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EFFECTS OF EXERCISES TO REDUCE ROUNDED SHOULDERS
ON CHEST EXPANSION, RESPIRATORY MUSCLE STRENGTH

USA CHINWARO

GRADUATE SCHOOL Srinakharinwirot University

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EFFECTS OF EXERCISES TO REDUCE ROUNDED SHOULDERS ON CHEST EXPANSION, RESPIRATORY MUSCLE STRENGTH AND PULMONARY FUNCTION IN COPD PATIENTS

USA CHINWARO

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BY

USA CHINWARO

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Rounded shoulders or the forward shoulder posture, also known as rounded shoulders, were mostly found in COPD patients which caused a further limitation of respiratory functions. A preliminary study found that eight weeks of pectoral muscle stretching and scapular muscle strengthening exercise could reduce rounded shoulder posture in healthy subjects. On the other hand the effects of the exercise program on COPD patients remain unknown. Therefore, the objective of this study was to demonstrate the effects of exercise program to reduce rounded shoulders on chest expansion, respiratory muscle strength, and pulmonary function in COPD patients. The aspects of forward shoulder posture (FSP), pectoralis minor length, scapular muscle strength, thoracic kyphosis, chest expansion magnitude, respiratory muscle strength, and pulmonary function were evaluated at the baseline, in weeks four, and weeks eight after training. There were forty male patients with COPD, participated in aged between sixty to ninety, were randomized into control (n=20) and exercise groups (n=20). With regards to the exercise group, the participants exercise training programs to reduce rounded shoulders three days per week for eight weeks whereas the control group was limited to physical activity throughout the experimental period. The results found that there were significant decreases in FSP and thoracic kyphosis with increases in pectoralis minor length and scapular muscle strength in the exercise group. Moreover, they showed a marked increase in respiratory parameters, including respiratory muscle strength and chest expansion, especially the middle and lower part. However, the pulmonary function, degree of breathlessness, and quality of life among COPD participants were not changed in this study. The present study concluded that the application of exercise programs could reduce FSP in COPD patients. Moreover, reduced FSP could increase the mobility of the chest wall which affected the increments of chest expansion and respiratory muscle strength among COPD patients.

Keyword : COPD, Forward shoulder posture, Respiratory muscle strength

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USA CHINWARO

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CHAPTER 1
INTRODUCTION

Background

Chronic obstructive pulmonary disease (COPD) is one of the most common types of chronic inflammatory lung disease and has a high mortality rate (1, 2). COPD includes the conditions of chronic bronchitis and parenchymal emphysema. These two conditions cause an obstruction of the airway in the lung and induce persistent degeneration of the respiratory system. Chronic bronchitis is characterized by inflammation of the lining cells in the small airway, which leads to small airway thickening and airflow obstruction from mucus gland hypersecretion. Parenchymal emphysema is a condition in which the alveolar walls are damaged by irritants. Airway and alveolar abnormalities from COPD are usually caused by long-term exposure to many kinds of irritating agents, such as noxious particles from cigarette smoke and irritating gases (3). In 2002, chronic obstructive pulmonary disease in the Thai elderly was found to occur in about 7.1% of the elderly population, (4) and incurred large expenses for the long-term treatment of patients, estimated at up to 7,714.88 million baht in total each year (5).

The destruction of the alveolar wall and lung parenchyma from COPD leads to an impairment of the alveolar function and its elasticity, especially during expiration. A previous study showed that chronic airflow limitation in COPD caused a reduction in lung volume, respiratory muscle strength, exercise capacity (6), and quality of life (QoL) (7). Airway narrowing, impaired gas exchange, and loss of lung elastic recoil can result in airway collapse, air trapping, and hyperinflation (3). COPD patients with lung hyperinflation have an impairment of the diaphragmatic efficiency for inspiration from flattening of the diaphragm (8-10). In addition, lung hyperinflation in COPD can lead to the development of an abnormal configuration called a barrel chest shape, which in turn leads to changes in the musculoskeletal structure, such as increased chest wall rigidity (9, 10), thoracic kyphosis, and a rounded shoulder posture (9, 11). Hyperinflation of the lung induces a passive increase in chest wall rigidity and affects its movement. In this situation, the respiratory muscles, including the external intercostal and diaphragm, are at non-optimal lengths for contraction during inspiration. Over a period of time, respiratory muscle strength will then be reduced, leading to an increase in work for breathing and dyspnea (12, 13) in a patient with COPD. According to respiratory function, it has been demonstrated that thoracic kyphosis is also associated with dyspnea (14) and respiratory dysfunction (15). A study in young healthy subjects reported that the approximation of the ribs to the pelvis from the thoracic kyphosis could increase intra-abdominal pressure (16), making it difficult for the diaphragm to descend (17, 18) caudally and to create maximal lung capacity during inspiration (19).

Rounded shoulder posture (9) is characterized by the resting shoulder position having a forward position from the ideal postural alignment, which is a straight line passing through the ear canal, shoulder joint, midline of the trunk, hip joint, greater trochanter of the femur, and the lateral malleolus. The shoulder girdle is positioned anteriorly, which involves the scapular protraction, anterior tilt, and downward rotation (20-22). This abnormal shoulder posture causes an imbalance of the upper quadrant muscles,(22, 23) and is an important cause of various shoulder problems, including subacromial impingement and shoulder pain. Shortened or tightness of the anterior shoulder girdle muscle, especially the pectoral muscles, and weakness of the scapular muscles, especially the lower trapezius and serratus anterior (23, 24), subsequently lead to a forward alignment of the shoulder posture. The pectoral muscles being in a shortened position resist the chest wall from expanding, and this further increases the work required for breathing (25) and decreases exercise capacity (26) and the quality of life in COPD patients. A previous study reported that a reduction in pulmonary function, including vital capacity (VC), forced vital capacity (FVC), and expiratory residual volume (ERV), was related with an increased forward shoulder posture (27). Furthermore, impaired pulmonary function in COPD has been found to be associated with a decreased pectoralis minor muscle length in RSP (28). Therefore, poor posture from rounded shoulder in COPD not only leads to musculoskeletal problems but also causes deteriorative effects on the pulmonary system. A study by Urbannowicz and coworkers in 2009 (29) confirmed that COPD patients tended to have an elevated scapular due to lung hyperinflation, and therefore, recommended exercise programs should be performed to prevent scapular elevation related to COPD (29). Many studies have suggested exercises for correcting muscle imbalance and this is considered an appropriate treatment for RSP (19, 30, 31). Stretching the tightened muscles and strengthening the weakened muscles, especially the serratus anterior and lower trapezius, have also been used to actively counteract the strength and movement loss associated with RSP (32). In 2008, Putt and coworkers reported that stretching the pectoralis major, especially in the clavicular part, by proprioceptive neuromuscular facilitation (PNF) could increase the shoulder range of motion (ROM) and the vital capacity immediately in COPD patients (25). Gaude and coworkers in 2014 reported the results from postural correction treatment at 4 weeks and 12 weeks by using a shoulder brace, which improved dyspnea and increased pulmonary function in patients with COPD (33) .

Recently, the Global Initiative for Obstructive Lung Disease (GOLD) (3) reported that musculoskeletal dysfunction is a possible critical element for COPD patients, resulting in decreased exercise tolerance and a limited quality of life in patients. GOLD guidelines recommend the important goal of treatment in COPD patients should involve an improvement of the musculoskeletal function to increase exercise capacity and thereby the quality of life. Diminished muscle imbalance in rounded shoulder has been shown to be an effective treatment for musculoskeletal dysfunction and also for improving the pulmonary function. Our preliminary study demonstrated that performing pectoral muscles self-stretching and scapular muscle strengthening exercises for eight weeks could alleviate rounded shoulder and also improve chest expansion and respiratory muscle strength in normal subjects (unpublished data). However, the effects of these exercise have not been studied in COPD patients with rounded shoulder. Therefore, the present study aimed: (1) to investigate the effect of following an exercises training program, comprising pectoral muscle self-stretching and scapular muscles strengthening exercises, on rounded shoulder posture, and (2) to study whether such an exercise program for reducing rounded shoulder posture could also improve chest expansion, respiratory muscle strength, and pulmonary function in COPD patients. We hypothesized that pectoral muscles self-stretching and scapular muscles strengthening exercises could reduce rounded shoulder posture in COPD patients. And also that if so, the decrement of rounded shoulder in COPD patients might improve chest expansion, respiratory muscle strength, and pulmonary function. Research questions were formulated to guide the research.

Research questions

1. Would following an exercise training program including pectoral muscles self-stretching and scapular muscles strengthening exercises alleviate rounded shoulder posture in COPD patients?

2. Would reducing rounded shoulder posture increase chest expansion, respiratory muscle strength, and pulmonary function in COPD patients?

Objectives of this study

1. To investigate the effects of an exercise training program on rounded shoulder posture in COPD patients

2. To investigate the effects of an exercise training program for reducing rounded shoulder posture on chest expansion, respiratory muscle strength, and pulmonary function in COPD patients.

Study hypothesis

1. Exercise training program can reduce rounded shoulder posture in COPD patients.

2. Following an exercise training program for reducing rounded shoulder can increase chest expansion, respiratory muscle strength, and pulmonary function in COPD patients.

Key output

The exercise program followed in this study could be applied to reduce rounded shoulder posture and improve respiratory function in COPD patients, and hence it is recommended that this program should be included in the pulmonary rehabilitation program of COPD patients.

Keywords

Forward shoulder posture, Thoracic excursion, Maximum inspiratory pressure, Spirometry, Therapeutic exercise, Obstructive lung disease.

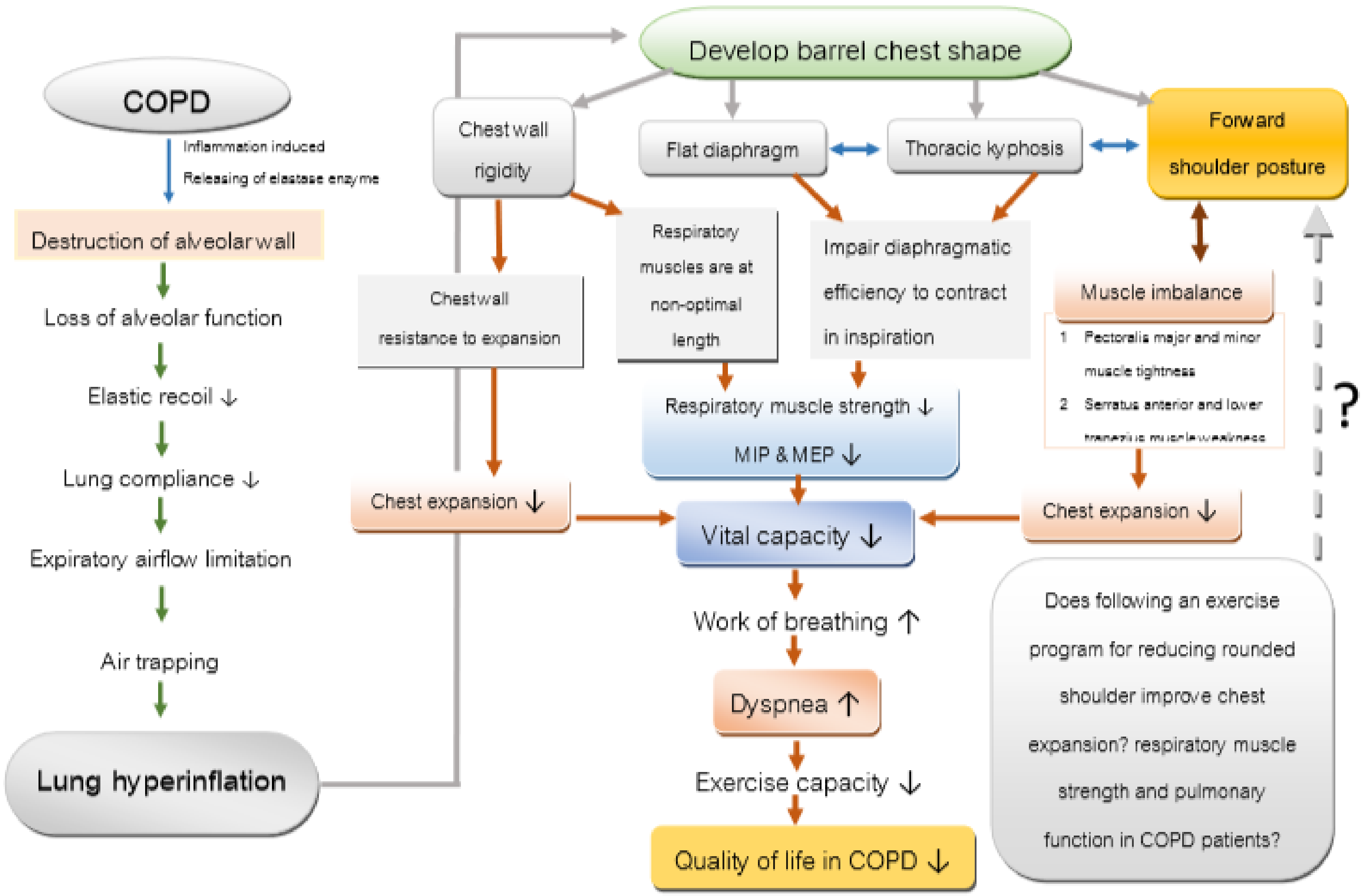


Figure 1: Conceptual framework

CHAPTER 2
LITERATURE REVIEW

2.1 Chronic obstructive pulmonary disease

2.1.1 Chronic obstructive pulmonary disease

Chronic obstructive pulmonary disease (COPD) is one of the most common lung disease, with an increasing mortality rate ranking it among the top five severe chronic diseases in the world (1, 2). According to its pathology, COPD consists of chronic bronchitis and pulmonary emphysema.

1. Chronic bronchitis is characterized by inflammation of the airway, which causes chronic cough and mucus gland hypersecretion.

2. Pulmonary emphysema (parenchymal destruction) is characterized by a loss of elastic recoil with an enlargement of the alveoli and respiratory bronchioles, and also destruction of the alveolar walls.

Definitions for COPD from the Global Initiative for Chronic Obstructive Lung Disease (GOLD) and American Thoracic Society (ATS) and European Respiratory Society (ERS) are shown in Table 1. Such organizations focus on the preventability and treatability of this disease given that airflow limitation is usually progressive and not fully reversible.

Table 1 : Definition of chronic obstructive pulmonary disease (COPD)

Source	Definition
GOLD [3]	A common, preventable, and treatable disease that is characterized by persistent respiratory symptoms and airflow limitation that is due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases
ATS and ERS [34]	A preventable and treatable disease state characterized by airflow limitation that is not fully reversible. The airflow limitation is usually progressive and is associated with an abnormal inflammatory response of the lungs to noxious particles or gases, primarily caused by cigarette smoking Although COPD affects the lungs, it also produces significant systemic consequences.
GOLD; Global initiative for Obstructive Lung Disease, ATS; American Thoracic Society, ERS; European Respiratory Society	

GOLD; Global initiative for Obstructive Lung Disease, ATS; American Thoracic Society, ERS; European Respiratory Society

2.1.2 Causes of COPD

The most common risk factor of COPD is tobacco usage, such as from smoking cigarettes (> 20 pack per years of smoking), pipes, cigars, hookahs, and in cannabis joints. Moreover, air pollution and noxious fumes from the burning of biomass fuels are other COPD risk factors as well.

Nonsmokers may also develop COPD. Other factors, including genetics, such as a severe hereditary deficiency of alpha-1 antitrypsin (AATD), and airway hyper-responsiveness during childhood can also contribute to a person developing COPD (3, 35).

2.1.3 Pathophysiology of COPD

Smoking is a major cause of lung inflammation in patients with COPD. Chronic inflammation damages parenchymal tissue (emphysema), and disturbs the reparative process in the small airway (small airway fibrosis). These pathological changes cause air trapping and progressive airflow limitation. However, the exact mechanism of inflammatory response in COPD is still unknown. Oxidative stress and an excess of the proteinase enzyme produced during inflammation may cause a structural change in COPD. In parenchymal cells, the destruction of elastin is associated with a loss of tissue elasticity in the lung. This causes the small airway to collapse during exhalation, air trapping, and reduced lung capacity. In the bronchial airway, inflammation affects breathing through the thickening of the bronchial wall and increased sputum production, which cause a narrowing of the airway. A decrease in FEV_1 and FEV_1/FVC from spirometry are the characteristics of airflow limitation in COPD (3, 35).

