THE PULMONARY FUNCTION AND RESPIRATORY MUSCLE STRENGTH IN THAI OBESE CHILDREN

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Entitled

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MUSCLE STRENGTH IN THAI OBESE CHILDREN

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THE PULMONARY FUNCTION AND RESPIRATORY MUSCLE STRENGTH IN THAI OBESE CHILDREN

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ABSTRACT

This study was to compare the pulmonary function, respiratory muscle strength, and physical activity level between obese and nonobese children and to determine the correlation between pulmonary function, respiratory muscle strength and physical activity level in both child groups. Thai healthy children aged between 10-12 years participated in this study. They were classified into an obese group with body weight > +3 standard deviations and a nonobese group with body weight between ± 1.5 standard deviations of children who have the same height. Children in both groups were measured for pulmonary function, forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), FEV_1/FVC ratio, vital capacity (VC), inspiratory muscle strength (MIP), expiratory muscle strength (MEP), and physical activity level.

The results showed that FVC, FEV_1 and VC of the obese group were statistically higher than the nonobese group ($p<0.05$). FEV_1/FVC ratio of the obese group was statistically lower than the nonobese group ($p<0.05$). MIP and MEP were not significantly different between obese and nonobese groups ($p>0.05$). Physical activity levels were not significantly different between obese and nonobese groups ($p>0.05$). Moreover, the results demonstrated that physical activity level in the obese group had no correlation with FVC, FEV_1, FEV_1/FVC ratio and VC ($r = 0.203$, 0.170, -0.067 and 0.133 respectively, $p > 0.05$) and similarly the nonobese group showed no correlation with FVC, FEV_1, FEV_1/FVC ratio and VC ($r = 0.225$, 0.168, -0.207 and 0.168 respectively, $p > 0.05$). Additionally, the results demonstrated that physical activity level in the obese group had no correlation with MIP and MEP ($r = 0.151$ and 0.355 respectively, $p > 0.05$) and similarly the nonobese group showed no correlation with MIP and MEP ($r = 0.202$ and 0.006 respectively, $p > 0.05$).

In conclusion, this study provides information about the pulmonary function and respiratory muscle strength in Thai obese children. FVC, FEV_1 and VC of the obese group were higher than the nonobese group. In addition, FEV_1/FVC ratio of the obese group was lower than the nonobese group. Although, all parameters including pulmonary function of both groups were in the normal range. However, obese children tend to observe airway obstruction higher than nonobese children. Moreover, respiratory muscle strength and physical activity level were not different between groups. Additionally, physical activity level had no correlation with pulmonary function and respiratory muscle strength in both groups.

KEY WORDS: OBESE CHILDREN/ PULMONARY FUNCTION/ MAXIMAL INSPIRATORY PRESSURE/ MAXIMAL EXPIRATORY PRESSURE/ PHYSICAL ACTIVITY

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การศึกษาค่าสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจในเด็กไทยที่มีภาวะอ้วน
(THE PULMONARY FUNCTION AND RESPIRATORY MUSCLE STRENGTH IN THAI OBESE CHILDREN)

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บทคัดย่อ

การศึกษาครั้งนี้มีจุดประสงค์เพื่อเปรียบเทียบค่าสมรรถภาพปอด, ความแข็งแรงของกล้ามเนื้อหายใจและระดับกิจกรรมในเด็กไทยที่มีภาวะอ้วนกับเด็กไทยที่มีน้ำหนักตัวปกติ รวมทั้งศึกษาความสัมพันธ์ระหว่างค่าสมรรถภาพปอด, ความแข็งแรงของกล้ามเนื้อหายใจกับระดับกิจกรรมของเด็กทั้งสองกลุ่ม เด็กไทยสุขภาพดีอายุระหว่าง 10-12 ปีเข้าร่วมการศึกษาครั้งนี้ โดยแบ่งเป็นกลุ่มเด็กที่มีภาวะอ้วนคือ มีน้ำหนักตัวมากกว่า +3 SD และกลุ่มเด็กที่มีน้ำหนักตัวปกติคือ มีน้ำหนักตัวระหว่าง ± 1.5 SD ของเด็กที่มีความสูงเดียวกัน เด็กทั้งสองกลุ่มจะถูกวัดค่าสมรรถภาพปอดซึ่งประกอบด้วย forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), FEV_1/FVC ratio, vital capacity (VC), ความแข็งแรงของกล้ามเนื้อหายใจเข้า (MIP), ความแข็งแรงของกล้ามเนื้อหายใจออก (MEP) และตอบแบบสอบถามระดับการเคลื่อนไหวออกแรง/ ออกกำลังกายสำหรับเด็กอายุ 10-14 ปี

ผลการศึกษาพบว่าค่า FVC, FEV_1 และ VC ในกลุ่มเด็กที่มีภาวะอ้วนมีค่าสูงกว่ากลุ่มเด็กที่มีน้ำหนักตัวปกติอย่างมีนัยสำคัญทางสถิติ ค่า FEV_1/FVC ratio ในกลุ่มเด็กที่มีภาวะอ้วนมีค่าต่ำกว่ากลุ่มเด็กที่มีน้ำหนักตัวปกติอย่างมีนัยสำคัญทางสถิติ ความแข็งแรงของกล้ามเนื้อหายใจเข้าและกล้ามเนื้อหายใจออกไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติระหว่างสองกลุ่ม ระดับกิจกรรมของเด็กทั้งสองกลุ่มไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ นอกจากนี้พบว่าไม่มีความสัมพันธ์กันอย่างมีนัยสำคัญทางสถิติระหว่างค่าสมรรถภาพปอด, ความแข็งแรงของกล้ามเนื้อหายใจกับระดับกิจกรรมในเด็กทั้งสองกลุ่ม

การศึกษาครั้งนี้ทำให้ทราบข้อมูลของค่าสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจในเด็กไทยที่มีภาวะอ้วน โดยค่า FVC, FEV_1 และ VC ในกลุ่มเด็กที่มีภาวะอ้วนมีค่าสูงกว่ากลุ่มเด็กที่มีน้ำหนักตัวปกติ ค่า FEV_1/FVC ratio ในกลุ่มเด็กที่มีภาวะอ้วนมีค่าต่ำกว่ากลุ่มเด็กที่มีน้ำหนักตัวปกติ โดยเด็กทั้งสองกลุ่มนั้นมีค่าสมรรถภาพปอดอยู่ในเกณฑ์ปกติ ซึ่งพบว่าเด็กอ้วนมีแนวโน้มที่จะเกิดภาวะทางเดินหายใจอุดกั้นได้มากกว่าเด็กที่มีน้ำหนักตัวปกติ ส่วนค่าความแข็งแรงของกล้ามเนื้อหายใจและระดับกิจกรรมระหว่างเด็กทั้งสองกลุ่มไม่มีความแตกต่างกัน นอกจากนี้ยังไม่พบความสัมพันธ์ระหว่างระดับกิจกรรมกับค่าสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจในเด็กทั้งสองกลุ่ม

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CONTENTS

		Page
ACKNOWLEDGEMENT		**iii**
ABSTRACT		**iv**
LIST OF TABLES		**ix**
LIST OF FIGURES		**xi**
LIST OF ABBREVIATIONS		**xii**
CHAPTER		
I	**INTRODUCTION**	**1**
	Purposes of the study	4
	Parameters	4
	Scope of the study	5
	Hypotheses of the study	5
	Advantages of the study	6
II	**LITERATURE REVIEW**	**7**
	2.1 Respiratory system	7
	2.2 Test of pulmonary function	11
	2.3 Test of respiratory muscle strength	15
	2.4 Obesity in childhood and adolescence	17
	2.5 Physical activity	18
	2.6 The pulmonary function and respiratory muscle strength in obese children	19
III	**MATERIALS AND METHODS**	**23**
	3.1 Subjects	23
	3.2 Design of the study	24
	3.3 Instrumentations	24
	3.4 Procedure	26
	3.5 Statistical analysis	29

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CONTENTS

(Continued)

		Page
CHAPTER		
IV	**RESULTS**	**30**
	4.1 Characteristics of subjects	30
	4.2 Comparison of pulmonary function between the obese and nonobese groups	31
	4.3 Comparison of respiratory muscle strength between the obese and nonobese groups	33
	4.4 Comparison of physical activity level between the obese and nonobese groups	34
	4.5 Correlation between physical activity level and pulmonary function	35
	4.6 Correlation between physical activity level and respiratory muscle strength	36
V	**DISCUSSION**	**37**
	5.1 Characteristics of subjects	37
	5.2 Method of testing	37
	5.3 Comparison of pulmonary function between the obese and nonobese groups	39
	5.4 Comparison of respiratory muscle strength between the obese and nonobese groups	43
	5.5 Comparison of physical activity level between the obese and nonobese groups	45
	5.6 Correlation of physical activity level with pulmonary function and respiratory muscle strength	45
	5.7 Limitation of the study	46
	5.8 Clinical implications and further study	46

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CONTENTS

(Continued)

		Page
CHAPTER		
VI	**CONCLUSION**	**48**
REFERENCES		**49**
APPENDIX		**57**
BIOGRAPHY		**88**

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LIST OF TABLES

TABLE		Page
2.1	Typical patterns of impairment	15
2.2	Comparison of pulmonary function and respiratory muscle strength in obese children	21
4.1	Characteristics of subjects	30
4.2	Comparison of FVC, FEV_1, VC and FEV_1/FVC ratio between the obese and nonobese group	31
4.3	Comparison of MIP and MEP between the obese and nonobese group	33
4.4	Comparison of physical activity level between the obese and nonobese group	34
4.5	Correlation of physical activity level with the pulmonary function	35
4.6	Correlation of the physical activity level and the respiratory muscle strength	36
5.1	Comparison of pulmonary function and respiratory muscle strength between the present study and other previous studies in obese children	40
5.2	Comparison of FVC, FEV_1, VC and FEV_1/FVC ratio between the obese and nonobese group	41
5.3	Comparison of MIP and MEP between the obese and nonobese group	41
5.4	Normal respiratory muscle strength in healthy children	43
D.1	FVC, FEV_1 and VC on week 1 and 2	74
D.2	MIP and MEP on week 1 and 2	74
D.3	Reliability of FVC, FEV_1, VC, MIP and MEP separated by a week	75
E.1	Characteristics of the subjects	76
E.2	Means and standard deviations of absolute FVC, FEV_1, VC and FEV_1/FVC ratio	77

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LIST OF TABLES

(Continued)

TABLE		Page
E.3	Means and standard deviations of absolute MIP and MEP	77
E.4	Correlation of physical activity level and FVC, FEV_1, VC and FEV_1/FVC ratio	79
E.5	Correlation of physical activity level and MIP, MEP	80
G.1	Characteristics of subjects	83
G.2	Pulmonary function of obese subjects	84
G.3	Pulmonary function of nonobese subjects	85
G.4	Maximal respiratory pressure of obese and nonobese subjects	86
G.5	Physical activity level of obese and nonobese subjects	87

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LIST OF FIGURES

FIGURES		Page
2.1	Classic spirogram.	11
2.2	Flow-volume curve and volume-time curve in normal, obstruction and restriction.	14
3.1	Spirometer (Pony FX pulmonary function).	25
3.2	Mouth pressure meter (Micro Medical).	25
3.3	Measurement of pulmonary function.	27
3.4	Measurement of respiratory muscle strength.	28
3.5	The research procedures.	29
4.1	Comparison of FVC, FEV_1 and VC between obese and nonobese groups.	32
4.2	Comparison of FEV_1/FVC ratio between obese and nonobese groups.	32
4.3	Comparison of MIP and MEP between obese and nonobese groups.	34
E.1	Means and standard deviations of absolute FVC, FEV_1 and VC	78
E.2	Means and standard deviations of absolute FEV_1/FVC ratio.	78
E.3	Means and standard deviations of absolute MIP and MEP.	79

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LIST OF ABBREVIATIONS

BMI	Body mass index
BTPS	Body temperature and pressure saturated with water vapor
ERV	Expiratory reserve volume
FEV_1	Forced expiratory volume in one second
FEV_1/FVC	Ratio of FEV_1 to the FVC
FRC	Functional residual capacity
FVC	Forced vital capacity
IC	Inspiratory capacity
IRV	Inspiratory reserve volume
MEP	Maximal expiratory pressure
MIP	Maximal inspiratory pressure
$PaCO_2$	Arterial carbon dioxide tension
PEF	Peak expiratory flow
PFT	Pulmonary function test
RMS	Respiratory muscle strength
RV	Residual volume
SD	Standard deviations
TLC	Total lung capacity
VC	Vital capacity
V_T	Tidal volume

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CHAPTER I

INTRODUCTION

Childhood obesity is the common pediatric chronic illness in developing countries (1-4). A survey showed that the prevalence of obese children aged 6-12 years in Bangkok, Thailand had increased significantly from 5.8% in 1990 to 13.3% in 1996 (5). From 1996 to 2001, obese children had increased 15-36% (6, 7). There is no doubt that the percentages are even greater nowadays because children like to eat food consisting of flour or fat and Thai society has changed from an agricultural life-style to an industrialized life-style with an increase in sedentary activities (1, 2, 5, 8). There are three major components to treat obesity that consist of dietary therapy, behavior therapy and increased physical activity (1, 3, 8).

The obese children trend to be obese adolescents and adults more than normal children (1, 5). The obese persons have alteration in many body systems such as musculoskeletal, cardiovascular, endocrine and respiratory systems (5, 9-18). The most common pulmonary complications in obese children are asthma, obstructive sleep apnea syndrome (OSAS), restrictive lung disease and obesity-hypoventilation syndrome (Pickwickian syndrome) (9-12, 14-16, 18-22).

The obesity may contribute to lung volume during breathing. First, fat deposition in chest wall decreases efficiency to expand chest wall. Second, fat deposition in abdomen pushes diaphragm muscle to thoracic cavity, so the inspiration probably is limited. This caused by diaphragm muscle contracts difficulty into abdominal cavity. Then, the volume of inspiration and expiration will decrease. The air exchange in obese persons is insufficiency, probably attribute to attempt breathing and lead to hypoxia. This hypoxia is associated most mortality that is usually caused by a decrease in the concentration of oxygen in alveoli. This could also affect the hypertension in lung and right heart hypertrophy (18, 23).

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A few studies have investigated pulmonary function and respiratory muscle strength in obese children and the results of these are controversial (20, 24-27). Marcus et al in 1996 (26) studied pulmonary function test (PFT) in 22 obese children and adolescents. They found PFT were normal in all but only two subjects have abnormal lung function including restrictive deficit and obstructive abnormality. On the other hand, Inselman et al in 1993 (24) studied the effect of obesity on pulmonary function in children aged between 8-15 years and they found pulmonary function decreased especially expiratory reserve volumes (ERV), forced expiratory volume in one second (FEV_1), maximum voluntary ventilation (MVV) whereas vital capacity (VC) and forced vital capacity (FVC) were normal. In addition, maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) representing to inspiratory and expiratory muscles strength respectively were normal.

Mallory et al in 1989 (25) reported that PFT in obese children and adolescents showed 18% of subject with a restrictive defect and 47% with obstructive changes. They concluded these abnormalities in children and adolescents with morbid obesity were associated with sleep breathing disorders. Recently in 2003, Li et al (20) found pulmonary abnormalities are common among obese children. The reduction in static lung volume was found to be significantly correlated with the degree of obesity.

Nevertheless these studies were conducted in other countries. The standard pulmonary function and respiratory muscle strength depend on many factors such as gender, age, weight, height and nationality (28-30). Susiva et al in 1992 (27) evaluated the lung function before and after camping in twenty-one Thai obese children who attended a 4-week summer camping in Siriraj Hospital. All children received dietary therapy, exercises and life-style education. Before camping, twelve out of all children were found restrictive lung and after camping, only six of them had improvement of lung function.

However, the respiratory muscle strength in Thai obese children have not been investigated. Therefore, it is interesting in study on the pulmonary function and respiratory muscle strength in Thai obese children by comparing with normal children.

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The result of this study might be used to evaluate pulmonary abnormalities in obese children and to promote pulmonary related health to Thai children.

Moreover, common sedentary activities such as watching television have also been implicated in childhood obesity because these activities reduce resting metabolism, displace physical activity and expose children to food advertisements. Several studies have shown that watching television negatively correlated with physical activity and positively correlated with body mass (31). The influence of sedentary behavior on weight related problems could be attributed to a reduction of physical activity. Abbott et al in 2004 (32) examined the relation in 47 children aged 5-10.5 years between habitual physical activity and body composition. The result showed body fat and body mass index (BMI) were inversely correlated with physical activity level. Elgar et al in 2005 (33) reported that physical activity was related to subsequent change in body mass. Additionally, this study will be investigated the physical activity for children by determination the correlation pulmonary function, respiratory muscle strength and physical activity level in both children groups.

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Purpose of the Study

General Objective

The purpose of this study was to compare the pulmonary function, respiratory muscle strength, physical activity level between obese and nonobese children group and to determine the correlation between pulmonary function, respiratory muscle strength and physical activity level in both children groups.

Specific Objectives

1. To compare the pulmonary function between obese and nonobese children group.
2. To compare the respiratory muscle strength between obese and nonobese children group.
3. To compare physical activity level between obese and nonobese children group.
4. To determine the correlation between the pulmonary function and physical activity level in obese children group.
5. To determine the correlation between the pulmonary function and physical activity level in nonobese children group.
6. To determine the correlation between the respiratory muscle strength and physical activity level in obese children group.
7. To determine the correlation between the respiratory muscle strength and physical activity level in nonobese children group.

