RESPIRATORY MUSCLE STRENGTH
IN THAI HEALTHY SUBJECTS AGED 30-70 YEARS

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Orawan Ponngeon

RESPIRATORY MUSCLE STRENGTH IN THAI HEALTHY SUBJECTS AGED 30-70 YEARS

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ABSTRACT

The purpose of this study was to determine the relationship between respiratory muscle strength and age, gender, weight and height. Two hundreds and forty-nine healthy volunteers (122 females and 127 males) aged 30-70 years participated in this study. The subjects of each gender were divided into four age groups; 30-39, 40-49, 50-59 and 60-70 years. Inspiratory and expiratory muscle strength of each subject were determined by maximal inspiratory mouth pressure (MIP) and maximal expiratory mouth pressure (MEP), respectively, using a mouth pressure meter (Spirovis). Each subject performed 10 and 12 trials of MIP and MEP test, respectively, and the highest value of each test was accepted.

Results showed that mean of MIP in females in 30-39, 40-49, 50-59 and 60-70 year groups were 93.13± 26.38, 94.20±29.96, 84.41±24.09 and 71.90±20.75 cmH_2O, respectively, and that of MEP were 94.45± 31.19, 95.03±33.99, 99.94±28.83 and 79.90±25.55 cmH_2O, respectively. Mean of MIP in males in 30-39, 40-49, 50-59 and 60-70 year groups were 133.27± 23.94, 131.38±30.11, 118.16±31.17 and 105.81±18.09 cmH_2O, respectively, whereas the mean of MEP were 177.03± 42.42, 184.25±47.43, 159.10±55.24 and 160.32±45.98 cmH_2O, respectively. Two way analysis of variance indicated that gender affected MIP and MEP ($p<0.001$). Males had MIP and MEP higher than females. MIP decreased with age older than 60 years ($p<0.05$) but age had no effect on MEP in both genders. MIP was correlated with age and weight in both genders but only correlated to height in males, whereas MEP was not correlated with age, weight and height in both genders. MIP equation was 77.57-0.59Age+0.62Weight ($p=0.004$) for females and 124.39-0.91Age+0.63Weight ($p=0.018$) for males.

Respiratory muscle strength in females was less than in males. Findings from this study could be used as preliminary data of respiratory muscle strength in Thai. Predicted MIP from regression equation could possibly be applied for clinical screening tests.

KEY WORDS: RESPIRATORY MUSCLE STRENGTH / MAXIMAL INSPIRATORY MOUTH PRESSURE / MAXIMAL EXPIRATORY MOUTH PRESSURE / AGE / GENDER / WEIGHT / HEIGHT

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ความแข็งแรงของกล้ามเนื้อหายใจในคนไทยสุขภาพดีอายุ 30-70 ปี (RESPIRATORY MUSCLE STRENGTH IN THAI HEALTHY SUBJECTS AGED 30-70 YEARS)

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บทคัดย่อ

การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อหาความสัมพันธ์ระหว่างความแข็งแรงของกล้ามเนื้อหายใจและอายุ เพศ น้ำหนักและส่วนสูง ในอาสาสมัครสุขภาพดี จำนวน 249 คน (หญิง 122 และชาย 127 คน) อายุ 30-70 ปี แบ่งเป็น 4 กลุ่ม ได้แก่ 30-39, 40-49, 50-59และ 60-70 ปีในเพศหญิงและเพศชาย ตัวแปรในการศึกษานี้ได้แก่ ความแข็งแรงของกล้ามเนื้อหายใจเข้าและกล้ามเนื้อหายใจออก วัดโดยเครื่องวัดความแข็งแรงของกล้ามเนื้อหายใจ ทำการวัดความแข็งแรงของกล้ามเนื้อหายใจเข้า จำนวน 10 ครั้งและกล้ามเนื้อหายใจออก จำนวน 12 ครั้ง นำค่าที่สูงที่สุดมาวิเคราะห์ผล

ผลการศึกษาพบว่า ค่าเฉลี่ยของความแข็งแรงของกล้ามเนื้อหายใจเข้าในเพศหญิง อายุ 30-39, 40-49, 50-59 และ 60-70 ปี เท่ากับ 93.13±26.38, 94.20±29.96, 84.41±24.09 และ 71.90±20.75 ซม.น้ำ ตามลำดับและกล้ามเนื้อหายใจออก เท่ากับ 94.45± 31.19, 95.03±33.99, 99.94±28.83 และ 79.90±25.55 ซม.น้ำ ตามลำดับ ส่วนความแข็งแรงของกล้ามเนื้อหายใจเข้าในเพศชาย อายุ 30-39, 40-49, 50-59 และ 60-70 ปี เท่ากับ 133.27± 23.94, 131.38±30.11, 118.16±31.17 และ 105.81±18.09 ซม.น้ำ ตามลำดับและกล้ามเนื้อหายใจออก เท่ากับ 177.03± 42.42, 184.25±47.43, 159.10±55.24 และ 160.32±45.98 ซม.น้ำ ตามลำดับ โดยที่ผลการวิเคราะห์ความแปรปรวนพบว่า เพศมีผลต่อความแข็งแรงของกล้ามเนื้อหายใจเข้าและหายใจออก โดยเพศชายมีค่ามากกว่าเพศหญิง ความแข็งแรงของกล้ามเนื้อหายใจเข้าลดลงเมื่ออายุมากกว่า 60 ปี แต่อายุไม่มีผลต่อกล้ามเนื้อหายใจออกในทั้งสองเพศ ความแข็งแรงของกล้ามเนื้อหายใจเข้ามีความสัมพันธ์กับอายุและน้ำหนักในทั้งสองเพศ และสัมพันธ์กับส่วนสูงเฉพาะในเพศชาย ส่วนความแข็งแรงของกล้ามเนื้อหายใจออกไม่มีความสัมพันธ์กับอายุ น้ำหนักและส่วนสูงในทั้งสองเพศ สมการความแข็งแรงของกล้ามเนื้อหายใจเข้าในเพศหญิงเท่ากับ 77.57-0.59อายุ+0.62น้ำหนัก และเพศชายเท่ากับ 124.39-0.91อายุ+0.63น้ำหนัก

ความแข็งแรงของกล้ามเนื้อหายใจในเพศหญิงมีค่าน้อยกว่าเพศชาย ผลการศึกษานี้สามารถใช้เป็นข้อมูลพื้นฐานความแข็งแรงของกล้ามเนื้อหายใจในคนไทย คาดคะเนค่าความแข็งแรงของกล้ามเนื้อหายใจเข้าจากสมการและอาจนำไปประยุกต์ใช้ในทางคลินิกเพื่อการคัดกรองได้

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LIST OF ABBREVIATIONS

A	Age
BMI	Body mass index
bpm	beat per min
ºC	Degree Celsius
cm	Centimeter (s)
cmH_2O	Centimeters of water
COPD	Chronic Obstructive Pulmonary Disease
FEV_1	Forced expiratory volume in 1 second
FVC	Forced vital capacity
Ht	Body height
kg	kilogram (s)
MEP	Maximal Expiratory Mouth Pressure
MIP	Maximal Inspiratory Mouth Pressure
mmHg	Millimeters of mercury
RV	Residual volume
TLC	Total lung capacity
tpm	time per min
Wt	Body weight
yrs	years

CHAPTER I
INTRODUCTION

Respiratory muscles are skeletal muscle (1) that consists of diaphragmatic, intercostals, abdominal and accessory muscles. The important role of respiratory muscles is to displace the chest wall rhythmically in order to pump gas in and out of the lungs (2). The performance of respiratory muscle can be measured in term of strength and endurance. Respiratory muscle strength can be quantified by measuring of Maximum Inspiratory Mouth Pressure (MIP) and Maximum Expiratory Mouth Pressure (MEP) (3). The MIP is an index of the strength of the inspiratory muscles that are diaphragm muscles, external intercostals, and accessory muscles such as scalenes and sternomastoid muscles. In contrast, the MEP measures the strength of the expiratory muscles including abdominal, internal intercostal muscles and other muscles (4, 5).

Measuring of MIP and MEP is simple, quick and noninvasive clinical procedures for determining respiratory muscle strength (4, 6-13). Measurements of maximal respiratory pressure were determined in healthy subjects (10, 13), patients with pulmonary disease including chronic obstructive pulmonary disease (COPD) (5) and restrictive lung disease (14), and other diseases inducing respiratory muscle weakness such as malnutrition (5), endrocrine diseases, long term treatment of corticosteroids (5, 15, 16), kyphoscoliosis (17) and Parkinson's disease (18).

The MIP is used for maintaining ventilation and predicting the success of weaning from mechanical ventilation in neuromuscular disease and severe thoracic malformation patients (20). The MEP is mainly used in facilitating airway clearance (21) and diagnosis of neuromuscular disease, which may weaken this pressure (19). Moreover, a sufficient MEP is crucial for efficient coughing to prevent accumulation of secretion in the lower airway (4, 19, 22, 23) leading to chest infection (24), a

serious cause of morbidity and mortality in patients with respiratory and neuromuscular diseases (25).

Age and gender have an influence on measuring respiratory muscle performance. Chen and Kuo (26) studied relationship between respiratory muscle function and age, gender including other factors in 160 subjects aged range 16 to 75 years. They found MIP and MEP values were greater in men than women in Chineses and decreased with age. Similarly, Ringqvist (7) studied the ventilatory capacity in healthy subjects aged range between 18-83 years by using MIP and MEP. They showed that MIP and MEP values in males were higher than females and decreased when age was over than 50 years. Black and Hyatt (12) studied normal values of maximal respiratory pressures and relationship with age and gender in 120 subjects aged range 20-80 years. This study demostrated the decrease of MIP in females older than 55 years. However, the MEP decreased with age in both genders.

Height and weight are the other factors that influence respiratory muscle strength. Wilson et al (8) studied predicted normal values of maximal respiratory pressure in 138 Caucasian adults aged range between 18 to 70 years and 235 children aged range between 7 to 17 years. This study demonstrated that there was a correlation between respiratory muscle strength and height in females. This results corresponded with the study of Harik-Khan et al (27) who determined maximal inspiratory pressure in the Baltimore longitudinal study. On the contrary, Enright and coworkers (4) studied the correlations and reference values of respiratory muscle strength in the elderly. The study did not showed the any correlation between respiratory strength and height except the correlation of weight and respiratory muscle strength in both genders. This is consistent with study of Harik-Khan et al. McConnell and coworker (28) also studied maximum static respiratory pressure in healthy elderly men and women. They found to be poor correlation between respiratory muscle strength and height. Nevertheless, weight was found correlate with respiratory muscle strength only in females. Up to now, the correlations between characteristics of subjects and respiratory muscle performance are still controversial.

The accurate measurement and interpretation of respiratory muscle strength are the important factors in order to the diagnosis of respiratory muscle weakness (28). Various methods affect the variety of normal value of respiratory mouth pressure (29). Ringqvist (7) and Black and Hyatt (12) established the normative data but their methods also differed. Ringqvist (7) suggested that measuring peak performance of MIP and MEP required an extensive series of maneuvers for the inexperienced subjects to learn the maneuvers. An average of 10 or more measurement maneuvers per test were used to establish the normative data. In contrast, Black and Hyatt (12) established their data based on the best of only two technically acceptation. Data of Black and Hyatt were 10 to 20 cmH_2O lower than data of Ringqvist. Many studies used five or less maneuver to establish normative data (3, 4, 8-10, 12, 30, 31) and found that normative data were lower than the result of Ringqvist. Wen and coworker (29) studied number of maneuvers that required to measure maximal inspiratory pressure. They recommended the more maneuvers per test which provided the more accurate assessment of true respiratory muscle strength. Additionally, it was suggested that data of Ringqvist which were higher than Black and Hyatt resulted from learning effect.

Jarugjitaree and Chaipiyaporn (32) studied respiratory muscle strength in young Thai adults aged between 18-25 years. They found that MIP and MEP in males were higher than females by using method similar to Black and Hyatt. However, the data of 30-70 years old are lacking. At this age range, people are at risk of COPD. There are many normal values references of MIP and MEP in variable normal subjects (1, 3, 4, 7-10, 12, 27, 30, 31) and variations of normal values. However, reference values of respiratory muscle strength in individual nationality are essential. For this reason, the purposes of these study is to determine the relationship between respiratory muscle strength and subject characteristics which are age,gender, height and weight.

Purpose of the Study

General Objective

To determine the relationship between respiratory muscle strength and characteristics of subject which are age, gender, height and weight.

Specific Objectives

1. To determine effects of age-group and gender on MIP and MEP.
2. To study correlation between MIP and age, height and weight in each gender.
3. To study correlation between MEP and age, height and weight in each gender.
4. To determine reference equations of MIP and MEP with age, height and weight in each gender.
5. To determine the preliminary data of MIP and MEP in Thai subjects.

Parameters of the Study

1. Respiratory muscle strength: Maximal inspiratory mouth pressure (MIP)
   Maximal expiratory mouth pressure (MEP)
2. Age
3. Gender
4. Height
5. Weight

Scope of the Study

This study determines the respiratory muscle strength in Thai healthy subjects aged ranges 30-70 years using measurement of MIP and MEP.

Hypotheses of the Study

1. There would be significant effects of age and gender on MIP and MEP.
2. There would be significant correlation between MIP and age, height and weight in female.

3. There would be significant correlation between MEP and age, height and weight in female.
4. There would be significant correlation between MIP and age, height and weight in male.
5. There would be significant correlation between MEP and age, height and weight in male.

Advantages of the Study

1. To provide preliminary data of respiratory muscle strength of Thai healthy subjects age range 30-70 years.
2. To provide predict values of respiratory muscle strength from reference equation in Thai healthy subjects age range 30-70 years.
3. To apply for clinical screening test for people who have risk of respiratory muscle failure from respiratory muscle weakness.
4. To develop reliable methods of MIP and MEP measurement.

CHAPTER II
LITERATURE REVIEW

2.1 Anatomy and physiology of respiratory muscles

2.1.1 Anatomy of respiratory muscles

2.1.1.1 Inspiratory muscles

2.1.1.1.1 Diaphragmatic muscles

The diaphragm is a musculotendinous sheet which separates the thoracic cavity from the abdominal cavity (33). It consists of a central tendon with peripheral striated muscle attaching the tendon to the sternum, ribs and vertebral column. The dome extends upward from the costal margin to about the level of the fifth intercostals space. Its precise level cannot be marked because the diaphragm moves up and down the respiratory cycle (34). When diaphragm contraction, the volume of the thoracic cavity increases by tensing with flattening its floor and increases drawing air into the lungs. Diaphragmatic contraction is responsible for roughly 75 percents of air movement in normal breathing at rest. The effectiveness of the diaphragm in changing thoracic volume is related to the strength of its contraction and its dome-shaped configuration when relaxed (35).

2.1.1.1.2 External intercostals muscles

External intercostal muscle passes from the lower border of one rib to the upper border of the rib below, running in a downward and forward direction. It extends from the tubercle of the rib to the costochondral junction, where it is replaced by fibrous tissue that extends to the sternum (34). It assists inhalation by elevating the ribs. Its contraction is responsible for roughly 25 percents to the volume of air into the lung (36).

2.1.1.1.3 Accessory muscles

Accessory muscles for inspiration including the sternocleidomastoid, serratus anterior, pectoralis minor and scalene muscles (34).

Sternocleidomastoid muscle runs from near the midline to the posterosuperior aspect of the neck. Lower attachment is the medial one third of the clavicle and upper attachment is the mastoid process and the lateral half of the superior nuchal line of skull.

Serratus anterior muscle is a large flat muscle that is of major importance in protracting the scapula and in holding it against the chest wall. The proximal attachments are by individual digitations from the upper eight ribs and distal attachment is the whole of the medial border of the scapula.

Pectoralis minor muscle arises from the third to fifth ribs and inserts into the coracoid process of the scapula.

Scalene muscle is attached to the posterior tubercles of the transverse process of all the cervical vertebrae (Scalenus medius) and above to the anterior tubercles of the second to sixth cervical vertebrae (Scalenus anterior) and attaches below to the first rib. They assist the external intercostals muscle by elevating ribs (36).

2.1.1.2 Expiratory muscles

2.1.1.2.1 The internal intercostals muscles

The internal intercostal muscles pass from the floor of the costal groove of the rib above downward and backward to the upper border of the rib below. They extends form the sternum to the angles of the ribs and continues backward from this point. They depress the ribs and reduce the width and depth of the thoracic cavity (34).

2.1.1.2.2 The abdominal muscles

Abdominal muscles include the external and internal abdominal oblique, transverses abdominis and rectus abdominis muscles.

The external abdominal oblique muscle is attached above to the outer surfaces of the lower eight ribs. Its fibers pass downward and medially. They become aponeurotic and blend with the aponeurosis of the internal oblique muscle to form the anterior layer of the rectus sheath.

The internal abdominal oblique muscle is attached to the lateral one half of inguinal ligament and the anterior two thirds of the iliac crest. Above, the muscle is attached to the costal margin and in front it becomes aponeurotic and spits into two layers.

The transverses abdominis muscle is attached below to the lateral one third of the inguinal ligament, the iliac crest and the conjoint tendon, posteriorly to the thoracolumbar fascia, above to the inner surfaces of the lower six ribs and anteriorly to the linea alba.

The rectus abdominis muscle runs vertically from the crest and the symphysis of the pubis to the fifth, sixth and seventh costal cartilages. It is about 7.5 cm wide and is contained with the rectus sheath.

Generally, they act together to maintain or increase intraabdominal pressure in activities such as coughing or deep expiration (34). Contraction of the abdominal muscle results in an inward displacement of the abdomen and an increase in abdominal pressure (Pab). They assist the internal intercostals muscles in exhalation by compressing the abdomen and forcing the diaphragm upward (36).

2.1.2 Physiology of respiratory muscles

The physiology principles of respiratory muscles are like other skeletal muscles. However, there are some differences from other skeletal muscles in several

important aspects. They are the only skeletal muscle which life depends, control under both voluntary and involuntary, deal chiefly with elastic and resistant load, while most other skeletal muscles cope mainly with inertial loads. The physiologic principles of skeletal muscle function are reasonably well known and the intrinsic physiologic properties of the respiratory muscles include;

2.1.2.1 Force-length relationships

In the respiratory system, as the lungs inflate the inspiratory muscles shorten and the expiratory muscles lengthen. The lung volume is an index of respiratory muscle length and the pressures that these muscles can develop is an index of their force. The relationship between maximal inspiratory and expiratory pressures that can be generated at different lung volumes is a measure of the force-length properties of respiratory muscle (37). When the lung volume increases, MIP decreases whereas MEP increases (38). The various respiratory muscle groups can be made to lengthen differently to achieve the same lung volume and the transformation from a force developed by respiratory muscles to a pressure acting on the system depends on the mechanical advantages of muscles and geometric (33). Maximal inspiratory and expiratory pressure-volume curves of the respiratory muscles are only indirect expressions of the force-length relationships of these muscles (37). Recently, the force-length relationship of the human diaphragm have been inferred from pressure measurements and chest roentgenograms taken at different lung volumes (39). The diaphragm is rich in tendon organs that increase their firing rate during inspiration.

2.1.2.2 Force-velocity relationships

The lung volume is an index of inspiratory and expiratory muscle length in the respiratory system. Inspiratory and expiratory rate of airflow are a key of the velocity of muscle shortening. The faster the velocity of contraction of muscle, the less is the force that it develops (37). When maximal inspiratory and expiratory efforts are made through different sized orifices to vary resistance to airflow, the maximal pressure exerted by the respiratory muscles decrease as the rate of airflow increases (40, 41). Muscle function may be coordinated in such a way that the muscles are always shortening at the velocity that will produce optimum power (33).

2.1.2.3 Fatigue

Fatigue of respiratory muscles is unable to produce sufficient force to sustain adequate movement of air into and out of the lungs. Respiratory muscle can be fatigue. Respiratory muscle fatigue is important in a variety of clinical disorders associated with respiratory muscle failure (33). Respiratory muscles contain three types of fibers but are composed chiefly of two of them. Type I which are slow-twitch and high-oxidation fibers as well as type II which are fast-twitch and low-oxidation fibers. Type I fibers are approximately three times more efficient than type II fibers in sustaining an isometric contraction and thus are more resistant to fatigue (42).

There are two basic types of respiratory muscles fatigue. They are central and peripheral fatigue. The most causes of respiratory muscle fatigue are peripherals and it can be attributed to failure of metabolic regenerative process in the muscle fiber. Increasing of work or decreasing in strength or efficiency can lead to respiratory muscle fatigue (33).

2.2 Mechanics of breathing

Breathing is achieved by changes in the size of the thoracic cavity, brought about by contraction of the respiratory muscles. Enlargement of the thorax can occur by displacement outward either of the rib cage or the abdominal wall (33).

Prime functions of the respiratory system include 1) maintaining a constant internal environment by providing oxygen for metabolic needs and excreting carbon dioxide, 2) transporting of gas by the blood to and from the body cells, 3) concerning intracellular oxygen utilization through metabolic transformations and 4) being generally considered the provide of biochemistry (43).

The other roles include controlling acid-base balance, defending the body against inhaled particles (e.g. bacteria, pollen), acting as a filter to prevent clots from entering the systemic circulation and regulating various hormonal and humeral concentrations by means of the pulmonary capillary endothelium (43).

2.3 Control of breathing

Main types of control regulate breathing are automatic or metabolic control and voluntary or behavioral control. Automatic control is concerned with oxygen delivery and acid-base balance. Another, voluntary is related to coordinated activities in which breathing may be temporarily suspended or altered.

The respiratory control system consists of 1) central controller (driver) located in the brainstem (Medulla and Pons), 2) muscles of the chest wall (also the smooth muscle of airways), and 3) various sensors that report back to the central controller as the results of the intended action.

The sensory component includes central chemoreceptor (on or near the surface of medulla), peripheral chemoreceptor (on carotid bodies) and proprioceptors (lung stretch, irritant and C-fiber receptor; plus diaphragm, intercostals and abdominal muscle, muscle spindles and tendon and joint organs) (44).

2.4 Assessment of respiratory muscle strength

Respiratory muscle strength can be measured in airway pressure and transdiaphragmatic pressure. Airway pressures are assessed by measuring the maximum inspiratory mouth pressure (MIP) and maximum expiratory mouth pressure (MEP). Transdiaphragmatic pressure (Pdi) provides the most direct method of assessing diaphragmatic strength by passing of two balloon catheters, one to measure esophageal pressure (Pes) and the other to measure gastric pressure (Pga) (45). Usually, MIP and MEP are measured in clinic because it is simple to perform.

2.4.1 Maximum inspiratory mouth pressure (MIP) and maximum expiratory mouth pressure (MEP)

Maximum respiratory mouth pressures are measured at the mouth during forceful efforts against a closed or virtually closed airway. Provided that the glottis is open, the mouth pressure in this situation is equal to alveolar pressure and includes a contribution from the passive recoil of the respiratory system. Therefore, mouth (or alveolar) pressure can only be exactly equal with muscle pressure if the respiratory

system recoil is zero, a situation which applies at functional residual capacity (FRC) (5).

MIP is an index of inspiratory muscle strength (4). Measurement can be performed at residual volume (RV) or FRC (5, 24) following maximum expiration (12). In practice, patients can perform maneuver easier from RV than FRC (5, 24).

MEP is an index of expiratory muscle strength (5). MEP is usually measured at total lung capacity (TLC) following a maximum inspiration (12). MEP value is usually greater than MIP because at TLC the expiratory muscles strength are greatest (i.e. optimal) length, while the inspiratory muscles are optimal length at much smaller lung volumes (5).

Normal values of MIP and MEP

Ringqvist in 1966 (7) studied the ventilatory capacity in healthy patients: an analysis of causal factors with special reverence to respiratory force. He measured MIP and MEP in subjects aged range 18-83 years. He used an average of 10 maneuvers per test to establish his normative data. He found MIP and MEP in males higher than females and decreased when age over than 50 years (Table 2.1).

Black and Hyatt in 1969 (12) determined MIP and MEP in 120 normal adults (60 males and 60 females) aged 20 to 74 years. They reported mean MIP and MEP between gender and aged range (Table 2.1). Furthermore, they created regression equation (Table 2.2).

Wilson et al in 1984 (8) measured MIP and MEP in 370 normal Caucasian children and adults. They found correlation of age and height with respiratory muscle strength and reported regression equation (Table 2.2).

Chen and Kuo in 1989 (26) studied relationship between respiratory muscle function and age, gender and other factors in 160 Chinese volunteers (80 males

and 80 females) aged 16 to 75 years. They reported mean MIP and MEP and regression equation (Table 2.1 and Table 2.2).

Enright et al in 1994 (4) studied correlations and reference values of respiratory muscle strength in elderly in 4,443 ambulatory participants of the Cardiovascular Health Study, age 65 years and older. They reported mean values were 57/116 cmH_2O (MIP/MEP) for women and 83/174 cmH_2O for men. They reported mean MIP and MEP and regression equation (Table 2.1 and Table 2.2).

Johan et al in 1997 (46) studied maximal respiratory pressures in adult Chinese, Malays and Indians (221 Chinese, 111 Malays, 120 Indians). They found males had higher respiratory muscle strength than females. Chinese males had higher MIP and MEP than Malays and Indians. They reported regression equation of respiratory muscle strength in Table 2.2.

Nerder et al in 1999 (47) studied reference values of maximal respiratory pressure and voluntary ventilation in 100 non-smoking subjects (50 males and 50 females), 20 to 80 years old. They reported mean MIP and MEP and regression equation (Table 2.1 and Table 2.2).

2.4.2 Sniff test

Sniff mouth pressure is one index of respiratory muscle strength. It can be measured at nasal, esophageal and transdiaphragmatic sniff pressure. The nose appears to act as Starling resister, so nasal flow is low and largely independent of driving pressure, esophageal pressure (Pes) (48). Transdiaphragmatic pressure (Pdi) measured during a sniff reflects diaphragm strength and esophageal pressure (Pes) reflects the integrated pressure of the inspiratory muscles on the lungs (49).

The maximal sniff is a natural maneuver, easily performed and repeatable without fatiguing (50). However, the pressures measured during a sniff may be less than maximal static values because of shortening of the inspiratory muscle (51) and

may be difficult or impossible in patient with upper airway distortion and particularly if the nose is completely obstructed (49).

2.4.3 Transdiaphragmatic pressure (Pdi)

Transdiaphragmatic pressure (Pdi) is the difference between pulmonary pressure (Ppl) and abdominal pressure (Pab). In practical, it is generally equal to the difference between esophageal pressure (Pes) and gastric pressure (Pga). So that

$$Pdi = Pga – Pes$$

Pes and Pga are most often measured by passing a pair of probes and balloon catheters through the nose to esophageal or stomach while monitoring the signal on an oscilloscope or computer screen (49). Disadvantages of this procedure is require cooperation of subject and if untrained usually fail to increase Pdi because of lake of coordination (4).

Table 2.1 Mean and SD of respiratory muscle strength from different studies

Reference	Number of maneuvers (times)	Age range (year)	No. of subject (male/ female)	Mean and SD of Pressure (cmH_2O)			
				MIP		MEP	
				males	females	males	females
Ringqvist (7) (Caucasian)	≥10	18-29	37/33	146±26	113±24	247±41	170±29
		30-39	12/8	148±21	97±24	248±38	163±29
		40-49	15/14	134±29	104±27	253±52	178±33
		50-59	13/12	118±17	82±16	252±32	157±28
		60-69	16/17	115±30	84±18	209±49	157±27
		>70	13/10	95±14	82±16	200±42	152±27
Neder et al (47) (Brazilian)	5	20-29	50/50	129.3±17.6	101.6±13.1	147.3±11.0	114.1±14.8
		30-39		136.1±22.0	91.5±10.1	140.3±21.7	100.6±12.1
		40-49		115.8±87.0	87.0±9.1	126.3±18.0	85.4±13.6
		50-59		118.1±17.6	79.3±9.5	114.7±6.9	83.0±6.2
		60-69		100.0±10.6	85.3±5.5	111.2±10.9	75.6±10.7
		70-80		92.8±72.8	72.7±3.9	111.5±21.0	69.6±6.7
Black and Hyatt (12) (Caucasian)	2	20-54	60/60	124±44	87±32	233±84	152±54
		55-59		103±32	77±26	218±74	145±40
		60-64		103±32	73±26	209±74	140±40
		65-69		103±32	70±26	197±74	135±40
		70-74		103±32	65±26	185±74	128±40
Chen and Kuo (26) (Chinese)	3	16-30	10/10	123.4±5.5	89.3±3.1	141.2±8.8	97.9±5.4
		31-45	10/10	116.5±5.1	76.0±3.4	136.6±8.9	92.8±4.2
		46-60	10/10	92.8±4.3	71.6±5.6	133.6±9.0	88.4±6.2
		61-75	10/10	83.4±4.7	59.9±4.5	117.4±7.4	75.1±5.1
Enright et al (4) (Caucasian)	5	65-69	704/1,131	84	59	188	125
		70-74	728/888	81	56	179	121
		75-79	472/589	74	49	161	102
		80-84	253/243	64	45	142	84
		85+	102/91	56	40	131	94

Table2.2 Regression equation of respiratory muscle strength from different studies

Reference	Age range (year)	No. of subject (male/ female)	Equation	R	R^2	P-value
Black and Hyatt (12)	20-80	60/60	**Males**			
			MIP = 143-0.55A			<0.01
			MEP = 268-1.03A			<0.01
			Females			
			MIP = 104-0.51A			<0.01
			MEP = 170-0.53A			<0.01
Herik-Khan (27)	20-90	139/128	**Males**			
			MIP = 126-1.028A+0.343Wt	0.648	0.42	<0.05
			Females			
			MIP = 171-0.694A+0.861Wt-0.743Ht	0.556	0.31	<0.05
Wilson (8)	18-70	48/87	**Males**			
			MIP = 142-1.03A	0.458	0.21	0.001
			MEP = 180-0.91A	0.374	0.14	0.009
			Females			
			MIP = -43+0.71Ht	0.225	0.051	0.035
			MEP = 3.5+0.55Ht	0.232	0.054	0.031
Neder (47)	20-80	50/50	**Males**			
			MIP = 155.3-0.80A			<0.01
			MEP = 165.3-0.81A			<0.01
			Females			
			MIP = 110.4-0.49A			<0.01
			MEP = 115.6-0.61A			<0.01
Chen and Kuo (52)	16-75	80/80	**Males**			
			MIP = 149-1.00A	0.624	0.389	0.001
			MEP = 157-0.55A	0.245	0.060	<0.05
			Females			
			MIP = 101-0.62A	0.479	0.229	0.001
			MEP = 109-0.47A	0.322	0.103	<0.01
Johan (46)	20-80	Chinese 131/90	**Males**			
			MIP = 37.24-0.67A+0.15Ht+0.85Wt	0.405	0.164	<0.05
			MEP = -0.106-0.52A+1.05Ht+1.03Wt	0.420	0.176	<0.05
			Females			
			MIP = 68.80-0.49A-0.05Ht+0.22Wt	0.263	0.069	<0.05
			MEP = 112.14-0.59A-0.11Ht-0.07Wt	0.293	0.085	<0.05
		Malay 69/42	**Males**			
			MIP = 151.32-0.33A-0.55Ht+0.38Wt	0.219	0.047	<0.05
			MEP = 109.82+0.05A-0.22Ht+0.30Wt	0.146	0.021	<0.05
			Females			
			MIP = 52.48+0.18A-0.09Ht+0.12Wt	0.144	0.020	<0.05
			MEP = 181.87-0.16A-0.90Ht+0.43Wt	0.242	0.058	<0.05

Definition of abbreviations: A = Age (yrs), Ht = height (cm), Wt = weight (kg)

2.5 Factors affecting respiratory mouth pressure

2.5.1 Age

Many previously studied (4, 7-9, 12, 52) were found relationship between respiratory muscle strength and age. Gaultier (53), Jeffrey (54), Marienne (55) and coworkers suggested that MIP and MEP increase with age from children to adult. However, Black and Hyatt (12), Enright (4) and McConnell et al (28) showed negative correlation of age with both MIP and MEP in person who older than 55 years whereas, Ringqvist found MIP and MEP decreased in aged older 50 years.