The destruction of the alveolar wall and lung parenchyma from COPD lead to an impairment of the alveolar function and its elasticity, especially during expiration. Therefore, expiration airflow limitation, air trapping, and dynamic lung hyperinflation are the pathologies mostly found in COPD patients (3). According to lung hyperinflation, COPD patients have diaphragm inefficiency in terms of its ability to contract during inspiration due to its abnormal alignment (9). Lung hyperinflation changes the geometry of the thorax and shortens the diaphragm; therefore, the diaphragm is of a suboptimal length to contract and generate sufficient pressure during inspiration (12, 36). This mechanical disadvantage decreases its capability to generate sufficient force for inspiration, leading to an increase in work to breath in COPD patients (12, 13). Lung hyperinflation also affects the length of the intercostal muscles and their ability to contract and limits the thoracic cage rising up during inspiration (8, 9).

2.1.4 Symptoms

COPD is a chronic disease characterized by persistent respiratory symptoms. The most common respiratory symptoms include dyspnea and a chronic and productive cough (3), as detailed below:

Dyspnea is a major cause of disability and anxiety in COPD patients. Increased dyspnea is a main symptom of exacerbation in COPD patients.

Cough is the first symptom of COPD. In the early stage, a patient may show this symptom irregularly or frequently depending on the severity of the disease. Chronic cough occurring in the chronic stage of the disease may be productive or unproductive.

Sputum production: COPD patients have an increased production of sticky mucus due to increased airway inflammation.

Wheezing: COPD makes breathing difficult due to a progressive obstruction of the airflow such that adventitious sound can arise during breathing, especially during expiration through the narrowed airway.

Other symptoms: General fatigue, weight loss, anorexia, depression, anxiety, syncope, and ankle swelling are the other but less common symptoms that can occur in COPD.

2.1.5 Assessment of COPD

Spirometry is an important technique that is required to make a diagnosis of COPD (37). In addition, spirometry is able to identify the severity of the disease, its progression, and also the responsiveness of therapy. The major parameter that is responsible for a COPD diagnosis is FEV_1/FVC. The presence of a post-bronchodilator $FEV_1/FVC < 0.7$ confirms the presence of persistent airflow limitation, where FVC (forced vital capacity) is the volume of air forcibly exhaled from the point of maximal inspiration, and FEV_1 (forced expiratory volume in one second) is the volume of air exhaled during the first second of this maneuver.

The severity classification of airflow obstruction in COPD according to GOLD guidelines is shown in Table 2. An obstructive pattern of COPD from spirometry is shown in Figure 3, which presents a reduction in both FEV_1 and FVC.

Table 2 : Severity of airflow limitation in COPD by GOLD

In patients with COPD : FEV_1/FVC < 70 predicted (3, 35)			
GOLD	Definition	FEV_1/FVC	FEV_1
		Post bronchodilator	Post bronchodilator
I	Mild	< 70% predicted	≥ 80% predicted
II	Moderate	< 70% predicted	50% - 79% predicted
III	Severe	< 70% predicted	30%- 49% predicted
IV	Very severe	< 70% predicted	< 30% predicted

FVC, forced vital capacity; FEV_1, forced expiratory volume in one second.

Source: Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease 2017 (3)

Spirometry

Figure 2 and 3 show spirometry tracing of normal (3) and the patient with obstructive lung disease (3).

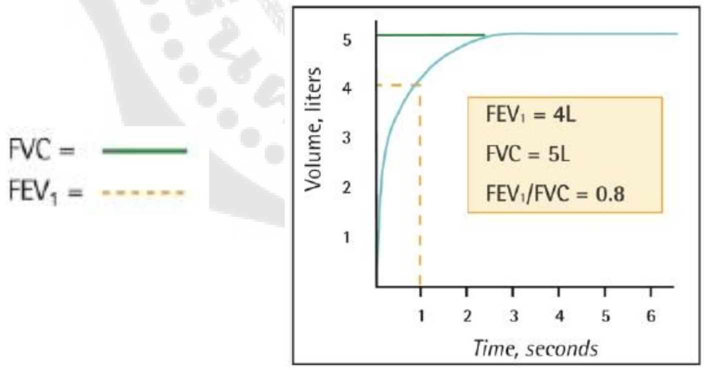


Figure 2 : Normal spirometry tracing

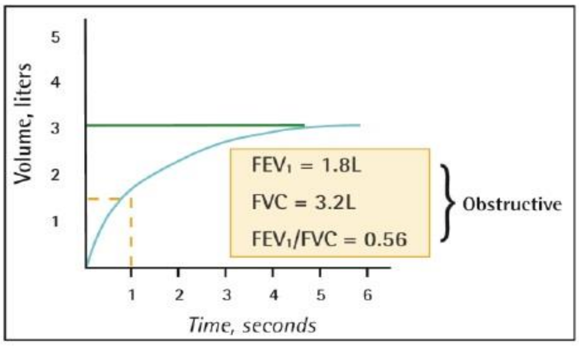


Figure 3 : Typical spirometry tracing of a patient with obstructive disease

2.1.6 Assessment of COPD symptoms

The modified British Medical Research Council (mMRC) Dyspnea Scale takes the form of a questionnaire that is required to be completed for the characterization of a patient's breathlessness, which is related to the patient's health status and mortality risk, as shown in Table 3. An mMRC score < 2 is identified as a small degree of breathlessness, while an mMRC score ≥ 2 is classed as a large degree of breathlessness.

Table 3 : Modified British Medical Research Council (mMRC) dyspnea scale—Thai version

mMRC	เกณฑ์การให้คะแนน ภาวะหายใจลำบาก กรุณาทำเครื่องหมาย ✓ เพียง 1 ข้อ	
เกรด 0	รู้สึกหายใจหอบ ขณะออกกำลังกายอย่างหนักเท่านั้น	☐
เกรด 1	หายใจหอบเมื่อเดินอย่างเร่งรีบบนพื้นราบ หรือเมื่อเดินขึ้นที่สูงชัน	☐
เกรด 2	เดินบนพื้นราบได้ช้ากว่าคนอื่นที่อยู่ในวัยเดียวกันเพราะหายใจหอบ หรือต้องหยุดเพื่อหายใจ เมื่อเดินตามปกติบนพื้นราบ	☐
เกรด 3	ต้องหยุดเพื่อหายใจ หลังจากเดินได้ประมาณ 100 เมตร หรือหลังเดินได้สักพัก บนพื้นราบ	☐
เกรด 4	หายใจหอบมากเกินกว่าที่จะออกจากบ้าน หรือหอบมากขณะแต่งตัว หรือเปลี่ยนเครื่องแต่งตัว	☐

Source: สมาคมอุรเวชช์แห่งประเทศไทย. แนวปฏิบัติบริการสาธารณสุข โรคปอดอุดกั้นเรื้อรัง พ.ศ.2556. กรุงเทพมหานคร: สำนักงานหลักประกันสุขภาพแห่งชาติ; 2556 (38)

Moreover, the COPD Assessment Test (CAT) is recommended to assess a comprehensive list of the symptoms (39, 40) in COPD (Table 4). The CAT assessment covers eight items, namely dyspnea, cough, sputum production and wheezing, systemic symptoms of fatigue, sleep disturbance, limitation in daily activities, social life, and emotional health and feeling control. CAT scores range from 0–40 (40), with a score less than 10 denoted as a low impact to health status, 10–20 as a moderate impact to health status, 21–30 as a high impact to health status, and more than 30 as a very high impact to health status (40). Moreover, the CAT is a fairly new questionnaire that has been developed for measuring a COPD patient's health status. The Thai CAT questionnaire has an acceptability reliability (Cronbach's alpha coefficient of 0.853) and validity (moderately correlated with the St. George's Respiratory Questionnaire (SGRQ) questions ($r = 0.652$, $p < 0.001$)) (41). It has the characteristic of being a short and simple tool for assessment of the health status of Thai COPD patients (41).

Table 4 : COPD assessment test (CAT)—Thai version

โปรดกาเครื่องหมาย (X) ลงในช่องด้านล่างที่อธิบายถึงอาการปัจจุบันของท่านได้ดีที่สุด กรุณาเลือกเพียงคำตอบเดียวสำหรับแต่ละคำถามเท่านั้น ตัวอย่าง: ข้าพเจ้ามีความสุขมาก 0 1(X) 2 3 4 5 ข้าพเจ้าเศร้าใจมาก				
ลำดับ	รายการที่ได้คะแนนน้อยที่สุด	CAT	รายการที่ได้คะแนนมากที่สุด	คะแนน
1	ข้าพเจ้าไม่เคยมีอาการไอ	0 1 2(X) 3 4 5	ข้าพเจ้าไอตลอดเวลา	2
2	ข้าพเจ้าไม่มีเสมหะในปอดเลย	0 1 2(X) 3 4 5	ปอดของข้าพเจ้าเต็มไปด้วยเสมหะ	2
3	ข้าพเจ้าไม่รู้สึกแน่นหน้าอกเลย	0 1 2 3(X) 4 5	ข้าพเจ้าไม่รู้สึกแน่นหน้าอกมาก	3
4	ข้าพเจ้าเดินขึ้นเนินหรือขึ้นบันไดหนึ่งชั้น ข้าพเจ้ายังคงหายใจได้คล่อง	0 1(X) 2 3 4 5	เมื่อข้าพเจ้าเดินขึ้นเนินหรือขึ้นบันไดหนึ่งชั้น ข้าพเจ้ารู้สึกเหนื่อยหอบอย่างมาก	1
5	ข้าพเจ้าทำกิจกรรมต่างๆที่บ้านได้โดยไม่จำกัด	0 1(X) 2 3 4 5	ข้าพเจ้าทำกิจกรรมต่างๆที่บ้านได้อย่างจำกัดมาก	1
6	ข้าพเจ้ามีความมั่นใจที่จะออกไปนอกบ้านทั้งๆที่ปอดข้าพเจ้ามีปัญหา	0 1 2(X) 3 4 5	ข้าพเจ้าไม่มีความมั่นใจเลยที่จะออกไปนอกบ้านเพราะปอดข้าพเจ้ามีปัญหา	2
7	ข้าพเจ้านอนหลับสนิท	0 1 2(X) 3 4 5	ข้าพเจ้านอนหลับไม่สนิทเพราะปอดของข้าพเจ้ามีปัญหา	2
8	ข้าพเจ้ารู้สึกกระฉับกระเฉงอย่างมาก	0 1 2(X) 3 4 5	ข้าพเจ้ารู้สึกอ่อนเพลียและเหนื่อยล้า	2
			Total score	…15….

Source: Pothirat C, Kiatboonsri S, Chuchottaworn C. Validation of the New COPD Assessment Test Translated into Thai in Patients with Chronic Obstructive Pulmonary Disease. BMC Pulmonary Medicine. 2014;14:193. (41)

2.1.7 Goals for the treatment of stable COPD

Goals for the treatment of COPD are suggested by GOLD and consist of a reduction in symptoms (relieve symptoms, improve exercise tolerance, and improve health status) and the risk of symptoms worsening (prevent disease progression, prevent and treat exacerbations, and reduce mortality). Therefore, COPD treatment needs co-operation between the physician and patient in order to promote a good quality of life (35).

2.2 Rounded shoulder posture

2.2.1 Ideal alignment

The ideal alignment is to the normal curves of the spine, including a slight extension of the neck, slight flexion of the upper back, and slight extension of the low back. When measured by the plumb line the reference line would go through the head when it is not tilted forward or back, through the center of the external auditory meatus and the upper cervical vertebral bodies, through the center of thorax and the lumbar vertebral bodies, through behind the axis of the hip joint and through in front of the axis of knee joint, and finally through in front of the lateral malleolus (Figure 4) (19).

Figure 4 : Ideal alignment

Source: Kendall FP ME, Provance PG. Muscles: Testing and Function. 4, editor (19)

2.2.2 Definition of rounded shoulder posture

Rounded shoulder posture (9) is the condition where the acromion process of the scapular is located anterior to the plumb line. In 1993, Kendall and coworkers defined the position of the forward shoulder posture as related to scapula elevation causing abduction in the horizontal plane (19). Moreover, the characteristic of rounded shoulder is also related to different planes of the scapular, including anterior tipping in the medial-lateral axis, internal rotation in the vertical axis, and downward rotation in the perpendicular plane (Figure 5) (20, 21), which typically lead to upper quadrant muscles imbalance, musculoskeletal injury, and poor posture balance (24).

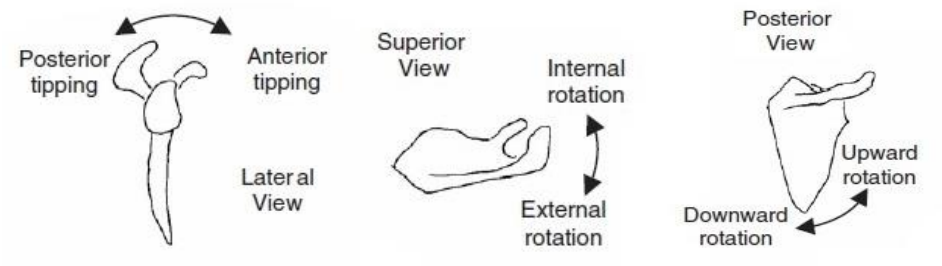


Figure 5 : Different planes of the scapular in the rounded shoulder posture

Source: Ludewig PM, Cook TM. Alterations in Shoulder Kinematics and Associated Muscle Activity in People with Symptoms of Shoulder Impingement. Physical therapy. 2000;80(1):276-91 (21)

2.2.3 Upper crossed syndrome

Upper crossed syndrome (UCS), or shoulder girdle crossed syndrome, is described as asymmetrical alignment of the shoulders in the sagittal plane. UCS is characterized by a tightness of the upper trapezius and levator scapulae on the dorsal side crosses with tightness of the pectoralis major and minor, and weakness of the deep cervical flexors crossed with weakness of the middle and lower trapezius. Specific UCS postural changes include a forward head posture, increased cervical lordosis and thoracic kyphosis, elevated and protracted shoulders, and internal rotation or abduction and winging of the scapula (Figures 6–7). These postural changes decrease glenohumeral stability as the glenoid fossa becomes more vertical due to serratus anterior weakness, leading to abduction, internal rotation, and winging of the scapula. These incur compensatory increased activation of the levator scapulae and upper trapezius to maintain glenohumeral centralization (28, 31).

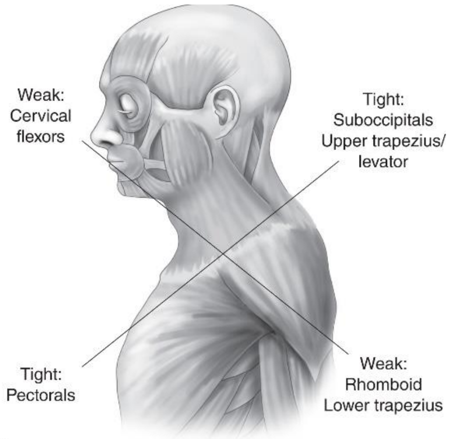


Figure 6 : Muscle imbalance in upper crossed syndrome

Source: Morais N, Cruz J, Marques A. Posture and Mobility of the Upper body Quadrant and Pulmonary Function in COPD: AN Exploratory Study. Brazilian Journal of Physical Therapy. 2016;20(4):345-54. (28)

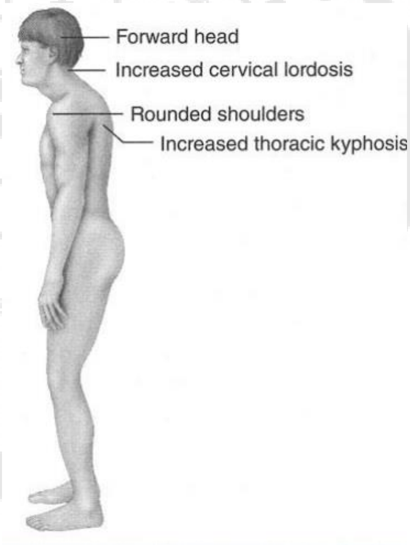


Figure 7 : Characteristic of upper cross syndrome

Source: Morais N, Cruz J, Marques A. Posture and Mobility of the Upper body Quadrant and Pulmonary Function in COPD: AN Exploratory Study. Brazilian Journal of Physical Therapy. 2016;20(4):345-54. (28)

It is common in UCS to see forward head and forward shoulder posture (rounded shoulders) as the most common postural faults. In Figure 8, the crossed lines are drawn marked as the K. line, which is a hypertonic line or line of muscles tightness (shortened), and the L. line, which is a hypotonic line or line of muscles weakness (lengthened). This is characteristic of upper crossed syndrome or muscle imbalance in the upper body part caused by gravity and daily activity (42).