Parameters

1. Dynamic lung function
    - Forced vital capacity: FVC (Litre, L)
    - Forced expiratory volume in one second: FEV_1 (Litre, L)
    - Ratio of FEV_1/FVC
2. Static lung function
    - Vital capacity: VC (Litre, L)

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3. Respiratory muscle strength
    - Maximal inspiratory pressure: MIP (cmH_2O)
    - Maximal expiratory pressure: MEP (cmH_2O)
4. Physical activity level

Scope of the Study

This study focused on comparison of the pulmonary function, respiratory muscle strength, physical activity level between obese and nonobese children group. Pulmonary function test (FVC, FEV_1, ratio of FEV_1/FVC and VC), maximal respiratory pressure (MIP and MEP) were examined. The correlation between these parameters and physical activity level in obese and nonobese children group were determined.

Hypotheses of the Study

1. There would be a significant difference in the pulmonary function between obese and nonobese children group.
2. There would be a significant difference in respiratory muscle strength between obese and nonobese children group.
3. There would be a significant difference in physical activity level between obese and nonobese children group.
4. There would be a significant correlation between pulmonary function and physical activity level in obese children group.
5. There would be a significant correlation between pulmonary function and physical activity level in nonobese children group.
6. There would be a significant correlation between respiratory muscle strength and physical activity level in obese children group.
7. There would be a significant correlation between respiratory muscle strength and physical activity level in nonobese children group.

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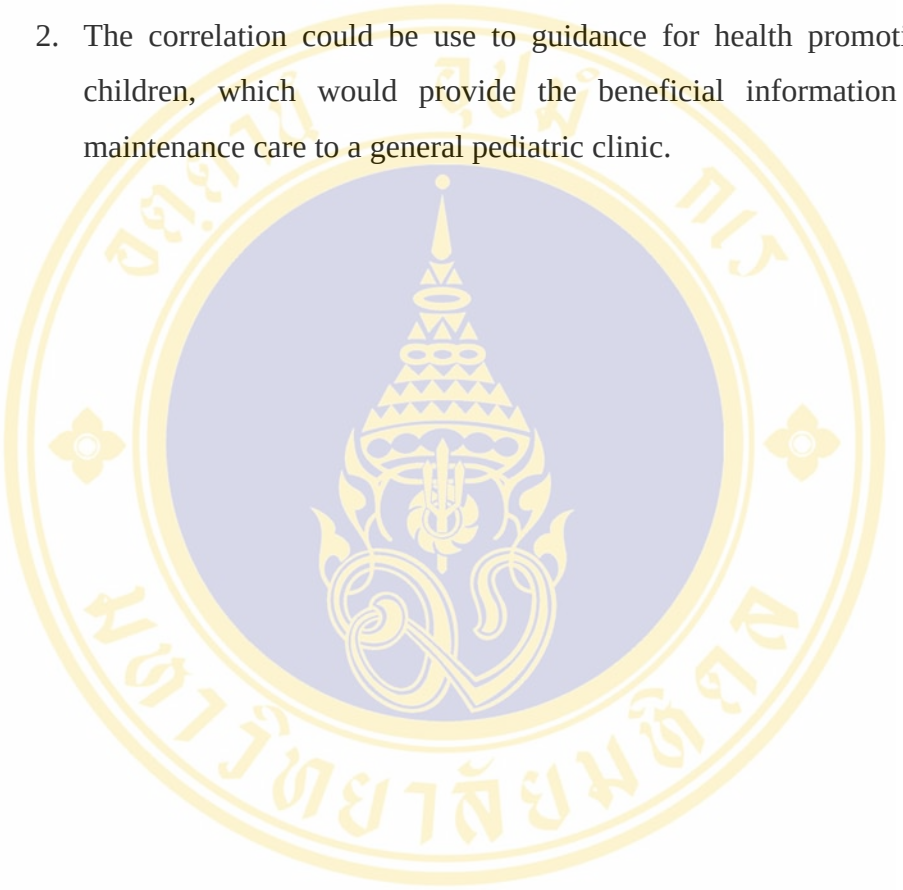
Advantages of the Study

1. The results of this study would provide the information about the pulmonary function and respiratory muscle strength in Thai obese children. In addition, the results would provide preliminary data of respiratory muscle strength in Thai healthy boys and girls aged 10-12 years.
2. The correlation could be use to guidance for health promoting in Thai children, which would provide the beneficial information for health maintenance care to a general pediatric clinic.



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CHAPTER II

LITERATURE REVIEW

2.1 Respiratory System

The main function of the respiratory system is to exchange gases such as oxygen and carbon dioxide in order to maintain pH within specific levels throughout any physiologic condition. The five fundamental processes which involved in the maintenance of homeostasis of respiratory system are as following (34):

1. Ventilation and distribution of gas volumes
2. Gas exchange and transportation
3. Circulation of blood through the lungs
4. Mechanical interaction of respiratory forces that initiate breathing (respiratory muscles) and the forces that resist the flow of air (lung compliance and airway resistance)
5. Control and organization of respiratory movements

2.1.1 Functional anatomy of respiratory system

On gross inspection, each lung is cone shaped and covered by visceral pleura. The right lung is slightly larger than the left and is divided by the oblique and horizontal fissures into upper, middle and lower lobes. The left lung has two lobes, upper and lower separated by an oblique fissure. The lobes are further subdivided into bronchopulmonary segments, each receiving a segmental bronchus and artery and giving rise to a vein.

The airways, pleura and connective tissue of the lung are vascularized by the systemic circulation through the bronchial arteries. The bronchial veins bypass the pulmonary circulation and join the pulmonary veins to return blood to the heart. The pulmonary circulation perfuses alveoli.

The lung and airways are innervated through the pulmonary plexus. Located at the root of each lung, this plexus is performed from branches of the sympathetic trunk

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and vagus nerve. Recently, a nonadrenergic, noncholinergic inhibitory nerve fiber has been identified in the airway smooth muscle. Sympathetic stimulation causes bronchodilation and marginal vasoconstriction, whereas parasympathetic stimulation produces bronchoconstriction and indirect vasodilation.

The respiratory system is conceptually divided into two major divisions: 1) a conducting portion which includes the nose, pharynx, larynx, bronchi and bronchioles, 2) a respiratory portion consisting of the terminal portion of the bronchial tree and alveoli. It is the site of gas exchange. The transitional zone, separating the conducting and respiratory portions consists of the respiratory bronchioles.

In the conducting zone, air moves by bulk flow under the pressure gradients created by the respiratory muscles and the elastic recoil of the lung. The total cross-sectional area of the airways increases rapidly at the respiratory zone. Forward velocity of airflow therefore decreases and the gases readily move by diffusion through the alveoli into the pulmonary capillaries (34).

2.1.2 Mechanics of breathing

Breathing is achieved by changes in the size of 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 (35).

The mechanics of breathing is initiated by the difference between atmospheric pressure and intrapulmonary or intra-alveolar pressure. During the inspiration, intra-alveolar pressure is lower than atmospheric pressure, so the air can flow into the lung. On the other hand, intra-alveolar pressure is higher than atmospheric pressure and the air is expelled out of the lung during the expiration. The variation of intra-alveolar pressure directly relates to the variation of intrathoracic or intrapleural pressure, which is controlled by the initiation of respiratory muscle function (34, 36, 37).

2.1.3 Muscles of respiration

Respiratory muscles are the muscles that provide the motive power for the act of breathing. They are customarily divided into inspiratory and expiratory muscles (38).

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2.1.2.1 Inspiratory muscles

2.1.2.1.1 Diaphragmatic muscles

The most important muscle of inspiration is the diaphragm. The diaphragm is a musculotendinous sheet which separates the thoracic cavity from the abdominal cavity (35). When diaphragm contraction, the volume of the thoracic cavity increases by tensing with flattening it's floor and increases drawing air into the lungs. Diaphragmatic contraction is responsible for roughly 75% 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 (39).

2.1.2.1.2 External intercostals muscles

The external intercostals muscle participates in inspiration. It 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 (40). It assists inhalation by elevating the ribs. Its contraction is responsible for roughly 25 % to the volume of air into the lung (41).

2.1.2.1.3 Accessory muscles

Accessory muscles for inspiration including the sternocleidomastoid, serratus anterior, pectoralis minor and scalene muscles (40). They assist the external intercostals muscles by elevating ribs (41).

2.1.2.2 Expiratory muscles

2.1.2.2.1 Internal intercostals muscles

The internal intercostals muscles extend from the sternum to the angles of the ribs and continue backward from this point. They depress the ribs and reduce the width and depth of the thoracic cavity (40).

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2.1.2.2.2 Abdominal muscles

Abdominal muscles include the external and internal abdominal oblique, transverses abdominis and rectus abdominis muscles. They act together to maintain or increase intraabdominal pressure in activities such as coughing or deep expiration (40). They assist the internal intercostals muscles in exhalation by compressing the abdomen and forcing the diaphragm upward (41).

The contraction of respiration muscles generates force to move chest wall and expand the lung. This produces the variation of intrathoracic and intra-alveolar pressure to overcome resistance of breathing (elastic recoil of lungs and thorax). The respiratory muscles have both inspiratory and expiratory function (34, 37).

Inspiration: Normal inspiration is an active movement involving the contraction of diaphragm, scalenes and parasternal intercostals muscles. The diaphragm performs about 70% to 80% of the work of breathing and responsible for lung expansion in the longitudinal dimension. The contraction of external intercostals make the lower ribs up and out toward the upper ribs. This action increases the volume of the thoracic cavity. In patients with cardiopulmonary disorders, the accessory muscles of inspiration including sternocleidomastoids, scalenes, serratus anterior, pectoralis major and minor, trapezius and erector spinae may have an important role even at rest. The function of these muscles depends on the severity of cardiopulmonary status. However, the deep inspiration also performs by the accessory muscles both in normal and cardiopulmonary disorders.

Expiration: Expiration is a passive process that occur when the intercostals and diaphragm relax and the elastic properties of lung tissue recoils. Muscles relaxation allows dropping of ribs into preinspiratory position and raising the diaphragm. These activities compress the lung that increase intrathoracic pressure above atmospheric pressure and contribute flowing air out of the lung. In forced expiration, the abdominal muscles force the diaphragm back to its resting position and expel air out of lung. Contraction of internal intercostals muscles also depresses the ribs and help in forceful exhalation.

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2.2 Test of Pulmonary Function

2.2.1 Assessment of the pulmonary function

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 (28, 42, 43). The lung volumes are subdivided into static and dynamic lung volumes.

2.2.1.1 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. The gas volumes of thorax and lung are the same except in the case of pneumothorax (44, 45).

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) (43). This review will focus on detail only VC.

2.2.1.2 Dynamic lung volumes and forced ventilatory flows

Dynamic lung volumes and flow are assessed during forced inspiration or expiratory, or during forced breathing when maximal effort is applied throughout the respiratory maneuvers (45). The parameters are forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and ratio of FEV_1/FVC (43, 46).

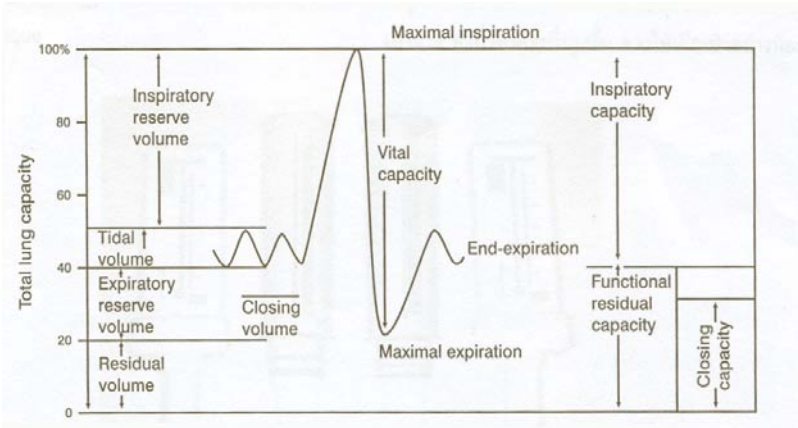

Figure 2.1 Classic spirogram.

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Vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in one 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 (45). The measurement may be made in term of inspiratory vital capacity (IVC) or expiratory vital capacity (EVC) and made in term of slow vital capacity (SVC) or forced vital capacity (FVC).

Vital capacity is the maximal volume of air exhaled from the point of maximal inhalation or the maximal volume of air inhaled from a point of maximal exhalation. VC is measurement of the respiratory muscles capacity to maximally shorten against elastic forces of the lung and chest wall. The reduction of VC can detect the inspiratory muscle weakness (37, 47-49).

Forced vital capacity (FVC)

Forced vital capacity 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 (43).

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 one second (FEV_1) and ratio of FEV_1/FVC

Forced expiratory volume in one second (FEV_1) is the volume of gas expired in one second from the beginning an FVC maneuver (42). 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)

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and FEV_1 is used to classification severity of disease (50). An increased ratio of FEV_1/FVC (>80% prediction) signify a predominantly restrictive abnormality.

The standard values of spirometry depend on many factors including age, gender, weight, height, smoking status, and race (28-30, 51).

2.2.2 Interpretation of pulmonary function tests

Spirometey should be interpreted using the flow volume and volume time curves as well as the absolute values for flows and volumes. The flow volume loop and volume time curve are often overloaded but provide valuable information. Certain disease states have characteristically shaped loops, so it is important to be able to recognize the different patterns (28, 44, 52).

Normal

Normal values for FEV_1 and FVC are based on population studied and vary according to race, height, age and gender. They are expressed in both absolute numbers and percent predicted of normal.

A normal flow volume loop has a rapid peak expiratory flow rate with a gradual decline in flow back to zero. The inspiratory portion of the loop is a deep curve plotted on the negative portion of the flow axis. Inspiratory data is often overlooked, but the flow volume loop gives the opportunity of assessing this information as well.

The normal volume time curve has a rapid upslope and approaches a plateau soon after exhalation. The maximum volume attained represents the forced vital capacity (FVC), while the volume attained after one second represents the forced expiratory volume (FEV_1).

Obstructive Lung Disease

Obstructive lung disease also changes the appearance of the flow volume curve. As with a normal curve, there is a rapid peak expiratory flow, but the curve descends more quickly than normal and takes on a concave shape, reflected by a marked decrease in the forced expiratory flow over the middle 50% of the FVC

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(FEF_{25-75}). With more severe disease, the peak becomes sharper and the expiratory flow rate drops precipitously. This results from dynamic airway collapse, which occurs as diseased conducting airways are more readily compressed during forced expiratory efforts. On the volume time curve, this is seen as a slower ascent to maximum volume, with a gradual upsloping versus the rapid rate seen in normal individuals. This equates with a prolonged forced expiratory time demonstrable on physical exam.

Restrictive Lung Disease

The shape of the flow volume loop is relatively unaffected in restrictive disease, but the overall size of the curve will appear smaller when compared to normal on the same scale. Similarly, there will be a rapid upslope on the volume time curve, but such patients will reach a smaller vital capacity.

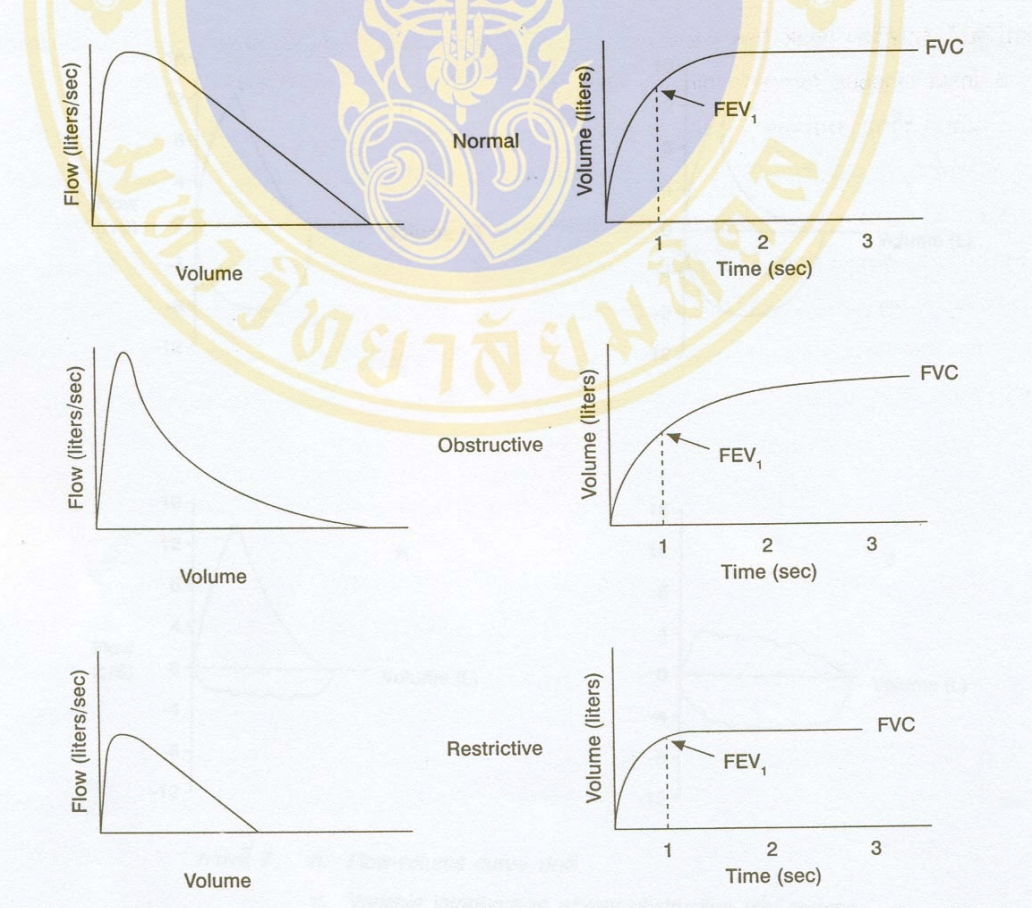

Figure 2.2 Flow-volume curve and volume-time curve in normal, obstruction and restriction.

