabil Ther Technol. 2011;3:1-6.

56. Yoshizaki K, Hamada J, Tamai K, Sahara R, Fujiwara T, Fujimoto T. Analysis of the scapulohumeral rhythm and electromyography of the shoulder muscles during elevation and lowering: comparison of dominant and nondominant shoulders. J Shoulder Elbow Surg. 2009;18:756-63.

57. Hodges PW, Pengel LHM, Herbert RD, Gandevia SC. Measurement of muscle contraction with ultrasound imaging. Muscle Nerve. 2003;27:682-92.

58. Chan V, Perlas A. Basics of ultrasound imaging. In: Narouze S, editor. Atlas of ultrasound-guided procedures in interventional pain management: Springer New York; 2011.

59. Whittaker JL, Teyhen DS, Elliot JM, Cook K, Langevin HM, Dahl HH, et al. Rehabilitative ultrasound imaging: understanding the technology and its applications. J Orthop Sports Phys Ther. 2007;37:434-49.

60. Contreras Ortiz SH, Chiu T, Fox MD. Ultrasound image enhancement: a review. Biomed Signal Process Control. 2012;7:419-28.

61. McDicken WN. Diagnostic ultrasonics. Edinburgh, UK: W.B. Saunders Company; 1991.

62. Lee JP, Tseng WY, Shau YW, Wang CL, Wang HK, Wang SF. Measurement of segmental cervical multifidus contraction by ultrasonography in asymptomatic adults. Man Ther. 2007;12:286-94.

63. Hides JA, Richardson CA, Jull GA. Magnetic resonance imaging and ultrasonography of the lumbar multifidus muscle: comparison of two different modalities. Spine. 1995;20:54-8.

64. Stokes M, Rankin G, Newham DJ. Ultrasound imaging of lumbar multifidus muscle: normal reference ranges for measurements and practical guidance on the technique. Man Ther. 2005;10:116-26.

65. Bunce SM, Hough AD, Moore AP. Measurement of abdominal muscle thickness using M-mode ultrasound imaging during functional activities. Man Ther. 2004;9:41-4.

66. Hodgins MJ. Interpreting the meaning of pain severity scores. Pain Res Manage. 2002;7:192-8.

67. Bijur PE, Silver W, Gallagher EJ. Reliability of the visual analog scale for measurement of acute pain. Acad Emerg Med. 2001;8:1153-7.

68. Vernon H, Mior S. The neck disability index: a study of reliability and validity. J Manipulative Physiol Ther. 1991;14:409-15.

69. Tashjian RZ, Deloach J, Porucznik CA, Powell AP. Minimal clinically important differences (MCID) and patient acceptable symptomatic state (PASS) for visual analog scales (VAS) measuring pain in patients treated for rotator cuff disease. J Shoulder Elbow Surg. 2009;18:927-32.

70. Jensen MP, Karoly P. Self-report scales and procedures for assessing pain in adults. In: Turk DC, Melzack R, editors. Handbook of pain assessment. 2nd ed. New York, NY: The Guilford Press; 2001.

71. Butler PV. Linear analogue self-assessment and procrustean measurement: a critical review of visual analogue scaling in pain assessment. J Clin Psychol Med Settings. 1997;4:111-29.

72. Vernon H. The neck disability index: state-of-the-art, 1991-2008. J Manipulative Physiol Ther. 2008;31:491-502.

73. Uthaikhup S, Paungmali A, Pirunsan U. Validation of Thai versions of the neck disability index and neck pain and disability scale in patients with neck pain. Spine. 2011;36:1415-21.

74. Hodges PW, Tucker K. Moving differently in pain: a new theory to explain the adaptation to pain. Pain. 2011;152:90-8.

75. Lund JP, Donga R, Widmer CG, Stohler CS. The pain-adaptation model: a discussion of the relationship between chronic musculoskeletal pain and motor activity. Can J Physiol Pharmacol. 1991;69:683-94.