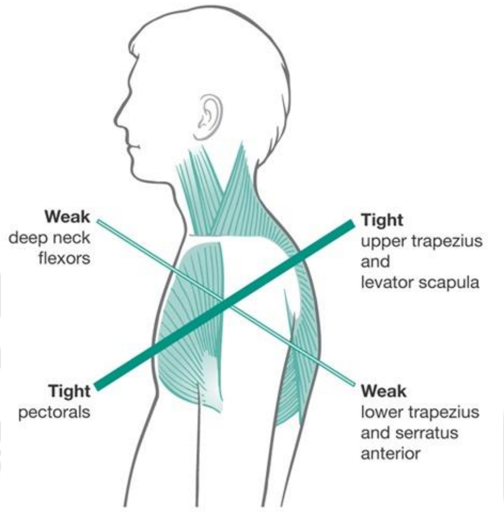


Figure 8 : Upper cross syndrome (muscle imbalance)

Source : Morris CE, Bonnefin D, Darville C. The Torsional Upper Crossed Syndrome: A Multi-Planar update to Janda's Model, with a Case Series Introduction of the Mid-Pectoral Fascial Lesion as an Associated Etiological Factor. Journal of Bodywork and Movement Therapies. 2015;19(4):681-9 (42)

2.3 Effect of rounded shoulder posture on the respiration system

Lung hyperinflation in COPD can lead to developing an abnormal configuration of the chest wall called a barrel chest. The thoracic dimensions are determined by using anteroposterior (AP) and lateral chest radiographs performed at total lung capacity, functional residual capacity, and residual volume (43). With barrel chest, the sternum appears prominent, and the AP diameter of the thorax is greater than normal (43), leading to an increase in the AP dimension. Barrel chest in COPD causes structural changes of the thorax, including thoracic kyphosis (9, 11), rounded shoulder, and an elevated sternum and rib cage (8, 10, 43).

In 2009, Urbanowicz and coworkers reported that elevated scapulae were presented in male COPD patients with lung hyperinflation (29). Moreover, scapular elevation, abduction, and protraction have been found especially in higher stages of COPD (29). A previous study reported that the respiratory variables, including vital capacity, forced vital capacity, and expiratory residual volume were decreased with increasing RSP and they also showed a high correlation (r = 0.808 in VC, r = 0.723 in FVC, r = 0.814 in ERV) between the degree of RSP and the respiratory variables (27). Furthermore, impaired pulmonary function in COPD has been found to be associated with a decreased pectoralis minor muscle length (28) in RSP.

RSP is an abnormal posture caused by an imbalance of the upper quadrant muscles (22, 23). Shortness or tightness of the anterior shoulder girdle muscle, especially the pectoral muscles, and weakness of the scapular muscles, especially the lower trapezius and serratus anterior (23, 24), can subsequently lead to an abnormal alignment of the shoulder. Pectoral muscles, including the pectoralis major and minor, in a shortened position resist the chest wall from expanding, especially, the pectoralis minor, which is an accessory muscle during inspiration. This is an important muscle that causes a forward shoulder posture when it's tight. Limitations from the structural changes in rounded shoulder lead to an increase in work for breathing (25) and a decrease in exercise capacity (26) and the quality of life of COPD patients. A study by Putt and coworkers in 2008 showed that a stretching technique performed by PNF had an immediate effect on the pectoralis major, especially in the clavicular part, and could increase shoulder ROM and vital capacity in COPD patients (25). Gaude and coworkers in 2014 reported that postural correction at 4 weeks and 12 weeks could be achieved by the use of a shoulder brace together with improved dyspnea and increased pulmonary function in patients with COPD (33). The lower trapezius and serratus anterior are the scapular stabilizer muscles and also help to elevate the rib cage during inspiration. Many studies have demonstrated that weakness of these two scapular stabilizer muscles, especially the lower trapezius and serratus anterior muscles, is an important cause of rounded shoulder posture. Therefore, a poor posture from rounded shoulder in

COPD not only leads to musculoskeletal problems but can also cause deteriorative effects on the pulmonary system.

2.4 Rounded shoulder and exercise

Muscle imbalance plays a significant role in rounded shoulder posture. Shortened or tightness of the anterior shoulder girdle muscles, especially the pectoral muscles, and weakness of the scapular muscles, especially the lower trapezius and serratus anterior, change the position of the scapular to anterior tilting, protraction, and downward rotation (20-22). These abnormalities can possibly result in musculoskeletal problems, such as shoulder pain and shoulder impingement (21, 44).

The major muscles that play a role in upward rotation and scapular posterior tilt are the lower trapezius (LT) and serratus anterior (SA) (45, 46) muscles. The LT maintains scapular upward rotation, while the SA is a stabilizer of the scapular during arm elevation (shoulder abduction) at 90º (45, 46). Sahrmann and coworkers suggested that an exercise program involving stretching the tightened muscle and strengthening the weakened muscles would be appropriate for correcting muscle imbalance (31). Putt and coworkers (25) reported as increment in vital capacity and shoulder ROM in COPD patients after applying a pectoralis muscle stretching technique to reduce RSP. Therefore, to reduce rounded shoulder, specific exercise programs can play a key role, with some reviewed exercise programs shown in Table 5 and electromyography (EMG) for measure maximum voluntary isometric contraction (MVIC) activity of scapular muscle including serratus anterior (SA), middle and lower trapezius (LT) muscle as shown in Table 6.

Table 5 : Reviewed exercise programs for reducing rounded shoulder

Study, year	Subjects	Scapular measurement	Strengthening program	Stretching program	Strengthening or flexibility measurements (pre-post intervention)	Study duration	Effectiveness of intervention (P < 0.05)
Wang et al., 1999[47]	20 asymptomatic FSP (9 M, 11 F) Age > 18 years old No control group	Computerized eletromechanical system digitalized palpable landmarks on spine and scapula	Home-based elastic resistance exercise (scapular retraction and elevation, shoulder abduction and external rotation); 3 x wk, 1 x 10 reps for first 2 wks, then 5 reps added every 2 wks	Pectoralis corner stretch; 3 x wk, 10 x 10 s, then 5 reps added every 2 wks	None	6 wks	No change in scapular in rest position
Roddey et al., 2002[48]	38 FHRSP (13 M, 25 F) Mean age 28 years old 3 groups; 1. 13 mild FHRSP 2. 10 moderate FHRSP 3. Control; 15 mild FHRSP	Sum of scapula distance for Lt. and Rt. sides; Palpate and mark surface landmarks, measured distances from third thoracic spinous process to inferior angle of acromion and medial border at the root of the scapular spine	None	Pectoralis wall stretch; once daily 3 x 30 s each side	None	2 wks	Change in resting scapular position in moderate FHRSP group (change score TSD 1.7 ± 1.2 cm)

Table 5 : Reviewed exercise programs for reducing rounded shoulder (Continued)

Study, year	Subjects	Scapular measurement	Strengthening program	Stretching program	Strengthening or flexibility measurements (pre-post intervention)	Study duration	Effectiveness of intervention (P < 0.05)
Kluemper et al., 2006[45]	Swimmer with FSP (High school and college; (14 M, 25 F) 1. Intervention gr.=25 2. Control gr. = 15 Mean age 16 years old		Supervised exercise; elastic resistance exercise (scapular retraction, shoulder external rotation, and flexion) ; 3 x wk, 3 x 10 reps first week, increased by 5 reps next 2 wks, then increased band resistance and repeated	Pectoralis minor and pectoralis major stretching (Passive-assisted stertch); 3 x wk, 2 x 30 s	None	6 wks	Intervention gr. Significantly reduced FSP more than in the control group
Lee et al., 2015[50]	1. SPT alone 2. SPT after stretch PM 3. SPT with shoulder brace	1. FSP 2. Scapular upward rotatio angle 3. PMI	SPT exercise 3 s	Pectoralis passive stretch; 4 x 30 s, rest between set 30 s	Strength; EMG of LT and SA Flexibility; None	1 time	Degree of FSP decreased and PMI increased SPT after stretch PM and SPT with shoulder brace compared to SPT alone

Table 5 : Reviewed exercise programs for reducing rounded shoulder (Continued)

Study, year	Subjects	Scapular measurement	Strengthening program	Stretching program	Strengthening or flexibility measurements (pre-post intervention)	Study duration	Effectiveness of intervention ($P < 0.05$)
Rosa et al., 2017[51]	1. Healthy group (14 M, 25 F; Age mean 25 years old) 2. Shoulder pain (14 M, 25 F; Age 26 years old)	PMI and 3D scapular kinematic	None	Pectoralis wall stretch; once daily 1 x 60 s, 4 reps each side	None	6 wks	No change in pectoralis minor length or scapular kinematics

M, male; F, famale; FSP, forward shoulder posture; FHRSP, forward head /rounded shoulder posture; TSD, total scapular distance; PMI, pectoralis minor index; SPT, scapular posterior tilt; EMG, electromyography; LT, lower trapezius; SA, serratus anterior.

Table 6 : EMG activity studies for each performed exercise

Author, year	Exercise	MVIC%			Exercise	
		SA	MT	LT	Starting position	Action
Decker et al., 1999[52]	Push-up plus	104.0%	None	None	Prone with the hand shoulder-width apart and the chest near the floor. Performed with the scapular retracted and elbow flexed.	Subject then extended his elbows to a standard push-up position and continued to rise up by scapular protracted. And then returned to the starting position.
Ekstrom et al., 2003[32]	Diagonal exercise with shoulder flexion, horizontal flexion, and ER (D1 flexion)	100.0%	21.0%	39.0%	Sitting position, diagonal exercise with a combination of shoulder flexion, horizontal flexion, and external rotation (D1 flexion), with a hand-held dumbbell.	Subject held dumbbell following direction of the exercise.
Ekstrom et al., 2003[32]	Shoulder abduction in scapular plane above 120°	96%	49.0%	61.0%	Standing position, shoulder abduction in the plane of scapular above 120°	Subject held dumbbell following direction of the exercise.
Decker et al., 1999[52]	Knee push-up plus	72.0%	None	None	Modified from the push-up plus; was performed exactly like the push-up plus, except that the body weight was supported by the hands and knees, rather than the hands and feet.	Subject then extended his elbows to a standard push-up position and continued to rise up by scapular protracted. And then returned to the starting position.

Table 6 : EMG activity studies for each performed exercise (Continued)

Author, year	Exercise	MVIC%			Exercise	
		SA	MT	LT	Starting position	Action
Meyer et al., 2005[55]	ER at 90° of abduction	66.2%	88.4%	None	Standing position, Shoulder abduction and elbow flexion 90° and full internal rotation of shoulder [Low fixation position]	Subject moved external rotation of shoulder and then returned to the starting position
Ekstrom et al., 2003[32]	Arm raise overhead in line with the LT muscle fibers	43.0%	101.0%	97.0%	Prone position, arm raised above the head with the upper extremity in line with the lower trapezius muscle fibers	Subject raised arm above the head, held dumbbell.
Cools et al., 2007[54]	Prone shoulder abduction	25.0%	78.4%	76.71%	Prone position with shoulder in neutral position	Subject performs shoulder abduction to 90° with external rotation in a horizontal plane.
Cools et al., 2007[57]	Horizontal abduction	17.3%	63.8%	50.3%	Prone position with shoulder resting in 90° forward flexion	Subject horizontal abduction to horizontal position.
Cools et al., 2007[54]	Horizontal abduction with ER	15.5%	78.2%	79.2%	Prone position with shoulder resting in 90° forward flexion	Subject performs horizontal abduction to horizontal position, together with an addition external rotation of the shoulder at the end of the movement
Ekstrom et al., 2003[32]	Shoulder horizontal extension with ER	9%	87.0%	74.0%	Prone position, shoulder horizontal extension with external rotation	Subject raise arm above the head, hold dumbbell.

EMG, electromyography; ER, external rotation; IR, internal rotation; SA, serratus anterior, ML, middle trapezius; LT, lower trapezius.

CHAPTER 3
METHODOLOGY

3.1 Research design

The present research represents a randomized experimental study by simple random sampling (single blind) in an envelopment conceal. In total, there were 40 participants, who were randomly split in to two groups: a control group of 20 persons and exercise group of 20 persons.

3.2 Participants

The participants was recruited from Nakhon Nayok Hospital and Banna Hospital in Nakhon Nayok province, Thailand. The inclusion criteria were as follows;

1) Male, age ≥ 60 years old;

2) Stable mild to moderate COPD according to GOLD Guildlines, 2017 (3) with the participants diagnosed by a physician;

3) Rounded shoulder posture (22, 30, 31);

4) Patients must receive the same conventional physical therapy treatment;

5) Stable hemodynamics.

Participants were excluded from this study according to the following criteria:

1) BMI > 30 kg/m2 (55-57);

2) Receiving long-term oxygen therapy or on a mechanical ventilator within 4 weeks before starting the experiment (33);

3) Acute exacerbation within 3 months before staring the experiment (58);

4) Medical diagnosis of heart failure, unstable angina, recent myocardial infraction, or aortic aneurysm (59);

5) Uncontrolled hypertension;

6) Scoliosis (33, 60);

7) Unable to follow the commands;

8) Chronic neck and/or shoulder pain over 6 months or VAS > 4 (61);

9) Fracture at the clavicle, scapula, humerus, sternum or spine within previous 2 months (51);

10) Severe musculoskeletal problems that mean they cannot participate in the exercise program i.e., shoulder tendinitis, osteoarthritis, bursitis, herniated nucleus pulposus (protrusion);

11) Severe neurological problems, i.e., head injury, spinal injury, peripheral nerve disorder;

12) Thoracic outlet syndrome or a recent complaint of numbness or tingling in the upper extremity.

Participants were discontinued from this study according to the following criteria:

1) Decline to participate this study;

2) Participate in the training program for less than 80% volume (20 sessions from 24 sessions) (47, 49);

3) Admitted to hospital during the experiment period.

This study was approved by the ethics committee of the Faculty of Physical Therapy, Srinakharinwirot University (Ethics number PTPT2018-002), research ethics committee of Nakhon Nayok Hospital (REC 10/2560), research ethics committee from Nakhon Nayok Public health Office (NPHO 2018-004). All the participants were given information about the objectives, processes, and protocol of the study before signing informed consent.

3.3 Sources of data collection (Research setting)

This research was performed at Nakhon Nayok Hospital and Banna Hospital in Nakhon Nayok province, Thailand.

3.4 Sample size

The sample size was calculated from Gaude G et al. 2014 (33) by using the G-Power program (software version 3.1.9.2). ANOVA with repeated measures and the interaction within/between factors was used for the analysis with a statistical power of 0.8, an α error probability of 0.05, and effect size of 0.38. The sample size from the calculation was 16 participants per group. Then, a 20% drop out contingent was added equaling 4 persons per group. Overall, the two groups comprised 20 participants per group.

3.5 Variables

The independent variable was the exercise program for reducing rounded shoulder.

The dependent variables of this study included:

1) Rounded shoulder posture

2) Pectoralis minor index (PMI)

3) Postural Thoracic kyphosis

4) Muscle strength of lower trapezius and serratus anterior muscle

5) Respiratory muscle strength: maximal inspiratory pressure (PImax) and maximal expiratory pressure (PEmax)

6) Chest expansion (CE)

7) Pulmonary function test (PFT)

8) Quality of life by COPD assessment test (CAT)

9) Modified Medical Research Council (mMRC) dyspnea scale.

Control variable: Physical therapy (conventional) treatment.

3.6 Outcome measures

The primary outcomes of this study included:

1. Rounded shoulder posture
2. Maximal inspiratory and maximal expiratory pressure (PImax and PEmax)
3. Chest expansion (CE)
4. Pulmonary function test (PFT)

The secondary outcomes of this study included:

1. Pectoralis minor index (PMI)
2. Postural thoracic kyphosis
3. Muscle strength of lower trapezius and serratus anterior
4. Breathlessness; mMRC dyspnea scale
5. Quality of life (QoL); CAT

3.7 Material and research tools

3.7.1 Rounded shoulder posture was assessed by using a Vernier height gauge (Qingdao Wepro Tool Co., Ltd), as shown in Figure 9.

3.7.2 The pectoralis minor index was calculated from the pectoralis minor length, which was measured by a Vernier caliper (Mitutoyo, Japan), as shown in Figure 10.

3.7.3 Thoracic kyphosis curve was assessed by a flexible ruler (60 cm length), as shown in Figure 11.

3.7.4 Muscle strength was assessed by using a handheld dynamometer (Baseline electronic push/pull dynamometer, Model 12-0342, Ufam Decoration Co., LTD), as shown in Figure 12.

3.7.5 Respiratory muscle strength was assessed by using a respiratory pressure meter (RPM; Micro RMA of Micro Medical Ltd., England), as shown in Figure 13.

3.7.6 Chest expansion was measured by tape measurement, as shown in Figure 14.

3.7.7 The pulmonary function test was performed using a spirometer (KoKo® Feraris Respiration, Inc., USA), as shown in Figure 15.

3.7.8 Breathlessness score was assessed using a rating from the modified British Medical Research Council (mMRC) dyspnea scale.

