การทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวในผู้มีอาการปวดคอและปวดหลังส่วนล่าง

นางสาวฉัตราชู ทองประเสริฐ

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PERFORMANCE OF CORE STABILIZER MUSCLES IN INDIVIDUALS WITH NECK PAIN AND LOW BACK PAIN

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science Program in Physical Therapy
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ฉัตราชู ทองประเสริฐ : การทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวในผู้มีอาการปวดคอและปวดหลังส่วนล่าง (PERFORMANCE OF CORE STABILIZER MUSCLES IN INDIVIDUALS WITH NECK PAIN AND LOW BACK PAIN) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ผศ. ดร. รสลัย กัลยาณพจน์พร, 142 หน้า.

วัตถุประสงค์: การศึกษานี้มีวัตถุประสงค์หลักเพื่อเปรียบเทียบการทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวบริเวณหลังส่วนล่างในผู้มีอาการปวดคอระยะกึ่งเฉียบพลัน ระยะเรื้อรัง และผู้ไม่มีอาการปวด รวมทั้งเปรียบเทียบการทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวบริเวณคอในผู้มีอาการปวดหลังส่วนล่างระยะกึ่งเฉียบพลัน ระยะเรื้อรัง และผู้ไม่มีอาการปวด วัตถุประสงค์รองคือเพื่อหาความสัมพันธ์ระหว่างระดับการทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวบริเวณหลังส่วนล่างกับความรุนแรงของอาการปวดและภาวะทุพพลภาพของอาการปวดคอ นอกจากนี้ยังศึกษาความสัมพันธ์ระหว่างระดับการทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวบริเวณคอกับความรุนแรงของอาการปวดและภาวะทุพพลภาพของอาการปวดหลังส่วนล่างด้วย วิธีการวิจัย: ผู้เข้าร่วมการศึกษาจำนวน 122 คน ประกอบด้วย 5 กลุ่ม กลุ่มละ 23 คน คือ กลุ่มผู้มีอาการปวดคอระยะกึ่งเฉียบพลัน กลุ่มผู้มีอาการปวดคอระยะเรื้อรัง กลุ่มผู้มีอาการปวดหลังส่วนล่างระยะกึ่งเฉียบพลัน กลุ่มผู้มีอาการปวดหลังส่วนล่างระยะเรื้อรัง และกลุ่มสุดท้ายประกอบด้วยผู้ไม่มีอาการปวดที่มีการจับคู่ตามอายุและเพศกับกลุ่มผู้มีอาการปวด จำนวน 30 คน ผู้เข้าร่วมการศึกษาทุกคนได้รับการทดสอบการทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัว 2 การทดสอบ: การทดสอบการทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวบริเวณคอ (CCFT) และการทดสอบการทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวบริเวณหลังส่วนล่าง (ADIT) ผลการศึกษา: ค่า pressure change จากการทดสอบ ADIT สำหรับการทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวบริเวณหลังส่วนล่างของผู้มีอาการปวดคอระยะกึ่งเฉียบพลันและระยะเรื้อรังมีค่าลดลงอย่างมีนัยสำคัญเมื่อเทียบกับกลุ่มควบคุม ($p < 0.05$) ค่า activation score และ performance index จากการทดสอบ CCFT สำหรับการทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวบริเวณคอของผู้เข้าร่วมการศึกษาที่มีอาการปวดหลังส่วนล่างระยะกึ่งเฉียบพลันและระยะเรื้อรังยังมีค่าน้อยกว่ากลุ่มควบคุมอย่างมีนัยสำคัญ ($p < 0.05$) โดยพบความแตกต่างอย่างมีนัยสำคัญในค่าสัดส่วนของจำนวนผู้เข้าร่วมการศึกษาที่มีผลการตอบสนองต่อการทดสอบ CCFT และ ADIT เป็นปกติและไม่ปกติ ในผู้เข้าร่วมการศึกษาในกลุ่มระยะกึ่งเฉียบพลันและระยะเรื้อรังกับกลุ่มควบคุม ($p < 0.05$) ความรุนแรงของอาการปวดและภาวะทุพพลภาพในบริเวณหนึ่งของกระดูกสันหลังไม่มีความสัมพันธ์กับระดับการทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวของกระดูกสันหลังในบริเวณอื่นที่อยู่ห่างไกลกัน สรุปผลการศึกษา: การทำงานผิดปกติของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวทั้งในบริเวณคอและหลังส่วนล่างปรากฏทั้งในผู้มีอาการปวดคอและผู้มีอาการปวดหลังส่วนล่าง ระดับความรุนแรงของอาการปวดและภาวะทุพพลภาพไม่มีผลต่อระดับการทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัว

ภาควิชา กายภาพบำบัด ลายมือชื่อนิสิต .....

สาขาวิชา กายภาพบำบัด ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

ปีการศึกษา 2559

5776666637 : MAJOR PHYSICAL THERAPY
KEYWORDS: CORE STABILIZER MUSCLES / CRANIOCERVICAL FLEXION TEST / ABDOMINAL DRAWING-IN TEST / NECK MUSCLES / ABDOMINAL MUSCLES

CHATTRACHOO THONGPRASERT: PERFORMANCE OF CORE STABILIZER MUSCLES IN INDIVIDUALS WITH NECK PAIN AND LOW BACK PAIN. ADVISOR: ASST. PROF. ROTSALAI KANLAYANAPHOTPORN, Ph.D., 142 pp.

Objectives: The primary objectives of this study were to compare the performance of back stabilizer muscles in individuals with subacute neck pain, chronic neck pain, and asymptomatic conditions as well as to compare the performance of neck stabilizer muscles in individuals with subacute low back pain, chronic low back pain, and asymptomatic conditions. The secondary objectives were to identify the correlations between level of performance of back stabilizer muscles and pain severity and disability of neck pain. Furthermore, the correlations between level of performance of neck stabilizer muscles and pain severity and disability of low back pain were studied. Methods: One hundred and twenty-two participants were recruited. They consisted of five groups with 23 participants in each of the subacute neck pain, chronic neck pain, subacute low back pain, and chronic low back pain groups. The last group consisted of 30 age- and gender-matched control participants. All participants performed two core stabilizer muscle tests: the craniocervical flexion test (CCFT) and the abdominal drawing-in test (ADIT). Results: Significantly lower pressure change values from the ADIT for back stabilizer muscle performance were found in the participants with neck pain when comparing subacute and the chronic pain groups to the control group ($p < 0.05$). The activation score and performance index from the CCFT for neck stabilizer muscle performance of the participants in the subacute and the chronic low back pain groups were also lower than the control group ($p < 0.05$). Significant differences in the proportions of the participants whom were classified as normal and abnormal responses on the ADIT and the CCFT among subacute, chronic, and control groups were demonstrated ($p < 0.05$). The pain severity and disability in one spinal region did not correlate with the level of the performance of core stabilizer muscles in the remote spinal region. Conclusion: Abnormal performance of core stabilizer muscles both in the cervical and the lumbar spines is present both in neck pain and low back pain individuals. Pain severity and disability had no effect on the level of core stabilizer muscle performance.

Department:	Physical Therapy	Student's Signature	.....
Field of Study:	Physical Therapy	Advisor's Signature	.....
Academic Year:	2016		

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CHAPTER 1
INTRODUCTION

1.1 Background and rationale

Neck pain and low back pain are frequently found in general population. The majority of research around the world indicates that most adults will experience an episode of neck pain or low back pain at some point during their lifetime. The ranges of 1-year prevalence of neck pain and low back pain were 16.7%-75.1% and 36%-72%, respectively (Dunn et al. 2004, Barrero et al. 2006, Fejer et al. 2006, Ihlebæk et al. 2006, Pedisic et al. 2013). In Thailand, the 1-year prevalence of neck pain ranges from 26% to 70.3% (Janwantanakul et al. 2008, Pensri et al. 2009, Dajpratham et al. 2010, Polruk et al. 2014) and the 1-year prevalence of low back pain ranges from 34% to 73.3% (Janwantanakul et al. 2008, Pensri et al. 2009, Dajpratham et al. 2010, Prombumroong et al. 2011, Puntumetakul et al. 2011, Taechasubamorn et al. 2011).

The concomitant findings of neck pain in patients with low back pain and vice versa are common (Hill et al. 2004, Hoving et al. 2004, IJzelenberg et al. 2004, Childs et al. 2008). Although various causes can be responsible for these findings, it is postulated that the poor performance of core stabilizer muscles in the neck and low back might play a role in the development of pain in the area that initially has no symptom. It was found that a number of people with neck pain for 4 to 12 months but had no low back pain showed poor performance of back core stabilizer muscles (Moseley 2004). When these people were followed for two years, approximately 75% of those who previously possessed poor performance of back core stabilizer muscles

reported low back pain (Moseley 2004). However, no studies have demonstrated the similar phenomenon in patients with low back pain who initially do not have neck pain whether they would possess poor performance of neck core stabilizer muscles.

In the literature, the performance of core stabilizer muscles was defined as the strength and endurance of the muscles. The test commonly used for assessing the performance of core stabilizer muscles of the cervical spine is the craniocervical flexion test (CCFT) while it is the abdominal drawing in test (ADIT) for the performance of core stabilizer muscles of the lumbar spine. For an objective measurement in research study and clinical setting, these tests have been found to use in conjunction with a pressure biofeedback unit. The results suggest that these tests are able to discriminate between asymptomatic and neck pain or low back pain patients (Hodges et al. 1996, Jull et al. 1999, Cairns et al. 2000, Jull 2000, Falla et al. 2004, Jull et al. 2004, Fernández-de-las-Peñas et al. 2007, Falla et al. 2011). When testing with the CCFT for neck muscle performance, it is recommended that three data should be recorded (Jull et al. 2008). First, the **activation score** which represents the strength of the neck core stabilizer muscles is the highest pressure level that a person can maintain while holding the neck steady in craniocervical flexion position for 10 seconds. Second, the **performance index** which represents the endurance of the neck core stabilizer muscles is the value of the activation score multiplied by the number of successfully repetitions. With the ADIT for back muscle performance, the amount of **pressure change** that a person can reduce from baseline and hold steady for 10 seconds is recorded which is used to indicate the strength and endurance of the back core stabilizer muscles (Richardson et al. 1995, Garnier et al. 2009).

With neck pain and low back pain, the strength and endurance of core stabilizer muscles in the area of pain are found to reduce when comparing with asymptomatic individuals (Hodges et al. 1996, Hodges et al. 1998, Cairns et al. 2000, Jull 2000, Nederhand et al. 2000, Falla et al. 2004, Jull et al. 2004, Falla et al. 2011). In the spine, core stabilizer muscles are the muscles that lie deep closed to the spine and help stabilizing the spine during function. In the cervical spine, these muscles that are considered as core stabilizer muscles are deep cervical flexor muscles such as longus capitis and longus colli muscles while the main core stabilizer muscle of the lumbar spine is transversus abdominis muscle (Richardson et al. 1995, Jull et al. 2008).

In consideration of the ability of the motorneurons to increase their excitability at the multiple sites along the motor pathway (Hodges et al. 2011), it is therefore possible that the sites where abnormal muscle control or poor muscle performance occurs would not be limited only to the anatomical site of pain. With poor performance of core stabilizer muscles in one spinal area, biomechanical demands would be posted on the other spinal segments in order to compensate for the alteration in postural strategy (Moseley 2004). Together with sustained and repetitive use in an altered spinal biomechanics for prolonged duration, further adaptation or compensation in the muscles, i.e. hypertrophy, atrophy, lengthening, shortening, stiffness, weakness, and recruitment pattern alteration would then take place (Sahrmann 2010). Consequently, an alteration in function of muscles other than those specific muscles in the painful site would be plausible.

The aims of this study were to examine the performance of neck stabilizer muscles in people with low back pain and the performance of back stabilizer muscles in people with neck pain in subacute and chronic conditions.

1.2 Research questions

1) Were there any differences in the performance of back stabilizer muscles in individuals with subacute neck pain, chronic neck pain, and asymptomatic conditions?
2) Were there any differences in the performance of neck stabilizer muscles in individuals with subacute low back pain, chronic low back pain, and asymptomatic conditions?
3) Did level of core stabilizer muscles performance correlate with severity of pain and disability?

1.3 Primary objectives

1) To compare the performance of back stabilizer muscles in individuals with subacute neck pain, chronic neck pain, and asymptomatic conditions.
2) To compare the performance of neck stabilizer muscles in individuals with subacute low back pain, chronic low back pain, and asymptomatic conditions.

1.4 Secondary objectives

1) To identify the correlation between level of performance of back stabilizer muscles and severity of neck pain.
2) To identify the correlation between level of performance of neck stabilizer muscles and severity of low back pain.
3) To identify the correlation between level of performance of back stabilizer muscles and disability of neck pain.

4) To identify the correlation between level of performance of neck stabilizer muscles and disability of low back pain.

1.5 Hypotheses

1) There would be statistically significant differences in the performance of back stabilizer muscles in individuals with subacute neck pain, chronic neck pain, and asymptomatic conditions.
2) There would be statistically significant differences in the performance of neck stabilizer muscles in individuals with subacute low back pain, chronic low back pain, and asymptomatic conditions.
3) The level of performance of back stabilizer muscles would negatively correlate with severity of neck pain.
4) The level of performance of neck stabilizer muscles would negatively correlate with severity of low back pain.
5) The level of performance of back stabilizer muscles would negatively correlate with disability of neck pain.
6) The level of performance of neck stabilizer muscles would negatively correlate with disability of low back pain.

1.6 Scope of the study

This study investigated participants with neck pain or low back pain and their age- and gender-matched controls.

1.7 Expected benefit

The results of this study would provide physical therapists an evidence for early intervention for preventing neck pain in individuals with low back pain as well as to prevent low back pain in individuals with neck pain.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter describes the spinal stabilization system, core stabilizer muscles of the cervical and the lumbar spines, tests for core stabilizer muscle performance, tools for measuring performance of core stabilizer muscles, performance of core stabilizer muscles in pain conditions, relationship between neck pain and low back pain, and conceptual framework of the study.

2.2 Spinal stabilization system

Spinal column consists of 33 vertebrae including seven cervical, 12 thoracic, five lumbar, five sacral, and four coccygeal bony segments. Vertebrae in each region has a distinct morphology which reflects its specific function and movement potential (Neumann 2010). Of all moveable vertebrae, cervical vertebrae are the smallest and the most mobile. They align between the skull and the first thoracic vertebra which form a lordotic curve of approximately 30-35 degrees (Neumann 2010). Thoracic vertebrae are located between cervical and lumbar regions which form a kyphotic curve of approximately 40-45 degrees. Lumbar vertebrae form a lordotic curve of approximately 40-50 degrees (Neumann 2010) Sacral and coccygeal segments are fused together.

The spinal stabilization system consists of three subsystems including passive, active, and neural control subsystems that provide both static and dynamic stability (Figure 2.1) (Panjabi 1992).

- The **passive subsystem** includes vertebrae, facet articulation, intervertebral discs, spinal ligaments, and joint capsules that cannot voluntarily generate spinal motions by themselves. These structures help limit spinal motion when they are stretched. For bony structures, the shape of their articular surfaces that form a joint indicates the degree of stability (Comerford et al. 2001). If the articular surfaces are perfectly fit with each other, the joint will have high stability. Impairments in the passive subsystem might be caused by mechanical injury such as overstretch of the ligament, microtrauma of the vertebra, or extrusion of the intervertebral disc.
- The **active subsystem** includes muscles and tendons that surround the spinal column and can generate force to help stabilize the spine. These structures are required to have high endurance rather than high strength. In general, muscles of the spine can be categorized into two groups, i.e. global and local muscles (Bergmark 1989). Global muscles are superficial muscles that generate movements and can stabilize multiple segments of the spine. Local muscles or core stabilizer muscles attach closed to the spine and function to provide segmental stabilization to the spine. The core stabilizer muscles are early activated before any body movements. Impairment of the active subsystem is presented as an altered pattern of muscle function in that the global superficial muscles are recruited prior to the local core stabilizer muscles.
- The **neural control subsystem** or nervous system includes force and motion transducers that locate in ligaments, tendons, and muscles. They

provide the information regarding muscle length and muscle tone to the central nervous system which use it for adjusting tension within the muscles. Impairment of the neural control subsystem can influence functions both of the passive and the active subsystems.

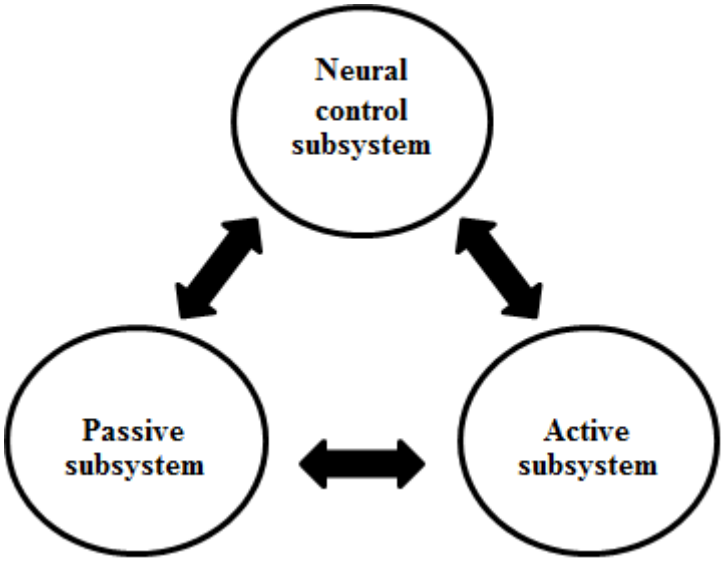

Figure 2.1 The spinal stabilization system (from Panjabi, 1992)

When there is an impairment in any subsystems, the remaining subsystems have to work more for maintaining the spinal stabilization. With inadequate compensation for the impairment, the spine will lose its stiffness and become unstable. Greater range of movement in the neutral zone which is defined as a zone within the physiological range that provides no restraint for any movements (Panjabi 1992) becomes larger. The large neutral zone would therefore put the spine into the condition of minimal protection from any stress and strain. The spine would be at risk of injury and pain.

2.3 Core stabilizer muscles of the lumbar and the cervical spine

2.3.1 Core stabilizer muscles of the lumbar spine

All muscles of the lumbar spine can function as spinal stabilizer. They can be categorized into tertiary, secondary, and primary stabilizer muscles (Richardson et al. 1992, Norris 1999). The **tertiary stabilizer muscles** are the superficial muscles that attach between thoracic cage and pelvis which include the rectus abdominis and erecter spinae muscles. They primarily move the spine but can stabilize the spine in the presence of pain or when the spine is under high load.

The **secondary stabilizer muscles** are located deeper than the primary stabilizer muscles. They consist of the internal abdominal oblique, external abdominal oblique, and quadratus lumborum muscles. They do not only provide stability to the spine but also act to move the spine.

The **primary stabilizer muscles** are the deepest trunk muscles which consist of four muscle groups. These muscles enclose abdominal cavity (Richardson et al. 1995, Hodges 1999, Agur et al. 2013). They are the transversus abdominis, deep fibers of the lumbar multifidus, diaphragm, and pelvic floor muscles (Figure 2.2). Transversus abdominis muscle originates from iliac crest and inner surfaces of the cartilages of the lower six ribs at which it interdigitates with diaphragm muscle before ending on the thoracolumbar fascia. The deep fibers of lumbar multifidus muscle span over two vertebral segments which are suitable for controlling intervertebral shear and torsion without generating torque (MacDonald et al. 2006). Diaphragm muscle attaches on the sternum and xiphoid process anteriorly, the costal margin laterally, and the first three lumbar vertebrae and the arcuate ligaments posteriorly. Pelvic floor muscles attach between pelvic bone and the sacrum. When the transversus abdominis muscle contracts,

it also induces contraction of pelvic floor muscles contraction (Sapsford et al. 2001). The primary stabilizer muscles cannot create significant joint movements but their contraction raises intra-abdominal pressure which helps stiffening the lumbar spinal segments and the sacroiliac joints (Hodges 1999, Richardson et al. 2002). As a result, the neutral zone would be reduced (Richardson et al. 1995, Neumann et al. 2002, Hodges et al. 2003, Hodges et al. 2005).

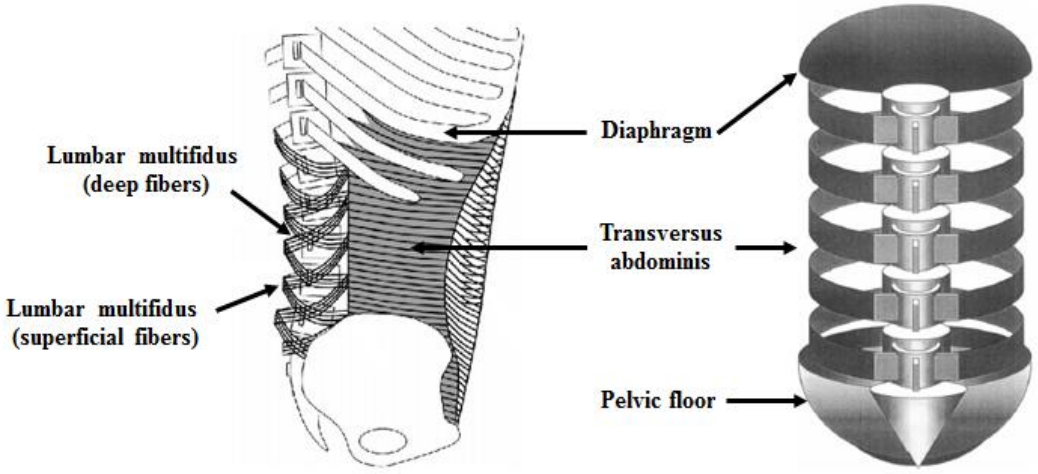

Figure 2.2 The core stabilizer muscles of the lumbar spine: transversus abdominis, lumbar multifidus, diaphragm, and pelvic floor muscles (from Hodges, 1999)

To be claimed as a core stabilizer muscle, it is proposed that the muscle has to possess specific characteristics. They are postural control muscles. In the lumbar spine, it was shown that the transversus abdominis and lumbar multifidus muscles were activated earlier than the prime movers of the upper and lower extremity movements (Hodges et al. 1996, Hodges et al. 1998, Moseley et al. 2002, Marshall et al. 2003). In healthy subjects, the transversus abdominis muscle was activated at 38.90±20.00, 24.17±25.00, and 24.80±22.00 milliseconds before the activation of the prime mover muscle for shoulder flexion, abduction, and extension, respectively (Figure 2.3)

(Hodges et al. 1996). The lumbar multifidus muscle was slightly activated at 9.30±32.00 milliseconds after the activation of the prime mover muscle for flexion, but more activated at 56.8±54.00 and 74.10±54.00 milliseconds after the activation of the prime mover muscle for abduction and extension (Hodges et al. 1996) Furthermore, the transversus abdominis muscle was activated at 86.00±40.00, 57.00±38.00 and 71.00±35.00 milliseconds before the activation of the prime mover muscle for hip flexion, abduction, and extension, respectively (Figure 2.4) (Hodges et al. 1998). The lumbar multifidus muscle was activated before or after than 50 milliseconds of the prime mover muscle activation for hip flexion abduction, and extension, respectively (Hodges et al. 1997).

The earlier activation than the prime mover is considered as a feedforward postural control that maintains balance and provides stability to the spine before perturbation (Shumway-Cook et al. 2012). EMG onsets of core stabilizer muscles between 150 milliseconds before and 50 milliseconds after prime mover muscle activation are considered as feedforward postural control (Falla et al. 2004). As a result, the transversus abdominis and lumbar multifidus muscles are important core stabilizer muscles of the lumbar spine.