Several factors may affect respiratory muscle strength in the elderly include;

1) The age-related decrease in muscle strength such as muscle atrophy and peak tetanic tension are: (1) a decrease in muscle mass (cross-sectional fiber); (2) a decrease in the number of muscle fibers especially type II “fast twitch” and motor units; (3) alterations in neuromuscular junctions; (4) loss of peripheral motor neurons with selective denervation of type II muscle fibers (56).

2) Decrease in muscle work capacity due to decreased efficiency in energy metabolism reduced respiratory muscle strength (57). Data obtained from adult and aged rats suggest that impairment of the sarcoplasmic reticulum Ca^{2+} pump, owing to uncoupling of adenosine triphosphate (ATP) hydrolysis from Ca^{2+} transport, may contribute to a slowing of contraction (reduced maximal shortening velocity) and relaxation (58).

3) Chest wall compliance decreases progressively with age. The stiffening is presumably related to calcification and other structural changes within the rib cage and its articulations, i.e. calcification of costal cartilage and rib-vertebral articulations and narrowing of intervertebral disk spaces (56) making restriction of chest wall. Decreasing compliance of chest wall may increase the MEP (10). These modifications of the chest wall not only alter its compliance but also modify the curvature of the diaphragm with a negative effect on its force-generating capability. The geometric changes in the rib cage both the kyphotic curvature of the spine and the anteroposterior

diameter of the chest were increased with aging. Hence, RV increase with increasing age lead to an altered force-length relationship of diaphragm and diminished static outward recoil of the chest wall, resulting decreased MIP at RV (59).

On the contrary, McElvaney et al (10) studied maximal static respiratory pressure in the normal elderly. They found no relation between MIP and MEP with age in person older than 55 years of age.

2.5.2 Gender

Gender have an effect on both MIP and MEP (19). The values of MIP and MEP in females were 65% to 70% of those obtained in males (7, 12, 60) or about one-third (7, 8, 12, 31). The possible explanation was that males are generally stronger than females (4) such as body size and physical activity in males are more than females (52).

2.5.3 Changes in lung volume and chest shape

MIP and MEP measurements are dependent on lung volume (7, 60, 61) and length-tension properties of skeletal muscle (5). Systematic measurement of maximum pressure at different lung volumes (Figure 2.1) shows that the greatest expiratory pressure are obtained with efforts initiated at full inflation while the most negative inspiratory pressure are recorded at low lung volumes (38). Inspiratory pressure is highest at the lower end of vital capacity (VC), indicating that at such volume there is an optimal inspiratory muscle length. Inspiratory muscle shortening is limited near total lung volume (TLC) primarily by the elastic recoil of the lungs. At TLC, the load imposed by lungs and chest wall equals the maximum force the muscles can develop at that length. The maximal force of the expiratory muscles is achieved at the highest lung volumes, with most of the force-generating capacity gone when lung volume approaches residual volume (RV) (short muscle). It is remarkable that a structure of such a complex architecture as the chest wall having multiple muscle participation both in inspiratory and expiratory efforts that has a force-length characteristic function similar to that of a single muscle fiber (62). The highest MEP

were obtained at lung volumes greater than 70% of TLC and the highest MIP were obtained at volumes less than 40% to 50% of TLC (7, 60).

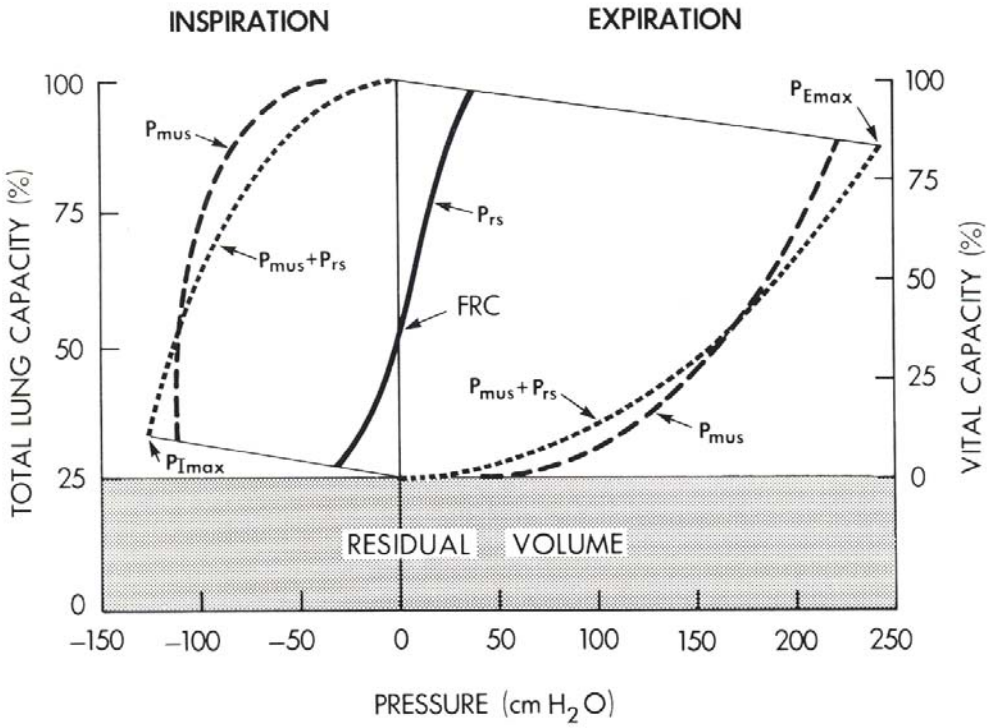

Figure 2.1 Volume-pressure diagram of respiratory system, showing the pressures generated by the respiratory muscles (Pmus) and the muscle plus the recoil of respiratory system (Pmus+Prs) during inspiration and expiration. FRC = functional residual capacity; PImax = maximal inspiratory pressure; PEmax = maximal expiratory pressure (63).

2.5.4 Association with body habitus

Enright et al in 1994 (4) showed significant correlations between respiratory muscle strength and weight, height, body mass index (BMI) and an index of body fat percentage (measured by bioelectrical reactance). In subject who heavy weight, small waist and low body fat have stronger respiratory and malnutrition person was reduced respiratory muscle strength (4, 64). Arora and Rochester (64) studies have confirmed the correlation between body weight and diaphragm mass. Malnutrition in elderly man has a 12% reduction in MIP and elderly woman with a waist size of 10 inches above the mean, has an 11% reduction in MIP (4).

On the contrary, McConnell and coworker (28) observed poor correlation between respiratory mouth pressure and height in both genders. They found significant correlations between respiratory mouth pressure with weight, body surface area (BSA) and BMI only females. Body weight and percentage body fat content increase with advancing age, especially in women (28). In addition, increasing of age is association with vertebral collapse, increased kyphosis that cause of reduction height. These changes would appear effect respiratory muscle strength in women but not in men. In male subjects, they found only correlation between BSA or BMI and MIP (28).

2.5.5 Physical activity

One of the factors affecting the maximal respiratory muscle pressure is the physical activity (52). McConnell and coworker (28) suggest that respiratory muscle strength is influenced strongly by physical activity. In athlete had respiratory muscle strength higher than sedentary person (65).

2.5.6 Other factors

Other factors that may be influence respiratory muscle strength are following;

2.5.6.1 Techniques

It is essential to compare the values obtained with the measurement in healthy individuals using similar techniques in the same laboratory (66). Black and Hyatt (12) and Cook (60) are 10-20 cmH_2O less than Ringqvist because method of Ringqvist use of an extensive series of measurements in each subject whereas in Black and Hyatt used only two technically satisfactory measurements. Different techniques are cause of wide variation of values.

2.5.6.2 Attention

One problem with measurement of respiratory mouth pressure is attention. Hence, the subject must make maximal contraction for the true result of respiratory muscle strength (24).

2.5.6.3 Type of mouthpiece

Flanged mouthpiece give values lower than obtained with a rubber tube mouthpiece (67). The flanged mouthpiece can be attached to a short, rigid tube but a rubber tube mouthpiece has to be held tightly around the lips to prevent air leaks (12).

2.6 Pulmonary function tests

Spirometry is measurement of respiratory function both volume and flow of lungs. It useful for indirect information about respiratory performance and it is routine part of clinical practice (68). The standard values of spirometry depend on many factors including gender, age, height (69). The lung volumes are subdivided into static and dynamic lung volumes.

2.6.1 Static lung volume

The volume of gas in the lung and intrathoracic airways is determined by the properties of the lung parenchyma and surrounding organs and tissue, surface tension, the force exerted by respiratory muscles, by lung reflexes and by the properties airways (70). The gas volumes of thorax and lung are the same except in the case of pneumothorax.

The parameters are total lung capacity (TLC), vital capacity (VC), residual volume (RV), tidal volume (V_T or TV), functional residual capacity (FRC), expiratory reserve volume (ERV), inspiratory capacity (IC) and inspiratory reserve volume (IRV). The lung volumes should be expressed in liters at Body Temperature and Pressure Standard (BTPS) (68). This review will focus detail only VC.

2.6.2 Dynamic lung volumes and forced ventilatory flows

Dynamic lung volumes and flows are assessed during forced inspiration or expiration, or during forced breathing when maximal effort is applied throughout the respiratory maneuvers (70). The parameters are forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1) and ratio of FEV_1/FVC (68).

Vital capacity (VC), slow vital capacity (SVC), forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1) and ratio of FEV_1/FVC are the examples of the tests that are going to be mentioned.

Vital capacity (VC)

The vital capacity is the volume change at the mouth between full inspiration and complete expiration (70). The measurement may be made in term of inspiratory vital capacity (ICV) or expiratory vital capacity (EVC) and made in term of slow vital capacity (SVC) or force vital capacity (FVC).

Slow vital capacity (SVC)

Slow vital capacity or relaxed vital capacity can measure either open or closed circuit technique. Although the open circuit technique may be preferred because of hygiene concerns, this technique does not allow the monitoring of the inhalation to TLC and therefore is less than optimum (68).

The open circuit, the subjects may inhale completely before insert the mouthpiece and exhale into the spirometer. The closed circuit technique may be used with or without CO_2 absorption. Subjects may also re-breathing from the spirometer circuit (68).

For both techniques, the maneuver is not forced; it is performed in a relaxed manner with the subject using a mouthpiece and a nose clip. A minimum of two acceptable VC maneuvers should be obtained with a maximum of four attempts. The largest VC should be reported (68).

Forced vital capacity (FVC)

Force vital capacity (FVC) is maximal volume of air exhaled with maximally forced effort from a position of maximal inspiration. FVC can measure in both open and closed circuit. The subjects inhale from FRC and then, if using the open circuit method, insert mouthpiece into mouth and exhale maximally as soon as possible. A minimum of three acceptable FVC maneuvers, if the subject shows large

variation of FVC volume more than 0.2 liter reproducibility criteria may require that up to but no more than eight maneuvers (68).

FVC normally equals the SVC should be within 5% of each other but FVC can be lower than SVC in subjects who have obstruction disease. Decreased FVC is a common feature of restrictive disease including pulmonary fibrosis, neuromuscular disease or chest deformities.

Forced expiratory volume in 1 second (FEV_1) and ratio of FEV_1/FVC

Forced expiratory volume in 1 second (FEV_1) is the volume of gas expired in one second from the beginning an FVC maneuver (71). The FEV_1 and ratio of FEV_1/FVC are used to indices of obstructive disease. If the ratio of FEV_1/FVC lower than 70% is confirms the presence of chronic obstructive pulmonary disease (COPD) and FEV_1 is used to classification severity of disease (72).

CHAPTER III
MATERIALS AND METHODS

3.1 Subjects:

Thai healthy volunteers who aged range between 30-70 years participated in this study. The subjects were classified as aged range 30-39 years, 40-49 years, 50-59 years and 60-70 years in each gender. The inclusion and exclusion criteria are as following.

3.1.1 Inclusion criteria:

3.1.1.1 Respiratory function within the normal values according to FVC, FEV_1 and ratio of FEV_1/FVC > 80% prediction values (69) (Appendix F) and ATS-LDL-78-Adult Questionnaire (Appendix C).

3.1.1.2 Normal vital sign (73): blood pressure; BP (95-140/60-90 mmHg), heart rate; HR (60-100 beats/min), respiratory rate; RR (12-20 times/min) and body temperature (oral temperature) (35.7-37.8 ºC).

3.1.1.3 Sedentary or active habitual physical activity (total physical of index score was between 3-8) (74, 75) (Appendix D).

3.1.1.4 Ability to understand verbal instruction.

3.1.1.5 No prior experience with the procedures.

3.1.2 Exclusion criteria:

3.1.2.1 Current cigarette smokers.

3.1.2.2 Taking any medicines that affect the respiratory system.

3.1.2.3 Drinking alcohol within 6 hours before the test.

3.1.2.4 Having pulmonary such as tuberculosis, asthma, current respiratory system infection or cardiovascular diseases that involve respiratory muscle function.

3.1.2.5 Having musculoskeletal or neurology conditions that involve respiratory muscle function.

3.2 Design of the study:

This study is a descriptive study design to determine the relationship between respiratory muscle strength and characteristics of subjects.

3.3 Instrumentations:

3.3.1 Mouth pressure meter (Spirovis)

The mouth pressure meter (Spirovis, COSMED pulmonary function equipment, Italy) is a hand-held instrument for assessing respiratory muscles strength both inspiratory and expiratory muscles. Inspiratory and expiratory muscles strength express in terms of Maximal inspiratory mouth pressure (MIP) and Maximal expiratory mouth pressure (MEP), respectively. MIP and MEP are readily and digitally monitored in units of cmH_2O. This device measures pressure range from -350 to 350 cmH_2O in 1 second and had the accuracy of ± 1% (weight of 120 grams). Calibration was set by the factory and was claimed to remain constant through out the lifetime of the device (Figure 3.1).

Figure 3.1 Mouth pressure meter (Spirovis).

3.3.2 Spirometer

The spirometer (Spirotouch® Spirometry system, Burdick, INC., USA) will be used for pulmonary function test including force vital capacity (FVC), force expiratory volume in one second (FEV_1) and ratio of FEV_1/FVC. The spirometer will be calibrated with 3 liters syringe daily before testing (Figure 3.2).

Figure 3.2 Spirometer (Spirotouch®).

3.3.3 Thermometer

3.3.4 Sphygmomanometer

3.3.5 Stopwatch

3.3.6 Weight scale

3.3.7 Height scale

3.4 Procedure:

A demographic information, medical history and habitual physical activity were obtained from subjects. Vital sign, height and weight were measured. Each subject received and explanted of all procedures. Subjects read and signed a consent form prior to participation in this study (Appendix A.1-A.2, Appendix B and Appendix C). After that pulmonary function test and respiratory muscle strength was measured.

3.4.1 Measurement of pulmonary function

Determinations of pulmonary function test are force vital capacity (FVC), force expiratory volume in one second (FEV_1) and ratio of FEV_1/FVC.

Force vital capacity (FVC), force expiratory volume in one second (FEV_1) and ratio of FEV_1/FVC

The subject was asked to sit comfortable and inhaled maximally with attached nose clip, then the mouthpiece was firstly inserted. The subject had to close their lips tightly around mouthpiece. Then the subject blowed air into the spirometer as hard and fast as possible until no further gas can be exhaled. Exhalation more than 6 second for three maneuvers but no more than 8 maneuvers were accepted according to American Thoracic Society (ATS) (68). The values from this test were included in normal lung function.

3.4.2 Measurement of respiratory muscle strength

The subjects rest on a comfortable chair for 10 minutes after pulmonary function test. Then the MIP or MEP was tested. Subject's lips were hold around the mouthpiece. MIP was determined from residual volume following a maximum expiration (Muller maneuver). Subjects were instructed to 1) inhale to total lung capacity, 2) exhale slowly to residual volume and then 3) inhale maximally. MEP was also determined at total lung capacity following a maximum inspiration (Valsalva maneuver). Subjects were instructed to 1) exhale to residual volume, 2) inhale slowly to total lung capacity and then 3) exhale maximally. MIP was measured 10 times per test and MEP was measured 12 times per test. Each maneuver was separated by 1 minute resting period. The value of MIP and MEP were accepted which being sustained for at least 1 second. The highest value of MIP and MEP were accepted (Figure 3.3). This protocol was concluded in Figure 3.4.

Figure 3.3 Measurement of the respiratory muscle strength.

Healthy subjects

↓

Questionnaire

- Demographics data
- Medical data
- Physical activity

↓

Pulmonary function test

- Dynamic lung function: FVC, FEV_1 and FEV_1/FVC = 3 times

↓

Respiratory muscles strength

- Maximal inspiratory mouth pressure (MIP) = 10 times
- Maximal expiratory mouth pressure (MEP) = 12 times

↓

Data analysis

Figure 3.4 Experimental protocol.

3.5 Statistic analysis

The SPSS for Microsoft Windows Release 11.0 program was used for data analysis. The level of statistical significance was set as the 0.05 level for all data analysis in this study.

3.5.1 Kolmogorov-Smirnov Goodness of fit test was used to test for distribution of the data.

3.5.2 Two-way mixed Analysis of Variance (Post-Hoc: Bonferroni) was used to test the effect of gender and age-group on MIP and MEP.

3.5.3 Pearson correlation was used to test correlation of age, weight and height on MIP and MEP.

3.5.4 Multiple regressions was used to test relationship between age, weight, height on MIP and MEP.

CHAPTER IV
RESULTS

4.1 Characteristics of Subjects

Two hundreds and forty-nine volunteers participated in this study which they were classified into 8 groups by age and gender. Each group of subjects consisted of females and males within four age-groups including 30-39, 40-49, 50-59 and 60-70 years old. Means and standard deviations of age, height, weight, BMI, physical activity, FVC, FEV_1 and FEV_1/FVC are presented in Table 4.1. Kolmogorov Smirnov Goodness of Fit test shows all parameters were in normal distribution except physical activity score.

4.2 Effect of Age and Gender on Maximal Inspiratory Mouth Pressure (MIP)

Effect of age and gender on Maximal Inspiratory Mouth Pressure (MIP) was investigated in four age-groups; 30-39, 40-49, 50-59 and 60-70 years old in both genders.

Table 4.2 shows means and standard deviations of MIP in females and males in four age-groups. Mean and standard deviation of MIP in females of 30-39, 40-49, 50-59 and 60-70 year groups were 93.13± 26.38, 94.20±29.96, 84.41±24.09 and 71.90±20.75 cmH_2O, respectively. Whereas, mean and standard deviation of MIP in males of 30-39, 40-49, 50-59 and 60-70 year groups were 133.27± 23.94, 131.38±30.11, 118.16±31.17 and 105.81±18.09 cmH_2O, respectively.

Two-Way mixed Analysis of Variance was used to test the effect of age and gender on MIP. Females had MIP lower than males in all age-groups (Figure 4.1). The statistical analysis shows significantly differences of MIP with age-groups in both genders. There are significantly differences between aged 30-39 years and 60-70 years

and between aged 40-49 years and 60-70 years ($p < 0.05$) in both female and male groups (Figure 4.2 and 4.3).

4.3 Effect of Age and Gender on Maximal Expiratory Mouth Pressure (MEP)

Effect of age and gender on Maximal Expiratory Mouth Pressure (MEP) was investigated in four age-groups; 30-39, 40-49, 50-59 and 60-70 years old in both genders.

Table 4.3 shows means and standard deviations of MEP in female and males within four age-groups. Mean and standard deviation of MEP in females of 30-39, 40-49, 50-59 and 60-70 year groups were 94.45± 31.19, 95.03±33.99, 99.94±28.83 and 79.90±25.55 cmH_2O, respectively. Whereas, mean and standard deviation of MEP in males of 30-39, 40-49, 50-59 and 60-70 year groups were 177.03± 42.42, 184.25±47.43, 159.10±55.24 and 160.32±45.98 cmH_2O, respectively.

Two-Way mixed Analysis of Variance was used to test the effect of age and gender on MEP. Females had MEP lower than males in all age-groups (Figure 4.4). It seems that MEP was slightly decreased with age when age older than 50 years old in males and decrease when age older than 60 years old in females. However, there were no statistically significant differences between MEP and age-group in both genders ($p > 0.05$) (Figure 4.5 and Figure 4.6).

Table 4.1 Characteristics of subjects

Demographic Characteristic data	Mean ± SD							
	30-39 years		40-49 years		50-59 years		60-70 years	
	Female (n = 30)	Male (n = 33)	Female (n = 30)	Male (n = 32)	Female (n = 32)	Male (n = 31)	Female (n =30)	Male (n = 31)
Age (yrs)	34.68±3.47	34.33±2.62	44.17±3.12	44.44±2.69	53.31±2.83	53.84±3.05	65.80±3.17	64.74±3.17
Height (cm)	156.77±4.57	167.36±5.74	156.77±5.39	166.59±4.49	153.69±4.36	165.61±4.50	152.63±6.59	162.84±6.86
Weight (Kg)	57.37±10.88	65.53±9.09	62.42±11.47	70.97±7.90	62.30±9.86	71.00±7.09	55.48±7.43	66.19±9.76
BMI (Kg/m^2)	23.32±4.12	23.40±3.32	25.41±4.66	25.42±2.33	26.41±4.44	25.89±2.50	23.89±3.40	24.90±3.09
Physical activity score	7.10±0.82	7.37±0.67	7.08±0.93	7.24±0.69	7.02±0.96	6.94±1.03	5.30±1.05	5.23±1.29
FVC (liter)	2.79±0.32	4.04±0.61	2.84±0.40	3.67±0.41	2.29±0.27	3.39±0.44	2.14±0.30	2.97±0.49
FEV_1 (liter)	2.41±0.29	3.41±0.48	2.36±0.38	3.10±0.33	1.88±0.24	2.80±0.38	1.71±0.24	2.38±0.39
FEV_1/FVC	86.55±4.46	84.88±5.58	82.93±3.94	84.69±4.00	82.47±4.43	83.35±4.77	80.33±4.70	80.29±4.85

BMI = Body Mass Index

FVC = Forced Vital Capacity

FEV_1 = Forced Expiratory Volume in 1 second

Table 4.2 Mean and SD of Maximal Inspiratory Mouth Pressure (MIP) in both genders

Age-group (yrs)	MIP (cmH_2O)							
	Female				Male			
	N	Mean	SD	Range	N	Mean	SD	Range
30-39	30	93.13	26.38	53 - 167	33	133.27	23.94	81 - 185
40-49	30	94.20	29.96	25 - 167	32	131.38	30.11	78 - 202
50-59	32	84.41	24.09	45 - 154	31	118.16	31.17	50 - 188
60-70	30	71.90	20.75	34 - 109	31	105.81	18.09	50 - 137

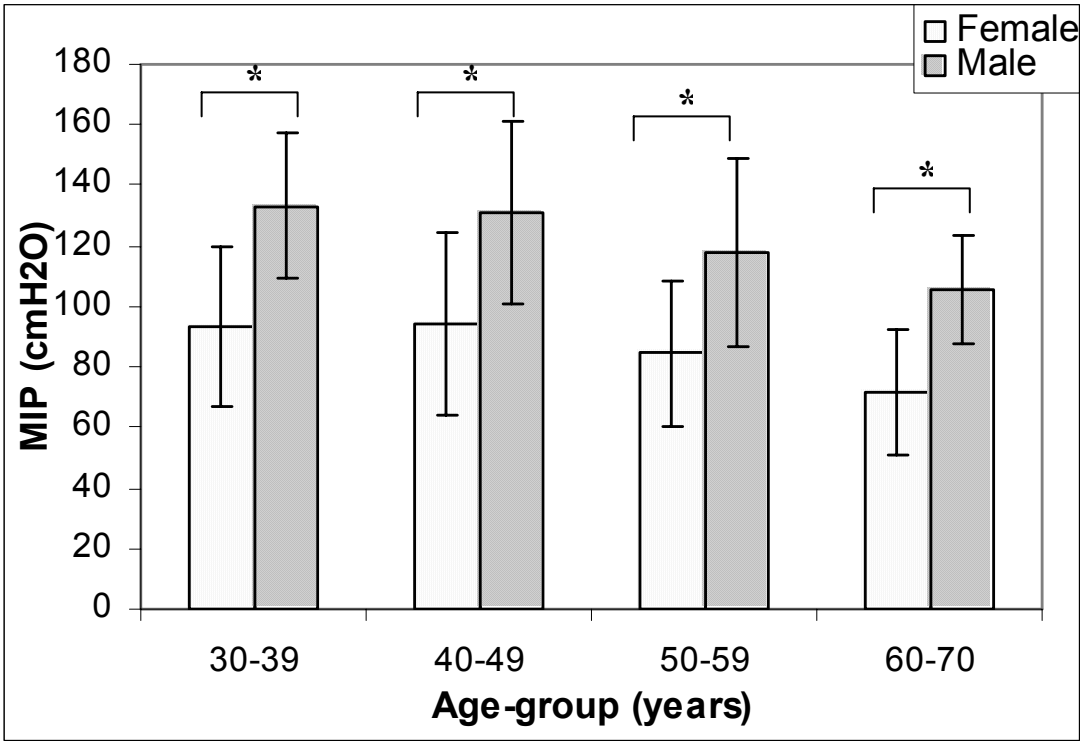

Figure 4.1 Comparison of means and SD of Maximal Inspiratory Mouth Pressure (MIP) between female and male within age-group; 30-39, 40-49, 50-59 and 60-70 years. (* = Significantly different at $p < 0.001$)

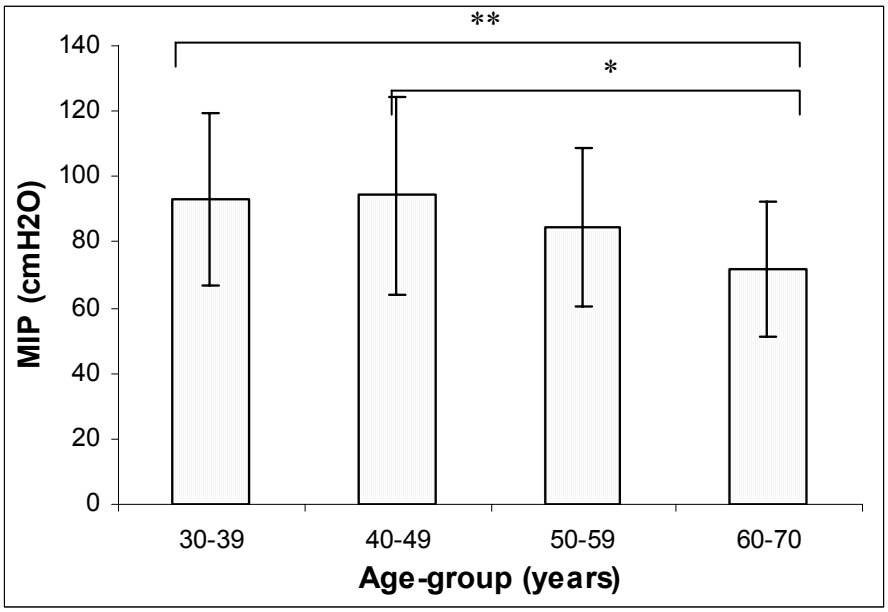

Figure 4.2 Comparison of means and SD of Maximal Inspiratory Mouth Pressure (MIP) among the age-groups of 30-39, 40-49, 50-59 and 60-70 years in females. (* = Significantly different at $p < 0.05$, ** = Significantly different at $p < 0.001$)

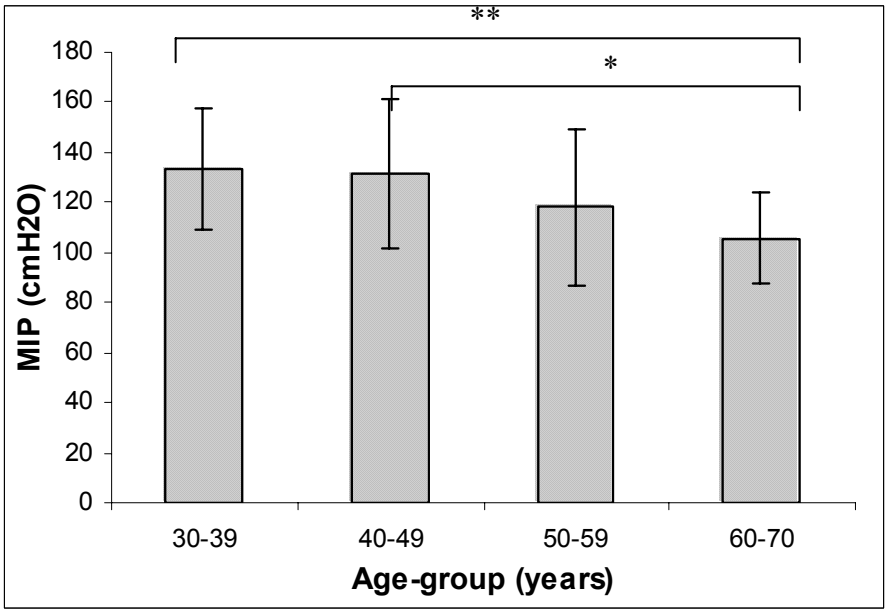

Figure 4.3 Comparison of means and SD of Maximal Inspiratory Mouth Pressure (MIP) among the age-groups of 30-39, 40-49, 50-59 and 60-70 years in males. (* = Significantly different at $p < 0.05$, ** = Significantly different at $p < 0.01$)