3.7.9 Quality of life was assessed using the COPD assessment test (CAT).

Figure 9 : Vernier high gauge caliper

(Qingdao Wepro Tool Co., Ltd)

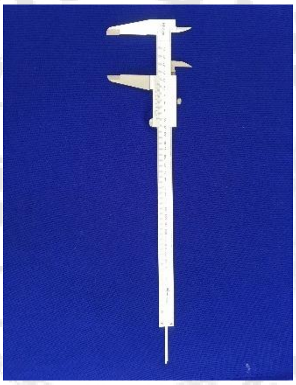


Figure 10 : Vernier caliper

(Mitutoyo, Japan)

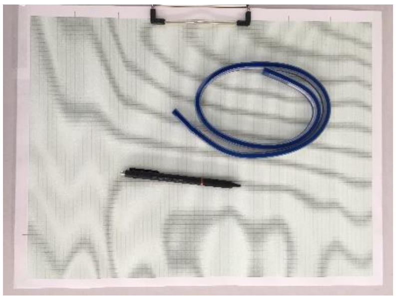


Figure 11 : Flexible ruler, pencil, and millimeter paper

Figure 12 : Handheld dynamometer

(Baseline electronic push/pull dynamometer, Model 12-0342, Ufam Decoration Co., LTD)

Figure 13 : Respiratory pressure meter

(Micro RMA of Micro Medical Ltd., England)

Figure 14 : Measuring tape

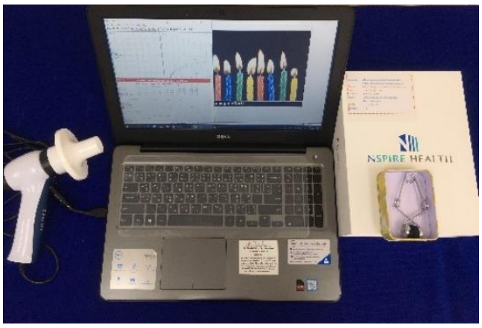


Figure 15 : Spirometer

(KoKo® Feraris Respiration, Inc., USA)

3.8 Procedures

Mild to very severe COPD patients from Nakhon Nayok Hospital and Banna Hospital in Nakhon Nayok province, Thailand, were recruited in accordance with the inclusion criteria. The study details were explained to the participants, including a brief rationale, the project objectives, and the experimental procedures, and all participants were asked to sign a consent form agreeing their participation in this study. The participants were randomized into two groups: a control group and an intervention (exercise) group, with participants' vital signs routinely monitored throughout the experiment. For the control group, the participants received only conventional physical therapy treatment; whereas the intervention group were given an added exercise program to perform for reducing rounded shoulder together with conventional physical therapy treatment for 8 weeks, as shown in Figures 12–15. Rounded shoulder posture, pectoralis minor index (PMI, postural thoracic kyphosis, muscle strengthening test results (serratus anterior and lower trapezius), chest expansion (CE), respiratory muscle strength (PImax and PEmax), and pulmonary function test results were assessed at pre-training, 4 weeks post-training, and 8 weeks post-training. Breathlessness and quality of life in each patient were evaluated as well. After 4 weeks of training and 8 weeks of training, all the data were summarized and analyzed using a statistical analysis program.

3.9 Intervention

All the participants received the same physiotherapy treatment (conventional treatment) as a home program, including education about pursed-lip breathing, relaxation techniques, coughing and huffing techniques.

All medication prescribed to each participant throughout the study by their doctor was recorded as some medicines can have an effect on the study results.

For the control group, the participants received only conventional treatment without carrying out an exercise training program for reducing rounded shoulder throughout the eight weeks of the experiment.

For the intervention group, before exercise, the participants' vital signs were measured and then during exercise the participants' pulse rate (PR), and oxygen saturation (SpO_2) were monitored every 5 minutes. The participants followed an exercise training program for reducing rounded shoulders, which was modified from the study by Lee et al., 2015 (50, 62). The exercise program comprised pectoral muscles self-stretching at 90° and 120° of shoulder abduction with external rotation, and serratus anterior and lower trapezius strengthening exercises.

3.9.1 Pectoral muscles self-stretching exercise

1. Stretching the pectoralis major muscle (clavicular part) and pectoralis minor muscle (51, 63, 64):

1.1 The participants were positioned in a standing position behind a white line, with 90° shoulder abduction and 90° elbow flexion at the corner, as shown in Figure 16 (A);

1.2 The participants actively stretched their pectoral muscle by moving their trunk in rotation to the opposite side, as shown in Figure 16 (B);

1.3 Participants sustained each stretch for 60 seconds at the end range of motion without pain, all while fully breathing in and out with pursed lips. Then, they returned to the starting position.

1.4 The stretching exercise was performed for 5 times/set, 1 set/day, 3 days/week, for 8 weeks. (47, 49)

A.

B.

Figure 16 : Pectoralis major (clavicular part) and pectoralis minor stretching exercise: (A) starting position, (B) stretch at the end range of motion

2. Stretching the pectoralis major muscle (sternal costal part) (49):

2.1 The participants were positioned in a standing position behind a yellow line, with 120° shoulder abduction and elbow flexion at the corner, as shown in Figure 17 (A);

2.2 The participants actively stretched their pectoral muscle by moving their trunk in rotation to the opposite side, as shown in Figure 17 (B);

2.3 Participants sustained each stretch for 60 seconds at the end range of motion without pain, all while fully breathing in and out with pursed lips. Then, they returned to the staring position.

2.4 The stretching exercise was performed for 10 times/set, 1 set/day, 3 days/week, for 8 weeks (47, 49).

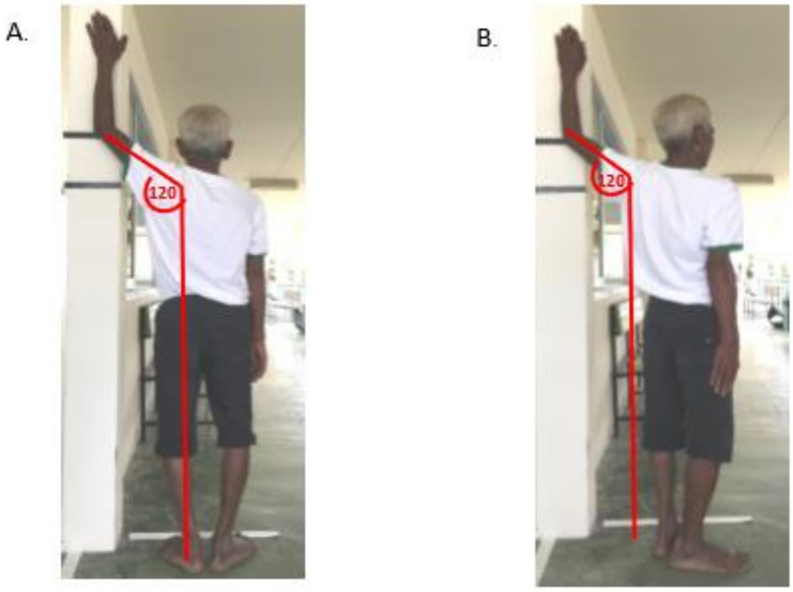


Figure 17 : Pectoralis major; sternal costal part:

(A) starting position, (B) stretch at the end range of motion

3.9.2 Serratus anterior and lower trapezius strengthening exercise

1. Push-ups with an extra element to strengthen scapular protraction and serratus anterior muscle (modified from Kisner and Colby, 2013) (65):

1.1 The participants were positioned leaning against a table for standing push-ups (distance between patient and table 60–100 cm) with the trunk leaning forward, hands against the table, and elbows extended, as shown in Figure 18;

1.2 The patients pushed their trunk away from the table with scapular protraction, while breathing out with pursed lips;

1.3 Then, they returned to the starting position while breathing in;

1.4 Progression of the exercise was to add a strengthening exercise performed following the program in Table 7 , with 3 sets/day with 2 min rest between each set (66, 67), 3 days/week, for 8 weeks (49, 65). The strengthening protocol is shown in Table 7.

Figure 18 : Serratus anterior exercise push-up on table;

modified from Kisner and Colby, 2013

2. Scapular posterior tilting exercise (SPT) to strengthen the lower trapezius muscle (modified from Lee et al., 2015) (50, 62):

2.1 The participants were positioned in a prone position sitting on a chair with extended elbow, pronate forearm with extended wrists, hands, fingers, and shoulder abduction of approximately 145º. Then the participants were instructed to lift their arms up to the level of their earlobe line, as shown in Figure 19 (A, B);

2.2 Participants were trained to follow the program in Table 7, with 3 sets/day with 2 min rest between each set (66, 67), 3 days/week for 8 weeks (49, 65). The strengthening protocol is shown in Table 7.

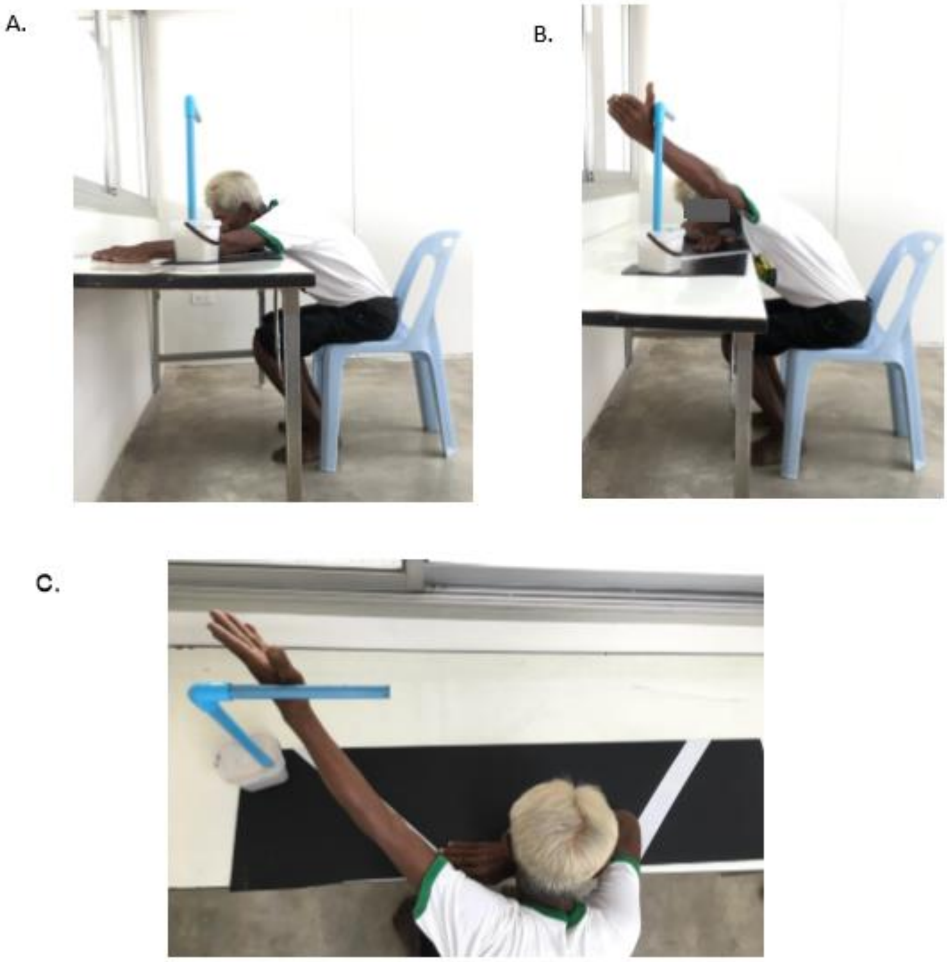


Figure 19 : Scapular posterior tilt exercise:

(A) starting position (B) SPT in long arm; modified from Lee et al, 2015 (C) overview

Table 7 : Protocol for strengthening exercise modified from ACSM 2014

<table>
<tr><th colspan="3">Group</th></tr>
<tr><td rowspan="4">Control
(Conventional chest physical therapy)</td><td colspan="2">Exercise
(Exercise program for reduce rounded shoulder posture plus conventional chest physical therapy)
Training program 3 days/week, 8 weeks</td></tr>
<tr><td>1. Stretching pectoral muscle exercise</td><td>2. Strengthening scapular muscle exercise</td></tr>
<tr><td>- Pectoralis minor muscle
- Pectoralis major muscle</td><td>- Serratus anterior muscle
- Lower trapezius muscle</td></tr>
<tr><td><u>Protocol for stretching exercise</u>
moderate stretching
Hold stretch 60 sec./time
5 times/set, 1 set/day
3 days/weeks, 8 weeks</td><td><u>Protocol for strengthening exercise</u> modified from ACSM 2014
<table><tr><th>Weeks</th><th>Times</th><th>Sets</th></tr><tr><td>1-2</td><td>8-20</td><td>1</td></tr><tr><td>3-4</td><td>10-22</td><td>2</td></tr><tr><td>5-6</td><td>12-24</td><td>3</td></tr><tr><td>7-8</td><td>14-26</td><td>4</td></tr></table></td></tr>
<tr><td colspan="3">Conventional chest physical therapy education about
- pursed-lip breathing
- relaxation technique
- coughing and huffing technique</td></tr>
</table>

3.10 Outcome measurements

3.10.1 Rounded shoulder posture

Rounded shoulder posture was assessed in the sitting position with their back against a wall. The participants were palpated and set a marker at a posterior angle of the acromion process of the scapular. The distance between the posterior angle of the acromion process to the wall was measured during end expiration in centimeters using a Vernier height gauge, as shown in Figure 20. Rounded shoulder posture is defined as a distance between the posterior angle of the acromion process to the back wall of more than 2.54 cm (1 inch) (22, 30, 31, 44). The measurement was repeated about 3 times and the average value was recorded in centimeters.

Figure 20 : Marking position for measuring the rounded shoulder posture

3.10.2 Pectoralis minor index (PMI)

Pectoralis minor index (PMI) was calculated from the equation of Borstad et al., 2005 (21), as follows:

PMI = (Pectoralis minor length (cm)/subject height (cm)) x 100

PMI < 7.44 cm indicates pectoralis minor shortening (21).

The pectoralis minor muscle length was measured in a sitting position with an intraclass correlation coefficient of ICC 0.86–0.95 (51). The marking position was set at the inferior angle of the coracoid process and sternochondral joint of the 4th rib (21, 68), as shown in Figure 21. The distance between these landmarks were measured during expiration in centimeters using a Vernier caliper as ICC 0.76–0.93 (69). The measurement was repeated about 3 times and the average value was recorded in centimeters.

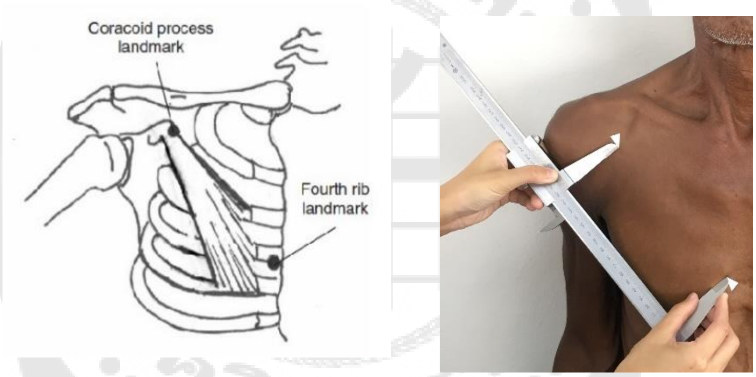


Figure 21 : Marking position for measuring the pectoralis minor length

Source: Borstad JD, Ludewig PM. The Effect of Long versus Short Pectoralis Minor Resting Length on Scapular Kinematics in Healthy Individuals. Journal of Orthopaedic and Sports Physical Therapy . 2005;35(4):227-38. (21)

3.10.3 Postural thoracic kyphosis

Postural thoracic kyphosis or thoracic spinal kyphosis was measured in each subject using a flexicurve ruler, which is a rubber and flexible ruler that can follow the spinal curve and has a length of approximately 60 centimeters. First, the subjects were asked to uncover their spine and to adopt a comfortable and natural standing position (natural posture). The patients were asked for consent to the use of ink for skin marking on the C7 and T12 positions (70, 71). The flexible (flexicurve) ruler was pressed against their back along the spinous process in the midline from C7 to S1 (Figure 22A). Then, using the flexible ruler attached to millimeter-marked paper, the ruler plate was laid flat on the millimeter-marked paper and the curve formed was traced out on the paper (70, 71). The flexicurve kyphosis index or kyphosis index (KI%) was calculated taking the apex of the kyphosis height (E) and dividing it by the length of the entire thoracic curve (L), then multiplied by 100; i.e., E/L x 100 (72) (Figure 22B). The flexicurve kyphosis angle (θ; Theta) was calculated by using the line drawn perpendicular to the triangle mark by the thoracic curve. For the thoracic kyphosis angle, that triangle was formed by points A (Apex), B (at the cranial end of the curve; C7), and C (at the caudal end; T12); while for the lumbar lordosis angle that triangle was formed by points A (Apex), B (at the cranial end of the curve; L1), and C (at the caudal end; S1). The formula for the calculation was: theta (θ) = 4 arc tan (E/L_1) + arc tan (E/L_2) (72). The measurement was repeated about 3 times and the average value was recorded in degrees.