76. Arlotta M, LoVasco G, McLean L. Selective recruitment of the lower fibers of the trapezius muscle. J Electromyogr Kinesiol. 2011;21:403-10.

77. Hides J, Wilson S, Stanton W, McMahon S, Keto H, McMahon K, et al. An MRI investigation into the function of the transversus abdominis muscle during "drawing-in" of the abdominal wall. Spine. 2006;31:175-8.

78. Gildea JE, Hides JA, Hodges PW. Morphology of the abdominal muscles in ballet dancers with and without low back pain: a magnetic resonance imaging study. J Sci Med Sport; 2013; Available from http://www.sciencedirect.com/science/article/pii/S1440244013001965.

79. Wannaprom N, Uthaikhup S. A comparison of the thickness of the lower trapezius muscle between the dominant and non-dominant arms in healthy subjects. Term paper, Chiang Mai University, 2013.

APPENDICES

Appendix A

Certificate of ethical clearance

เอกสารรับรองโครงการวิจัยโดยคณะกรรมการจริยธรรมการวิจัย

Certificate of Approval

No. 072/2014

Name of Ethics Committee : Ethics Committee, Faculty of Associated Medical Sciences, Chiang Mai University **Address of Ethics Committee :** 110 Intavaroros Rd., Amphoe Muang, Chiang Mai, Thailand 50200	
Principal Investigator : Miss Chalomjai Pensri Department of Physical Therapy. Faculty of Associated Medical Sciences, Chiang Mai University.	
Protocol title : Measurement of Thickness of the Lower Trapezius Muscle Using Ultrasound Imaging in Individuals with Chronic Neck Pain **STUDY CODE:** 004E/57	
Documents filed	**Document reference**
Research protocol	-Version 1.0 dated 10 January, 2014
Informed consent documents	-Version 1.0 dated 10 January, 2014
Patient information sheet	-Version 1.0 dated 10 January, 2014
Advertisements	-Version 1.0 dated 10 January, 2014
Principal Investigator Curriculum vitae	-Version 1.0 dated 10 January, 2014

Opinion of the Ethics Committee/Institutional Review Board :

The Ethics Committee has reviewed the protocol and documents above and give the favorable opinion

Date of Approval : January 30, 2014 **Expiration Date :** January 29, 2015

Progress report is required to be submitted to the Ethics Committee for continuing review

[ ] at 3 month interval
[ ] at 6 month interval
[√] annually (in this case please submit at least 60 days prior to expiration date)

This Ethics Committee is organized and operates according to GCPs and relevant international ethical guidelines, the applicable laws and regulations.

Signed : ....

(Assistant Professor Netr Suwankrughasn)

Chairperson, Faculty of Associated Medical Sciences

Signed : ....

(Assistant Professor Wasna Sirirungsi, Ph.D)

Dean, Faculty of Associated Medical Sciences

Appendix B

Consent form

หนังสือแสดงความยินยอมการเข้าร่วมในโครงการวิจัย

ข้าพเจ้านาย/นาง/นางสาว..ขอให้ความยินยอมของตนเองที่จะเข้าร่วมในการศึกษาวิจัยเรื่องการวัดความหนาของกล้ามเนื้อทราพีเซียสส่วนล่างโดยใช้ภาพถ่ายอัลตราซาวด์ในผู้ที่มีอาการปวดคอเรื้อรัง

ข้าพเจ้าได้รับทราบข้อมูลและคำอธิบายเกี่ยวกับการวิจัยนี้แล้ว ข้าพเจ้าได้มีโอกาสซักถามเกี่ยวกับการวิจัยนี้และได้รับคำตอบเป็นที่พอใจและเข้าใจแล้วข้าพเจ้ามีเวลาเพียงพอในการอ่านและทำความเข้าใจกับข้อมูลในเอกสารนี้อย่างถี่ถ้วน และได้รับเวลาเพียงพอในการตัดสินใจว่าจะเข้าร่วมการศึกษาวิจัยนี้หรือไม่