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The typical test patterns discussed are summarized in Table 2.1. Because test results are nonspecific in lesions of the major airway, they are not included, the most diagnostically useful measure being the contour of the full flow-volume loop (28, 44, 52, 53).

Table 2.1 Typical patterns of impairment

Measurement	Obstructive	Restrictive
FVC (L)	N to ↓	↓
FEV_1 (L)	↓	↓
FEV_1/FVC (%)	N to ↓ (< 80%)	N to ↑ (≥ 80%)
FEF_{25-75} (L/s)	↓	N to ↓
PEF (L/s)	↓	N to ↓
FEF_{50} (L/s)	↓	N to ↓
Slope of FV curve	↓	↑
MVV (L/min)	↓	N to ↓

FEF_{25-75}, forced expiratory flow rate over the middle 50% of the FVC; FEF_{50}, forced expiratory flow after 50% of the FVC has been exhaled; FEV_1, forced expiratory volume in 1 second; FV, flow-volume; FVC, forced expiratory vital capacity; N, normal; PEF, peak expiratory flow; ↓, decreased; ↑, increased.

2.3 Test of Respiratory Muscle Strength

2.3.1 Assessment of the 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). Usually, MIP and MEP are measured in clinic because it is simple to perform (53).

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

Maximum inspiratory 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 be exactly equated with muscle pressure if the respiratory system recoil is zero, a situation which applies at functional residual capacity (FRC) (47, 54, 55).

MIP is an index of inspiratory muscle strength (54, 56). Measurement can be performed at residual volume (RV) or FRC (56, 57) following maximum expiration (58). In practice, patients can perform maneuver easier from RV than FRC (55, 57).

MEP is an index of expiratory muscle strength (54, 55). MEP is usually measured at total lung capacity (TLC) following a maximum inspiration (58). MEP value is usually greater than MIP because at TLC the expiratory muscles strength is greatest (i.e. optimal) length, while the inspiratory muscles are optimal length at much smaller lung volumes (55).

2.3.2 Factors affecting respiratory mouth pressure

2.3.2.1 Age

Most evidence showed that respiratory muscle strength decreased with aging. Many previously studied were found relationship between respiratory muscle strength and age (56, 58-61). Jeffrey and coworkers (62) suggested that MIP and MEP increase with age from children to adult.

2.3.2.2 Gender

Gender has an effect on both MIP and MEP (59, 63). The values of MIP and MEP in females were 65% to 70% of obtained in males (58, 64). The possible explanation was that males are generally stronger than females (56) such as body size and physical activity in males are more than females (65).

All of previous literatures reported that for the same body height men have greater inspiratory and expiratory muscle strength than women (59, 60).

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2.3.2.3 Body habitus

Enright et al in 1994 (56) showed significant correlations between respiratory muscle strength and weight, height, body mass index (BMI) and an index of body fat percentage. In subject who heavy weight, small waist and low body fat have stronger respiratory and malnutrition person was reduced respiratory muscle strength (56, 66). On the contrary, McConnell and coworker (67) observed poor correlation between respiratory mouth pressure and height in both genders.

Wilson and coworkers in 1984 (60) reported a significant relationship between respiratory pressure and height in women. MIP in children was correlated with weight.

2.3.2.5 Physical activity

One of the factors a affecting the maximal respiratory pressure is the physical activity. McConnell and coworker suggest that respiratory muscle strength is influenced strongly by physical activity (31, 67).

Other factors that may be influence maximal respiratory pressure including smoking status (30), attention (57) and type of mouthpiece (58).

2.4 Obesity in Childhood and Adolescence

2.4.1 Definition and prevalence

Obesity is the excess storage of energy in the form of fat. There has been a significant increase in the prevalence of obesity in all age groups in the United States, particularly since the early 1980s. Data from the 1988 to 1991 National Health and Nutrition Examination Survey (NHANES) III cohort suggest that approximately 14% of US children are overweight (1, 4). In Thailand, a survey showed that the prevalence of obese children aged 6-12 years in Bangkok, Thailand had increased significantly from 5.8% in 1990 to 13.3% in 1996 (5). From 1996 to 2001, obese children had increased 15-36% (6, 7).

Weight for height is another index to follow the growth of children; it does not significantly change with socioeconomic status and possibly other factors. It should be emphasized that weight for height is more reliable and better parameter to evaluate the growth of children (68-70).

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2.4.2 Comorbidities

Obesity has alteration in many body systems such as musculoskeletal, cardiovascular, endocrine and respiratory systems. It is associated with an increased risk of osteoarthritis, cardiovascular disease, endocrine disorders such as type II diabetes mellitus and pulmonary complications (2, 4, 19, 71, 72).

The most common pulmonary complications in obese children are asthma, restrictive lung disease, sleep-disordered breathing such as obstructive sleep apnea syndrome (OSAS), and obesity-hypoventilation syndrome (OHS) or Pickwickian syndrome (9-12, 14-16, 18, 20, 21).

2.5 Physical Activity

The management of body weight can be very complex. However, in the simplest terms, the balance between energy intake and energy expenditure determines weight gain, weight maintenance, or weight loss. There are three general components of energy expenditure: resting energy expenditure, the thermal effect of a meal, and energy expenditure in the form of physical activity. Of these three components, energy expenditure from physical activity is the most variable and provides the greatest opportunity for interventions to modify total energy expenditure (2-4, 73, 74).

Physical activity in the form of regular exercise appears to be a key factor in the management of body weight and the treatment of chronic conditions typically associated with obesity. While it is clear that changes in dietary intake may have the greatest impact on body weight over the short-term, the addition of physical activity to a dietary program has been shown to enhance weight loss. Moreover, adequate physical activity has been shown to be one of the best predictors of long-term maintenance of weight loss and the prevention of weight gain. Therefore, weight management interventions should include an appropriate physical activity program (2, 3).

Yu et al in 2002 (75) investigated the total daily energy expenditure and physical activity pattern of a group of obese and nonobese Hong Kong children. They reported that obese children spent more time in sedentary activities. Similar to Elgar et

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al in 2005 (33) concluded the sedentary behavior and physical activity in early adolescence both influenced body mass in late adolescence. The result indicated that promoting healthy diets and physical activities might have long-term health benefits for young people.

Abbott and Davies in 2004 (32) examined the relation in 47 children, aged 5-10.5 years between habitual physical activities, minutes spent in moderate, vigorous and hard intensity activity and body composition parameters. They found body fat and BMI were significantly inversely correlated with physical activity level.

2.6 The Pulmonary Function and Respiratory Muscle Strength in Obese Children

In obese children, the several studies showed pulmonary abnormalities including obstructive and restrictive pattern whereas the other studies did not find any abnormalities in obese children. For example, Marcus et al in 1996 (26) studied pulmonary function test (PFT) in 22 obese children and adolescents. They found PFT were normal in all but only two subjects have abnormal lung function including restrictive deficit and obstructive abnormality.

Li et al in 2003 (20) investigated the predominant pulmonary function abnormality in local population of obese children and assessed the correlation between the severity of lung function impairment and the degree of obesity as assessed by dual energy X ray absorptionmetry (DEXA) in 64 obese patients. They found that the reduction in FRC and diffusion impairment were the commonest abnormalities found in obese patients. The reduction in static lung volume was correlated with the degree of obesity.

Inselman et al in 1993 (24) studied the effect of obesity on pulmonary function in children aged between 8-15 years and they found pulmonary function decreased especially expiratory reserve volumes (ERV), forced expiratory volume in one second (FEV_1), maximum voluntary ventilation (MVV) whereas vital capacity (VC) and

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forced vital capacity (FVC) were normal. In addition, maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) representing to inspiratory and expiratory muscles strength respectively were normal.

Tantisira K.G. et al in 2003 (21) studied the association of in body mass index (BMI) with pulmonary function in the childhood asthma management program (CAMP). They found the decrease in FEV_1/FVC ratio had potential relevance in the relationship between BMI and asthma severity.

Susiva et al in 1992 (27) evaluated the lung function before and after camping in twenty-one Thai obese children who attended a 4-week summer camping in Siriraj Hospital. All children received dietary therapy, exercises and life-style education. Before camping, twelve out of all children were found restrictive lung and after camping, only six of them had improvement of lung function.

Mallory et al in 1989 (25) reported that PFT in obese children and adolescents showed 18% of subject with a restrictive defect and 47% with obstructive changes. They concluded these abnormalities in children and adolescents with morbid obesity were associated with sleep breathing disorders.

Several studies have been investigated the effect of obesity on pulmonary function in children (20, 21, 24-27). Summary of these studies is presented in Table 2.2.

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Table 2.2 Comparison of pulmonary function and respiratory muscle strength in obese children

Authors	Spirometry									
	ERV	VC	FVC	FEV_1	FEV_1/ FVC	RV	Raw	MVV	MIP	MEP
Mallory et al 1989			↑	↔	↓					
Susiva et al 1992			↓							
Inselman et al 1993	↓	↔	↔	↓		↑	↑	↓	↔	↔
Marcus et al 1996			↑	↑	↑	↑				
Tantisira et al 2003					↓					
Li et al 2003			↑	↑	↑	↑				

ERV: expiratory reserve volume

VC: vital capacity

FVC: forced vital capacity

FEV_1: forced expiratory volume in 1 second

RV: residual volume

Raw: airway resistance

MVV: maximum voluntary ventilation

MIP: maximum inspiratory pressure

MEP: maximum expiratory pressure

↑: increase

↓: decrease

↔: not change

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From the literature review, the children with obesity frequently show the pulmonary complications such as asthma, restrictive lung disease, obstructive sleep apnea syndrome (OSAS), and obesity-hypoventilation syndrome (OHS) or Pickwickian syndrome. In addition, the obesity leads to the comorbidities including cardiovascular diseases, endocrine disorders such as type II diabetes mellitus, orthopedic complications, renal disease and hypertension. Previous study about the pulmonary function and respiratory muscle strength in obese children showed controversy. Thus, the study about pulmonary function and respiratory muscle strength in Thai obese children could be providing the beneficial information for health maintenance care to a general pediatric clinic.

Moreover, the study of correlation between physical activity level and obesity showed body fat and body mass index (BMI) were inversely correlated with physical activity level. Therefore, physical activity promotion may be recommended as an adjunctive therapy to the management of body weight and the treatment of chronic conditions typically associated with obesity.

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CHAPTER III

MATERIALS AND METHODS

3.1 Subjects

Thai healthy children aged between 10-12 years voluntarily participated in this study. The subjects were classified into two groups; obese group and nonobese group according to National growth references for children under 20 years of age: Nutrition Division, Department of Health, Ministry of Public Health, Thailand (69, 70). Obese group consisted of children who had body weight more than 3 standard deviations whereas nonobese group consisted of children who had body weight between -1.5 to +1.5 standard deviations by children who had the same height. Classification of subject used weight for height criteria because it is more reliable and better parameter to evaluate the growth of children (68, 70, 76). Subjects met the inclusion and exclusion criteria as follows;

3.1.1 Inclusion criteria

- Healthy children both gender
- Ability to understand verbal instruction and cooperate to test.
- No prior experience with the procedures.

3.1.2 Exclusion criteria

- Demonstrate abnormal posture such as scoliosis or kyphosis.
- Have a history of pulmonary disease such as asthma, current respiratory system infection.
- Have a history of cardiovascular disease such as ventricular septal defect (VSD), atrial septal defect (ASD), Tetralogy of Fallot (TOF), persistent ductus arteriosus (PDA).
- Have structural abnormalities of upper airways including oral cavity, severe enough to interfere pulmonary function test.

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- Have a history of thoracic, back or abdominal surgery.

Exclusion criteria evaluated from demographic information, medical history and all subjects were interviewed by examiner (Appendix C.1, C.2).

3.2 Design of the Study

This study was a descriptive study design to determine the mean values of pulmonary function, respiratory muscle strength and to determine the correlation between pulmonary function, respiratory muscle strength and physical activity level in obese and nonobese children.

3.3 Instrumentations

3.3.1 Spirometer

The spirometer (Pony FX pulmonary function equipment, Cosmed, INC., Italy) were used for pulmonary function test including forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), vital capacity (VC) and ratio of FEV_1/FVC as shown in Figure 3.1. The spirometer was calibrated by using a 3 liters calibration syringe (Cosmed, INC., Italy) daily before testing.

3.3.2 Mouth pressure meter

The Micro Medical™ Respiratory Pressure Meter (Micro Medical Ltd.,UK) was a hand-held instrument for assessment respiratory muscles strength both inspiratory and expiratory muscles. Inspiratory and expiratory muscles strength express in term of maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP), respectively. MIP and MEP are readily and digitally monitored in units of cmH_2O. This device measures pressure range is ±300 cmH_2O at the accuracy of ±3%. The calibration was set by the factory and was claimed to remain constant through out the lifetime of the device (Figure 3.2).

3.3.3 Weight scale

The bathroom scale was used to measure subject's weight. It was calibrated daily before testing.

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3.3.4 Height scale

The measurement tape that was attached the wall room and heighten from the floor 15 centimeters was used for height measurement.

Figure 3.1 Spirometer (Pony FX pulmonary function) (A), paper mouthpiece (B) and nose clip (C).

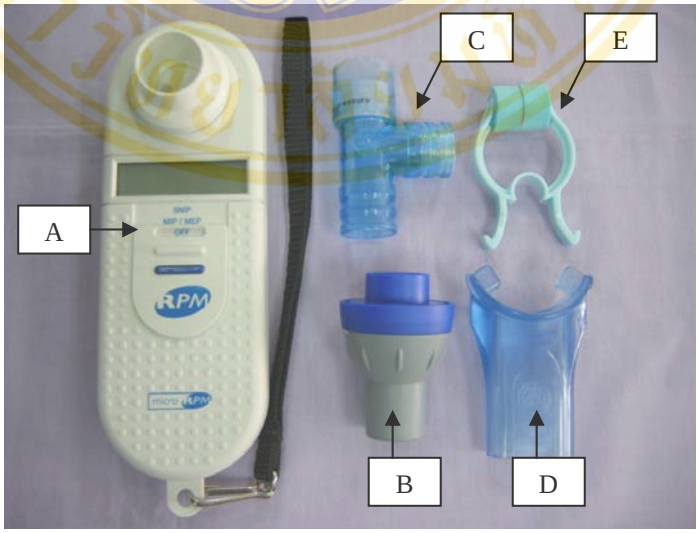

Figure 3.2 Mouth pressure meter (Micro Medical) microcomputer unit (A), mouth pressure bacterial filter (B), respiratory pressure valve assembly (C), mouthpiece (D) and nose clip (E).

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3.4 Procedures

A participant information sheet, consent form, a demographic and medical history sheet were given to all subjects who met the inclusion criteria. These documents were taken for the subjects' parent or guardian sign a consent form prior to participation. This study was approved by Ethics Committee of Faculty of Medicine Siriraj Hospital, Mahidol University.

All documents were collected before testing. The subjects who aged between 10-12 years were interviewed about a physical activity questionnaire for children aged 10-14 years old (77-79) (Appendix C.3). Then, the procedures of testing were clearly explained and demonstrated to each subject prior to data collection until the subject try to perform accurately. The order of testing including static lung function (VC), dynamic lung function (FVC, FEV_1, ratio of FEV_1/FVC), MIP and MEP would be random. The measurements of pulmonary function and respiratory muscle strength are described below.

3.4.1 Measurement of pulmonary function

Determinations of pulmonary function test (PFT) consist of (1) forced vital capacity (FVC): the largest volume measures on complete forced exhalation after full inspiration, (2) forced expiratory volume in one second (FEV_1): volume of air exhaled during the first second of FVC, (3) vital capacity (VC): measured by slow exhalation and (4) ratio of FEV_1/ FVC. Pulmonary function was tested following the guidelines recommended by the American Thoracic Society (ATS) (48, 49).

PFT was measured by a spirometer. The subjects were asked to sit comfortable and wear a nose clip during the test. They will perform each test for three trials. Between each trial, subjects were rest at least 1 minute. A tester was verbally encouraging the subjects to achieve maximal effort. The best value of each parameter was recorded. The values were expressed as both an absolute value in liters and a percentage of the predicted normal value. Predicted values were calculated by PFT instrument's software according to Chinese reference mode because this software had not Thai reference. Dejsomritrutai et al in 2002 concluded the pulmonary function in Thai people was very much similar to the Chinese in Hong Kong (29). Normative data in this study preferred according to ATS (52).

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Figure 3.3 Measurement of pulmonary function

3.4.2 Measurement of respiratory muscle strength

The subject rest on a comfortable chair and the MIP or MEP was tested. Subject's lips were held around the mouthpiece. MIP was determined from residual volume following a maximum expiration, called 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 maximum inspiration, called Valsalva maneuver. Subjects were instructed to 1) exhale to residual volume, 2) inhale slowly to total lung capacity and then 3) exhale maximally. MIP and MEP were measured 3 times per test. Each maneuver was separated by one minute resting period until the subjects recover from the exhaustion. The value of MIP and MEP was acceptable when the subjects sustain breathing for at least 1 second. The highest value of MIP and MEP was chosen.

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Figure 3.4 Measurement of respiratory muscle strength

3.4.3 Assessment and evaluation of physical activity

Physical activity questionnaire for children aged 10-14 years old was used to evaluate physical activity level (79). The self-report questionnaire consisted of seven questions that asked about physical activity (Appendix C.3).

Level of physical activity was classified in three levels: inactive, insufficiently active and sufficiently active (Appendix C.4).