Figure 22 : Postural thoracic kyphosis measurement

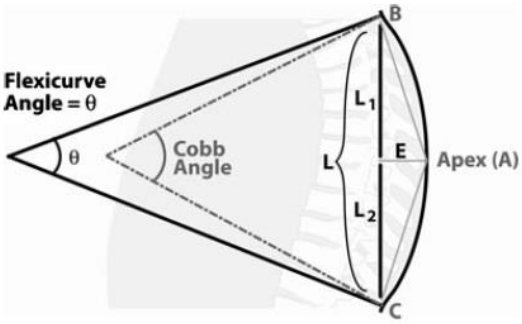


Figure 22B : Method for calculating the flexicurve kyphosis index and flexicurve kyphosis angle

Source: Greendale GA, Nili NS, Huang MH, Seeger L, Karlamangla AS. The Reliability and Validity of Three Non-Radiological Measures of Thoracic Kyphosis and their Relations to the Standing Radiological Cobb angle. Osteoporosis international. 2011;22(6):1897-905. (72)

3.10.4 Muscle strength test

3.10.4.1 Serratus anterior muscle strength test

The serratus anterior (SA) muscle test was performed as described by Kendall et al., (19) with the resistance force from the hand held dynamometer (HHD) being applied to the elbow when flexed at 90º and the shoulder flexed at 90º measured by a goniometer in the supine position, as shown in Figure 23. The force was applied on the ulna near the olecranon process about 2 cm along the long axis of the humerus. The assessor monitored the triceps muscle visually and under palpation while forcing production during the SA muscle test (73). The scapular motion of the patient was scapular protraction. The resistance force was the maximum isometric contraction then holding the contraction for about 5 seconds for one test, followed by 2 minutes rest or until there is no sign of fatigue. The measurement was repeated about 3 times and the maximal value was recorded in kilograms and then was normalized by kilograms body weight and then multiply by 9.8 for newtons (N). (74)

Figure 23 : Serratus anterior muscle strength test

A.Positioning for measured muscle strength of SA B. Measured muscle strength by HHD

3.10.4.2 Lower trapezius muscle strength test

The lower trapezius (LT) muscle test was performed as described by Michener et al., 2005 (73), with the resistance force from the HHD applied to the spine of the scapular midway between the acromion process and the root of the spine in a prone lying position with shoulder abduction of 145º measured by a goniometer. The force on the scapular was applied with shoulder abduction of 145º, as shown in Figure 24. The scapular motion of the patient was scapular adduction and depression. The resistance force was the maximum isometric contraction and then holding the contraction for about 5 seconds for one test, followed by 2 minutes rest or until there was no sign of fatigue. The measurement was repeated about 3 times and the maximal value was recorded in kilograms and then was normalized by kilograms body weight and then multiply by 9.8 for newtons (N). (74)

Figure 24 : Lower trapezius muscle strength test

A. Measured muscle strength by HHD B. Positioning for measured muscle strength of LT

3.10.5 Respiratory muscle strength

Respiratory muscle strength assessment followed the protocol from the American Thoracic Society (ATS) (75). The maximal inspiratory pressure (PImax) and maximal expiratory pressure (PEmax) were evaluated using a micro respiratory pressure meter (Micro RPM; Micro Medical Ltd., England) in cm H_2O. The pressure created during maximum inspiration and expiration were used to represent the strength of the inspiratory and expiratory muscles, respectively (75).

Participants were assessed in a sitting position with an ICC of 0.86–0.90 (76), as shown in Figure 25. Normal respiration, connection to a maneuver, and breathing through a one-way tube with a small hole to prevent the glottis close were all assessed. A nose clip was applied and participants then were asked to expire slowly to residual volume and then to perform a deep inspiration against the maneuver for the PImax test. Participants then inspired slowly to total lung capacity and then fully expired against the maneuver for the PEmax test. The measurement was repeated about 3 times and the maximum value was recorded in cm H_2O (75).

Figure 25 : Respiratory muscle strength test in a sitting position

3.10.6 Chest expansion (CE)

Chest expansion is demonstrated by the thoracic circumference at the end of forced inspiration minus thoracic circumference at the end of forced expiration (77). Participants were assessed in a sitting position without support with an ICC of 0.78–0.96 (78), elbow flexion, and a hand on the waist position, as shown in Figure 26. The three levels, namely upper, middle, and lower chest expansion were assessed using a tape in centimeters (ICC 0.95-0.97) (79). For upper chest expansion (UCE), the tape was placed at the 3rd intercostal space at the midclavicular lines and the 5th thoracic spinous process. For middle chest expansion (MCE), the tape was placed at the 5th intercostal space at the midclavicular lines and the 7th thoracic spinous process. For lower chest expansion (LCE), the tape was placed at the lowest part of the rib at the midclavicular line (77, 80), as shown in Figure 26. The measurement was repeated about 3 per level and the maximum value was recorded for each level in centimeters.

A. B. C.

(A) upper chest expansion, (B) middle chest expansion, (C) lower chest expansion

Figure 26 : Chest expansion measurement by tape

3.10.7 Pulmonary function test

The pulmonary function test was evaluated by spirometry (KoKo®, Feraris Respiratory, Inc., USA.), which represents the gold standard, in a sitting position (Figure 27), following the protocol from the American Thoracic Society (ATS) (37). A nose clip was applied to participants, who were then asked to breathe in and out through a mouthpiece. Participants were instructed to breathe slowing for 1–2 breaths and then to perform a maximal inspiration, followed by a forced maximal expiration. The measurement was repeated about 3 times but not more than 8 times (37, 81, 82). The maximal values of FEV_1/FVC, FVC, and FEV_1 were recorded in percent predicted.

Figure 27 : Pulmonary function test in a sitting position

3.10.8 Breathlessness

The level of breathlessness of participants was assessed using the modified British Medical Research Council (mMRC) dyspnea scale, which evaluates and characterizes the level of breathlessness and relates it to health status and mortality risk, as seen in appendix B (83). An mMRC score < 2 is identified as a small degree of breathlessness, while an mMRC score ≥ 2 is a large degree of breathlessness.

3.10.9 Quality of life

All the participants were evaluated by the COPD assessment test (CAT) to assess their quality of life, as shown in appendix C (41). An assessment of validation showed that the Thai CAT questionnaire was moderately correlated (r = 0.652) with the quality of life questionnaire in the St. George's Respiratory Questionnaire (SGRQ). The Thai CAT questionnaire thus can be said to have an acceptable reliability and validity and could serve as a quick and simple tool for assessment of the health status of our Thai COPD patients (41). The CAT covers eight items, including dyspnea, cough, sputum production and wheeze, systemic symptoms of fatigue, sleep disturbance, limitation in daily activities, social life, emotional health, and feeling of control. CAT scores range from 0 to 40 (40). A CAT score < 10 is denoted as a low impact to health status, 10–20 as a moderate impact to health status, 21–30 as a high impact to health status, and > 30 as a very high impact to health status (40).

3.11 Statistical analysis

Results are expressed herein as the mean ± SE and were analyzed by IBM SPSS program version 23. To test the normal distribution, a Komogorov–Smirnov goodness of fit test was used. We used the unpaired T-test for testing the characteristics of the participants at baseline. For the baseline no significant difference, we used two-way ANOVA (repeated measurement) for comparing the main effect of all parameters between pre-training, post-training 1 (4 weeks), and post-training 2 (8 weeks), within and between groups in a normal distributed condition. The level of significance for the statistical tests was set at $p < 0.05$.

3.12 Ethical considerations

This study was approved by the ethics committee of the Faculty of Physical Therapy, Srinakharinwirot University, the research ethics committee of Nakhon Nayok Hospital (REC 10/2560), and the research ethics committee from Nakhon Nayok Public Health Office (NPHO 2018-004), and all the participants received information about the objectives, process, and protocols of the study before signing informed consent.

CHAPTER 4

RESULT

A flowchart of the process utilized throughout the study is given in Figure 28. In total, 40 COPD (stage I–IV) patients were assessed for eligibility and randomly assigned into 2 groups: a control (CT) and an intervention (exercise; Exs) group, with 20 participants in each group. Two participants in the control group were excluded at eighth week as they exacerbated their COPD; while in the exercise group, four participants were excluded at fourth week due to COPD exacerbation (n = 1) and them discontinuing the exercise intervention (n = 3). However, the intention to treat these was still analyzed in this study.

Before starting the study, all the experimental equipment was reliably calibrated by an expert to ensure good quality control. The intra-rater reliability of a tester was examined for all parameters. Each testing procedure was performed by the same investigator. In each parameter, the same protocol was performed twice on five volunteers by the same tester, five days apart from the first measurement. The intraclass correlation coefficient ($ICC_{3,1}$) was determined from the two measurements. In the present study, ICC values of all the outcome measures were demonstrated to lie in the range of 0.960–0.997 (Table 8), which were considered to demonstrate an excellent level of reliability ($p < 0.01$).

The demographic data of the COPD participants in both the control and exercise group are shown in Table 9 and 10. There was no significant difference in rounded shoulder posture (9), pectoralis minor index (PMI), lower trapezius (LT) and serratus anterior (SA) muscle strength between dominant and non-dominant side. Therefore, the data of dominant side are shown in the results. There was no significant difference in any of the characteristics of the subjects, i.e., regarding their age, body mass index (BMI), weight, height, number of participants in each stage of COPD, COPD assessment test (CAT) for quality of life, and breathlessness score (mMRC) ($p > 0.05$). Baseline characteristics of all the participants in the control and exercise group are shown in Table 11. There was no significant difference in the baseline data between the control and exercise group ($p > 0.05$), which reflected the identical characteristics of the participants in the two groups.

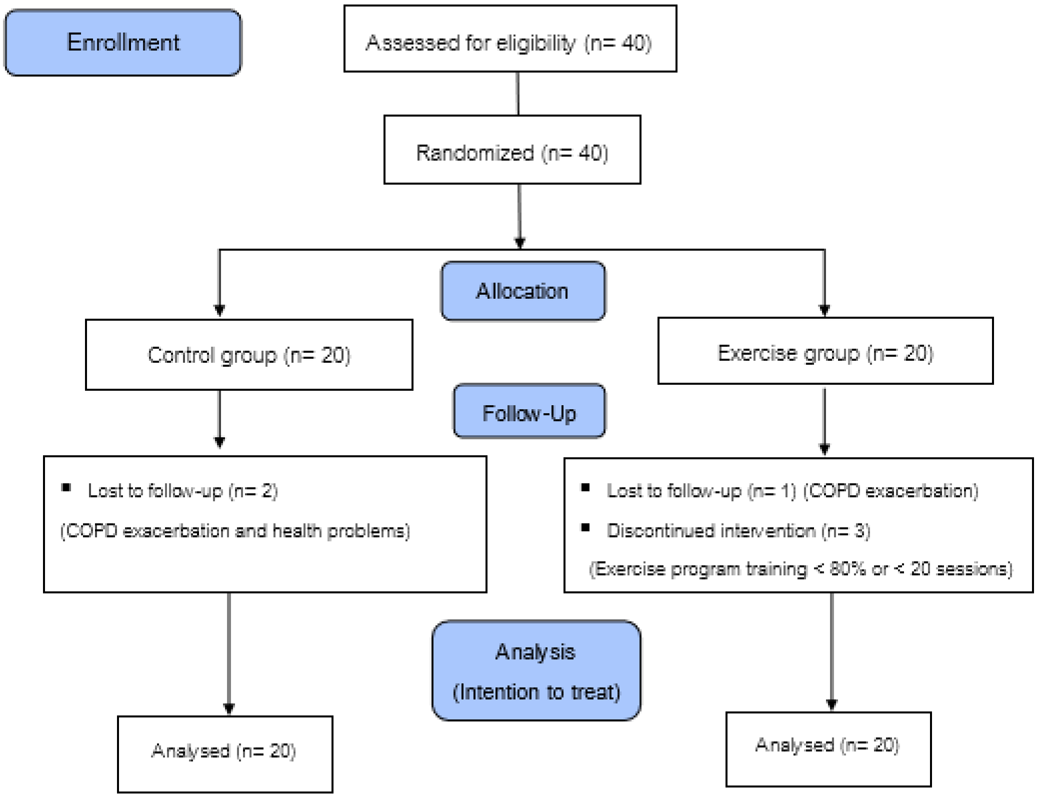


Figure 28 : Flow chart for the present study

Table 8 : Intra-rater reliability of a tester for all parameters

Parameters	ICC $_{3,1}$		ICC $_{3,1}$	
	Dominant side	SEM	Non-dominant side	SEM
Rounded shoulder posture (RSP; cm)	0.997	0.08	1.00	0.00
Pectoralis muscle index (PMI)	0.960	0.01	0.958	0.03
Serratus anterior muscle strength (SA; kg)	0.989	0.11	0.979	0.19
Lower trapezius muscle strength (LT; kg)	0.984	0.05	0.972	0.11
	ICC $_{3,1}$		SEM	
Thoracic kyphosis (TK; degree)	0.984		0.17	
Chest expansion; CE				
- Upper chest expansion (UCE; cm)	0.997		0.02	
- Middle chest expansion (MCE; cm)	0.994		0.04	
- Lower chest expansion (LCE; cm)	0.994		0.01	
Maximal inspiratory pressure (PImax; cmH_2O)	0.973		1.05	
Maximal expiratory pressure (PEmax; cmH_2O)	0.964		1.03	
Spirometry				
- FVC; forced vital capacity (L)	0.994		0.01	
- FEV1; forced expiratory volume in one second (L)	0.997		0.00	
- FEV1/FVC	0.964		0.01	

Table 9 : Demographic data of the patients with COPD (Mean ± SE)

Parameters	Groups	0 week At baseline	At 4 weeks	At 8 weeks	Within group			Between group		
					0&4 weeks	0&8 weeks	4&8 weeks	0 week (Baseline)	4 weeks	8 weeks
Dominant side RSP (cm)	Control	7.6 ± 0.24	7.6 ± 0.26	8.0 ± 0.30	0.81	0.04*	0.11	0.52	0.01	<0.001 ***
	Exercise	7.3 ± 0.35	6.4 ± 0.35	6.2 ± 0.35	<0.001***	<0.001***	0.18			
Non-dominant side RSP (cm)	Control	7.0 ± 0.27	6.8 ± 0.30	7.1 ± 0.28	0.15	0.47	0.12	0.47	0.09	0.01*
	Exercise	6.7 ± 0.26	6.1 ± 0.26	5.8 ± 0.32	<0.001***	<0.001***	0.09			
Dominant side PMI	Control	9.61 ± 0.13	9.59 ± 0.13	9.53 ± 0.13	0.64	0.22	0.40	0.99	0.11	0.008**
	Exercise	9.62 ± 0.14	9.91 ± 0.15	10.05 ± 0.13	<0.001***	<0.001***	0.04*			
Non-dominant side PMI	Control	9.93 ± 0.13	9.84 ± 0.15	9.85 ± 0.14	0.11	0.24	0.85	0.40	0.40	0.11
	Exercise	9.78 ± 0.12	10.00 ± 0.11	10.14 ± 0.11	<0.001***	<0.001***	0.02*			
Dominant side Muscle strength of LT (N)	Control	1.64 ± 0.10	1.69 ± 0.11	1.63 ± 0.09	0.40	0.91	0.11	0.489	0.05	0.010*
	Exercise	1.74 ± 0.10	2.04 ± 0.14	2.09 ± 0.14	<0.001***	0.003**	0.67			
Non-dominant side Muscle strength of LT (N)	Control	1.46 ± 0.11	1.56 ± 0.14	1.41 ± 0.12	0.17	0.57	0.05	0.409	0.073	0.006**
	Exercise	1.58 ± 0.09	1.91 ± 0.13	1.89 ± 0.12	<0.001***	0.08	0.07			
Dominant side Muscle strength of SA (N)	Control	3.66 ± 0.20	3.78 ± 0.27	3.51 ± 0.21	0.30	0.36	0.08	0.467	0.384	0.009**
	Exercise	3.45 ± 0.19	4.08 ± 0.22	4.5 ± 0.29	<0.001***	<0.001***	0.008**			
Non-dominant side Muscle strength of SA (N)	Control	3.36 ± 0.18	3.6 ± 0.25	3.37 ± 0.21	0.09	0.94	0.14	0.424	0.578	0.031*
	Exercise	3.16 ± 0.17	3.78 ± 0.23	4.12 ± 0.26	<0.001***	<0.001***	0.026*			

[a] Chi-square tests, SE; standard error of the mean.

[b] COPD stage was identified according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guideline.