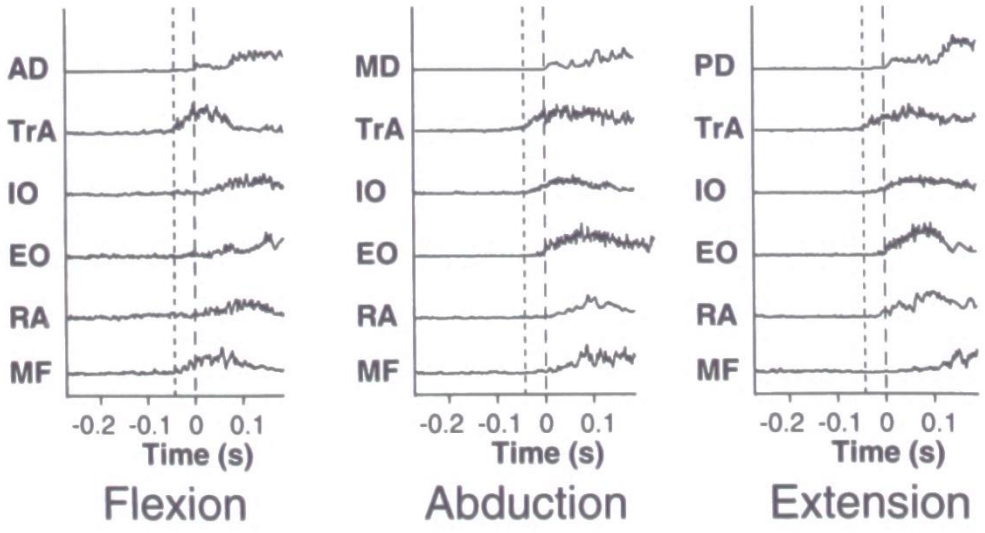

Figure 2.3 The activation of transversus abdominis and lumbar multifidus muscles during shoulder flexion, abduction and extension of normal subjects (from Hodges et. al., 1996)
AD = anterior deltoid muscle, MD = middle deltoid muscle, PD = posterior deltoid muscle, TrA = transversus abdominis muscle, IO = internal abdominal oblique muscle, EO = external abdominal oblique muscle, RA = rectus abdominis muscle and MF = lumbar multifidus muscle

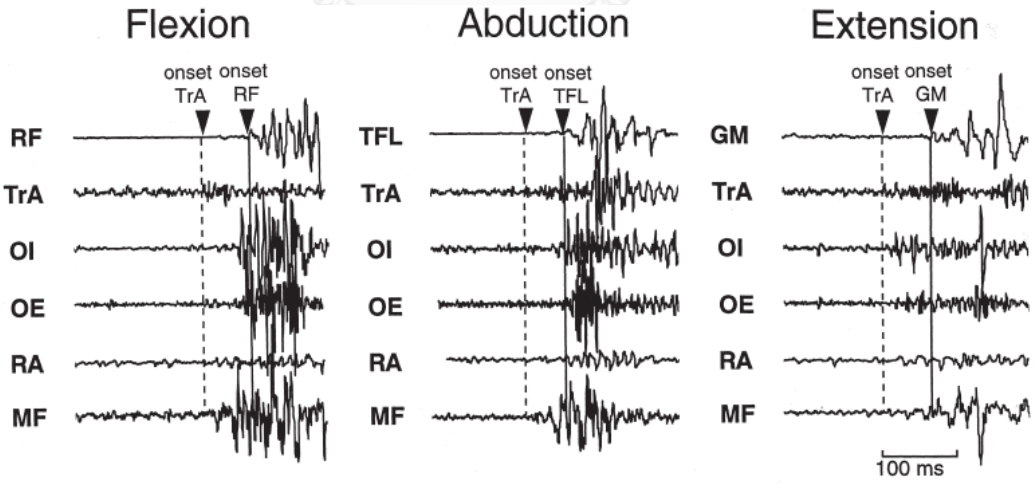

Figure 2.4 The activation of transversus abdominis muscle during hip flexion, abduction and extension (from Hodges et. al., 1997)
RF = rectus femoris mudcle, TFL = tensor fascia latae muscle, GM = gluteus maximus muscle, TrA = transversus abdominis muscle, OI = internal abdominal oblique muscle, OE = external abdominal oblique muscle, RA = rectus abdominis muscle and MF = lumbar multifidus muscle

2.3.2 Core stabilizer muscles of the cervical spine

The role of muscles of the cervical spine in cervical stability has been studied in recent decade. It has been demonstrated that the deep cervical flexor and deep cervical extensor muscles play a significant role in providing stability in the cervical spine (Schomacher et al. 2013). Deep cervical flexor muscles include longus capitis and longus colli muscles (Figure 2.5) (Mayoux-Benhamou et al. 1994, Neumann 2010, Agur et al. 2013). Longus capitis muscle attaches from occipital bone to transverse processes of three to six cervical vertebrae. Longus colli muscle attaches from the first cervical vertebra, bodies of one to three cervical vertebrae, and transverse processes of three to six cervical vertebrae. It helps maintain normal lordosis of the cervical spine. Posteriorly, the deep cervical extensor muscles include cervical multifidus, semispinalis cervicis, and cervical rotatores muscles (Figure 2.6) (Boyd-clark et al. 2001, Schomacher et al. 2013). They attach between transverse processes and spinous processes of the cervical vertebrae, with the exception of the cervical rotatores muscle attached between transverse process and the two superior segments (Agur et al. 2013). Their action is craniocervical extension.

Other cervical muscles that lay superficially such as anterior scalene and sternocleidomastoid muscles are not considered as core stabilizer muscles. Their primary function is to produce torque than stabilization to the cervical spine (Conley et al. 1995).

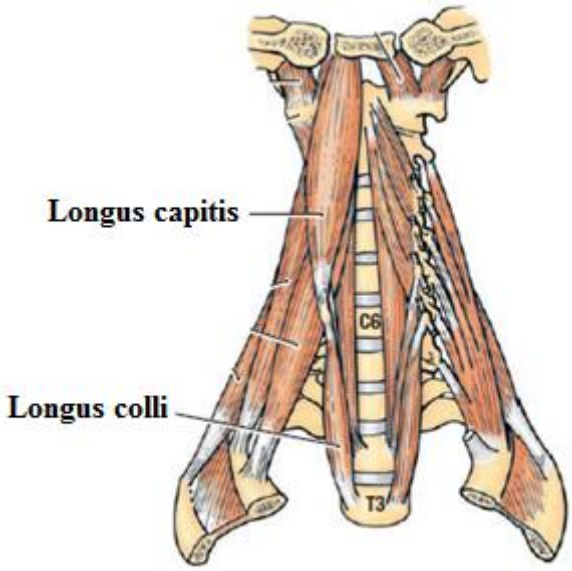

Figure 2.5 The deep cervical flexor muscles: longus capitis and longus colli muscles (modified from Agur et. al., 2013 page 334)

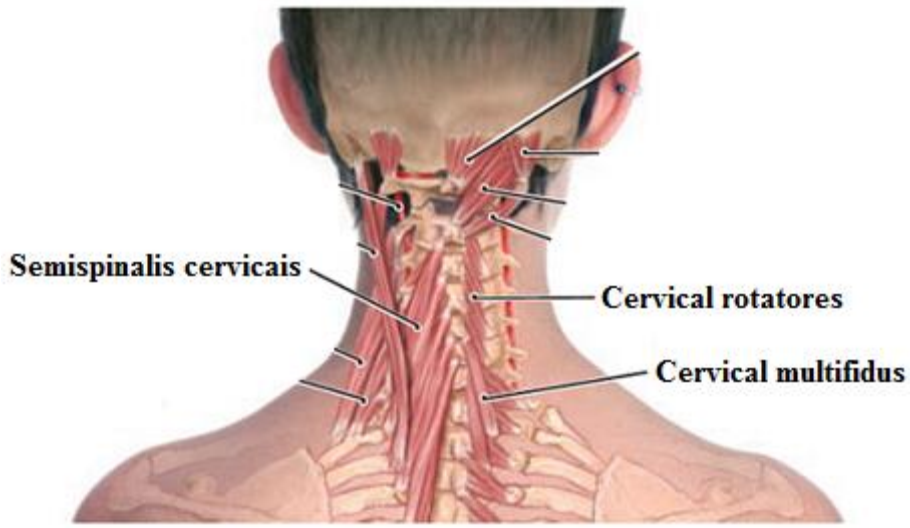

Figure 2.6 The deep cervical extensor muscles: cervical multifidus, semispinalis cervicis, and cervical rotatores muscles (modified from Agur et. al., 20 13 page 789)

Previous studies reported an early activation of deep cervical flexor muscles before the prime movers that produced upper extremity movements (Falla et al. 2004, Falla et al. 2004, Falla et al. 2011).

In normal subjects, activation of deep cervical flexor muscles were reported less than 50 milliseconds before prime mover muscles of shoulder flexion (Figure 2.7) (Falla et al. 2004). The cervical spine has no structure to create the cavity for stabilization same as lumbar spine. However, contraction of deep cervical flexor muscle is mainly used for stabilization.

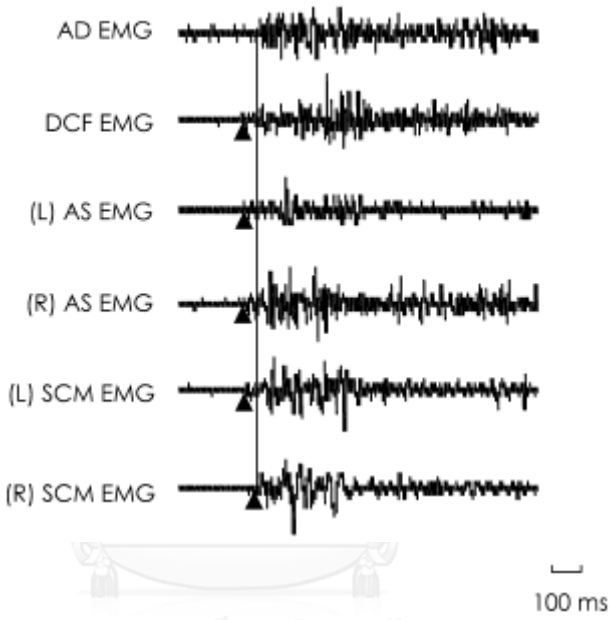

Figure 2.7 The activation of deep cervical flexor muscles during shoulder flexion (from Fall et. al., 2004)
DCF = deep cervical flexor muscles, AS = anterior scalene muscle and SCM = sternocleidomastoid muscle

For deep cervical extensor muscles, the activation in normal subjects were early activated before superficial cervical extensor muscles during cervical extension in craviocervical neutral comparing with chronic neck pain subjects (Figure 2.8) (Elliott et al. 2010, O'Leary et al. 2011).

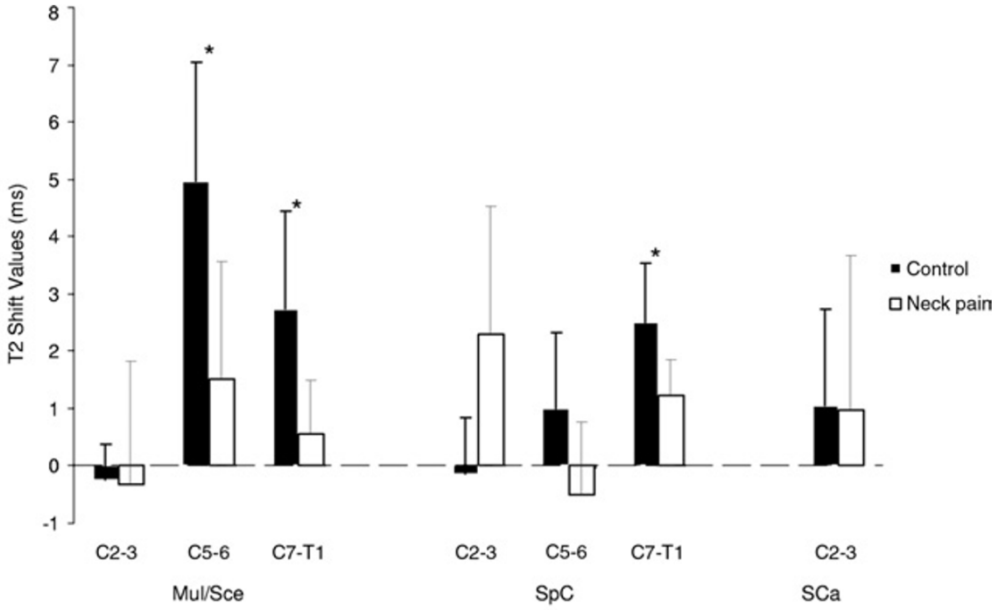

Figure 2.8 The activation of deep cervical extensor muscles during cervical extension in craniocervical neutral exercise (from O'Leary et. al., 2011)
Mul/Sce = cervical multifidus/semispinalis cervicis muscles, SpC = splenius capitis muscle and SCa = semispinalis capitis muscle

2.4 Tests for core stabilizer muscle performance

2.4.1 Craniocervical flexion test (CCFT)

The CCFT examines the performance of deep cervical flexor muscles. It represents the ability of an individual to maintain a low intensity contraction of deep cervical flexor muscles in craniocervical flexion for a certain period (Jull et al. 2008). To be successful, the head nod action has to be performed with minimal superficial cervical flexor muscle activity and in absence of any other substitution strategies such as cervical extension.

2.4.2 Abdominal drawing-in test (ADIT)

The ADIT assesses the performance of co-contraction of deep abdominal and back muscles: transversus abdominis and lumbar multifidus muscles (Richardson et al. 1995). It can be done in many starting positions such as four-point kneeling, supine crooking lying, prone lying and wall support standing positions (Richardson et al. 1995, Norris 2001). During testing, a person is instructed to contract the lower abdominal muscles towards the lumbar spine. No movements of the spine or pelvis which usually occurs with the contraction of the superficial abdominal muscles are allowed. To be successful, the contraction must be held with normal breathing.

2.5 Tools for measuring performance of core stabilizer muscles

To objectively measure the performance of core stabilizer muscles, several tools have been used during the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance.

2.5.1 Magnetic resonance imaging (MRI)

MRI uses strong magnetic fields and radio waves to field gradients to generate images of the organs and tissue in the body. It is a goal standard instrument for measuring cross-sectional area of a muscle (Hides et al. 2006, Cagnie et al. 2008). When muscle contracts, its cross-sectional area increases. Thus, the greater cross-sectional area during contraction will represent the greater muscle activity. The person who has pain tends to have a smaller cross-sectional area when comparing with normal subjects during the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance (Cagnie et al. 2010, Gildea et al. 2013). The use of

the MRI to measure core stabilizer muscle performance was shown to have excellent intra-rater (ICC = 0.84-0.95) (Hides et al. 2006) and inter-rater reliabilities (ICC = 0.94) (Cagnie et al. 2008). However, this instrument is expensive and requires a specialist for operation.

2.5.2 Ultrasound imaging

Ultrasound imaging uses high-frequency sound waves to create images of organs and tissues within the body. It measures muscle activity by measuring the change in thickness or cross-sectional area during muscle contraction. The greater increase in muscle thickness represents the greater muscle activity. Changes in thickness from resting baseline values during the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance were found to be lesser in subjects who had neck pain or low back pain (Hides et al. 1994, Jesus et al. 2008, Jun et al. 2013). This measurement was reported to provide excellent intra-rater (ICC = 0.88-0.98) (Jull et al. 2007) and inter-rater reliabilities (ICC = 0.93) (Teyhen et al. 2005). Moreover, the results from the ultrasound imaging were found to have excellent correlation with those of the MRI (r = 0.99) (Reeves et al. 2004). However, this instrument is expensive and requires a specialist for operation.

2.5.3 Electromyography (EMG)

EMG is an instrument that is widely used as a gold standard instrument for measuring muscle activity (Soderberg et al. 2000). This instrument records the electrical current from muscle activity or myoelectric which is referred to as a myogram. Two types of electrode used with the EMG can be classified as invasive and

non-invasive electrodes. The invasive electrode needs to be inserted into the body which include fine-wire and nasopharyngeal electrodes. The non-invasive electrode is usually placed over the skin where the muscle locates.

Fine-wire electrode measures muscle activity of core stabilizer muscles by inserting a fine wire into a muscle fiber (Hogrel 2005). With this technique, a researcher can be sure that the detected muscle activity is from the muscle of interest. Deep situated muscle can also be studied. However, the penetration of a fine wire through the skin can cause pain and microtrauma to the muscle. A number of studies used fine-wire electrode for measuring the performance of transversus abdominis and lumbar multifidus muscles (Hodges et al. 1996, Hodges et al. 1997, Hodges et al. 1998, Hodges et al. 1999, Hodges et al. 1999, Hodges et al. 1999, Hodges et al. 2000, Moseley et al. 2002, Neumann et al. 2002).

Nasopharyngeal electrode is a specially developed electrode that is inserted through the nose to be attached on the posterior wall of the oropharyngeal cavity (Figure 2.9) (Falla et al. 2003). A positive linear relationship was evident between the amplitude of deep cervical muscle activity and the progressive stages of the CCFT. This measurement demonstrated high reliability with low variability in the within-subject values that ranged from 6.7% to 10.3% (Falla et al. 2003).

Surface electrode can measure muscle activity from a large area. It is recommended to be better than the fine-wire electrode when measuring muscles that lie superficially (Hogrel 2005). However, the results can be confounded by crosstalk skinfold thickness of target area (Neumann et al. 2002). The point for electrode placement for the transversus abdominis muscles during the ADIT is at two centimeters anterior to the proximal end of a line drawn vertically from the anterior superior iliac

spine (Hodges et al. 1996) or at horizontally at two centimeter inferior and medial to the anterior superior iliac spine (Chanthapetch et al. 2009). Other placements have also been reported (O'Sullivan et al. 1997, Marshall et al. 2003, Moseley et al. 2005). For the lumbar multifidus muscle, the placement is at the fourth and fifth lumbar vertebral interspace and two centimeters lateral to the spinous process (Hodges et al. 1996). This method showed excellent intra-rater (ICC 0.84-0.97) (Dankaerts et al. 2004) and inter-rater reliability (ICC = 0.90) (Marshall et al. 2003).

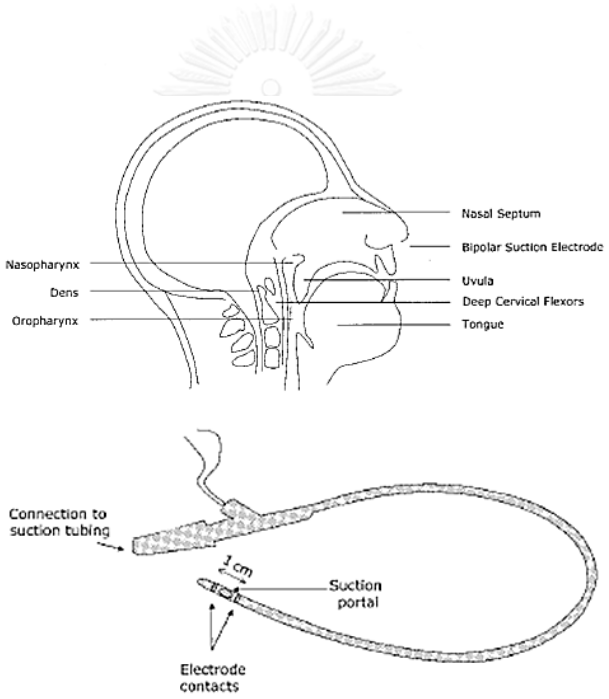

Figure 2.9 The nasopharyngeal electrode (from Falla et. al., 2003)

Besides the use of EMG for measuring muscle activity, it is also used for providing biofeedback during a training program. This is known as an EMG biofeedback. A specific level of muscle activity is set as a target and the EMG biofeedback will show visual, auditory, or other signals to indicate that the target is reached.

2.5.4 Pressure biofeedback unit

A pressure biofeedback unit is used not only to evaluate activity of the abdominal and neck muscles but also to provide biofeedback to the patients during exercise interventions (Lima et al. 2012). The unit consists of a three-chamber air-filled pressure bag, a catheter and a sphygmomanometer gauge (Figure 2.10).

Figure 2.10 The pressure biofeedback unit

The CCFT for neck stabilizer muscle performance is measured by placing the pressure biofeedback unit below the occiput while a person lays supine (Figure 2.11) (Jull et al. 2008). Then, the pressure biofeedback unit is inflated to 20 mmHg. The person is requested to slowly feel the back of his/her head slide up the plinth in a head nod action. The pressure dial should elevate while the person keeps normal breathing pattern and holds the pressure for 10 seconds. The pressure shown on the pressure dial represented the performance of the core stabilizer muscles of the cervical spine. The highest pressure level that a person could achieve 10-second holding is recorded as an

activation score to represent the strength of the neck core stabilizer muscles. The score that is a result of the multiplication of the activation score with the number of successfully repetitions is known as the performance index is also recorded to indicate the endurance of the neck core stabilizer muscles (Jull et al. 2008).

This method was proved to be valid with a positive correlation between the craniocervical flexion range of motion and the deep cervical flexor muscle activity from an EMG using nasopharyngeal electrode (r = 0.56) (Falla et al. 2003). The increasing angle of craniocervical flexion during testing was found to be associated with an increasing EMG amplitude in the deep cervical flexor muscles. Furthermore, the activation score demonstrated excellent intra-rater reliability (ICC = 0.81, standard error of measurement = 1.48-1.84 mmHg) and inter-rater reliability (ICC = 0.86, standard error of measurement = 4.30-4.53 mmHg) (Juul et al. 2013). The performance index demonstrated excellent intra-rater reliability (ICC = 0.78–0.93) (Jull et al. 1999, Hudswell et al. 2005, Fernández-de-las-Peñas et al. 2007) and moderate inter-rater reliability (ICC = 0.54) (Hudswell et al. 2005).

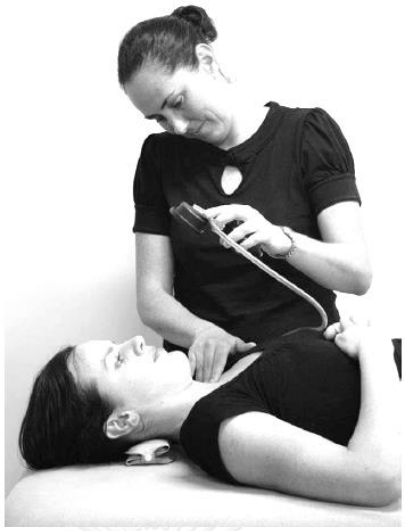

Figure 2.11 The craniocervical flexion test (from Jull, O'Leary et al., 2008)

The ADIT for back stabilizer muscle performance is commonly measured in two positions, i.e. prone and supine. For prone position, a pressure biofeedback unit is placed under abdomen in line with right and left anterior superior iliac spines (Figure 2.12) (Richardson et al. 1995). The pressure biofeedback unit is inflated to 70 mmHg and the person is asked to draw abdomen towards the spine with normal breathing to reduce the pressure for 4-10 mmHg without spinal movement from superficial muscles such as rectus abdominis muscle and hold for 10 seconds. The pressure change is recorded as the performance of the lumbar stabilizer muscles. For supine position, the person is in supine crook-lying with the pressure biofeedback unit located under the lumbar lordosis between the first sacral and first lumbar spinous processes. The pressure at baseline is set at 40 mmHg (O'Sullivan et al. 1997). The person is required to contract abdominal muscles and keep the pressure steady at 40 mmHg while performing limb movements for each testing level. The level that the person can perform correctly would be recorded as the performance of the lumbar stabilizer

muscles. Since the testing in supine has limb movements that offer more perturbation to the spine, it is therefore difficult to accomplish in the early stage. It might be suitable for progression of training. Testing in prone position in a static posture is easy to learn for the start and the ADIT in prone position is commonly used. The excellent intra-rater (ICC = 0.87) and inter-rater reliabilities (ICC = 0.89) (Rathod 2016) were reported for using the pressure biofeedback unit for measuring the performance of the lumbar core stabilizer muscles. This method also presented a high positive predictive value (0.8) and low negative predictive value (0.2) with surface EMG (Lima et al. 2012).

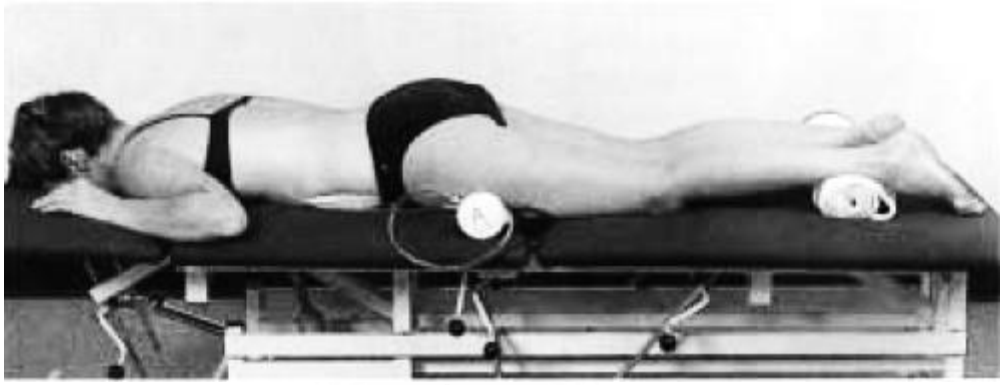

Figure 2.12 The abdominal drawing-in test (from Richardson and Jull, 1995)

2.6 Performance of core stabilizer muscles in pain conditions

Poor performance of core stabilizer muscles had been reported in pain conditions. Several impairments have been found in association with this poor performance such as a decrease in muscle cross-sectional area, muscle thickness, muscle strength, and muscle endurance. Alteration in muscle pattern recruitment has also been shown.

2.6.1 Performance of core stabilizer muscles in neck pain

Decreased isometric deep cervical flexor muscle strength was demonstrated in neck pain sufferers with moderate to severe disability. The decrease was shown at maximum, 50%, and 25% of maximal voluntary contraction (O'Leary et al. 2007). On average, the neck pain sufferers showed a decrease of 15.9% compared with the asymptomatic group. The cross-sectional area and thickness of longus colli muscle of the persons with neck pain were smaller than the asymptomatic group as shown by MRI (Cagnie et al. 2010) and ultrasound imaging (Jesus et al. 2008, Jun et al. 2013). Testing using the pressure biofeedback unit revealed an average activation score of 3±1.30 mmHg in chronic whiplash (Jull 2000), 4.02±1.90 mmHg in chronic cervicogenic headache (Jull et al. 1999), and 6.60±2.30 mmHg in chronic tension-type headache (Fernández-de-las-Peñas et al. 2007) which were lower than individuals with no neck pain. The performance index was also found to be lower in subjects who had pain. It was 10.60±15.30 in chronic cervicogenic headache (Jull et al. 1999) and 32.40±15.80 in chronic tension-type headache (Fernández-de-las-Peñas et al. 2007).

When performing the craniocervical flexion, patients with neck pain initiated the movement with the recruitment of superficial cervical flexor muscle such as sternocleidomastoid and anterior scalene muscles (Jull 2000, Falla et al. 2004, Jull et al. 2004). The increase in superficial cervical flexor muscles activity are proposed to be a compensation for the reduced strength of the deep cervical flexor muscles. Furthermore, The activation of the deep cervical flexor muscles was delayed after the recruitment of the deltoid muscles during upper limb movement (Figure 2.13) (Falla et al. 2004). Greater delayed onset of the deep cervical flexor muscles during rapid shoulder flexion was found to be associated with high level of neck pain ($r = 0.50$, $p <$

0.01) and low activation score (r = -0.36, p < 0.05) (Falla et al. 2011). Histologically, the deep cervical extensor muscles in chronic neck pain change their morphology in that there is fat deposit within the muscles as shown on MRI (Schomacher et al. 2013).