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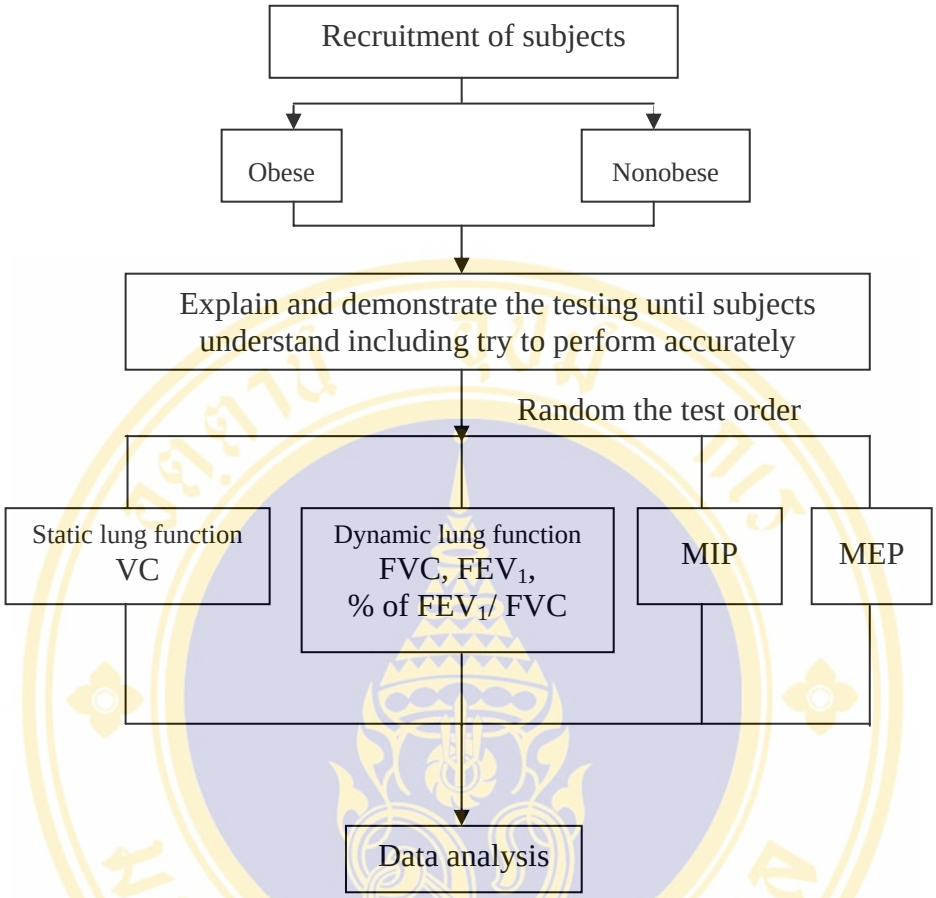

Figure 3.5 The research procedures.

3.5 Statistical Analysis

Statistical analysis was calculated with the SPSS for window release 11.0 program. The level of statistical difference for all analyses was set at p-value less than 0.05 ($p<0.05$).

Kolmogorov-Smirnov Goodness of fit test was used to test for distribution of the data. Unpaired t-test was used to test for difference of pulmonary function and respiratory muscle strength between obese and nonobese groups. If data was not in normal distribution, Mann-Whitney U test would be used.

Mann-Whitney U test was used to test for difference of physical activity level between both groups. In addition, Spearman rank correlation coefficient would be used to determine the correlation between the pulmonary function, respiratory muscle strength and physical activity level in both groups.

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CHAPTER IV

RESULTS

4.1 Characteristics of Subjects

Sixty volunteers participated in this study were classified into 2 groups by body weight. These subjects were recruited from four primary schools in Bangkoknoi district, Bangkok. These were Khosit Samosorn, Wat Umarintraram, Mongkolvijit Vithaya and Naruemontin Thonburi schools. The obese group consisted of 20 boys and 10 girls. The nonobese group consisted of 18 boys and 12 girls. The characteristics of each group including means and standard deviations of age, height, weight and BMI are presented in Table 4.1. Both groups were similar in age but significantly different in height, weight and BMI ($p<0.05$).

Table 4.1 Characteristics of subjects

Subject's characteristics	Obese group (n=30)			Nonobese group (n=30)			*p*-value[a]
	Male	Female	Total	Male	Female	Total	
Gender	20	10	30	18	12	30	-
Age (yrs)	11.10 ± 0.85	11.20 ± 0.79	11.13 ± 0.82	11.17 ± 0.71	10.92 ± 0.67	11.07 ± 0.69	0.735
Height (cm)	150.35 ± 6.30	149.90 ± 5.80	150.20 ± 6.04	144.22 ± 4.89	142.50 ± 8.84	143.53 ± 6.66	0.001*
Weight (kg)	67.45 ± 7.01	72.80 ± 12.01	69.23 ± 9.14	37.61 ± 5.16	36.67 ± 8.86	37.23 ± 6.75	0.001*
BMI (kg/m^2)	29.83 ± 2.35	32.29 ± 3.95	30.65 ± 3.14	18.02 ± 1.72	17.83 ± 2.76	17.95 ± 2.15	0.001*

a; *p*-value from unpaired t-test

*; significant difference at $p<0.05$

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4.2 Comparison of Pulmonary Function between the Obese and Nonobese Groups

Table 4.2 shows means and standard deviations of forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), vital capacity (VC) and FEV_1/FVC ratio in both groups. Means and standard deviations of FVC, FEV_1, VC and FEV_1/FVC ratio in obese group were 2.66 ± 0.44, 2.34 ± 0.35, 2.74 ± 0.40 L and 88.24 ± 6.69 % respectively. Means and standard deviations of FVC, FEV_1, VC and FEV_1/FVC ratio in nonobese group were 2.16 ± 0.39, 1.99 ± 0.35, 2.18 ± 0.37 L and 92.08 ± 4.10 % respectively.

Pulmonary function including FVC, FEV_1, VC and FEV_1/FVC ratio of obese group were significantly different from those of the nonobese group ($p<0.05$). FVC, FEV_1, VC of obese group were higher than nonobese group. FEV_1/FVC ratio of obese group was lower than nonobese group (Figure 4.1- 4.2).

Table 4.2 Comparison of means and standard deviations of absolute forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), vital capacity (VC) and FEV_1/FVC ratio between the obese and nonobese group

Pulmonary function	**Obese group** Mean ± SD	**Nonobese group** Mean ± SD	***p*-value**[a]
FVC (L)	2.66 ± 0.44	2.16 ± 0.39	0.001*
FEV_1 (L)	2.34 ± 0.35	1.99 ± 0.35	0.001*
VC (L)	2.74 ± 0.40	2.18 ± 0.37	0.001*
FEV_1/FVC ratio (%)	88.24 ± 6.69	92.08 ± 4.10	0.010*

a; *p*-value from unpaired t-test

*; significant difference at $p<0.05$

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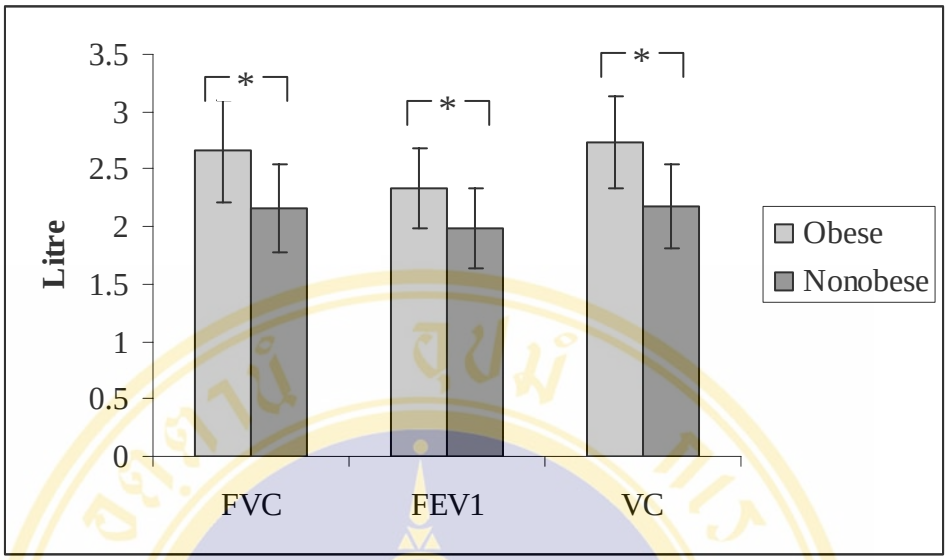

Figure 4.1 Comparison of means and standard deviations of absolute forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and vital capacity (VC) between the obese and nonobese group (* statistically significant at $p < 0.05$).

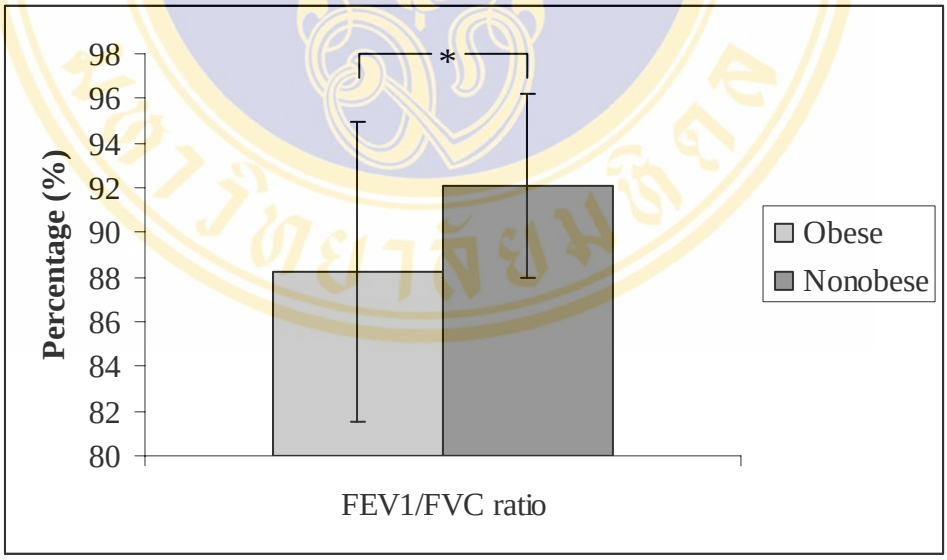

Figure 4.2 Comparison of means and standard deviations of absolute FEV_1/FVC ratio the obese and nonobese group (* statistically significant at $p < 0.05$).

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4.3 Comparison of Respiratory Muscle Strength between the Obese and Nonobese Groups

Table 4.3 shows means and standard deviations of maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) in both groups. Means and standard deviations of MIP and MEP in obese group were 81.60 ± 28.16 and 70.33 ± 26.48 cmH_2O, respectively. Means and standard deviations of MIP and MEP in nonobese group were 83.30 ± 21.73 and 71.77 ± 24.08 cmH_2O, respectively.

MIP and MEP are not significantly different between the obese and nonobese groups ($p>0.05$) (Figure 4.3).

Table 4.3 Comparison of means and standard deviations of absolute maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) between the obese and nonobese group

Respiratory muscle strength	**Obese group** Mean ± SD (cmH_2O)	**Nonobese group** Mean ± SD (cmH_2O)	***p*-value**[a]
MIP	81.60 ± 28.16	83.30 ± 21.73	0.794
MEP	70.33 ± 26.48	71.77 ± 24.08	0.827

a; *p*-value from unpaired t-test

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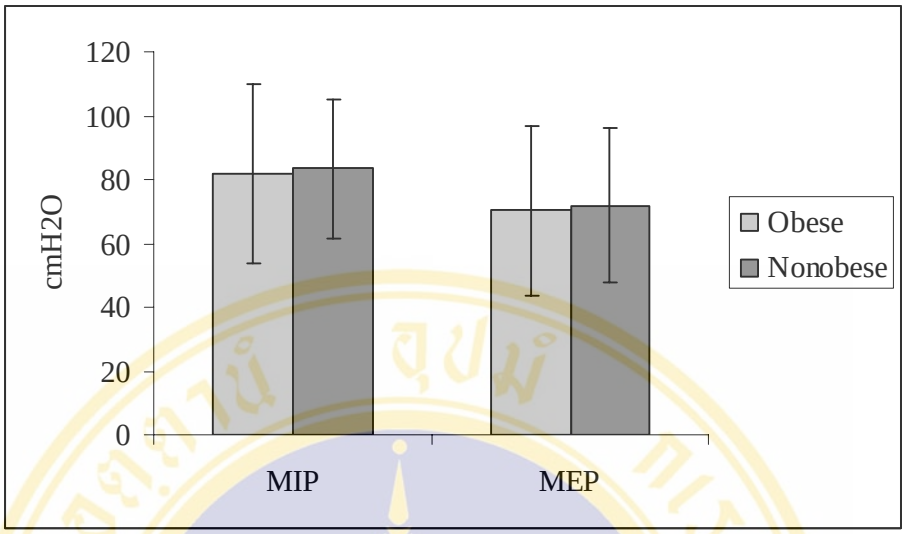

Figure 4.3 Comparison of means and standard deviations of absolute maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) between the obese and nonobese group.

4.4 Comparison of Physical Activity Level between the Obese and Nonobese Groups

Table 4.4 shows the comparison of physical activity level between the obese and nonobese groups. Six of the obese subjects reportedly were in the inactive level. Thirteen were in the insufficiently active level and eleven were in the sufficiently active level. In addition, nine of the nonobese subjects reportedly were in the inactive level. Ten were in the insufficiently active level and eleven were in the sufficiently active level. The results showed no significant differences between the obese and nonobese groups ($p>0.05$).

Table 4.4 Comparison of physical activity level between the obese and nonobese groups

Level / Group	Inactive	Insufficiently active	Sufficiently active	Total (n)	*p*-value[b]
Obese	6	13	11	30	0.725
Nonobese	9	10	11	30	

b; *p*-value from Mann-Whitney U Test

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4.5 Correlation between Physical Activity Level and Pulmonary Function

Spearman rank correlation coefficients were used to determine correlations of physical activity level and the pulmonary function test (FVC, FEV_1, VC and FEV_1/FVC ratio) in both groups. The results are shown in Table 4.5. The results demonstrated that physical activity level in the obese group had no correlation with FVC, FEV_1, VC and FEV_1/FVC ratio (r = 0.203, 0.170, 0.133 and -0.067, respectively). Similarly, the nonobese group that shows no correlation of the physical activity level with FVC, FEV_1, VC and FEV_1/FVC ratio (r = 0.225, 0.168, 0.168 and -0.207 respectively).

Table 4.5 The correlation of physical activity level with the pulmonary function (FVC, FEV_1, FEV_1/FVC ratio, VC)

Pulmonary function	**Physical activity level**			
	Obese group		**Nonobese group**	
	Correlation coefficient	*p*-value[c]	Correlation coefficient	*p*-value[c]
FVC	0.203	0.283	0.225	0.233
FEV_1	0.170	0.368	0.168	0.376
VC	0.133	0.485	0.168	0.374
FEV_1/FVC ratio	-0.067	0.725	-0.207	0.273

c; *p*-value from Spearman's rho

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4.6 Correlation between Physical Activity Level and Respiratory Muscle Strength

Spearman rank correlation coefficients were used to determine correlations between physical activity level and maximal respiratory pressure (MIP, MEP) in both groups. The results are shown in Table 4.6. The results demonstrated that the physical activity level in the obese group had no correlation with the MIP and MEP (r = 0.151 and 0.355, respectively). Similarly, the nonobese group shows no correlation between physical activity level and MIP and MEP (r = 0.202 and 0.006, respectively).

Table 4.6 The correlation of the physical activity level and the maximal respiratory pressure (MIP, MEP)

Respiratory muscle strength	**Physical activity level**			
	Obese group		**Nonobese group**	
	Correlation coefficient	*p*-value[c]	Correlation coefficient	*p*-value[c]
MIP	0.151	0.424	0.202	0.285
MEP	0.355	0.054	0.006	0.975

c; *p*-value from Spearman's rho

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CHAPTER V

DISCUSSION

5.1 Characteristics of Subjects

Sixty subjects were healthy children screened by their demographic information and medical history. Additionally, all subjects were interviewed by the examiner in order to ensure healthy status.

Demographic data of subjects were similar in age but significant differences in height, weight and BMI. Weight and BMI were used to classify subjects into two groups; obese group and nonobese group. In the present study, subjects in obese group were usually more hypersthenic than the nonobese subjects in the same age. The age range of subjects was 10-12 years old. These age groups have lung mature development and could be cooperated with the tests accurately (80). In the present study, subjects never perform pulmonary function and respiratory muscle strength before they were recruited to participate in order to normalize learning effects which may not be equal among experience subjects.

5.2 Method of Testing

In the present study, method in pulmonary function test including forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), FEV_1/FVC ratio and vital capacity (VC) were set specially for children. The balloon animation program on spirometer was used in this study because this program would encourage children to perform maximal effort (81).

In the present study, numbers of maneuvers were performed three times per test similar to the previous studies (27, 44, 82). The best value of each parameter was recorded. Practice was performed until subjects could perform the test accurately and forcefully. Because respiratory muscle strength is unique and unlike any other physical activities that perform in daily life, therefore learning is important factor that needs to

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be considered in MIP and MEP measurements (83-86). In that manner, more numbers of trial enabled inexperienced subjects to learn in order to perform peak pressure of respiratory muscle strength test in single test session.

Before the data collection, reliability of pulmonary function and respiratory muscle strength were determined. Ten children were selected to participate in test-retest reliability. The subjects performed two sessions of pulmonary function and respiratory muscle strength separated by a week. The intratester reliability of pulmonary function was 0.94, 0.90, and 0.83 for FVC, FEV_1 and VC respectively. The intratester reliability of respiratory muscle strength was 0.88 for MIP and 0.93 for MEP test. Therefore, the test-retest reliabilities of the method in this study were good (Appendix D). Therefore, single test session of pulmonary function test and 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.

The type of mouthpiece was flanged mouthpiece which made by rubber for using in respiratory muscle strength test. The values obtained with this flanged mouthpiece are higher than that of paper mouthpiece (58). This study selected the flanged mouthpiece because it can hold tightly around the lips and prevent air leaks better than paper mouthpiece.