Table 10 : Baseline characteristics of all participants in this study (Mean ± SE)

Characteristics	Control (n=20)	Exercise (n= 20)	*p*-value
Age (years)	71.10 ± 1.02	70.80 ± 1.00	0.83
Body mass index; BMI (kg/m^2)	21.84 ± 0.60	22.22 ± 0.66	0.68
Weight (kgs)	59.39 ± 1.80	58.38 ± 1.80	0.69
Height (cm)	164.90 ± 1.31	162.25 ± 1.69	0.22
Duration of disease (years)	9 ± 1.71	8 ± 0.79	0.59
Duration of disease (min-max; years)	1 - 31	1 - 15	0.59
Smoking (pack-year)	28.78 ± 4.05	25.75 ± 3.79	0.58
COPD stage [a] (n)			0.712
I	1	3	
II	13	12	
III	4	4	
IV	2	1	
CAT [a]			0.695
- Low impact (< 10 point)	17	15	
- Moderate impact (10-20 points)	3	5	
- High impact (21-30 points)	0	0	
- Very high impact (> 30 points)	0	0	
mMRC [a]			0.514
- Low impact (< 2 points)	14	11	
- High impact (≥ 2 points)	6	9	

[a] Fisher's Exact Tests

COPD stage was identified according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guideline

Table 11 : Baseline characteristics of all participants in this study

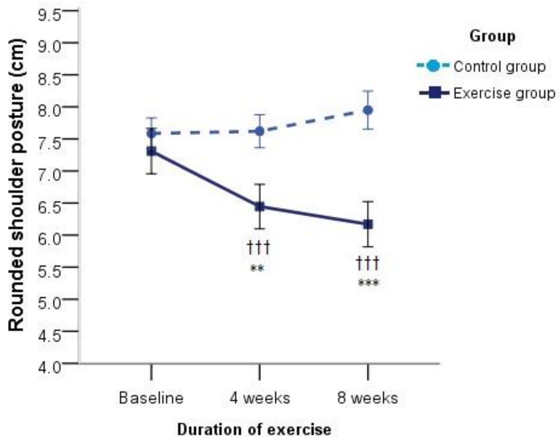
Characteristics	Side	Control (n= 20)	Exercise (n=20)	*p*-value
Rounded shoulder posture; RSP (cm)	Dominant	7.6 ± 0.24	7.3 ± 0.35	0.52
	Non-dominant	7.0 ± 0.27	6.7 ± 0.27	0.47
Pectoralis minor index; PMI	Dominant	9.61 ± 0.13	9.62 ± 0.14	0.99
	Non-dominant	9.93 ± 0.13	9.78 ± 0.12	0.40
Muscle strength test (Normalized by body weight; kg and multiply 9.8 for newton)				
- Lower trapezius (N)	Dominant	1.64 ± 0.10	1.74 ± 0.10	0.49
- Serratus anterior (N)		3.7 ± 0.20	3.45 ± 0.19	0.47
- Lower trapezius (N)	Non-dominant	1.50 ± 0.11	1.58 ± 0.09	0.41
- Serratus anterior (N)		3.4 ± 0.18	3.16 ± 0.17	0.43
Thoracic kyphosis (degree)		39.93 ± 2.16	40.57 ± 1.97	0.83
Chest expansion				
- Upper part (cm)		3.2 ± 0.15	3.4 ± 0.15	0.45
- Middle part (cm)		3.6 ± 0.17	3.9 ± 0.17	0.29
- Lower part (cm)		4.7 ± 0.27	4.7 ± 0.28	0.90
Respiratory muscle strength				
- PImax (cmH2O)		70.40 ± 3.72	65.80 ± 2.24	0.30
- PEmax (cmH2O)		95.10 ± 5.23	90.30 ± 4.35	0.49
Pulmonary function test				
- FVC (%predicted)		74.05 ± 4.29	81.30 ± 3.27	0.19
- FEV1 (%predicted)		56.85 ± 3.72	59.05 ± 4.32	0.70
- FEV1/FVC (%predicted)		73.15 ± 3.78	68.80 ± 4.38	0.46

4.1 Effect of 8-week pectoral muscles self-stretching and scapular muscles strengthening exercises on rounded shoulder posture, pectoralis minor index, lower trapezius and serratus anterior muscle strength, and thoracic kyphosis in COPD patients

The key results for the side measurements of the structural changes for rounded shoulder posture (9), pectoralis minor index (PMI), thoracic kyphosis, and lower trapezius and serratus anterior muscle strength are shown in Figures 30 and 31. In terms of the change in RSP within a group (Figure 29A), the control group showed a significantly increased RSP at week 8 (8.0 ± 0.30 cm) when compared to baseline (7.6 ± 0.24 cm cm; p = 0.036); whereas the exercise group demonstrated a reduction in RSP at week 4 (6.4 ± 0.35 cm) and week 8 (6.2 ± 0.35 cm) when compared to baseline (7.3 ± 0.35 cm; $p < 0.001$, $p < 0.001$, respectively). Compared to the control, RSP was significantly reduced in the exercise group at week 4 (CT = 7.6 ± 0.26 cm, Exs = 6.4 ± 0.35 cm; p = 0.01) and week 8 (CT = 8.0 ± 0.30 cm, Exs = 6.2 ± 0.35 cm; $p < 0.001$). These results indicated that RSP in COPD patients without exercise gradually increased with time. Whereas, performing an 8-week exercise training program that included pectoral muscles self-stretching and scapular muscles strengthening could alleviate RSP in COPD patients from week 4 to week 8 of performing the exercise training.

Regarding the pectoralis minor index (PMI) (Figure 29B), there was no change in PMI within the control group; whereas in the exercise group, the results showed a significantly improved PMI at week 4 (9.91 ± 0.15; $p < 0.001$) and at week 8 (10.05 ± 0.13; $p < 0.001$) when compared to their baseline (9.62 cm). Moreover, there was significantly increased PMI (p=0.036) in exercise group when compared week 4 and week 8 of training. When compared to the control group, participants in the exercise group showed a significantly increased PMI at week 8 of performing the exercise training (CT = 9.53 ± 0.13, Exs = 10.05 ± 0.13; p = 0.008). Regarding thoracic kyphosis (Figure 29C), the exercise group showed a significantly reduced degree of thoracic kyphosis at week 4 (33.53 ± 1.79 degree; $p<0.001$) and week 8 (33.55 ± 1.85 degree; $p<0.001$) when compared to baseline (40.57 ± 2.28 degree). These results implied that the exercise program improved the posture of the thoracic spine by alleviating the degree of thoracic kyphosis from week 4 to week 8 of training. The two major scapular stabilizer muscles, namely the lower trapezius (LT) and serratus anterior (SA), were evaluated by measuring their strength or force in newton (N) unit using a handheld dynamometer (HHD) and normalized by kilogram body weight (Figures 30A, 30B). When compared to baseline (1.74 ± 0.10 N), the exercise group showed a significantly increased force was generated by the lower trapezius muscle at week 4 (2.04 ± 0.14 N; $p<0.001$) and at week 8 (2.09 ± 0.14 N; $p=0.003$); whereas the force was not changed in the control group (Figure 30A). When compared to the control (1.63 ± 0.09 N), it was found there was a significantly increased lower trapezius muscle strength in the exercise group at week 8 of training (2.09 ± 0.14 N; $p=0.010$). Moreover, the force of the serratus anterior muscle was also improved in the exercise group after 4 weeks (3.45 ± 0.19 N; $p<0.001$) and after 8 weeks (4.5 ± 0.29 N; $p<0.001$) training when compared with baseline (3.45 ± 0.19 N). In addition, there was significantly increased force of serratus anterior muscle ($p=0.008$) in exercise group when compared week 4 and week 8 of training. A markedly increased serratus anterior muscle force was also observed at week 8 of training when compared with the control group (Exs = 4.5 ± 0.29 N, CT = 3.51 ± 0.21 N; $p= 0.009$) (Figure 30B). These results indicated that reducing rounded shoulders by performing 8-week pectoral muscles self-stretching and scapular muscle strengthening, including the lower trapezius and serratus anterior, exercises could improve the pectoralis minor muscle length, as represented by PMI, and also the scapular muscle strength, especially in the lower trapezius and serratus anterior muscles.

A



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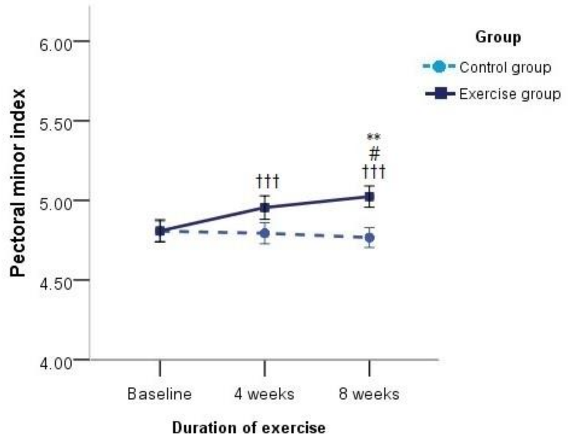

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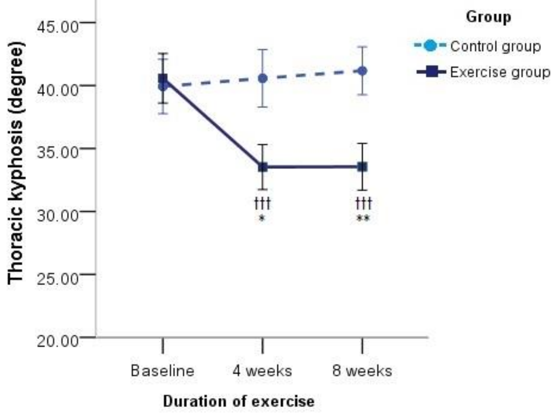
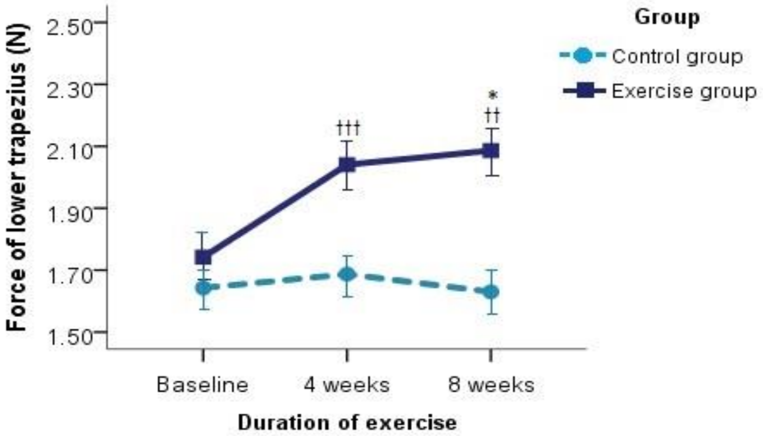


Figure 29 : Comparison of the degree of rounded shoulder posture (A), pectoralis minor index (B), and thoracic kyphosis (C) between the control group and exercise group at baseline, and at 4 and 8 weeks of the study period.

†; $p < 0.05$ compared to baseline, ††; $p < 0.01$ compared to baseline, †††; $p < 0.001$ compared to baseline, *; $p < 0.05$ compared to control, #; $p < 0.05$ compared to 4 weeks and 8 weeks, **; $p < 0.01$ compared to control, ***; $p < 0.001$ compared to control.

A



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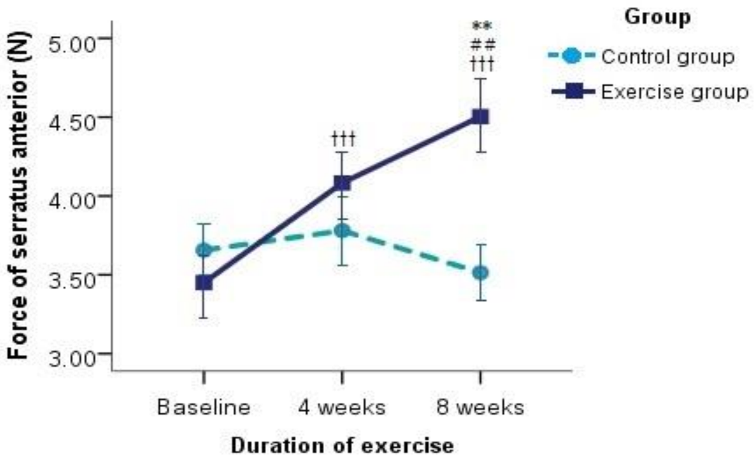

Figure 30 : Comparison of the muscle force in the lower trapezius (A) and serratus anterior (B) between the control group and exercise group at baseline, and at 4 and 8 weeks of the study period

†; $p < 0.05$ compared to baseline, ††; $p < 0.01$ compared to baseline, †††; $p < 0.001$ compared to baseline, *; $p < 0.05$ compared to control, ##; $p < 0.01$ compared to 4 weeks and 8 weeks, **; $p < 0.01$ compared to control, ***; $p < 0.001$ compared to control.

4.2 Effect of 8-week exercise for reducing rounded shoulder posture on chest expansion

The three parts of the chest wall, namely the upper, middle, and lower parts, were evaluated regarding chest expansion (Figures 31A, 31B, 31C) Compared to baseline (middle part = 3.9 ± 0.17cm, lower part = 4.72 ± 0.28 cm), the exercise group showed markedly increased middle and lower chest expansion at week 4 (middle part = 4.2 ± 0.13 cm, p = 0.012; lower part = 5.2 ± 0.24 cm, p = 0.002) and at week 8 (middle part = 4.9 ± 0.16 cm, p < 0.001; lower part = 6.0 ± 0.32 cm; p < 0.001). When compared to baseline (3.9 ± 0.17 cm), middle chest expansion in the exercise group showed a significant improvement at week 4 (4.2 ± 0.13 cm, p = 0.012) to week 8 (4.9 ± 0.16 cm, p < 0.001). There was significantly increased middle chest expansion (p<0.001) in exercise group when compared week 4 (4.2 ± 0.13 cm) and week 8 (4.9 ± 0.16 cm) of training. Furthermore, lower chest expansion demonstrated an increment at week 8 (6.0 ± 0.32 cm) in the exercise group when compared to the control group (5.0 ± 0.34 cm; p = 0.039). In addition, there was significantly increased lower chest expansion (p=0.002) in exercise group when compared week 4 (5.2 ± 0.24 cm) and week 8 (6.0 ± 0.32 cm) of training. However, upper chest expansion did not show a statistically significant change after 8 weeks of exercise training, indicating an improvement in chest expansion occurred mainly in the middle and lower part by 8-week of reducing RSP with the exercise program.

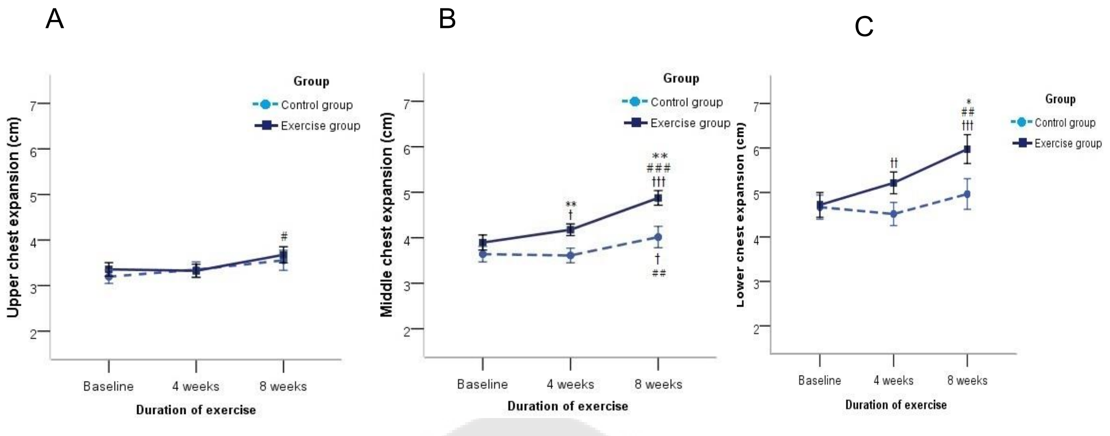

Figure 31: Comparison of upper (A), middle (B), and lower chest expansion (C) between the control group and exercise group at baseline, and at 4 and 8 weeks of the study period

†; $p < 0.05$ compared to baseline, ††; $p < 0.01$ compared to baseline, †††; $p < 0.001$ compared to baseline, *; $p < 0.05$ compared to control, ##; $p < 0.01$ compared to 4 weeks and 8 weeks, ###; $p < 0.001$ compared to 4 weeks and 8 weeks **; $p < 0.01$ compared to control, ***; $p < 0.001$ compared to control

4.3 Effect of 8-week exercise for reducing rounded shoulder posture on respiratory muscle strength (maximal inspiratory and expiratory pressure)

The strength of the inspiratory and expiratory muscles was measured by maximal inspiratory (PImax) and expiratory pressure (PEmax), respectively (Figures 32A, 32B). Compared to baseline (PImax = 65.8 ± 2.24 cmH_2O, PEmax = 90.3 ± 4.35 cmH_2O), the exercise group showed significantly increased PImax and PEmax at week 4 (PImax=78.7 ± 3.09 cmH_2O; $p < 0.001$, PEmax = 102.3 ± 4.18 cmH_2O; $p < 0.001$) and week 8 (PImax = 89.5 ± 4.49 cmH_2O; $p < 0.001$, PEmax = 115.5 ± 6.31 cmH_2O; $p < 0.001$). Moreover, there was significantly increased PImax ($p<0.001$) and PEmax ($p=0.009$) in exercise group when compared week 4 (PImax = 78.7 ± 3.09 cmH_2O, PEmax = 102.3 ± 4.18 cmH_2O) and week 8 (PImax = 89.5 ± 4.49 cmH_2O, PEmax = 115.5 ± 6.31 cmH_2O) of training. When compared to the control (PImax = 70.4 ± 3.72 cmH_2O, PEmax = 95.1 ± 5.23 cmH_2O), PImax and PEmax of the exercise group were significantly increased in week 8 (PImax = 89.5 ± 4.49 cmH_2O; $p < 0.001$, PEmax = 115.5 ± 6.31 cmH_2O; $p < 0.001$) through exercise training. Therefore, these results indicated that the improvement in shoulder posture by performing the 8-week exercise training program could increase the effectiveness of the inspiratory and expiratory muscles to create the maximum force during inspiration and expiration.