ข้าพเจ้าทราบว่าผู้วิจัยยินดีที่จะตอบคำถามประการใดที่ข้าพเจ้าอาจจะมีได้ตลอดระยะเวลาการเข้าร่วมการวิจัยครั้งนี้ ผู้วิจัยรับรองว่าจะเก็บข้อมูลเฉพาะที่เกี่ยวกับตัวข้าพเจ้าเป็นความลับ และจะเปิดเผยได้เฉพาะในรูปที่เป็นสรุปผลการวิจัย และผู้วิจัยจะปฏิบัติในสิ่งที่ไม่ก่อให้เกิดอันตรายต่อร่างกายหรือจิตใจของข้าพเจ้าตลอดการวิจัยนี้และรับรองว่าหากเกิดมีอันตรายใดๆ จากการวิจัยดังกล่าวข้าพเจ้าจะได้รับการดูแลรักษาอย่างเต็มที่

ข้าพเจ้ายินยอมเข้าร่วมการวิจัยโดยสมัครใจ และสามารถถอนตัวออกจากการวิจัยนี้เมื่อใดก็ได้โดยไม่มีผลกระทบต่อสิทธิในการรับการรักษาพยาบาลหรือสิทธิอื่นๆ ที่ข้าพเจ้าพึงได้รับ และกรณีที่เกิดข้อข้องใจหรือปัญหาที่ข้าพเจ้าต้องการปรึกษากับผู้วิจัย ข้าพเจ้าสามารถติดต่อกับผู้วิจัย คือนางสาวชโลมใจ เพ็ญศรี ได้ที่ คณะเทคนิคการแพทย์ สาขากายภาพบำบัด หมายเลขโทรศัพท์ 083-1674046 หรือ ผศ. ดร. สุรีพร อุทัยคุปต์ ที่ภาควิชากายภาพบำบัด คณะเทคนิคการแพทย์ มหาวิทยาลัยเชียงใหม่ หมายเลขโทรศัพท์ 0-5394-9249 หรือ 084-6112727

โดยการลงนามนี้ข้าพเจ้าไม่ได้สละสิทธิใดๆ ที่ข้าพเจ้าพึงมีทางกฎหมาย

ลายมือชื่ออาสาสมัคร..วันที่..............................

(...)

ลายมือชื่อผู้ให้ข้อมูลการวิจัย...วันที่..............................

(...)

พยาน...วันที่..............................

(...)

Appendix C

Information sheet

เอกสารชี้แจงโครงการวิจัย (ข้อมูลสำหรับอาสาสมัคร)

แนะนำโครงการวิจัย

การศึกษานี้เป็นโครงการวิจัยเกี่ยวกับการวัดความหนาของกล้ามเนื้อทราพีเซียส (กล้ามเนื้อสะบัก) ส่วนล่าง โดยใช้ภาพถ่ายอัลตราซาวด์ในผู้ที่มีอาการปวดคอเรื้อรังเปรียบเทียบกับผู้ที่ไม่มีอาการปวดคอ

ทำไมต้องทำวิจัยนี้

เนื่องจากอาการปวดคอพบได้บ่อยในกลุ่มประชากรโดยทั่วไปและจากการวิจัยที่ผ่านมาพบว่าผู้ที่มีอาการปวดคอส่วนใหญ่มักจะมีอาการอ่อนแรงและมีการทำงานที่ผิดปกติของกล้ามเนื้อสะบักส่วนล่าง การศึกษานี้จะทำให้ทราบถึงความหนาของกล้ามเนื้อสะบักส่วนล่างทั้งในขณะพักและในขณะที่มีการหดตัวในผู้ที่มีอาการปวดคอเรื้อรังข้างเดียวซึ่งผลการศึกษานี้จะเป็นประโยชน์ในการนำมาวางแผนการรักษาแก่ผู้ที่มีอาการปวดคอให้มีประสิทธิภาพมากยิ่งขึ้น