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5.3 Comparison of Pulmonary Function between the Obese and Nonobese Groups

The results of pulmonary function test in Thai obese and nonobese children aged 10-12 years were shown in Table 4.2. Table 5.1 showed the comparison of pulmonary function test between the present study and other previous studies. The studies of Mallory et al, Marcus et al and Li et al (20, 25, 26) found that FVC in obese children was higher than normal. However, Susiva et al (27) found that FVC in Thai obese children decreased when compared with predicted values but Inselman et al (24) showed that FVC in obese children was normal similar to this study. The present study found that FVC and VC in obese children were significantly higher than nonobese children but the values of FVC and VC of both groups were normal according to the interpretation of American Thoracic Society (ATS) (48, 49).

For FEV_1 value, Inselman et al (24) found that obese children had a low FEV_1 when compared to the normal group but the study of Mallory et al (25) showed that the FEV_1 was not changed. On the contrary, Marcus et al (26) and Li et al (20) found that FEV_1 in obese children were higher than normal. The results are similar to the results of this study that the FEV_1 in obese group was significantly higher than nonobese group. However, FEV_1 in both groups were in normal range.

The obese children in the present study were healthy. They had no any pulmonary abnormalities that affected from obesity such as obstructive sleep apnea syndrome (OSAS), obesity hypoventilation syndrome or Pickwickian syndrome. Therefore, the results in the present study did not show the pulmonary abnormalities in obese children.

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Table 5.1 Comparison of pulmonary function and respiratory muscle strength between the present study and other previous studies in obese children

Authors	Pulmonary function test					
	FVC	FEV_1	FEV_1/FVC	VC	MIP	MEP
Mallory et al 1989	↑	↔	↓			
Susiva et al 1992	↓					
Inselman et al 1993	↔	↓		↔	↔	↔
Marcus et al 1996	↑	↑	↑			
Tantisira et al 2003			↓			
Li et al 2003	↑	↑	↑			
The present study	↑	↑	↓	↑	↔	↔

FVC: forced vital capacity

FEV_1: forced expiratory volume in 1 second

VC: vital capacity

MIP: maximum inspiratory pressure

MEP: maximum expiratory pressure

↑: increase

↓: decrease

↔: not change

The normal value of FVC, FEV_1 and VC depend on the subject's stature, age, gender and race. Stature is best estimated with body height (44). Nevertheless height should not be different between groups because height was one of many factors which affected pulmonary function and respiratory muscle strength (56, 59, 60). The taller subjects have higher lung volume and flows. However, in the present study subjects' height in the obese group was higher than it in the nonobese group with the same age. Therefore, it is possible that the high FVC, FEV_1 and VC values are caused by height, not weight difference. Moreover, the previous study found that FVC was correlated with FEV_1, if obese children had a high FVC; it may contribute to increase FEV_1 (44).

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When, the researcher arranged both groups of children to have a same height, which consisted of ten children per group (Table 5.2-5.3). The result of characteristic comparison between two groups showed significantly different only weight and BMI, moreover, only VC in obese children was statistically higher than nonobese children ($p<0.05$) but other pulmonary function parameters were not different between two groups.

Table 5.2 Comparison of means and standard deviations of absolute forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), vital capacity (VC) and FEV_1/FVC ratio between the obese and nonobese group

Pulmonary function	**Obese group (n=10)** Mean ± SD	**Nonobese group (n=10)** Mean ± SD	***p*-value[a]**
FVC (L)	2.48 ± 0.19	2.30 ± 0.29	0.124
FEV_1 (L)	2.26 ± 0.21	2.10 ± 0.28	0.182
VC (L)	2.57 ± 0.18	2.16 ± 0.30	0.002*
FEV_1/FVC ratio (%)	90.85 ± 5.69	91.20 ± 5.01	0.887

a; *p*-value from unpaired t-test

*; significant difference at $p<0.05$

Table 5.3 Comparison of means and standard deviations of absolute maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) between the obese and nonobese group

Respiratory muscle strength (cmH_2O)	**Obese group (n=10)** Mean ± SD	**Nonobese group (n=10)** Mean ± SD	***p*-value[a]**
MIP	81.40 ± 25.22	90.30 ± 21.46	0.407
MEP	72.70 ± 23.06	81.70 ± 25.61	0.420

a; *p*-value from unpaired t-test

VC in the obese children was statistically higher than the nonobese children. It would be possible that the obese children in this study usually strengthen than normal children. Although, obese children had VC higher than normal children but it did not

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mean that obesity contribute to great lung function. Over time, obese children might be getting more fat deposition in chest wall and it led to restrict lung expansion thus, VC would be decreased.

Obesity with the large adipose mass on the chest wall diminished chest wall compliance and elastic recoil of the lung. This may be altered the lung function such as reduction of FEV_1 and FVC. Although, the obese children in this study had body weight more than 3 standard deviations by children who have the same height but high body weight in these children might not be attributed by adipose mass. Body composition consists of major components such as adipose tissue, skeletal muscle, visceral organs, and bone (2). Therefore, the obese children in this study had the normal pulmonary function because they might have other factors which contribute to body growth besides adipose tissue. But weight for height that used in the present study can have limitation when used in individuals with unusual body fat distribution, which can be due to extreme stature; it remains one of the most effective monitoring to available (2, 76). Therefore, obese children who had extreme stature, less adipose mass may be normal of lung elasticity and compliance.

Findings of the present study were agreed with Tang et al that they found no significant difference between the obese and nonobese children in any of the lung function test measurements. FEV_1, FVC and peak expiratory flow rate (PEFR) were similar in both groups. They concluded that both groups had similar habitual level of physical activity, therefore physiologic responses were not sufficiently different between the obese and nonobese children (87).

Marcus et al and Li et al found that the FEV_1/FVC ratio increased from normal whereas, Mallory et al and Tantisira et al showed that the FEV_1/FVC ratio decreased from normal. In the present study, FEV_1/FVC ratio in obese group was lower than nonobese group but it was normal range in both groups. FEV_1/FVC ratio is used to determine airway obstruction and this decrease makes diagnoses of airway obstruction in obese children (44). Mallory et al showed a high incidence of mild obstructive lung disease in obese children. Therefore, obese children in the present study who had a

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low FEV_1/FVC ratio trend to observe airway obstruction higher than nonobese children. Airway obstruction may be an important predisposing factor for the development of the obesity-hypoventilation syndrome (25).

The impact of body weight on pulmonary function can be thought as a sum of changes in muscle mass and fat mass. Weak inspiratory and expiratory muscles decrease vital capacity (36, 44, 62). In contrast, stronger muscles will trend to improve vital capacity and FEV_1. An increase in body weight is expected to raise pulmonary function until the fat accumulation is above a threshold (2, 72).

5.4 Comparison of Respiratory Muscle Strength between the Obese and Nonobese Groups

Inspiratory muscle strength (MIP) in Thai obese and nonobese children aged 10-12 years was 81.60 ± 28.16 and 83.30 ± 21.73 cmH_2O, respectively. Moreover, expiratory muscle strength (MEP) in Thai obese and nonobese children was 70.33 ± 26.48 and 71.77 ± 24.08 cmH_2O, respectively. Normal respiratory muscle strength in healthy children is shown in Table 5.2 (60, 88, 89).

Table 5.4 Normal respiratory muscle strength in healthy children

Age (years)	MIP (cmH_2O)		MEP (cmH_2O)	
	Male	Female	Male	Female
8	77 ± 24	71 ± 29	99 ± 23	74 ± 25
10	105 ± 27	71 ± 29	123 ± 27	74 ± 25
11-13	114 ± 27	108 ± 29	161 ± 37	126 ± 32
13-17	126 ± 22	109 ± 21	166 ± 44	135 ± 29

According to review of literature, there has not been studied respiratory muscle strength in Thai children especially Thai obese children. However, the normal respiratory muscle strength from foreign study can be used to roughly compare with respiratory muscle strength in Thai children. The results of MIP and MEP in Thai

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children were lower than the foreign results. It was different because the values of MIP and MEP depend on main factors such as race and subjects' height.

In this study, there were no significant differences of respiratory muscle strength between obese and nonobese children. With similar to Inselman et al, the authors suggested that obesity with fat deposit was not involving the respiratory muscle strength (24). VC might also be improve because it can accurately reflect the strength of respiratory muscle in individuals with normal lung compliance. This study, the result showed that VC in both groups was not change from normal range. Therefore, the possible cause of a remained MIP and MEP was a normal VC (22, 44, 52, 57, 61). Furthermore, physical activity level that effects to the strength of skeletal muscles including respiratory muscles was not different between groups. Therefore, MIP and MEP were remained normal and the results showed there were not differences of these parameters between obese and nonobese children.

Obesity is often defined as a condition of abnormal or excessive fat accumulation in adipose tissue (2). However, obese individuals not only differ in the amount of excess fat that they store, but also differ in the regional distribution of fat within the body. There are two types of obesity; android obesity and gynoid obesity. Android obesity is abdominal fat distribution type and gynoid obesity is peripheral fat distribution type (8). Abdominal fat distribution type interferes the pulmonary function and respiratory muscle strength. Obese children trend to have android obesity which might increase the risk of obstructive sleep apnea syndrome (OSAS) by enhancing mass loading of respiratory muscles (2, 4, 8, 19, 76). It would be possible that the obese children had less abdominal fat distribution, so respiratory muscle strength was not involved. However, in this study the types of obesity were not classified.

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5.5 Comparison of Physical Activity Level between the Obese and Nonobese Groups

Physical activity level between both groups reportedly was not different (Appendix G, Table G.5). Level of physical activity was classified in three levels: inactive, insufficiently active and sufficiently active (Appendix C.4). The reasons are possible that children in both groups have the same classes including physical activity class. Furthermore, other physical activities at school and home such as exercising, watching TV, playing computer and games or playing internet would not different between the groups. Watching television is the most common leisure-time activity involving both physical inactivity and inappropriate food intake (2, 90).

Several methods have been used to estimate the amount of physical activity in children, such as physical activity questionnaires, pedometers, accelerometers, filmed or video-recorded activity sessions, expired air collection, and measurement of oxygen consumption by means of portable devices. All these methods have different levels of accuracy and reliability (75, 90). Questionnaires are the most common used to estimate physical activity level. Therefore, questionnaire was used in this study to evaluate the physical activity because it can be easy to use and good reliability (78).

5.6 Correlation between Physical Activity Level and Pulmonary Function and Respiratory Muscle Strength

The results of this study showed that physical activity level had no correlation with pulmonary function including FVC, FEV_1, VC and FEV_1/FVC ratio in both groups (Table 4.5). Additionally, physical activity level had no correlation with MIP and MEP in both groups (Table 4.6).

In the present study, the pulmonary function in both groups was significant difference but there were in normal ranges. Furthermore, the respiratory muscle strength in both groups was not differences. Therefore, physical activity level between both groups was not different. This finding is similar to the Tang and colleagues' study (87) that both groups did not show a difference in lung function because they

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had similar physical activity level. Characteristics of children are frequently active or naughty; so children in both groups are healthy. The collected physical activity data was not appropriate distribution thus, the statistic using in the study might not be enough to detect the correlation (91).

5.7 Limitation of the Study

In the present study lacked an indicator for measuring actual fat mass in subjects. Dual energy X-ray absorptionmetry (DEXA) is the method for accurately measuring total and regional measurement of bone mass, lean mass and fat mass. DEXA scan are more objective and reliable method of assessing adiposity than anthropometric assessments but it is not appropriate in clinic (20).

Physical activity level could be evaluated by observation or using some type of monitoring such as pedometers or accelerometers especially in young children. But these methods are not convenient to use. Questionnaires are the most common used to estimate physical activity level. The use of questionnaires to evaluate the physical activity in children may be error resulting from children's communication. But this physical questionnaire might be used to assess the physical activity in Thai children roughly. Moreover, the suitable questionnaire for Thai children should be developed.

5.8 Clinical Implications and Further Study

This study provided the information about the pulmonary function and respiratory muscle strength in Thai obese children. In addition, this study provided preliminary data of respiratory muscle strength in Thai healthy boys and girls aged 10-12 years. Children have excess body weight and abnormalities of body systems, trend to have more pulmonary complications than them in children with typical weight.

The data of this study provided the beneficial information for health maintenance care and treatment childhood obesity to a general pediatric clinic, school and home. Besides dietary intake control, a role of physical therapy is an important to

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providing suitable exercise intervention for obese children in order to decrease body weight and prevent pulmonary abnormalities in obese children.

For further study, improving method for assessing obesity in children especially fat distribution type should be considered in order to more accurately demonstrate pulmonary function.

It is also interesting to study sleep-related respiratory condition or sleep-disordered breathing such as obstructive sleep apnea syndrome (OSAS), obesity hypoventilation syndrome or Pickwickian syndrome because obesity is one of the strongest risk factors for these conditions in order to assess respiratory complications and risk factors in obese children.

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CHAPTER VI

CONCLUSION

The present study compared the pulmonary function, respiratory muscle strength between obese and nonobese children group. The correlation of physical activity level with pulmonary function and respiratory muscle strength in both children groups were also determined. Sixty healthy children (38 boys and 22 girls) aged 10-12 years were participated in this study. Forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), vital capacity (VC) and FEV_1/FVC ratio were used to indicate pulmonary function. Inspiratory and expiratory muscle strength were measured by maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP), respectively. It can be concluded from the present study that:

1. FVC, FEV_1 and VC of obese group were significantly higher than nonobese group.
2. FEV_1/FVC ratio of obese group was significantly lower than nonobese group.
3. MIP and MEP of obese group were not different from nonobese group.
4. Physical activity level of obese group was not different from nonobese group.
5. The physical activity level had no correlation with pulmonary function in both groups.
6. The physical activity level had no correlation with respiratory muscle strength in both groups.

Although, all parameters including pulmonary function of both groups were in normal range. However, obese children trend to observe airway obstruction higher than nonobese children. Therefore, pediatricians not only manage body weight, but also have a regard for pulmonary abnormalities in obese children.

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APPENDIX

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APPENDIX A

THE ETHICAL COMMITTEE ON RESEARCH INVOLVING HUMAN SUBJECT

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บางกอกน้อย BANGKOKNOI
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Siriraj Ethics Committee

Certificate of Approval COA no.Si 004/2005

Protocol Title : The pulmonary function and respiratory muscle strength in Thai obese children.

SiEC number : 215/2547

Principal Investigator/Affiliation : Miss Noppawan Charususin / School of Physiotherapy : Department of Orthopedic Surgery Faculty of Medicine Siriraj Hospital, Mahidol University

Research site : School of Physiotherapy : Department of Orthopedic Surgery / Faculty of Medicine Siriraj Hospital

Approval includes :

1. EC Submission form
2. Participant information sheet
3. Informed consent form
4. Principal Investigator's Curriculum vitae

Approval date : January 6, 2006

Expired date : January 5, 2007

This is to certify that Siriraj Ethics Committee is in full Compliance with International Guidelines For Human Research Protection such as Declaration of Helsinki, The Belmont Report, CIOMS Guidelines and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP)

(Prof. Sumalee Nimmannit,M.D.) January 23, 2006
Chair Person date

(Clin. Prof. Piyasakol Sakolsatayadorn) January 26, 2006
Dean of Faculty of Medicine Siriraj Hospital date

Page 1 of 2

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APPENDIX B.1

CONSENT FORM

(หนังสือแสดงเจตนายินยอมเข้าร่วมการวิจัย)

วันที่…....เดือน……..พ.ศ…….

ข้าพเจ้า…….....อายุ…..……ปี อาศัยอยู่บ้านเลขที่……หมู่.....ถนน.....แขวง/ตำบล..... เขต/อำเภอ..……จังหวัด…….....รหัสไปรษณีย์.....….. โทรศัพท์…….....

ขอแสดงเจตนายินยอมให้เด็กในปกครองของข้าพเจ้าเข้าร่วมโครงการวิจัย เรื่อง การศึกษาค่าสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจในเด็กไทยที่มีภาวะอ้วน

โดยข้าพเจ้าได้รับทราบรายละเอียดเกี่ยวกับที่มาและจุดมุ่งหมายในการทำวิจัยรายละเอียดขั้นตอนต่างๆ ที่จะต้องปฏิบัติหรือได้รับการปฏิบัติ ประโยชน์ที่คาดว่าจะได้รับของการวิจัยและความเสี่ยงที่อาจจะเกิดขึ้นจากการเข้าร่วมการวิจัย รวมทั้งแนวทางป้องกันและแก้ไขหากเกิดอันตรายขึ้น โดยได้อ่านข้อความที่มีรายละเอียดอยู่ในเอกสารชี้แจงผู้เข้าร่วมการวิจัยโดยตลอด อีกทั้งยังได้รับคำอธิบายและตอบข้อสงสัยจากหัวหน้าโครงการวิจัยเป็นที่เรียบร้อยแล้ว

ข้าพเจ้าจึงสมัครใจให้เด็กในปกครองของข้าพเจ้าเข้าร่วมโครงการวิจัยนี้

หากข้าพเจ้ามีข้อสงสัยเกี่ยวกับขั้นตอนของการวิจัย หรือหากเกิดผลข้างเคียงที่ไม่พึงประสงค์จากการวิจัยขึ้นกับเด็กในปกครองของข้าพเจ้า ข้าพเจ้าจะสามารถติดต่อกับนางสาวนพวรรณ จารุสุสินธ์ ที่บ้านเลขที่ 72/2 ซอยสามเสน 9 ถนนสามเสน แขวงวชิรพยาบาล เขตดุสิต กรุงเทพฯ 10300 โทรศัพท์ 0-1384-1198

หากเด็กในปกครองของข้าพเจ้าได้รับการปฏิบัติไม่ตรงตามที่ได้ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย ข้าพเจ้าจะสามารถติดต่อกับประธานคณะกรรมการจริยธรรมการวิจัยในคน หรือผู้แทน ได้ที่ สำนักงานคณะกรรมการจริยธรรมการวิจัยในคน ตึกอดุลยเดชวิกรม ชั้น 5 ร.พ.ศิริราช โทร. (02)419-7000 ต่อ 6405

ข้าพเจ้าได้รับทราบถึงสิทธิ์ที่ข้าพเจ้าจะได้รับข้อมูลเพิ่มเติมทั้งทางด้านประโยชน์และโทษจากการเข้าร่วมการวิจัย และสามารถถอนตัวหรืองดเข้าร่วมการวิจัยได้ทุกเมื่อ โดยจะไม่มีผลกระทบต่อการบริการและการรักษาพยาบาลที่ข้าพเจ้าจะได้รับต่อไปในอนาคตและยินยอมให้ผู้วิจัยใช้ข้อมูล

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ส่วนตัวของข้าพเจ้าที่ได้รับจากการวิจัย แต่จะไม่เผยแพร่ต่อสาธารณะเป็นรายบุคคล โดยจะนำเสนอเป็นข้อมูลโดยรวมจากการวิจัยเท่านั้น

ข้าพเจ้าได้เข้าใจข้อความในเอกสารชี้แจงผู้เข้าร่วมการวิจัย และหนังสือแสดงเจตนายินยอมนี้โดยตลอดแล้ว จึงลงลายมือชื่อไว้

ลงชื่อ.....ผู้เข้าร่วมการวิจัย/ผู้แทนโดยชอบธรรม/ วันที่.....