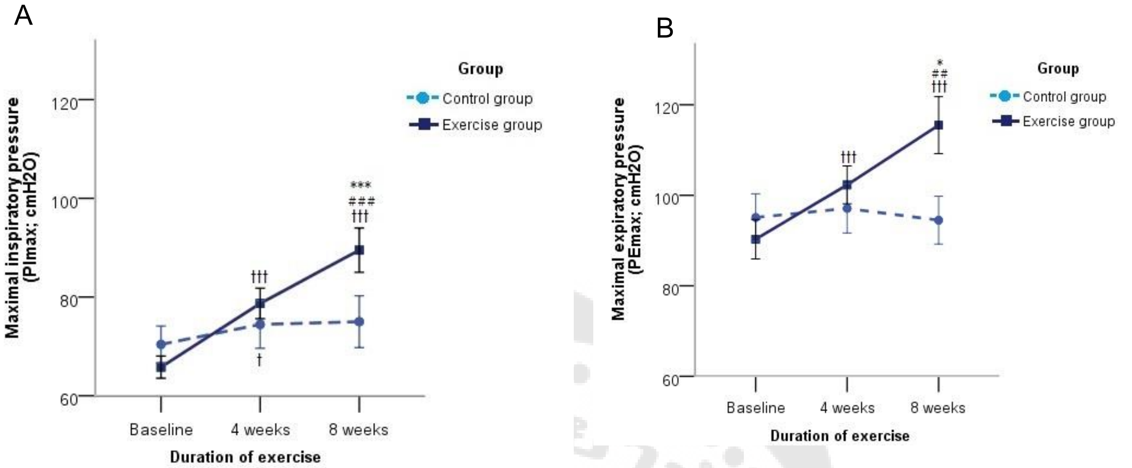

Figure 32 : Comparison of inspiratory muscle strength (A) and expiratory muscle strength (B) between the control group and exercise group at baseline, and at 4 and 8 weeks of the study period †, $p < 0.05$ compared to baseline; ††, $p < 0.01$ compared to baseline; †††, $p < 0.001$ compared to baseline; *, $p < 0.05$ compared to control; ##; $p < 0.01$ compared to 4 weeks and 8 weeks, ###; $p < 0.001$ compared to 4 weeks and 8 weeks, **, $p < 0.01$ compared to control; ***, $p < 0.001$ compared to control.

4.4 Effect of 8-week exercise for reducing rounded shoulder posture on pulmonary function (%FVC predicted, %FEV_1 predicted, %FEV_1/FVC, breathlessness (mMRC), and COPD assessment test (CAT) for the quality of life

Regarding the pulmonary function test, the exercise group did not show a significant difference in pulmonary function parameters, including %FVC predicted, %FEV_1 predicted, and %FEV_1/FVC, when compared within group and with the control group, as shown in Table 12. These results indicated that the 8-week exercise program performed for reducing rounded shoulders did not change the pulmonary function in the COPD patients.

Also, considering the mMRC and CAT score, the breathlessness (mMRC) and the quality of life of the participants with COPD (CAT) were not changed in the exercise group when compared within group and with the control group, as shown in Table 13. These results imply that the 8-week exercise training program did not change the patients' quality of life. However, the training program did not induce the full severity of breathlessness in the participants with COPD.

Table 12 : Group comparison of pulmonary function parameters at baseline, and at 4 and 8 weeks of the study period

Pulmonary function test	Groups	0 week At baseline	At 4 weeks	At 8 weeks	Within group 0&4 weeks	Within group 0&8 weeks	Within group 4&8 weeks	Between group 0 week (Baseline)	Between group 4 weeks	Between group 8 weeks
FVC (%predict)	Control	74.05±4.29	78.05±3.67	81.70±4.14	0.027†	0.007††	0.163	0.187	0.418	0.117
	Exercise	81.30±3.27	82.15±3.40	90.10±3.21	0.628	0.002††	0.004††			
FEV_1 (%predict)	Control	56.85±3.72	59.60±3.79	60.25±3.99	0.092	0.122	0.712	0.702	0.975	0.764
	Exercise	59.05±4.32	59.20±4.38	62.10±4.64	0.925	0.164	0.105			
FEV_1/FVC (%predict)	Control	73.15±3.78	71.95±3.70	70.00±3.39	0.430	0.082	0.080	0.457	0.395	0.265
	Exercise	68.80±4.38	67.45±3.69	64.40±3.60	0.375	0.017†	0.008††			

CG, control group; EG, exercise group; †, $p < 0.05$ compared to baseline within group; ††, $p < 0.01$ compared to baseline within group.

Table 13 : COPD Assessment test (CAT) and modified Medical Research Council (mMRC) dyspnea scale; comparison at baseline, and at 4 and 8 weeks of the study period

Parameters		Baseline Control (n=20)	Baseline Exercise (n= 20)	Baseline *p*-value	4 weeks Control (n=20)	4 weeks Exercise (n= 20)	4 weeks *p*-value	8 weeks Control (n=20)	8 weeks Exercise (n= 20)	8 weeks *p*-value
CAT [a]	- Low impact (< 10 point)	17	15	0.695	15	16	1.00	14	14	1.00
	- Moderate impact (10-20 points)	3	5		5	4		6	6	
	- High impact (21-30 points)	0	0		0	0		0	0	
	- Very high impact (> 30 points)	0	0		0	0		0	0	
mMRC [a]	- Low impact (< 2 points)	14	11	0.514	17	13	0.273	16	15	1.00
	- High impact (≥ 2 points)	6	9		3	7		4	5	

[a] Fisher's Exact Tests

CHAPTER 5
DISCUSSION AND CONCLUSIONS

Muscle imbalance due to pathological hyperinflation in COPD is a major cause of postural problems, including rounded shoulders. A postural malalignment from rounded shoulders not only causes problems with the musculoskeletal functions but also causes additive problems with the respiratory system in COPD patients. There are several factors associated with breathing difficulty in COPD. A slouched posture with rounded shoulders from a tripod position is one important factor related to shortness of breath in COPD (84). In rounded shoulder posture, the rib cage and sternum are compressed against the diaphragm, which causes improper breathing. A previous study showed that COPD patients had a limited range of shoulder flexion. Moreover, impaired pulmonary functions in COPD is related to a shortened pectoralis minor muscle length (28). Therefore, improving postural malalignment from rounded shoulders is now a crucial part of the pulmonary rehabilitation program for COPD. This study demonstrated the effects of following an 8-week exercise program for reducing rounded shoulders on respiratory function, including chest expansion, respiratory muscle strength, and pulmonary function in COPD patients. Eligible male COPD patients with a mild to very severe degree of COPD were included in this study. The results showed that an exercise training program including pectoral muscles self-stretching and scapular muscles strengthening performed 3 days/week for 8 weeks could alleviate rounded shoulders in COPD together with an increase in pectoralis minor index, scapular muscles strength, and reduction in thoracic kyphosis. In addition, the alleviation of rounded shoulders by this exercise program promoted better chest expansion, especially in the middle and lower part, and respiratory muscle strength in COPD patients.

5.1 Effect of the 8-week pectoral muscles self-stretching and scapular muscles strengthening exercise on rounded shoulder posture, pectoralis minor index, lower trapezius and serratus anterior muscle strength, and thoracic kyphosis in COPD patients

Rounded shoulders posture have the characteristics of a protracted scapular, downward rotated, and anterior tipped with an increase in upper thoracic kyphosis (21). Pectoral muscles tightness, especially the pectoralis minor muscle, and stabilizing muscle weakness of the scapular muscles, particularly the lower trapezius and serratus anterior, are typical characteristic of upper quadrant muscles imbalance in RSP (22, 50, 62). A previous study found a relationship between a decreased pectoralis minor muscle length and RSP (50). Moreover, strengthening of the lower trapezius and serratus anterior muscles were also associated with the improvement of RSP (50). The evidence supported the view that improving the pectoralis minor muscle flexibility and activating the lower trapezius and serratus anterior muscles were important for a patient with scapular dyskinesia induced subacromial impingement syndrome (24). For this reason, correcting muscle imbalance by stretching the tightened muscles and strengthening the antagonist muscles is important to alleviate RSP (31). Additionally, a study by Lee and coworkers recommended that scapular muscles exercise after pectoralis minor muscle stretching could be an effective approach for improving the scapular arrangement and its muscle activity (62). Therefore, the exercise training program applied in the present study included a static self-stretching exercise for the pectoral muscles and lower trapezius muscle, and a serratus anterior muscle strengthening exercise.

Regarding our findings, the degree of RSP was significantly reduced with an increase in pectoralis minor index (PMI) in the exercise group. The decrease in RSP was demonstrated with less scapular anterior tilting in the sagittal plane and less scapular internal rotation in the transverse plane (21, 22). A previous study found that pectoral muscles self-stretching could induce a lengthening of the pectoralis minor muscle and hence decreased RSP (22). Consequently, it seems that decreasing RSP is associated with an increase in pectoralis minor muscle length. The mechanism of static stretching is described by a viscoelastic effect on the muscle-tendon unit. The viscoelastic effect of muscle stretching increases the range of motion, which is related with a reduction in the resistance to stretch and muscle stiffness, and an increase in muscle compliance (85). These responses are generated during a period of 30–60 seconds of static stretching (86). An increase in tension on the stretched muscle stimulates the Golgi tendon organ (GTO) in the muscle tendon, which temporarily suppresses muscle spindle activity (65). Consequently, reducing tension in the stretched pectoral muscles allows them to lengthen and reduces RSP.

To correct muscle imbalance, strengthening exercises for the agonist muscles are important to counteract muscle weakness related to RSP. The lower trapezius and serratus anterior are the primary agonist muscles to control posterior tilting and upward rotation of the scapular, which are necessary for the subacromial space expansion in RSP (87). Moreover, a reduction in the lower trapezius and serratus anterior muscles activity has been reported with a decreased scapular posterior tilting and upward rotation in impingement syndrome patients (88). Therefore, activation of the lower trapezius and serratus anterior muscle is important for correcting muscle imbalance in rounded shoulders. During the contraction of the lower trapezius and serratus anterior muscles, the tension in the pectoral muscles, which are the antagonist muscles , are reduced by inhibiting impulses from motor neurons (62). For this reason, the antagonist muscles simultaneously relax. In addition, strengthening the agonist muscles induces a retraction, upward rotation, and posterior tilting of the scapular, therefore re-establishing the normal plane of the scapular in RSP. Our results demonstrate a significant increase in the lower trapezius and serratus anterior muscle force in the exercise group, as evaluated by the hand held dynamometer (HHD). Thus, the present study suggests that an 8-week scapular muscles strengthening exercise focusing on the lower trapezius and serratus anterior muscles after pectoral muscles stretching could be a potent method to increase the length of the pectoralis minor muscle and the strength of the scapular muscles, thus reducing RSP in COPD patients with rounded shoulders. This knowledge supports our research hypothesis. These findings are consistent with a study by Lee and coworkers in 2015, who reported that pectoralis minor muscle stretching with a scapular posterior tilting exercise was an effective method for modifying scapular alignment and scapular muscle activity in subjects with a short pectoralis minor muscle length (50). Furthermore, our findings are similar to a previous study that reported that an 8-week exercise program focused on stretching the anterior shoulder muscles (pectoral muscles, levator scapulae, and sternocleidomastoid) and strengthening posterior shoulder muscles (middle trapezius, lower trapezius, and serratus anterior) could decrease RSP in swimmers [(49)].

Additionally, this study showed that correcting the upper quadrant muscle imbalance in COPD patients improved not only shoulder posture but also the posture of the thoracic spine. Much evidence has been reported showing that rounded shoulder and thoracic kyphotic posture are mostly found in patients with COPD (28, 29, 33). These abnormal postures affect the pulmonary function, including forced vital capacity (FVC) in COPD (89). In this study, we found a reduction in the degree of thoracic kyphosis in the exercise trained participants when compared to the control. A review showed the association between rounded shoulders and an increased degree of thoracic kyphosis (90). Reduced RSP and thoracic kyphosis after correcting muscle imbalance are consistent with the findings of Pin and coworkers in their 2016 study, in which they found that rehabilitation with resistive and stretching exercise could rebalance muscle force and restore muscle elasticity, thus reducing rounded shoulders and thoracic kyphosis (91). Consequently, the reduction in rounded shoulders and in the degree of thoracic kyphosis found in this study led to a better posture with the upper trunk more erect in COPD participants.

5.2 Effect of the 8-week exercise for reducing rounded shoulder posture on chest expansion and respiratory muscle strength

Poor posture with rounded shoulder and thoracic kyphosis causes a limitation of the respiratory function. The upper quadrant and vertebral muscles are attached at the thoracic wall. The imbalance of the upper extremity muscles potentially affects the rib cage biomechanics, which can restrict the mobility of the chest wall and then limit ventilation (14, 28). Musculoskeletal dysfunction induced by poor posture leads to reduced respiratory muscle performance (92). Moreover, the thoracic kyphosis is concomitantly related with dyspnea and ventilatory dysfunction in the elderly (14). Alteration of the upper body alignment changes the respiratory muscle length, especially the diaphragm, affecting its force generation capacity. According to the length–tension relationship of the muscle, the capacity of a muscle fiber to generate the active force necessary depends on its muscle length. Previous evidence has shown a reduction in respiratory muscle strength in the non-optimal muscle length in a supine body position (93).

Our findings demonstrated an improvement of chest expansion mainly in the middle and lower parts when compared to the control. Two parts of the pectoral muscles, namely the pectoralis major and minor, originate from the anterior surface of the chest wall for the pectoralis major and the third to fifth ribs for the pectoralis minor. Moreover, the insertion of the pectoralis major muscle is at the bicipital groove of the humerus, while the pectoralis minor is inserted at the coracoid process of the scapular. They help to stabilize the scapular and raise the ribs during inspiration. The tightness of the pectoralis muscle from rounded shoulder limits the mobility and compliance ability of the chest wall to create maximal lung capacity in inspiration (25). COPD patients with rounded shoulders and thoracic kyphosis have a reduced ability to raise and expand the thorax, which in turn limits the lung capacity [(33)]. To reduce RSP, pectoralis muscles stretching causes the pectoralis muscle fibers to lengthen, as shown by an increased PMI in our results, and thereby the compliance of the anterior chest wall is improved. The increment in chest expansion was apparently demonstrated at the middle part, which is the area of the pectoralis minor muscle. Reducing RSP and thoracic kyphosis makes the thoracic more erect. Straightening the thoracic spine in COPD patients reduced the approximation of the ribs to the pelvis, decreasing intra-abdominal pressure and making it easier for the diaphragm to descend caudally (33). The diaphragm, which is attached at the lower thoracic, then can work more effectively to expand the lower chest and create maximum contraction force during respiration, as was shown by increased lower chest expansion and respiratory muscle strength in this study.