Table 4.3 Mean and SD of Maximal Expiratory Mouth Pressure (MEP) in both genders

Age-group (yrs)	MEP (cmH_2O)							
	Female				Male			
	N	Mean	SD	Range	N	Mean	SD	Range
30-39	30	94.45	31.19	48 - 156	33	177.03	42.42	84 - 277
40-49	30	95.03	33.99	34 - 199	32	184.25	47.43	96 - 323
50-59	32	99.94	28.83	50 - 171	31	159.10	55.24	45 - 284
60-70	30	79.90	25.55	34 - 123	31	160.32	45.98	53 – 237

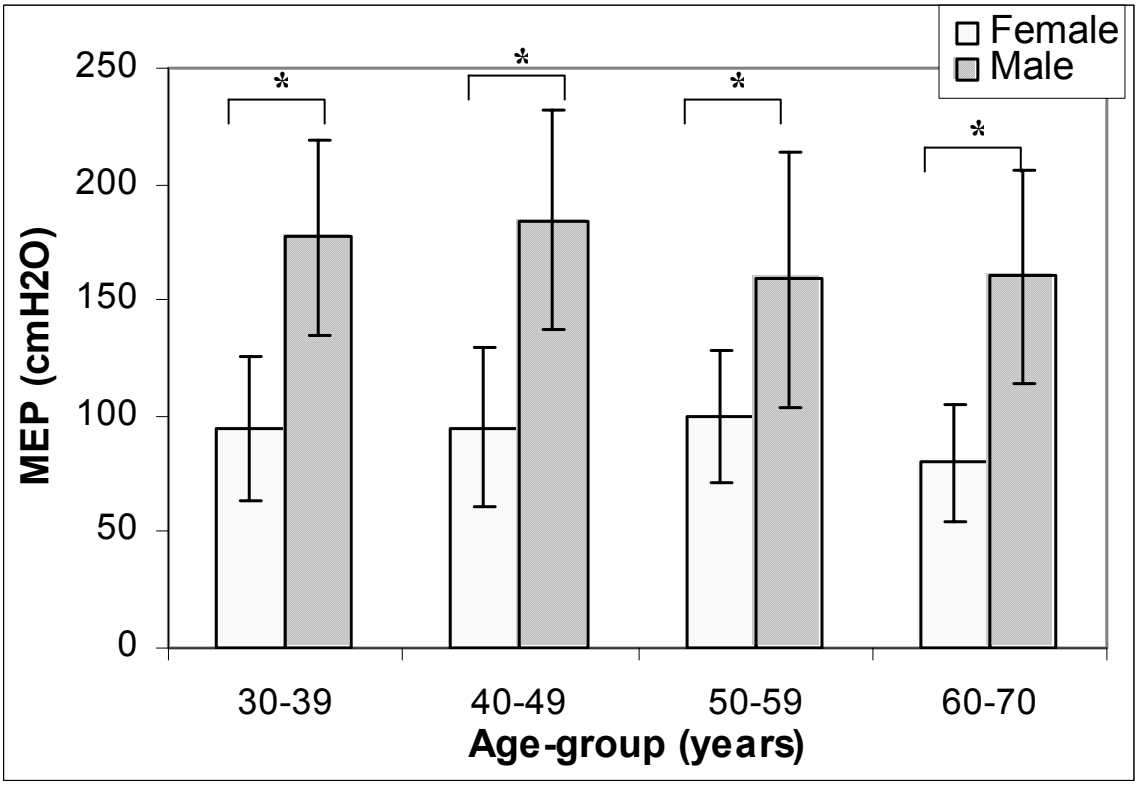

Figure 4.4 Comparison of means and SD of Maximal Expiratory Mouth Pressure (MEP) between female and male within age-group; 30-39, 40-49, 50-59 and 60-70 years. (* = Significantly different at $p < 0.001$)

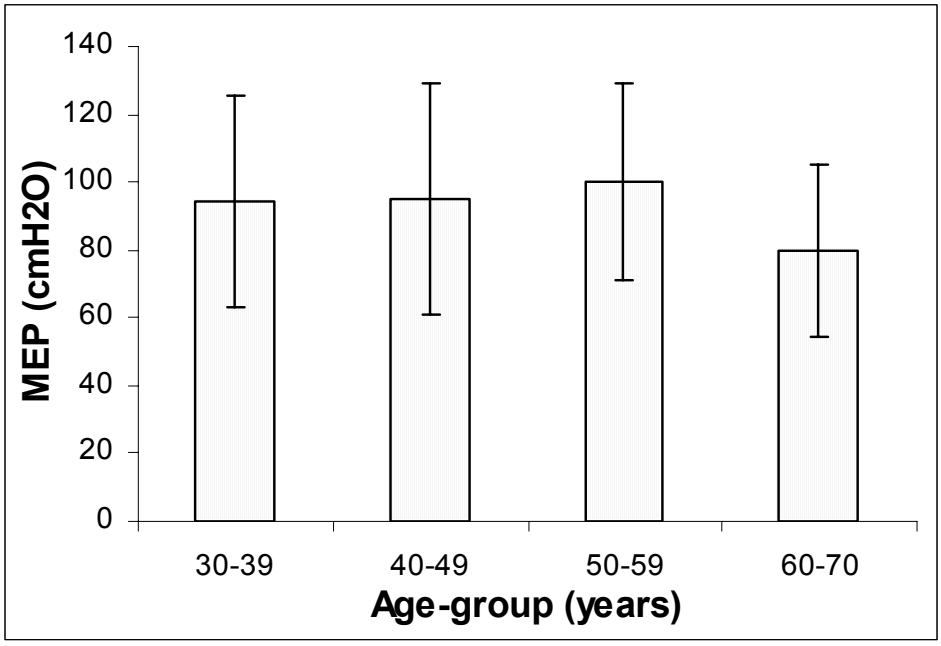

Figure 4.5 Comparison of means and SD of Maximal Expiratory Mouth Pressure (MEP) between age-group; 30-39, 40-49, 50-59 and 60-70 years in females. ($p > 0.05$)

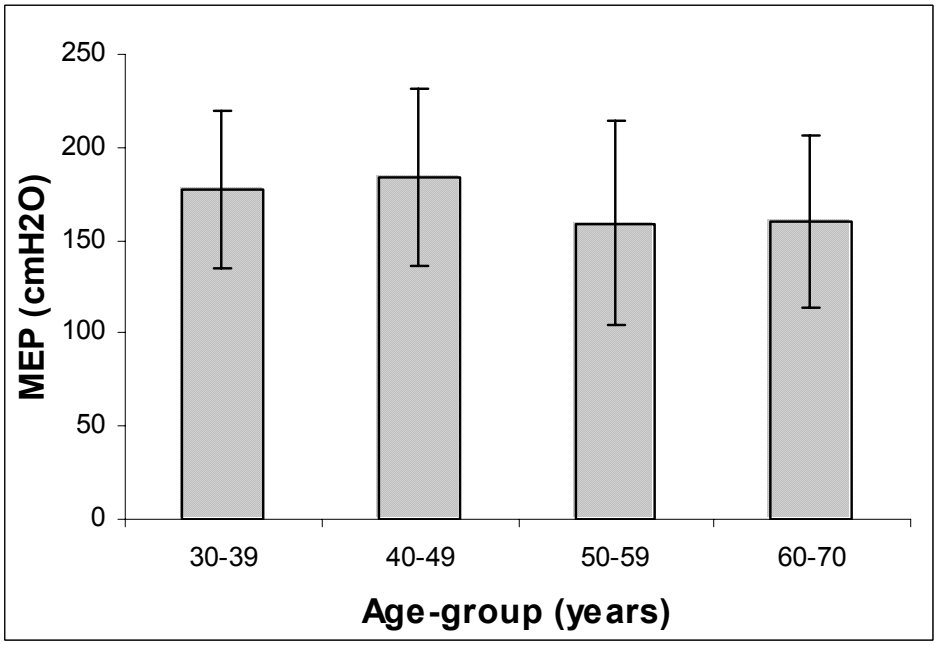

Figure 4.6 Comparison of means and SD of Maximal Expiratory Mouth Pressure (MEP) between age-group; 30-39, 40-49, 50-59 and 60-70 years in males. ($p > 0.05$)

4.4 Correlation of Maximal Inspiratory Mouth Pressure (MIP) and Maximal Expiratory Mouth Pressure (MEP) with age, height and weight in Females

Pearson Correlation was used to determine correlation of MIP and MEP with age, height and weight in females (aged 30-70 years) in Table 4.4. It demonstrated that MIP had significantly negative correlation with age ($r = -0.288$, $p < 0.01$), no correlation with height ($r = 0.090$, $p > 0.05$) and it had significant correlation with weight ($r = 0.266$, $p < 0.01$) (Figure 4.7 to Figure 4.9). On the other hand, MEP had no correlation with age, height and weight ($r = -0.170$, $r = -0.056$ and $r = -0.012$, $p > 0.05$, respectively) (Figure 4.10 to Figure 4.12).

4.5 Correlation of Maximal Inspiratory Mouth Pressure (MIP) and Maximal Expiratory Mouth Pressure (MEP) with age, height and weight in Males

Pearson Correlation was used to determine correlation of MIP and MEP with age, height and weight in males (aged 30-70 years) in Table 4.4. It was demonstrated that MIP had negative correlation with age ($r = -0.370$, $p < 0.01$) and it had positive correlation with height and weight ($r = 0.217$, $r = 0.178$, $p < 0.05$, respectively) (Figure 4.13 to Figure 4.15). On the other hand, MEP had no correlation with age, height and weight ($r = -0.147$, $r = 0.145$ and $r = 0.074$, $p > 0.05$, respectively) (Figure 4.16 to Figure 4.18).

Table 4.4 Pearson Correlation of Maximal Inspiratory Mouth Pressure (MIP) and Maximal Expiratory Mouth Pressure (MEP) with age, height and weight in both genders

Gender	Parameters	Age	Height	Weight
Female (n = 122)	**MIP**	-0.288**	0.090	0.266**
	MEP	-0.170	-0.056	-0.012
Male (n = 127)	**MIP**	-0.370**	0.217*	0.178*
	MEP	-0.147	0.145	0.074

* = Significantly different at $p < 0.05$, ** = Significantly different at $p < 0.01$

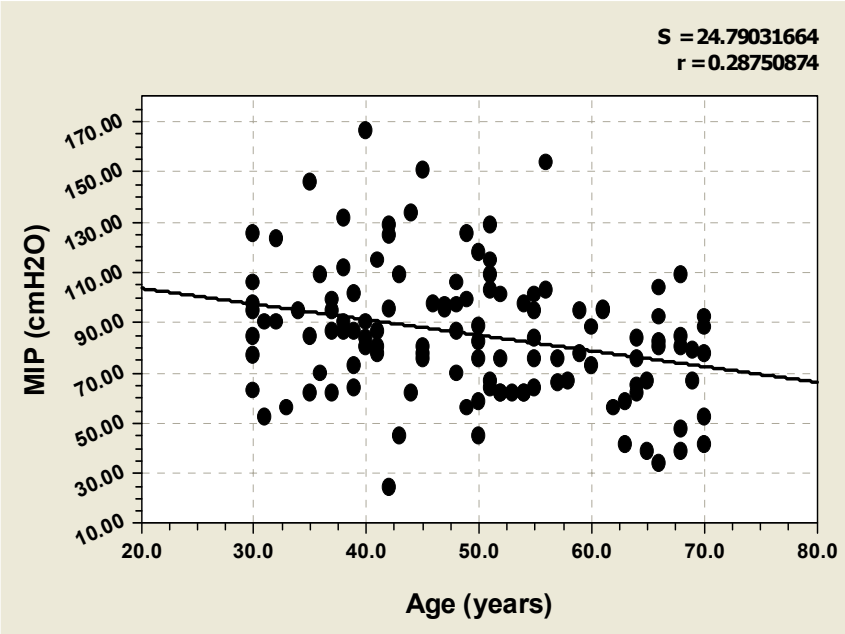

Figure 4.7 Scatter Plots and Correlation of Maximal Inspiratory Mouth Pressure (MIP) with age in females. (r = Correlation coefficient, S = Standard Error of Estimate) (n=122)

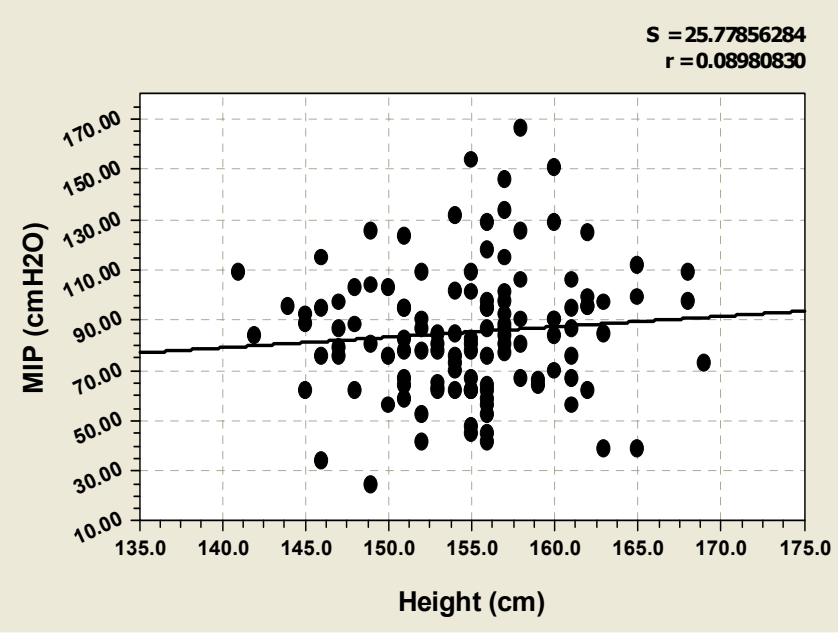

Figure 4.8 Scatter Plots and Correlation of Maximal Inspiratory Mouth Pressure (MIP) with height in females. (r = Correlation coefficient, S = Standard Error of Estimate) (n=122)

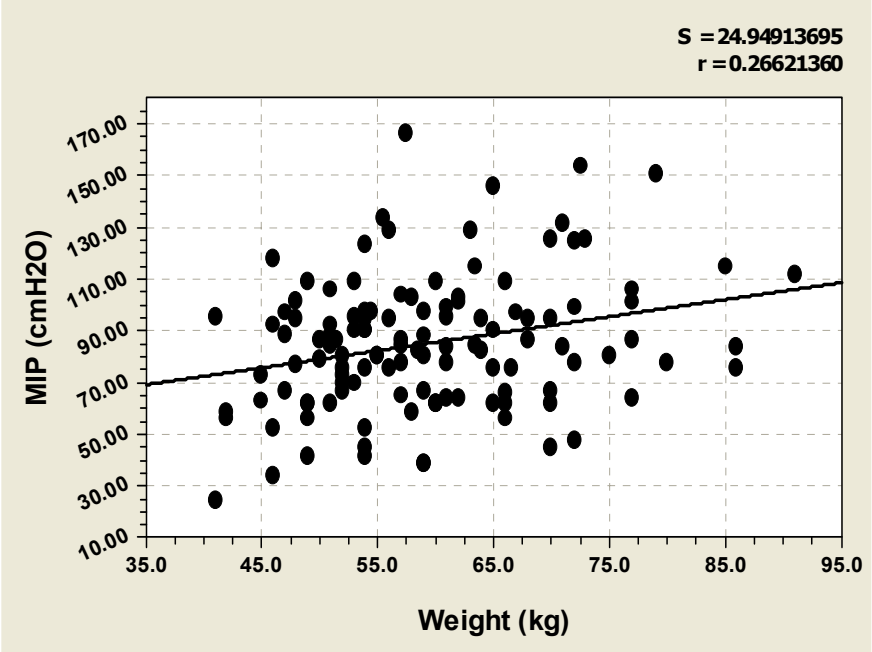

Figure 4.9 Scatter Plots and Correlation of Maximal Inspiratory Mouth Pressure (MIP) with weight in females. (r = Correlation coefficient, S = Standard Error of Estimate) (n=122)

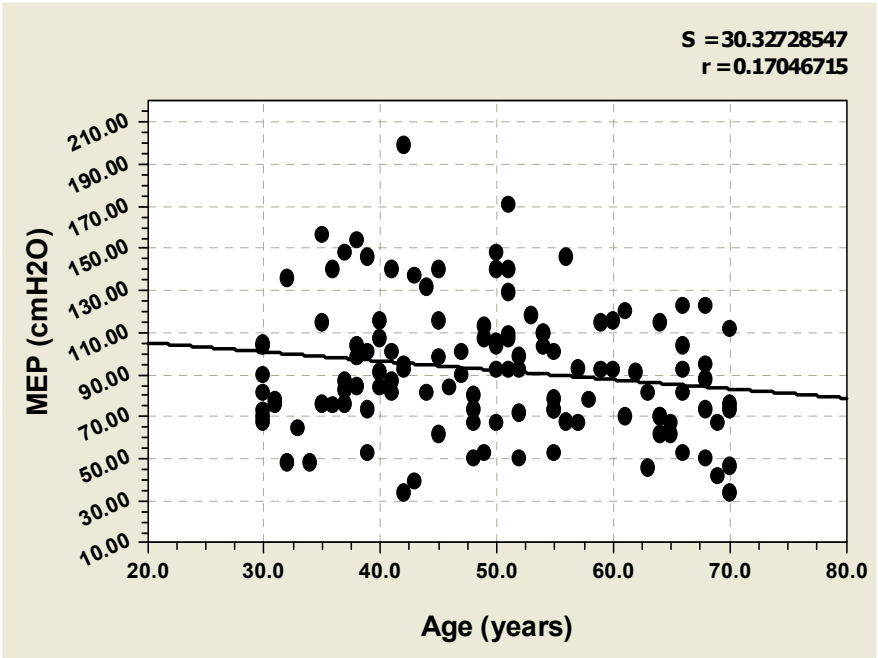

Figure 4.10 Scatter Plots and Correlation of Maximal Expiratory Mouth Pressure (MEP) with age in females. (r = Correlation coefficient, S = Standard Error of Estimate) (n=122)

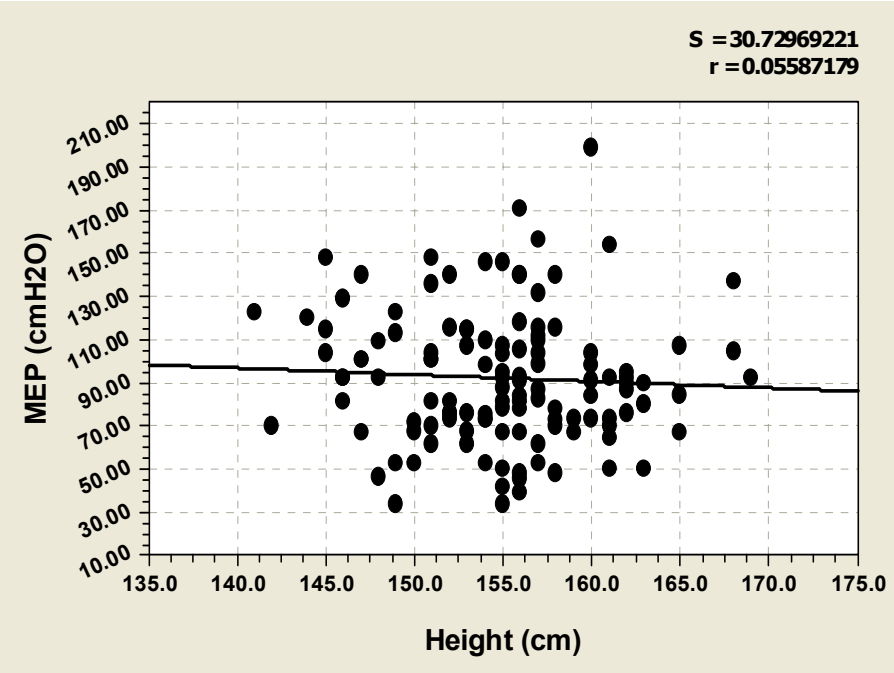

Figure 4.11 Scatter Plots and Correlation of Maximal Expiratory Mouth Pressure (MEP) with height in females. (r = Correlation coefficient, S = Standard Error of Estimate) (n=122)

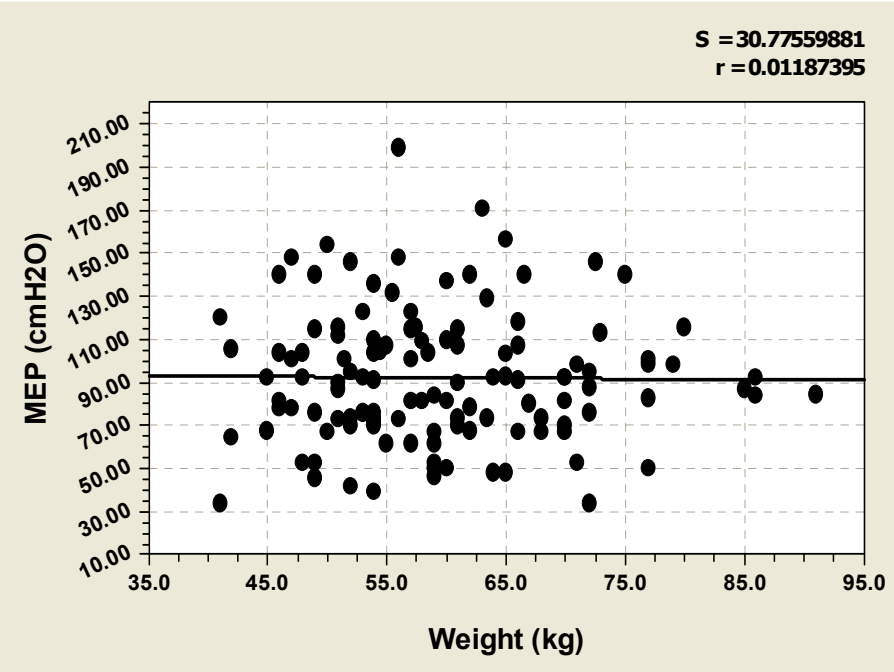

Figure 4.12 Scatter Plots and Correlation of Maximal Expiratory Mouth Pressure (MEP) with weight in females. (r = Correlation coefficient, S = Standard Error of Estimate) (n=122)

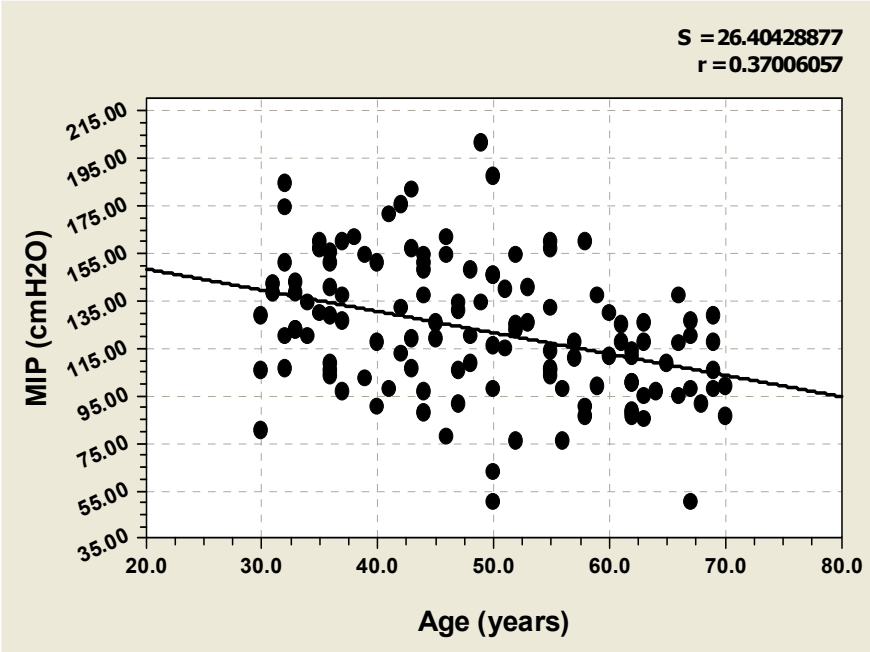

Figure 4.13 Scatter Plots and Correlation of Maximal Inspiratory Mouth Pressure (MIP) with age in males. (r = Correlation coefficient, S = Standard Error of Estimate) (n=127)

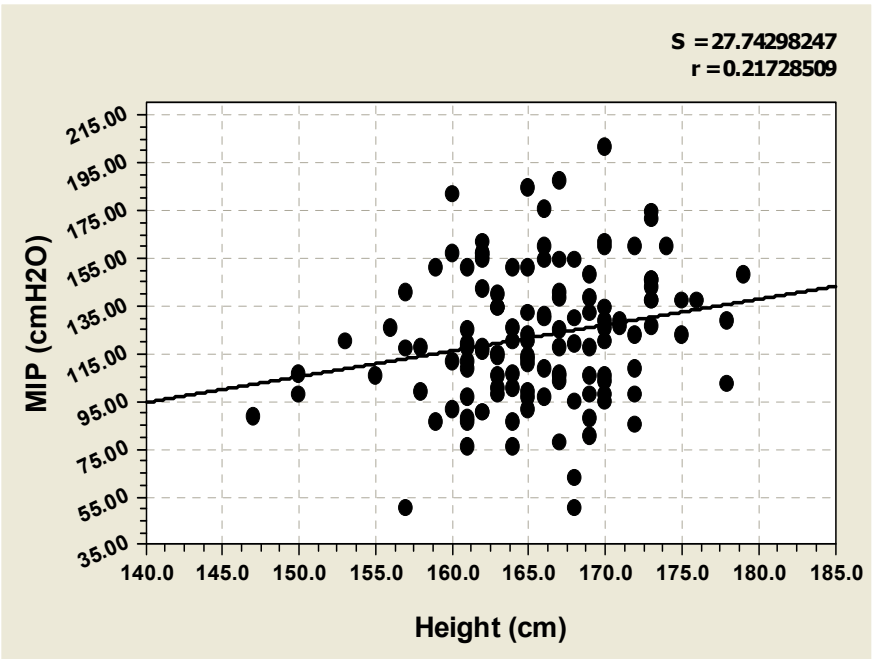

Figure 4.14 Scatter Plots and Correlation of Maximal Inspiratory Mouth Pressure (MIP) with height in males. (r = Correlation coefficient, S = Standard Error of Estimate) (n=127)

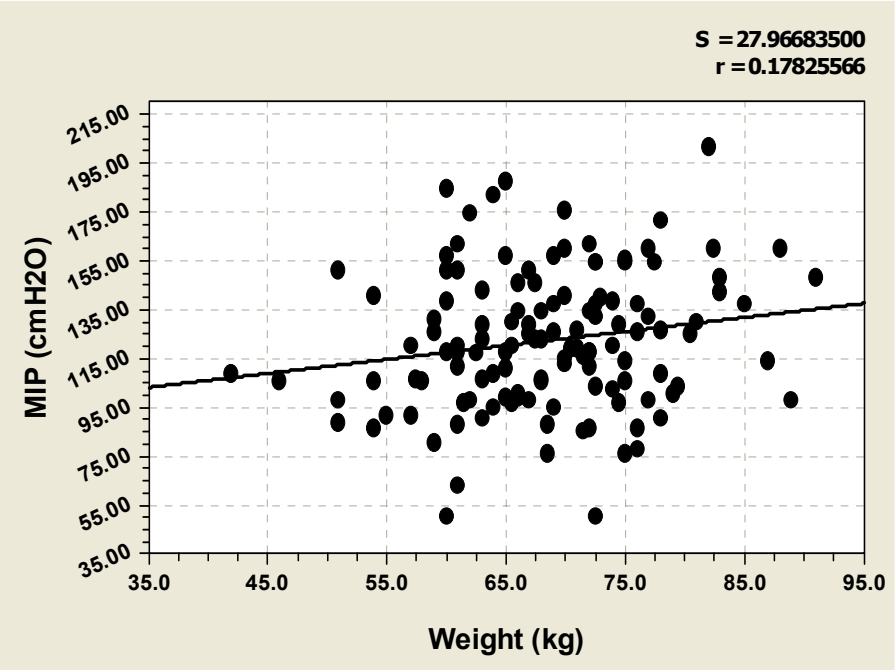

Figure 4.15 Scatter Plots and Correlation of Maximal Inspiratory Mouth Pressure (MIP) with weight in males. (r = Correlation coefficient, S = Standard Error of Estimate) (n=127)

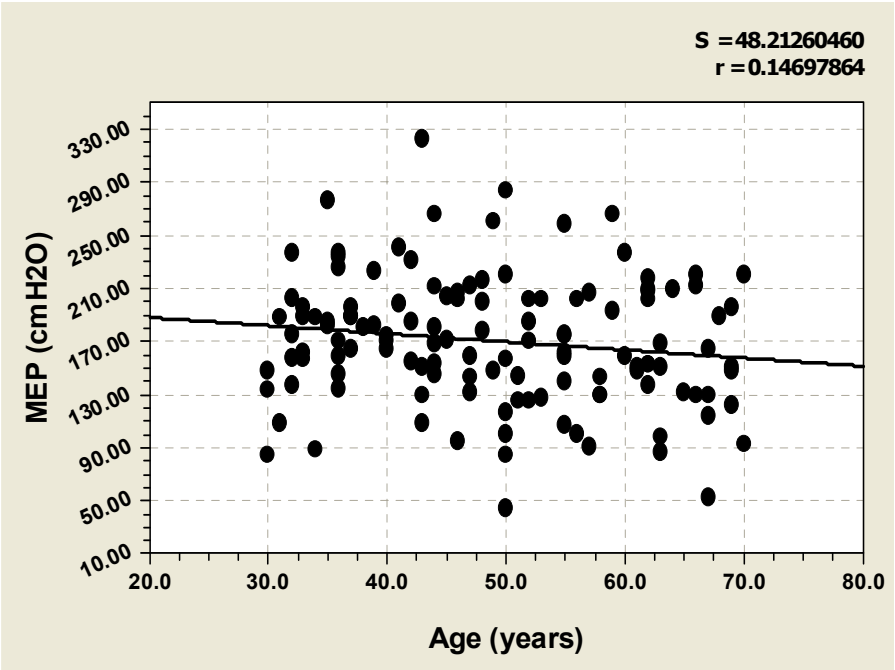

Figure 4.16 Scatter Plots and Correlation of Maximal Expiratory Mouth Pressure (MEP) with age in males. (r = Correlation coefficient, S = Standard Error of Estimate) (n=127)