มีอาสาสมัครกี่คนที่จะเข้าร่วมโครงการวิจัยนี้

อาสาสมัครเพศหญิงและชายที่มีอายุระหว่าง 18 - 59 ปี จำนวน 48 คน แบ่งเป็นกลุ่มที่มีอาการปวดคอเรื้อรังข้างขวาแบบไม่ทราบสาเหตุจำนวน 24 คน และ กลุ่มที่ไม่มีอาการปวดคอจำนวน 24 คน

อะไรบ้างที่อาสาสมัครต้องทำหากเข้าร่วมโครงการวิจัย

อาสาสมัครจะต้องตอบแบบสอบถามข้อมูลทั่วไปและแบบสอบถามข้อมูลเกี่ยวกับความรุนแรงของ อาการปวดคอ และแบบสอบถามดัชนีวัดความบกพร่องความสามารถของคอ หลังจากนั้นท่านจะได้รับการ ตรวจประเมินการวัดความหนาของกล้ามเนื้อสะบักส่วนล่างทั้ง 2 ข้างขณะที่แขนพักข้างลำตัวและแขนกาง 120 องศา และขณะยกแขนขึ้นจากพื้นเตียง ด้วยเครื่องอัลตราซาวด์ โดยท่านจะต้องเปลี่ยนใส่เสื้อที่เปิดบริเวณสะบักและนอนคว่ำบนเตียงรักษา จากนั้นผู้ตรวจประเมินจะบีบเจลอัลตรา

ซาวด์ตรงบริเวณกล้ามเนื้อสะบักและตามด้วยการเคลื่อนหัวอัลตราซาวด์บนกล้ามเนื้อ การตรวจประเมินจะทำโดยนักกายภาพบำบัดที่เป็นเพศหญิงและในห้องตรวจที่ปิดมิดชิด

ท่านต้องอยู่ในโครงการวิจัยนี้นานเท่าไร?

ท่านจะได้รับการตรวจประเมินเพียงครั้งเดียว โดยเก็บข้อมูลจะใช้ระยะเวลาประมาณ 60 นาที

ท่านจะมีความเสี่ยงอะไรบ้างหากเข้าร่วมโครงการวิจัย?

ท่านจะมีความเสี่ยงน้อยมากในการเข้าร่วมโครงการวิจัย แต่ท่านอาจจะมีความเสี่ยงต่อการเกิดผื่นคันจากเจลอัลตราซาวด์ และ/หรือเมื่อยล้าเล็กน้อยจากการยกแขน แต่อย่างไรก็ตามทั้งนี้ผู้วิจัยจะมีการสอบถามความรู้สึกของท่านตลอดระยะเวลาที่มีการเก็บข้อมูลและให้ท่านพักในระหว่างการทดสอบ และหากท่านเกิดการแพ้จากเจลอัลตร้าซาวด์ ท่านจะได้รับการปฐมพยาบาลเบื้องต้น เช่น การทาด้วยคาลามายด์ หรือการนำส่งสถานพยาบาลตามความจำเป็น

การถอนท่านออกจากโครงการวิจัย

ท่านสามารถถอนตัวออกจากโครงการวิจัยได้ตลอดเวลาหากไม่ประสงค์ที่จะเข้าร่วมงานวิจัย โดยไม่จำเป็นต้องชี้แจงเหตุผลแก่ผู้วิจัย และการถอนตัวจากการศึกษาวิจัยดังกล่าวจะไม่กระทบต่อสวัสดิการการดูแลรักษาพยาบาลใดๆ ที่ท่านพึงจะได้รับ

ท่านจะได้รับประโยชน์อะไรบ้างจากการเข้าร่วมโครงการวิจัยนี้?