(.....)

ลงชื่อ.....ผู้ให้ข้อมูลและขอความยินยอม/หัวหน้าโครงการวิจัย/ วันที่.....

(.....)

ในกรณีผู้เข้าร่วมการวิจัยอ่านหนังสือไม่ออก ผู้ที่อ่านข้อความทั้งหมดแทนผู้เข้าร่วมการวิจัย คือ .....จึงลงลายมือชื่อไว้เป็นพยาน

ลงชื่อ.....พยาน/ วันที่.....

(.....)

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APPENDIX B.2

PARTICIPANT INFORMATION SHEET

(เอกสารชี้แจงผู้เข้าร่วมการวิจัย)

ในเอกสารนี้อาจมีข้อความที่ท่านอ่านแล้วยังไม่เข้าใจ โปรดสอบถามหัวหน้าโครงการวิจัย หรือผู้แทนให้ช่วยอธิบายจนกว่าจะเข้าใจดี ท่านอาจจะขอเอกสารนี้กลับไปอ่านที่บ้านเพื่อปรึกษาหารือกับญาติพี่น้อง เพื่อนสนิท แพทย์ประจำตัวของเด็กในปกครองของท่านหรือแพทย์ท่านอื่น เพื่อช่วยในการตัดสินใจเข้าร่วมการวิจัย

ชื่อโครงการ การศึกษาค่าสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจในเด็กไทยที่มีภาวะอ้วน

ชื่อผู้วิจัย นางสาวนพวรรณ จารุสุสินธ์

สถานที่วิจัย - คลินิกโภชนาการ ตึกเจ้าฟ้ามหาจักรีชั้น 1 ร.พ.ศิริราช เขตบางกอกน้อย กรุงเทพฯ
-โรงเรียนในเขตบางกอกน้อย กรุงเทพมหานคร

ผู้ให้ทุน ไม่มี

โครงการวิจัยนี้ทำขึ้นเพื่อประเมินค่าสมรรถภาพปอดและความแข็งแรงกล้ามเนื้อหายใจในเด็กไทยที่มีภาวะอ้วน ซึ่งจะมีประโยชน์ที่คาดว่าจะได้รับคือ

1. ทำให้ได้ทราบข้อมูลของค่าสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจในเด็กที่มีภาวะอ้วนเมื่อเปรียบเทียบกับเด็กที่มีน้ำหนักตัวปกติ

2. ข้อมูลที่ได้จากการประเมินสมรรถภาพของปอดและความแข็งแรงของกล้ามเนื้อหายใจนี้ใช้เป็นแนวทางในการวางแผนเพื่อป้องกันการเกิดภาวะแทรกซ้อนทางระบบทางเดินหายใจและปอดในเด็กที่มีภาวะอ้วน อันเป็นแนวทางที่จะช่วยลดอัตราป่วยและอัตราการเสียชีวิต

3. ความสัมพันธ์ระหว่างระดับกิจกรรมกับสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจของเด็กทั้งสองกลุ่ม สามารถนำไปใช้เป็นแนวทางในการส่งเสริมสุขภาพให้แก่เด็กไทยได้

เด็กในปกครองของท่านได้รับเชิญให้เข้าร่วมการวิจัยนี้เพราะเด็กในปกครองของท่านเป็นผู้ที่มีภาวะอ้วน/ เป็นผู้ที่มีน้ำหนักตัวปกติ ที่มีคุณสมบัติตามเกณฑ์ที่ผู้วิจัยกำหนด และการวิจัยนี้ทำขึ้นเพื่อให้ได้ทราบข้อมูลของค่าสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจในเด็กที่มีภาวะ

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อ้วนเมื่อเปรียบเทียบกับเด็กที่มีน้ำหนักตัวปกติ และนำไปเป็นแนวทางในการวางแผนเพื่อป้องกันการเกิดภาวะแทรกซ้อนทางระบบทางเดินหายใจในเด็กที่มีภาวะอ้วนต่อไป

โครงการนี้เป็นการศึกษานำร่อง จะรับผู้เข้าร่วมวิจัยทั้งสิ้น 20 คน โดยแบ่งออกเป็นกลุ่มเด็กอ้วน 10 คน และเด็กปกติ 10 คน เมื่อทำโครงการนำร่องแล้วเสร็จ จะทำการคำนวณจำนวนผู้เข้าร่วมการวิจัยที่เหมาะสมในการศึกษาต่อไป โดยใช้ระยะเวลาที่จะทำการวิจัยทั้งสิ้นประมาณ 12 เดือน

โดยมีขั้นตอนการวิจัยดังนี้

1. ขั้นเตรียมการ ผู้วิจัยคัดเลือกผู้เข้าร่วมวิจัยที่มีคุณสมบัติตามเกณฑ์ที่กำหนด

จากนั้นผู้เข้าร่วมวิจัยที่มีอายุ 10-12 ปีจะได้รับเอกสารดังนี้

- เอกสารชี้แจงผู้เข้าร่วมการวิจัย
- หนังสือแสดงเจตนายินยอมเข้าร่วมการวิจัย
- แบบสอบถามเกี่ยวกับข้อมูลส่วนตัวและประวัติทางสุขภาพ

เพื่อให้ผู้ปกครองที่ใกล้ชิดกับผู้เข้าร่วมวิจัยเป็นผู้อ่านและตอบคำถามเกี่ยวกับเด็กในปกครอง รวมทั้งลงลายมือชื่อเป็นหลักฐาน

หลังจากนั้น 1 สัปดาห์ผู้วิจัยจะเก็บเอกสารทั้งหมดกลับคืนแล้วเริ่มทำการวิจัย และตอบแบบสอบถามระดับการเคลื่อนไหวออกแรง/ ออกกำลังกายสำหรับเด็กอายุ 10-14 ปี กับผู้วิจัย

2. ขั้นตอนการเก็บข้อมูล ผู้เข้าร่วมวิจัยจะได้รับการชั่งน้ำหนักและวัดส่วนสูง หลังจากนั้นผู้วิจัยจะอธิบายขั้นตอนการทดสอบแก่ผู้เข้าร่วมวิจัยและสาธิตวิธีทำจนเข้าใจ ตลอดจนได้ทดลองทำด้วยตนเองจนสามารถทำได้อย่างถูกต้อง จากนั้นทำการวิจัยโดยมีรายละเอียดดังนี้

2.1 ประเมินสมรรถภาพของปอด โดยใช้เครื่องวัดการทำงานของปอด

- การวัดค่าปริมาตรของลมที่เป่าออกอย่างเร็วและแรง, ค่าปริมาตรของลมที่เป่าออกในเวลา 1 วินาที และค่าปริมาตรของลมที่เป่าออกในเวลา 1 วินาทีคิดเป็นร้อยละของปริมาตรของลมที่เป่าออกอย่างเร็วและแรง โดยให้ผู้เข้าร่วมวิจัยนั่งบนเก้าอี้ในท่าสบาย ผู้เข้าร่วมวิจัยหายใจเข้าเต็มที่แล้วทำการปิดจมูกโดยใช้ที่หนีบจมูกหนีบพร้อมกับอมท่อเป่า (mouth piece) แล้วหายใจออกอย่างเร็วและแรง เป็นเวลาอย่างน้อย 6 วินาที ทำทั้งหมด 3 ครั้ง โดยในแต่ละครั้งผู้เข้าร่วมการวิจัยจะได้รับการพักเป็นเวลาอย่างน้อย 1 นาที

- การวัดความจุปอด โดยให้ผู้เข้าร่วมวิจัยนั่งบนเก้าอี้ในท่าสบาย ผู้เข้าร่วมวิจัยทำการปิดจมูกโดยใช้ที่หนีบจมูกหนีบพร้อมกับอมท่อเป่า (mouth piece) แล้วหายใจเข้า-ออกตามปกติผ่านท่อเป่า เมื่อผู้วิจัยให้สัญญาณผู้เข้าร่วมวิจัยจึงหายใจเข้าลึกจนเต็มที่ แล้วเป่าออกมาเข้าไปในเครื่องอย่างแรงและเร็ว และนานที่สุดเท่าที่จะทำได้อย่างน้อย 6 วินาที แล้วหายใจเข้า-ออกตามปกติ ทำทั้งหมด 3 ครั้ง โดยในแต่ละครั้งผู้เข้าร่วมการวิจัยจะได้รับการพักเป็นเวลาอย่างน้อย 1 นาที

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2.2 ทดสอบความแข็งแรงของกล้ามเนื้อหายใจ ด้วยการวัดความดันของการหายใจเข้าและออก เริ่มต้นจากให้ผู้เข้าร่วมวิจัยนั่งสบายๆ อมท่อเป่าไว้ในปาก

- ทดสอบความแข็งแรงของกล้ามเนื้อหายใจเข้า: โดยหายใจออกจนสุดเมื่อหายใจออกสุดแล้วทำการหายใจเข้าให้ลึกมากที่สุดเท่าที่จะสามารถทำได้ค้างไว้อย่างน้อย 2 วินาที ทำทั้งหมด 3 ครั้ง โดยในแต่ละครั้งผู้เข้าร่วมการวิจัยจะได้รับการพักเป็นเวลาอย่างน้อย 1 นาที

- ทดสอบความแข็งแรงของกล้ามเนื้อหายใจออก: โดยหายใจเข้าให้สุดเมื่อหายใจเข้าสุดแล้วให้หายใจออกให้มากที่สุดเท่าที่จะสามารถทำได้ค้างไว้อย่างน้อย 2 วินาที ทำทั้งหมด 3 ครั้ง โดยในแต่ละครั้งผู้เข้าร่วมการวิจัยจะได้รับการพักเป็นเวลาอย่างน้อย 1 นาที

ความเสี่ยงที่อาจจะเกิดขึ้นเมื่อเข้าร่วมการวิจัย โดยเด็กในปกครองของท่านอาจเกิดอาการเหนื่อย เมื่อพักแล้วอาการเหล่านี้ยังไม่ทุเลาลง ส่งผลให้ผู้เข้าร่วมวิจัยไม่สามารถทำการทดสอบค่าสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจต่อไปได้ ผู้วิจัยจะยุติการวิจัยทันที และจะส่งผู้เข้าร่วมวิจัยปรึกษากุมารแพทย์ผู้เชี่ยวชาญต่อไป

หากเด็กในปกครองของท่านไม่เข้าร่วมในโครงการวิจัยนี้ เด็กในปกครองของท่านก็จะได้รับการตรวจเพื่อการวินิจฉัย และรักษาโรคของเด็กในปกครองของท่านตามวิธีการที่เป็นมาตรฐานของกุมารแพทย์ของเด็กในปกครองของท่านต่อไปตามปกติ

หากเกิดผลข้างเคียงที่ไม่พึงประสงค์จากการวิจัย เด็กในปกครองของท่านจะได้รับการช่วยเหลือจากผู้วิจัยและส่งปรึกษากุมารแพทย์ผู้เชี่ยวชาญต่อไป และหากมีข้อสงสัยที่จะสอบถามเกี่ยวข้องกับการวิจัย หรือเมื่อบาดเจ็บ/เจ็บป่วยจากการวิจัยสามารถติดต่อผู้วิจัย (นางสาวนพวรรณ จารุสุสินธ์) ได้ตลอดเวลาที่เบอร์โทรศัพท์ของผู้วิจัย 0-1384-1198

หากมีข้อมูลเพิ่มเติมทั้งด้านประโยชน์และโทษที่เกี่ยวข้องกับการวิจัยนี้ ผู้วิจัยจะแจ้งให้ทราบโดยรวดเร็วไม่ปิดบัง โดยงานวิจัยครั้งนี้ผู้เข้าร่วมการวิจัยไม่ต้องเสียค่าใช้จ่ายใดๆ ทั้งสิ้น

ข้อมูลส่วนตัวของผู้เข้าร่วมการวิจัยจะถูกเก็บรักษาไว้ ไม่เปิดเผยต่อสาธารณะเป็นรายบุคคล แต่จะรายงานผลการวิจัยเป็นข้อมูลส่วนรวม ข้อมูลของผู้เข้าร่วมการวิจัยเป็นรายบุคคลอาจมีคณะบุคคลบางกลุ่มเข้ามาตรวจสอบได้ เช่น คณะกรรมการจริยธรรมฯ เป็นต้น

ผู้เข้าร่วมการวิจัยมีสิทธิ์ถอนตัวออกจากโครงการวิจัยเมื่อใดก็ได้ โดยไม่ต้องแจ้งให้ทราบล่วงหน้า และการไม่เข้าร่วมการวิจัยหรือถอนตัวออกจากโครงการวิจัยนี้จะไม่มีผลกระทบต่อการบริการและการรักษาที่สมควรได้รับแต่ประการใด

หากเด็กในปกครองของท่านได้รับการปฏิบัติที่ไม่ตรงตามที่ได้ระบุไว้ในเอกสารชี้แจงนี้ ท่านจะสามารถแจ้งให้ประธานคณะกรรมการจริยธรรมฯ ทราบได้ที่ สำนักงานคณะกรรมการจริยธรรมการวิจัยในคน ตึกอดุลยเดชวิกรม ชั้น 5 ร.พ. ศิริราช เบอร์โทร.(02)419-7000 ต่อ 6405

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ข้าพเจ้าได้อ่านรายละเอียดในเอกสารนี้ครบถ้วนแล้ว

ลงชื่อ...../วันที่.....

(.....)

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APPENDIX C.1

DATA COLLECTION FORM

หมายเลข.....

วันที่.....เดือน.....พ.ศ.....

ชื่อ-สกุล..... เพศ ☐ ชาย ☐ หญิง อายุ.....ปี

ส่วนสูง.....เซนติเมตร น้ำหนัก.....กิโลกรัม Percentile ที่.....

Posture: ☐ ปกติ (Normal) ☐ หลังค่อม (Kyphosis)

☐ หลังคด (Scoliosis) ☐ หลังคดและค่อม (Kyphoscoliosis)

Activity level: ☐ Inactive ☐ Insufficiently active ☐ Sufficiently active

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Pulmonary function test

Variables	Trial 1	Trial 2	Trial 3	Best	Predicted	% Predicted
FVC (l)						
FEV_1 (l)						
FEV_1/FVC (%)						
VC (l)						

Respiratory muscle strength

Variables	Trial 1	Trial 2	Trial 3	Best
MIP (cmH_2O)				
MEP (cmH_2O)				

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APPENDIX C.2

DEMOGRAPHIC INFORMATION AND MEDICAL HISTORY

แบบสอบถามข้อมูลส่วนตัวและประวัติทางสุขภาพของเด็กในปกครองของท่าน

หมายเลขแบบสอบถาม.....

วันที่.....เดือน.....พ.ศ.....

ชื่อผู้ปกครอง.....นามสกุล.....

ที่อยู่: บ้านเลขที่.....หมู่.....ถนน.....แขวง/ตำบล.....เขต/อำเภอ.....

จังหวัด.....รหัสไปรษณีย์.....เบอร์โทรศัพท์…….

1. ชื่อเด็ก.....นามสกุล.....

2. อายุ.....ปี

3. ปัจจุบันศึกษาอยู่ชั้น ☐ ประถมศึกษาปีที่ 1 ห้อง.....
☐ ประถมศึกษาปีที่ 2 ห้อง.....
☐ ประถมศึกษาปีที่ 3 ห้อง.....
☐ ประถมศึกษาปีที่ 4 ห้อง.....
☐ ประถมศึกษาปีที่ 5 ห้อง.....
☐ ประถมศึกษาปีที่ 6 ห้อง.....

4. โรคประจำตัว (โปรดระบุ)

1. .....

2. .....

5. ปัจจุบันเด็กยังเป็นโรคประจำตัวนี้อยู่หรือไม่ ☐ ไม่เป็น ☐ เป็น.....

6. ปัจจุบันเด็กต้องทานรับประทานยาเป็นประจำหรือไม่

☐ ไม่ต้องรับประทานยา

☐ ต้องรับประทานยา โปรดระบุชื่อยา/ ชนิดของยา/สรรพคุณของยา

.....