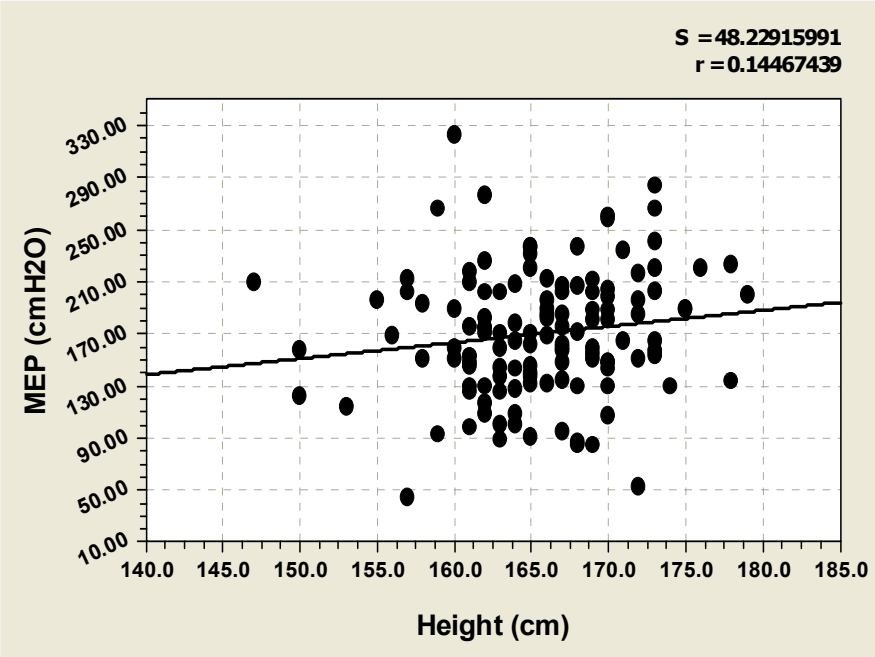

Figure 4.17 Scatter Plots and Correlation of Maximal Expiratory Mouth Pressure (MEP) with height in males. (r = Correlation coefficient, S = Standard Error of Estimate) (n=127)

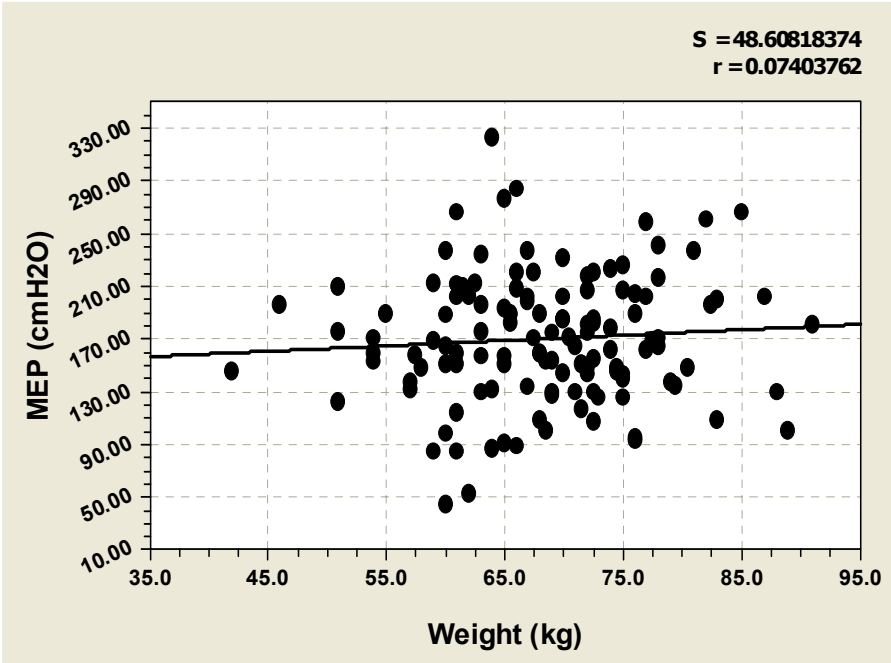

Figure 4.18 Scatter Plots and Correlation of Maximal Expiratory Mouth Pressure (MEP) with weight in males. (r = Correlation coefficient, S = Standard Error of Estimate) (n=127)

4.6 Multiple linear regression of Maximal Inspiratory Mouth Pressure (MIP) and Maximal Expiratory Mouth Pressure (MEP)

The regression equations for prediction of MIP and MEP are shown in Table 4.5. Stepwise multiple linear regression analysis was used to calculate the data. Regression analysis of the data showed that age was a strong negative predictor and weight was a positive predictor of MIP in both genders ($p < 0.05$), whereas height does not result in significance for predicted equation. MEP equations showed that age tended to be negative predictor of regression but did not show any significance for predicted equation in both genders ($p > 0.05$).

Table 4.5 Multiple linear regressions of Maximal Inspiratory Mouth Pressure (MIP) and Maximal Expiratory Mouth Pressure (MEP)

Equation	R	R^2	SEE	p-value
Males				
MIP = 124.39-0.91A+0.63Wt	0.419	0.175	25.914	0.018*
MEP = 200.36-0.61A	0.147	0.022	48.213	0.099
Females				
MIP = 77.57-0.59A+0.62Wt	0.382	0.146	24.016	0.004*
MEP = 113.68-0.44A	0.178	0.032	29.565	0.051

* = significantly different at $p < 0.05$

R = Correlation coefficient, R^2= Squares of the correlation coefficient

SEE = Standard Error of Estimate

A = Age (years), Wt = weight (kg)

CHAPTER V
DISCUSSION

5.1 Characteristics of Subjects

All subjects were healthy individuals screened by their demographic information, medical history and habitual physical activity. Additionally, pulmonary function test was used to ensure normal lung function according to American Thoracic Society (ATS) recommendation (68).

Demographic data of subjects were in normal distribution which indicated that subjects can be representative of the population except the data of habitual physical activity score. This is not surprised because physical activity level was limited only in sedentary and active. The age range of subjects was 30-70 years old. This age group tends to have respiratory function deterioration related to age (76). In the present study, naïve subjects never perform MIP or MEP before were recruited to participate in order to normalize learning effects which may not be equal among experience subjects.

5.2 Methods of testing

In the present study, Maximal Inspiratory Mouth Pressure (MIP) and Maximal Expiratory Mouth Pressure (MEP) were used to determine respiratory muscle strength both inspiratory and expiratory muscles in Thai healthy subjects within four aged-groups; 30-39, 40-49, 50-59 and 60-70 years. These tests were implied to determine inspiratory and expiratory muscle strength (7, 12, 27, 47). However, the number of maneuver was different among previous studies (4, 9, 10, 12, 27, 52, 77).

Seventeen subjects were recruited to determine optimal numbers of maneuver to perform respiratory muscle strength. According to the result of pilot study, optimal numbers of respiratory muscle strength test were 10 times per test for MIP and 12

times per test for MEP. The highest values of MIP and MEP were accepted similar to previous studies (4, 10, 27, 47, 49, 52, 53, 60) (Appendix I).

Similar to this present study, Fiz et al (78) determined optimal numbers for test of respiratory muscle strength in inexperienced COPD patients and found that nine maneuvers were required for establishing peak performance in single test session. Ringqvist (7) also conducted approximately ten maneuvers per test which found higher values than others studies (79) that performed maneuver per test less than his study. Wen et al (29) found that 65% from their test required more than 10 maneuvers to reach peak performance. In the present study, numbers of maneuver were similar to these two previous studies (>10 times/session).

Because respiratory muscle strength is unique and unlike any other physical activities that performed in daily life, therefore learning is important factor that needs to be considered in MIP and MEP measurements (7, 10, 22, 80). In addition, subjects learned to relax while focusing on sensations of muscle contraction in the chest wall (80). In that manner, more numbers of trial enabled inexperienced subjects to learn to perform peak pressure of respiratory muscle strength test in single test session.

Before the data collection, reliability of respiratory muscle strength was determined. Seventeen subjects were selected to participate in test-retest reliability. Subjects performed two test sessions of respiratory muscle strength separated by a week. The intratester reliability of respiratory muscle strength was 0.92 for MIP and 0.94 for MEP test. Therefore, the test-retest reliabilities of the protocol in this study are high (Appendix J).

From previous studies, Smieltzer et al (22) found that in the second testing session values of MIP and MEP was increased and suggested that one practice session was needed for respiratory muscle strength testing in healthy subjects. On the other hand, others investigators observed increases in MIP and MEP in the second week but it was not statistically significant (10, 12, 28). Black and Hyatt (12) suggested that it had small learning effect. The present study found high values of test-retest

reliabilities of respiratory muscle strength although there were the slight increase in values of MIP and MEP on the second week. Therefore, one test session of respiratory muscle strength was adequate for this study. Another reason, it is not practical to test for two occasions and separated by a week in clinical situations.

This study compared present study with other studies in the literature (4, 7, 12, 47, 52). This is not ideal because the authors use different techniques in different studies. First, the number to perform the test in present study is different from previous studies (10, 12, 28, 47, 52). This study had values higher than previous studies that performed three to five maneuvers per test. Second, the type of mouthpiece used in this study was rubber tube mouthpiece. The values obtained with this rubber tube mouthpiece are higher than that of flanged mouthpiece (67). This study selected the rubber mouthpiece because it can hold tightly around the lips and prevent air leaks better than flanged mouthpiece.

5.3 Comparison of mean and standard deviation of Maximal Inspiratory Mouth Pressure (MIP) and Maximal Expiratory Mouth Pressure (MEP) with other studies

The results of respiratory muscle strength in Thai healthy subjects aged 30-70 years were classified according to age and gender (Table 4.2 and Table 4.3).

Table 5.1 showed differences in mean and standard deviation of respiratory muscle strength of the present study and others studies. Values of MIP and MEP were lower than those of Ringqvist (7). Differences of anthropometrics data and life style between Asian and Caucasian may be the cause of the lower values of respiratory muscle strength in the present study. Many studies which performed three to five maneuvers per test reported lower MIP than the present study. This is because this study promoted learning effect by testing with more numbers of MIP and MEP. In this present study, subjects performed 10 times per test for MIP and 12 times per test for MEP. Hence, the results of MIP in this study is higher than other studies with performed 2 to 5 times per test (12, 27, 47, 52).

Table 5.1 Mean and SD of respiratory muscle strength from different studies

Reference	Number of maneuvers (times)	Age range (year)	No. of subject (male/ female)	Mean and SD of Pressure (cmH_2O)			
				MIP		MEP	
				males	females	males	females
Present study (Thai)	MIP=10 MEP=12	30-39	33/30	133.27±23.94	93.13±26.38	177.03±42.42	94.45±31.19
		40-49	32/30	131.38±30.11	94.20±29.96	184.25±47.43	95.03±33.99
		50-59	31/32	118.16±31.17	84.41±24.09	159.10±55.24	99.94±28.83
		60-70	31/30	105.81±18.09	71.90±20.75	160.32±45.98	79.90±25.55
Ringqvist (7) (Caucasian)	≥10	18-29	37/33	146±26	113±24	247±41	170±29
		30-39	12/8	148±21	97±24	248±38	163±29
		40-49	15/14	134±29	104±27	253±52	178±33
		50-59	13/12	118±17	82±16	252±32	157±28
		60-69	16/17	115±30	84±18	209±49	157±27
		>70	13/10	95±14	82±16	200±42	152±27
Neder et al (47) (Brazilian)	5	20-29	50/50	129.3±17.6	101.6±13.1	147.3±11.0	114.1±14.8
		30-39		136.1±22.0	91.5±10.1	140.3±21.7	100.6±12.1
		40-49		115.8±87.0	87.0±9.1	126.3±18.0	85.4±13.6
		50-59		118.1±17.6	79.3±9.5	114.7±6.9	83.0±6.2
		60-69		100.0±10.6	85.3±5.5	111.2±10.9	75.6±10.7
		70-80		92.8±72.8	72.7±3.9	111.5±21.0	69.6±6.7
Black and Hyatt (12) (Caucasian)	2	20-54	60/60	124±44	87±32	233±84	152±54
		55-59		103±32	77±26	218±74	145±40
		60-64		103±32	73±26	209±74	140±40
		65-69		103±32	70±26	197±74	135±40
		70-74		103±32	65±26	185±74	128±40
Chen and Kuo (26) (Chinese)	3	16-30	10/10	123.4±5.5	89.3±3.1	141.2±8.8	97.9±5.4
		31-45	10/10	116.5±5.1	76.0±3.4	136.6±8.9	92.8±4.2
		46-60	10/10	92.8±4.3	71.6±5.6	133.6±9.0	88.4±6.2
		61-75	10/10	83.4±4.7	59.9±4.5	117.4±7.4	75.1±5.1
Enright et al (4) (Caucasian)	5	65-69	704/1,131	84	59	188	125
		70-74	728/888	81	56	179	121
		75-79	472/589	74	49	161	102
		80-84	253/243	64	45	142	84
		85+	102/91	56	40	131	94

MEP in this study is lower than the studies Caucasian. Reasons for lower values of MEP are following; Firstly, Ringqvist (7) and Black and Hyatt (12) started the test with MEP and followed by MIP but this present study alternated between MIP and MEP. Since MIP was primarily measured, MIP was also affected to a lesser degree of strength of the expiratory muscle (4). For this reason, subjects in the present study may be had fatigue in who performed MIP in the first. Secondly, Asian had anthropometrics data lower than Caucasian. The bigger body size, the more strength. It is reasonable that why MEP in Caucasian is higher than Asian. In addition, value of anthropometrics data of Asian is lower than Caucasian, thus it may be possible that the expiratory muscle of Asian has less strength than Caucasian. Nevertheless, the MEP in the present study was higher than Neder's which were done in Brazilian because numbers to perform maneuver were 12 times per test while the study of Neder performed only 5 times per test. However, when compared with data of Chen and Kuo (52) in Chinese people that their subjects performed 3 times per test the values are lower than this present study. These may be the present study performed numbers of maneuver per test more than Chen and Kuo and promoted the learning effect of respiratory muscle strength test.

5.4 Effect of Age and Gender on Maximal Inspiratory Mouth Pressure (MIP)

In this study, the results of two-way mixed analysis of variance showed that MIP in aged-group 30-39 years and 40-49 years were different from that of 60-70 years ($p < 0.05$). This indicated that age had an effect on MIP. This is in accordance with previous studies which found that MIP was slightly decreased by age at over 50 years in both genders (4, 12, 28, 53-55). In order to explain these results, it is necessary to understand anatomical and physiological change in respiratory system by aging. Changes in skeletal muscle occurred with increasing age such as decreased muscle mass, decreased the number of muscle fibers especially Type II and motor units, alteration of neuromuscular junctions, loss of peripheral motor neuron and decreased in muscle work capacity was due to decreased efficiency in energy metabolism (57). Residual volume (RV) increased with increasing age that lead to an altered force-

length relationship of diaphragm and diminished static outward recoil of the chest wall, resulting decreased MIP at RV (16).

There was statistically significant difference of MIP between male and female subjects in all aged-group in this present study. Males had higher MIP than that of females similar to previous studies (4, 7, 10, 12, 27, 28, 47, 52). It might be partly explained by anthropometrics difference that females were shorter and lighter than males (52) and males have higher strength than females (4).

5.5 Effect of Age and Gender on Maximal Expiratory Mouth Pressure (MEP)

For MEP, no difference between aged-group was showed. Although, MEP was slightly decreased at age over 50 years in male and 60 years in female. However, no significant differences of MEP among aged-groups in both genders. The result of this study was close to McElvaney et al (10) that showed no relationship between respiratory muscle strength and age. This may be explained that chest wall compliance decrease progressively with age. Change of the thoracic wall involves calcification and stiffness of the articulations of rib cage that make the chest wall less compliant. This decreased compliance of chest wall may increase the MEP (10). However, the result of the present study is different from previous studies (4, 12, 28). It is suggested that MEP was decreased with age older than 55 years old.

Conversely, comparison of data in the present study with Ringqvist and Neder (47), it was shown that the small differences of MEP values between aged-group similar to present study. In addition, both studies did not perform statistical analysis. Decreasing of MEP in aged over 50 years old in male and 60 years old in female in the present study may be explained by changes in skeletal muscle occurred by increasing age such as decreased muscle mass, decreased the number of muscle fibers especially Type II and motor units, alteration of neuromuscular junctions, loss of peripheral motor neuron and decreased in muscle work capacity was due to decreased efficiency in energy metabolism (57) and decreased respiratory muscle strength.

There was statistically significant difference of MEP between male and female subjects in all aged-group in the present study. Males had MEP higher than females such as previous studies (4, 7, 10, 12, 27, 28, 47, 52). It might be partly explained by anthropometrics difference that females were shorter and lighter than males (52) and males have higher strength than females (4).

5.6 Correlation of Maximal Inspiratory Mouth Pressure (MIP) and Maximal Expiratory Mouth Pressure (MEP) with age, height and weight

The results of this study showed that MIP had negative correlation with age and positive correlation with weight in both genders. Only male had positive correlation between MIP and height. MEP had no correlation with age, height and weight in both genders.

Many investigators demonstrated that age had the strongest correlation with the respiratory muscle strength (4, 7, 12, 28, 46, 47, 52). The aging process is associated with a reduction in the diaphragmatic and respiratory accessory muscular mass, as well as with a decline in the work output for a same level of neural stimulation and changes in the elastic recoil properties of the lung and chest wall (4). Therefore, advanced age reduces the capacity of the respiratory muscle to generate pressure.

Many studies found correlation between respiratory muscle strength and height and weight. For female, Enright et al (4) and McConnell et al (28) found correlation between respiratory muscle strength (both MIP and MEP) with weight. In contrast, Wilson and co-workers (8) found correlation of respiratory muscle strength with height. Besides, Harik-Khan et al (27) found correlation between respiratory muscle strength with both height and weight in female. For male, Enright et al and Harik-Khan found correlation between MIP and MEP with weight. In this present study, correlation of MIP with weight in both male and female while correlation with height was found only in male. This may be explained by the results of Schoenberg et al in 1978 (81). It was found that weight affected lung function values and suggested that

the lung function increment with weight was due to increasing muscle bulk. Increase in weight was due to increase diaphragmatic muscle mass and increase respiratory muscle strength. In the result of this study showed correlation of MIP and height in male. This may be explained by the work of Carpenter and co-workers in 1999 (82). They suggested that standing height showed a direct and linear relationship with MIP in both genders. Similarly, pulmonary function studies have found that lung volumes are directly related of height due to increase intrathoracic space. On the other hand, the present study found correlation between MIP and height only in male, this result can not be explained by the physiological phenomenon. However, the results of the present study showed no correlation of MEP with age, height and weight. It may be MEP not changed with age advanced. In addition, weight and height in this study were not effect on expiratory muscle strength.

5.7 Comparison of regression equation of Maximal Inspiratory Mouth Pressure (MIP) and Maximal Expiratory Mouth Pressure (MEP) with other studies

In the present study, MIP and MEP were analyzed by multiple linear regressions. Only age and weight had an independent predictive role for MIP in both genders. On the other hand, the MEP equation did not showed independent prediction power. These results may be explained as following. MIP was significantly different between age groups and tended to decrease with age thus regression was showed correlation, whereas MEP was not significantly different between age groups and not decrease with age, thus these variables can not predict MEP value.

Table 5.2 showed regression equations of the present study and other studies. Most of those equations revealed that age was strong negative predictor of MIP and MEP similar to the present study. In addition, Harik-Khan, Wilson, Johan and co-workers and this study showed correlation of height and weight with MIP and MEP in equations. When compared residual sum of squares (R^2) of equation between the previous studies and the present study was showed low R^2. Those results indicate age, height and weight are not good predictor of respiratory muscle strength test. However,

the reference equations derived from this study are useful in the assessment of respiratory muscle strength.

5.8 Limitation of the Study

The numbers to perform respiratory muscle test in the present study are 10 and 12 times per session for MIP and MEP test, respectively. This is not practical to apply in clinical test especially, patients with severe respiratory muscle weakness who had difficultly to perform high repetitions of test. Subjects in this study are healthy volunteers who are sedentary or active persons. This study was not randomly selected. Therefore, it may not be representative of the general population. The equations of respiratory muscle strength in this study showed low R^2 thus apply for clinical test may be used with caution. To apply the values of this study for clinical or research should use similar method and devices to the present study.

5.9 Clinical Implications

This study provided preliminary data of respiratory muscle strength that are MIP and MEP in Thai healthy female and male aged 30-70 years. In addition, reference equation in the present study could be used to apply for clinical screening test for healthy population and for people who have risk of respiratory muscle weakness such as neuromuscular disease; multiple sclerosis; myasthenia gravis and COPD patients. However, application of these values of respiratory muscle strength prediction equations to other populations should be done with the similar instruments and procedures.

Table 5.2 Regression equation of respiratory muscle strength from different studies

Reference	Age range (year)	No. of subject (male/ female)	Equation	R	R^2	P-value
The present study	30-70	127/122	**Males**			
			MIP = 124.39-0.91A+0.63Wt	0.419	0.175	0.018
			MEP = 200.36-0.61A	0.147	0.022	0.099
			Females			
			MIP = 77.57-0.59A+0.62Wt	0.382	0.146	0.004
			MEP = 113.68-0.44A	0.178	0.032	0.051
Black and Hyatt (12)	20-80	60/60	**Males**			
			MIP = 143-0.55A			<0.01
			MEP = 268-1.03A			<0.01
			Females			
			MIP = 104-0.51A			<0.01
			MEP = 170-0.53A			<0.01
Herik-khan (27)	20-90	139/128	**Males**			
			MIP = 126-1.028A+0.343Wt	0.648	0.42	<0.05
			Females			
			MIP = 171-0.694A+0.861Wt-0.743Ht	0.556	0.31	<0.05
Wilson (8)	18-70	48/87	**Males**			
			MIP = 142-1.03A	0.458	0.21	0.001
			MEP = 180-0.91A	0.374	0.14	0.009
			Females			
			MIP = -43+0.71Ht	0.225	0.051	0.035
			MEP = 3.5+0.55Ht	0.232	0.054	0.031
Neder (47)	20-80	50/50	**Males**			
			MIP = 155.3-0.80A			<0.01
			MEP = 165.3-0.81A			<0.01
			Females			
			MIP = 110.4-0.49A			<0.01
			MEP = 115.6-0.61A			<0.01
Chen and Kuo (52)	16-75	80/80	**Males**			
			MIP = 149-1.00A	0.624	0.389	0.001
			MEP = 157-0.55A	0.245	0.060	<0.05
			Females			
			MIP = 101-0.62A	0.479	0.229	0.001
			MEP = 109-0.47A	0.322	0.103	<0.01
Johan (46)	20-80	Chinese 131/90	**Males**			
			MIP = 37.24-0.67A+0.15Ht+0.85Wt	0.405	0.164	<0.05
			MEP = -0.106-0.52A+1.05Ht+1.03Wt	0.420	0.176	<0.05
			Females			
			MIP = 68.80-0.49A-0.05Ht+0.22Wt	0.263	0.069	<0.05
			MEP = 112.14-0.59A-0.11Ht-0.07Wt	0.293	0.085	<0.05

A = Age (yrs), Ht = Height (cm), Wt = Weight (kg)

Table 5.2 Regression equation of respiratory muscle strength from different studies (cont.)

Reference	Age range (year)	No. of subject (male/ female)	Equation	R	R^2	P-value
The present study	30-70	127/122	**Males**			
			MIP = 124.39-0.91A+0.63Wt	0.419	0.175	0.018
			MEP = 200.36-0.61A	0.147	0.022	0.099
			Females			
			MIP = 77.57-0.59A+0.62Wt	0.382	0.146	0.004
			MEP = 113.68-0.44A	0.178	0.032	0.051
Johan (46)	20-80	Malay 69/42	**Males**			
			MIP = 151.32-0.33A-0.55Ht+0.38Wt	0.219	0.047	<0.05
			MEP = 109.82+0.05A-0.22Ht+0.30Wt	0.146	0.021	<0.05
			Females			
			MIP = 52.48+0.18A-0.09Ht+0.12Wt	0.144	0.020	<0.05
			MEP = 181.87-0.16A-0.90Ht+0.43Wt	0.242	0.058	<0.05
		Indian 77/43	**Males**			
			MIP = 112.47-0.31A-0.31Ht+0.51Wt	0.191	0.036	<0.05
			MEP = -13.66-0.62A+0.79Ht+0.06Wt	0.331	0.109	<0.05
			Females			
			MIP = 54.65-0.48A-0.01Ht+0.24Wt	0.339	0.114	<0.05
			MEP = 130.36-0.49A-0.40Ht+0.17Wt	0.251	0.063	<0.05

A = Age (yrs), Ht = Height (cm), Wt = Weight (kg)

CHAPTER VI
CONCLUSION

The present study determined the relationship between respiratory muscle strength and age, gender, weight and height. The regression equations of respiratory muscle strength were also investigated. Two hundreds and forty-nine healthy volunteers (122 females and 127 males) aged 30-70 years within eight groups; 30-39, 40-49, 50-59 and 60-70 years in female and male were participated in this study. Inspiratory and expiratory muscle strength were indicated by maximal inspiratory mouth pressure (MIP) and maximal expiratory mouth pressure (MEP), respectively, measured by using a mouth pressure meter (Spirovis). It can be concluded from the present study that:

1. Respiratory muscle strength in female was lower than male in all age group.
2. MIP decreased with age older than 60 years in both genders.
3. MIP was correlate with age and weight in females.
4. MIP was correlate with age, weight and height in males.
5. MEP was not correlate with age, weight and height in both genders.
6. MIP equation was 77.57-0.59Age+0.62Weight from female and 124.39-0.91Age+0.63Weight ($p=0.018$) from male.

This data could be applied in clinic and research for useful indexes of respiratory muscle strength in Thai healthy female and male aged 30 to 70 years.

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APPENDIX

APPENDIX A.1

CONSENT FORM

(หนังสือยินยอมเข้าร่วมการศึกษา)

เขียนที่.....

วันที่.....เดือน.....พ.ศ. .....

ข้าพเจ้า.....อยู่บ้านเลขที่.....
หมู่ที่.....ตำบล.....ถนน.....
เขต/อำเภอ.....จังหวัด.....โทร.....

ข้าพเจ้าได้รับทราบรายละเอียดของโครงการวิจัยเรื่อง **"ความแข็งแรงของกล้ามเนื้อหายใจในคนไทยสุขภาพดีที่มีอายุระหว่าง 30-70 ปี"** ดังนี้ การศึกษานี้มีวัตถุประสงค์เพื่อหาค่าความแข็งแรงของกล้ามเนื้อหายใจในคนไทยที่มีสุขภาพดี รวมทั้งหาความสัมพันธ์ระหว่างอายุและเพศที่มีผลต่อค่าความแข็งแรงของกล้ามเนื้อหายใจ แล้วนำข้อมูลที่ได้ไปหาสมการที่เกี่ยวข้องเพื่อใช้เป็นค่าคาดคะเนค่าความแข็งแรงของกล้ามเนื้อหายใจในคนไทย ข้าพเจ้าจะได้กรอกแบบสอบถามเกี่ยวกับข้อมูลส่วนตัว ประวัติทางสุขภาพ ทำการชั่งน้ำหนัก วัดส่วนสูง วัดอัตราการเต้นของหัวใจ อัตราการหายใจ ความดันโลหิต อุณหภูมิกาย ตรวจร่างกายทางทรวงอกและทำการวัดสมรรถภาพปอด ข้าพเจ้าจะได้รับการอธิบายวัตถุประสงค์และวิธีการวิจัย ก่อนที่จะเข้ารับการวัดความแข็งแรงของกล้ามเนื้อหายใจ และต้องทำการวัดเป็นเวลา 1 ชั่วโมง 30 นาทีต่อครั้งต่อสัปดาห์ จำนวน 1 ครั้ง ซึ่งประโยชน์ที่คาดว่าจะได้รับจากการศึกษาครั้งนี้ ข้าพเจ้าจะได้ทราบสมรรถภาพปอดและค่าความแข็งแรงของกล้ามเนื้อหายใจ ในการเก็บข้อมูลครั้งนี้จะไม่มีอันตรายหรือผลเสียต่อสุขภาพแต่อย่างใด

หากผู้วิจัยมีข้อมูลเพิ่มเติมทั้งด้านประโยชน์ และโทษที่เกี่ยวข้องกับการวิจัยจะแจ้งให้ข้าพเจ้าทราบอย่างรวดเร็วโดยไม่ปิดบัง

ข้าพเจ้ามีสิทธิ์ที่จะยกเลิกการเข้าร่วมโครงการวิจัยโดยมิต้องแจ้งให้ทราบล่วงหน้า โดยการยกเลิกการเข้าร่วมการวิจัยครั้งนี้จะไม่มีผลกระทบต่อการได้รับการบริการหรือการรักษาที่ข้าพเจ้าจะได้รับแต่ประการใด

ข้าพเจ้ายินดีที่จะถูกคัดออกจากการเข้าร่วมการวิจัย เมื่อผู้วิจัยพบว่าข้าพเจ้าไม่ได้อยู่ในเกณฑ์การคัดเข้าร่วมการวิจัยและเมื่อข้าพเจ้าไม่สามารถเข้าร่วมการวิจัยได้จนครบกระบวนการวิจัย

ข้าพเจ้าให้ข้อมูลตรงกับความเป็นจริงทุกประการ และรับทราบจากผู้วิจัยว่าจะไม่เปิดเผยข้อมูลหรือผลการวิจัยของข้าพเจ้าเป็นรายบุคคลต่อสาธารณชน

ข้าพเจ้าได้รับการอธิบายเกี่ยวกับการวิจัยและซักถามผู้วิจัยจนหมดข้อสงสัยโดยตลอดแล้ว และยินดีเข้าร่วมในการวิจัย จึงได้ลงลายมือชื่อไว้เป็นหลักฐานต่อหน้าพยาน

ลงชื่อ.....ผู้เข้าร่วมโครงการ

(.....)

ลงชื่อ.....หัวหน้าโครงการ

(นางสาวอรวรรณ โพนเงิน)

ลงชื่อ.....พยาน

(.....)