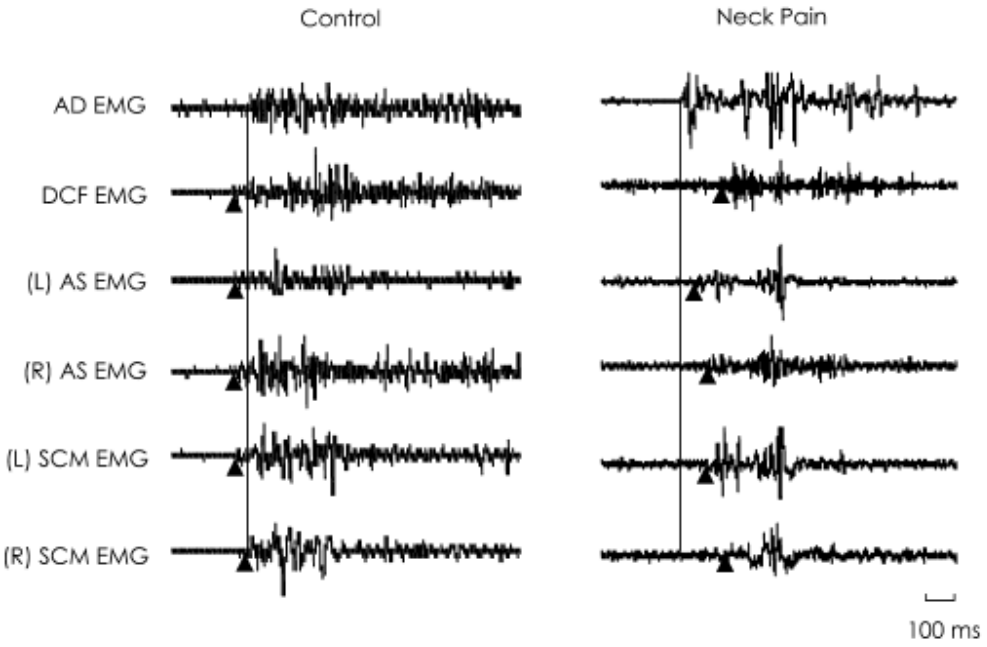

Figure 2.13 The activation of deep cervical muscles during shoulder flexion in normal subjects and neck pain (from Falla et. al., 2004)
DCF = deep cervical flexor muscles, AS = anterior scalene muscle and SCM = sternocleidomastoid muscle

2.6.2 Performance of core stabilizer muscles in low back pain

Individuals with low back pain also possess impairments similar to those with neck pain. There was an evidence of lumbar multifidus muscle wasting ipsilateral to the symptomatic side in patients with acute/subacute low back pain (Hides et al. 1994, Hides et al. 1996, Gildea et al. 2013). However, no significant difference in lumbar multifidus muscle thickness between patients with low back pain and control group (Teyhen et al. 2005).

The pressure change of the ADIT in chronic low back pain group was 1.17±4.36 and 1.78±2.43 mmHg that lower than control group (Hodges et al. 1996, Cairns et al. 2000). Furthermore, the delayed activation of the back stabilizer muscles after the deltoid muscles during rapid arm movements in shoulder flexion, extension, and abduction was shown when being compared with the control group (Figure 2.14) (Hodges et al. 1996). During the lower limb movements, the transversus abdominis muscle was also activated after prime movers for hip flexion, abduction, and extension including rectus femoris, tensor fascia latae, and gluteus maximus, respectively (Figure 2.15) (Hodges et al. 1998).

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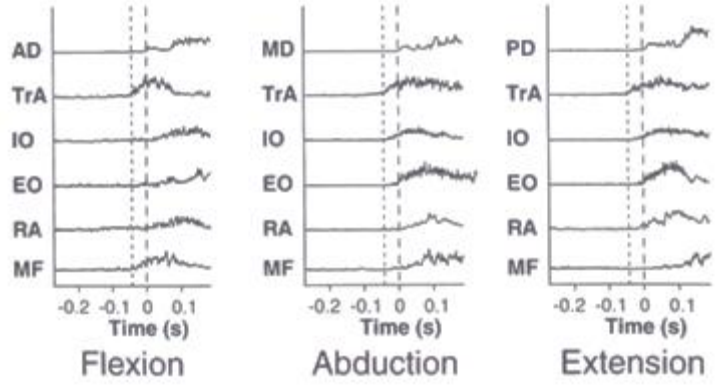

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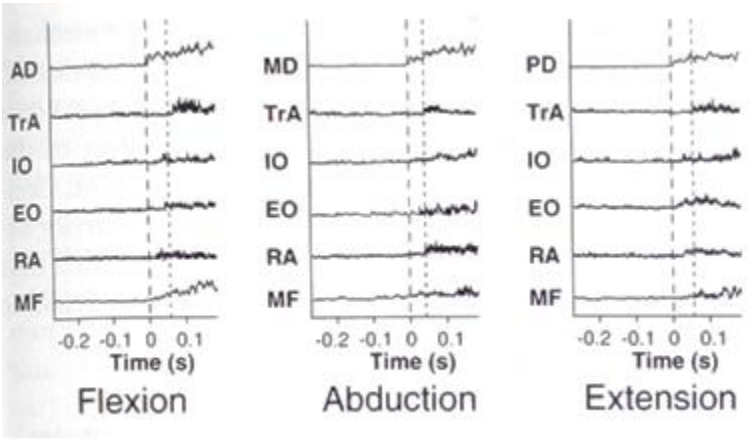
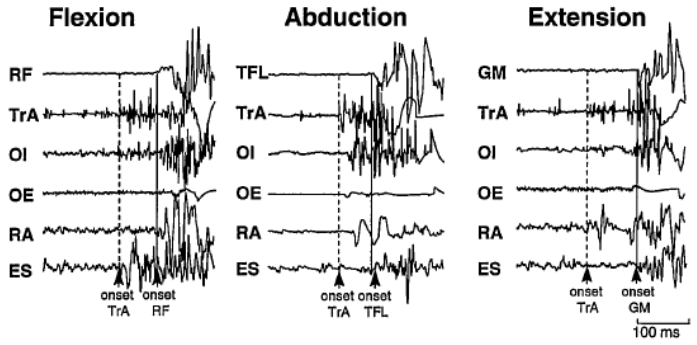


Figure 2.14 The activation of transversus abdominis and lumbar multifidus muscles during shoulder flexion, abduction and extension in normal subjects (A) and low back pain (B) (from Hodges et. al., 1996)
AD = anterior deltoid muscle, MD = middle deltoid muscle, PD = posterior deltoid muscle, TrA = transversus abdominis muscle, IO = internal abdominal oblique muscle, EO = external abdominal oblique muscle, RA = rectus abdominis muscle and MF = lumbar multifidus muscle

A



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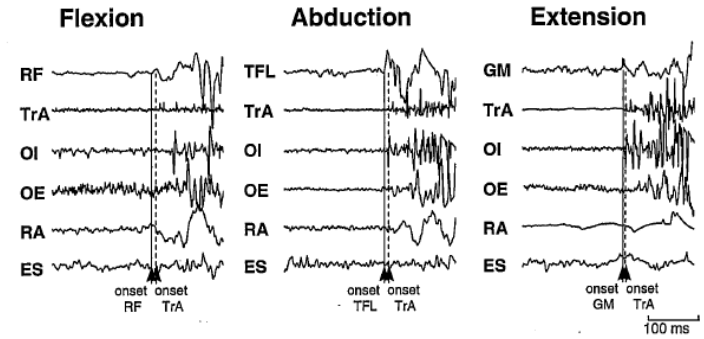

Figure 2.15 The activation of transversus abdominis muscle during hip flexion, abduction and extensionin normal subjects (A) and low back pain (B) (from Hodges et. al., 1998)
RF = rectus femoris mudcle, TFL = tensor fascia latae muscle, GM = gluteus maximus muscle, TrA = transversus abdominis muscle, OI = internal abdominal oblique muscle, OE = external abdominal oblique muscle, RA = rectus abdominis muscle and ES = erector spinae muscle

2.7 Relationship between neck pain and low back pain

Previous studies have found the association between the concomitant neck pain and low back pain and vice versa (Tulder et al. 2002, Hill et al. 2004, Hoving et al. 2004, IJzelenberg et al. 2004). The relationship between the performance of core stabilizer muscles and spinal pain was also reported. It was found that people with neck pain for 4 to 12 months showed a reduced capacity to perform the ADIT (Moseley 2004). Furthermore, over 2-year follow-up, both neck pain and control who presented abnormal response to the ADIT reported low back pain up to 74% and 75%, respectively (Figure 2.16). No studies have demonstrated the similar phenomenon in patients with low back pain.

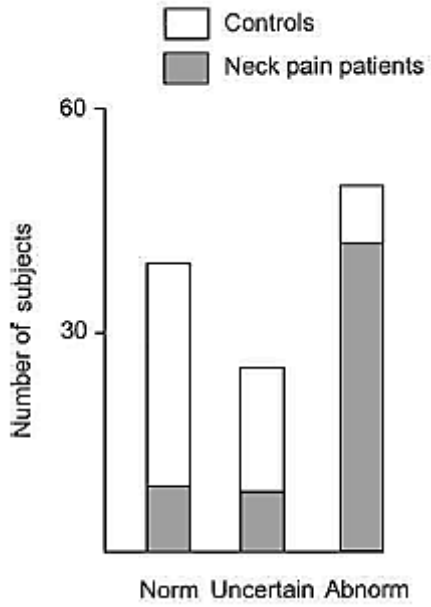

Figure 2.16 The proportion between normal and abnormal response of the ADIT in neck pain and normal subjects (from Moseley 2004)

Poor performance of lumbar stabilizer muscles on the ADIT in people with neck pain was proposed to be caused by an alteration in postural strategy that posted biomechanical demands on the other spinal segments (Moseley 2004). After injury or pain in one subsystem of the spinal stabilization system, the other subsystems have to work in compensation to maintain the stability of the spine. Focusing on the active subsystem, there might be change in motorneurons excitability in the core stabilizer muscles. These changes were not limited to the site of pain but also found at the multiple sites along the motor pathway. With cortical changes, alteration in motor planning would be expected (Figure 2.17) (Hodges et al. 2011).

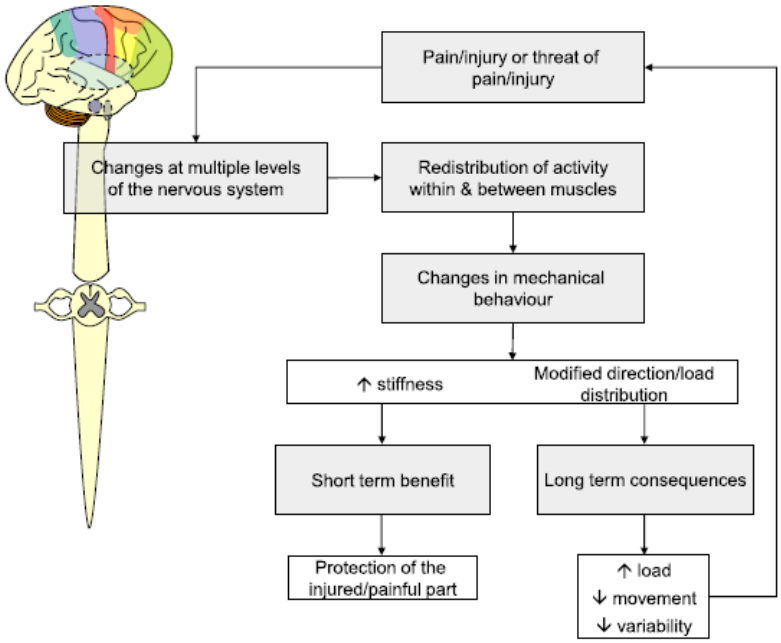

Figure 2.17 The motor adaptation to pain (from Hodges 2011)

In regard to the kinesiopathological model (Figure 2.18), pain and changes in excitability of motorneurons might lead to movement impairment if they persist for prolonged period. With sustained posture and repetition of an impaired movement, alterations in the three subsystems of the spinal stabilization system (Figure 2.1) together with the supporting system would bring about the perpetuation of pain (Sahrmann 2010). Further adaptation or compensation in the muscles, i.e. hypertrophy, atrophy, lengthening, shortening, stiffness, weakness, and recruitment pattern alteration would then take place. As the whole body is anatomically connected, the relative flexibility/stiffness of the altered tissues would induce tissue pathology and functional limitation in the other areas apart from the site of pain.

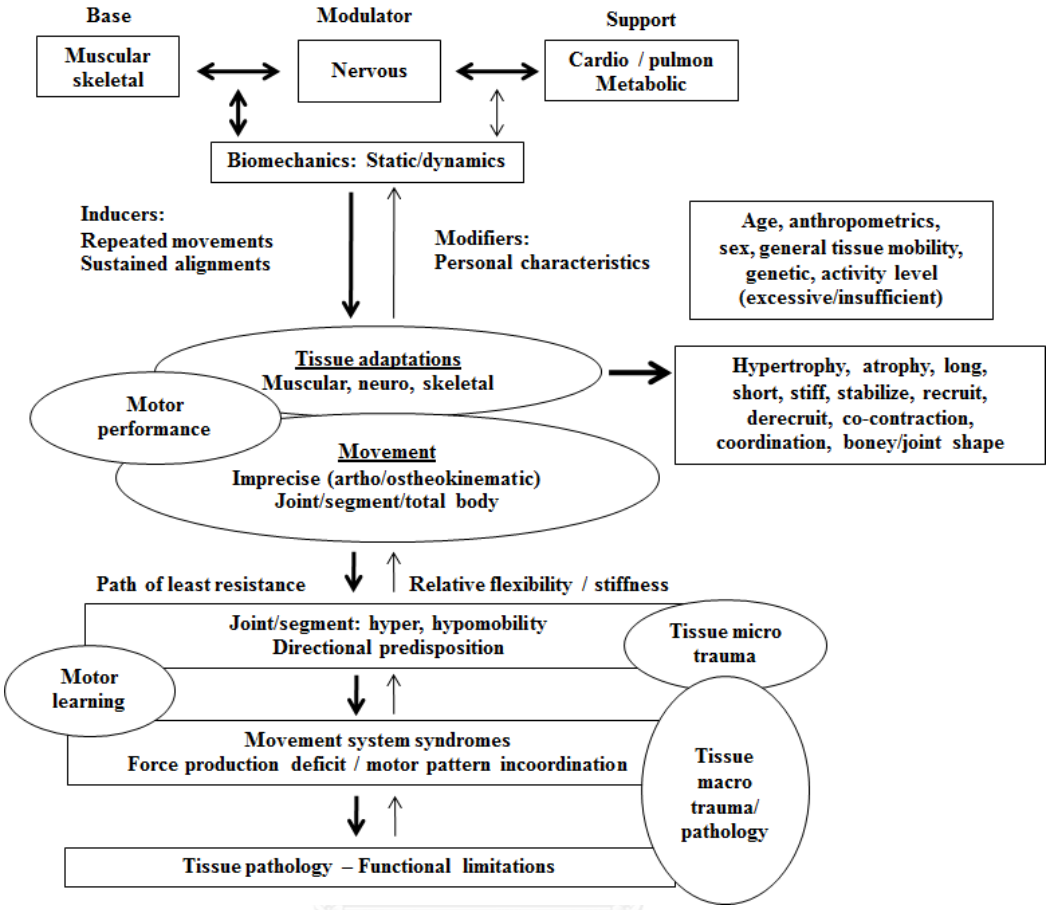

Figure 2.18 The kinesiopathological model of the human movement system (from Sahrmann 2010 page 5)

Although it was shown that people with neck pain of longer than four months performed badly on the ADIT, no previous studies have examined people with neck pain of lesser duration. Moreover, no studies have reported the performance of neck stabilizer muscles on the CCFT in people with low back pain. The aims of this study were to examine the performance of neck stabilizer muscles in people with low back pain and the performance of back stabilizer muscles in people with neck pain in subacute and chronic conditions.

2.8 Conceptual framework

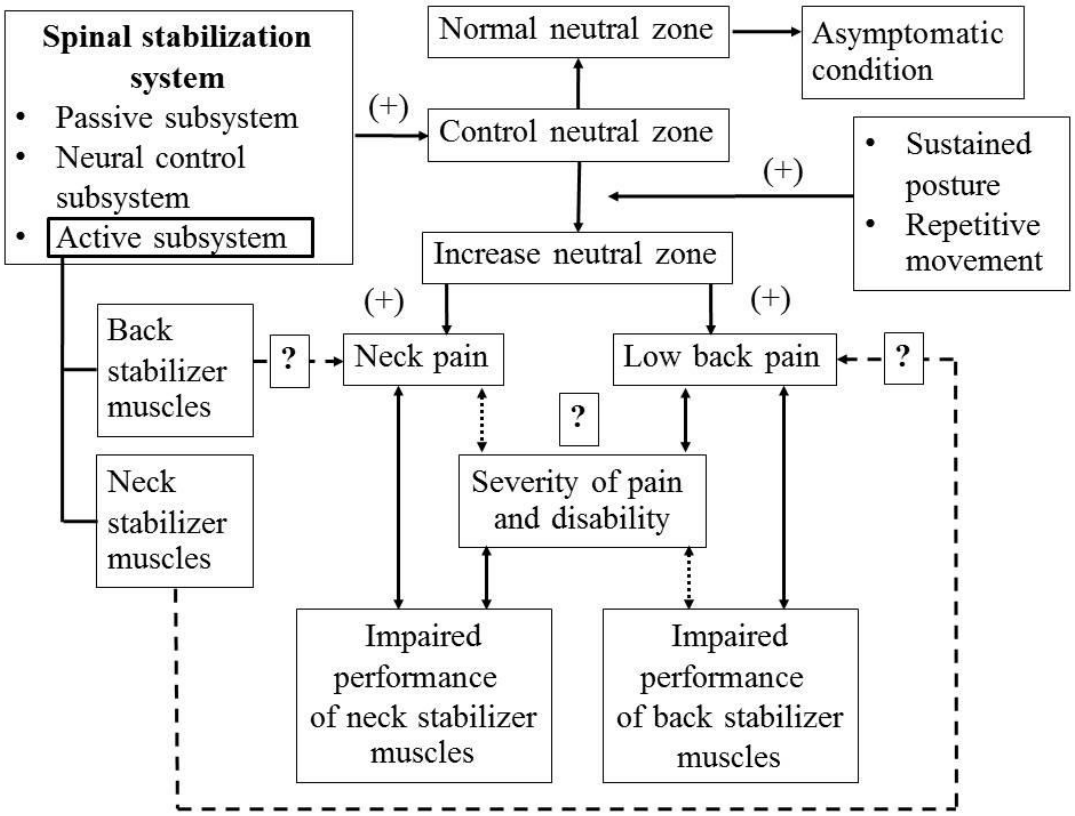

Figure 2.19 Conceptual framework

CHAPTER 3
METHODS

3.1 Introduction

This chapter describes the study design, characteristics of participants, materials, and procedure of this study.

3.2 Study design

This study was a cross-sectional study design with age- and gender-matched.

3.3 Participants

Ethical approval for the study was granted by the Chulalongkron University Human Ethics Committee (No. 068.1/59) (Appendix A). An advertisement was posted around the University area in order to recruit the participants. All participants who met the selection criteria signed the consent form before participating in the study. The sample size was calculated using the formula for testing the differences of two independent means (Chirawatkun 2010). The significant level was set at 0.05 (Z_α=1.96) and a power of test at 80% (Z_β=0.842).

Formula:

$$\text{n/group} = 2\left[\frac{(Z_\alpha + Z_\beta)\sigma}{\mu_1 - \mu_2}\right]^2$$

n = sample size/group

σ = variance

Z_α = Z-value for type I error

Z_β = Z-value for type II error

$\mu_1 - \mu_2$ = mean difference

The calculation was based on Jorgensen and colleagues (Jorgensen et al. 2014) (see Appendix B for details). The calculation revealed that this study needed 23 participants.

3.3.1 Inclusion criteria

The participants aged between 20 and 45 years old both males and females with normal body mass index (18.5–22.9 kg/m^2) (WHO 2000) were recruited. The participants were classified into three groups including neck pain group, low back pain group and age- and gender-matched control group. For neck pain and low back pain groups, the participants were categorized into two subgroups according to their pain duration.

1. Group 1 – Neck pain

   Neck pain is defined as perceived pain within the region bounded superiorly by the superior nuchal line, laterally by the lateral border of the neck, and inferiorly by the imaginary transverse line through the tip of the third thoracic spinous process (Côté et al. 1998). The pain might occur with or without radiation to head, trunk, and upper extremities (Childs et al. 2008, Guzman et al. 2008). The participants were classified into two subgroups (Jensen et al. 2007):

- Subacute neck pain. The pain had been present between one and three months.
- Chronic neck pain. The pain had been present for more than three months.

2. Group 2 – Low back pain

Low back pain was defined as pain perceived within the region bounded superiorly by imaginary transverse line through the tip of the twelfth thoracic spinous process, laterally by vertical line to the lateral borders of the lumbar erector spinae, and inferiorly by imaginary transverse line through the inferior gluteal folds (Krismer et al. 2007). The pain might also occur with or without lower extremity pain (Delitto et al. 2012). The participants were classified into two subgroups (Von Korff 1994, Delitto et al. 2012):

- Subacute low back pain. The pain had been present between one and three months.
- Chronic low back pain. The pain had been present for more than three months.

3. Group 3 – Age- and gender-matched control

Control group had to have no pain or discomfort in the spine which lasted longer than one day within the last two years. They were age- and gender-matched (± 3 years) (Jorgensen et al. 2014) with the participants in pain groups.

3.3.2 Exclusion criteria

The participants were excluded if they met any of the following criteria:

- Had abdominal skinfold thickness at two centimeters inferior to the navel and one centimeter lateral to the midline greater than 20 millimeters (Chanthapetch et al. 2009)
- Had undergone abdominal wall and spinal surgery
- Had spinal deformity such as scoliosis that was tested positive with the Adam's forward bend test (found one side of the rib cage to be higher than the other side) (Patias et al. 2010)
- Had neurological condition, fracture, cancer and infectious disease of the spine
- Had participated in the training program of neck or back stabilization within the last one year
- Unable to lie prone
- Unable to perform the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance due to pain
- Had menstruation or currently pregnant for female participants

3.4 Materials

3.4.1 Pressure biofeedback unit

A pressure biofeedback unit (Chattanooga, USA) (Figure 3.1) was used to measure the performance of core stabilizer muscles. It consists of a three-chamber air-filled pressure bag, a catheter, and a sphygmomanometer gauge. The size of pressure

bag is 16.7×24 centimeters and is made from an inelastic material. The sphygmomanometer gauge shows a range of 0-200 mmHg, with 2-mmHg intervals on the scale. The accuracy of the apparatus is ±3 mmHg.

Figure 3.1 Pressure biofeedback unit

3.4.2 Skinfold caliper

Skinfold caliper (Moore and Wright, United Kingdom) with 1-millimeter resolution was used to measure abdominal skinfold thickness at two centimeters lateral to the navel and one centimeter lateral to the midline (Chanthapetch et al. 2009).

3.4.3 Stopwatch

A stopwatch was used to record the holding time that the participants could achieve during the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance.

3.4.4 Plinth

A plinth was used for performing the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance.

3.4.5 Screening questionnaire

The screening questionnaire was used to screen for the eligibility of participants. This questionnaire includes age, gender, weight, height, body mass index, inclusion and exclusion criteria (Appendix I).

3.4.6 Visual analog scale

Visual analog scale is the most commonly used tool for measuring pain intensity. It was used to assess pain intensity at neck and lower back in this study. Participants were asked to rate their pain levels on a 100-millimeter linear line. The anchor on the left end represents “no pain” and the right end represents “pain as bad as it could be” (Appendix J). A ruler was used for measuring the distance from “no pain” anchor to the marked point in millimeters. The results were categorized into four categories: 0-4 millimeters is no pain, 5-44 millimeters is mild pain, 45-74 millimeters is moderate pain, and 75-100 millimeters is severe pain. The moderate to excellent test-

retest reliability of pain measurement was reported in the previous study (ICC = 0.71-0.94) (Hawker et al. 2011).

3.4.7 Neck disability index

Neck disability index was used to estimate disability from neck pain (Appendix K). It has 10 items that related with activity of daily living and pain (Vernon et al. 1991). Each item is scored from 0 to 5. The maximum sum score of 10 items is 50 and minimum sum score is 0. The higher score represents the greater level of disability. The sum score of 0-4 is classified as no disability, 5-15 as mild disability, 15-25 as moderate disability, 25-34 as severe disability, and over 35 as complete disability. Thai version reported the moderate to excellent test-retest reliability (ICC = 0.74-0.91), moderate convergent validity (r = 0.64) and excellent internal consistency (Cronbach α values = 0.85) (Uthaikhup et al. 2011). The standard error of measurements was 5.8 and minimal detectable change (scale range = 0–100) was 16.1 points (Uthaikhup et al. 2011).