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APPENDIX C.3

PHYSICAL ACTIVITY QUESTIONNAIRE FOR CHILDREN AGED 10-14 YEARS OLD

แบบสัมภาษณ์เด็กอายุ 10-14 ปี
เกี่ยวกับการเคลื่อนไหวออกแรง/ออกกำลังกาย

คำชี้แจง : ขอให้น้อง/หนูตอบคำถามทุกข้อ โดยให้คิดถึงกิจกรรมการเคลื่อนไหวต่างๆที่น้อง/หนูได้ทำในระหว่างอยู่ที่โรงเรียนหรืออยู่ที่บ้าน การเดินทางไป-กลับระหว่างสถานที่ต่างๆ การออกกำลังกายเพื่อฝึกความแข็งแรงของกล้ามเนื้อ การยืดเหยียดกล้ามเนื้อหรือการเล่นกีฬา **ในช่วง 7 วันที่ผ่านมา**

: ข้อมูลที่ได้จากแบบสัมภาษณ์นี้ จะถูกเก็บไว้เป็นความลับ และนำมาประมวลผลเพื่อใช้เป็นข้อมูลพื้นฐานในการศึกษาถึงความสัมพันธ์ระหว่างระดับกิจกรรมกับค่าสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจของน้อง/ หนู

ข้อมูลทั่วไปของน้อง/หนู

1. เพศของน้อง/หนู ☐ ชาย ☐ หญิง
2. วัน เดือน ปี เกิดของน้อง/หนู วันที่.....เดือน.....พ.ศ.....
3. น้อง/หนูกำลังเรียนหนังสืออยู่หรือไม่
   ☐ ไม่ได้เรียนแล้ว ⇒ (ข้ามไปตอบข้อ 6 ในข้อมูลการเคลื่อนไหวออกแรง/ออกกำลัง)
   ☐ กำลังเรียนอยู่ระดับชั้น
      ☐ ประถมศึกษาปีที่..../..... ☐ มัธยมศึกษาปีที่...../.....

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ข้อมูลการเคลื่อนไหวออกแรง/ออกกำลังกาย

ข้อต่อไปนี้ **ขอให้ท่านสัมภาษณ์น้อง/หนู** โดยให้น้อง/หนูคิดถึงการเดินทางไปและกลับจากโรงเรียน **ในช่วง 7 วันที่ผ่านมา**ว่าน้อง/หนูได้เดินหรือถีบจักรยานไปและกลับจากโรงเรียนเป็นเวลาและระยะเวลาเท่าไร

4. **ช่วง 7 วันที่ผ่านมา** น้อง/หนูได้เดินไปและกลับจากโรงเรียนเป็นเวลากี่วันและระยะเวลารวมกันนานเท่าไรต่อวัน

.....วันต่อสัปดาห์ ระยะเวลารวมกันต่อวันนาน.....ชั่วโมง.....นาที *หรือ*

❑ ไม่ทราบ/ไม่แน่ใจระยะเวลา

❑ ไม่ได้เดิน

5. **ช่วง 7 วันที่ผ่านมา น้อง**/หนูได้ถีบจักรยานไปและกลับจากโรงเรียนเป็นเวลากี่วัน และระยะเวลารวมกันนานเท่าไรต่อวัน

.....วันต่อสัปดาห์ ระยะเวลารวมกันต่อวันนาน.....ชั่วโมง.....นาที *หรือ*

❑ ไม่ทราบ/ไม่แน่ใจระยะเวลา

❑ ไม่ได้ถีบจักรยาน

ข้อต่อไปนี้ **ขอให้ท่านสัมภาษณ์น้อง/หนู** โดยให้น้อง/หนูคิดถึงการออกกำลังวิ่งเล่น ว่ายน้ำ ถีบจักรยาน เล่นกีฬา หรือเล่นเกมที่มีการเคลื่อนที่ระหว่างอยู่ที่โรงเรียน หรืออยู่ที่บ้านเป็นเวลาและระยะเวลานานเท่าไร

6. **ช่วง 7 วันที่ผ่านมา** น้อง/หนูได้ออกกำลัง วิ่งเล่น ว่ายน้ำ ถีบจักรยาน เล่นกีฬาหรือเล่นเกมที่มีการเคลื่อนที่อย่างเต็มที่ ซึ่งกิจกรรมดังกล่าวต้องออกแรง/ออกกำลังมาก และทำให้น้อง/หนูรู้สึกเหนื่อย หรือเหนื่อยมากโดยหายใจแรงและเร็ว หรือหายใจไม่ทันหรือหอบ **รวมเป็นระยะเวลาอย่างน้อยวันละ 20 นาที** เป็นเวลากี่วัน

.....วันต่อสัปดาห์ ❑ ไม่ได้ทำ

โปรดระบุชนิด/ ประเภทของการออกกำลัง

o ..... *ระยะเวลาประมาณ.....นาที*

o ..... *ระยะเวลาประมาณ.....นาที*

o ..... *ระยะเวลาประมาณ.....นาที*

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7. **ช่วง 7 วันที่ผ่านมา** น้อง/หนูได้ออกกำลัง วิ่งเล่น ว่ายน้ำ ถีบจักรยาน เล่นกีฬา หรือเล่นเกมที่มีการเคลื่อนที่ ซึ่งกิจกรรมดังกล่าวต้องออกแรง/ออกกำลังกายพอประมาณ และทำให้น้อง/หนูรู้สึกค่อนข้างเหนื่อย หรือเหนื่อยกว่าปกติพอควร โดยหายใจเร็วกว่าปกติเล็กน้อย หรือหายใจกระชั้นขึ้น **รวมเป็นระยะเวลาอย่างน้อยวันละ 30 นาที** เป็นเวลากี่วัน

.....วันต่อสัปดาห์ ❑ ไม่ได้ทำ

โปรดระบุชนิด/ ประเภทของการออกกำลัง

o ..... *ระยะเวลาประมาณ.....นาที*

o ..... *ระยะเวลาประมาณ.....นาที*

o ..... *ระยะเวลาประมาณ.....นาที*

8. **ช่วง 7 วันที่ผ่านมา** ในช่วงวันเรียนหนังสือ (ไม่รวมวันหยุดเสาร์-อาทิตย์) ระหว่างอยู่ที่บ้าน น้อง/หนูได้นั่งดูโทรทัศน์ เล่นเกมคอมพิวเตอร์ติดต่อกันนานกว่า **2 ชั่วโมง** เป็นเวลากี่วัน

.....วันต่อสัปดาห์ *ระยะเวลาประมาณ.....ชั่วโมง.....นาที*

❑ ไม่ได้ทำ

ข้อต่อไปนี้ **ขอให้ท่านสัมภาษณ์น้อง/หนู** โดยให้น้อง/หนูคิดถึงการออกกำลังฝึกกล้ามเนื้อเพื่อความแข็งแรงและความอ่อนตัว ระหว่างอยู่ที่โรงเรียนหรืออยู่ที่บ้าน

9. **ช่วง 7 วันที่ผ่านมา** น้อง/หนูได้มีการออกกำลังฝึกความแข็งแรงของกล้ามเนื้ออย่างเป็นเรื่องเป็นราว เช่น ยกน้ำหนัก วิดพื้น ดึงข้อ ซิตอัพ เล่นบาร์ ฯลฯ เป็นเวลากี่วัน

.....วันต่อสัปดาห์ ❑ ไม่ได้ทำ

โปรดระบุชนิด/ ประเภทของการออกกำลัง

o ..... *ระยะเวลาประมาณ.....นาที*

o ..... *ระยะเวลาประมาณ.....นาที*

o ..... *ระยะเวลาประมาณ.....นาที*

10. **ช่วง 7 วันที่ผ่านมา** น้อง/หนูได้มีการทำกายบริหารยืดเหยียดกล้ามเนื้อ อย่างเป็นเรื่องเป็นราว เช่น การก้มแตะพื้น/แตะปลายเท้า การเอียงตัว เอียงศีรษะ หมุนไหล่ หมุนตัวฯลฯ เป็นเวลากี่วัน

.....วันต่อสัปดาห์ ❑ ไม่ได้ทำ

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โปรดระบุชนิด/ ประเภทของการออกกำลัง

o ……. *ระยะเวลาประมาณ.....นาที*

o ……. *ระยะเวลาประมาณ.....นาที*

o ……. *ระยะเวลาประมาณ.....นาที*

****

ขอขอบคุณที่ท่านให้ความร่วมมือในการตอบแบบสัมภาษณ์

น.ส.นพวรรณ จารุสุสินธ์ (หัวหน้าโครงการวิจัย)

(ดัดแปลงจากแบบสอบถามโดย กองออกกำลังกายเพื่อสุขภาพ กรมอนามัย กระทรวงสาธารณสุข)

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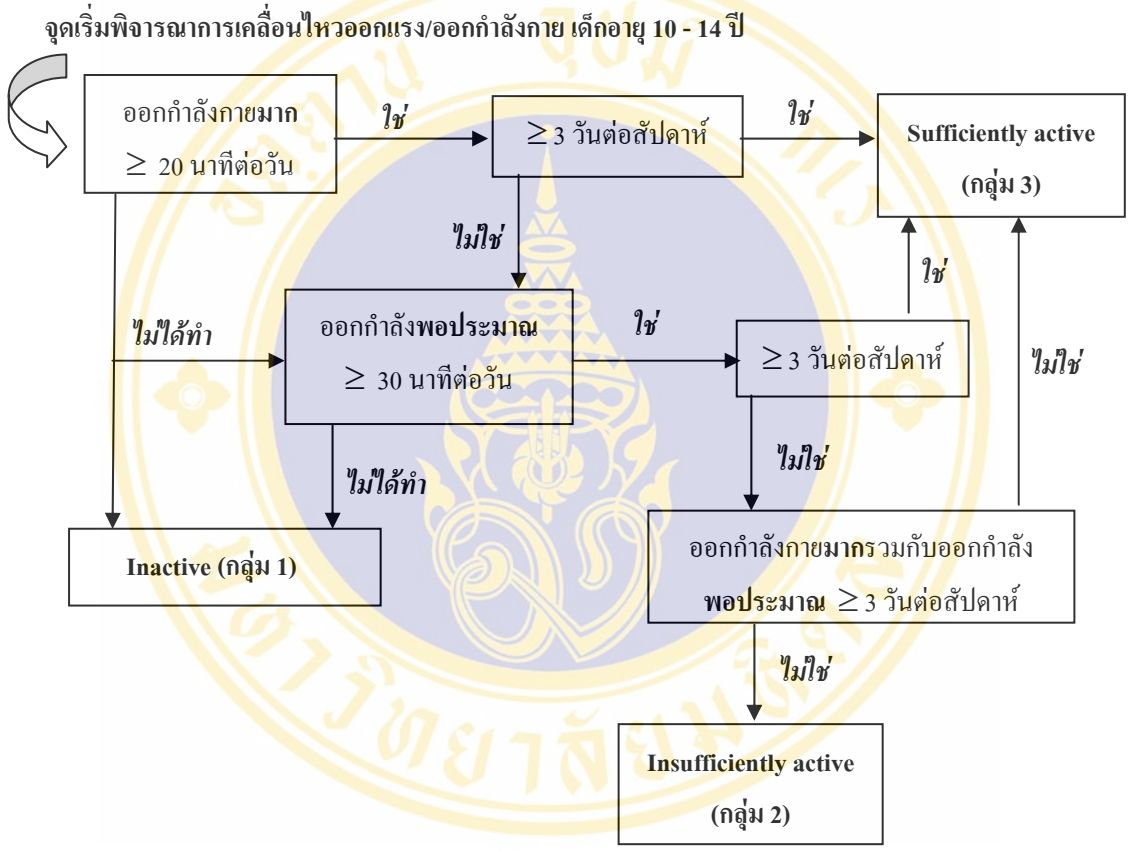
APPENDIX C.4

INTERPRETATION OF PHYSICAL ACTIVITY QUESTIONNAIRE FOR CHILDREN AGED 10-14 YEARS OLD



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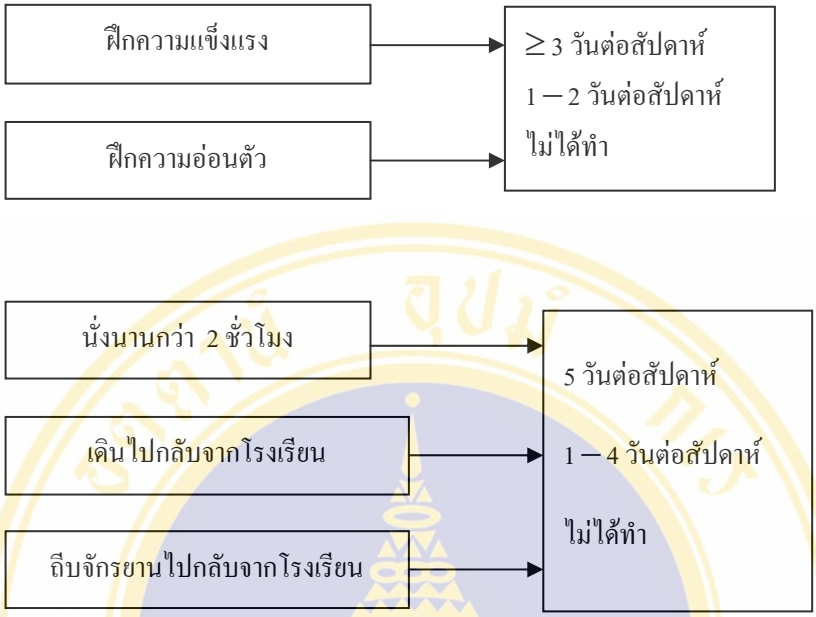

Reference

คู่มือแบบสัมภาษณ์การเคลื่อนไหวออกแรง/ออกกำลังกาย
: คำอธิบายการใช้แบบสัมภาษณ์ แนวทางการจัดการและการวิเคราะห์ข้อมูล
กองออกกำลังกายเพื่อสุขภาพ กรมอนามัย กระทรวงสาธารณสุข 2547

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APPENDIX D

TEST-RETEST RELIABILITY OF PULMONARY FUNCTION TEST AND RESPIRATORY MUSCLE STENGTH

The purpose of the pilot study was to determine the test-retest reliability of pulmonary function test and respiratory muscle strength. Forced vital capacity (FVC), forced expired volume in 1 second (FEV_1), vital capacity (VC), ratio of FEV_1/FVC, maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) were performed for test-retest reliability.

Ten healthy children participated in this study. They did the same procedure as in method (page 26-27). Each parameter was performed three trials. The highest values of all parameters were recorded. At least 1 week after the first session, they performed the whole procedure again.

Intraclass correlation coefficient ($ICC_{3,1}$) was used to determine the test-retest reliability for each maneuver of FVC, FEV_1, VC, MIP and MEP.

Raw data of FVC, FEV_1, VC, MIP and MEP are shown in Table C.1 Reliability of FVC, FEV_1, VC, MIP and MEP are shown in Table C.2, C.3. Good intratester reliability of FVC, FEV_1, VC, MIP and MEP values separated by a week are illustrated.

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Table D.1 Forced vital capacity (FVC), forced expired volume in 1 second (FEV_1) and vital capacity (VC) on week 1 and 2

Subject No.	FVC (Litre)		FEV_1 (Litre)		VC (Litre)	
	1st week	2nd week	1st week	2nd week	1st week	2nd week
1	2.07	2.38	2.16	2.17	2.45	2.50
2	2.48	2.48	2.13	2.07	2.01	2.07
3	1.99	2.01	1.77	1.88	2.13	1.92
4	2.01	1.95	1.72	1.74	1.91	2.02
5	3.07	2.98	1.97	2.14	1.26	1.55
6	2.09	2.15	1.88	1.95	2.06	2.05
7	2.33	2.50	2.05	2.01	2.31	1.98
8	1.73	1.82	1.61	1.68	1.94	1.91
9	2.16	2.14	1.94	1.89	2.26	2.20
10	2.14	2.18	2.02	1.99	2.18	2.19

Table D.2 Maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) on week 1 and 2

Subject No.	MIP (cmH_2O)		MEP (cmH_2O)	
	1st week	2nd week	1st week	2nd week
1	33	36	24	24
2	66	52	38	45
3	31	34	44	52
4	70	63	59	64
5	39	44	32	32
6	56	68	53	60
7	92	82	64	83
8	68	65	85	82
9	66	76	54	52
10	50	56	51	63

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Table D.3 Reliability of forced vital capacity (FVC), forced expired volume in 1 second (FEV_1), vital capacity (VC), maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) separated by a week

Tests		**$ICC_{3,1}$**
Pulmonary function test	FVC (Litre)	0.9440
	FEV_1 (Litre)	0.8990
	VC (Litre)	0.8263
Respiratory muscle strength	MIP (cmH_2O)	0.8811
	MEP (cmH_2O)	0.9292

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APPENDIX E

RESULT OF THE PILOT STUDY

The aim of this pilot study was to compare the mean value of pulmonary function test, respiratory muscle strength in obese and nonobese children. Twenty subjects participated in this pilot study. The subjects' characteristics are presented in Table E.1.

Table E.1 Characteristics of the subjects

	Obese group						Nonobese group				
No.	Gender	Age (yrs)	Ht (cm)	Wt (kg)	BMI (kg/m^2)	**No.**	Gender	Age (yrs)	Ht (cm)	Wt (kg)	BMI (kg/m^2)
O1	F	10	143	56	27.38	N1	F	10	150	38	16.89
O2	M	10	141	70	35.21	N2	M	11	138	31	26.28
O3	F	11	145	62	29.49	N3	M	10	141	48	24.14
O4	M	12	165	75	27.55	N4	M	11	146	35	16.42
O5	M	12	162	88	33.53	N5	F	11	133	30	16.96
O6	M	11	153	69	29.48	N6	F	11	142	45	22.32
O7	M	12	161	75	28.93	N7	M	10	142	34	16.86
O8	F	12	150	87	38.67	N8	M	11	136	33	17.84
O9	F	10	143	58	28.36	N9	M	10	126	22	13.86
O10	M	10	152	70	30.29	N10	M	10	131	28	16.32
Mean		11	151.5	71	30.89	**Mean**		10.5	139	34.4	17.79
SD		0.94	8.72	10.84	3.71	**SD**		0.53	7.21	7.73	3.07

Comparison of absolute means and standard deviations of pulmonary function test (FVC, FEV_1, VC, % FEV_1/FVC) and maximal respiratory pressure (MIP, MEP) in both groups are shown in Tables E.2-E.5.