APPENDIX A.2

PARTICIPANT INFORMATION SHEET

(เอกสารแนะนำสำหรับอาสาสมัคร)

ชื่อโครงการวิจัย ความแข็งแรงของกล้ามเนื้อหายใจในคนไทยสุขภาพดี ที่มีอายุระหว่าง 30-70 ปี
Respiratory muscle strength in Thai healthy subjects age range 30-70 years

ชื่อหัวหน้าโครงการ นางสาวอรวรรณ โพนเงิน

เรียน ท่านผู้เข้าร่วมการวิจัย

การศึกษานี้มีวัตถุประสงค์เพื่อหาค่าความแข็งแรงของกล้ามเนื้อหายใจในคนไทยที่มีสุขภาพดีรวมทั้งหาความสัมพันธ์ระหว่างอายุและเพศที่มีผลต่อค่าความแข็งแรงของกล้ามเนื้อหายใจ แล้วนำข้อมูลที่ได้ไปหาสมการที่เกี่ยวข้องเพื่อใช้เป็นค่าคาดคะเนค่าความแข็งแรงของกล้ามเนื้อหายใจในคนไทย

ขั้นตอนการวิจัย

1. ขั้นเตรียมการ

ผู้วิจัยคัดเลือกผู้เข้าร่วมวิจัยที่มีคุณสมบัติตามที่กำหนด โดยสอบถามเกี่ยวกับข้อมูลส่วนตัว ประวัติทางสุขภาพด้วยการใช้แบบสอบถาม ทำการชั่งน้ำหนัก วัดส่วนสูง วัดอัตราการเต้นของหัวใจ อัตราการหายใจ ความดันโลหิต อุณหภูมิกาย และทำการวัดสมรรถภาพปอด คือ ค่าปริมาตรของลมที่เป่าออกอย่างเร็วและแรง ค่าปริมาตรของลมที่เป่าออกในเวลา 1 วินาที และค่าปริมาตรของลมที่เป่าออกในเวลา 1 วินาทีคิดเป็นร้อยละของปริมาตรของลมที่เป่าออกอย่างเร็วและแรง โดยผู้เข้าร่วมวิจัยนั่งบนเก้าอี้ในท่าสบาย ทำการวัดโดยให้ผู้เข้าร่วมวิจัยหายใจเข้าเต็มที่หลังจากนั้นทำการปิดจมูกโดยใช้ที่หนีบจมูกหนีบพร้อมกับอมท่อเป่า แล้วหายใจออกอย่างเร็วและแรง เป็นเวลาอย่างน้อย 6 วินาที จำนวน 3 ครั้ง ในการเป่าแต่ละครั้งจะได้รับการพักเป็นเวลาอย่างน้อย 1 นาที หลังการวัดสมรรถภาพปอดผู้เข้าร่วมการวิจัยจะได้รับการพักเป็นเวลา 5 นาทีแล้วผู้วิจัยจะทำการตรวจร่างกายระบบทางเดินหายใจเพื่อคัดกรองผู้ที่ไม่เข้าเกณฑ์การทดลองออก ผู้เข้าร่วมวิจัยจะได้รับการอธิบายวัตถุประสงค์ ขั้นตอนในการทดสอบ และประโยชน์ที่คาดว่าจะได้รับจากการวิจัยนี้ จากนั้นผู้เข้าร่วมวิจัยลงลายมือชื่อไว้ในใบยินยอมเข้าร่วมการวิจัย

2. ขั้นตอนการเก็บข้อมูล

ผู้เข้าร่วมวิจัยจะได้รับการพักหลังจากที่วัดสมรรถภาพปอดเป็นเวลา 10 นาที หลังจากนั้นจะได้รับการฝึกการวัดความแข็งแรงของกล้ามเนื้อหายใจ แบ่งเป็น วัดความแข็งแรงของกล้ามเนื้อหายใจเข้า โดยให้ผู้เข้าร่วมการวิจัย อมท่อเป่า ไว้ในปากแล้วทำการหายใจออกจนสุดเมื่อหายใจออกสุดแล้วทำการหายใจเข้าให้ลึกมากที่สุดเท่าที่จะสามารถทำได้ จำนวน 10 ครั้ง โดยในแต่ละครั้งผู้เข้าร่วมการวิจัยจะได้รับการพักเป็นเวลาอย่างน้อย1 นาที และจะได้รับการพัก 10 นาที แล้วฝึกการวัดความแข็งแรงของกล้ามเนื้อหายใจออก โดยให้ผู้ร่วมการวิจัย อมท่อเป่าไว้ในปาก แล้วหายใจเข้าให้สุดเมื่อหายใจเข้าสุดแล้วให้หายใจออกให้มากที่สุดที่จะทำได้ จำนวน 12 ครั้ง โดยในแต่ละครั้งผู้เข้าร่วมการวิจัยจะได้รับการพักเป็นเวลาอย่างน้อย 1 นาที

ในระหว่างและหลังทำการเก็บข้อมูล ผู้วิจัยจะสอบถามเกี่ยวกับอาการผิดปกติต่างๆ ที่อาจจะเกิดขึ้น ได้แก่ อาการหน้ามืด วิงเวียนศีรษะ หอบเหนื่อย หากมีความผิดปกติดังกล่าวเกิดขึ้น ทางผู้วิจัยจะหยุดทำการเก็บข้อมูลทันทีและให้ผู้เข้าร่วมวิจัยนั่งพัก ซึ่งปกติแล้วอาการจะหายไปได้เองภายในเวลา 2-3 นาที แต่ถ้ายังมีอาการผิดปกติดังกล่าวอยู่ ทางผู้วิจัยจะทำการส่งปรึกษาแพทย์ผู้ร่วมวิจัยทันที

การศึกษาในครั้งนี้ไม่มีค่าตอบแทน/ค่าเดินทาง/ค่าชดเชยการขาดงานแก่ผู้ร่วมวิจัย แต่อย่างไรก็ตาม จากผลการศึกษานี้ ท่านจะได้ทราบค่าสมรรถภาพปอดและทราบค่าความแข็งแรงของกล้ามเนื้อหายใจของท่าน หากพบว่าท่านมีความผิดปกติของระบบหายใจ ทางผู้วิจัยจะได้แนะนำวิธีการรักษาที่เหมาะสมต่อไป โดยผู้วิจัยจะไม่เปิดเผยชื่อ ประวัติ ข้อมูลที่เกี่ยวข้องกับท่านให้ผู้อื่นทราบ

การศึกษาครั้งนี้ไม่ก่อให้เกิดความเสี่ยงหรืออันตรายใดๆต่อผู้เข้าร่วมวิจัย แต่อย่างไรก็ตามหากเกิดอันตรายใดๆต่อท่าน ทางผู้วิจัยสามารถทำการช่วยเหลือและนำส่งโรงพยาบาลได้ทันท่วงที ทั้งนี้หากท่านเห็นสมควรที่จะยกเลิกการเข้าร่วมการศึกษา ท่านสามารถยกเลิกได้ตลอดเวลา โดยไม่มีผลกระทบใดๆต่อการเข้ารับการบริการและการรักษาที่ท่านพึงได้รับในครั้งต่อไป

หากท่านมีข้อสงสัยประการใด ท่านสามารถสอบถามผู้วิจัยได้ตลอดเวลา ที่หมายเลขโทรศัพท์ 0-6617-2500

.....

(นางสาวอรวรรณ โพนเงิน)

หัวหน้าโครงการ

APPENDIX B

FOR SUBJECT SCREENING QUESTIONNAIRE

แบบสอบถามเพื่อการวิจัย

เรื่อง"ความแข็งแรงของกล้ามเนื้อหายใจในคนไทยสุขภาพดีที่มีอายุระหว่าง 30-70 ปี"

แบบสอบถามต่อไปนี้ เป็นการประเมินสภาพความเจ็บป่วยของอาสาสมัครที่เข้าร่วมการศึกษา เพื่อพิจารณาว่ามีความผิดปกติหรือไม่ เพื่อเป็นข้อมูลในการคัดกรอง ทางผู้วิจัยจะปกปิดข้อมูลของท่านเป็นความลับ มิได้เปิดเผยแต่ประการใด ดังนั้นกรุณากรอกข้อมูลด้วยความเป็นจริง หากมีข้อสงสัยใดๆกรุณาสอบถามผู้วิจัยทันที

1. **ชื่อ-นามสกุล(นาย/นาง/นางสาว)**.....

2. **ประวัติในปัจจุบัน**

ท่านมีอาการเหล่านี้ ก่อนมาทำการทดสอบหรือไม่

2.1 ไข้ ☐ไม่มี ☐มี

2.2 อาการปวดศีรษะอย่างรุนแรง ☐ไม่มี ☐มี

2.3 หายใจลำบาก หอบเหนื่อย ☐ไม่มี ☐มี

2.4 อ่อนเพลีย วิงเวียนศีรษะ มึนงง ☐ไม่มี ☐มี

ประวัติในอดีต

2.5 ท่านเคยเป็นโรคอัมพฤกหรืออัมพาตหรือไม่

☐ไม่เคย ☐เคย, ระบุระยะเวลา.....

2.6 ท่านเคยได้รับอุบัติเหตุร้ายแรงหรือไม่

☐ไม่เคย ☐เคย, ระบุระยะเวลา.....

2.7 ท่านมีโรคประจำตัวอื่นๆหรือไม่

☐ไม่มี ☐มี, ระบุโรค.....

2.8 ท่านเป็นโรคติดต่อ ต่อไปนี้หรือไม่

2.9.1 เริมบริเวณริมฝีปาก ☐ไม่เคย ☐เคย

2.9.2 ไวรัสตับอักเสบ ☐ไม่เคย ☐เคย

3. **ประวัติการใช้ยา**

3.1 ปัจจุบันท่านต้องรับประทานยาเป็นประจำหรือไม่

□ไม่ □ใช่, ระบุชื่อยา.....

3.2 ท่านได้รับประทานยาก่อนมาทำการทดสอบหรือไม่

□ไม่ □ใช่, ระบุชื่อยา.....

4. ก่อนมาทำการทดสอบ 6 ชั่วโมง ท่านได้ดื่มเครื่องดื่มที่มีแอลกอฮอล์ เช่น สุรา ไวน์ หรือไม่

□ไม่ดื่ม □ดื่ม

6. การตรวจร่างกาย

6.1 รูปร่างทรวงอก

□อกบุ๋ม(Funnel chest) □อกไก่(Pigeon chest) □อกถังเบียร์(Barrel chest)

□หลังคด(Scoliosis) □หลังค่อม(Kyphosis)

□หลังคดและค่อม (Kyphoscoliosis)

□ปกติ(Normal)

6.2 สมรรถภาพปอด

FVC……..ml

FEV_1…….ml

FEV_1/FVC……%

APPENDIX C

แบบสอบถามโครงการวิจัย
ATS-LDL-78-Adult Questionnaire

ขอขอบคุณสำหรับความร่วมมือในการตอบแบบสอบถามนี้ ขอความกรุณาให้ตอบตรงตามความเป็นจริงที่สุด ข้อมูลทั้งหลายจะนำไปใช้ในทางการแพทย์เท่านั้น และถือเป็นความลับ การตอบคำถามจะสามารถทำได้โดยทำเครื่องหมายถูก (√) ลงใน □ของข้อที่ถูกที่สุด หรือเติมคำลงในช่องว่าง

1. **<u>ทั่วไป</u>** (เฉพาะผู้วิจัยกรอก)

ชื่อ.....นามสกุล..... 1□□□□

ที่อยู่.....

.....

ผู้สัมภาษณ์..... 2□□

วันที่สัมภาษณ์..... 3□□□□□□

2. <u>ประวัติส่วนตัว</u>

1. วันเดือนปีเกิด..... 4□□□□□□
2. สถานที่เกิด(จังหวัด).....
3. เพศ □1. ชาย □2. หญิง 5□
4. สถานภาพ □1. โสด □2. แต่งงาน 6□
   □3. หม้าย □4. หย่า
5. เชื้อชาติ □1. ไทย □2. จีน □3. อื่นๆ..... 7□
6. การศึกษา □1. ประถมศึกษา 8□
   □2. มัธยมศึกษา
   □3. อาชีวศึกษา
   □4. มหาวิทยาลัย
   □5. ไม่ได้เรียน

3. <u>อาการไอ</u>

7 A ปกติท่านไอบ่อยหรือไม่

☐1. ใช่ ☐2. ไม่ใช่ 9☐

(ถ้าตอบ ‘‘ไม่’’ ข้ามไปข้อ 7 C)

7 B ท่านไอบ่อยๆ มากกว่า 4-6 ครั้งต่อวันและเกิน 4 วันต่อสัปดาห์ขึ้นไปหรือไม่

☐1. ใช่ ☐2. ไม่ใช่ 10☐

7 C ท่านมีอาการไอเมื่อตื่นนอนตอนเช้าหรือขณะเปลี่ยนอิริยาบถบ่อยๆหรือไม่

☐1. ใช่ ☐2. ไม่ใช่ 11☐

7 D ท่านมีอาการไอทั้งวันทั้งคืนหรือไม่

☐1. ใช่ ☐2. ไม่ใช่ 12☐

ถ้าตอบ “ใช่” ข้อใดข้อหนึ่ง ให้ตอบคำถามข้อ 7E และ 7F ต่อ

7E ท่านไอเช่นนี้เกือบทุกวัน ติดต่อกัน 3 เดือนหรือมากกว่าหรือไม่

☐1. ใช่ ☐2. ไม่ใช่ 13☐

7F ท่านมีอาการไอเช่นนี้มากี่ปี.....ปี 14☐☐

4. <u>เสมหะ</u>

8A ท่านไอมีเสหะจากหลอดลมบ่อยๆหรือไม่

☐1. ใช่ ☐2. ไม่ใช่ 15☐

(ถ้าตอบว่า ‘‘ไม่ใช่’’ ข้ามไปตอบข้อ 8C)

8B ท่านไอมีเสมหะเช่นนี้วันละ 2 ครั้งขึ้นไปและ 4 วันต่อสัปดาห์ขึ้นไป หรือไม่

☐1. ใช่ ☐2. ไม่ใช่ 16☐

8C ท่านมีเสมหะบ่อยๆหลังตื่นนอนตอนเช้า หรือขณะเปลี่ยนอิริยาบถ หรือไม่

☐1. ใช่ ☐2. ไม่ใช่ 17☐

8D ท่านมีเสมหะบ่อยๆตลอดวันหรือไม่

☐1. ใช่ ☐2. ไม่ใช่ 18☐

ถ้าท่านตอบว่า “ใช่” ในข้อใดข้อหนึ่ง ให้ตอบคำถามข้อ 8E และ 8F ต่อ

8E ท่านมีเสมหะเช่นนี้เกือบทุกวันเป็นเวลา 3 เดือนติดต่อกันขึ้นไป หรือไม่

☐1. มี ☐2. ไม่มี 19☐

8F ท่านมีเสมหะเช่นนี้มากี่ปี.....ปี 20☐☐

5. <u>อาการไอมีเสมหะ</u>

9A ในแต่ละปีท่านมีอาการไอมีเสมหะเป็นเวลานานเกิน 3 สัปดาห์ขึ้นไปหรือไม่

☐1. มี ☐2. ไม่มี 21☐

ถ้าตอบ "มี" ให้ตอบข้อ 9B ต่อ

9B ท่านมีอาการดังกล่าว (อย่างน้อย 1 ครั้งต่อปี) มานานกี่ปี.....ปี 22☐☐

6. <u>เสียงวี๊ด (Wheeze)</u>

10A ท่านเคยมีเสียงดังวี๊ด เมื่อ

1. เป็นหวัด ☐1. มี ☐2. ไม่มี 23☐
2. บางครั้งในช่วงที่ไม่เป็นหวัด ☐1. มี ☐2. ไม่มี 24☐
3. บ่อยครั้ง ☐1. มี ☐2. ไม่มี 25☐

ถ้าตอบ "มี" ในข้อ 1, 2 หรือ 3 จาก 10A

10B ท่านมีอาการเช่นนี้มากี่ปี.....ปี 26☐☐

11A ท่านเคยมีเสียงหายใจดังวี๊ดร่วมกับอาการหอบเหนื่อยหรือไม่

☐1. มี ☐2. ไม่มี 27☐

ถ้าตอบ "มี" ในข้อ 11A

11B ท่านเริ่มมีอาการดังกล่าว (ข้อ 11A) ครั้งแรกเมื่ออายุเท่าใด.....ปี 28☐☐

11C ท่านมีอาการดังกล่าวมากกว่า 2 ครั้งขึ้นไปหรือไม่

☐1. มี ☐2. ไม่มี 29☐

11D ท่านเคยต้องใช้ยารักษาอาการดังกล่าวหรือไม่

☐1. เคย ☐2. ไม่เคย 30☐

7. <u>อาการหอบเหนื่อย</u>

12 ถ้าท่านไม่สามารถเดินได้จากสาเหตุนอกเหนือจากโรคปอดและโรคหัวใจ โปรดระบุและข้ามไปข้อ 14A

สาเหตุ.....

13A ท่านมีอาการเหนื่อยหอบขณะเดินอย่างเร่งรีบหรือเดินขึ้นที่ลาดชันเล็กน้อยหรือไม่

☐1. ใช่ ☐2. ไม่ใช่ 31☐

ถ้าตอบ "ใช่" ในข้อ 13A

13B ท่านเดินช้ากว่าคนอื่นในวัยเดียวกัน บนพื้นราบเนื่องจากอาการเหนื่อยหอบหรือไม่

☐1. ใช่ ☐2. ไม่ใช่ 32☐

13C ท่านเคยต้องหยุดพักหายใจเมื่อเดินธรรมดาบนพื้นราบหรือไม่

☐1. เคย ☐2. ไม่เคย 33☐

13D ท่านเคยต้องหยุดพักหายใจหลังจากเดินประมาณ 100 เมตร (หรือประมาณ 2-3 นาที) บนพื้นราบหรือไม่

☐1. เคย ☐2. ไม่เคย 34☐

13E ท่านเหนื่อยเกินกว่าจะเดินออกนอกบ้านหรือเหนื่อยขณะเปลี่ยนเสื้อผ้า

☐1. ใช่ ☐2. ไม่ใช่ 35☐

8. <u>Chest Cold and Chest illnesses</u>

14A เมื่อท่านเป็นหวัดท่านมักจะมีอาการทางปอด (เช่น ไอ, เสมหะเพิ่มขึ้น, แน่นหน้าอก, หอบเหนื่อย) ด้วย (มากกว่า 50 %)

☐1. มี ☐2. ไม่มี 36☐

15A ในช่วงเวลา 3 ปีหลัง ท่านมีอาการทางปอดที่ทำให้ต้องหยุดงาน, อยู่กับบ้าน, หรืออยู่กับเตียงหรือไม่

☐1. มี ☐2. ไม่มี 37☐

15B ท่านมีเสมหะร่วมด้วยหรือไม่ กับอาการดังกล่าว

☐1. มี ☐2. ไม่มี 38☐

15C ในช่วง 3 ปีหลัง ท่านมีอาการป่วยกี่ครั้งที่มีเสมหะร่วมด้วยและเป็นอยู่นานเกิน 1 สัปดาห์

☐1. มี ☐2. ไม่มี 39☐

9. <u>ประวัติอดีต</u>

16 ท่านมีโรคทางปอดก่อนอายุ 16 ปีหรือไม่

☐1. มี ☐2. ไม่มี 40☐

17 ท่านเคยมีโรคหรือภาวะเหล่านี้หรือไม่

1A หลอดลมอักเสบบ่อยครั้ง ☐1. เคย ☐2. ไม่เคย 41☐

ถ้าตอบ "เคย" ในข้อ 1A

1B ท่านได้รับการวินิจฉัยจากแพทย์หรือไม่ ☐1. ได้รับ ☐2.ไม่ได้รับ 42☐

1C ท่านเริ่มเป็นโรคนี้เมื่ออายุเท่าใด.....ปี 43☐☐

2A ปอดอักเสบ ☐1. เคย ☐2. ไม่เคย 44☐

ถ้าตอบ "เคย" ในข้อ 2A

2B ท่านได้รับการวินิจฉัยจากแพทย์หรือไม่ ☐1. ได้รับ ☐2.ไม่ได้รับ 45☐

2C ท่านเริ่มเป็นโรคนี้เมื่ออายุเท่าใด.....ปี 46☐☐

3A แพ้อากาศ ☐1. เคย ☐2. ไม่เคย 47☐

ถ้าตอบ "เคย" ในข้อ 3A

3B ท่านได้รับการวินิจฉัยจากแพทย์หรือไม่ ☐1. ได้รับ ☐2.ไม่ได้รับ 48☐

3C ท่านเริ่มเป็นโรคนี้เมื่ออายุเท่าใด.....ปี 49☐☐

18A ท่านเคยเป็นโรคหลอดลมอักเสบเรื้อรังหรือไม่

☐1. เคย ☐2. ไม่เคย 50☐

ถ้าตอบ "เคย" ในข้อ 18A

18B ท่านยังคงเป็นโรคหลอดลมอักเสบเรื้อรังอยู่ ☐1. เป็น ☐2.ไม่เป็น 51☐

18C ท่านได้รับการวินิจฉัยจากแพทย์หรือไม่ ☐1. ได้รับ ☐2.ไม่ได้รับ 52☐

18D ท่านเริ่มเป็นโรคนี้เมื่ออายุเท่าใด.....ปี 53☐☐

19A ท่านเคยเป็นโรคถุงลมโป่งพองหรือไม่

☐1. เคย ☐2. ไม่เคย 54☐

ถ้าตอบ "เคย" ในข้อ 19A

19B ท่านยังคงเป็นโรคถุงลมโป่งพองอยู่ ☐1. เป็น ☐2.ไม่เป็น 55☐

19C ท่านได้รับการวินิจฉัยจากแพทย์หรือไม่ ☐1. ได้รับ ☐2.ไม่ได้รับ 56☐

19D ท่านเริ่มเป็นโรคนี้เมื่ออายุเท่าใด.....ปี 57☐☐

20A ท่านเคยเป็นโรคหอบหืดหรือไม่

☐1. เคย ☐2. ไม่เคย 58☐

ถ้าตอบ "เคย" ในข้อ 20A

20B ท่านยังคงเป็นโรคหอบหืดอยู่ ☐1. เป็น ☐2.ไม่เป็น 59☐

20C ท่านได้รับการวินิจฉัยจากแพทย์หรือไม่ ☐1. ได้รับ ☐2.ไม่ได้รับ 60☐

20D ท่านเริ่มเป็นโรคนี้เมื่ออายุเท่าใด.....ปี 61☐☐

21E ถ้าปัจจุบันท่านไม่เป็นโรคนี้แล้ว โรคนี้หายไปเมื่อท่านอายุเท่าใด.....ปี 62☐☐

21 ท่านเคย

A เป็นโรคทางทรวงอกอื่นๆหรือไม่ ☐1. เคย ☐2. ไม่เคย 63☐

ถ้าตอบว่า "เคย" โปรดระบุ.....

B เคยได้รับการผ่าตัดทรวงอกหรือไม่ ☐1. เคย ☐2. ไม่เคย 64☐

ถ้าตอบว่า "เคย" โปรดระบุ.....

C เคยได้รับอุบัติเหตุบริเวณทรวงอกหรือไม่ ☐1. เคย ☐2. ไม่เคย 65☐

ถ้าตอบว่า "เคย" โปรดระบุ.....

22A เคยมีแพทย์บอกว่า ท่านเป็นโรคหัวใจหรือไม่

☐1. เคย ☐2. ไม่เคย 66☐

ถ้าตอบ "เคย" ในข้อ 22A

22B ท่านเคยได้รับการรักษาโรคหัวใจในช่วง 10 ปีหลังหรือไม่

☐1. เคย ☐2. ไม่เคย 67☐

23A เคยมีแพทย์บอกว่า ท่านมีความดันโลหิตสูงหรือไม่

☐1. เคย ☐2. ไม่เคย 68☐

ถ้าตอบ "เคย" ในข้อ 23A

23B ท่านเคยได้รับการรักษาความดันโลหิตสูงในช่วง 10 ปีหลังหรือไม่

☐1. เคย ☐2. ไม่เคย 69☐

10. <u>ประวัติอาชีพ</u>

24A ท่านทำงานเต็มเวลา (มากกว่า 30 ชั่วโมงต่อสัปดาห์) เป็นเวลานานมากกว่า 6 เดือนขึ้นไปหรือไม่

☐1. ใช่ ☐2. ไม่ใช่ 70☐

ถ้าตอบ "ใช่" ในข้อ 24A

24B ท่านเคยทำงานที่มีฝุ่นเป็นเวลานานกว่า 1 ปีขึ้นไปหรือไม่

☐1. เคย ☐2. ไม่เคย 71☐

โปรดระบุงาน/โรงงาน.....

จำนวนปีที่ทำงาน.....ปี 72☐☐

ปริมาณฝุ่นที่สัมผัส ☐1. น้อย ☐2. ปานกลาง ☐3. มาก 73☐

24C ท่านเคยสัมผัสกับก๊าซหรือควัน สารเคมี ในงานที่ทำหรือไม่

☐1. เคย ☐2. ไม่เคย 74☐

โปรดระบุงาน/โรงงาน.....

จำนวนปีที่ทำงาน.....ปี 75☐☐

ปริมาณฝุ่นที่สัมผัส ☐1. น้อย ☐2. ปานกลาง ☐3. มาก 76☐

24D ปกติท่านทำอาชีพอะไร (อาชีพที่ทำนานที่สุด)

1. งาน-อาชีพ.....
2. จำนวนปีที่ทำ.....ปี
3. ตำแหน่งหน้าที่.....
4. ธุรกิจ, ภาคสนาม, หรืออุตสาหกรรม.....

11. <u>บุหรี่</u>

25A ท่านเคยสูบบุหรี่หรือไม่ ☐1. เคย ☐2. ไม่เคย 77☐

(ถ้าสูบบุหรี่รวมแล้วน้อยกว่า 20 ซอง จนถึงปัจจุบัน หรือน้อยกว่า 1 มวนต่อวัน ไม่เกิน1 ปี ให้ตอบว่า ‘‘ไม่เคย’’)

ถ้าตอบ “เคย” ในข้อ 25A

25B ปัจจุบันท่านยังคงสูบบุหรี่อยู่ (ใน1 เดือน) ☐1. ใช่ ☐2. ไม่ใช่ 78☐

25C ท่านเริ่มสูบบุหรี่เป็นประจำเมื่ออายุเท่าใด.....ปี

25D ถ้าท่านหยุดสูบบุหรี่แล้ว ท่านหยุดเมื่ออายุเท่าใด.....ปี

25E ปัจจุบัน ท่านสูบบุหรี่กี่มวนต่อวัน.....มวนต่อวัน

25F โดยเฉลี่ยทั้งหมด ท่านสูบบุหรี่กี่มวนต่อวัน.....มวนต่อวัน

25G ชนิดของบุหรี่ที่สูบ ☐1. ธรรมดา ☐2. ก้นกรอง ☐3. ยาเส้น 79☐

25H ท่านสูดควันบุหรี่เข้าปอดหรือไม่

☐1. ไม่ ☐2. เล็กน้อย 80☐

☐3. ปานกลาง ☐4. เต็มที่

25I ท่านสูบบุหรี่หมดมวนหรือไม่ ☐1. หมด ☐2. ไม่หมด 81☐

26A ท่านเคยสูบ ‘‘ไปป์’’เป็นประจำหรือไม่ (มากกว่า 12 ออนซ์)

☐1. เคย ☐2. ไม่เคย 82☐

27A ท่านเคยสูบ ‘‘ซิการ์’’ เป็นประจำหรือไม่ (มากกว่า 1 มวนต่อสัปดาห์เป็นเวลา 1 ปี)

☐1. เคย ☐2. ไม่เคย 83☐

12. <u>ประวัติครอบครัว</u>

28 แพทย์เคยวินิจฉัยบิดาหรือมารดาของท่านว่าเป็นโรคทางปอดเรื้อรังต่อไปนี้หรือไม่

	บิดา (84-89)			**มารดา** (90-95)			
	1.เป็น	2.ไม่เป็น	3.ไม่ทราบ	1.เป็น	2.ไม่เป็น	3.ไม่ทราบ	
A หลอดลมอักเสบเรื้อรัง	☐	☐	☐	☐	☐	☐	☐☐
B ถุงลมโป่งพอง	☐	☐	☐	☐	☐	☐	☐☐
C หอบหืด	☐	☐	☐	☐	☐	☐	☐☐
D มะเร็งปอด	☐	☐	☐	☐	☐	☐	☐☐
E โรคปอดอื่นๆ	☐	☐	☐	☐	☐	☐	☐☐

	1. มีชีวิต	2. เสียชีวิต		1. มีชีวิต	2. เสียชีวิต	
29A บิดามารดายังมีชีวิตอยู่หรือไม่	☐	☐		☐	☐	☐☐
B โปรดระบุ อายุขณะนี้	.....ปี		อายุขณะนี้	.....ปี		
อายุ(ถ้าเสียชีวิต)	.....ปี		อายุ(ถ้าเสียชีวิต)	.....ปี		
C โปรดระบุ สาเหตุการตาย	.....			.....		

Reference

Division of Respiratory Disease and Tuberculosis, Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand.

APPENDIX D

HABITUAL PHYSICAL ACTIVITY

Questionnaire, codes, and method of calculation of scores on habitual physical activity

1) What is your main occupation?
.....……. 1-3-5
2) At work I sit
never/seldom/sometimes/often/always…….. 1-2-3-4-5
3) At work I stand
never/seldom/sometimes/often/always…….. 1-2-3-4-5
4) At work I walk
never/seldom/sometimes/often/always……. 1-2-3-4-5
5) At work I lift heavy loads
never/seldom/sometimes/often/very often…… 1-2-3-4-5
6) After working I am tired
very often/often/sometimes/seldom/never…… 5-4-3-2-1
7) At work I sweat
very often/often/sometimes/seldom/never…….. 5-4-3-2-1
8) In comparison with others of my own age I think my work is physically
much heavies/heavies/as heavy/lighter/much lighter……... 5-4-3-2-1
9) Do you play sport?
yes/no
If yes:
-which sport do you play most frequently?.....Intensity 0.76-1.26-1.76
-how many hours a week?...<1/1-2/2-3/3-4/>4 Time 0.5-1.5-2.5-3.5-4.5
-how many months a year?..<1/1-3/4-6/7-9/>9 Proportion0.04-0.17-0.42-0.67-0.92
If you play a second sport:
-which sport do you play most frequently?.....Intensity 0.76-1.26-1.76
-how many hours a week?...<1/1-2/2-3/3-4/>4 Time 0.5-1.5-2.5-3.5-4.5
-how many months a year?..<1/1-3/4-6/7-9/>9 Proportion0.04-0.17-0.42-0.67-0.92
10) In comparison with others of my own age I think my physical activity during leisure time is
much more/more/the same/less/much less…… 5-4-3-2-1
11) During leisure time I sweat
very often/often/sometimes/seldom/never…… 5-4-3-2-1
12) During leisure time I play sport
never/seldom/sometimes/often/very often……. 1-2-3-4-5
13) During leisure time I watch television
never/seldom/sometimes/often/very often……. 1-2-3-4-5
14) During leisure time I walk
never/seldom/sometimes/often/very often……. 1-2-3-4-5
15) During leisure time I cycle
never/seldom/sometimes/often/very often……. 1-2-3-4-5

16) How many minutes do you walk and/or cycle per day to and from work, school and shopping?<5/5-15/15-30/30-45/>45…… 1-2-3-4-5

Score categories for question 1 (I_1):

1 = "Low level" occupations such as office or clerical work, driving, shop keeping, teaching, or studying
2 = "Middle level" occupations such as factory work, plumbing, or carpentry
3 = "High level" occupations such as dock work or construction work

Calculation of the simple sport –score (I_9):

(a score of zero is given to people who do not play a sport)
$I_9 = \sum$ (intensity × time × proportion)
= 0/0.01-<4/4-<8/8-<12/≥12…… 1-2-3-4-5

Calculation of scores of the indices of physical activity:

Work index = $[I_1 + (6 – I_2) + I_3 + I_4 + I_5 + I_6 + I_7 + I_8]/8$
Sport index = $[I_9 + I_{10} + I_{11} + I_{12}]/4$
Leisure-time index = $[(6 – I_{13}) + I_{14} + I_{15} + I_{16}]/4$
Total score = work index + sport index + leisure-time index

Activity level:

Sedentary subject = scores below 6
Active subject = scores 6 – 8
Athletic subject = scores above 8

Reference

Baecke JAH, Burema J, Frijters JER. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. Am J Clin Nutr 1982; 36: 936-942.