ท่านจะไม่ได้รับประโยชน์โดยตรงจากการเข้าร่วมโครงการวิจัย แต่ข้อมูลโดยรวมของงานวิจัยนี้จะ เป็นประโยชน์ต่อการวางแผนการรักษาในผู้ที่มีอาการปวดคอเรื้อรังให้มีประสิทธิภาพมากยิ่งขึ้น

การรักษาความลับเกี่ยวกับตัวท่าน

ข้อมูลส่วนตัวของท่านจะถูกปกปิดเป็นความลับ การนำเสนอข้อมูลและผลการศึกษาจะได้รับการรายงานเป็นค่าเฉลี่ยของผู้เข้าร่วมการศึกษาวิจัยทั้งหมด โดยไม่มีการเปิดเผยเอกลักษณ์เฉพาะบุคคล เอกสารทั้งหมดของการวิจัยครั้งนี้จะถูกเก็บรักษาไว้อย่างมิดชิดเป็นเวลา 5 ปีนับจากการศึกษาสิ้นสุดลง หลังจากนั้นเอกสารบันทึกข้อมูลทั้งหมดจะถูกทำลายด้วยวิธีการตัดย่อยสลายต่อไป

ท่านต้องเสียค่าใช้จ่ายหรือไม่?

ท่านไม่ต้องเสียค่าใช้จ่ายใดๆ ทั้งสิ้นในการเข้าร่วมงานวิจัย

หากเกิดการบาดเจ็บจากการวิจัยท่านจะได้รับค่าชดเชยหรือไม่?

ท่านจะไม่ได้รับค่าชดเชยหรือสินไหมทดแทนใดๆ จากการบาดเจ็บเนื่องมาจากโครงการวิจัย แต่อย่างไรก็ตามท่านมีความเสี่ยงน้อยมากในการที่จะได้รับการบาดเจ็บจากการเข้าร่วมงานวิจัย และหากมีการบาดเจ็บท่านจะได้รับการดูแลอย่างเต็มที่ตามมาตรฐานทางการแพทย์

ท่านจะได้รับค่าตอบแทนจากการเข้าร่วมโครงการนี้หรือไม่?

ท่านจะได้รับค่าเดินทางในการเข้าร่วมงานวิจัยจำนวน 200 บาท

เกี่ยวกับสิทธิของท่าน

ท่านมีสิทธิเต็มที่ในการสอบถามข้อมูลต่างๆ ก่อนการตัดสินใจเข้าร่วมงานวิจัยในครั้งนี้ และท่าน มีอิสระที่จะปฏิเสธการเข้าร่วมโครงการวิจัยโดยบอกกับผู้ให้ข้อมูลแก่ท่าน หรือสามารถแจ้งขอถอนตัวออก จากโครงการวิจัยได้ตลอดเวลาโดยไม่มีผลกระทบใดๆ ต่อท่าน

ท่านจะติดต่อเราได้อย่างไร

ในกรณีที่ท่านมีคำถามเกี่ยวกับโครงการวิจัย และการบาดเจ็บอันเนื่องมาจากการวิจัยโปรดติดต่อนางสาวชโลมใจ เพ็ญศรี ที่ภาควิชากายภาพบำบัด คณะเทคนิคการแพทย์ มหาวิทยาลัยเชียงใหม่ หมายเลขโทรศัพท์ 083-1674046 หรือ ผศ. ดร. สุรีพร อุทัยคุปต์ ที่ภาควิชากายภาพบำบัด คณะเทคนิคการแพทย์ มหาวิทยาลัยเชียงใหม่ หมายเลขโทรศัพท์ 0-5394-9249 หรือ 084-6112727

ในกรณีที่ท่านมีคำถามเกี่ยวกับสิทธิในฐานะอาสาสมัครโปรดติดต่อประธานคณะกรรมการจริยธรรมการวิจัย คณะเทคนิคการแพทย์ มหาวิทยาลัยเชียงใหม่ ผู้ช่วยศาสตราจารย์เนตร สุวรรณคฤหาสน์ ที่เบอร์โทรศัพท์ 0-5312-4099

Appendix D

Questionnaires

D1 A general questionnaire

<u>**แบบสอบถามข้อมูลทั่วไป**</u>

วันที่…………………………

รหัสอาสาสมัคร…………………..