3.4.8 Modified Oswestry low back pain disability questionnaire

Modified Oswestry low back pain disability questionnaire (Appendix L) was used to estimate disability from low back pain. It has 10 items that related with activity of daily living and pain (Fritz et al. 2001). Each item is scored from 0 to 5. The maximum sum score of 10 items is 50 and minimum sum score is 0. The higher score represents the greater level of disability. The sum score of 0-4 is classified as no disability, 5-15 as mild disability, 15-25 as moderate disability, 25-34 as severe disability, and over 35 as complete disability (Fairbank et al. 2000). For Thai version

of modified Oswestry low back pain disability questionnaire, the excellent test-retest reliability in low back pain group was presented (ICC = 0.98) (Sakulsriprasert et al. 2006).

3.5 Assessors

Two assessors participated in this study and they were physical therapists. Assessor 1 conducted the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance. This assessor was blinded from characteristics of the participants. The intra-rater reliability for measuring the activation score and the performance index of the CCFT and the pressure change of the ADIT were good with the intraclass correlation coefficient more than 0.86 (see Appendix C for details). Assessor 2 was responsible for recruiting and screening for the suitability of the participants as well as performing the measurement of the visual analog scale in the pain groups. Excellent intra-rater reliability for measuring the visual analog scale was established prior to conducting the study with the intraclass correlation coefficient of 0.99 (see Appendix C for details).

3.6 Procedure

The testing protocol was performed within one day. It consisted of a training session and a testing session with at least five minutes interval. All experiments took place in the laboratory room that standardized the environmental conditions to minimize any distractions throughout the experiment. All participants were measured after food consumption at least 30 minutes and empty bladder.

3.6.1 Training session

A training session was provided to familiarize participants with the testing protocol. They were instructed to perform the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance until the correct performance was achieved.

3.6.1.1 The CCFT with pressure biofeedback unit

The participants were in supine crook lying position on a plinth with the neck in a neutral position (Jull et al. 2008). A pillow or towel (s) might be used to keep neck in neutral position so that their forehead and chin were aligned horizontally to the plinth surface. The pressure biofeedback unit was placed below the occiput and inflated pressure to 20 mmHg (Jull et al. 2008). The participants were requested to slowly feel the back of their head slide up the plinth in a head nod action to elevate the pressure from 20 to 22 mmHg with normal breathing pattern. This process was repeated with the next pressure levels of 2-mmHg interval between levels. There were five levels of testing which consisted of the change in pressure from 20 to 22 mmHg for level one, 20 to 24 mmHg for level two, 20 to 26 mmHg for level three, 20 to 28 mmHg for level four, and 20 to 30 mmHg for level five. Throughout the CCFT, Assessor 1 placed fingers over both sternocleidomastoid muscles of the participants to palpate for the contraction of the muscles (Jull et al. 2008). The method of manual palpation for detecting the sternocleidomastoid muscles activity during the CCFT was proved to be valid as shown in Appendix E. To be successful, the CCFT had to be performed with minimal sternocleidomastoid muscles activity and in absence of any substitution

strategies. For the training session, the participants were allowed to practice at each target pressure level for no longer than 2-3 seconds.

3.6.1.2 The ADIT with pressure biofeedback unit

Participants were in prone position with the head lay comfortably and relaxed. The pressure biofeedback unit was placed under lower abdomen in line with right and left anterior superior iliac spines (Richardson et al. 1995). Then, the unit was inflated to 70 mmHg. Assessor 1 placed fingers over the thoracolumbar area for detecting any spinal movement. This technique was modified from previous study by placing fingers under rectus abdominis muscle (Garnier et al. 2009) which might cause discomfort during the ADIT in prone position that was found in pilot study. The participants were asked to draw abdomen toward the spine with normal breathing to reduce the pressure by 4-10 mmHg without spinal movement. To be successful, the ADIT had to be performed with minimal superficial abdominal muscles activity which no detectable spinal movement and in the absence of any other substitution strategies detected by Assessor 1 (Richardson et al. 1995, Garnier et al. 2009). For the training session, the participants were asked to hold the decreased pressure steadily for no longer than 2-3 seconds.

3.6.2 Testing session

Once the participants were able to perform both the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance correctly, the testing session started. The testing order of the CCFT and the ADIT was randomized with 2-minute rest in between.

3.6.2.1 The CCFT with pressure biofeedback unit

The testing protocol presented in section 3.6.1.1 was followed. However, the participants were required to hold steady at each target pressure level as long as they could up to 10 seconds. Two data were recorded, i.e. activation score and performance index (Jull et al. 2008).

- The **activation score** was defined as the highest pressure level that the participants could achieve 10-second holding with correct movement. The activation score ranged from 0 to 10 mmHg. The resting period between each successive target level was 30 seconds (Jull et al. 2016).
- The **performance index** was scored via the highest pressure level (activation score) at which the participants could repetitively hold for 10-second duration. It represented the isometric endurance of the deep cervical flexor muscles. The number of repetitions were then multiplied with the activation score and be referred to as the performance index. For example, if a participant could achieve an activation score of 6 mmHg and perform five of 10-second holds, then the performance index was 6×5 = 30. The performance index ranged from 0 to 100.

3.6.2.2 The ADIT with pressure biofeedback unit

The testing protocol presented in section 3.6.1.2 was followed. However, the participants were required to hold steady at the reduced pressure level as long as they could up to 10 seconds (Cairns et al. 2000). The amount of the reduced pressure in mmHg was recorded as **pressure change** which would be used for data analysis.

3.7 Statistical analysis

The IBM SPSS Statistics version 22.0 (IBM Corp. Released 2013, Armonk, NY, USA) software package was used for all statistical analyses. The significant level was set at $p < 0.05$. The descriptive statistics was performed to describe the demographic data which were expressed as mean, standard deviation (SD), median, minimum, and maximum. The Shapiro-Wilk test was used to test the distribution of the data. If data were normally distributed, the one-way analysis of variance (ANOVA) would be used to test for the differences between groups. If data were not normally distributed, the Kruskal Wallis test would be used to analyze the differences between groups.

- The primary objective was to compare the performance of core stabilizer muscles in individuals with neck pain, low back pain, and age- and gender-matched control groups.

The analysis by the Shapiro-Wilk test showed that the data from all outcome measures were not normally distributed. Therefore, separate Kruskal Wallis tests were used to analyze the differences in the activation score and performance index from the CCFT and the pressure change from the ADIT among three groups (subacute, chronic, and control). Mann-Whitney *U* test was used as a *post hoc* analysis to identify which pairs were responsible for the statistical significance.

Further analysis was conducted to examine whether there was a homogeneity in proportions of the participants whom were classified as normal and abnormal performance among subacute, chronic, and control groups. Chi-square test was conducted. The activation score and performance index from the CCFT for neck stabilizer muscle performance and the pressure change from the ADIT for back

stabilizer muscle performance were classified for statistical analysis. The criteria for categorization were based on previous studies that investigated the differences in muscle performance of cervical and lumbar core stabilizer muscles between symptomatic and asymptomatic subjects. This study classified results into two categories, i.e. normal and abnormal.

1. **Activation score** of the CCFT for neck stabilizer muscle performance (Jull 2000, Beer et al. 2012)
    - Normal when the value was greater than 4 mmHg.
    - Abnormal when the value was equal to or less than 4 mmHg.
2. **Performance index** of the CCFT for neck stabilizer muscle performance (Jull et al. 1999, Fernández-de-las-Peñas et al. 2007)
    - Normal when the value was greater than 20. This value was deemed appropriate as it was ranged between the 10.60±15.30 and 32.40±15.90 found in patients with chronic cervicogenic headache and chronic tension type headache. The participants should obtain the activation score of at least 4 mmHg with at least 6 repetitions.
    - Abnormal when the value was equal to or less than 20
3. **Pressure change** of the ADIT for back stabilizer muscle performance (Hodges et al. 1996, Moseley 2004)
    - Normal when the value was equal to or greater than 4 mmHg.
    - Abnormal when the value was less than 4 mmHg.

- The secondary objective was to identify the correlation between level of performance of core stabilizer muscles and severity of pain and disability in other areas where there was no pain.

The Spearman's correlation coefficient were used to test for the correlations of interest. Correlation coefficient (*r*) of 0-0.25 indicates little or no relationship, 0.25-0.50 is fair, 0.50-0.75 is moderate to good, and greater than 0.75 is good to excellence (Portney et al. 2009).

CHAPTER 4
RESULTS

There were 122 participants in this study (60 males and 62 females). There were 23 participants in each of the symptomatic groups while there were 30 participants in the age- and gender-matched control group. The demographic data for participants with neck pain and low back pain along with their age- and gender-matched control groups are presented in Tables 4.1 and 4.2. No statistically significant differences in demographic data between groups were shown.

Table 4.1 Demographic data of subacute neck pain, chronic neck pain and age- and gender-matched control groups

Variables	**Mean (SD)**				***p*-value**
	Subacute neck pain group (n=23)	**Chronic neck pain group (n=23)**	**Control for subacute neck pain (n=23)**	**Control for chronic neck pain (n=23)**	
Gender, N (%)					–
- Male	11 (47.80)	11 (47.80)	11 (47.80)	11 (47.80)	
- Female	12 (52.20)	12 (52.20)	12 (52.20)	12 (52.20)	
Age (years)	23.30 (2.88)	24.22 (4.12)	22.48 (2.57)	23.39 (3.74)	0.433
Body mass index (kg/m^2)	20.95 (1.15)	20.79 (1.26)	20.38 (1.38)	20.46 (1.36)	0.279
Abdominal skinfold thickness (mm)	15.88 (3.18)	16.62 (3.12)	15.28 (3.40)	15.20 (3.46)	0.284
Visual analog scale (mm)	43.78 (18.16)	50.26 (16.89)	–	–	–
Neck disability index	5.74 (3.96)	7.74 (3.57)	–	–	–

*p-value < 0.05

Table 4.2 Demographic data of subacute low back, chronic low back pain and age- and gender-matched control groups

Variables	**Mean (SD)**				***p*-value**
	Subacute low back pain group (n=23)	**Chronic low back pain group (n=23)**	**Control for subacute low back pain (n=23)**	**Control for chronic low back pain (n=23)**	
Gender, N (%)					-
- Male	11 (47.80)	12 (52.20)	11 (47.80)	12 (52.20)	
- Female	12 (52.20)	11 (47.80)	12 (52.20)	11 (47.80)	
Age (years)	22.70 (3.27)	25.13 (5.39)	22.43 (2.89)	24.61 (5.13)	0.236
Body mass index (kg/m^2)	20.77 (1.45)	20.73 (1.26)	20.45 (1.31)	20.56 (1.35)	0.667
Abdominal skinfold thickness (mm)	16.73 (2.99)	15.32 (3.87)	15.17 (3.15)	15.50 (3.45)	0.114
Visual analog scale (mm)	47.26 (18.14)	52.35 (20.21)	–	–	–
Modified Oswestry low back pain disability questionnaire	4.34 (3.41)	6.39 (4.00)	–	–	–

*p-value < 0.05

Mean (SD), median, minimum, and maximum values of the activation score and performance index of the CCFT for neck stabilizer muscle performance, and pressure change of the ADIT for back stabilizer muscle performance of all participants are presented in Table 4.3. In general, the control groups showed higher performance of core stabilizer muscles than the subacute and the chronic groups.

Table 4.3 The mean (SD), median, minimum, and maximum values of the activation score, the performance index, and the pressure change of pain groups and age- and gender-matched control groups

	Mean (SD)	**Median**	**Minimum**	**Maximum**
Activation score (mmHg)				
- Subacute neck pain group (n=23)	3.04 (1.80)	4	0	6
Control group (n=23)	6.78 (2.24)	6	2	10
- Chronic neck pain group (n=23)	2.96 (1.19)	4	0	4
Control group (n=23)	6.78 (2.15)	6	2	10
- Subacute low back pain group (n=23)	4.35 (2.31)	4	0	10
Control group (n=23)	6.96 (2.16)	6	2	10
- Chronic low back pain group (n=23)	4.26 (2.72)	4	0	10
Control group (n=23)	6.52 (2.19)	6	2	10
Performance index				
- Subacute neck pain group (n=23)	12.00 (9.01)	10	0	24
Control group (n=23)	37.48 (20.32)	42	4	80
- Chronic neck pain group (n=23)	11.13 (8.31)	12	0	28
Control group (n=23)	35.57 (19.06)	42	4	60
- Subacute low back pain group (n=23)	17.04 (13.70)	16	0	50
Control group (n=23)	37.48 (20.82)	48	4	80
- Chronic low back pain group (n=23)	21.74 (21.53)	16	0	80
Control group (n=23)	36.61 (20.33)	40	4	80

	Mean (SD)	Median	Minimum	Maximum
Pressure change (mmHg)				
- Subacute neck pain group (n=23)	3.13 (1.46)	2	2	8
Control group (n=23)	4.43 (1.90)	4	2	10
- Chronic neck pain group (n=23)	3.04 (1.46)	2	0	6
Control group (n=23)	4.35 (1.87)	4	2	10
- Subacute low back pain group (n=23)	1.65 (0.98)	2	0	4
Control group (n=23)	4.35 (1.87)	4	2	10
- Chronic low back pain group (n=23)	2.00 (1.35)	2	0	4
Control group (n=23)	4.48 (2.00)	4	2	10

Kruskal Wallis tests showed significant differences in the activation score, the performance index, and the pressure change among three groups ($p < 0.05$) both in the neck pain and low back pain. *Post hoc* analyses with Mann-Whitney *U* test revealed significantly lower activation score, performance index, and pressure change values in the subacute and the chronic pain groups than the control group ($p < 0.05$). These phenomena were demonstrated both in the neck pain (Tables 4.4) and low back pain conditions (Tables 4.5).

Table 4.4 The level of significance (*p*-values) from *post hoc* analyses with Mann-Whitney *U* tests of the activation score, performance index and pressure change between subacute neck pain, chronic neck pain and age- and gender-matched control groups

Activation score

Groups	Subacute neck pain (n=23)	Chronic neck pain (n=23)	Control (n=23)
Subacute neck pain	-	0.867	<0.001*
Chronic neck pain		-	<0.001*

Performance index

Groups	Subacute neck pain (n=23)	Chronic neck pain (n=23)	Control (n=23)
Subacute neck pain	-	0.649	<0.001*
Chronic neck pain		-	<0.001*

Pressure change

Groups	Subacute neck pain (n=23)	Chronic neck pain (n=23)	Control (n=23)
Subacute neck pain	-	0.971	0.006*
Chronic neck pain		-	0.012*

*p-value < 0.05

Table 4.5 The level of significance (*p*-values) from *post hoc* analyses with Mann-Whitney *U* tests of the activation score, performance index and pressure change between subacute low back pain, chronic low back pain and age- and gender-matched control groups

Activation score

Groups	Subacute low back pain (n=23)	Chronic low back pain (n=23)	Control (n=23)
Subacute low back pain	-	0.889	<0.001*
Chronic low back pain		-	0.004*

Performance index

Groups	Subacute low back pain (n=23)	Chronic low back pain (n=23)	Control (n=23)
Subacute low back pain	-	0.724	0.001*
Chronic low back pain		-	0.011*

Pressure change			
Groups	**Subacute low back pain (n=23)**	**Chronic low back pain (n=23)**	**Control (n=23)**
Subacute low back pain	-	0.384	<0.001*
Chronic low back pain		-	<0.001*

*p-value < 0.05

Table 4.6 presented that approximately 50% of the participants who had neck pain demonstrated abnormal response on the ADIT for back stabilizer muscle performance. While approximately 60% of the participants who had back pain demonstrated abnormal response on the CCFT for neck stabilizer muscle performance (Table 4.7). Chi-square tests showed significant differences in the proportions of the participants whom were classified as normal and abnormal responses on the ADIT and the CCFT among subacute, chronic, and control groups.

Table 4.6 Results of Chi-square tests for comparisons of the number of the participants whom were classified into normal and abnormal response for the activation score, performance index, and pressure change in subacute neck pain, chronic neck pain and age- and gender-matched control groups

Variables	**N (%)**				***p*-value**
	Subacute neck pain group (n=23)	**Chronic neck pain group (n=23)**	**Control for subacute neck pain (n=23)**	**Control for chronic neck pain (n=23)**	
Activation score					<0.001*
- Normal	3 (13.0)	0 (0.0)	20 (87.0)	20 (87.0)	
- Abnormal	20 (87.0)	23 (100.0)	3 (13.0)	3 (13.0)	
Performance index					<0.001*
- Normal	7 (30.4)	3 (13.0)	18 (78.3)	17 (73.9)	
- Abnormal	16 (69.6)	20 (87.0)	5 (21.7)	6 (26.1)	

Variables	N (%)				*p*-value
	Subacute neck pain group (n=23)	**Chronic neck pain group (n=23)**	**Control for subacute neck pain (n=23)**	**Control for chronic neck pain (n=23)**	
Pressure change					0.018*
- Normal	11 (47.8)	11 (47.8)	19 (82.6)	19 (82.6)	
- Abnormal	12 (52.2)	12 (52.2)	4 (17.4)	4 (17.4)	

*p-value < 0.05

Table 4.7 Results of Chi-square tests for comparisons of the number of the participants whom were classified into normal and abnormal response for the activation score, performance index, and pressure change in subacute low back pain, chronic low back pain and age- and gender-matched control groups

Variables	N (%)				*p*-value
	Subacute low back pain group (n=23)	**Chronic low back pain group (n=23)**	**Control for subacute low back pain (n=23)**	**Control for chronic low back pain (n=23)**	
Activation score					<0.001*
- Normal	6 (26.1)	8 (34.8)	21 (91.3)	19 (82.6)	
- Abnormal	17 (73.9)	15 (65.2)	2 (8.7)	4 (17.4)	
Performance index					<0.001*
- Normal	6 (26.1)	9 (39.1)	17 (73.9)	18 (78.3)	
- Abnormal	17 (73.9)	14 (60.9)	6 (26.1)	5 (21.7)	
Pressure change					<0.001*
- Normal	2 (47.8)	5 (21.7)	19 (82.6)	19 (82.6)	
- Abnormal	21 (52.2)	18 (78.3)	4 (17.4)	4 (17.4)	

*p-value < 0.05

The performance of neck stabilizer muscles showed no correlations with the pain severity and disability of low back pain (*r* ranged from -0.08 to -0.26) (Table 4.8). Similarly, the performance of back stabilizer muscles showed no correlations with the severity and disability of neck pain (*r* ranged from -0.12 to 0.08).

Table 4.8 The correlations between pain, disability and performance of core stabilizer muscles

Variables	**Correlation coefficient (*r*)**	***p*-value**
Activation score (n=46)		
- Visual analog scale (low back pain groups)	-0.183	0.225
- Modified Oswestry low back pain disability questionnaire	-0.076	0.616
Performance index (n=46)		
- Visual analog scale (low back pain groups)	-0.262	0.079
- Modified Oswestry low back pain disability questionnaire	-0.110	0.466
Pressure change (n=46)		
- Visual analog scale (neck pain groups)	0.079	0.601
- Neck disability index	-0.118	0.443

*p-value < 0.05

CHAPTER 5
DISCUSSION

The primary objectives of this study were to examine the performance of lumbar stabilizer muscles in subacute neck pain, chronic neck pain, and age- and gender-matched control groups as well as to examine the performance of cervical stabilizer muscles in subacute low back pain, chronic low back pain and age- and gender-matched groups. The results suggest that people with neck pain or low back pain presented abnormal performance of core stabilizer muscles both in the cervical and the lumbar spines. For the secondary objectives, pain severity and disability in one spinal region did not correlate with the level of the performance of core stabilizer muscles in the remote spinal region.

This is the first study that investigated the performance of the cervical core stabilizer muscles in patients who had low back pain. The lower activation score and the performance index values from the CCFT for neck stabilizer muscle performance in the subacute and chronic low back pain groups than the control group indicate the plausible link between low back pain and neck pain. This study found approximately 70% of subacute low back pain participants and 60% to 65% of chronic low back pain participants demonstrated abnormal responses on the activation score and the performance index from the CCFT for neck stabilizer muscle performance (Table 4.7). These proportions of abnormal responses were much higher than the control group. Although there have been no evidence for cause and effect of poor performance of cervical core stabilizer muscles and the development of neck pain, abnormal CCFT for

neck stabilizer muscle performance responses in low back pain groups might put the cervical spine to be at risk of neck injury.

The lower pressure change values from the ADIT for back stabilizer muscle performance in the subacute and chronic neck pain groups than the control group also indicate the plausible link between neck pain and low back pain. These results support previous study that found people with chronic neck pain more than four months had a reduced capacity to perform the ADIT for back stabilizer muscle performance (Moseley 2004). Furthermore, the reduced performance of the lumbar core stabilizer muscles in these neck pain patients was associated with an increased risk of developing low back pain at 2-year follow-up period. Approximately 50% of subacute neck pain participants and 50% of chronic neck pain participants demonstrated abnormal responses on the pressure change from the ADIT for back stabilizer muscle performance (Table 4.6). These amount of proportion was lower than the 75% reported by the previous study (Moseley 2004). These differences might be explained by differences in characteristics of the participants. The chronic neck pain participants in this study had mild level of the neck disability index (7.74±3.57) while it was moderate to severe disability (37.00±7.00) in the previous study (Moseley 2004). Chronic neck pain who had high level of disability might demonstrate poorer muscle performance and abnormal response to the ADIT for back stabilizer muscle performance than those who had low level of disability.

This study found the performance of core stabilizer muscles in the area of pain was less than normal when being compared with the controls. On average, the neck pain participants in this study showed activation score (2.96±1.19 to 3.04±1.80 mmHg) compared to the previous studies that reported the range from 3 to 4.2 mmHg in patients

with chronic whiplash (3.00±1.30 mmHg) (Jull 2000) and chronic cervicogenic headache (4.20±1.90 mmHg) (Jull et al. 1999). However, the value was lower than 6.60 ± 2.30 mmHg that was reported in patients with chronic tension-type headache (Fernández-de-las-Peñas et al. 2007).

For the control group, the activation score was in line with the previous studies which showed the range of 6.10±1.50 to 8.00±1.70 mmHg (Jull et al. 1999, Jull 2000). The values of the performance index of neck pain groups (11.13±8.31 to 12.00±9.01) were also coincided with previous studies that assessed in patients with chronic cervicogenic headache (10.60±15.30) (Jull et al. 1999) and lower than chronic tension-type headache (32.40±15.80) (Fernández-de-las-Peñas et al. 2007). Likewise, the values of the pressure change for the ADIT (1.65±0.98 to 2.00±1.35 mmHg) of no greater than 2 mmHg were coincided with previous studies which reported similar values (1.17±4.36 to 1.78±2.43 mmHg) (Hodges et al. 1996, Cairns et al. 2000). Furthermore, the result was lower than 1.80±1.50 mmHg that demonstrated in neck pain patients with pain duration of more than 4 to 12 months (Moseley 2004).

No correlations between the performance of core stabilizer muscles with pain severity and disability in the other areas without pain were found in this study. In other words, the pain severity and disability of neck pain had no effect on the ADIT for back stabilizer muscle performance. The pain severity and disability of back pain also had no effect on the CCFT for neck stabilizer muscle performance. These results suggest that the performance of core stabilizer muscles in one spinal region does not get worse with increasing pain severity and disability in the remote spinal region. The reasons for these results were unclear. However, these outcomes support the finding of the previous studies that studied the effects of pain severity on the performance of core stabilizer

muscles within that same painful area. No strong correlation (r=-0.36) between the CCFT for neck stabilizer muscle performance and pain severity in chronic neck pain was reported (Falla et al. 2011). Likewise, no correlation between the ADIT for back stabilizer muscle performance and chronicity was demonstrated in chronic low back pain (Cairns et al. 2000). Therefore, the possibility to find strong correlations between the performance of core stabilizer muscles in one spinal region and pain severity and disability of the other spinal regions might be difficult.

Limitations of this study

There were few limitations of this study. First, this study did not follow participants who presented abnormal response for the CCFT or the ADIT for longer period. The cause and effect between the abnormal response and the development of spinal pain could not be established. A prospective study would be required. Second, the pressure biofeedback unit could detect difference for 2 mmHg that might not be suitable for detecting minimal change between subacute and chronic conditions. The digital pressure biofeedback should be used in future study.

CHAPTER 6
CONCLUSION

Individuals with neck pain not only had abnormal performance of core stabilizer muscles in the cervical spine but also had abnormal performance of core stabilizer muscles in the lumbar spine. Similarly, individuals with low back pain had abnormal performance of core stabilizer muscles both in the cervical and the lumbar spines. Pain severity and disability had no effect on the level of core stabilizer muscle performance. These findings provide physical therapists an evidence for early intervention for preventing neck pain in individuals with low back pain as well as for preventing low back pain in individuals with neck pain.

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APPENDIX

APPENDIX A
CERTIFICATE OF APPROVAL

Ethical approval grants by the Ethical Review Committee for Research involving Human Research Participants, Health Science Group, Chulalongkorn University, Thailand

AF 02-12

The Research Ethics Review Committee for Research Involving Human Research Participants, Health Sciences Group, Chulalongkorn University
Jamjuree 1 Building, 2nd Floor, Phyathai Rd., Patumwan district, Bangkok 10330, Thailand,
Tel/Fax: 0-2218-3202 E-mail: eccu@chula.ac.th

COA No. 108/2016

Certificate of Approval

Study Title No. 068.1/59 : PERFORMANCE OF CORE STABILIZER MUSCLES IN INDIVIDUALS WITH NECK PAIN AND LOW BACK PAIN

Principal Investigator : MISS CHATTRACHOO THONGPRASERT

Place of Proposed Study/Institution : Faculty of Allied Health Sciences, Chulalongkorn University

The Research Ethics Review Committee for Research Involving Human Research Participants, Health Sciences Group, Chulalongkorn University, Thailand, has approved constituted in accordance with the International Conference on Harmonization – Good Clinical Practice (ICH-GCP).