Zoll J, Sanchez H, Guessan B, Ribera F, Lampert E, Bigard X, et al. Physical activity changes the regulation of mitochondrial respiration in human skeletal muscle. J Physiol 2002;543:191-200.

แบบสอบถามกิจกรรมที่ทำเป็นประจำ (Habitual Physical Activity)

ชื่อ.....อายุ.....ปี เพศ.....

กรุณาทำเครื่องหมาย √ ลงใน ☐ ที่ตรงกับกิจกรรมที่ท่านทำมากที่สุด

1. อาชีพหลักของท่าน คือ ..... ☐

2. ขณะทำงาน ท่านนั่งบ่อยแค่ไหน?

☐ ไม่เคย ☐ นานๆครั้ง ☐ บางครั้ง ☐ บ่อย ☐ ตลอดเวลา ☐

3. ขณะทำงาน ท่านยืนบ่อยแค่ไหน?

☐ ไม่เคย ☐ นานๆครั้ง ☐ บางครั้ง ☐ บ่อย ☐ ตลอดเวลา ☐

4. ขณะทำงาน ท่านเดินบ่อยแค่ไหน?

☐ ไม่เคย ☐ นานๆครั้ง ☐ บางครั้ง ☐ บ่อย ☐ ตลอดเวลา ☐

5. ขณะทำงาน ท่านยกของหนักบ่อยแค่ไหน?

☐ ไม่เคย ☐ นานๆครั้ง ☐ บางครั้ง ☐ บ่อย ☐ บ่อยมาก ☐

6. หลังเลิกงาน ท่านรู้สึกเหนื่อยบ่อยแค่ไหน?

☐ บ่อยมาก ☐ บ่อย ☐ บางครั้ง ☐ นานๆครั้ง ☐ ไม่เคย ☐

7. ขณะทำงาน ท่านมีเหงื่อออกบ่อยแค่ไหน?

☐บ่อยมาก ☐ บ่อย ☐ บางครั้ง ☐ นานๆครั้ง ☐ ไม่เคย ☐

8. เมื่อเปรียบเทียบกับคนที่อายุเท่ากับท่าน ท่านคิดว่างานที่ท่านทำหนักหรือเบากว่าแค่ไหน?

☐ หนักกว่ามาก ☐ หนักกว่า ☐ หนักเท่ากัน ☐ เบากว่า ☐ เบากว่ามาก ☐

9. ท่านเล่นกีฬาหรือไม่?

☐เล่น ☐ ไม่เล่น ☐

<u>ถ้าเล่น</u>

- กีฬาที่ท่านเล่นบ่อยที่สุด คือ ..... ☐
- ท่านเล่นกีฬากี่ชั่วโมงต่อสัปดาห์?

☐ น้อยกว่า 1 ชม.☐ 1-2ชม. ☐ 2-3 ชม. ☐ 3-4 ชม. ☐ มากกว่า 4 ชม. ☐

- ท่านเล่นกีฬากี่เดือนต่อปี?

☐ น้อยกว่า 1 เดือน☐ 1-3 เดือน☐ 4-6 เดือน ☐ 7-9 เดือน ☐ มากกว่า 9 เดือน ☐

ถ้าท่านมีกีฬาอื่นที่เล่นรองลงมา

- กีฬาที่ท่านเล่นบ่อยรองลงมา คือ ..... ☐
- ท่านเล่นกีฬากี่ชั่วโมงต่อสัปดาห์?

☐ น้อยกว่า 1 ชม. ☐ 1-2ชม. ☐ 2-3 ชม. ☐ 3-4 ชม. ☐ มากกว่า 4 ชม. ☐

- ท่านเล่นกีฬากี่เดือนต่อปี?

☐ น้อยกว่า 1 เดือน ☐ 1-3 เดือน ☐ 4-6 เดือน ☐ 7-9 เดือน ☐ มากกว่า 9 เดือน ☐

10. เมื่อเปรียบเทียบกับคนที่อายุเท่ากับท่าน ท่านคิดว่างานที่ท่านทำในเวลาว่างมากหรือน้อยกว่าแค่ไหน?

☐มากกว่ามาก ☐ มากกว่า ☐ เท่ากัน ☐ น้อยกว่า ☐ น้อยกว่ามาก ☐

11. ในเวลาว่าง ท่านมีเหงื่อออกบ่อยแค่ไหน?

☐ บ่อยมาก ☐ บ่อย ☐ บางครั้ง ☐ นานๆครั้ง ☐ ไม่เคย ☐

12. ในเวลาว่าง ท่านเล่นกีฬาบ่อยแค่ไหน?

☐ ไม่เคย ☐ นานๆครั้ง ☐ บางครั้ง ☐ บ่อย ☐ บ่อยมาก ☐

13. ในเวลาว่าง ท่านดูโทรทัศน์บ่อยแค่ไหน?

☐ ไม่เคย ☐ นานๆครั้ง ☐ บางครั้ง ☐ บ่อย ☐ บ่อยมาก ☐

14. ในเวลาว่าง ท่านเดินบ่อยแค่ไหน?

☐ ไม่เคย ☐ นานๆครั้ง ☐ บางครั้ง ☐ บ่อย ☐ บ่อยมาก ☐

15. ในเวลาว่าง ท่านปั่นจักรยานบ่อยแค่ไหน?

☐ ไม่เคย ☐ นานๆครั้ง ☐ บางครั้ง ☐ บ่อย ☐ บ่อยมาก ☐

16. ท่านใช้เวลากี่นาทีต่อวัน ในการเดินและ/หรือปั่นจักรยาน เพื่อไปและกลับจากที่ทำงาน โรงเรียน และซื้อของ ?

☐น้อยกว่า 5 นาที ☐ 5-15 นาที ☐ 15-30 นาที ☐ 30-45 นาที ☐ มากกว่า 45 นาที ☐

การคำนวณคะแนนกิจกรรมที่ทำเป็นประจำ

การทำงาน = [(1)…+(6-(2)...)+(3)…+(4)…+(5)…+(6)…+(7)…+(8)…]/8 = …….

การออกกำลังกาย = [(9)…+(10)…+(11)…+(12)…]/4 = ……

เวลาว่าง = [(6-(13)…)+(14)…+(15)…+(16)…]/4 = ……

คะแนนรวม = …….

Reference

Baecke JAH, Burema J, Frijters JER. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. Am J Clin Nutr 1982; 36: 936-942.

APPENDIX E

DATA COLLECTION FORM

Name……..... Sex F/M Age.....yrs

Weight……..…...kg, Height……..……cm, BMI……...……kg/m^2

BP ……mmHg HR.....bpm RR.....tpm Body temperature…..…ºC

Pulmonary function data

Variable	Trial 1	Trial 2	Trial 3	Summary
FVC (liter)				
FEV1 (liter)				
FEV1/FVC (%)				

MIP and MEP data

Times	MIP (cmH_2O)	MEP (cmH_2O)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

APPENDIX F

REFERENCE SPIROMETRIC VALUES FOR HEALTHY LIFETIME NONSMOKERS IN THAILAND

	Equations	r^2	SEE
FVC (L):			
Males	$-2.601+0.122A-0.00046A^2+0.00023H^2-0.00061AH$	0.669	0.434
Females	$-5.914+0.088A-0.0003A2+0.056H-0.0005AH$	0.618	0.324
FEV_1 (L):			
Males	$-7.697+0.123A+0.067H-0.00034A^2-0.0007AH$	0.70	0.371
Females	$-10.603+0.085A-0.00019A^2+0.12H-0.00022H^2$ $-0.00056AH$	0.681	0.275
FEV_1/FVC (%):			
Males	$19.362+0.49A+0.829H-0.0023H^2-0.0041AH$	0.24	5.364
Females	$83.126+0.243A+0.002A^2+0.08H-0.0036AH$	0.22	4.986

A = age (years), H = height (cm)

Reference

Dejsomritrutai W, Maranetra K, Maneechotesuwan K, Chierakul N, Tscheikuna J, Suthamsmai T, et al. Reference Spirometry Values for Healthy Lifetime Nonsmokers in Thailand. J Med Assoc Thai 2000; 83:457-466.

APPENDIX G

THE ETHICAL COMMITTEE ON RESEARCH INVOLVING HUMAN SUBJECT

ถนนพรานนก บางกอกน้อย กรุงเทพฯ ๑๐๗๐๐
โทร. (๖๖-๒) ๔๑๑-๑๔๒๘, ๔๑๑-๓๒๕๓
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Faculty of Medicine Siriraj Hospital
Mahidol University

The Ethical Committee on Research Involving Human Subject
Faculty of Medicine Siriraj Hospital, Mahidol University

No. 199/2003

Protocol Title	Respiratory muscle strength in Thai healthy subjects age range 30 – 70 years
Protocol Number	-------
Principal Investigator	Miss. Orawan Pon-ngeon
Name of Department	Orthopedic Surgery

The aforementioned project and informed consent have been reviewed and approved by the Ethical Committee, Faculty of Medicine Siriraj Hospital, Mahidol University, based on the Declaration of Helsinki on December 3 , 2003

Signature of Chairman .....

(Prof. Sumalee Nimmannit)

Signature of Dean .....

(Clin. Prof. Piyasakol Sakolsatayadorn)

APPENDIX H
PILOT STUDY

The purpose of this study was to find correlation of respiratory muscle strength and characteristics of subjects. The maximal inspiratory mouth pressure (MIP) and maximal expiratory mouth pressure (MEP) maneuver were performed.

Procedure

Forty-four subjects participated in this pilot. Subjects informed about characteristic data, medical data, and habitual physical activity, vital sign, weight, height and pulmonary function test were measured. After that respiratory muscles strength was measured. Subjects sat on a comfortably chair and held the mouthpiece in their mouth. MIP was determined from residual volume following a maximum expiration (Muller maneuver). The subject was instructed to 1) inhale to total lung capacity, 2) exhale slowly to residual volume and 3) inhale maximally. MEP was determined at total lung capacity following a maximum inspiration (Valsalva maneuver). The subject was instructed to 1) exhale to residual volume, 2) inhale slowly to total lung capacity and 3) exhale maximally. MIP was measured 10 times per test and MEP was measured 12 times per test. Each maneuver was separated by 1 minute resting period. The value of MIP and MEP was accepted when subjects could be sustained the constant pressures at least 1 second. The highest value of MIP and MEP would be accepted.

Data analysis

Kolmogorov-Smirnov Goodness of fit was used to determine the normal distribution in all parameters. Pearson Correlation was used to determine the correlation of MIP and MEP and characteristics of subjects which were age, gender, height and weight.

Results

Demographics data of subjects were shown in Table H.1. All parameters were normal distribution ($p > 0.05$). Mean and SD of MIP and MEP in males were greater than females in all age groups. Pearson Correlations were shown in Table H.2. The results of Pearson Correlation indicated correlation between MIP and height and weight in female ($p < 0.05$). The others were no correlated.

Table H.1 Mean and SD of demographics data of subjects classified by age group

Demographics data	Mean ± SD							
	30-39 yr		40-49 yr		50-59 yr		60-70 yr	
	M (n=4)	F (n=7)	M (n=4)	F (n=7)	M (n=4)	F (n=7)	M (n=4)	F (n=7)
Age (yrs)	32.25±1.71	32.71±2.93	45.25±2.22	43.29±3.04	53.50±3.70	54.43±2.23	66.75±1.71	65.86±3.08
Height (cm)	167.00±6.32	156.14±3.02	170.00±8.04	158.43±4.93	165.75±7.37	155.29±2.69	166.50±6.19	150.86±3.48
Weight (kg)	61.00±7.70	55.43±12.69	72.75±8.18	59.29±13.86	72.25±11.79	62.71±9.86	64.00±3.56	55.86±8.41
BMI (kg/m^2)	21.83±2.24	22.75±5.22	25.13±1.53	23.54±5.29	26.16±2.53	26.01±4.02	23.08±1.50	24.47±2.94
Physical activity level score	7.28±0.57	6.77±1.13	7.41±0.49	7.07±0.88	6.66±0.92	7.29±0.88	6.13±1.76	4.91±0.26
FVC (liter)	4.06±0.77	2.67±0.25	3.92±0.42	2.97±0.57	3.54±0.70	2.30±0.26	3.38±0.72	2.06±0.20
FEV_1(liter)	3.52±0.67	2.26±0.21	3.26±0.31	2.49±0.54	2.96±0.51	1.91±0.24	2.58±0.41	1.68±0.21
FEV_1/FVC(%)	86.50±2.38	84.86±5.24	83.25±7.27	83.86±5.40	84.00±3.83	83.29±3.77	77.25±4.86	80.86±5.87
MIP (cmH_2O)	122.25±29.81	83.14±33.59	155.25±19.17	80.57±32.59	114.00±48.14	79.57±32.59	105.00±10.55	63.71±16.72
MEP (cmH_2O)	134.50±56.32	71.71±15.21	212.25±71.85	73.29±25.48	115.00±49.13	77.00±24.39	116.25±43.28	61.57±18.67

Table H.2 Pearson Correlation

Data	**Males**		**Females**	
	Pearson Correlation	**Sig. (p-value)**	**Pearson Correlation**	**Sig. (p-value)**
Age & MIP	-0.220	0.413	-0.230	0.240
Age & MEP	-0.211	0.433	0.000	0.998
Height & MIP	0.134	0.621	0.376	0.049*
Height & MEP	0.035	0.885	0.242	0.215
Weight & MIP	0.410	0.115	0.645	0.001*
Weight & MEP	0.178	0.508	0.368	0.054

* Significantly different at $p < 0.05$

APPENDIX I
OPTIMAL NUMBERS OF
RESPIRATORY MUSCLE STRENGTH TESTING

The purpose of this pilot study was to determine optimize numbers of time to perform respiratory muscle strength. The mouth pressure meters (Spirovis, COSMED pulmonary function equipment, Italy) was used to determine respiratory muscle strength these were maximal inspiratory mouth pressure (MIP) and maximal expiratory mouth pressure (MEP).

Procedure

Seventeen subjects who met the inclusion and exclusion criteria as explained in method section participated in this pilot study. Subjects sat on a comfortably chair and held the mouthpiece in their mouth. MIP was determined from residual volume following a maximum expiration (Muller maneuver). The subject was instructed to 1) inhale to total lung capacity, 2) exhale slowly to residual volume and 3) inhale maximally. MEP was determined at total lung capacity following a maximum inspiration (Valsalva maneuver). The subject was instructed to 1) exhale to residual volume, 2) inhale slowly to total lung capacity and 3) exhale maximally. MIP and MEP were measured with 20 maneuvers per test. Each maneuver was separated for 1 minute of rest period. The values of MIP and MEP accepted were being sustained for at least 1 second.

Data Analysis

The data of MIP and MEP of this study were analyzed by Repeated Measures Analysis of Variance.

Results

Demographics data of subjects were shown in Table I.1 and raw data of MIP and MIP are shown in Table I.2-I.3, respectively. Means with SD of MIP and MEP for 20 maneuvers are showed in Figure I.1-I.2.

The result of repeated measures analysis of variance of MIP indicated that the mean ±SD of MIP varied from 72.53 ±28.33 cmH_2O at the first maneuver to 90.65 ±35.25 cmH_2O (highest values at the nineteenth maneuver). Maximal values of MIP were achieved at the tenth maneuver. There were significant difference between the first ninth, the tenth and the nineteenth maneuver ($p < 0.05$). However, nineteen maneuvers were not practical for clinical setting because it spend a long time. Consequently, MIP should be performed 10 times per test.

The result of repeated measures analysis of variance of MEP indicated that the mean ±SD of MEP varied from 62.65 ±28.26 cmH_2O at the first maneuver to 75.71 ±47.58 cmH_2O (highest values at the eighteenth maneuver). There were significant difference between the twelfth and first eleventh maneuver ($p < 0.05$). The difference between the twelfth and the later values were not significant. Consequently, MEP test would be performed 12 times per test.

Table I.1 Demographics data

Demographic data (F=11, M=6)	**Mean ±SD**
Age (yrs)	45.88±14.14
Height (cm)	159.94±7.96
Weight (kg)	60.65±12.53
BMI (kg/m^2)	23.62±4.27
Physical activity level score	6.38±1.24
FVC (liters)	2.91±0.81
FEV_1 (liters)	2.44±0.68
FEV_1/FVC (%)	84.00±4.34

Table I.2 Maximal Inspiratory Mouth Pressure (MIP) data

Subjects	MIP maneuvers (times)																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1	109	111	104	106	104	115	118	115	109	126	112	115	109	115	112	102	115	120	126	132
2	42	50	42	42	45	49	45	45	50	53	48	44	39	48	48	46	50	48	50	48
3	88	81	87	90	84	78	76	81	88	76	90	85	95	87	84	93	88	99	95	84
4	44	48	52	48	48	56	39	53	45	49	50	42	50	53	50	42	35	50	50	53
5	90	87	90	72	84	80	85	87	76	81	70	81	64	81	90	97	87	101	94	92
6	92	81	83	112	115	92	95	88	109	99	104	113	109	109	105	120	115	120	123	126
7	20	22	25	25	20	22	20	20	25	22	26	25	27	25	25	23	25	29	27	22
8	31	32	33	39	39	36	36	36	42	45	42	42	45	36	36	36	48	43	36	43
9	64	70	84	87	78	67	84	95	103	92	83	78	78	95	81	101	104	90	92	84
10	95	90	73	84	92	84	87	76	73	87	75	84	74	78	78	73	71	70	79	76
11	64	59	62	67	64	56	60	56	50	67	59	59	56	76	67	70	64	73	76	56
12	64	53	62	64	60	53	62	59	81	68	62	62	59	53	64	73	67	59	70	57
13	129	126	109	112	134	126	129	120	123	113	129	118	122	122	109	119	126	123	137	121
14	92	119	129	132	146	148	146	137	143	146	143	157	157	146	157	148	150	146	137	160
15	72	81	76	92	64	73	95	81	84	106	121	120	112	109	118	117	115	120	120	119
16	64	69	73	84	73	83	81	85	81	95	90	90	78	104	90	109	115	123	123	123
17	73	70	96	98	90	84	79	85	78	87	87	95	78	82	105	109	101	92	106	111

Table I.3 Maximal Expiratory Mouth Pressure (MEP) data

Subjects	MEP maneuvers (times)																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1	62	56	64	65	62	64	63	63	67	70	67	70	71	73	78	66	71	76	70	64
2	78	73	67	64	59	66	67	67	64	70	64	69	73	78	78	75	70	76	73	78
3	48	31	31	32	42	39	36	34	48	31	45	42	39	36	36	34	38	31	31	37
4	53	53	53	50	53	45	58	54	48	41	53	64	54	57	48	46	45	50	48	41
5	87	91	77	84	76	79	70	78	76	78	78	84	92	87	92	97	115	120	123	106
6	84	78	76	62	87	81	73	76	78	67	68	76	95	87	76	81	78	64	81	70
7	31	28	28	28	25	28	34	25	28	34	29	25	28	31	26	25	28	25	31	31
8	31	28	28	39	28	29	25	28	36	25	23	29	28	34	43	23	25	26	28	34
9	41	36	42	53	59	48	37	48	48	59	53	68	62	56	64	53	66	68	68	73
10	70	64	56	53	58	45	43	46	42	35	34	48	34	34	42	36	35	35	38	31
11	36	38	39	36	34	31	34	39	30	38	36	42	31	34	39	36	41	48	35	35
12	83	72	81	73	83	83	79	82	84	74	84	81	73	73	81	81	82	81	76	73
13	73	67	74	88	76	68	62	62	69	73	62	87	84	73	82	76	70	73	74	78
14	144	118	120	116	172	201	188	188	186	182	180	193	193	211	207	200	193	197	174	227
15	74	84	106	110	106	104	133	140	137	144	132	160	140	155	151	168	144	152	157	148
16	101	112	129	126	111	104	103	115	112	106	101	109	133	130	96	120	129	123	106	109
17	34	36	52	43	45	34	42	53	48	39	36	39	50	39	45	45	42	42	37	38

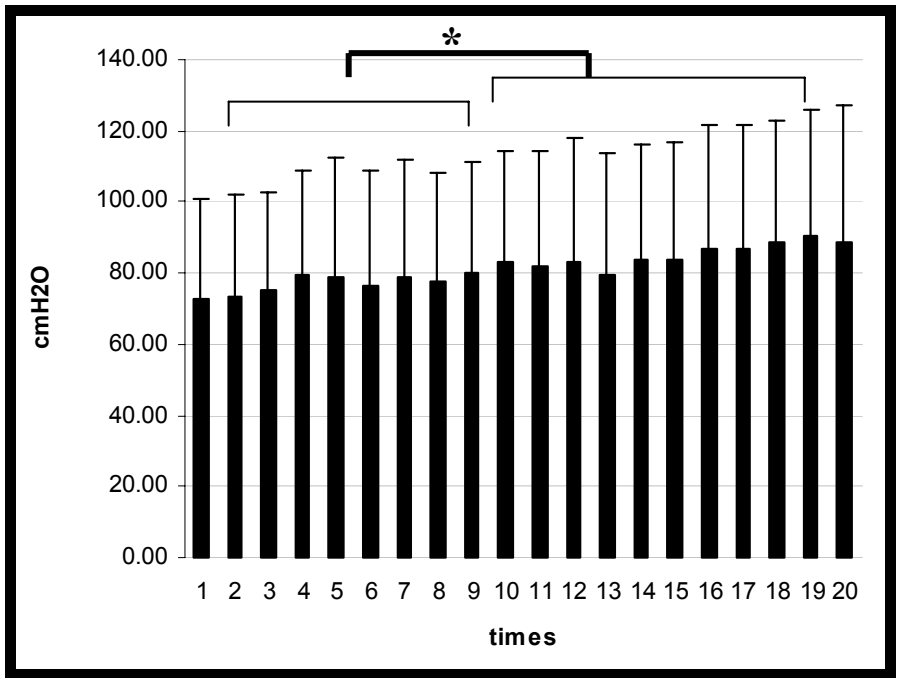

Figure I.1 Mean and SD of Maximal Inspiratory Mouth Pressure (MIP) for 20 maneuvers (* significantly different at $p < 0.05$).

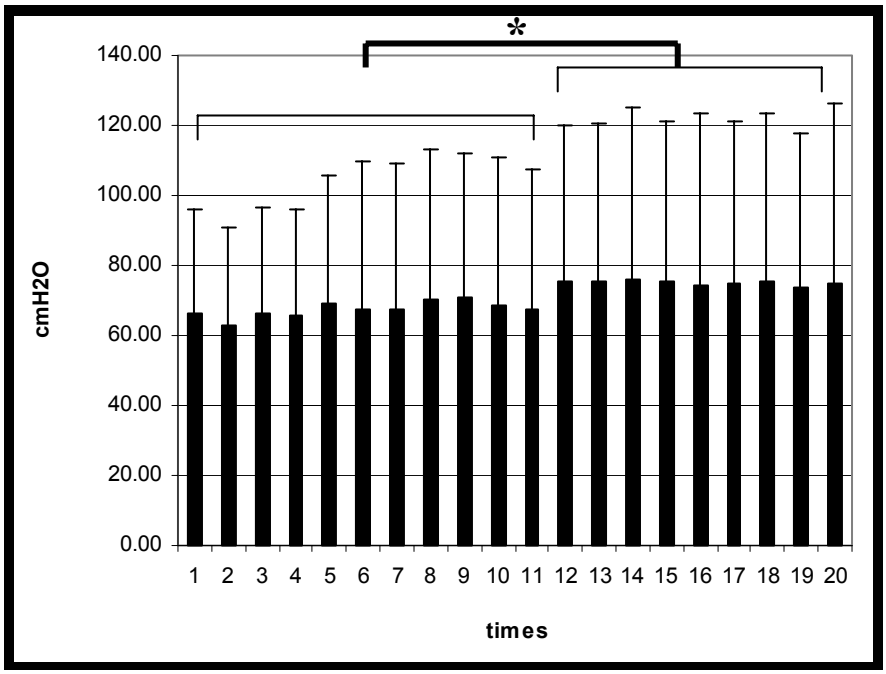

Figure I.2 Mean and SD of Maximal Expiratory Mouth Pressure (MEP) for 20 maneuvers (* significantly different at $p < 0.05$).

APPENDIX J
RELIABILITY OF RESPIRATORY MUSCLE STRENGTH

The purpose of this pilot was to determine the reliability of respiratory muscle strength. Maximal inspiratory mouth pressure (MIP) and maximal expiratory mouth pressure (MEP) were performed for test-retest reliability.

Procedure

Seventeen subjects participated in this study. Subjects inform about characteristic data, medical data, and habitual physical activity, vital sign, weight, height and pulmonary function test were measured. After that respiratory muscles strength will be measured. Subjects sat on a comfortably chair and held the mouthpiece in their mouth. MIP was determined from residual volume following a maximum expiration (Muller maneuver).The subject was instructed to 1) inhale to total lung capacity, 2) exhale slowly to residual volume and 3) inhale maximally. MEP was determined at total lung capacity following a maximum inspiration (Valsalva maneuver). The subject was instructed to 1) exhale to residual volume, 2) inhale slowly to total lung capacity and 3) exhale maximally. MIP was measured 10 times per test and MEP was measured 12 times per test. Each maneuver was separated by 1 minute resting period. The value of MIP and MEP was accepted when subjects can be sustained the constant pressures at least 1 second. The highest value of MIP and MEP were accepted. Subjects performed the whole procedure again in a week for reliability test.

Data Analysis

Intraclass correlation coefficient (ICC 3,1) was used to determine the intratester reliability for each maneuver of MIP and MEP.

Results

Raw data of MIP and MEP are shown in Tables J.1- J.2. Reliability of MIP and MEP are shown in Table J.3. Good intratester reliability of both MIP and MEP values separated by a week were illustrated.

Table J.1 Maximal Inspiratory Mouth Pressure (MIP) on week 1 and 2.

Subjects	**1st week** (cmH_2O)	**2nd week** (cmH_2O)
1	126	132
2	53	64
3	90	120
4	56	70
5	90	120
6	115	153
7	25	41
8	45	49
9	103	120
10	95	101
11	67	76
12	81	67
13	134	134
14	148	157
15	106	129
16	95	130
17	98	109
Mean	**89.82**	**104.24**
SD	**32.73**	**36.14**

Table J.2 Maximal Expiratory Mouth Pressure (MEP) on week 1 and 2.

Subjects	**1st week** (cmH_2O)	**2nd week** (cmH_2O)
1	70	104
2	78	73
3	48	50
4	64	56
5	91	137
6	87	90
7	34	42
8	39	62
9	68	73
10	70	62
11	42	45
12	84	84
13	88	89
14	201	214
15	160	171
16	129	162
17	53	47
Mean	**82.71**	**91.82**
SD	**44.13**	**50.37**

Table J.3 Reliability of Maximal Inspiratory Mouth Pressure (MIP) and Maximal Expiratory Mouth Pressure (MEP) separated by a week.

Tests	**ICC (3,1)**
MIP	0.9239
MEP	0.9433

APPENDIX K
SAMPLE SIZE CALCULATION

The sample size for the specific objective of this study aimed to determine respiratory muscle strength correlating age range. The MIP values in males (40-49 years and 50-59 years) were selected to calculate. The sample size per group was calculated from the following equation (72):

$$N = 2[(Z_\alpha + Z_\beta)\ \sigma 2]/\ (Mc-Mt)^2$$

N	=	sample size per group
$\mathbf{Z_\alpha}$	=	Z-value when the level of confidence is set at 95% (= 1.96)
$\mathbf{Z_\beta}$	=	Z-value when the power of testing is set at 90% (= 1.28)
$\boldsymbol{\sigma^2}$	=	pool variance
Mc	=	mean of parameter in male aged 40-49 years
Mt	=	mean of parameter in male aged 50-59 years

$$\begin{aligned} N &= 2[(Z_\alpha + Z_\beta)\ \sigma 2]/\ (Mc-Mt)^2 \\ &= 2[(1.96+1.28)\ (48.14)^2]/\ (155.25-114.00)^2 \\ &= 28.59 \end{aligned}$$

Therefore, the appropriate sample size was twenty-nine subjects per group.

APPENDIX L
RAW DATA OF PILOT STUDY

Table L.1 Demographics data of subjects (n=44).