<u>**คำชี้แจง-กรุณาตอบคำถามต่อไปนี้**</u>

1. เพศ………………
2. วัน/เดือน/ปี เกิด...อายุ………………..ปี
3. น้ำหนัก…………………….กิโลกรัม ส่วนสูง……………........เซนติเมตร
4. โรคประจำตัว………………………………………..
5. อาชีพ………………………………………
6. กิจกรรมที่ต้องใช้แขนเป็นประจำ โปรดระบุ………………………………………

ข้อมูลของลักษณะอาการปวดคอ

1. ท่านมีอาการปวดคอหรือไม่

   ☐ มี ☐ ไม่มี

2. ท่านมีอาการปวดคอข้างขวาข้างเดียว

   ☐ ใช่ ☐ ไม่ใช่

3. ระยะเวลาของอาการปวด

   ☐ น้อยกว่า 3 เดือน ☐ มากกว่าหรือเท่ากับ 3 เดือนขึ้นไป

4. ท่านมีอาการชาร้าวลงแขนหรือไม่

   ☐ มี ☐ ไม่มี

5. ท่านเคยได้รับอุบัติเหตุหรือผ่าตัดที่บริเวณคอหรือไม่

☐ เคย ☐ ไม่เคย

6. ท่านเคยได้รับการออกกำลังกายบริเวณกระดูกสะบักภายใน 12 เดือน ที่ผ่านมาหรือไม่

☐ เคย ☐ ไม่เคย

7. ท่านมีความผิดปกติทางระบบประสาทและกล้ามเนื้อ หรือผิดปกติของระบบร่างกาย เช่น อัมพาต ปวดกล้ามเนื้อ

☐ มี ☐ ไม่มี

8. ท่านมีความผิดปกติของกระดูกสันหลังส่วนคอ ส่วนอก และส่วนหลัง อย่างเด่นชัด เช่น กระดูกสันหลังคด

☐ มี ☐ ไม่มี

D2 Visual Analog Scale questionnaire (VAS)

แบบสอบถามวัดระดับความรุนแรงของอาการปวดคอ

รหัสอาสาสมัคร………………….

โดยเฉลี่ยแล้วมีระดับความรุนแรงของอาการปวดคออยู่ในระดับใด (โปรดทำเครื่องหมายบนเส้นด้านล่างนี้)

ไม่มีอาการปวด **ปวดจนไม่สามารถทนได้**

D3 Neck Disability Index-Thai version (NDI-TH)

ดัชนีวัดความบกพร่องความสามารถของคอ (Neck Disability Index)

รหัสอาสาสมัคร………………….

แบบสอบถามนี้ใช้ในการประเมินผลกระทบของ**<u>อาการปวดคอ</u>**ที่มีต่อความสามารถในการจัดการชีวิตประจำวันของท่าน โปรดเลือกข้อที่ตรงกับอาการและความสามารถของท่าน**<u>มากที่สุด</u>**เพียงข้อเดียว และกรุณาให้ข้อมูลในทุกข้อ

ข้อที่ 1 ความรุนแรงของอาการปวด

- ☐ ในขณะนี้ไม่มีอาการปวด
- ☐ ในขณะนี้มีอาการปวดเพียงเล็กน้อย
- ☐ ในขณะนี้มีอาการปวดปานกลาง
- ☐ ในขณะนี้มีอาการปวดค่อนข้างมาก
- ☐ ในขณะนี้มีอาการปวดมาก
- ☐ ในขณะนี้มีอาการปวดมากที่สุดเท่าที่จะจินตนาการได้

ข้อที่ 2 การดูแลตนเอง (เช่น อาบน้ำ/ชำระล้างร่างกาย แต่งตัว เป็นต้น)

- ☐ สามารถทำเองได้ตามปกติ โดยไม่ทำให้อาการปวดเพิ่มขึ้น
- ☐ สามารถทำเองได้ตามปกติ แต่มีอาการปวดเพิ่มขึ้น
- ☐ การทำเองทำให้มีอาการปวด จึงทำให้ต้องทำอย่างช้า ๆ และระมัดระวัง
- ☐ ทำเองได้เป็นส่วนใหญ่ แต่จะต้องการความช่วยเหลืออยู่บ้าง
- ☐ ต้องการการช่วยเหลือในการดูแลตนเองเกือบทั้งหมด ทุกวัน
- ☐ ไม่สามารถแต่งตัวได้เองอาบน้ำ/ชำระล้างร่างกายเองได้ด้วยความยากลำบาก และต้องอยู่บนเตียง