Signature: ..... Signature: .....

(Associate Professor Prida Tasanapradit, M.D.) Chairman

(Assistant Professor Nuntaree Chaichanawongsaroj, Ph.D.) Secretary

Date of Approval : 30 May 2016 Approval Expire date : 29 May 2017

The approval documents including

1) Research proposal
2) Patient/Participant Information Sheet and Informed Consent Form
3) Researcher
4) Questionnaire

Protocol No. 068.1/59
Date of Approval 30 MAY 2016
Approval Expire Date 29 MAY 2017

The approved investigator must comply with the following conditions:

1. *The research/project activities must end on the approval expired date of the Research Ethics Review Committee for Research Involving Human Research Participants, Health Sciences Group, Chulalongkorn University (RECCU). In case the research/project is unable to complete within that date, the project extension can be applied one month prior to the RECCU approval expired date.*
2. *Strictly conduct the research/project activities as written in the proposal.*
3. *Using only the documents that bearing the RECCU's seal of approval with the subjects/volunteers (including subject information sheet, consent form, invitation letter for project/research participation (if available).*
4. *Report to the RECCU for any serious adverse events within 5 working days*
5. *Report to the RECCU for any change of the research/project activities prior to conduct the activities.*
6. *Final report (AF 03-12) and abstract is required for a one year (or less) research/project and report within 30 days after the completion of the research/project. For thesis, abstract is required and report within 30 days after the completion of the research/project.*
7. *Annual progress report is needed for a two- year (or more) research/project and submit the progress report before the expire date of certificate. After the completion of the research/project processes as No. 6.*

APPENDIX B
SAMPLE SIZE CALCULATION

The sample size was calculated using the formula for testing the differences of two independent means (Chirawatkun 2010). The significant level was set at 0.05 (Z_α=1.96) and a power of test at 80% (Z_β=0.842).

Formula:

$$n/group = 2\left[\frac{(Z_\alpha + Z_\beta)\sigma}{\mu_1 - \mu_2}\right]^2$$

n = sample size/group

σ = variance

Z_α = Z-value for type I error

Z_β = Z-value for type II error

$\mu_1 - \mu_2$ = mean difference

The calculation was based on the previous study from Hodges which assessed the ADIT for back stabilizer muscle performance with pressure biofeedback unit (mmHg) in low back pain (n = 6) and control group (n = 9) (Hodges et al. 1996). Mean and standard deviation (SD) of the pressure change in neck pain and control were 1.78 ± 2.43 and 5.82 ± 3.13 mmHg. Based on this study, the mean and SD was used to calculate the pool variance. The pool variance was 2.88. The cut off pressure between normal and abnormal response was 4 mmHg that set as mean difference. From formula 1, the sample size for each group was 9 participants.

$$\text{n/group} = 2\left[\frac{(Z_\alpha + Z_\beta)\sigma}{\mu_1 - \mu_2}\right]^2$$

$$\text{n/group} = 2\left[\frac{(1.96+0.842)\ 2.88}{4}\right]^2$$

$$\text{n/group} = 8.14$$

$$\text{n/group} \approx 9$$

The CCFT for neck stabilizer muscle performance, the calculation was based on Jorgensen and colleagues which assessed the intra-rater reliability of neck pain measurements including the activation score of the CCFT, range of motion, joint position error, gaze stability, smooth pursuit neck torsion test and neuromuscular control of deep extensors in chronic neck pain (n = 21) and control group (n = 21) (Jorgensen et al. 2014). Based on this study, the standard error (SE) of the CCFT was converted to SD. The SD was 4.796 that set as variance. The minimal detectable change was used as mean difference of the CCFT that was 3.99. The total sample size for each group was 23 participants.

$$\text{n/group} = 2\left[\frac{(Z_\alpha + Z_\beta)\sigma}{\mu_1 - \mu_2}\right]^2$$

$$\text{n/group} = 2\left[\frac{(1.96+0.842)\ 4.796}{3.99}\right]^2$$

$$\text{n/group} = 22.69$$

$$\text{n/group} \approx 23$$

The maximum of sample size was presented from the CCFT. Therefore, this study was used 23 participants for each group.

APPENDIX C
RELIABILITY STUDY

1. Introduction

This appendix describes the reliability of manual palpation and EMG biofeedback during the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance and the reliability of measurement of the visual analog scale. The topics consist of objectives, characteristics of participants, materials, assessors, procedures, statistical analysis, results, discussion and conclusion.

2. Objectives

This study was to estimate the reliability of manual palpation and EMG biofeedback during the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance and to estimate the reliability of measurement of the visual analog scale.

3. Participants

Thirty participants from main study in three periods including beginning, middle and end were recruited. The beginning period was participants who participated before number 50. The middle period was participants who participated during number 50-100. The end period was participants who participated after number 100. The participants were classified into three groups including neck pain group, low back pain group, and control group. There were 10 participants for each group. The characteristics of participants in this study followed topic of participants in CHAPTER 3.

4. Materials

Materials of this study followed topic of materials in CHAPTER 3.

4.1 EMG biofeedback

The Myomed 932® (Enraf-Nonius, Delft, the Netherlands) was used to provide feedback for the contraction of superficial muscles during the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance. The feedback can be set to be visual and/or audio feedback.

4.2 Silver/silver chloride surface electrodes

Silver/silver chloride surface electrodes (Medicotest Blue Sensor type M-00-S, Ambu, Denmark) were used to measure muscle activity of the superficial muscles during testing. These muscles were sternocleidomastoid and rectus abdominis muscles. All electrodes had one centimeter in diameter and were placed with center-to-center spacing of less than 2.2 centimeters (Ng et al. 1998).

4.3 Skin preparing equipment

Seventy percent ethyl alcohol was used with cotton ball to clean the skin over the electrode placement. This was to decrease the skin resistance.

5. Assessors

Two assessors participated in this study. Assessor 1 conducted the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance while using manual palpation to monitor the contraction of the superficial

muscles and placed surface electrode. Assessor 2 operated EMG biofeedback for monitoring the contraction of the superficial muscles during the tests. These two assessors were blinded from each other's results. Assessor 2 measured the visual analog scale for participants in pain groups.

6. Procedures

Procedures of this study followed topic of procedures in CHAPTER 3. This study was changed that participants were performed the CCFT and the ADIT at random order with half of the participants performed the CCFT prior to the ADIT with two repetitions and rest two minutes between repetitions or until no fatigue. From the pilot study, the learning effect from performance of core stabilizer muscles was found in the CCFT and the ADIT between the first and second tests after one week. To prevent that effect and represent real performance of core stabilizer muscles, this study would be tested within one day. The activation score and performance index were recorded as result of the CCFT and the pressure change was recorded as the result of the ADIT from manual palpation and EMG biofeedback. The visual analog scale was measured by using the same ruler. The second measurement was occurred after the first measurement for one day. The assessor would not be able to remember the results.

6.1 Training session

A training session was provided to familiarize participants with the testing protocol. They were instructed to perform the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance until the correct performance was achieved.

6.1.1 CCFT with pressure biofeedback unit

Participants were in supine crook lying position on a plinth with the neck in a neutral position (Jull et al. 2008). The pillow or towel might be used to keep neck in neutral position that lie horizontal to the plinth. Assessor 1 prepared the skin over both sternocleidomastoid muscles and left lateral epicondyle of humerus. Two silver/silver chloride surface electrodes were placed on one third of distance from the sternal notch to the mastoid process for detecting muscle activity of sternocleidomastoid from both sides during test (Falla et al. 2002). A reference electrode was placed on left lateral epicondyle of humerus. An adhesive tape was used to prevent sliding of electrode during measurement. The pressure biofeedback unit was placed below the occiput and inflated pressure to 20 mmHg (Jull et al. 2008). Participants were requested to slowly feel the back of their head slide up the plinth in a head nod action to elevate the pressure from 20 to 22 mmHg with normal breathing pattern and held head position for 2-3 seconds in training session. This process was repeated through each 2-mm Hg increment of the test to 30 mmHg. There are five stages of testing consisting of 20-22 mmHg for stage one, 20-24 mmHg for stage two, 20-26 mmHg for stage three, 20-28 mmHg for stage four and 20-30 mmHg for stage five. Throughout the training, Assessor 1 placed fingers over both sternocleidomastoid muscles to palpate contraction of sternocleidomastoid muscles (Jull et al. 2008). To be successful, the CCFT had to be performed with minimal sternocleidomastoid muscles activity and in absence of any substitution strategies.

6.1.2 ADIT with pressure biofeedback unit

Participants were in prone position with the head lay comfortably and relaxed. After prepared the skin above rectus abdominis muscles and left lateral epicondyle of humerus, two silver/silver chloride surface electrodes were placed at two centimeters inferior to the navel and one centimeter lateral to the midline for detecting muscle activity of rectus abdominis muscles from both sides during test (Chanthapetch et al. 2009). A reference electrode was placed on left lateral epicondyle of humerus. An adhesive tape was used to prevent sliding of electrode during measurement. The pressure biofeedback unit was placed under lower abdomen in line with right and left anterior superior iliac spines (Richardson et al. 1995). It was inflated to 70 mmHg and the participants were asked to draw abdomen toward the spine with normal breathing to reduce the pressure for 4-10 mmHg without spinal movement and hold for 2-3 seconds. Assessor 1 placed hand over the thoracolumbar area for detecting any spinal movement that modified from previous studies for suitable with prone position (Richardson et al. 1995, Garnier et al. 2009). To be successful, the ADIT had to be performed with minimal superficial abdominal muscles activity and in the absence of any other substitution strategies detected by assessor (Richardson et al. 1995, Garnier et al. 2009).

6.2 Testing session

All participants were measured after food consumption at least 30 minutes and empty bladder. The order of the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance were randomized and the duration between tests was two minutes.

6.2.1 The CCFT with pressure biofeedback unit

Testing session, participant was requested to elevate the target pressure from 20 to 22 mmHg and to hold the position for 10 seconds detected by the stopwatch then resting period was provided for 30 seconds (Jull et al. 2016). Assessor 1 monitored contraction of sternocleidomastoid muscles from manual palpation and assessor 2 from EMG biofeedback. Two data were recorded, i.e. activation score and performance index (Jull et al. 2008). The activation score was defined as the highest pressure achieved with correct movement. The highest activation score is 10 mmHg. The performance index represents the isometric endurance of the deep cervical flexor muscles which documented as the number of times the participants could perform at their best activation score multiplied by the activation score. For example, if participants could achieved 26 mmHg and performed five repetitions, the performance index was 6×5=30. The highest performance index is 100.

6.4.2 The ADIT with pressure biofeedback unit

Testing session, participants were requested to slowly draw abdomen off the pressure from 70 mmHg and hold the position for 10 seconds; the holding time was detected by the stopwatch (Garnier et al. 2009). Assessor 1 monitored spinal movement from manual palpation and assessor 2monitored contraction of rectus abdominis muscles from EMG biofeedback. The pressure change was recorded.

7. Statistical analysis

The IBM SPSS Statistics version 22.0 (IBM Corp. Released 2013, Armonk, NY, USA) software package was used for all statistical analyses. The significant level was set at $p < 0.05$. The descriptive statistics was performed to describe the demographic data which were expressed as mean, standard deviation (SD), median, minimum and maximum. The Shapiro-Wilk test was used to calculate distribution of data. The differences of demographic data between groups were used Kruskal Wallis test. The descriptive statistical analysis was used to analyze demographic data. The intraclass correlation coefficient (ICC) with 95% confidence interval (95% CI) would be used to determine the intra-rater reliability of the results of the CCFT and the ADIT from manual palpation and EMG biofeedback. The expected value of intraclass correlation coefficient would be more than 0.75 (good reliability) (Portney et al. 2009).

8. Results

Fifteen males and 15 females were participated in this study. The demographic data were presents in Table 1. The mean (SD), median, minimum and maximum of activation score, performance index and pressure change were presented in Table 2.

Table 1 Demographic data of participants (n = 30)

Variables	**Mean (SD)**			***p*-value**
	Neck pain group (n=10)	**Low back pain group (n=10)**	**Control group (n=10)**	
Gender N (%)				-
- Male	5 (50.00)	4 (40.00)	6 (60.00)	
- Female	5 (50.00)	6 (60.00)	4 (40.00)	
Age (years)	22.70 (3.56)	22.70 (2.31)	26.60 (2.72)	0.936
Body mass index (kg/m^2)	21.03 (1.19)	20.88 (1.80)	20.97 (1.86)	0.988

Variables	Mean (SD)			*p*-value
	Neck pain group (n=10)	Low back pain group (n=10)	Control group (n=10)	
Abdominal skinfold thickness (mm)	16.21 (3.82)	16.62 (2.32)	16.82 (3.49)	0.854
Neck disability index	15.00 (10.33)	-	-	-
Modified Oswestry low back pain disability questionnaire	-	8.60 (7.43)	-	-

Table 2 Mean (SD), median, minimum and maximum of activation score, performance index and pressure change of participants. (n = 30)

	Mean (SD)	Median	Minimum	Maximum
Total (n=30)				
Activation score (mmHg)				
- Manual palpation 1	3.13 (2.86)	2	0	10
- Manual palpation 2	2.80 (3.04)	2	0	10
- EMG biofeedback 1	2.53 (2.73)	2	0	10
- EMG biofeedback 2	2.87 (3.35)	2	0	10
Performance index				
- Manual palpation 1	10.07 (13.84)	4	0	50
- Manual palpation 2	9.27 (13.56)	4	0	50
- EMG biofeedback 1	8.53 (12.59)	4	0	40
- EMG biofeedback 2	9.47 (15.60)	4	0	64
Pressure change (mmHg)				
- Manual palpation 1	2.87 (1.55)	2	2	8
- Manual palpation 2	2.60 (1.75)	2	0	8
- EMG biofeedback 1	2.13 (1.96)	2	0	8
- EMG biofeedback 2	2.00 (1.97)	2	0	8

	Mean (SD)	Median	Minimum	Maximum
Neck pain group (n=10)				
Activation score (mmHg)				
- Manual palpation 1	2.40 (2.27)	2	0	6
- Manual palpation 2	2.00 (2.11)	2	0	6
- EMG biofeedback 1	1.80 (2.39)	1	0	6
- EMG biofeedback 2	2.40 (2.80)	2	0	8
Performance index				
- Manual palpation 1	4.20 (3.94)	4	0	12
- Manual palpation 2	5.00 (5.60)	4	0	16
- EMG biofeedback 1	3.60 (4.30)	2	0	12
- EMG biofeedback 2	4.40 (4.50)	4	0	12
Pressure change (mmHg)				
- Manual palpation 1	3.00 (1.94)	2	2	8
- Manual palpation 2	2.80 (1.93)	2	2	8
- EMG biofeedback 1	2.40 (2.46)	2	0	8
- EMG biofeedback 2	2.40 (2.27)	2	0	8
Low back pain group (n=10)				
Activation score (mmHg)				
- Manual palpation 1	1.60 (1.58)	2	0	4
- Manual palpation 2	1.00 (1.41)	0	0	4
- EMG biofeedback 1	1.20 (1.40)	1	0	4
- EMG biofeedback 2	0.80 (1.40)	0	0	4
Performance index				
- Manual palpation 1	5.00 (8.23)	2	0	24
- Manual palpation 2	2.60 (6.26)	0	0	20
- EMG biofeedback 1	3.20 (6.20)	1	0	20
- EMG biofeedback 2	1.80 (3.82)	0	0	12
Pressure change (mmHg)				
- Manual palpation 1	2.00 (0.00)	2	2	2
- Manual palpation 2	1.40 (0.97)	2	2	2
- EMG biofeedback 1	0.80 (1.03)	0	0	2
- EMG biofeedback 2	0.60 (0.97)	0	0	2

	Mean (SD)	Median	Minimum	Maximum
Control group (n=10)				
Activation score (mmHg)				
- Manual palpation 1	5.40 (3.13)	5	2	10
- Manual palpation 2	5.40 (3.41)	6	0	10
- EMG biofeedback 1	4.60 (2.99)	4	0	10
- EMG biofeedback 2	5.40 (3.78)	6	0	10
Performance index				
- Manual palpation 1	21.00 (18.29)	17	0	50
- Manual palpation 2	20.20 (17.87)	16	0	50
- EMG biofeedback 1	18.80 (16.69)	11	0	40
- EMG biofeedback 2	22.20 (21.80)	18	0	64
Pressure change (mmHg)				
- Manual palpation 1	3.60 (1.58)	4	2	6
- Manual palpation 2	3.60 (1.58)	4	2	6
- EMG biofeedback 1	3.20 (1.40)	3	2	6
- EMG biofeedback 2	3.00 (1.70)	3	0	6

The intra-rater reliability of manual palpation from the activation score, performance index and pressure change were good with the intraclass correlation coefficient more than 0.86 in beginning, middle and end periods (Table 3). In the same way, the intra-rater reliability of EMG biofeedback from the activation score, performance index and pressure change were good with the intraclass correlation coefficient more than 0.78 in three periods (Table 3). The intra-rater reliability of measurement of the visual analog scale were good with the intraclass correlation coefficient 0.99 (Table 4).

Table 3 The intraclass correlation coefficient (ICC) of the maximum pressure achieved from the CCFT and the pressure change from the ADIT in three periods (n=30)

	ICC (95% CI)	
	Manual palpation	**EMG biofeedback**
Activation score		
- Beginning period (n=10)	0.959 (0.845-0.990)	0.973 (0.894-0.993)
- Middle period (n=10)	0.872 (0.567-0.966)	0.780 (0.335-0.940)
- End period (n=10)	0.888 (0.614-0.971)	0.882 (0.596-0.969)
Performance index		
- Beginning period (n=10)	0.865 (0.549-0.965)	0.925 (0.730-0.981)
- Middle period (n=10)	0.966 (0.870-0.991)	0.920 (0.713-0.980)
- End period (n=10)	0.917 (0.702-0.979)	0.917 (0.702-0.979)
Pressure change		
- Beginning period (n=10)	0.914 (0.695-0.978)	1.000 (1.000-1.000)
- Middle period (n=10)	0.867 (0.553-0.965)	0.928 (0.739-0.982)
- End period (n=10)	0.947 (0.802-0.987)	0.920 (0.711-0.979)

Table 4 Mean (SD) and the intraclass correlation coefficient (ICC) of the visual analog scale (n=30)

	Mean (SD)	**ICC (95% CI)**
The visual analog scale (1st)	48.95 (15.79)	0.999 (0.998-1.000)
The visual analog scale (2nd)	49.05 (15.81)	

4.9 Discussion

The objective of this study was to estimate the reliability of manual palpation and EMG biofeedback during the CCFT and the ADIT and to estimate the reliability of measurement of the visual analog scale. The good reliability in beginning, middle and end periods were presented in this study. These results were consistent the results of previous studies (Garnier et al. 2009, Juul et al. 2013). This might be from assessors who had practiced with clearly setting procedure to correctly performance of the CCFT and the ADIT. Moreover, the assessors used consistent verbal feedback to participants. The good reliability of measurement of the visual analog scale was presented in this study. This result was higher than previous study that reported moderate to good test-

retest reliability of visual analog scale (ICC = 0.71-0.94) (Hawker et al. 2011). The limitation that was not assessed inter-rater reliability. However, this study was used one assessor with manual palpation, and one assessor with EMG biofeedback and visual analog scale.

10. Conclusion

The reliability between manual palpation and EMG biofeedback during the CCFT and the ADIT was good with the intraclass correlation coefficient that could be used in next study.

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APPENDIX D

DATA OF RELIABILITY STUDY

No.	Groups	VAS (mm) 1	VAS (mm) 2	NDI	ODQ	CCFT												ADIT			
						Activation score				Repetitions				Performance index				Pressure change			
						EMG biofeedback		Manual palpation		EMG biofeedback		Manual palpation		EMG biofeedback		Manual palpation		EMG biofeedback		Manual palpation	
						1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
1	NP	37	37	4	-	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2
2	NP	42	43	10	-	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2
3	NP	24	24	3	-	0	0	2	0	0	0	1	0	0	0	2	0	2	2	2	2
4	NP	49	48	5	-	0	2	2	2	0	5	2	2	0	10	4	4	0	2	2	2
5	NP	56	56	21	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
6	NP	70	69	7	-	2	4	2	2	2	1	2	3	4	4	4	6	4	4	4	4
7	NP	51	51	4	-	6	8	6	4	1	1	1	4	6	8	6	16	8	8	8	8
8	NP	33	33	4	-	6	6	6	6	2	2	2	2	12	12	12	12	4	2	4	2
9	NP	59	60	8	-	2	2	4	4	4	3	2	2	8	6	8	8	0	0	2	2
10	NP	49	49	6	-	2	2	2	2	3	2	3	2	6	4	6	4	2	2	2	2
11	LBP	55	56	-	3	4	4	4	4	5	3	6	5	20	12	24	20	2	2	2	2
12	LBP	77	77	-	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
13	LBP	23	23	-	7	2	0	4	2	1	0	4	0	2	0	16	0	0	0	2	0
14	LBP	52	52	-	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
15	LBP	59	59	-	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
16	LBP	52	52	-	3	0	0	2	0	0	0	1	0	0	0	2	0	0	0	2	0
17	LBP	69	69	-	10	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2
18	LBP	33	33	-	2	2	0	2	0	1	0	1	0	2	0	2	0	2	2	2	2
19	LBP	25	25	-	0	2	2	2	2	3	1	2	1	6	2	4	2	2	0	2	2
20	LBP	64	65	-	1	2	2	2	2	4	2	4	4	8	4	8	8	4	4	4	4
21	C	-		-	-	10	10	10	10	1	2	1	2	10	20	10	20	2	2	2	2
22	C	-		-	-	6	8	6	6	2	2	4	2	12	16	24	12	2	2	2	2
23	C	-		-	-	0	0	2	2	0	0	0	1	0	0	0	2	6	6	6	6
24	C	-		-	-	4	6	4	6	10	6	7	4	40	36	28	24	4	4	4	4
25	C	-		-	-	4	10	6	10	10	5	8	5	40	50	48	50	4	4	6	6
26	C	-		-	-	8	8	10	8	5	8	5	6	40	64	50	48	2	2	4	4
27	C	-		-	-	4	4	4	4	1	2	2	2	4	8	8	8	2	0	2	2
28	C	-		-	-	2	0	2	0	2	0	1	0	4	0	2	0	2	2	2	2
29	C	-		-	-	2	2	2	2	4	2	4	4	8	4	8	8	4	4	4	4
30	C	-		-	-	6	6	8	6	5	4	4	5	30	24	32	30	4	4	4	4

CCFT = craniocervical flexion test, ADIT = abdominal drawing-in test, NP = neck pain group, LBP = low back pain group, C = control group, VAS = visual analog scale, NDI = neck disability index and ODQ = modified Oswestry low back pain disability questionnaire

APPENDIX E
VALIDITY STUDY

1. Introduction

This chapter describes the criterion validity of manual palpation for monitoring the contraction of the superficial muscles during the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance, using the EMG biofeedback as the accepted standard of measurement. The topics consist of objective, characteristics of participants, materials, assessors, procedures, statistical analysis, result, discussion and conclusion.

2. Objective

This study was to estimate the criterion validity of manual palpation for monitoring the contraction of the superficial muscles during the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance, using the EMG biofeedback as the accepted standard of measurement.

3. Participants

Thirty participants from reliability study. The participants were classified into three groups including neck pain group, low back pain group, and control group. The characteristics of participants in this study followed topic of participants in Appendix C.

4. Materials

Materials of this study followed topic of materials in Appendix C.

5. Assessors

Assessors of this study followed topic of assessors in Appendix C.

6. Procedures

Procedures of this study followed topic of procedures in Appendix C. The activation score and the performance index were recorded as result of the CCFT and the pressure change was recorded as the result of the ADIT from manual palpation and EMG biofeedback. The first results of the CCFT and the ADIT from Appendix C would be used to calculate.

7. Statistical analysis

The statistical analysis was followed CHAPTER 3. The criterion validity was tested by examining the correlation between the pressure biofeedback readings of the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance which used manual palpation and EMG biofeedback for monitoring the contraction of the superficial muscles. If data was normally distributed, the Pearson's correlation coefficient was calculated would be used. If data was not normally distributed, the Spearman's correlation coefficient would be used. Correlation coefficient (r) of 0-0.25 indicated little or no relationship, 0.25-0.50 was fair, 0.50-0.75

was moderate to good and greater than 0.75 was good to excellence (Portney et al. 2009).

8. Results

The demographic data of this study was presented in Appendix C (Table 1). The mean (SD), median, minimum and maximum of activation score, performance index and pressure change were presented in Appendix C (Table 2) The Spearman's correlation coefficient were demonstrated excellent correlations between the test results obtained between the two methods i.e. the activation score, performance index and pressure change (r = 0.914, 0.918 and 0.803 $p < 0.01$) (Table 1). These excellent correlations also showed when conducting subgroup analyses (Table 1).