No.	Sex	Age (yrs)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Physical Activity Level score	FVC (liter)	FEV_1 (liter)	FEV1/FVC (%)	MIP (cmH_2O)	MEP (cmH_2O)
1	F	30	158	70	28.04	6	3.05	2.64	87	126	70
2	F	30	153	45	19.22	5	2.72	2.26	83	63	68
3	F	31	156	46	18.9	7.875	2.43	2.1	86	53	78
4	F	32	158	65	26.03	7.25	2.35	2.11	90	90	48
5	F	33	161	42	16.2	5.875	2.79	2.45	88	56	64
6	F	35	153	49	20.93	7.625	2.87	2.13	74	62	76
7	F	38	154	71	29.93	7.75	2.5	2.14	86	132	98
8	F	40	160	54	21.09	7.75	2.83	2.55	90	90	91
9	F	41	157	85	34.48	5.5	2.4	1.98	83	115	87
10	F	42	149	41	18.4	6.25	2.39	2.01	84	25	34
11	F	42	162	53	20.19	8	3.89	3.43	88	96	92
12	F	43	156	54	22.18	7.375	2.65	2.23	84	45	39
13	F	47	162	61	23.24	7.375	3.12	2.28	73	96	90
14	F	48	163	67	25.21	7.25	3.49	2.98	85	97	80
15	F	52	155	60	24.97	7	2.29	1.81	79	62	50
16	F	52	157	77	31.23	7.375	2.77	2.38	86	101	99
17	F	53	156	66	27.12	8	2.4	2.05	85	62	118
18	F	55	157	71	28.8	5.5	2.19	1.72	79	84	53
19	F	55	154	56	23.61	7.875	2.18	1.89	87	76	73
20	F	56	150	62	27.55	8	1.93	1.68	87	103	68
21	F	58	158	47	18.82	7.25	2.33	1.86	80	67	78
22	F	61	151	54	23.68	5.125	1.97	1.67	82	95	70
23	F	63	151	58	25.43	4.75	2.38	2.03	86	59	81
24	F	65	151	59	25.87	5	1.91	1.44	75	67	62
25	F	66	146	46	21.58	5	1.83	1.64	89	34	81
26	F	68	155	72	29.96	5.25	2.22	1.86	84	48	88
27	F	69	155	52	21.64	4.75	2.21	1.66	75	67	42
28	F	69	147	50	23.13	4.5	1.93	1.44	75	79	67
29	M	30	169	59	20.65	7.125	4.37	3.86	88	81	84
30	M	32	161	51	19.67	7.375	2.96	2.6	88	151	176
31	M	33	175	68	22.2	6.625	4.72	4.13	87	123	190
32	M	34	163	66	24.8	8	4.19	3.48	83	134	88
33	M	43	160	64	25	7.625	3.49	3.13	90	182	323

Table L.1 Demographics data of subjects (n=44) (Cont.).

No.	Sex	Age (yrs)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Physical Activity Level score	FVC (liter)	FEV_1 (liter)	FEV1/FVC (%)	MIP (cmH_2O)	MEP (cmH_2O)
34	M	44	173	69	23.05	7	4.48	3.51	78	137	154
35	M	46	168	75	26.57	8	3.94	3.51	89	154	207
36	M	48	179	83	25.9	7	3.78	2.88	76	148	201
37	M	50	157	60	24.3	7.375	2.8	2.37	85	50	45
38	M	51	163	73	27.47	7.25	3.23	2.88	89	140	126
39	M	55	169	68	23.8	5.375	4.45	3.62	81	106	160
40	M	58	174	88	29.06	6.625	3.66	2.96	81	160	129
41	M	65	166	64	23.22	7.25	3.43	2.6	76	109	132
42	M	66	170	69	23.7	4.75	3.12	2.55	82	95	129
43	M	67	172	62	20.95	8	4.34	3.08	71	98	53
44	M	69	158	61	24.43	4.5	2.62	2.08	80	118	151

Table L.2 Raw data of Maximal Inspiratory Mouth Pressure (MIP).

Subjects	MIP maneuvers (times)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	109	111	104	106	104	115	118	115	109	126
2	45	45	55	50	48	62	59	53	63	62
3	42	50	42	42	45	49	45	45	50	53
4	88	81	87	90	84	78	76	81	88	76
5	44	48	52	48	48	56	39	53	45	49
6	36	39	50	48	42	39	59	62	48	53
7	109	126	132	126	127	120	112	132	105	120
8	90	87	90	72	84	80	85	87	76	81
9	92	81	83	112	115	92	95	88	109	99
10	20	22	25	25	20	22	20	20	25	22
11	78	81	71	90	78	93	81	84	87	96
12	31	32	33	39	39	36	36	36	42	45
13	81	81	84	76	81	81	92	92	96	91
14	87	97	92	90	92	88	73	95	90	92
15	56	56	53	50	56	51	62	45	45	42
16	101	88	81	92	90	81	87	100	98	84
17	48	53	62	62	53	59	56	50	50	47
18	67	45	59	73	81	67	70	59	84	70
19	35	48	45	76	76	71	62	62	75	66
20	64	70	84	87	78	67	84	95	103	92
21	45	67	48	55	56	59	57	60	53	51
22	95	90	73	84	92	84	87	76	73	87
23	42	34	25	31	28	59	53	53	56	59
24	22	36	34	36	28	62	66	62	59	67
25	17	26	26	22	31	24	34	22	20	25
26	20	25	22	31	34	42	36	42	41	48
27	64	59	62	67	64	56	60	56	50	67
28	25	27	59	51	42	69	67	52	61	79
29	64	53	62	64	60	53	62	59	81	68
30	137	146	134	123	151	148	148	146	148	134
31	111	100	104	106	111	106	105	120	120	123
32	129	126	109	112	134	126	129	120	123	113
33	84	140	157	160	179	179	176	162	182	176
34	127	129	132	129	137	123	118	134	137	135
35	139	154	146	146	148	137	140	140	140	151
36	92	119	129	132	146	148	146	137	143	146
37	44	42	43	50	45	42	39	48	39	39
38	126	129	129	131	140	137	135	134	134	137
39	72	81	76	92	64	73	95	81	84	106
40	107	126	112	134	143	149	158	160	156	154
41	87	87	92	98	98	103	109	109	104	95
42	64	69	73	84	73	83	81	85	81	95
43	73	70	96	98	90	84	79	85	78	87
44	73	70	81	87	92	98	95	106	118	106

Table L.3 Raw data of Maximal Expiratory Mouth Pressure (MEP).

Subjects	MEP maneuvers (times)											
	1	2	3	4	5	6	7	8	9	10	11	12
1	62	56	64	65	62	64	63	63	67	70	67	70
2	56	68	48	65	62	55	56	55	49	42	57	50
3	78	73	67	64	59	66	67	67	64	70	64	69
4	48	31	31	32	42	39	36	34	48	31	45	42
5	53	53	53	50	53	45	58	54	48	41	53	64
6	53	57	76	70	74	55	59	60	46	64	56	62
7	67	62	78	87	98	90	76	73	90	81	75	84
8	87	91	77	84	76	79	70	78	76	78	78	84
9	84	78	76	62	87	81	73	76	78	67	68	76
10	31	28	28	28	25	28	34	25	28	34	29	25
11	66	78	92	62	50	73	88	82	80	73	88	70
12	31	28	28	39	28	29	25	28	36	25	23	29
13	85	90	62	71	76	81	72	68	73	71	69	54
14	50	45	42	60	64	62	56	73	68	76	80	69
15	45	40	42	34	36	39	34	34	34	34	46	50
16	84	95	67	87	80	73	84	67	68	85	99	87
17	70	64	64	76	84	64	91	106	109	118	103	95
18	36	36	45	39	37	53	40	41	39	47	45	36
19	23	26	27	50	48	64	56	62	59	62	73	61
20	41	36	42	53	59	48	37	48	48	59	53	68
21	69	76	76	50	53	67	74	67	78	59	75	69
22	70	64	56	53	58	45	43	46	42	35	34	48
23	34	20	42	36	36	67	64	40	60	56	81	78
24	25	57	36	36	41	53	62	45	56	50	43	36
25	60	45	62	56	67	81	62	62	64	53	54	70
26	48	39	34	45	48	51	64	55	70	73	73	88
27	36	38	39	36	34	31	34	39	30	38	36	42
28	67	45	46	45	56	53	42	42	42	51	34	39
29	83	72	81	73	83	83	79	82	84	74	84	81
30	123	107	143	112	160	171	176	154	165	168	165	160
31	154	140	139	137	153	146	151	158	176	158	169	190
32	73	67	74	88	76	68	62	62	69	73	62	87
33	148	202	207	228	283	221	269	323	238	210	280	300
34	98	154	143	137	123	120	148	146	123	113	126	123
35	120	174	182	207	198	198	186	187	190	169	166	190
36	144	118	120	116	172	201	188	188	186	182	180	193
37	36	34	42	40	31	34	45	42	32	34	39	34
38	109	93	101	84	107	104	104	109	109	123	124	126
39	74	84	106	110	106	104	133	140	137	144	132	160
40	98	109	113	105	129	116	120	113	109	108	104	109
41	80	70	92	95	83	112	111	109	126	123	132	120
42	101	112	129	126	111	104	103	115	112	106	101	109
43	34	36	52	43	45	34	42	53	48	39	36	39
44	90	101	98	91	123	134	151	146	112	109	99	139

APPENDIX M
RAW DATA OF THE STUDY

Table M.1 Demographics data of female 30-39 years subjects (n=30).

No.	Sex	Age (yrs)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Physical Activity Level score	FVC (liter)	FEV_1 (liter)	FEV1/FVC (%)	MIP (cmH_2O)	MEP (cmH_2O)
1	F	30	158	70	28.04	6	3.05	2.64	87	126	70
2	F	30	153	45	19.22	5	2.72	2.26	83	63	68
3	F	30	158	51	20.42	7.875	2.93	2.49	85	106	73
4	F	30	156	70	28.76	8	2.49	2.25	92	95	81
5	F	30	163	51	19.19	8	3.07	2.69	88	85	90
6	F	30	168	54.5	19.3	7.75	3.5	3.29	94	98	105
7	F	30	157	48	19.47	6.625	2.95	2.63	89	77	104
8	F	31	156	46	18.9	7.875	2.43	2.1	86	53	78
9	F	31	152	53	22.93	6.625	2.97	2.62	88	90	76
10	F	32	158	65	26.03	7.25	2.35	2.11	90	90	48
11	F	32	151	54	23.68	7.5	2.46	2.24	91	124	136
12	F	33	161	42	16.2	5.875	2.79	2.45	88	56	64
13	F	34	156	64	26.29	7.25	2.32	1.96	85	95	48
14	F	35	153	49	20.93	7.625	2.87	2.13	74	62	76
15	F	35	153	57	24.34	8	2.6	2.28	88	85	115
16	F	35	157	65	26.37	7.25	3.12	2.45	79	146	156
17	F	36	152	49	21.2	7.5	2.61	2.12	81	109	140
18	F	36	154	53	22.34	6.875	2.4	2.27	95	70	75
19	F	37	162	72	27.43	7.875	2.96	2.6	88	99	76
20	F	37	157	77	31.23	7.375	2.51	2.29	91	87	83
21	F	37	151	56	24.56	5.625	2.65	2.45	93	95	148
22	F	37	162	51	19.43	8	3.4	2.91	86	62	87
23	F	38	154	71	29.93	7.75	2.5	2.14	86	132	98
24	F	38	165	91	33.42	7.125	2.7	2.33	86	112	85
25	F	38	160	54	21.09	6.5	2.97	2.44	82	90	104
26	F	38	161	50	19.28	5.875	2.96	2.49	84	87	154
27	F	39	154	48	20.23	7.25	2.56	2.12	83	102	53
28	F	39	159	61	24.12	8	3.02	2.52	83	64	74
29	F	39	154	52	21.92	6.375	3.27	2.79	85	73	146
30	F	39	147	51.5	23.6	6.5	2.26	2.01	89	87	101

Table M.2 Demographics data of female 40-49 years subjects (n=30).

No.	Sex	Age (yrs)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Physical Activity Level score	FVC (liter)	FEV_1 (liter)	FEV1/FVC (%)	MIP (cmH_2O)	MEP (cmH_2O)
1	F	40	160	54	21.09	7.75	2.83	2.55	90	90	91
2	F	40	160	86	33.59	6.875	3.07	2.42	79	84	84
3	F	40	158	57.5	23.03	7.125	3.04	2.54	84	167	116
4	F	40	153	55	23.49	7.375	3	2.46	82	81	107
5	F	41	157	85	34.48	5.5	2.4	1.98	83	115	87
6	F	41	151	57	24.99	7.75	2.4	1.97	82	78	101
7	F	41	152	57	24.67	6.5	3.05	2.64	87	87	81
8	F	41	158	75	30.04	7.875	2.97	2.65	89	81	140
9	F	42	149	41	18.4	6.25	2.39	2.01	84	25	34
10	F	42	162	53	20.19	8	3.89	3.43	88	96	92
11	F	42	162	72	27.43	5.125	3.2	2.75	86	125	95
12	F	42	160	56	21.87	7.625	3.11	2.66	85	129	199
13	F	43	156	54	22.18	7.375	2.65	2.23	84	45	39
14	F	43	168	60	21.25	7.375	3.37	2.78	83	109	137
15	F	44	157	55.5	22.51	5.5	2.47	2.07	84	134	132
16	F	44	155	60	24.97	7.875	2.84	2.29	81	62	81
17	F	45	157	55	22.3	8	2.49	1.97	79	81	62
18	F	45	160	79	30.85	8	3.06	2.34	76	151	98
19	F	45	152	80	34.62	8	2.39	1.85	77	78	116
20	F	45	147	66.5	30.77	6.5	2.51	1.93	77	76	140
21	F	46	156	59	24.24	7.875	2.86	2.34	83	98	84
22	F	47	162	61	23.24	7.375	3.12	2.28	73	96	90
23	F	47	147	47	21.75	5.75	2.42	1.95	80	97	101
24	F	48	163	67	25.21	7.25	3.49	2.98	85	97	80
25	F	48	161	77	29.7	8	2.53	2.2	87	106	50
26	F	48	160	52	20.31	7.25	2.62	2.2	84	70	74
27	F	48	156	68	27.94	5.5	3.31	2.78	84	87	67
28	F	49	150	49	21.77	8	2.4	1.93	81	56	53
29	F	49	165	61	22.46	7.25	3.09	2.64	85	99	107
30	F	49	149	73	32.88	5.625	2.19	1.89	86	126	113

Table M.3 Demographics data of female 50-59 years subjects (n=32).

No.	Sex	Age (yrs)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Physical Activity Level score	FVC (liter)	FEV_1 (liter)	FEV1/FVC (%)	MIP (cmH_2O)	MEP (cmH_2O)
1	F	50	145	47	22.35	7.75	2.11	1.82	86	89	148
2	F	50	156	46	18.9	7.875	2.78	2.22	80	118	140
3	F	50	155	70	29.13	7.5	2.13	1.74	81	45	67
4	F	50	146	86	40.34	7.125	2.71	2.41	91	76	92
5	F	50	156	42	17.25	5.75	2.11	1.83	86	59	106
6	F	50	151	58.5	25.65	6.5	2.72	2.08	77	83	104
7	F	51	148	58	26.47	6.625	1.99	1.73	87	103	109
8	F	51	156	62	25.47	7	2.38	1.86	78	64	140
9	F	51	146	63.5	29.55	4.875	2	1.72	86	115	129
10	F	51	156	63	25.88	7.75	2.12	1.76	83	129	171
11	F	51	155	66	27.47	8	2.08	1.73	83	109	107
12	F	51	161	70	27	4.75	2.39	1.86	78	67	92
13	F	52	155	60	24.97	7	2.29	1.81	79	62	50
14	F	52	157	77	31.23	7.375	2.77	2.38	86	101	99
15	F	52	150	54	24	7.375	2.09	1.65	79	76	72
16	F	52	148	70	31.95	7.375	2.12	1.54	72	62	92
17	F	53	156	66	27.12	8	2.4	2.05	85	62	118
18	F	54	154	60	25.29	7.5	2.89	2.33	81	62	110
19	F	54	157	54	21.9	6.375	2.37	1.87	79	98	110
20	F	54	155	65	27.05	6.875	2.34	1.88	81	62	103
21	F	55	157	71	28.8	5.5	2.19	1.72	79	84	53
22	F	55	154	56	23.61	7.875	2.18	1.89	87	76	73
23	F	55	155	62	25.8	8	2.38	2.01	84	101	79
24	F	55	161	68	26.23	7.75	2.42	2.01	83	95	74
25	F	55	151	77	33.77	6.125	2.12	1.94	91	64	101
26	F	56	150	62	27.55	8	1.93	1.68	87	103	68
27	F	56	155	72.5	30.17	7.875	2.61	2.28	87	154	146
28	F	57	156	65	26.7	7.875	2.06	1.71	83	76	93
29	F	57	159	66	26.1	5.875	2.17	1.86	86	66	67
30	F	58	158	47	18.82	7.25	2.33	1.86	80	67	78
31	F	59	153	61	26.05	5.5	2.11	1.61	76	78	115
32	F	59	146	48	22.51	7.75	1.87	1.45	78	95	92

Table M.4 Demographics data of female 60-70 years subjects (n=30).

No.	Sex	Age (yrs)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Physical Activity Level score	FVC (liter)	FEV_1 (liter)	FEV1/FVC (%)	MIP (cmH_2O)	MEP (cmH_2O)
1	F	60	157	51	20.69	8	2.93	2.39	82	88	116
2	F	60	169	45	15.75	4.5	2.18	1.72	79	73	92
3	F	61	151	54	23.68	5.125	1.97	1.67	82	95	70
4	F	61	144	41	19.77	5.25	2.04	1.74	85	96	120
5	F	62	156	66	27.12	6.625	1.97	1.71	87	56	91
6	F	63	151	58	25.43	4.75	2.38	2.03	86	59	81
7	F	63	156	49	20.13	8	2.63	1.98	75	42	46
8	F	64	153	57	24.34	4.25	2.11	1.81	86	65	62
9	F	64	161	52	20.06	4.5	2.43	1.94	80	76	70
10	F	64	145	49	23.3	5	1.86	1.42	76	62	115
11	F	64	142	61	30.25	7.375	1.79	1.51	84	84	70
12	F	65	151	59	25.87	5	1.91	1.44	75	67	62
13	F	65	165	59	21.67	4.25	2.66	2.18	82	39	67
14	F	66	146	46	21.58	5	1.83	1.64	89	34	81
15	F	66	149	59	26.57	5.25	2.47	1.85	75	81	53
16	F	66	149	57	25.67	5.5	1.73	1.44	83	104	123
17	F	66	145	46	21.87	4	1.76	1.41	80	92	104
18	F	66	155	64	26.63	5.75	2.03	1.51	74	83	92
19	F	68	155	72	29.96	5.25	2.22	1.86	84	48	88
20	F	68	155	52	21.64	5.25	2.05	1.64	80	81	95
21	F	68	141	53	26.65	5.5	2.14	1.63	76	109	123
22	F	68	163	59	22.2	4	2.51	1.86	74	39	50
23	F	68	154	63.5	26.77	4.75	2.43	2.02	83	85	74
24	F	69	155	52	21.64	4.75	2.21	1.66	75	67	42
25	F	69	147	50	23.13	4.5	1.93	1.44	75	79	67
26	F	70	148	59	26.93	5.5	1.95	1.49	77	88	47
27	F	70	155	72	29.96	5.25	1.93	1.54	80	78	34
28	F	70	157	51	20.69	6.5	2.13	1.56	74	92	112
29	F	70	152	54	23.37	4.5	1.94	1.7	88	42	74
30	F	70	152	54	23.37	5.25	1.96	1.65	84	53	76

Table M.5 Demographics data of male 30-39 years subjects (n=33).

No.	Sex	Age (yrs)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Physical Activity Level score	FVC (liter)	FEV_1 (liter)	FEV1/FVC (%)	MIP (cmH_2O)	MEP (cmH_2O)
1	M	30	169	59	20.65	7.125	4.37	3.86	88	81	84
2	M	30	167	58	20.79	8	4.44	3.2	72	106	148
3	M	30	178	67	21.14	8	3.9	3.47	89	129	134
4	M	31	169	60	21	7.125	3.73	3.21	86	139	188
5	M	31	162	83	31.62	5.125	3.37	3.01	89	142	109
6	M	32	161	51	19.67	7.375	2.96	2.6	88	151	176
7	M	32	165	57	20.93	5.875	3.28	2.79	85	120	137
8	M	32	165	60	22.03	8	4.07	3.69	91	185	238
9	M	32	150	57.5	25.55	7.375	3.18	2.89	91	107	158
10	M	32	173	62	20.71	7.625	4.24	3.53	83	174	203
11	M	33	175	68	22.2	6.625	4.72	4.13	87	123	190
12	M	33	172	63	21.29	7.875	4.39	4.03	92	123	197
13	M	33	167	74	26.53	7.25	4.91	3.78	77	139	162
14	M	33	173	63	21.04	7.625	5	4.28	86	143	157
15	M	34	163	66	24.8	8	4.19	3.48	83	134	88
16	M	34	170	65.5	22.66	8	4.61	4.02	87	120	188
17	M	35	166	65.5	23.58	6.375	3.4	2.95	87	130	183
18	M	35	162	65	24.76	7.125	3.31	2.98	90	157	277
19	M	35	172	70	23.66	7.75	4.42	3.64	82	160	185
20	M	36	161	42	16.2	8	3.25	3.05	94	109	146
21	M	36	162	75	28.57	7.875	3.74	3.39	91	156	227
22	M	36	167	79.5	28.5	7.75	4.35	3.44	79	104	135
23	M	36	163	54	20.32	8	4.45	3.06	69	106	170
24	M	36	165	67	24.6	7.125	3.79	3.19	84	151	238
25	M	36	167	54	19.36	6.75	3.68	3.2	87	141	159
26	M	36	171	63	21.54	7.75	4.51	3.57	79	129	235
27	M	37	171	71	24.28	7	4.74	3.7	78	127	165
28	M	37	166	65.5	23.76	7.75	3.46	2.81	81	97	190
29	M	37	166	82.5	29.93	6.75	4.84	4.26	88	160	196
30	M	37	175	76	24.81	7.5	4.32	3.63	84	137	190
31	M	38	170	72	24.91	7.75	4.17	3.44	82	162	182
32	M	39	162	72.5	27.62	7	2.83	2.39	85	154	183
33	M	39	178	74	23.35	7.875	4.59	3.97	87	102	224

Table M.6 Demographics data of male 40-49 years subjects (n=32).

No.	Sex	Age (yrs)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Physical Activity Level score	FVC (liter)	FEV_1 (liter)	FEV1/FVC (%)	MIP (cmH_2O)	MEP (cmH_2O)
1	M	40	162	72	27.43	6.625	2.98	2.48	83	118	174
2	M	40	164	60	22.3	7.625	3.39	2.83	84	151	165
3	M	40	162	78	26.67	7.25	3.07	2.86	93	90	171
4	M	41	170	67	23.18	7.75	4.07	3.43	84	98	199
5	M	41	173	78	26.06	6.625	3.93	3.09	79	171	241
6	M	42	166	70	24.4	6.5	3.76	2.99	80	176	185
7	M	42	169	72.5	25.38	6.875	2.93	2.69	92	132	155
8	M	42	165	70	25.71	8	3.49	3.12	89	113	232
9	M	43	160	64	25	7.625	3.49	3.13	90	182	323
10	M	43	164	68	25.28	7.875	3.48	3.1	89	107	109
11	M	43	160	60	23.43	7.75	3.42	2.76	81	157	151
12	M	43	161	71	27.39	7.875	3.69	3.2	87	119	129
13	M	44	173	69	23.05	7	4.48	3.51	78	137	154
14	M	44	166	77.5	28.12	6	3.3	2.73	83	154	169
15	M	44	165	74.5	27.36	7.125	3.24	2.84	88	97	146
16	M	44	169	61	21.35	6.5	3.67	3.15	86	88	211
17	M	44	169	91	31.86	8	4.04	3.54	88	148	182
18	M	44	159	61	24.12	7	3.73	3.1	83	151	266
19	M	45	170	76	26.29	7.875	3.98	3.34	84	126	204
20	M	45	168	70.5	24.97	7.875	4.12	3.42	83	119	172
21	M	46	168	75	26.57	8	3.94	3.51	89	154	207
22	M	46	162	61	23.24	7.875	3.1	2.59	83	162	202
23	M	46	167	76	27.25	8	4.17	3.36	81	78	96
24	M	47	170	75	25.95	8	3.19	2.57	81	106	143
25	M	47	165	57	20.93	6.125	4.27	3.54	83	92	132
26	M	47	166	59	21.41	7.625	3.93	3.46	88	131	213
27	M	47	163	68	25.59	7	3.95	3.48	88	134	160
28	M	48	179	83	25.9	7	3.78	2.88	76	148	201
29	M	48	172	78	26.36	7.25	3.90	3.25	83	109	217
30	M	48	164	74	27.51	6.25	3.26	2.74	84	120	179
31	M	49	170	72	24.91	5.5	3.52	2.96	84	134	148
32	M	49	170	82	28.37	7.375	4.17	3.59	86	202	260

Table M.7 Demographics data of male 50-59 years subjects (n=31).

No.	Sex	Age (yrs)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Physical Activity Level score	FVC (liter)	FEV_1 (liter)	FEV1/FVC (%)	MIP (cmH_2O)	MEP (cmH_2O)
1	M	50	157	60	24.3	7.375	2.8	2.37	85	50	45
2	M	50	173	66	22.05	7.875	3.99	3.31	83	146	284
3	M	50	173	67.5	22.55	8	4.33	3.28	76	146	221
4	M	50	168	61	21.61	6.625	4.03	3.22	80	63	84
5	M	50	163	89	33.49	8	4.06	3.29	81	98	101
6	M	50	167	65	23.3	7.875	3.11	2.66	86	188	157
7	M	50	162	71.5	27.24	6.75	3.38	2.09	85	116	117
8	M	51	163	73	27.47	7.25	3.23	2.88	89	140	126
9	M	51	163	70	26.34	7.75	3.3	2.85	86	115	145
10	M	52	167	72.5	25.99	7.5	3.39	2.87	85	154	185
11	M	52	167	67	24.02	5.875	3.25	2.52	77	125	202
12	M	52	161	75	28.93	8	2.89	2.72	94	76	125
13	M	52	165	67.5	24.79	8	4	3.65	91	123	171
14	M	53	164	69	25.65	7.375	2.89	2.41	83	126	128
15	M	53	157	70	28.39	7.75	3.47	3.06	88	141	202
16	M	55	169	68	23.8	5.375	4.45	3.62	81	106	160
17	M	55	170	77	26.64	5.75	2.82	2.45	87	160	259
18	M	55	170	72.5	25.08	7.5	3.44	2.62	76	104	107
19	M	55	165	77	28.28	6.5	3.12	2.69	86	132	162
20	M	55	167	63	22.58	6.5	3.07	2.63	86	107	176
21	M	55	162	69	26.29	5.25	3.39	2.78	82	157	174
22	M	55	165	75	27.54	8	3.01	2.53	84	114	140
23	M	56	164	68.5	25.46	5.75	3.17	2.56	81	76	101
24	M	56	169	77	26.95	7.625	3.05	2.57	84	98	202
25	M	57	167	72	25.81	6.25	3.24	2.75	85	118	207
26	M	57	165	65	23.87	7.625	3.39	2.77	82	111	91
27	M	58	174	88	29.06	6.625	3.66	2.96	81	160	129
28	M	58	162	63	24.00	7.875	2.84	2.43	86	90	129
29	M	58	164	72	26.76	4.125	3.73	3.12	84	87	143
30	M	59	173	85	28.40	5.625	3.40	2.74	81	137	266
31	M	59	158	65	26.03	6.875	3.31	2.27	69	99	193

Table M.8 Demographics data of male 60-70 years subjects (n=31).

No.	Sex	Age (yrs)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Physical Activity Level score	FVC (liter)	FEV_1 (liter)	FEV1/FVC (%)	MIP (cmH_2O)	MEP (cmH_2O)
1	M	60	168	81	28.69	7.25	3.06	2.41	79	130	237
2	M	60	160	61	23.82	5	2.76	2.35	85	112	160
3	M	61	161	80.5	31.05	7.375	3.06	2.69	88	125	148
4	M	61	169	65	22.75	4.25	3.64	3	82	118	151
5	M	62	163	79	29.73	4.5	3.54	3.05	86	101	137
6	M	62	164	66	24.53	7.75	3.44	2.77	80	101	208
7	M	62	161	68.5	26.42	4	2.58	2.17	84	88	153
8	M	62	163	87	32.74	5.5	3.34	2.85	85	114	202
9	M	62	147	51	23.60	4.25	2.13	1.84	86	89	210
10	M	62	161	54	20.80	3.25	3.18	2.31	73	87	153
11	M	62	161	72	27.77	4	2.62	2.17	83	112	218
12	M	63	172	71.5	24.16	5	3.59	2.86	80	85	151
13	M	63	168	64	22.67	4.75	2.83	1.95	69	95	87
14	M	63	161	60	23.14	4	3.31	2.71	82	118	98
15	M	63	156	59	24.24	6.875	2.88	2.21	77	126	169
16	M	64	161	61.5	23.72	5.75	2.56	2.14	84	97	210
17	M	65	166	64	23.22	7.25	3.43	2.6	76	109	132
18	M	66	170	69	23.7	4.75	3.12	2.55	82	95	129
19	M	66	176	72.5	23.4	5	3.02	2.45	81	137	221
20	M	66	157	62.5	25.35	4.75	2.44	1.96	80	117	213
21	M	67	172	62	20.95	8	4.34	3.08	71	98	53
22	M	67	168	72.5	25.68	5.75	3.13	2.61	83	50	129
23	M	67	173	78	26.06	5.75	2.85	2.5	88	127	165
24	M	67	153	61	26.05	4.75	3.11	2.19	70	120	115
25	M	68	160	55	21.48	3.75	2.46	1.91	78	92	190
26	M	69	158	61	24.43	4.5	2.62	2.08	80	118	151
27	M	69	170	74.5	25.77	5.5	3.29	2.55	78	129	148
28	M	69	155	46	19.14	3.75	2.4	1.93	80	106	196
29	M	69	150	51	22.66	6.25	2.29	1.82	79	98	123
30	M	70	165	66	24.24	4.25	2.97	2.42	82	99	221
31	M	70	159	76	30.06	4.5	2.19	1.71	78	87	92

Table M.9 Raw data of Maximal Inspiratory Mouth Pressure (MIP) of female 30-39 years subjects (n=30).