ข้อที่ 3 การยกของ

☐ สามารถยกของหนักได้ โดยไม่มีอาการปวดเพิ่มขึ้น

☐ สามารถยกของหนักได้ แต่มีอาการปวดเพิ่มขึ้น

☐ อาการปวดทำให้ไม่สามารถยกของหนักขึ้นจากพื้นได้แต่สามารถยกได้หากของนั้นอยู่ในที่ที่เหมาะสมเช่น บนโต๊ะ

☐ อาการปวดทำให้ไม่สามารถยกของหนักขึ้นจากพื้นได้ แต่สามารถยกได้หากของนั้นมีน้ำหนักเบาถึงปานกลางและจัดวางอยู่ในที่ที่เหมาะสม

☐ สามารถยกของที่มีน้ำหนักเบามากๆ ได้

☐ ไม่สามารถยก/ถือ/หิ้ว/แบก/อุ้มหรือสะพายสิ่งของใด ๆ ได้เลย

หัวข้อที่ 4 การอ่าน

☐ สามารถอ่านได้มากตามที่ต้องการ โดยไม่มีอาการปวดคอ

☐ สามารถอ่านได้มากตามที่ต้องการ โดยมีอาการปวดคอเพียงเล็กน้อย

☐ สามารถอ่านได้มากตามที่ต้องการ โดยมีอาการปวดคอปานกลาง

☐ ไม่สามารถอ่านได้มากตามที่ต้องการ เพราะมีอาการปวดคอปานกลาง

☐ แทบจะไม่สามารถอ่านได้เลยเพราะมีอาการปวดคอมาก

☐ ไม่สามารถอ่านได้เลย

ข้อที่ 5 อาการปวดศีรษะ

☐ ไม่มีอาการปวดศีรษะเลย

☐ มีอาการปวดศีรษะเพียงเล็กน้อย และนาน ๆ ครั้ง

☐ มีอาการปวดศีรษะปานกลาง และนาน ๆ ครั้ง

☐ มีอาการปวดศีรษะปานกลาง และบ่อยครั้ง

☐ มีอาการปวดศีรษะมาก และบ่อยครั้ง

☐ มีอาการปวดศีรษะเกือบตลอดเวลา

ข้อที่ 6 การตั้งสมาธิ

☐ สามารถตั้งสมาธิได้อย่างที่ต้องการ โดยไม่มีความยากลำบาก

☐ สามารถตั้งสมาธิได้อย่างที่ต้องการ โดยมีความยากลำบากเพียงเล็กน้อย

☐ มีความยากลำบากปานกลางในการตั้งสมาธิเมื่อต้องการ

☐ มีความยากลำบากอย่างมากในการตั้งสมาธิเมื่อต้องการ

☐ มีความยากลำบากมากที่สุดในการตั้งสมาธิเมื่อต้องการ

☐ ไม่สามารถตั้งสมาธิได้เลย

ข้อที่ 7 การทำงาน

☐ สามารถทำงานได้มากตามที่ต้องการ

☐ สามารถทำงานประจำได้เท่านั้น ไม่มากไปกว่านั้น

☐ สามารถทำงานประจำได้เกือบทั้งหมด แต่ไม่มากไปกว่านั้น

☐ ไม่สามารถทำงานประจำได้เลย

☐ แทบจะทำงานอะไรไม่ได้เลย

☐ ไม่สามารถทำงานอะไรได้เลย

ข้อที่ 8 การขับขี่รถ

☐ สามารถทำได้โดยไม่มีอาการปวดคอ

☐ สามารถทำได้นานตามที่ต้องการ โดยมีอาการปวดคอเพียงเล็กน้อย

☐ สามารถทำได้นานตามที่ต้องการ โดยมีอาการปวดคอปานกลาง

☐ ไม่สามารถทำได้นานตามที่ต้องการ เพราะมีอาการปวดคอปานกลาง

☐ แทบจะทำไม่ได้เลย เพราะมีอาการปวดคอมาก

☐ ไม่สามารถทำได้เลย

ข้อที่ 9 การนอนหลับ

- ☐ ไม่มีความยากลำบากในการนอนหลับ
- ☐ การนอนหลับถูกรบกวนเพียงเล็กน้อย(นอนไม่หลับน้อยกว่า 1 ชั่วโมง)
- ☐ การนอนหลับถูกรบกวนเล็กน้อย (นอนไม่หลับ 1-2 ชั่วโมง)
- ☐ การนอนหลับถูกรบกวนปานกลาง (นอนไม่หลับ 2-3 ชั่วโมง)
- ☐ การนอนหลับถูกรบกวนเป็นอย่างมาก (นอนไม่หลับ 3-5 ชั่วโมง)