Table 1 The correlation coefficient (r) of the maximum pressure achieved from the CCFT and the pressure change from the ADIT recorded between the manual palpation and the EMG biofeedback. (n=30)

	Activation score	**Performance index**	**Pressure change**
Total	0.914*	0.918*	0.803*
Neck pain (n = 10)	0.856*	0.932*	0.849*
Low back pain (n = 10)	0.853*	0.884*	1.000*
Control (n = 10)	0.962*	0.954*	0.853*

*p-value < 0.05

9. Discussion

The objective of this study was to estimate the criterion validity of the manual palpation for monitoring the contraction of the superficial muscles during the CCFT and the ADIT, using the EMG biofeedback as the accepted standard of measurement. The results of the study demonstrated excellent correlations between the pressure readings obtained from the two methods. These findings suggest that manual palpation can be used for monitoring the contraction of the superficial muscles during the CCFT and the ADIT.

This study set the threshold for contraction of sternocleidomastoid and rectus abdominis muscles at 10% of their MVICs which was regarded as minimal muscle contraction. The ability of manual palpation to detect this small change in muscle tension is plausible as it was reported that the mechanoreceptors in the fingers are capable to perceive the tension as small as 0.3 N (Hides et al. 2006). The previous study that use digital palpation to classify pelvic floor muscle strength into five grades on the Modified Oxford Scale also demonstrated excellent correlation (r = 0.90) between the digital palpation and the pelvic floor muscle contraction pressure (Pereira et al. 2014). The excellent correlation of the results of the ADIT obtained from the manual palpation and the EMG biofeedback suggests that the palpation for the thoracolumbar movement can be used to indicate a dominant contribution of trunk superficial muscles during the test. The ability of a trained therapist to palpate the motion of the body has been well presented in previous studies and the percentage of agreement of the findings between the therapists were moderate to high (K ranged from 0.65-0.77) (Hodges 1999, Humphreys et al. 2004). In the current study, the lower pressure readings which reflected the poor performance of the core stabilizer muscles were apparent in the

groups of individuals with neck and low back pain when comparing with asymptomatic individuals. These findings were in line with previous studies (Hodges et al. 1996, Hodges et al. 1998, Cairns et al. 2000, Jull 2000, Falla et al. 2004, Falla et al. 2004, Jull et al. 2004, Falla et al. 2011).

Nevertheless, the excellent correlations between the results of the CCFT and the ADIT obtained from the two methods were demonstrated across all three groups. These findings suggest that although the symptoms in the neck or in the back have an effect on the performance of the cervical and lumbar stabilizer muscles, they did not influence the ability of the assessment of the contraction of the superficial muscles. A major strength of this study is based on the use of the EMG biofeedback with surface electrodes which is an accepted standard for measurement of the superficial muscle activity. However, there are a few limitations when interpreting the findings. The use of surface electrodes not the fine wire electrodes may allow EMG signals from the surrounding muscles other than the ones that were tested could not be excluded. As these surrounding muscles would not be grouped as core stabilizer muscles, their muscle activities could still be regarded as the dominant contraction of the superficial muscles. The sample used was one of convenience with a mix of individuals both with and without spinal problems. Although this would provide clinical applicability to both symptomatic and asymptomatic individuals, a relatively small number of participants in each group would need further study to confirm the results.

10. Conclusion

The manual palpation was found to be a valid method for monitoring the contraction of the superficial muscles during the CCFT for neck stabilizer muscle performance and the ADIT for back stabilizer muscle performance.

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APPENDIX F

DATA OF VALIDITY STUDY

No.	Groups	VAS (mm)	NDI	ODQ	CCFT						ADIT	
					Activation score		Repetitions		Performance index		Pressure change	
					EMG biofeedback	Manual palpation	EMG biofeedback	Manual palpation	EMG biofeedback	Manual palpation	EMG biofeedback	Manual palpation
1	NP	37	4	-	0	0	0	0	0	0	2	2
2	NP	42	10	-	0	0	0	0	0	0	2	2
3	NP	24	3	-	0	2	0	1	0	2	2	2
4	NP	49	5	-	0	2	0	2	0	4	0	2
5	NP	56	21	-	0	0	0	0	0	0	0	2
6	NP	70	7	-	2	2	2	2	4	4	4	4
7	NP	51	4	-	6	6	1	1	6	6	8	8
8	NP	33	4	-	6	6	2	2	12	12	4	4
9	NP	59	8	-	2	4	4	2	8	8	0	2
10	NP	49	6	-	2	2	3	3	6	6	2	2
11	LBP	55	-	3	4	4	5	6	20	24	2	2
12	LBP	77	-	10	0	0	0	0	0	0	0	2
13	LBP	23	-	7	2	4	1	4	2	16	0	2
14	LBP	52	-	1	0	0	0	0	0	0	0	2
15	LBP	59	-	6	0	0	0	0	0	0	0	2
16	LBP	52	-	3	0	2	0	1	0	2	0	2
17	LBP	69	-	10	0	0	0	0	0	0	2	2
18	LBP	33	-	2	2	2	1	1	2	2	2	2
19	LBP	25	-	0	2	2	3	2	6	4	2	2
20	LBP	64	-	1	2	2	4	4	8	8	4	4
21	C	-	-	-	10	10	1	1	10	10	2	2
22	C	-	-	-	6	6	2	4	12	24	2	2
23	C	-	-	-	0	2	0	0	0	0	6	6
24	C	-	-	-	4	4	10	7	40	28	4	4
25	C	-	-	-	4	6	10	8	40	48	4	6
26	C	-	-	-	8	10	5	5	40	50	2	4
27	C	-	-	-	4	4	1	2	4	8	2	2
28	C	-	-	-	2	2	2	1	4	2	2	2
29	C	-	-	-	2	2	4	4	8	8	4	4
30	C	-	-	-	6	8	5	4	30	32	4	4

CCFT = craniocervical flexion test, ADIT = abdominal drawing-in test, NP = neck pain group, LBP = low back pain group, C = control group, VAS = visual analog scale, NDI = neck disability index and ODQ = modified Oswestry low back pain disability questionnaire

APPENDIX G
INFORMED CONSENT FORM

(ใบยินยอมสำหรับผู้เข้าร่วมการวิจัย)

หนังสือแสดงความยินยอมเข้าร่วมงานวิจัย

ทำที่.....

วันที่.....เดือน.....พ.ศ. .....

เลขที่ ประชากรตัวอย่างหรือผู้มีส่วนร่วมในการวิจัย.....

ข้าพเจ้า ซึ่งได้ลงนามท้ายหนังสือนี้ ขอแสดงความยินยอมเข้าร่วมโครงการวิจัย

ชื่อโครงการวิจัย	การทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวในผู้มีอาการปวดคอและปวดหลังส่วนล่าง
ชื่อผู้วิจัย	นางสาว ฉัตราชู ทองประเสริฐ
สถานที่ติดต่อผู้วิจัย	
(ที่ทำงาน)	คณะสหเวชศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย 154 ถนนพระราม 1 แขวงวังใหม่ เขตปทุมวัน กรุงเทพฯ 10330
(ที่บ้าน)	126 หมู่บ้านเมืองทองการ์เด้น ซอย พัฒนาการ 65 ถนนพัฒนาการ แขวงประเวศ เขตประเวศ กรุงเทพฯ 10250 โทรศัพท์มือถือ 0805963699
	E-mail: chattrachoo.t@gmail.com

ข้าพเจ้า ได้รับทราบรายละเอียดเกี่ยวกับที่มาและวัตถุประสงค์ในการทำวิจัย รายละเอียดขั้นตอนต่างๆที่จะต้องปฏิบัติหรือได้รับการปฏิบัติ ความเสี่ยง/อันตราย และประโยชน์ซึ่งจะเกิดขึ้นจากการวิจัยเรื่องนี้ โดยได้อ่านรายละเอียดในเอกสารชี้แจงผู้เข้าร่วมการวิจัยโดยตลอด และได้รับคำอธิบายจากผู้วิจัย จนเข้าใจเป็นอย่างดีแล้ว

ข้าพเจ้าจึงสมัครใจเข้าร่วมในโครงการวิจัยนี้ ตามระบุในเอกสารชี้แจงผู้เข้าร่วมการวิจัย โดยข้าพเจ้ายินยอม ตอบแบบคัดกรองเพื่อเป็นเกณฑ์หนึ่งในการคัดเลือกผู้เข้าร่วมงานวิจัย, ตอบแบบสอบถามระดับความเจ็บปวดและการจำกัดกิจกรรมจากอาการปวดคอและปวดหลังส่วนล่าง รวมไปถึงการทดสอบการทำงานสูงสุดของกล้ามเนื้อที่ทำหน้าที่ก้มคอและงอลำตัว และการทดสอบการทำงานของกล้ามเนื้อในบริเวณคอและหลังส่วนล่าง โดยเวลาที่ใช้ในการทดสอบ

ทั้งหมด 1 ชั่วโมง หลังการทดสอบเสร็จสิ้นผู้เข้าร่วมการวิจัยจะได้รับสมุดความรู้และคำปรึกษาเกี่ยวกับอาการปวดคอและปวดหลังส่วนล่าง และได้รับค่าเดินทาง เมื่อเสร็จสิ้นการวิจัยแล้วข้อมูลที่เกี่ยวข้องกับผู้เข้าร่วมการวิจัยจะถูกทำลาย

ข้าพเจ้ามีสิทธิ**ถอนตัว**ออกจากการวิจัยเมื่อใดก็ได้ตามความประสงค์ โดยไม่ต้องแจ้งเหตุผล ซึ่งการถอนตัวออกจากการวิจัยนั้น จะไม่มีผลกระทบในทางใดๆต่อข้าพเจ้าทั้งสิ้น

ข้าพเจ้าได้รับคำรับรองว่า ผู้วิจัยจะปฏิบัติต่อข้าพเจ้าตามข้อมูลที่ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย และข้อมูลใดๆ ที่เกี่ยวข้องกับข้าพเจ้า ผู้วิจัยจะเก็บรักษาเป็นความลับ โดยจะนำเสนอข้อมูลการวิจัยเป็นภาพรวมเท่านั้น ไม่มีข้อมูลใดในการรายงานที่จะนำไปสู่การระบุตัวข้าพเจ้า

หากข้าพเจ้าไม่ได้รับการปฏิบัติตรงตามที่ได้ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย ข้าพเจ้าสามารถร้องเรียนได้ที่คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย 254 อาคารจามจุรี 1 ชั้น 2 ถนนพญาไท เขตปทุมวัน กรุงเทพฯ 10330 โทรศัพท์/โทรสาร 0-2218-3202 **E-mail: eccu@chula.ac.th**

ข้าพเจ้าได้ลงลายมือชื่อไว้เป็นสำคัญต่อหน้าพยาน ทั้งนี้ข้าพเจ้าได้รับสำเนาเอกสารชี้แจงผู้เข้าร่วมการวิจัย และสำเนาหนังสือแสดงความยินยอมไว้แล้ว

ลงชื่อ..... ลงชื่อ.....

(นางสาว ฉัตราชู ทองประเสริฐ) (.....)

ผู้วิจัยหลัก ผู้เข้าร่วมการวิจัย

ลงชื่อ.....

(.....)

พยาน

APPENDIX H
PARTICIPANT INFORMATION SHEET

(ข้อมูลสำหรับผู้เข้าร่วมการวิจัย)

ข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย

ชื่อโครงการวิจัย	การทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวในผู้มีอาการปวดคอและปวดหลังส่วนล่าง
ชื่อผู้วิจัย	นางสาว ฉัตราชู ทองประเสริฐ
ตำแหน่ง	นิสิตหลักสูตรวิทยาศาสตรมหาบัณฑิต สาขาวิชากายภาพบำบัด แขนงวิชากายภาพบำบัดทางระบบกระดูกและกล้ามเนื้อ คณะสหเวชศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
สถานที่ติดต่อผู้วิจัย	
(ที่ทำงาน)	คณะสหเวชศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย 154 ถนนพระราม 1 แขวงวังใหม่เขตปทุมวัน กรุงเทพฯ 10330
(ที่บ้าน)	126 หมู่บ้านเมืองทองการ์เด้น ซอย พัฒนาการ 65 ถนนพัฒนาการ แขวงประเวศ เขตประเวศ กรุงเทพฯ 10250 โทรศัพท์มือถือ 0805963699
	E-mail: chattrachoo.t@gmail.com

1. ขอเรียนเชิญท่านเข้าร่วมในการวิจัย ก่อนที่ท่านจะตัดสินใจเข้าร่วมการวิจัย มีความจำเป็นที่ท่านควรทำความเข้าใจว่างานวิจัยนี้ทำเพราะเหตุใด และเกี่ยวข้องกับอะไร กรุณาใช้เวลาในการอ่านข้อมูลต่อไปนี้อย่างละเอียดรอบคอบ และสอบถามข้อมูลเพิ่มเติมหรือข้อมูลที่ไม่ชัดเจนได้ตลอดเวลา

2. โครงการนี้เกี่ยวข้องกับการทดสอบการทำงานของกล้ามเนื้อใน 2 บริเวณ คือ บริเวณคอและหลังส่วนล่าง ในผู้มีอาการปวดคอ ปวดหลังส่วนล่าง และผู้ไม่มีอาการปวดคอและหลังส่วนล่าง

3. วัตถุประสงค์

1) เพื่อเปรียบเทียบการทำงานของกล้ามเนื้อในบริเวณหลังส่วนล่างในผู้มีอาการปวดคอกับผู้ไม่มีอาการปวดคอและปวดหลังส่วนล่าง

2) เพื่อเปรียบเทียบการทำงานของกล้ามเนื้อในบริเวณคอในผู้มีอาการปวดหลังส่วนล่างกับผู้ไม่มีอาการปวดคอและหลังส่วนล่าง

4. รายละเอียดของกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย

ลักษณะของกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย

<u>เกณฑ์การคัดเข้า</u>

กลุ่มผู้มีอาการปวดคอ

1) อายุ 20-45 ปี

2) มีอาการปวดคอโดยไม่ได้มาจากโรคร้ายแรง ซึ่งมีอาการปวดอยู่ในบริเวณใต้กระดูกฐานกะโหลก ถึงกระดูกสันหลังระดับอกชิ้นที่ 3

3) มีอาการปวดคอต่อเนื่องหรือมีอาการปวดเป็นๆหายๆ ในระยะเวลา 1 เดือนขึ้นไป

4) ไม่มีอาการปวดหลังส่วนล่าง หรือมีอาการปวดหลังส่วนล่างที่อาการคงค้างไม่เกิน 1 วัน ในช่วงเวลา 2 ปีที่ผ่านมา

5) มีค่าดัชนีมวลกายอยู่ในเกณฑ์ปกติ (18.5-22.9 กิโลกรัมต่อตารางเมตร)

6) มีความหนาของผิวบริเวณหน้าท้อง น้อยกว่า 20 มิลลิเมตร

กลุ่มผู้มีอาการปวดหลังส่วนล่าง

1) อายุ 20-45 ปี

2) มีอาการปวดหลังส่วนล่างโดยไม่ได้มาจากโรคร้ายแรง ซึ่งมีอาการปวดอยู่ในใต้กระดูกซี่โครงที่ 12 ถึงบริเวณขอบล่างของก้น

3) มีอาการปวดหลังส่วนล่างต่อเนื่องหรือมีอาการปวดเป็นๆหายๆ ในระยะเวลา 1 เดือนขึ้นไป

4) ไม่มีอาการปวดหลังคอ หรือมีอาการปวดคอที่อาการคงค้างไม่เกิน 1 วัน ในช่วงเวลา 2 ปีที่ผ่านมา

5) มีค่าดัชนีมวลกายอยู่ในเกณฑ์ปกติ (18.5-22.9 กิโลกรัมต่อตารางเมตร)

6) มีความหนาของผิวบริเวณหน้าท้อง น้อยกว่า 20 มิลลิเมตร

กลุ่มผู้ไม่มีอาการปวดคอและปวดหลังส่วนล่าง

ผู้เข้าร่วมการวิจัยในกลุ่มนี้ ต้องมีอายุ 20-45 ปี ไม่มีอาการปวดคอและหลังส่วนล่าง หรือมีอาการปวดคอและปวดหลังส่วนล่างที่มีอาการคงค้างไม่เกิน 1 วัน ในระยะเวลา 2 ปีที่ผ่านมา โดยมีการจับคู่อายุและเพศ กับกลุ่มผู้มีอาการปวดคอและปวดหลังส่วนล่าง

<u>เกณฑ์การคัดออก</u>

1) มีการผ่าตัดบริเวณหน้าท้อง หรือกระดูกสันหลัง

2) มีภาวะผิดปกติของกระดูกสันหลัง เช่น กระดูกสันหลังคด

3) มีความผิดปกติทางการรับความรู้สึก เช่น อาการชา ไม่มีความรู้สึก อาการแสบร้อนและ/หรือ อาการอ่อนแรงบริเวณแขนและขา

4) ออกกำลังกายกล้ามเนื้อวิธีการเดียวกับที่ทำในการศึกษานี้ในบริเวณคอ และ/หรือหลังส่วนล่าง ในช่วงเวลา 1 ปีที่ผ่านมา

5) ไม่สามารถนอนคว่ำได้

6) ไม่สามารถทำการทดสอบได้ เนื่องจากอาการปวด

7) สตรีขณะมีประจำเดือน หรือตั้งครรภ์

วิธีการได้มาซึ่งกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย โดยผู้วิจัยใช้การเชิญชวนท่านด้วยวาจาและการติดประกาศเชิญชวน

เหตุผลที่ได้รับเชิญเข้าร่วมโครงการวิจัย เนื่องจากท่านมีคุณสมบัติตรงตามคุณลักษณะของผู้เข้าร่วมการวิจัย และผ่านเกณฑ์การคัดเข้า และเกณฑ์การคัดออกทุกประการ

การแบ่งกลุ่มผู้มีส่วนร่วมในการวิจัยครั้งนี้จะแบ่งผู้เข้าร่วมการวิจัยออกเป็น 5 กลุ่ม ได้แก่ กลุ่มผู้มีอาการปวดคอระยะกึ่งเฉียบพลัน 23 คน กลุ่มผู้มีอาการปวดคอระยะเรื้อรัง 23 คน กลุ่มผู้มีอาการปวดหลังส่วนล่างระยะกึ่งเฉียบพลัน 23 คน กลุ่มผู้มีอาการปวดหลังส่วนล่างระยะเรื้อรัง 23 คน และกลุ่มผู้ไม่มีอาการปวดคอและปวดหลังส่วนล่าง โดยมีการจับคู่อายุและเพศในกลุ่มผู้มีอาการปวดและไม่มีอาการปวด

5. กระบวนการการวิจัยที่กระทำต่อกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย

ในการวิจัยนี้มีผู้วิจัยทั้งหมด 2 คน เป็นเพศหญิง ซึ่งเป็นนักกายภาพบำบัดที่มีใบประกอบวิชาชีพ โดยผู้วิจัยคนที่ 1 ซึ่งเป็นผู้วิจัยหลัก จะเป็นผู้คัดกรองผู้เข้าร่วมการวิจัย และผู้วิจัยคนที่ 2 ซึ่งเป็นผู้ไม่ทราบกลุ่มของผู้เข้าร่วมการวิจัยจะเป็นผู้ทดสอบการทำงานของกล้ามเนื้อ โดยอาสาสมัครกรอกแบบคัดกรอง แบบทดสอบความเจ็บปวด แบบทดสอบการจำกัดกิจกรรมจากอาการปวดคอ

และปวดหลังส่วนล่าง หากพบว่าไม่อยู่ในเกณฑ์การคัดเข้า และหรืออยู่ในภาวะที่สมควรได้รับความช่วยเหลือ/แนะนำ ผู้วิจัยคนที่ 1 จะแจ้งให้ท่านทราบและให้คำแนะนำเพื่อลดภาวะความผิดปกติดังกล่าว ผู้เข้าร่วมการวิจัยที่จะได้รับการทดสอบต้องมีช่วงเวลาพักหลังจากรับประทานอาหารอย่างน้อย 30 นาที การทดสอบจะทำภายในห้อง 224 อาคารจุฬาพัฒน์ 2 คณะสหเวชศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย ผู้วิจัยทั้ง 2 คนจะปรากฏตัวอยู่ในห้องทดสอบตลอดเวลา โดยผู้วิจัยคนที่ 1 เป็นผู้การอธิบายขั้นตอนและฝึกปฏิบัติแก่ผู้เข้าร่วมการวิจัยจนสามารถปฏิบัติได้อย่างถูกต้อง ผู้วิจัยคนที่ 2 จะทำการทดสอบความสามารถในการทำงานสูงสุดของกล้ามเนื้อที่ทำหน้าที่ก้มคอและงอลำตัว จากนั้นจะทำการทดสอบการทำงานของกล้ามเนื้อในบริเวณคอ และหลังส่วนล่าง ซึ่งลำดับในการทดสอบจะมาจากการสุ่ม ในการทดสอบจะมีการติดขั้วไฟฟ้าบริเวณด้านหน้าลำคอ และหน้าท้อง เพื่อดูการทำงานของกล้ามเนื้อ โดยเวลาในการทดสอบทั้งหมด 1 ชั่วโมง แบ่งเป็นช่วงเวลาในการคัดกรอง 10 นาที และเป็นช่วงเวลาในการทดสอบ 50 นาที หลังการทดสอบเสร็จสิ้นผู้เข้าร่วมการวิจัยทุกคนจะได้รับสมุดความรู้และคำปรึกษาเกี่ยวกับอาการปวดคอและปวดหลังส่วนล่าง ประกอบด้วย การเกิดอาการปวดคอและปวดหลังส่วนล่าง การดูแลตัวเองเมื่อมีอาการปวดคอและปวดหลังส่วนล่าง รวมไปถึงการป้องกันไม่ให้เกิดอาการปวดคอและปวดหลังส่วนล่าง และได้รับค่าเดินทาง เมื่อเสร็จสิ้นการวิจัยแล้วข้อมูลที่เกี่ยวข้องกับผู้เข้าร่วมการวิจัยจะถูกทำลาย

6. กระบวนการให้ข้อมูลแก่กลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย ผู้วิจัยจะเป็นผู้อธิบายกระบวนการวิจัยแก่ผู้เข้าร่วมการวิจัย รวมถึงตอบข้อสงสัยเกี่ยวกับกระบวนการวิจัยแก่ผู้เข้าร่วมการวิจัย

7. ในการคัดกรองผู้มีส่วนร่วมในการวิจัยนั้น หากพบว่าท่านไม่อยู่ในเกณฑ์คัดเข้า และหรืออยู่ในภาวะที่สมควรได้รับความช่วยเหลือ/แนะนำ ผู้วิจัยจะแจ้งให้ท่านทราบและให้คำแนะนำเพื่อลดภาวะความผิดปกติดังกล่าว

8. ในการวิจัยครั้งนี้ท่านอาจมีความเสี่ยงที่จะมีอาการปวดเพิ่มขึ้นได้ ขณะการทดสอบการทำงานของกล้ามเนื้อในบริเวณคอและหลังส่วนล่าง โดยผู้เข้าร่วมวิจัยสามารถหยุดการทดสอบ และถอนตัวจากการวิจัยได้ทันที ผู้วิจัยจะดำเนินการปฐมพยาบาลเบื้องต้น และให้การรักษาทางกายภาพบำบัดเพื่อลดอาการปวด รวมถึงให้ความรู้เรื่องการดูแลตัวเองที่บ้านเมื่อมีอาการปวดคอและปวดหลังส่วนล่าง หากอาการปวดมากแนะนำไปพบแพทย์เป็นลำดับต่อไป

9. ประโยชน์ที่ได้รับจากการเข้าร่วมการวิจัยครั้งนี้ การวิจัยครั้งนี้จะเป็นประโยชน์ทางวิชาการ โดยเป็นการเพิ่มพูนความรู้เกี่ยวกับการทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัว

และสามารถใช้เป็นความรู้ในการป้องกันการเกิดอาการปวดคอในผู้ที่มีอาการปวดหลังส่วนล่าง และป้องกันการเกิดอาการปวดหลังส่วนล่างในผู้มีอาการปวดคอ

10. การเข้าร่วมในการวิจัยของท่านเป็นโดยความสมัครใจ และสามารถปฏิเสธที่จะเข้าร่วมหรือถอนตัวจากการวิจัยได้ทุกขณะ โดยไม่ต้องให้เหตุผล และจะไม่ส่งผลกระทบต่อการรักษาที่ท่านได้รับ

11. หากท่านมีความสงสัยให้สอบถามเพิ่มเติมได้โดยสามารถติดต่อผู้วิจัยได้ตลอดเวลา และหากผู้วิจัยมีข้อมูลเพิ่มเติมที่เป็นประโยชน์หรือโทษเกี่ยวกับการวิจัย ผู้วิจัยจะแจ้งให้ท่านทราบอย่างรวดเร็วเพื่อให้ท่านทบทวนว่ายังสมัครใจจะอยู่ในงานวิจัยต่อไปหรือไม่

12. ข้อมูลที่เกี่ยวข้องกับท่านจะถูกเก็บเป็นความลับ หากมีการเสนอผลการวิจัยจะเสนอเป็นภาพรวม ข้อมูลใดที่สามารถระบุถึงตัวท่านได้จะไม่ปรากฏในรายงาน

13.หากท่านไม่ได้รับการปฏิบัติตามข้อมูลดังกล่าวสามารถร้องเรียนได้ที่ คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย 224 อาคารจามจุรี 1 ชั้น 2 ถนนพญาไท เขตปทุมวัน กรุงเทพฯ 10330 โทรศัพท์/โทรสาร 0-2218-3202 E-mail: eccu@chula.ac.th

APPENDIX I
SCREENING QUESTIONNAIRE

(แบบคัดกรองสำหรับผู้เข้าร่วมการวิจัย)

โครงงานวิจัยเรื่อง
การทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวในผู้มีอาการปวดคอและปวดหลังส่วนล่าง