Subjects	MIP maneuvers (times)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	109	111	104	106	104	115	118	115	109	126
2	45	45	55	50	48	62	59	53	63	62
3	64	90	64	90	70	106	105	101	90	96
4	83	95	92	95	95	87	92	92	90	87
5	67	73	76	53	62	62	67	67	85	81
6	64	70	81	90	78	84	81	88	98	88
7	59	61	77	70	67	67	70	73	76	70
8	42	50	42	42	45	49	45	45	50	53
9	70	78	82	73	70	84	90	84	87	79
10	88	81	87	90	84	78	76	81	88	76
11	98	104	87	111	109	109	115	115	124	114
12	44	48	52	48	48	56	39	53	45	49
13	59	61	88	95	84	81	76	81	83	92
14	36	39	50	48	42	39	59	62	48	53
15	55	59	56	59	73	75	76	73	67	85
16	112	120	123	129	132	137	128	140	123	146
17	94	84	101	88	92	104	97	109	109	102
18	51	50	61	48	56	53	64	50	67	70
19	79	64	84	78	76	87	91	76	87	99
20	78	67	87	84	84	83	82	76	84	83
21	73	76	76	82	92	84	84	95	92	87
22	59	55	50	39	62	62	53	48	62	62
23	109	126	132	126	127	120	112	132	105	120
24	95	104	98	92	96	112	109	104	101	106
25	70	73	76	76	76	87	84	90	78	76
26	70	73	69	71	73	73	69	84	78	87
27	71	89	71	78	87	85	84	76	98	102
28	48	33	36	39	39	48	34	64	59	53
29	45	56	59	53	59	67	68	64	69	73
30	78	70	76	70	73	76	76	81	87	84

Table M.10 Raw data of Maximal Inspiratory Mouth Pressure (MIP) of female 40-49 years subjects (n=30).

Subjects	MIP maneuvers (times)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	90	87	90	72	84	80	85	87	76	81
2	64	70	59	53	67	81	80	74	70	84
3	81	105	134	139	167	148	78	90	81	102
4	61	56	78	76	79	67	67	73	81	64
5	92	81	83	112	115	92	95	88	109	99
6	50	56	59	64	59	69	67	73	78	70
7	73	69	81	73	70	75	81	78	87	82
8	64	73	78	73	68	81	81	73	73	70
9	20	22	25	25	20	22	20	20	25	22
10	78	81	71	90	78	93	81	84	87	96
11	81	92	87	98	95	95	115	123	125	118
12	109	123	113	109	115	126	129	115	109	117
13	31	32	33	39	39	36	36	36	42	45
14	76	78	64	90	87	106	98	107	92	109
15	115	134	115	123	130	127	126	115	127	126
16	45	59	50	53	60	56	53	59	53	62
17	62	63	78	63	78	59	66	76	79	81
18	121	118	130	148	149	140	146	151	146	146
19	59	62	73	67	73	73	76	78	76	75
20	76	67	67	65	59	64	67	50	50	53
21	53	55	78	50	98	90	77	92	84	92
22	81	81	84	76	81	81	92	92	96	91
23	67	78	84	90	84	84	76	95	92	97
24	87	97	92	90	92	88	73	95	90	92
25	70	71	89	95	95	84	78	98	76	106
26	59	59	51	56	67	57	56	70	64	70
27	62	78	87	70	73	62	67	76	84	67
28	34	53	42	34	45	32	39	39	32	56
29	70	81	87	91	99	84	78	81	76	78
30	109	120	115	120	118	120	120	120	120	126

Table M.11 Raw data of Maximal Inspiratory Mouth Pressure (MIP) of female 50-59 years subjects (n=32).

Subjects	MIP maneuvers (times)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	73	69	76	70	76	82	81	87	76	89
2	104	109	107	112	113	112	110	112	115	118
3	31	34	32	31	39	34	36	36	45	34
4	56	76	76	76	76	67	72	59	72	67
5	45	48	42	42	40	50	56	59	53	59
6	68	67	78	70	82	74	83	81	80	76
7	81	92	83	78	78	92	92	81	90	103
8	48	53	62	50	50	64	64	48	56	56
9	109	115	104	95	109	109	106	101	112	112
10	118	120	129	129	129	122	123	129	126	129
11	90	95	106	106	109	109	87	84	73	86
12	38	38	41	53	39	44	53	53	56	67
13	56	56	53	50	56	51	62	45	45	42
14	101	88	81	92	90	81	87	100	98	84
15	45	59	62	60	56	76	64	64	70	73
16	50	50	48	59	62	54	58	53	50	45
17	48	53	62	62	53	59	56	50	50	47
18	53	59	59	56	55	56	62	61	62	62
19	48	53	53	73	95	97	92	98	89	86
20	31	29	39	53	62	39	43	32	42	54
21	67	45	59	73	81	67	70	59	84	70
22	35	48	45	76	76	71	62	62	75	66
23	81	98	99	92	101	92	92	92	101	92
24	60	67	78	79	81	84	70	70	92	95
25	37	45	48	56	56	48	56	64	64	62
26	64	70	84	87	78	67	84	95	103	92
27	115	112	132	144	143	146	143	154	143	148
28	42	45	50	51	59	53	76	73	71	64
29	51	43	42	59	42	53	46	66	53	62
30	45	67	48	55	56	59	57	60	53	51
31	48	50	53	50	59	59	59	45	71	78
32	61	59	70	56	56	73	95	90	83	76

Table M.12 Raw data of Maximal Inspiratory Mouth Pressure (MIP) of female 60-70 years subjects (n=30).

Subjects	MIP maneuvers (times)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	64	84	52	62	52	59	71	83	84	88
2	42	49	48	57	64	67	62	73	70	73
3	95	90	73	84	92	84	87	76	73	87
4	57	59	62	75	78	87	87	88	96	95
5	39	36	46	39	45	53	49	56	39	54
6	42	34	25	31	28	59	53	53	56	59
7	39	34	41	39	36	42	42	39	36	42
8	56	53	54	65	62	53	64	59	56	64
9	55	62	53	70	56	59	55	53	62	76
10	56	62	62	43	46	50	58	53	62	61
11	45	48	69	73	77	76	81	76	83	84
12	22	36	34	36	28	62	66	62	59	67
13	28	28	28	39	28	32	34	28	31	39
14	17	26	26	22	31	24	34	22	20	25
15	81	73	78	62	62	64	64	64	73	81
16	45	48	42	69	57	76	76	94	92	104
17	74	70	76	78	76	81	92	91	92	88
18	76	71	73	76	70	78	74	78	83	67
19	20	25	22	31	34	42	36	42	41	48
20	48	55	66	59	70	67	76	59	81	78
21	91	97	98	104	109	109	109	104	104	104
22	31	36	34	34	39	39	39	36	31	34
23	62	64	59	85	76	73	69	76	78	81
24	64	59	62	67	64	56	60	56	50	67
25	25	27	59	51	42	69	67	52	61	79
26	31	39	43	62	61	64	47	55	80	88
27	78	78	70	78	62	71	59	50	56	64
28	70	87	73	89	81	81	92	81	76	87
29	22	25	25	34	33	39	35	34	42	36
30	31	34	32	31	46	34	36	53	42	45

Table M.13 Raw data of Maximal Inspiratory Mouth Pressure (MIP) of male 30-39 years subjects (n=33).

Subjects	MIP maneuvers (times)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	64	53	62	64	60	53	62	59	81	68
2	73	71	81	76	83	75	90	98	104	106
3	116	101	120	106	106	129	122	124	122	119
4	139	126	134	134	105	132	115	132	129	109
5	84	98	123	118	106	123	132	127	134	142
6	137	146	134	123	151	148	148	146	148	134
7	76	98	84	99	103	111	101	90	109	120
8	165	172	169	171	176	171	168	179	176	185
9	87	73	73	104	107	87	81	73	101	98
10	154	160	163	164	160	165	174	162	171	171
11	111	100	104	106	111	106	105	120	120	123
12	90	96	106	121	115	109	109	98	115	123
13	120	123	129	113	139	137	118	134	101	116
14	109	130	113	134	126	139	139	132	143	136
15	129	126	109	112	134	126	129	120	123	113
16	87	91	90	90	106	113	101	112	106	120
17	124	112	128	128	104	115	112	101	112	130
18	118	129	137	128	143	146	143	136	157	157
19	137	146	148	148	160	155	160	140	154	146
20	70	78	81	87	95	101	88	81	105	109
21	151	140	143	146	156	134	148	134	152	154
22	92	92	95	84	98	104	92	90	90	92
23	70	75	90	106	84	98	67	96	102	98
24	129	134	134	143	139	141	148	148	145	151
25	120	141	124	132	120	132	129	140	140	126
26	115	112	118	109	119	112	117	109	126	129
27	112	123	112	127	115	126	127	116	123	126
28	75	78	76	97	87	87	78	76	76	78
29	112	143	132	129	160	154	146	129	143	137
30	120	118	123	120	120	134	137	137	127	130
31	143	144	156	154	157	154	162	143	148	162
32	129	120	119	129	132	139	132	139	129	154
33	84	95	102	92	82	90	87	92	81	92

Table M.14 Raw data of Maximal Inspiratory Mouth Pressure (MIP) of male 40-49 years subjects (n=32).

Subjects	MIP maneuvers (times)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	73	87	116	106	109	115	113	107	106	118
2	106	118	125	140	148	146	143	134	148	151
3	71	78	87	90	90	89	78	76	73	89
4	85	64	78	78	92	98	70	87	70	78
5	146	153	154	160	157	160	167	160	162	171
6	137	137	151	144	140	143	157	143	165	176
7	104	120	130	120	126	129	128	120	131	132
8	112	98	113	103	106	112	112	109	102	105
9	84	140	157	160	179	179	176	162	182	176
10	83	98	95	97	85	95	98	90	90	107
11	134	132	134	129	130	134	137	148	157	146
12	84	112	101	106	109	109	115	119	116	101
13	127	129	132	129	137	123	118	134	137	135
14	110	120	125	127	123	127	131	137	154	149
15	92	86	84	93	92	97	87	86	91	90
16	67	71	73	73	73	70	70	74	84	88
17	137	134	143	143	140	136	128	132	148	146
18	137	141	112	132	134	134	151	151	148	151
19	62	64	89	70	57	84	70	104	126	109
20	92	92	102	95	106	92	95	115	115	119
21	139	154	146	146	148	137	140	140	140	151
22	116	143	151	160	159	154	137	162	151	143
23	67	62	78	74	67	66	78	73	67	76
24	106	106	100	92	98	88	102	90	98	90
25	70	73	87	81	90	81	76	76	80	92
26	112	129	118	129	122	129	131	129	129	113
27	115	134	115	115	101	115	118	127	123	120
28	92	119	129	132	146	148	146	137	143	146
29	90	97	109	106	93	95	87	104	90	109
30	88	98	98	101	101	115	118	109	118	120
31	115	120	123	133	125	123	125	129	134	121
32	179	185	190	190	196	202	190	193	195	202

Table M.15 Raw data of Maximal Inspiratory Mouth Pressure (MIP) of male 50-59 years subjects (n=31).

Subjects	MIP maneuvers (times)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	44	42	43	50	45	42	39	48	39	39
2	112	104	104	129	115	146	139	129	129	104
3	109	104	106	112	114	127	125	134	137	146
4	56	53	56	63	50	55	59	53	48	56
5	87	90	88	91	92	79	76	98	90	90
6	188	169	120	138	151	151	132	104	144	139
7	62	74	92	82	94	106	108	116	114	113
8	126	129	129	131	140	137	135	134	134	137
9	90	112	97	106	115	80	90	95	78	70
10	140	151	148	146	143	148	149	148	148	154
11	97	81	103	97	106	114	115	125	101	109
12	55	49	56	45	62	50	76	56	56	64
13	109	123	123	120	120	112	114	120	107	102
14	81	73	99	84	97	104	104	118	107	126
15	91	90	85	91	92	125	129	134	141	132
16	72	81	76	92	64	73	95	81	84	106
17	146	148	148	160	158	156	132	149	137	143
18	87	70	95	78	84	88	100	104	89	91
19	90	103	112	120	123	120	126	132	125	132
20	87	97	87	104	104	98	90	98	98	107
21	140	157	139	132	136	144	154	140	133	154
22	83	80	98	92	111	106	112	114	101	109
23	59	57	64	70	64	57	56	64	76	56
24	70	62	76	98	91	92	71	78	69	87
25	109	95	118	95	115	106	104	101	109	106
26	69	67	74	92	109	106	108	95	97	111
27	107	126	112	134	143	149	158	160	156	154
28	78	62	84	84	84	67	67	70	90	83
29	66	76	73	73	82	78	67	87	67	78
30	106	106	106	109	134	137	132	134	132	136
31	87	98	90	95	87	81	91	99	90	98

Table M.16 Raw data of Maximal Inspiratory Mouth Pressure (MIP) of male 60-70 years subjects (n=31).

Subjects	MIP maneuvers (times)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	89	81	115	120	120	126	125	122	130	123
2	98	112	90	95	92	101	109	101	104	102
3	66	60	62	103	107	97	111	71	122	125
4	80	104	98	104	101	95	112	104	118	109
5	76	81	87	89	92	92	101	95	92	92
6	64	67	73	71	76	78	101	95	87	88
7	72	67	70	85	68	85	76	88	78	76
8	75	87	97	92	99	100	114	106	114	108
9	58	73	66	64	55	69	63	62	76	89
10	48	48	50	70	64	73	87	76	76	83
11	45	42	56	63	69	84	85	84	98	112
12	60	60	69	69	67	74	70	70	85	67
13	73	64	76	76	70	80	84	84	90	95
14	70	66	92	98	78	87	109	109	118	109
15	106	126	120	118	105	108	107	105	107	113
16	64	69	84	77	81	71	76	78	87	97
17	87	87	92	98	98	103	109	109	104	95
18	64	69	73	84	73	83	81	85	81	95
19	104	109	134	129	129	137	134	134	115	123
20	87	92	101	108	111	116	111	106	117	109
21	73	70	96	98	90	84	79	85	78	87
22	45	36	36	34	48	45	44	50	43	50
23	95	87	98	93	73	99	92	93	101	127
24	78	77	98	94	106	90	113	120	105	116
25	64	66	64	78	81	92	76	78	92	87
26	73	70	81	87	92	98	95	106	118	106
27	120	123	123	115	120	110	120	121	120	129
28	59	77	94	96	104	101	97	104	100	106
29	64	64	98	76	67	78	67	81	76	90
30	81	92	87	90	97	83	92	87	99	87
31	64	62	53	62	53	59	87	67	87	67

Table M.17 Raw data of Maximal Expiratory Mouth Pressure (MEP) of female 30-39 years subjects (n=30).

Subjects	MEP maneuvers (times)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	62	56	64	65	62	64	63	63	67	70	67	70
2	56	68	48	65	62	55	56	55	49	42	57	50
3	61	57	56	64	70	62	58	50	73	64	60	53
4	76	81	78	64	81	70	73	78	73	70	70	81
5	73	64	77	62	70	59	74	90	85	62	78	73
6	70	78	76	90	94	98	92	93	92	90	81	105
7	81	92	93	92	98	98	95	104	100	78	101	98
8	78	73	67	64	59	66	67	67	64	70	64	69
9	57	50	64	53	45	70	76	76	76	67	76	62
10	48	31	31	32	42	39	36	34	48	31	45	42
11	116	129	113	106	110	116	123	136	134	129	132	132
12	53	53	53	50	53	45	58	54	48	41	53	64
13	40	45	39	34	34	45	40	30	31	39	48	42
14	53	57	76	70	74	55	59	60	46	64	56	62
15	115	76	111	108	108	104	93	70	67	84	81	98
16	84	87	95	120	111	110	123	129	143	153	156	129
17	98	97	96	122	137	129	116	140	126	132	127	126
18	31	45	42	36	43	42	56	75	71	73	59	62
19	59	59	48	46	50	60	76	76	62	48	54	59
20	71	70	76	64	76	67	73	83	69	73	76	73
21	146	140	132	140	145	123	115	134	106	148	116	123
22	76	81	87	68	68	67	72	67	64	62	69	67
23	67	62	78	87	98	90	76	73	90	81	75	84
24	65	67	62	72	78	78	71	73	85	73	67	81
25	95	98	98	95	84	90	104	104	98	84	95	95
26	123	134	134	134	132	148	145	148	149	154	143	140
27	53	42	45	39	45	42	48	45	53	39	48	48
28	48	56	45	48	50	59	62	72	59	50	53	74
29	83	95	95	93	104	123	134	139	143	137	146	141
30	81	78	84	84	85	101	84	87	76	84	92	101

Table M.18 Raw data of Maximal Expiratory Mouth Pressure (MEP) of female 40-49 years subjects (n=30).

Subjects	MEP maneuvers (times)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	87	91	77	84	76	79	70	78	76	78	78	84
2	62	70	64	62	80	84	62	68	62	60	64	62
3	70	78	101	87	106	81	98	106	116	109	92	113
4	88	87	95	78	81	85	87	105	107	90	95	104
5	84	78	76	62	87	81	73	76	78	67	68	76
6	59	76	77	70	67	83	95	101	81	73	84	82
7	65	62	62	68	70	73	73	74	76	81	78	70
8	118	132	135	137	120	140	118	112	123	106	123	102
9	31	28	28	28	25	28	34	25	28	34	29	25
10	66	78	92	62	50	73	88	82	80	73	88	70
11	62	67	50	56	42	51	76	79	60	85	95	83
12	102	135	97	135	125	146	141	152	141	160	199	174
13	31	28	28	39	28	29	25	28	36	25	23	29
14	90	95	101	90	101	120	110	137	124	127	110	101
15	113	111	129	129	123	123	105	132	118	129	132	120
16	62	63	59	52	62	56	53	76	64	81	80	70
17	56	40	48	43	47	53	50	59	62	59	62	45
18	81	90	77	71	93	90	98	92	78	76	78	81
19	81	84	98	76	97	109	116	87	73	76	102	84
20	76	64	67	108	98	130	127	140	132	130	126	117
21	69	64	73	84	70	57	62	64	59	53	50	64
22	85	90	62	71	76	81	72	68	73	71	69	54
23	81	95	84	78	85	87	90	92	99	101	92	98
24	50	45	42	60	64	62	56	73	68	76	80	69
25	45	48	50	42	42	45	42	42	42	50	48	48
26	68	53	70	67	62	58	62	62	59	58	62	74
27	48	53	67	48	42	48	48	50	62	53	54	50
28	36	45	31	34	40	36	31	53	48	45	36	34
29	85	70	67	83	88	101	92	107	92	99	101	70
30	74	76	101	81	78	84	100	95	90	113	103	98

Table M.19 Raw data of Maximal Expiratory Mouth Pressure (MEP) of female 50-59 years subjects (n=32).

Subjects	MEP maneuvers (times)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	104	137	129	120	127	141	134	126	148	134	118	125
2	105	92	109	78	76	82	84	101	112	90	140	129
3	43	59	61	62	62	64	48	67	56	59	59	53
4	62	66	81	92	84	78	62	70	62	80	71	81
5	74	65	67	73	92	104	87	104	98	106	98	106
6	75	81	81	96	90	102	91	104	96	90	92	89
7	109	84	102	99	81	79	87	78	81	81	73	81
8	109	106	95	129	106	121	126	107	122	121	116	140
9	96	84	87	87	98	95	115	101	120	98	120	129
10	85	98	117	146	157	143	160	171	148	138	161	167
11	88	78	69	81	62	64	75	76	107	97	81	90
12	53	60	59	71	82	69	72	81	87	76	81	92
13	45	40	42	34	36	39	34	34	34	34	46	50
14	84	95	67	87	80	73	84	67	68	85	99	87
15	53	68	60	54	57	49	59	72	48	64	53	56
16	50	64	72	81	79	92	65	67	59	42	46	48
17	70	64	64	76	84	64	91	106	109	118	103	95
18	81	84	90	106	106	109	95	89	90	110	98	98
19	56	64	76	72	68	92	84	84	90	102	110	108
20	63	70	66	73	76	63	81	87	78	71	67	103
21	36	36	45	39	37	53	40	41	39	47	45	36
22	23	26	27	50	48	64	56	62	59	62	73	61
23	70	76	71	76	76	71	69	78	71	79	64	70
24	65	53	59	61	56	67	59	55	74	73	62	73
25	50	53	56	76	78	95	101	92	70	67	69	70
26	41	36	42	53	59	48	37	48	48	59	53	68
27	61	56	78	78	90	92	90	90	115	123	120	146
28	56	69	54	59	59	43	59	57	62	84	92	93
29	45	53	51	34	54	53	48	39	36	50	67	65
30	69	76	76	50	53	67	74	67	78	59	75	69
31	85	71	76	79	81	95	96	81	92	88	97	115
32	59	62	53	64	53	42	52	55	70	84	70	92

Table M.20 Raw data of Maximal Expiratory Mouth Pressure (MEP) of female 60-70 years subjects (n=30).

Subjects	MEP maneuvers (times)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	106	95	106	116	106	101	97	107	112	109	95	112
2	77	81	74	79	78	92	81	81	85	81	84	87
3	70	64	56	53	58	45	43	46	42	35	34	48
4	64	62	76	97	110	118	113	120	81	90	111	95
5	91	81	73	81	62	83	84	76	79	78	71	71
6	34	20	42	36	36	67	64	40	60	56	81	78
7	27	34	46	22	25	20	25	25	30	29	23	25
8	56	62	62	56	62	55	44	49	45	45	57	46
9	39	42	64	48	48	55	53	50	70	56	67	60
10	69	76	97	96	99	93	102	106	95	107	107	115
11	48	64	61	67	58	67	62	70	62	67	66	67
12	25	57	36	36	41	53	62	45	56	50	43	36
13	45	42	56	39	55	56	67	57	67	53	59	64
14	60	45	62	56	67	81	62	62	64	53	54	70
15	52	42	42	53	49	49	39	41	48	45	48	51
16	95	123	98	94	106	92	101	81	95	76	90	95
17	60	60	66	78	64	72	77	64	92	68	85	104
18	54	67	64	87	76	92	79	71	76	70	78	83
19	48	39	34	45	48	51	64	55	70	73	73	88
20	78	92	78	95	70	59	45	45	67	51	50	51
21	45	45	46	51	67	68	90	90	98	104	115	123
22	22	27	20	20	20	32	38	40	41	34	50	42
23	62	67	54	72	74	65	66	67	62	59	68	66
24	36	38	39	36	34	31	34	39	30	38	36	42
25	67	45	46	45	56	53	42	42	42	51	34	39
26	30	33	35	31	34	41	40	25	26	20	42	47
27	25	17	14	29	20	15	17	34	17	20	34	15
28	66	65	76	87	73	87	99	84	81	99	102	112
29	65	67	64	53	65	67	74	69	70	62	69	70
30	55	64	51	50	49	46	50	76	53	50	53	56

Table M.21 Raw data of Maximal Expiratory Mouth Pressure (MEP) of male 30-39 years subjects (n=33).

Subjects	MEP maneuvers (times)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	83	72	81	73	83	83	79	82	84	74	84	81
2	95	120	106	113	132	118	109	99	137	148	129	143
3	115	101	134	106	101	119	127	120	109	116	116	127
4	104	144	188	165	134	144	165	140	146	129	171	140
5	84	109	83	74	74	62	74	56	62	81	95	90
6	123	107	143	112	160	171	176	154	165	168	165	160
7	90	124	134	112	109	109	92	129	118	98	106	137
8	179	202	211	225	204	230	219	216	211	238	224	235
9	129	120	129	132	120	146	148	158	143	148	129	140
10	132	149	169	174	160	165	182	203	199	171	171	186
11	154	140	139	137	153	146	151	158	176	158	169	190
12	93	109	132	104	123	176	134	148	104	167	175	197
13	155	162	148	134	134	123	143	129	129	134	129	146
14	107	104	125	132	132	148	148	157	150	156	140	151
15	73	67	74	88	76	68	62	62	69	73	62	87
16	137	155	174	179	160	176	165	157	171	165	179	188
17	127	130	134	140	109	168	148	152	112	172	169	183
18	244	216	277	260	246	250	252	232	266	253	255	246
19	160	134	165	174	164	174	168	179	185	176	137	168
20	100	108	90	119	146	126	120	112	146	137	115	109
21	157	174	211	200	200	163	151	148	126	157	202	227
22	81	74	78	87	79	73	84	95	95	98	109	135
23	126	134	138	148	157	163	170	168	134	149	154	160
24	151	188	188	162	213	238	193	206	202	211	200	200
25	113	100	140	111	137	123	111	135	141	130	159	148
26	160	179	228	179	235	228	221	206	216	210	227	225
27	144	107	108	107	112	123	120	129	162	165	148	160
28	112	116	134	124	129	151	157	185	183	190	151	186
29	187	196	161	171	194	185	151	173	166	167	167	174
30	169	171	166	160	134	130	168	154	179	190	179	148
31	143	137	129	171	171	182	165	180	162	147	171	160
32	104	174	167	174	183	158	157	174	127	157	155	157
33	138	148	176	171	168	176	190	218	224	207	218	209

Table M.22 Raw data of Maximal Expiratory Mouth Pressure (MEP) of male 40-49 years subjects (n=32).

Subjects	MEP maneuvers (times)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	98	87	92	120	132	124	126	139	141	132	151	174
2	73	87	85	90	95	106	165	134	153	143	120	132
3	98	85	81	104	95	154	171	157	146	127	132	157
4	143	157	182	168	174	185	199	182	132	165	126	142
5	182	219	241	213	216	223	204	167	196	190	223	213
6	122	123	154	174	185	162	146	134	169	146	162	179
7	99	90	129	154	151	118	133	141	115	155	154	126
8	157	151	158	201	202	201	207	218	218	204	221	232
9	148	202	207	228	283	221	269	323	238	210	280	300
10	76	78	73	75	92	90	109	106	93	88	98	106
11	92	112	105	132	138	124	126	109	102	151	149	137
12	92	92	101	116	95	118	118	129	113	129	121	109
13	98	154	143	137	123	120	148	146	123	113	126	123
14	136	120	160	169	148	104	151	123	109	109	112	143
15	90	98	99	107	127	140	132	122	146	144	132	146
16	120	146	132	140	157	146	174	179	186	179	211	204
17	151	120	182	165	118	129	118	174	143	132	165	170
18	219	266	232	249	230	249	213	252	215	210	239	234
19	106	106	140	174	185	204	129	190	174	154	148	109
20	153	171	132	160	137	172	127	139	148	138	140	145
21	120	174	182	207	198	198	186	187	190	169	166	190
22	158	160	202	202	184	172	160	148	175	137	148	143
23	75	84	62	81	70	81	66	95	96	70	87	90
24	129	137	126	112	118	137	129	143	112	123	140	140
25	64	62	96	102	83	111	112	132	121	126	130	129
26	108	95	162	165	126	116	208	179	179	213	181	193
27	132	143	132	137	160	106	134	114	129	134	132	113
28	144	118	120	116	172	201	188	188	186	182	180	193
29	123	160	166	168	166	185	176	196	202	183	202	217
30	113	132	104	148	151	167	179	168	118	106	104	145
31	78	87	86	115	124	148	110	95	83	98	105	95
32	213	165	193	168	227	238	260	256	232	218	235	213

Table M.23 Raw data of Maximal Expiratory Mouth Pressure (MEP) of male 50-59 years subjects (n=31).

Subjects	MEP maneuvers (times)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	36	34	42	40	31	34	45	42	32	34	39	34
2	284	220	279	238	235	210	207	252	241	247	230	218
3	140	132	207	189	197	186	168	157	188	162	210	221
4	65	75	64	84	70	74	76	77	67	70	62	78
5	63	61	73	70	63	66	69	92	93	101	81	89
6	129	107	123	106	108	114	143	146	146	151	150	157
7	67	60	59	58	86	86	89	86	117	108	102	115
8	109	93	101	84	107	104	104	109	109	123	124	126
9	126	108	81	76	79	123	98	95	140	145	143	129
10	165	143	117	163	151	137	147	151	151	134	171	185
11	165	165	165	202	179	164	169	182	202	162	183	177
12	98	116	109	113	106	97	109	116	104	90	125	104
13	86	90	134	91	118	134	129	110	106	171	140	118
14	92	83	84	81	92	83	92	84	100	112	113	128
15	159	134	135	129	158	170	176	186	202	155	155	151
16	74	84	106	110	106	104	133	140	137	144	132	160
17	199	230	252	216	202	246	259	249	217	252	204	249
18	107	86	86	83	73	72	76	104	90	80	76	78
19	104	109	119	160	146	144	140	148	162	152	148	146
20	113	126	148	158	171	151	169	168	176	168	172	176
21	120	151	172	166	165	165	162	156	162	141	158	174
22	137	137	123	128	127	129	137	120	133	140	132	126
23	80	89	87	101	98	92	95	79	73	87	87	98
24	171	130	138	148	127	102	185	174	157	185	171	202
25	109	123	123	104	137	160	173	155	176	207	196	207
26	76	76	91	88	76	83	74	87	90	90	81	84
27	98	109	113	105	129	116	120	113	109	108	104	109
28	101	101	97	129	126	106	104	104	102	115	106	119
29	134	115	126	118	118	129	114	127	143	126	106	100
30	188	260	216	213	253	237	227	230	258	213	260	266
31	144	165	188	183	176	193	169	166	164	167	177	179

Table M.24 Raw data of Maximal Expiratory Mouth Pressure (MEP) of male 60-70 years subjects (n=31).

Subjects	MEP maneuvers (times)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	185	205	196	174	176	171	221	211	230	237	228	223
2	76	73	101	118	104	138	126	126	110	134	160	144
3	138	134	115	118	139	148	125	141	115	132	131	146
4	70	87	126	121	106	120	123	129	129	140	123	151
5	95	137	101	95	104	90	116	89	116	92	92	95
6	106	109	115	181	151	207	207	172	190	208	188	179
7	100	102	109	101	151	106	120	135	130	153	134	135
8	134	151	123	144	162	175	202	200	188	172	166	140
9	93	114	169	198	184	162	162	136	158	210	174	190
10	113	137	149	138	146	151	153	132	115	138	151	134
11	113	155	122	188	157	165	190	203	202	218	207	218
12	95	99	134	133	145	130	151	119	129	149	128	116
13	60	64	71	82	78	70	87	76	74	76	83	76
14	81	77	78	74	72	73	71	78	98	78	68	73
15	154	132	135	142	142	167	153	169	162	164	161	119
16	109	118	134	148	148	160	176	143	193	171	202	210
17	80	70	92	95	83	112	111	109	126	123	132	120
18	101	112	129	126	111	104	103	115	112	106	101	109
19	165	190	204	198	176	216	221	143	186	167	182	176
20	151	168	140	148	162	161	171	183	213	193	174	193
21	34	36	52	43	45	34	42	53	48	39	36	39
22	129	95	109	102	112	123	104	96	102	109	96	110
23	149	165	127	109	134	125	133	137	103	145	141	136
24	87	99	95	93	88	87	83	115	80	93	111	101
25	149	174	172	174	176	164	185	176	184	190	169	169
26	90	101	98	91	123	134	151	146	112	109	99	139
27	90	90	132	134	119	129	111	134	128	148	134	118
28	140	162	161	141	160	157	160	153	179	196	180	178
29	62	70	75	75	65	64	70	90	113	104	123	113
30	144	174	204	214	221	214	217	218	210	204	199	213
31	59	87	58	87	67	92	62	88	64	64	57	56

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