- ☐ การนอนหลับถูกรบกวนอย่างสิ้นเชิง(นอนไม่หลับ 5-7 ชั่วโมง)

ข้อที่ 10 กิจกรรมนันทนาการ/การพักผ่อนหย่อนใจ

- ☐ สามารถทำกิจกรรมทุกอย่างได้ โดยไม่มีอาการปวดคอเลย
- ☐ สามารถทำกิจกรรมทุกอย่างได้ แต่มีอาการปวดคออยู่บ้าง
- ☐ สามารถทำกิจกรรมได้เป็นส่วนใหญ่ แต่ไม่ทั้งหมด เพราะมีอาการปวดคอ
- ☐ สามารถทำกิจกรรมได้เพียงบางอย่าง เพราะมีอาการปวดคอ
- ☐ แทบจะทำกิจกรรมต่าง ๆ ไม่ได้เลย เพราะมีอาการปวดคอ
- ☐ ไม่สามารถทำกิจกรรมใด ๆ ได้เลย

Appendix E

Intra-inter rater reliability

An intra-inter rater reliability study was conducted in 15 healthy participants (10 female, 5 male) aged between 21 and 43 years old. An intra-rater reliability was measured by the principal investigator on day one and 24 hours later to minimize any memory of the measurements. An inter-rater reliability was performed by two investigators (the principal investigator and a physiotherapy research assistant) within the same day. The order of the investigators was determined randomly. The images of the lower trapezius muscle were measured at rest (0° shoulder abduction) two times on the right side. The procedure and measurements were the same as in the main study. The results of the reliability study were presented in Table E1-E2.

Table E1 Intra-rater reliability of the lower trapezius muscle thickness

Investigator	Thickness (mm) (mean ± sd)		$ICC_{3,1}$ (95% CI)	SEM (mm)
	Day 1	Day 2		
Investigator 1	3.32 ± 0.81	3.44 ± 0.93	0.86 (0.62-0.95)	0.18
Investigator 2	3.27 ± 0.95	3.23 ± 0.94	0.89 (0.71-0.96)	0.15

Table E2 Inter-rater reliability of the lower trapezius muscle thickness

Day	Thickness (mm) (mean ± sd)		$ICC_{2,1}$ (95% CI)	SEM (mm)
	Investigator 1	Investigator 2		
1	3.32 ± 0.81	3.27 ± 0.95	0.90 (0.74-0.97)	0.13
2	3.44 ± 0.93	3.23 ± 0.94	0.91 (0.70-0.97)	0.11

CURRICULUM VITAE

Author's Name	Ms. Chalomjai Pensri	
Date/Year of Birth	13 November 1988	
Place of Birth	Phitsanulok Province, Thailand	
Education	2006	Certificated of high school Chalermkwansatree School, Phitsanulok
	2010	Bachelor of Science (Physical Therapy) Chiang Mai University, Chiang Mai
	2014	Master of Science (Movement and Exercise Sciences) Chiang Mai University, Chiang Mai