รหัสผู้เข้าร่วมงานวิจัย_____ วันที่_____เดือน_____พ.ศ._____

<u>คำชี้แจง</u> กรุณาเติมข้อความลงในช่องว่างหรือทำเครื่องหมาย ☑ ในคำตอบที่ท่านเลือก

<u>ส่วนที่ 1</u>

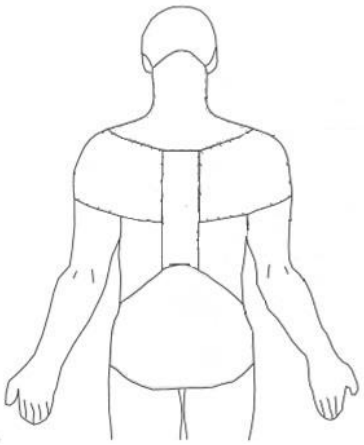
เพศ ( ) ชาย ( ) หญิง อายุ_____ปี

อาชีพ_____

น้ำหนัก_____กิโลกรัม ส่วนสูง_____เซนติเมตร BMI_____kg/m^2

<u>ส่วนที่ 2</u>

1. แรเงาบริเวณที่ท่านมีอาการปวดขณะนี้



2. ขณะนี้ท่านมีอาการปวดคอใช่หรือไม่ หากไม่มีอาการ ข้ามไปที่ข้อ 3

( ) ใช่ ( ) ไม่ใช่

2.1 ระยะเวลาที่ท่านมีอาการปวดคอ

( ) น้อยกว่า 1 เดือน

( ) 1 – 3 เดือน

( ) มากกว่า 3 เดือน ระบุ_____

2.2 ใน 2 ปีที่ผ่านมา ท่านมีอาการปวดหลังส่วนล่างใช่หรือไม่ (อาการคงค้างน้อยกว่าหนึ่งวัน)

( ) ใช่ ( ) ไม่ใช่

3. ขณะนี้ท่านมีอาการปวดหลังส่วนล่างใช่หรือไม่ หากไม่มีอาการ ข้ามไปที่ข้อ 4

( ) ใช่ ( ) ไม่ใช่

3.1 ระยะเวลาที่ท่านมีอาการปวดหลังส่วนล่าง

( ) น้อยกว่า 1 เดือน

( ) 1 – 3 เดือน

( ) มากกว่า 3 เดือน ระบุ_____

3.2 ใน 2 ปีที่ผ่านมา ท่านมีอาการปวดคอหรือไม่ (อาการคงค้างน้อยกว่าหนึ่งวัน)

( ) ใช่ ( ) ไม่ใช่

4. ท่านมีภาวะหรือโรคต่อไปนี้ ใช่หรือไม่

ใช่	ไม่ใช่	
( )	( )	เคยได้รับการผ่าตัดบริเวณหน้าท้อง หรือกระดูกสันหลัง ใน 2 ปีที่ผ่านมา
( )	( )	มีความผิดปกติทางการรับความรู้สึก เช่น อาการชา ไม่มีความรู้สึก อาการแสบร้อนและ/หรือ อาการอ่อนแรงบริเวณแขนและขา
( )	( )	มีการหักของกระดูกสันหลัง
( )	( )	มีภาวะเนื้องอกบริเวณกระดูกสันหลัง
( )	( )	มีการติดเชื้อของกระดูกสันหลัง และหมอนรองกระดูกสันหลัง
( )	( )	สตรีมีประจำเดือน หรือตั้งครรภ์
( )	( )	หลังรับประทานอาหาร อย่างน้อย 30 นาที

5. การออกกำลังกายที่ได้รับใน 1 ปีที่ผ่านมา (กล้ามเนื้อคอ กล้ามเนื้อหน้าท้องและ/หรือกล้ามเนื้อหลัง)

( ) ใช่ ระบุ_____

( ) ไม่ใช่ ระบุ_____

<u>ส่วนที่ 3</u> (สำหรับผู้วิจัย)

6. Adam's forward bend test ( ) Positive ( ) Negative

7. Abdominal skinfold _____ millimeters

APPENDIX J
VISUAL ANALOG SCALE

แบบสอบถามระดับความเจ็บปวด

<u>คำชี้แจง</u> กรุณาเขียนเครื่องหมาย X ลงบนเส้นตรงด้านล่าง ณ ตำแหน่งที่ตรงกับอาการปวดของท่าน โดยเส้นตรงจะแทนระดับอาการปวด เริ่มจากด้านซ้ายมือคือไม่ปวดเลย และระดับอาการปวดจะเพิ่มมากขึ้น จนถึงด้านขวาสุดคือปวดมากที่สุดจนทนไม่ไหว

<u>ระดับของอาการปวดคอขณะนี้</u>

0 10

ไม่ปวดเลย ปวดมากที่สุดจนทนไม่ไหว

<u>ระดับของอาการปวดหลังส่วนล่างขณะนี้</u>

0 10

ไม่ปวดเลย ปวดมากที่สุดจนทนไม่ไหว

APPENDIX K
NECK DISABILITY INDEX

แบบสอบถามการจำกัดกิจกรรมจากอาการปวดคอ

<u>คำชี้แจง</u> แบบสอบถามนี้ถูกออกแบบขึ้นเพื่อให้ข้อมูลกับผู้รักษาว่าอาการปวดคอมีผลต่อการทำกิจวัตรประจำวันของท่าน กรุณาตอบแบบสอบถามทุกข้อ โดยทำเครื่องหมาย ☑ ด้านหน้าข้อความเพียง ข้อเดียวที่จะบอกสภาพของท่านในวันนี้ได้ดีที่สุด หากมีตัวเลือกตรงกับท่านมากกว่า 1 ข้อ

<u>โปรดทำเครื่องหมายหน้าตัวเลือกที่บรรยายลักษณะใกล้เคียงกับท่านมากที่สุดเพียงข้อเดียว</u>

1. ความรุนแรงของอาการปวด
( ) ในขณะนี้ไม่มีอาการปวดเลย
( ) ในขณะนี้มีอาการปวดเพียงเล็กน้อย
( ) ในขณะนี้มีอาการปวดปานกลาง
( ) ในขณะนี้มีอาการปวดค่อนข้างมาก
( ) ในขณะนี้มีอาการปวดมาก
( ) ในขณะนี้มีอาการปวดมากที่สุดเท่าที่จะจินตนาการได้

2. การดูแลตนเอง (เช่น การอาบน้ำ/ชำระล้างร่างกาย แต่งตัว เป็นต้น)
( ) สามารถทำเองได้ตามปกติ โดยไม่ทำให้อาการปวดเพิ่มขึ้น
( ) สามารถทำเองได้ตามปกติ แต่มีอาการปวดเพิ่มขึ้น
( ) การทำเองทำให้มีอาการปวด จึงทำให้ต้องทำอย่างช้าๆและระมัดระวัง
( ) ทำเองได้เป็นส่วนใหญ่ แต่จะต้องการความช่วยเหลืออยู่บ้าง
( ) ต้องการการช่วยเหลือในการดูแลตนเองเกือบทั้งหมด ทุกวัน
( ) ไม่สามารถแต่งตัวได้เอง อาบน้ำ/ชำระล้างร่างกายเองได้ด้วยความยากลำบาก และต้องอยู่บนตียง

3. การยกของ

( ) สามารถยกของหนักได้ โดยไม่มีอาการปวดเพิ่มขึ้น

( ) สามารถยกของหนักได้ แต่มีอาการปวดเพิ่มขึ้น

( ) อาการปวดทำให้ไม่สามารถยกของหนักขึ้นจากพื้นได้ แต่สามารถยกได้หากของนั้นอยู่ในที่ที่เหมาะสม เช่น บนโต๊ะ

( ) อาการปวดทำให้ไม่สามารถยกของหนักขึ้นจากพื้นได้ แต่สามารถยกได้หากของนั้นมีน้ำหนักเบาถึงปานกลาง และจัดวางอยู่ในที่ที่เหมาะสม

( ) สามารถยกของที่มีน้ำหนักเบามากๆ ได้

( ) ไม่สามารถยก/ถือ/หิ้ว/แบก/อุ้ม หรือสะพายสิ่งของใด ๆ ได้เลย

4. การอ่าน

( ) สามารถอ่านได้มากตามที่ต้องการ โดยไม่มีอาการปวดคอ

( ) อ่านได้มากตามที่ต้องการ โดยมีอาการปวดคอเพียงเล็กน้อย

( ) สามารถอ่านได้มากตามที่ต้องการ โดยมีอาการปวดคอปานกลาง

( ) ไม่สามารถอ่านได้มากตามที่ต้องการ เพราะมีอาการปวดคอปานกลาง

( ) แทบจะไม่สามารถอ่านได้เลยเพราะมีอาการปวดคอมาก

( ) ไม่สามารถอ่านได้เลย

5. อาการปวดศีรษะ

( ) ไม่มีอาการปวดศีรษะเลย

( ) มีอาการปวดศีรษะเพียงเล็กน้อย และนาน ๆ ครั้ง

( ) อาการปวดศีรษะปานกลาง และนาน ๆ ครั้ง

( ) มีอาการปวดศีรษะปานกลาง และบ่อยครั้ง

( ) มีอาการปวดศีรษะมาก และบ่อยครั้ง

( ) มีอาการปวดศีรษะเกือบตลอดเวลา

6. การตั้งสมาธิ

( ) สามารถตั้งสมาธิได้อย่างที่ต้องการ โดยไม่มีความยากลำบาก

( ) สามารถตั้งสมาธิได้อย่างที่ต้องการ โดยมีความยากลำบากเพียงเล็กน้อย

( ) มีความยากลำบากปานกลางในการตั้งสมาธิเมื่อต้องการ

( ) มีความยากลำบากอย่างมากในการตั้งสมาธิเมื่อต้องการ

( ) มีความยากลำบากมากที่สุดในการตั้งสมาธิเมื่อต้องการ

( ) ไม่สามารถตั้งสมาธิได้เลย

7. การทำงาน

( ) สามารถทำงานได้มากตามที่ต้องการ

( ) สามารถทำงานประจำได้เท่านั้น ไม่มากไปกว่านั้น

( ) สามารถทำงานประจำได้เกือบทั้งหมด แต่ไม่มากไปกว่านั้น

( ) ไม่สามารถทำงานประจำได้เลย

( ) แทบจะทำงานอะไรไม่ได้เลย

( ) ไม่สามารถทำงานอะไรได้เลย

8. การขับขี่รถ (ตอบเฉพาะผู้ที่ขับขี่รถอยู่เป็นประจำ)

( ) สามารถทำได้โดยไม่มีอาการปวดคอ

( ) สามารถทำได้นานตามที่ต้องการ โดยมีอาการปวดคอเพียงเล็กน้อย

( ) สามารถทำได้นานตามที่ต้องการ โดยมีอาการปวดคอปานกลาง

( ) ไม่สามารถทำได้นานตามที่ต้องการ เพราะมีอาการปวดคอปานกลาง

( ) แทบจะทำไม่ได้เลย เพราะมีอาการปวดคอมาก

( ) ไม่สามารถทำได้เลย

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)

10. กิจกรรมนันทนาการ/การพักผ่อนหย่อนใจ

( ) สามารถทำกิจกรรมทุกอย่างได้ โดยไม่มีอาการปวดคอเลย

( ) สามารถทำกิจกรรมทุกอย่างได้ แต่มีอาการปวดคออยู่บ้าง

( ) สามารถทำกิจกรรมได้เป็นส่วนใหญ่ แต่ไม่ทั้งหมด เพราะมีอาการปวดคอ

( ) สามารถทำกิจกรรมได้เพียงบางอย่าง เพราะมีอาการปวดคอ

( ) แทบจะทำกิจกรรมต่าง ๆ ไม่ได้เลย เพราะมีอาการปวดคอ

( ) ไม่สามารถทำกิจกรรมใด ๆ ได้เลย

APPENDIX L
MODIFIRED OSWESTRY LOW BACK PAIN DISABILITY QUESTIONNAIRE

แบบสอบถามการจำกัดกิจกรรมจากอาการปวดหลังส่วนล่าง

<u>คำชี้แจง</u> แบบสอบถามนี้ถูกออกแบบขึ้นเพื่อให้ข้อมูลกับผู้รักษาว่าอาการปวดหลังส่วนล่างมีผลต่อการทำกิจวัตรประจำวันของท่าน กรุณาตอบแบบสอบถามทุกข้อ โดยทำเครื่องหมาย ☑ ด้านหน้าข้อความเพียงข้อเดียวที่จะบอกสภาพของท่านในวันนี้ได้ดีที่สุด หากมีตัวเลือกตรงกับท่านมากกว่า 1 ข้อ

<u>โปรดทำเครื่องหมายหน้าตัวเลือกที่บรรยายลักษณะใกล้เคียงกับท่านมากที่สุดเพียงข้อเดียว</u>

1. ระดับความเจ็บปวด

( ) สามารถทนปวดได้ โดยไม่ต้องใช้ยาแก้ปวด

( ) มีอาการปวดมาก แต่จัดการได้โดยไม่ต้องใช้ยาแก้ปวด

( ) ยาแก้ปวดทำให้หายปวดโดยสิ้นเชิง

( ) ยาแก้ปวดทำให้หายปวดได้ในระดับปานกลาง

( ) ยาแก้ปวดทำให้หายปวดได้เล็กน้อย

( ) ยาแก้ปวดไม่มีผลต่ออาการปวด

(หมายเหตุ ยาแก้ปวด หมายถึง ยาประเภทต่างๆที่ใช้รักษาบรรเทาอาการปวด เช่น ยากิน ยาใช้ภายนอก ยาฉีด เป็นต้น)

2. การดูแลตัวเอง (เช่น การทำความสะอาด การแต่งตัว)

( ) ดูแลตัวเองได้ตามปกติ โดยไม่ทำให้อาการปวดเพิ่มขึ้น

( ) ดูแลตัวเองได้ตามปกติ แต่มันทำให้อาการปวดเพิ่มขึ้น

( ) ปฏิบัติได้ช้าๆ โดยมีอาการปวด และต้องระมัดระวัง

( ) ต้องการความช่วยเหลือ แต่ก็สามารถจัดการธุระส่วนตัวส่วนใหญ่ได้

( ) ต้องการความช่วยเหลือทุกวัน สำหรับธุระส่วนตัวเกือบทุกเรื่อง

( ) แต่งตัวไม่ได้เลย อาบน้ำด้วยความลำบาก และอยู่แต่ที่เตียงนอน

3. การยกของ

( ) ยกของหนักได้โดยที่อาการปวดไม่เพิ่มขึ้น

( ) ยกของหนักได้ แต่มันทำให้อาการปวดเพิ่มขึ้น

( ) อาการปวดเป็นอุปสรรคในการยกของหนักขึ้นจากพื้น แต่ก็ยกได้ถ้าของที่มีน้ำหนักมากถูกจัดวางให้สะดวกในการยก (เช่น ของตั้งบนโต๊ะ)

( ) อาการปวดเป็นอุปสรรคในการยกของหนัก แต่ก็ยกได้ถ้าของที่มีน้ำหนักไม่มากนักถูกจัดวางให้สะดวกในการยก

( ) ยกได้แต่ของที่เบามาก

( ) ไม่สามารถยกหรือถืออะไรได้เลย

4. การเดิน

( ) อาการปวดไม่เป็นอุปสรรคในการเดินไกลๆ

( ) อาการปวดทำให้เดินได้ไม่เกิน 1 กิโลเมตร

( ) อาการปวดทำให้เดินได้ไม่เกิน 500 เมตร

( ) อาการปวดทำให้เดินได้ไม่เกิน 250 เมตร

( ) เดินได้โดยใช้ไม้ค้ำยันหรือไม้เท้าเท่านั้น

( ) อยู่ที่เตียงเกือบตลอดเวลาและต้องคลานไปเข้าห้องน้ำ

5. การนั่ง

( ) นั่งบนเก้าอี้แบบไหนก็ได้ นานเท่าที่ต้องการ

( ) นั่งบนเก้าอี้แบบที่ชอบเท่านั้น นานเท่าที่ต้องการ

( ) อาการปวดทำให้นั่งได้นานไม่เกิน 1 ชั่วโมง

( ) อาการปวดทำให้นั่งได้นานไม่เกิน ครึ่งชั่วโมง

( ) อาการปวดทำให้นั่งได้นานไม่เกิน 10 นาที

( ) อาการปวดทำให้ยืนไม่ได้เลย

6. การยืน

( ) ยืนได้นานเท่าที่ต้องการ โดยที่อาการปวดไม่เพิ่มขึ้น

( ) ยืนได้นานเท่าที่ต้องการ แต่มันทำให้อาการปวดเพิ่มขึ้น

( ) อาการปวดทำให้ยืนได้นานไม่เกิน 1 ชั่วโมง

( ) อาการปวดทำให้ยืนได้นานไม่เกิน ครึ่งชั่วโมง

( ) อาการปวดทำให้ยืนได้นานไม่เกิน 10 นาที

( ) อาการปวดทำให้ยืนไม่ได้เลย

7. การนอน

( ) อาการปวดไม่เป็นอุปสรรคต่อการนอนเต็มอิ่ม

( ) นอนได้เต็มอิ่ม แต่ต้องทานยาแก้ปวด

( ) แม้ว่าได้ทานยา ก็นอนได้น้อยกว่า 6 ชั่วโมง

( ) แม้ว่าได้ทานยา ก็นอนได้น้อยกว่า 4 ชั่วโมง

( ) แม้ว่าได้ทานยา ก็นอนได้น้อยกว่า 2 ชั่วโมง

( ) อาการปวดทำให้นอนไม่หลับเลย

8. การเข้าสังคม

( ) การใช้ชีวิตในสังคมเป็นปกติ และไม่ทำให้อาการปวดเพิ่มขึ้น

( ) การใช้ชีวิตในสังคมเป็นปกติ แต่มันเพิ่มระดับความเจ็บปวด

( ) อาการปวดเป็นอุปสรรคในการทำกิจกรรมที่ต้องออกแรงมาก (เช่น กีฬา, การเต้นรำ)

( ) อาการปวดเป็นอุปสรรคในการออกไปข้างนอกบ่อยๆ

( ) อาการปวดจำกัดการใช้ชีวิตในสังคม ให้อยู่แต่ในบ้าน

( ) แทบไม่มีการเข้าสังคม เนื่องจากอาการปวด

9. การเดินทาง

( ) เดินทางไปแต่ได้ทุกแห่งโดยอาการปวดไม่เพิ่มขึ้น

( ) เดินทางไปได้ทุกแห่ง แต่มันทำให้อาการปวดเพิ่มขึ้น

( ) อาการปวดจำกัดการเดินทางที่เกิน 2 ชั่วโมง

( ) อาการปวดจำกัดการเดินทางที่เกิน 1 ชั่วโมง

( ) อาการปวดจำกัดการเดินทาง โดยเดินทางได้ในระยะสั้นที่ไม่เกินครึ่งชั่วโมง

( ) อาการปวดเป็นอุปสรรคต่อการเดินทางทั้งหมด ยกเว้นการไปพบแพทย์ / นักกายภาพบำบัด หรือไปโรงพยาบาล

10. การทำงาน / งานบ้าน

( ) งานบ้าน / กิจกรรมทางการงาน ไม่ทำให้เกิดอาการปวด

( ) งานบ้าน / กิจกรรมทางการงาน เพิ่มอาการปวด แต่สามารถทำงานที่ต้องการทำทั้งหมดได้

( ) งานบ้าน / ภาระงานส่วนใหญ่ได้ แต่อาการปวดเป็นอุปสรรคต่อการทำกิจกรรมที่มีความเครียดทางกายเพิ่มขึ้น (เช่น การยกของ, การดูดฝุ่น)

( ) อาการปวดเป็นอุปสรรคในการทำสิ่งใดๆ ยกเว้นภาระงานที่เบา

( ) อาการปวดเป็นอุปสรรค แม้แต่ภาระงานที่เบา

( ) อาการปวดเป็นอุปสรรคในการทำงานใดๆหรืองานบ้านประจำ

APPENDIX M

DATA COLLECTION SHEET

รหัสผู้เข้าร่วมงานวิจัย_____ วันที่_____เดือน_____พ.ศ._____

แบบบันทึกข้อมูล

โครงงานวิจัยเรื่อง

การทำงานของกล้ามเนื้อให้ความมั่นคงแกนกลางลำตัวในผู้มีอาการปวดคอและปวดหลังส่วนล่าง

(Performance of Core Stabilizer Muscles in Individuals with Neck pain and Low back pain)

Core stabilizer muscle performance	
Craniocervical flexion test	**Abdominal drawing-in test**
Activation score: Pressure_____ mmHg	*Pressure change:* Pressure_____ mmHg
Performance index: Pressure_____ mmHg Repetition_____	

Sternocleidomastoid muscles				
	MVIC (μV)	10% MVIC (μV)	During craniocervical flexion test (μV)	
Right			Stage 1	
			Stage 2	
			Stage 3	
			Stage 4	
			Stage 5	
Left			Stage 1	
			Stage 2	
			Stage 3	
			Stage 4	
			Stage 5	
Rectus abdominis muscles				
	MVIC (μV)	10% MVIC (μV)	During abdominal drawing in test (μV)	
Right				
Left				

APPENDIX N
INSTRUCTION FOR PARTICIPANTS

Instruction for participants to perform maximum voluntary contraction of superficial muscles

1. Sternocleidomastoid muscles

ผู้วิจัยทดสอบหาค่าการทำงานสูงสุดของกล้ามเนื้อ sternocleidomastoid ในท่านอนหงาย ร่วมกับชันเข่าทั้ง 2 และแขนทั้ง 2 ข้าง วางข้างลำตัว โดยอธิบายให้ผู้เข้าร่วมการวิจัยทราบขั้นตอนการทดสอบ ดังนี้

“ ในขณะทำการทดสอบหาค่าการทำงานสูงสุดของกล้ามเนื้อคอชั้นตื้น ดิฉันจะให้คุณเก็บคางร่วมกับค่อยๆยกศีรษะให้ลอยพ้นจากเตียงช้าๆ เกร็งค้างไว้เป็นเวลา 10 วินาที ไม่กลั้นหายใจ จนกว่าดิฉันจะสั่งให้หยุด ”

คำสั่ง เก็บคางและเตรียมยกศีรษะนะคะ ... เริ่มค่ะ ... เกร็งค้างไว้นะคะ ... พอค่ะ

2. Rectus abdominis muscles

ผู้วิจัยทดสอบหาค่าการทำงานสูงสุดของกล้ามเนื้อ rectus abdominis ในท่านอนหงาย ร่วมกับชันเข่าทั้ง 2 และแขนทั้ง 2 ข้าง วางข้างไขว้ไปที่หัวไหล่ฝั่งตรงข้าม โดยอธิบายให้ผู้เข้าร่วมการวิจัยทราบขั้นตอนการทดสอบ ดังนี้

“ ในขณะทำการทดสอบหาค่าการทำงานสูงสุดของกล้ามเนื้อหน้าท้องชั้นตื้น ดิฉันจำให้แรงต้านเท่าๆกันบริเวณหัวไหล่ทั้ง 2 ข้าง และให้คุณค่อยๆยกลำตัวขึ้นมาตรงๆให้สะบักลอยพ้นจากเตียงช้าๆ เกร็งค้างไว้และออกแรงสู้กันเต็มที่เป็นเวลา 5 วินาที ไม่กลั้นหายใจ จนกว่าดิฉันจะสั่งให้หยุด ”

คำสั่ง เตรียมยกลำตัวขึ้นให้สะบักลอยพ้นจากเตียงนะคะ ... เริ่มค่ะ ... ออกแรงสู้กันเต็มที่นะคะ ... เกร็งค้างไว้นะคะ ... พอค่ะ

Instruction for participants to perform the craniocervical flexion test

ผู้วิจัยทดสอบ craniocervical flexion test ในท่านอนหงายร่วมกับชันเข่าทั้ง 2 ข้างและแขนทั้ง 2 ข้าง วางข้างลำตัว โดยอธิบายให้ผู้เข้าร่วมการวิจัยทราบขั้นตอนการทดสอบ ดังนี้

“ในขณะทำการทดสอบการทำงานของกล้ามเนื้อคอชั้นลึก ดิฉันจะวางมือบริเวณด้านหน้าของคอเพื่อดูการทำงานของกล้ามเนื้อคอชั้นตื้น โดยคุณจะต้องค่อยๆเก็บคางช้าๆให้เข็มบนหน้าปัดเพิ่มขึ้นจาก 20 mmHg 1 ช่องซึ่งเท่ากับ 22 mmHg เกร็งค้างไว้ 10 วินาที ไม่กลั้นหายใจ จนกว่าดิฉันจะสั่งให้หยุด และทดสอบขั้นต่อไปที่ความดัน 24 26 28 และ 30 mmHg”

คำสั่ง เตรียมตัวค่ะ ... เริ่มค่ะ ... เกร็งค้างไว้นะคะ ... พอค่ะ

Instruction for participants to perform the abdominal drawing in test

ผู้วิจัยทดสอบ abdominal drawing in test ในท่านอนคว่ำร่วมกับหมอนรองใต้เข่าทั้ง 2 ข้าง แขนทั้ง 2 ข้าง วางข้างลำตัว และศีรษะหันไปในทิศทางที่สบาย โดยอธิบายให้ผู้เข้าร่วมการวิจัยทราบขั้นตอนการทดสอบ ดังนี้