5.3 Effect of the 8-week exercise for reducing rounded shoulder posture on pulmonary functions (FVC, FEV_1, FEV_1/FVC; percentage of predicted), breathlessness score (mMRC), and COPD assessment test score (CAT) for the quality of life

The pulmonary function, also known as spirometry, is a gold standard measurement to diagnose and manage respiratory problems. A forced expiratory volume in one second/forced vital capacity ratio (FEV_1/FVC) is an indicator of an obstructive defect, whereas a restrictive defect is determined by the FVC. In addition, the severity of the abnormality is indicated by FEV_1. From the results, the exercise performed in the present study for reducing rounded shoulders led to no significant improvement of the pulmonary functions, including FEV_1, FVC, and FEV_1/FVC. This indicated that correcting rounded shoulder and thoracic kyphosis did not alleviate the abnormality of COPD. However, it tended to delay a worsening in the pathology of COPD. Our findings are consistent with a study by Wang in 2015, in which no noticeable changes were found in the respiratory function (FEV_1, FVC, and FEV_1/FVC) after posture was improved by stretching and mobilization of the thoracic cage in COPD patients with thoracic kyphosis. The explanation for the non-improvement of the pulmonary function in the COPD participants was reported as being due to the advanced age, advanced thoracic kyphosis, and the long duration of disease in the test patients (94). However, the effects on pulmonary function are still controversial as a study by Gaude and coworkers showed an improvement of the dyspnea index and pulmonary functions in patients with COPD that undertook postural correction for thoracic kyphosis (33).

The prevention of aggravated symptoms was also found in this study as it also showed there were no changes in the breathlessness score and quality of life in the exercise-trained COPD participants when compared to their control.

Limitations of the present study and suggestions for future research

The present study has various limitations. First, the reduction in rounded shoulder posture found in this study resulted from the combination of a static self-stretching and strengthening exercise program. Differential analysis was not performed in the present study. Second, the pectoralis minor muscle stretching was performed with patients with reduced rounded shoulder posture because it was impossible to discriminate the pure pectoralis minor stretching. Third, the program for strengthening lower trapezius muscle and serratus anterior was modified from classic exercise (modified from Kisner and Colby, 2013 (65) and modified from Lee et al., 2015 (50, 62)) that was appropriated for aging, therefore may be occur compensated workout of the muscles over more it. Fourth, we evaluate the muscle strength from hand held dynamometer (HHD) that not evaluated pure the muscle but evaluated the muscle group. Thus, future study should assess the muscle strength by electromyography (EMG). Fifth, the findings of this study cannot be recommended to applying to other conditions, such as females or other pulmonary diseases because the present study only comprised participants who were 60–90-year-old male COPD patients. Sixth, we did not evaluate the scapular positions due to reduced rounded shoulder posture. Thus, future study should assess the changes in scapular position in order to analyze the specific effect of a reduced rounded shoulder posture program on the directional change of the scapular. Furthermore, rounded shoulder posture should assess posture by plumb line or other evaluated for the functional posture. Seventh, we do not know the sustained effects of this exercise program since the exercise training period ended at 8 weeks. Therefore, the remaining effect of exercise could be evaluated in a future study. Finally, a single blinded study was performed in the present study by reason of the limited investigator quantity. To minimize the bias, blinding of all the therapists and assessors should be considered in a future study.

CONCLUSIONS

The findings of this study demonstrated that following a n 8-week pectoral muscle self-stretching and scapular muscles strengthening exercise program was an effective means to improve the pectoralis minor muscle length and the serratus anterior and lower trapezius muscle strength in COPD patients. The exercise program had an improving effect for correcting rounded shoulders and thoracic kyphosis. Furthermore, the corrected shoulder posture could induce improved chest expansion especially in the middle and lower part, respiratory muscle strength. Nevertheless, no significant effect was observed on the pulmonary function, level of breathlessness, and the quality of life in the patients with COPD.

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APPENDICES

APPENDIX A

No……………..

แบบบันทึกข้อมูลทั่วไปของผู้ป่วยโรคปอดอุดกั้นเรื้อรัง

คณะกายภาพบำบัด มหาวิทยาลัยศรีนครินทรวิโรฒ

เรื่อง ผลของการออกกำลังกายเพื่อลดภาวะไหล่งุ้ม ต่อการขยายตัวของทรวงอก ความแข็งแรงของกล้ามเนื้อหายใจ และสมรรถภาพปอดในผู้ป่วยโรคปอดอุดกั้นเรื้อรัง

วัตถุประสงค์

เพื่อศึกษาผลของโปรแกรมการออกกำลังกายเพื่อลดข้อไหล่งุ้มเป็นเวลา 8 สัปดาห์ ต่อการขยายตัวของทรวงอก ความแข็งแรงของกล้ามเนื้อหายใจ และสมรรถภาพปอดในผู้ป่วยโรคปอดอุดกั้นเรื้อรัง

คำชี้แจง: กรุณากรอกข้อมูลลงในช่องว่าง หรือทำเครื่องหมาย✓ ลงใน ☐

1. **ข้อมูลทั่วไป**

HN………………………………

ชื่อ-นามสกุล.. อายุ...........ปี เพศ ชาย .

น้ำหนัก............ กก. ส่วนสูง......................ซม. BMI…………………kg/m^2

วันเดือนปีเกิด..............................เบอร์โทรที่ติดต่อได้ ....

ที่อยู่...

....

สถานภาพ☐ โสด ☐ สมรส ☐ หย่า ☐ หม้าย

ถนัดแขน ☐ ซ้าย ☐ ขวา

2. **ข้อมูลด้านสุขภาพ**

COPD stage…………….. CAT………………. mMRC…………………

COPD duration……………… years

โรคประจำตัว..

ประวัติการสูบบุหรี่..

ประวัติการผ่าตัด..

ประวัติการเข้านอนโรงพยาบาลล่าสุดที่ผ่านมา..

ประวัติการรับยา (ทาน, พ่น,ฉีด)..

ประวัติการกิดอุบัติเหตุ (กระดูกหัก หรืออื่นๆ)..

คุณเคยมีประวัติเจ็บแน่นหน้าอกมาก่อนหรือไม่ ☐ ไม่เคย ☐ เคย จาก..

3. **ข้อมูลการตรวจร่างกาย**

ขณะพัก ; BP……………………………..mmHg, HR……………………bpm, SpO_2…………………%,

RPD……………..

COPD stage………………… FEV1………………… L, FEV1/FVC……………………..

ข้อมูลอื่นๆ เพิ่มเติม...

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แบบบันทึกข้อมูล

1) **Respiratory muscle strength test**

	Pre-test				Post-test 1 (4 week)				Post-test 2 (8 week)			
	1	2	3	Max	1	2	3	Max	1	2	3	Max
PImax (cmH_2O)												
PEmax (cmH_2O)												

ปัญหาระหว่างการทดสอบ ถ้ามีให้ระบุ ;..

2) **Chest expansion**

	Pre-test				Post-test 1 (4 week)				Post-test 2 (8 week)			
	1	2	3	Max	1	2	3	Max	1	2	3	Max
Upper (cm)												
Middle (cm)												
Lower (cm)												

ปัญหาระหว่างการทดสอบ ถ้ามีให้ระบุ ;..

3) Pulmonary function test

	Pre-test					Post-test 1 (4 week)					Post-test 2 (8 week)				
	ครั้งที่ 1	ครั้งที่ 2	ครั้งที่ 3	Best	% predicted	ครั้งที่ 1	ครั้งที่ 2	ครั้งที่ 3	Best	% predicted					
FVC (L)															
FEV1 (L)															
FEV1/FVC (%)															
$FEF_{25-75\%}$ (l/SEC)															
PEF (l/MIN)															
FEV1 POST (l)	.......%Change…….., ….mL, FVC post (L), ...%Change……..,……..mL					.......%Change…….., …….mL, FVC post (L), ...%Change……..,……..mL					.......%Change…….., …….mL, FVC post (L), ...%Change……..,……..mL				

Diagnosis……

แปลผลการตรวจ………………………………………………………………………………………………………

ปัญหาที่พบในการตรวจ…………………………………………………………………………………………………

4) Rounded shoulder posture or Forward shoulder

	Pre-test				Post-test 1 (4 week)				Post-test 2 (8 week)			
	1	2	3	Average	1	2	3	Average	1	2	3	Average
Right (cm)												
Left (cm)												

5) Pectoralis minor index

	Pre-test				Post-test 1 (4 week)				Post-test 2 (8 week)			
	1	2	3	Average	1	2	3	Average	1	2	3	Average
Right (cm)												
Left (cm)												

6) Thoracic kyphosis

	Pre-test				Post-test 1 (4 week)				Post-test 2 (8 week)			
	1	2	3	Average	1	2	3	Average	1	2	3	Average
TK (θ)												

7) Muscle strength

Lower trapezius muscle

	Pre-test				Post-test 1 (4 week)				Post-test 2 (8 week)			
	1	2	3	Max	1	2	3	Max	1	2	3	Max
Right (kg)												
Left (kg)												

Serratus anterior muscle

	Pre-test				Post-test 1 (4 week)				Post-test 2 (8 week)			
	1	2	3	Max	1	2	3	Max	1	2	3	Max
Right (kg)												
Left (kg)												

แบบบันทึกข้อมูลของ ……………………………………………………………………… No.…………

No.	Items		Results (Mean)		
			Pre-test (week 0)	Post-test 1 (week 4th)	Post-test 2 (week 8th)
1	CAT (point)				
2	mMRC (point)				
3	PImax (cmH_2O)				
4	PEmax (cmH_2O)				
5	RSP (cm)				
	Lt.				
	Rt.				
6	Pectoralis minor index				
	Lt.				
	Rt.				
7	Thoracic kyphosis (θ)				
8	Muscle strength (kg)				
	Lower trapezius (kg)	Dominant side			
		Non-dominant side			
	Serratus anterior (kg)	Dominant side			
		Non-dominant side			
9	Lung function				
	FVC (L)				
	FEV1 (L)				
	FVC/FEV1				
10	Chest expansion (cm)				
	Upper				
	Middle				
	Lower				

APPENDIX B

แบบประเมินความรู้สึกเหนื่อย

(Modified British Medical Research Council; mMRC dyspnea scale)

mMRC เป็นมาตรวัดความรู้สึกเหนื่อย ในการประกอบกิจกรรมในชีวิตประจำวัน โดยให้ผู้ป่วยเลือกว่ามีความเหนื่อยอยู่ในระดับใด ตามตัวเลขจากน้อยไปมากเพียงข้อเดียว คะแนนที่มากที่สุดคือ 4

mMRC	เกณฑ์การให้คะแนน ภาวะหายใจลำบาก กรุณาทำเครื่องหมาย ✓ เพียง 1 ข้อ	
เกรด 0	รู้สึกหายใจหอบ ขณะออกกำลังกายอย่างหนักเท่านั้น	☐
เกรด 1	หายใจหอบเมื่อเดินอย่างเร่งรีบบนพื้นราบ หรือเมื่อเดินขึ้นที่สูงชัน	☐
เกรด 2	เดินบนพื้นราบได้ช้ากว่าคนอื่นที่อยู่ในวัยเดียวกันเพราะหายใจหอบ หรือต้องหยุดเพื่อหายใจ เมื่อเดินตามปกติบนพื้นราบ	☐
เกรด 3	ต้องหยุดเพื่อหายใจ หลังจากเดินได้ประมาณ 100 เมตร หรือหลังเดินได้สักพัก บนพื้นราบ	☐
เกรด 4	หายใจหอบมากเกินกว่าที่จะออกจากบ้าน หรือหอบมากขณะแต่งตัว หรือเปลี่ยนเครื่องแต่งตัว	☐

ที่มา สมาคมอุรเวชช์แห่งประเทศไทย แนวปฏิบัติบริการสาธารณสุข โรคปอดอุดกั้นเรื้อรัง พ.ศ.2556

APPENDIX C

COPD Assessment Test; CAT assessment

CAT คือ แบบประเมินเพื่อวัดคุณภาพชีวิตของผู้ป่วย COPD เป็นการประเมินอาการ ความสามารถในการประกอบกิจวัตรประจำวัน ความรู้สึกดี และความมั่นใจของตนเองทั้งหมด 8 หัวข้อ โดยผู้ป่วยให้คะแนนตนเองในแต่ละหัวข้อ ระหว่างดี (0) จนถึงแย่มาก (5) แล้วนำคะแนนแต่ละหัวข้อมารวมกัน ดังนั้นคะแนนคุณภาพที่แย่ที่สุดจะเท่ากับ 40

โปรดกาเครื่องหมาย (x) ลงในช่องด้านล่างที่อธิบายถึงอาการปัจจุบันของท่านได้ดีที่สุด

กรุณาเลือกเพียงคำตอบเดียวสำหรับแต่ละคำถามเท่านั้น

โปรดกาเครื่องหมาย (X) ลงในช่องด้านล่างที่อธิบายถึงอาการปัจจุบันของท่านได้ดีที่สุด

กรุณาเลือกเพียงคำตอบเดียวสำหรับแต่ละคำถามเท่านั้น

ตัวอย่าง: ข้าพเจ้ามีความสุขมาก ( ) [X] 1 2 3 4 5 ข้าพเจ้าเศร้าใจมาก

ลำดับ	รายการที่ได้คะแนนน้อยที่สุด	CAT	รายการที่ได้คะแนนมากที่สุด	คะแนน
1	ข้าพเจ้าไม่เคยมีอาการไอ	0 1 [X] 3 4 5	ข้าพเจ้าไอตลอดเวลา	2
2	ข้าพเจ้าไม่มีเสมหะในปอดเลย	0 1 [X] 3 4 5	ปอดของข้าพเจ้าเต็มไปด้วยเสมหะ	2
3	ข้าพเจ้าไม่รู้สึกแน่นหน้าอกเลย	0 1 2 [X] 4 5	ข้าพเจ้าไม่รู้สึกแน่นหน้าอกมาก	3
4	ข้าพเจ้าเดินขึ้นเนินหรือขึ้นบันไดหนึ่งชั้น ข้าพเจ้ายังคงหายใจได้คล่อง	0 [X] 2 3 4 5	เมื่อข้าพเจ้าเดินขึ้นเนินหรือขึ้นบันไดหนึ่งชั้น ข้าพเจ้ารู้สึกเหนื่อยหอบอย่างมาก	1
5	ข้าพเจ้าทำกิจกรรมต่างๆที่บ้านได้โดยไม่จำกัด	0 [X] 2 3 4 5	ข้าพเจ้าทำกิจกรรมต่างๆที่บ้านได้อย่างจำกัดมาก	1
6	ข้าพเจ้ามีความมั่นใจที่จะออกไปนอกบ้านทั้งๆที่ปอดข้าพเจ้ามีปัญหา	0 1 [X] 3 4 5	ข้าพเจ้าไม่มีความมั่นใจเลยที่จะออกไปนอกบ้านเพราะปอดข้าพเจ้ามีปัญหา	2
7	ข้าพเจ้านอนหลับสนิท	0 1 [X] 3 4 5	ข้าพเจ้านอนหลับไม่สนิทเพราะปอดของข้าพเจ้ามีปัญหา	2
8	ข้าพเจ้ารู้สึกกระฉับกระเฉงอย่างมาก	0 1 [X] 3 4 5	ข้าพเจ้ารู้สึกอ่อนเพลียและเหนื่อยล้า	2
			Total score	…15….

APPENDIX D

Modified Borg Scale; Borg's rate of perceived exertion

Modified Borg scale คือ คะแนนประเมินความเหนื่อยขณะปัจจุบันขณะใดขณะหนึ่ง โดยอาจจะประเมินความเหนื่อยขณะอยู่กับที่ ก่อนทำกิจกรรม ขณะทำกิจกรรม หรือภายหลังทำกิจกรรมก็ได้ การประเมินสามารถกระทำโดยกำหนดการตรวจวัดความเหนื่อยตั้งแต่ 0-10

โดย 0 หมายถึง ไม่เหนื่อยเลย

1-10 หมายถึง ระดับความเหนื่อยที่มากขึ้นเรื่อยๆ

10 หมายถึง เหนื่อยมากที่สุดจนจะขาดใจ

จากนั้นให้ผู้ป่วยประเมินตนเองว่ามีความเหนื่อยอยู่ระดับใด ระหว่าง 0-10

แบบประเมินระดับความเหนื่อย			Rest	During activity
0	Nothing at all	ไม่รู้สึกเหนื่อยแม้แต่น้อย	☐	☐
0.5	Very, very slight (just noticeable)	แค่เริ่มรู้สึกเหนื่อยเล็กน้อยเท่านั้น	☐	☐
1	Very slight	เหนื่อยน้อยมาก	☐	☐
2	Slight	เหนื่อยเล็กน้อย	☐	☐
3	Moderate	เหนื่อยพอสมควร	☐	☐
4	Somewhat Severe	เหนื่อยค่อนข้างมาก	☐	☐
5	Severe	เหนื่อยมาก	☐	☐
6			☐	☐
7	Very Severe	เหนื่อยสุดสุด	☐	☐
8			☐	☐
9	Very, very severe (almost maximal)	เหนื่อยสาหัสสากรรจ์	☐	☐
10	Maximal	เหนื่อยที่สุดในชีวิต	☐	☐

VITA

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