“ ในขณะทำการทดสอบการทำงานของกล้ามเนื้อท้องชั้นลึก ดิฉันจะวางมือบริเวณหลังเพื่อดูการเคลื่อนไหวของหลัง โดยคุณจะต้องหายใจเข้าและออกผ่านท้อง เมื่อถึงช่วงหายใจออกค่อยๆแขม่วท้องส่วนล่างช้าๆให้สะดืออยู่ชิดกับกระดูกสันหลังมากที่สุด เข็มบนหน้าปัดลดลงจาก 70 mmHg กี่ช่องก็ได้ เกร็งค้างไว้ 10 วินาที ไม่กลั้นหายใจ จนกว่าดิฉันจะสั่งให้หยุด ”

คำสั่ง เตรียมตัวค่ะ ... เริ่มค่ะ ... เกร็งค้างไว้นะคะ ... พอค่ะ

APPENDIX O

DATA OF MAIN STUDY

No.	Groups	VAS (mm)	NDI	ODQ	CCFT			ADIT
					Activation score	Repetitions	Performance index	Pressure change
1	sNP	21	4	-	4	6	24	4
2	sNP	25	4	-	6	6	24	4
3	sNP	35	5	-	2	2	4	2
4	sNP	48	5	-	2	3	6	2
5	sNP	37	3	-	2	3	6	2
6	sNP	48	6	-	2	5	10	4
7	sNP	21	5	-	2	3	6	2
8	sNP	38	7	-	4	3	12	2
9	sNP	89	12	-	2	3	6	2
10	sNP	38	3	-	4	6	24	4
11	sNP	25	4	-	4	3	12	4
12	sNP	65	7	-	4	6	24	4
13	sNP	69	9	-	4	6	24	4
14	sNP	33	3	-	4	6	24	2
15	sNP	52	10	-	2	4	8	2
16	sNP	66	4	-	2	2	4	2
17	sNP	58	20	-	0	0	0	4
18	sNP	37	4	-	0	0	0	2
19	sNP	24	3	-	0	0	0	2
20	sNP	65	4	-	4	6	24	4
21	sNP	29	2	-	4	4	16	2
22	sNP	51	4	-	6	1	6	8
23	sNP	33	4	-	6	2	12	4
24	cNP	72	7	-	4	4	16	2
25	cNP	25	9	-	4	5	20	2
26	cNP	27	5	-	4	3	12	4
27	cNP	39	2	-	4	3	12	4
28	cNP	70	5	-	2	1	2	6
29	cNP	41	5	-	4	3	12	4
30	cNP	71	12	-	2	3	6	4
31	cNP	47	4	-	4	5	20	6
32	cNP	20	9	-	4	3	12	4
33	cNP	37	11	-	2	2	4	2
34	cNP	37	7	-	2	2	4	2
35	cNP	54	7	-	4	6	24	4
36	cNP	40	11	-	4	7	28	4
37	cNP	43	9	-	2	2	4	2
38	cNP	72	8	-	2	2	4	4
39	cNP	64	5	-	4	6	24	2
40	cNP	42	10	-	0	0	0	2
41	cNP	69	18	-	2	1	2	2
42	cNP	36	2	-	2	7	14	2
43	cNP	51	6	-	4	5	20	2
44	cNP	70	7	-	2	2	4	4
45	cNP	70	11	-	4	1	4	2
46	cNP	59	8	-	2	4	8	0

CCFT = craniocervical flexion test, ADIT = abdominal drawing-in test, sNP = subacute neck pain group, cNP = chronic neck pain group, sLBP = subacute low back pain group, cLBP = chronic low back pain group, C = control group, VAS = visual analog scale, NDI = neck disability index and ODQ = modified Oswestry low back pain disability questionnaire

No.	Groups	VAS (mm)	NDI	ODQ	CCFT			ADIT
					Activation score	Repetitions	Performance index	Pressure change
47	sLBP	49	-	5	4	3	12	2
48	sLBP	41	-	4	8	2	16	2
49	sLBP	20	-	0	6	7	42	2
50	sLBP	48	-	13	4	6	24	2
51	sLBP	34	-	4	4	3	12	2
52	sLBP	31	-	3	4	4	16	2
53	sLBP	54	-	7	4	4	16	2
54	sLBP	56	-	2	4	5	20	2
55	sLBP	71	-	5	8	2	16	2
56	sLBP	55	-	3	4	5	20	2
57	sLBP	67	-	1	10	5	50	2
58	sLBP	76	-	5	6	5	30	4
59	sLBP	40	-	4	6	5	30	2
60	sLBP	79	-	11	4	2	8	0
61	sLBP	23	-	7	4	1	4	0
62	sLBP	52	-	3	0	0	0	0
63	sLBP	34	-	5	4	4	16	2
64	sLBP	48	-	4	4	1	4	0
65	sLBP	69	-	10	0	0	0	2
66	sLBP	64	-	1	2	1	2	0
67	sLBP	23	-	2	4	10	40	2
68	sLBP	28	-	1	4	2	8	2
69	sLBP	25	-	0	2	3	6	2
70	cLBP	29	-	8	8	3	24	2
71	cLBP	30	-	3	8	4	32	4
72	cLBP	62	-	1	4	1	4	4
73	cLBP	47	-	7	6	3	18	4
74	cLBP	59	-	13	2	2	4	2
75	cLBP	94	-	10	4	4	16	2
76	cLBP	64	-	8	2	5	10	0
77	cLBP	64	-	16	4	3	12	2
78	cLBP	24	-	3	6	6	36	4
79	cLBP	31	-	2	4	4	16	0
80	cLBP	35	-	5	2	3	6	4
81	cLBP	78	-	12	6	6	36	2
82	cLBP	27	-	4	4	10	40	2
83	cLBP	64	-	3	8	7	56	2
84	cLBP	77	-	6	2	1	2	2
85	cLBP	41	-	10	6	10	60	2
86	cLBP	49	-	6	4	1	4	2
87	cLBP	36	-	5	10	8	80	2
88	cLBP	29	-	2	4	5	20	2
89	cLBP	76	-	6	4	6	24	2
90	cLBP	77	-	10	0	0	0	0
91	cLBP	52	-	1	0	0	0	0
92	cLBP	59	-	6	0	0	0	0
93	C	-	-	-	8	7	56	10
94	C	-	-	-	6	7	42	6
95	C	-	-	-	6	10	60	4

CCFT = craniocervical flexion test, ADIT = abdominal drawing-in test, sNP = subacute neck pain group, cNP = chronic neck pain group, sLBP = subacute low back pain group, cLBP = chronic low back pain group, C = control group, VAS = visual analog scale, NDI = neck disability index and ODQ = modified Oswestry low back pain disability questionnaire

No.	Groups	VAS	NDI	ODQ	CCFT			ADIT
					Activation score	Repetitions	Performance index	Pressure change
96	C	-	-	-	10	5	50	4
97	C	-	-	-	10	8	80	6
98	C	-	-	-	8	6	48	8
99	C	-	-	-	6	1	6	4
100	C	-	-	-	8	1	8	2
101	C	-	-	-	6	5	30	6
102	C	-	-	-	6	5	30	4
103	C	-	-	-	8	2	16	4
104	C	-	-	-	6	4	24	2
105	C	-	-	-	8	6	48	4
106	C	-	-	-	8	7	56	4
107	C	-	-	-	6	8	48	4
108	C	-	-	-	8	6	48	4
109	C	-	-	-	6	10	60	4
110	C	-	-	-	6	6	36	4
111	C	-	-	-	6	6	36	4
112	C	-	-	-	10	5	50	4
113	C	-	-	-	6	6	36	6
114	C	-	-	-	6	8	48	4
115	C	-	-	-	8	3	24	6
116	C	-	-	-	10	5	50	2
117	C	-	-	-	6	2	12	2
118	C	-	-	-	4	10	40	4
119	C	-	-	-	4	10	40	2
120	C	-	-	-	2	4	8	4
121	C	-	-	-	2	2	4	4
122	C	-	-	-	6	5	30	4

CCFT = craniocervical flexion test, ADIT = abdominal drawing-in test, sNP = subacute neck pain group, cNP = chronic neck pain group, sLBP = subacute low back pain group, cLBP = chronic low back pain group, C = control group, VAS = visual analog scale, NDI = neck disability index and ODQ = modified Oswestry low back pain disability questionnaire

APPENDIX P
PUBLISHED PAPER

HS-33

ความสัมพันธ์ระหว่างค่าความดันสูงสุดขณะทำการทดสอบ Cranio-cervical Flexion โดยใช้การวัดด้วยการคลำ และเครื่องตรวจสัญญาณไฟฟ้าในกล้ามเนื้อแบบป้อนกลับ เพื่อตรวจสอบการทำงานที่ไม่ต้องการของกล้ามเนื้อชั้นตื้น

Correlation Between the Highest Pressure Achieved During the Cranio-cervical Flexion Test Using Manual Palpation and EMG Biofeedback for Detecting Unwanted Superficial Muscle Contraction

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บทคัดย่อ

ในทางคลินิกและงานวิจัยโดยปกติใช้การคลำเพื่อตรวจจับการทำงานที่ไม่ต้องการของกล้ามเนื้อ sternocleidomastoid (SCM) ขณะทำการทดสอบ craniocervical flexion test (CCFT) แต่ยังไม่มีข้อมูลเรื่องความสัมพันธ์ระหว่างผลของการทดสอบด้วยการคลำและการใช้เครื่องตรวจสัญญาณไฟฟ้าในกล้ามเนื้อซึ่งเป็นเครื่องมือมาตรฐานในการตรวจจับการทำงานของกล้ามเนื้อ การศึกษานี้จึงมีจุดประสงค์เพื่อหาความสัมพันธ์ระหว่างค่าความดันสูงสุดด้วยการคลำและการใช้เครื่องตรวจสัญญาณไฟฟ้าในกล้ามเนื้อแบบป้อนกลับเพื่อตรวจจับการทำงานของกล้ามเนื้อ SCM ระหว่างการทดสอบ CCFT โดยมีอาสาสมัครเข้าร่วมงานวิจัยจำนวน 20 คน ประกอบด้วยผู้ที่มีอาการปวดคอมานานมากกว่า 1 เดือนจำนวน 10 คน และผู้ที่ไม่มีอาการปวดคอจำนวน 10 คน ผู้เข้าร่วมงานวิจัยทั้งหมดได้รับการทดสอบ CCFT ในขณะที่ผู้ทดสอบ 2 คนแยกตรวจจับการทำงานของกล้ามเนื้อ SCM ด้วยการคลำและการใช้เครื่องตรวจสัญญาณไฟฟ้าในกล้ามเนื้อแบบป้อนกลับ ระดับความดันที่สามารถทำได้มากที่สุดจะถูกบันทึกเพื่อนำไปวิเคราะห์ข้อมูล สถิติ Spearman's correlation coefficient (r) แสดงค่าสัมประสิทธิ์ความสัมพันธ์ของระดับความดันที่สามารถทำได้มากที่สุดระหว่างการคลำและการใช้เครื่องตรวจสัญญาณไฟฟ้าในกล้ามเนื้อแบบป้อนกลับมีค่าเท่ากับ 0.940 ($p < 0.001$) การวิเคราะห์ข้อมูลแบบกลุ่มย่อยแสดงความสัมพันธ์อย่างมีนัยสำคัญทางสถิติในกลุ่มผู้ที่มีอาการปวดคอ ($r = 0.856$, $p = 0.002$) และผู้ที่ไม่มีอาการปวดคอ ($r = 0.984$, $p < 0.001$) ผลการวิจัยนี้แนะนำว่าการคลำเป็นวิธีการที่มีความเหมาะสมในการใช้เพื่อตรวจจับการทำงานที่ไม่ต้องการของกล้ามเนื้อ SCM ขณะทำการทดสอบ CCFT

คำสำคัญ: การคลำ เครื่องตรวจสัญญาณไฟฟ้าในกล้ามเนื้อแบบป้อนกลับ ปวดคอ กล้ามเนื้อคอ

Abstract

In clinical and research settings, manual palpation is commonly used for detecting an unwanted contraction of the sternocleiomastoid muscles (SCM) during the craniocervical flexion test (CCFT). Nevertheless, no studies have investigated the correlation between the test results obtained by the manual palpation and the electromyography (EMG) which is considered as a gold standard for measuring muscle activity. The objective of this study was to evaluate the correlation between the highest pressure achieved obtained by the manual palpation and the EMG biofeedback during the CCFT. Twenty volunteers participated in this study. They consisted of 10 individuals with neck pain for more than one month and 10 asymptomatic participants. They were instructed to perform the CCFT while the muscle activity of the SCM muscle was simultaneously monitored by the manual

palpation and the EMG biofeedback by different assessors. The highest target pressure achieved was recorded for analysis. A Spearman's correlation coefficient (r) between the highest target pressure achieved from the manual palpation and the EMG biofeedback methods was 0.940 ($p < 0.001$). Subgroup analyses also revealed significant correlations in neck pain ($r = 0.856$, $p = 0.002$) and asymptomatic participants ($r = 0.984$, $p < 0.001$). The results of this study suggested that the manual palpation method was shown to be a suitable method for determining whether there is unwanted muscle activity from the SCM muscle during the CCFT.

Keywords: Craniocervical flexion test, Electromyography, Neck pain, Neck muscles

Introduction

Impairments of the deep cervical flexor muscles have been presented in patients who suffered from neck pain. The strength and endurance of these muscles were found to reduce with low muscle activity while there was high muscle activity in the sternocleidomastoid (SCM) muscle in comparison to the asymptomatic persons.(1-9) These findings suggest that the deep cervical flexor muscles lose their function as active spinal segmental stabilizers and a specific therapeutic exercise should be initiated.(2, 10)

The test that is generally conducted as a part of physical therapy examination for examining the function of the deep cervical flexor muscles are the cranio-cervical flexion test (CCFT). It aims to indirectly measure the strength and endurance of the deep cervical flexor muscles – the longus capitis and longus colli muscles.(11) The test requires an individual to perform cranio-cervical flexion movement over a pressure biofeedback unit in order to achieve the pressure targets of five incremental levels with negligible activity in the SCM muscle.(12) Any detectable muscle activity of SCM muscle is considered as a fail for that level. The greater the highest pressure achieved, the greater strength of the deep cervical flexor muscles.(13)

From the above, an ability of a therapist to detect activity of the SCM muscle during the CCFT is therefore critical for classifying the level of strength of the deep cervical flexor muscles. In general, the method used for determining activity of the SCM muscle is performed by direct manual palpation over the muscle.(11) However, it is well accepted that the electromyography (EMG) either the surface or the needle EMG is a gold standard for indicating the amount of muscle activity. Nevertheless, little is known about the correlation between the test results during the CCFT measured by manual palpation and EMG. Therefore, the aim of this study was to examine the correlation between the highest pressure achieved during the CCFT measured by these two methods.

Methods

1. Participants

Twenty participants aged between 20 and 45 years, both male and female with normal body mass index (18.5-22.9 kg/m^2) were recruited. They consisted of 10 individuals with neck pain for more than one month and 10 asymptomatic participants. Neck pain was defined as region of the superior nuchal line to the third thoracic spinous process.(14) They were excluded

if they had undergone abdominal wall or spinal surgery in the last two years, had spinal deformity such as scoliosis that had a positive test from Adam's forward bend test, had neurological condition, and had history of fracture, cancer, and infectious disease of the spine. The persons who were unable to perform CCFT and had participated in the training program of neck stabilization within the last one year were also excluded. The ethical approval was obtained from the Chulalongkron University Human Ethics Committee (No. 068.1/59). All participants who met the selection criteria signed the consent form before participating in the study.

2. Instruments

2.1 Pressure biofeedback unit

A pressure biofeedback unit (Chattanooga, USA) was used for measuring the performance of the deep cervical flexor muscles. It is reported to be accurate at ±3 mmHg (Figure 1).

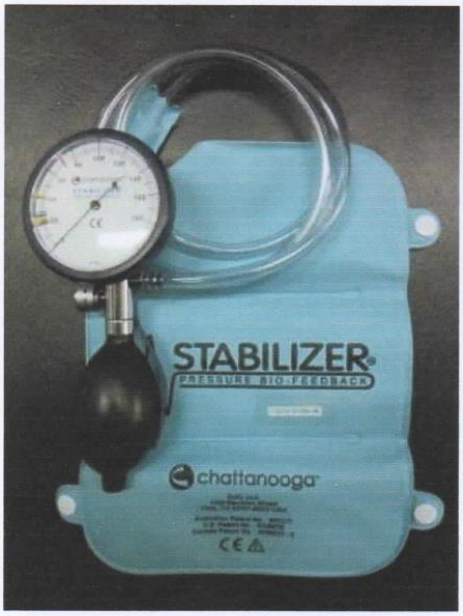

Figure 1 Pressure biofeedback unit

2.2 EMG biofeedback

The muscle activity of the SCM muscles was measured by the Myomed 932® (Enraf-Nonius, the Netherlands) EMG biofeedback. The silver/silver chloride surface electrodes of 10 millimeters in diameter, with a 22-millimeter inter-electrode distance, were positioned along the lower one-third of the muscle bellies on both sides (Figure 2).(15) A reference electrode was

placed on the lateral epicondyle of the left elbow. According to previous studies, the acceptable negligible activity of the SCM muscles during the CCFT was reported to be less than 10% of their maximum voluntary isometric contraction.(2, 13) Thus, the 10% MVIC was set as a threshold for the EMG biofeedback to determine that there was unwanted SCM muscle activity during the test. The threshold of each participant was set as a horizontal line marker shown the LCD screen of the EMG biofeedback. At the moment when the muscle activity rose above this threshold, the pressure level on the pressure biofeedback gauge would be recorded for further analysis.

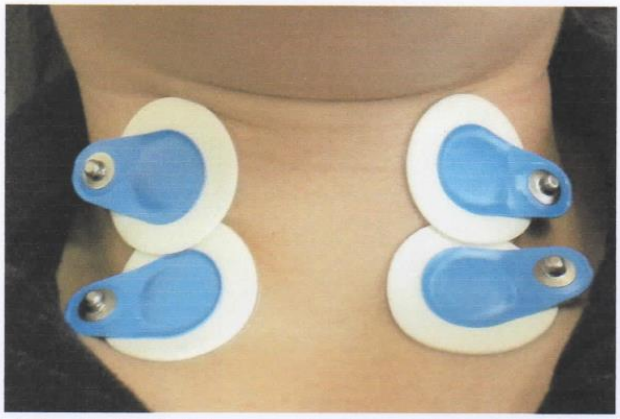

Figure 2 The placing of electrodes on the sternocleidomastoid muscles (SCM).

The maximum voluntary isometric contraction of the SCM muscles was established by having the participants lie in supine crook lying position. Then, they were instructed to flex neck to just clear the head from the plinth and held for 10 seconds.(2)

3. Procedure

Each participant was positioned in supine with the knees bent and the head in the horizontal line of the body (Figure 3). The pressure biofeedback unit was placed behind the neck at suboccipital region and inflated to the baseline pressure of 20 mmHg.(9, 11) Participants practiced the CCFT by gently nodding their head to achieve progressive pressure targets at increment of 2 mmHg from 22 to 30 mmHg holding for 2 - 3 seconds. The testing period began after food consumption for at least 30 minutes with an empty bladder.

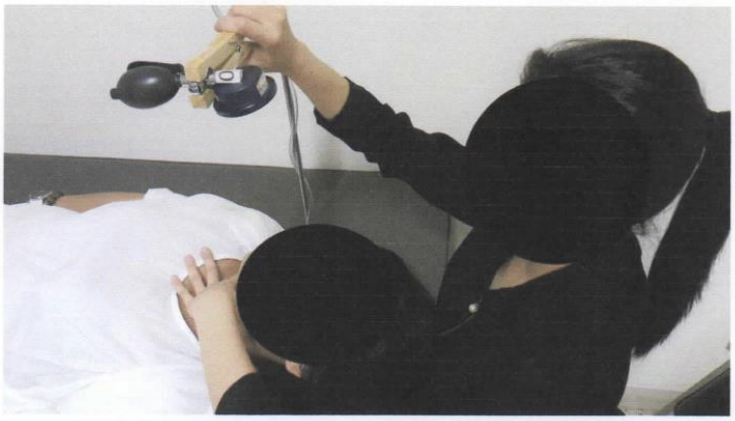

Figure 3 The setting of the participants during the craniocervical flexion test (CCFT).

Two assessors monitored the contraction of the SCMs at the same time. After the CCFT training period, one assessor placed fingers over both SCMs to manually palpate for muscle contraction. Another assessor monitored the LCD screen of the EMG biofeedback for activity of both SCMs. Assessor who conducted the manual palpation constantly watched on the pressure gauge and announced the target pressure level. By this means, the assessor who monitored the LCD screen of the EMG biofeedback would know the target pressure level that was being tested. Once the participants could achieve the set target pressure level, they were asked to perform the CCFT at the next target pressure level. Each increment was held steadily for 10 seconds with 30-second rest in between until the participants reached the highest pressure level at 30 mmHg. Each assessor independently recorded the pressure target on the pressure biofeedback unit at which the participants could perform the CCFT correctly. The highest pressure level achieved with negligible contraction of the SCM muscles was recorded for analysis.

4. Statistical analysis

Data analysis was performed using the SPSS software version 22.0. The significant level was set at $p < 0.05$. The descriptive statistics was used to describe the demographic data. The Spearman's correlation coefficient was used to determine the correlation of the highest pressure achieved recorded between the two methods. Correlation coefficient (r) of 0-0.25 indicates little or no relationship, 0.25-0.50 was fair, 0.50-0.75 was moderate to good and greater than 0.75 was good to excellence.(16)

Results

There were 9 females and 11 males participated in this study. The demographic data are presented in Table 1. Table 2 shows the correlation coefficients (r) between the highest pressure achieved from the CCFT recorded by the manual palpation and the EMG biofeedback methods. Significant positive correlation between the highest pressures achieved from two

methods was excellent correlation (r = 0.940, p < 0.001). Subgroup analyses also revealed significant correlations in neck pain (r = 0.856, p = 0.002) and asymptomatic participants (r = 0.984, p < 0.001).

Table 1 Demographic data (means (SD)) of the participants.

Variables	Total (n = 20)	Neck pain (n = 10)	Asymptomatic (n = 10)
Male / Female	11 / 9	5 / 5	6 / 4
Age (years)	23.0 (3.5)	22.7 (3.6)	23.3 (3.6)
Weight (kg)	57.8 (7.1)	56.6 (6.1)	59.1 (8.2)
Height (cm)	166.3 (8.6)	163.9 (6.6)	168.7 (10.0)
Body mass index (kg/m^2)	20.9 (1.3)	21.0 (1.2)	20.7 (1.5)

Table 2 The correlation coefficients (r) between the highest pressures achieved during the CCFT measured by the manual palpation and EMG biofeedback.

Variables	Correlation coefficient (r)	p – value
Total	0.940	<0.001
Neck pain	0.856	0.002
Asymptomatic	0.984	<0.001

Discussion

This study examined the correlation between the highest pressures achieved during the CCFT measured by the manual palpation and EMG biofeedback methods. Excellent correlation between the two methods was found both in the neck pain and asymptomatic participants. These findings suggest that the use of manual palpation for determining whether there is unwanted muscle contraction from the SCM muscles during the CCFT is acceptable.

The high correlation between the results obtained via the manual palpation and the EMG biofeedback methods helps validate the use of the manual palpation during the CCFT. As the CCFT is widely used not only in clinical setting but in research setting, these findings would provide both the therapists and the researchers with confidence to utilize the manual palpation during the CCFT.

The results of this study are in line with previous studies that examined manual palpation for pelvic floor muscle contraction. The strength of the pelvic floor muscle was classified into five grades, ranging from zero to five on the Modified Oxford Scale which is similar to the 5-stage increment pressure testing for the CCFT. Manual palpation of the pelvic floor muscle was shown to have moderate to good correlation with perineometer (17) and EMG (18, 19) as well as have moderate correlation with ultrasonography.(19, 20) The findings that a researcher could differentiate among various levels of muscle contraction suggest that an

individual who was trained would be able to perceive change in the strength of muscle contraction through manual palpation. In the present study, it was demonstrated that the minimal contraction of the SCM muscles as low as 10% of its maximum voluntary contraction was plausible to be detected via manual palpation.

The excellent correlations demonstrated both in the neck pain and asymptomatic participants also support the validation for the use of manual palpation during the CCFT in both populations. The findings of the lower highest pressure achieved during the CCFT in the neck pain than the asymptomatic participants also concur with previous studies.(1-4) These results confirm that the deep cervical flexor muscles tend to impair in persons with neck pain.

There are limitations to this study. Firstly, this study employed the surface electrodes not the intramuscular electrodes over the SCM muscles. Some artifacts during testing might interfere with the amount of the muscle activity. Nonetheless, this confounding would be minimal as the test was conducted in the superficial muscle of the neck. A previous study showed that at least 60% of the recorded muscle activity was from the SCM muscles. (21) Secondly, manual palpation closed to the surface EMG electrodes might interfere with the EMG data. However, the palpation in this study that took place as a light touch should not affect the data. This was evident by the negligible change in the resting muscle activity of the SCMs on the LCD screen of the EMG biofeedback during manual palpation. Thirdly, this study focused on identifying the highest pressure achieved during the CCFT which represents the strength of the deep cervical flexor muscles, the endurance of the muscles was not investigated. Nevertheless, it is speculated that the manual palpation of the SCM muscle activity could also be employed when testing for muscle endurance. However, further investigation is necessary to prove this notion.

Conclusion

Significant correlations between the highest pressure achieved obtained by the manual palpation and the EMG biofeedback during the CCFT were excellent. The results support the use of manual palpation for determining whether there is unwanted muscle activity from the SCM muscle during the CCFT.

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