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Table E.2 Comparison of means and standard deviations of absolute forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), vital capacity (VC) and ratio of FEV_1/ FVC

	Obese group	**Nonobese group**	
	Mean ± SD (L)	Mean ± SD (L)	*p*-value[a]
FVC	2.42 ± 0.29	1.94 ± 0.31	0.002*
FEV_1	2.31 ± 0.30	1.76 ± 0.30	0.001*
FEV_1/FVC ratio (%)	95.37 ± 2.60	90.29 ± 3.19	0.001*
VC	2.44 ± 0.33	2.06 ± 0.47	0.051

a; *p*-value from unpaired t-test

*; significant difference at $p<0.05$

Table E.3 Comparison of means and standard deviations of absolute maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP)

	Obese group	**Nonobese group**	
	Mean ± SD (cmH_2O)	Mean ± SD (cmH_2O)	*p*-value[a]
MIP	80.30 ± 25.71	77.30 ± 28.90	0.809
MEP	78.30 ± 24.09	76.70 ± 31.12	0.899

a; *p*-value from unpaired t-test

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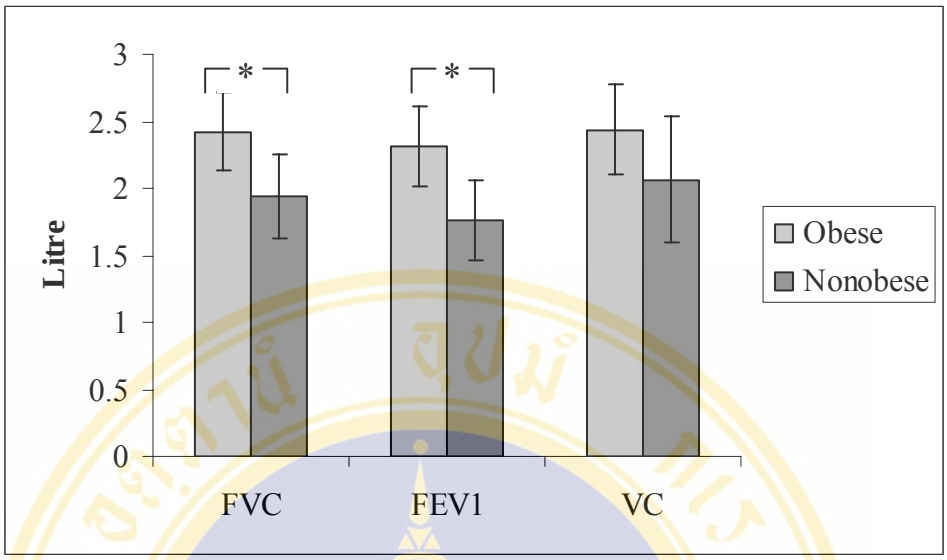

Figure E.1 Comparison of means and standard deviations of absolute forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and vital capacity (VC) (*statistically significant at $p < 0.05$).

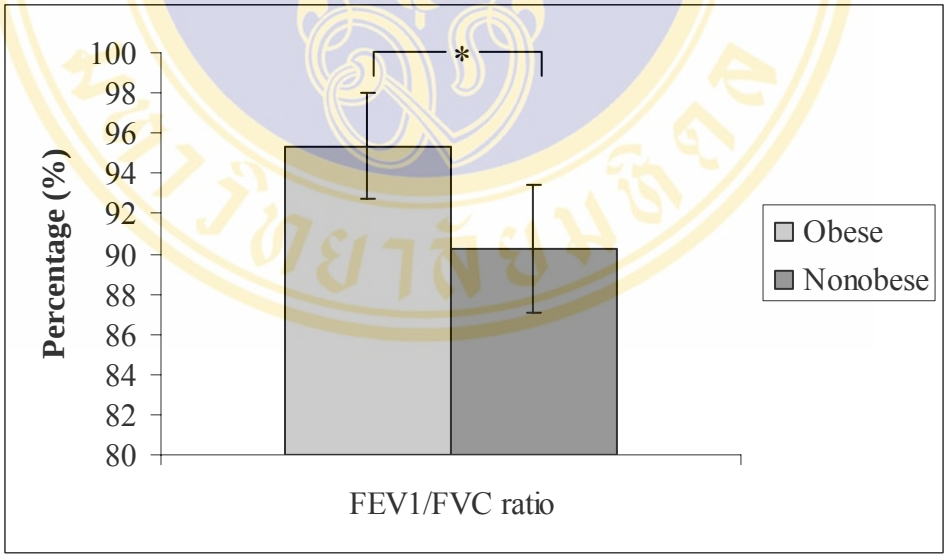

Figure E.2 Comparison of means and standard deviations of absolute ratio of FEV_1/ FVC (* statistically significant at $p < 0.05$).

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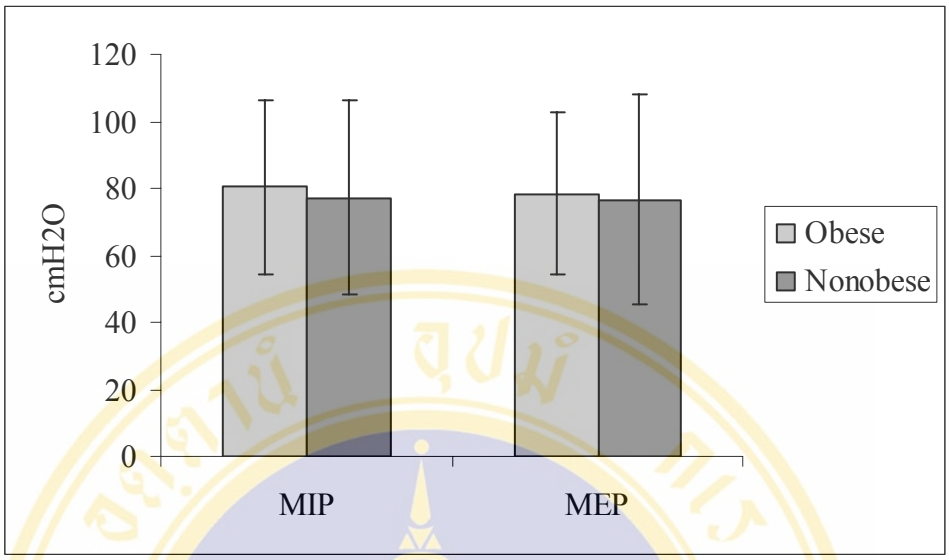

Figure E.3 Comparison of means and standard deviations of absolute maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP).

The correlation of physical activity level and pulmonary function test (FVC, FEV_1, VC, % FEV_1/FVC) and maximal respiratory pressure (MIP, MEP) in both groups are shown in Tables E.5-E.6.

Table E.4 The correlation of physical activity level and pulmonary function test (FVC, FEV_1, % FEV_1/FVC, VC)

	Physical activity level			
	Obese group		**Nonobese group**	
	Correlation coefficient	*p*-value[b]	Correlation coefficient	*p*-value[b]
FVC	-0.255	0.478	-0.007	0.984
FEV_1	-0.182	0.615	-0.007	0.984
VC	-0.034	0.927	0.420	0.227
FEV_1/FVC ratio (%)	-0.275	0.442	0.240	0.505

b; *p*-value from Spearman's rho

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Table E.5 The correlation of physical activity level and maximal respiratory pressure (MIP, MEP)

	Physical activity level			
	Obese group		**Nonobese group**	
	Correlation coefficient	*p*-value[b]	Correlation coefficient	*p*-value[b]
MIP	0.353	0.317	0.383	0.274
MEP	0.706	0.023*	0.406	0.245

b; *p*-value from Spearman's rho

*; correlation is significant at the 0.05 level (2-tailed)

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APPENDIX F

CALCULATION OF THE SAMPLE SIZE

The sample size for this study was calculated by the following equation

$$N = \frac{2S^2p[Z_{(1-\alpha/2)} + Z_{(1-\beta)}]^2}{(\mu_1-\mu_2)^2}$$

N = sample size for each subject group

S^2p = pooled variance

$\frac{S_1^2 + S_2^2}{2}$, if $n_1 = n_2$

n_1 = number of subject of obese group in the pilot study

n_2 = number of subject of nonobese group in pilot study

S_1^2 = variance of subject of obese group in the pilot study

S_2^2 = variance of subject of nonobese group in pilot study

$Z_{(1-\alpha/2)}$ = Z-value when set the confident level equal to 95% or significant level equal to 0.05 ($\alpha = 0.05$) = 1.96

$Z_{(1-\beta)}$ = Z-value when set the power of testing equal to 80% ($\beta = 0.2$) = 0.84

$\mu_1-\mu_2$ = the difference of means of parameter between obese group and nonobese group in the pilot study

From sample size calculation, the vital capacity (VC) is of concern for this study. Below is an example of sample size calculation using VC.

$$N\ (VC) = \frac{2S^2p[Z_{(1-\alpha/2)} + Z_{(1-\beta)}]^2}{(\mu_1-\mu_2)^2}$$

$$= \frac{2(0.16)[1.96+0.84]^2}{(2.44-2.06)^2}$$

$$= 16.58$$

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Accordingly, the appropriate sample size for each group in the present study is at least 17. Therefore appropriate statistical analyses, this study selected 30 subjects for each group to participate.

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APPENDIX G

RAW DATA OF THE STUDY

Table G.1 Characteristics of subjects

	Obese group						Nonobese group				
No.	Gender	Age (yrs)	Ht. (cm)	Wt. (kg)	BMI (kg/m^2)	**No.**	Gender	Age (yrs)	Ht. (cm)	Wt. (kg)	BMI (kg/m^2)
O1	M	10	141	70	35.21	N1	F	10	150	38	16.89
O2	F	11	145	62	29.49	N2	F	11	134	28	15.59
O3	M	12	150	59	26.22	N3	F	12	156	47	19.31
O4	M	10	141	62	31.18	N4	M	11	138	31	16.28
O5	M	12	159	81	32.04	N5	F	10	136	25	13.52
O6	F	11	144	69	33.27	N6	F	11	150	50	22.22
O7	M	11	143	64	31.29	N7	M	11	146	35	16.42
O8	M	12	157	76	30.83	N8	F	11	133	30	16.96
O9	M	11	153	69	29.48	N9	F	11	142	45	22.32
O10	F	12	158	70	28.04	N10	M	11	139	33	17.08
O11	M	12	157	84	34.08	N11	M	10	142	34	16.86
O12	M	11	143	58	28.36	N12	M	11	136	33	17.84
O13	F	12	160	99	38.67	N13	M	10	141	30	15.09
O14	F	12	154	68	28.67	N14	M	11	142	35	17.36
O15	F	11	147	72	33.32	N15	M	12	141	36	18.11
O16	M	12	160	73	28.52	N16	M	12	153	40	17.09
O17	F	12	150	87	38.67	N17	M	12	145	45	21.4
O18	F	10	143	58	28.36	N18	M	12	153	45	19.22
O19	F	11	150	75	33.33	N19	M	12	149	45	20.27
O20	M	11	147	62	28.69	N20	M	12	143	34	16.63
O21	M	10	152	70	30.29	N21	M	11	148	40	18.26
O22	M	10	155	63	26.22	N22	M	11	149	41	18.47
O23	M	10	142	65	32.24	N23	F	12	135	30	16.46
O24	F	10	148	68	31.04	N24	F	11	142	30	14.88
O25	M	10	147	62	28.69	N25	F	11	152	47	20.34
O26	M	11	150	66	29.33	N26	F	10	130	30	17.75
O27	M	11	158	70	28.04	N27	M	10	140	34	17.35
O28	M	12	155	69	28.72	N28	F	11	150	40	17.78
O29	M	12	150	66	29.33	N29	M	11	145	41	19.5
O30	M	12	147	60	27.77	N30	M	11	146	45	21.11

O = subject in the obese group

N = subject in the nonobese group

BMI = body mass index

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Table G.2 Pulmonary function of obese subjects

Subj. No.	FVC (L)	Pred FVC (L)	FEV_1 (L)	Pred FEV_1 (L)	FEV_1/FVC ratio (%)	Pred FEV_1/FVC ratio (%)	VC (L)	Pred VC (L)
O1	2.31	2.38	2.16	2.08	93.51	84	2.38	2.38
O2	2.39	2.38	2.24	2.24	93.72	84	2.33	2.38
O3	2.49	2.84	2.25	2.47	90.36	90	2.76	2.84
O4	2.38	2.38	1.95	2.08	81.93	84	2.57	2.38
O5	2.48	3.4	2.24	2.93	90.32	84	2.73	3.4
O6	2.38	2.28	2.09	2.14	87.81	92	2.62	2.28
O7	2.47	2.4	2.1	2.08	85.02	89	2.49	2.4
O8	2.89	3.48	2.52	3.1	87.19	91	2.7	3.48
O9	2.62	3.08	2.4	2.66	91.6	84	2.67	3.08
O10	3.21	3.15	2.95	2.94	91.9	92	2.94	3.15
O11	3.16	3.28	2.8	2.92	88.61	91	3.12	3.28
O12	2.16	2.4	1.78	2.08	82.41	89	3.54	2.4
O13	2.92	3.1	2.24	2.89	76.71	92	2.81	3.1
O14	2.74	2.79	2.36	2.63	86.13	92	2.64	2.79
O15	2.15	2.43	1.9	2.29	88.37	92	2.52	2.43
O16	3.26	3.48	2.9	3.1	88.96	91	3.55	3.48
O17	2.4	2.64	2.4	2.49	100.00	92	2.79	2.64
O18	1.76	2.23	1.68	2.09	95.45	92	1.86	2.23
O19	2.8	2.6	2.62	2.42	93.57	84	2.73	2.6
O20	3.18	2.68	2.22	2.33	69.81	84	2.77	2.68
O21	2.59	3.02	2.45	2.61	94.59	84	2.81	3.02
O22	3.43	3.14	3.04	2.71	88.63	84	3.34	3.14
O23	2.7	2.68	2.25	2.33	83.33	84	2.57	2.68
O24	2.18	2.51	1.99	2.35	91.28	84	2.32	2.51
O25	2.36	2.68	2.18	2.33	92.37	84	2.14	2.68
O26	3.37	2.96	2.49	2.56	73.89	84	3.21	2.96
O27	2.99	3.83	2.78	3.29	92.98	84	3.18	3.83
O28	3.34	3.42	2.72	3.04	81.44	91	3.18	3.42
O29	2.08	2.83	1.86	2.5	89.42	90	2.09	2.83
O30	2.73	2.65	2.62	2.32	95.97	90	2.88	2.65

O = subject in the obese group

N = subject in the nonobese group

Pred = predicted value

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Table G.3 Pulmonary function of nonobese subjects

Subj. No.	FVC (L)	Pred FVC (L)	FEV_1 (L)	Pred FEV_1 (L)	FEV_1/FVC ratio (%)	Pred FEV_1/FVC ratio (%)	VC (L)	Pred VC (L)
N1	2.31	2.60	2.11	2.42	91.34	84	1.85	2.60
N2	1.51	1.93	1.49	1.84	98.67	84	1.58	1.93
N3	2.54	2.87	2.39	2.64	94.09	89	3.00	2.87
N4	1.88	2.25	1.68	1.97	89.36	89	2.24	2.25
N5	1.43	1.87	1.36	1.72	95.10	91	1.51	1.87
N6	2.28	2.59	2.20	2.43	96.49	92	2.18	2.59
N7	2.38	2.61	2.19	2.27	92.02	90	2.27	2.61
N8	1.49	1.73	1.41	1.56	94.63	91	2.81	1.73
N9	1.97	2.18	1.71	2.04	86.80	92	2.05	2.18
N10	2.15	2.30	2.05	2.01	95.35	84	2.14	2.30
N11	2.13	2.43	1.97	2.12	92.49	84	2.13	2.43
N12	2.24	2.13	2.02	1.87	90.18	84	2.31	2.13
N13	2.23	2.43	2.08	2.12	93.27	84	2.12	2.43
N14	2.07	2.34	1.89	2.02	91.30	89	2.15	2.34
N15	1.93	2.29	1.59	1.96	82.38	89	1.84	2.29
N16	2.53	3.02	2.30	2.68	90.90	90	2.26	3.02
N17	2.47	2.52	2.10	2.20	85.02	90	2.16	2.52
N18	2.92	3.02	2.65	2.68	90.75	90	2.71	3.02
N19	2.54	2.77	2.25	2.44	88.58	90	2.34	2.77
N20	1.81	2.40	1.76	2.08	97.24	89	1.82	2.40
N21	2.69	2.71	2.34	2.38	86.99	90	2.48	2.71
N22	2.74	2.77	2.63	2.44	95.98	90	2.77	2.77
N23	2.01	1.82	1.90	1.66	94.53	91	1.88	1.82
N24	1.80	2.25	1.71	2.13	95.00	84	1.92	2.25
N25	2.67	2.68	2.56	2.49	95.88	84	2.79	2.68
N26	1.67	1.78	1.45	1.69	86.83	84	1.65	1.78
N27	1.98	2.38	1.95	2.08	98.48	84	2.16	2.38
N28	2.45	2.60	2.14	2.42	87.35	84	2.35	2.60
N29	2.05	2.68	1.93	2.33	94.15	84	1.89	2.68
N30	1.98	2.79	1.81	2.42	91.41	84	1.88	2.79

O = subject in the obese group

N = subject in the nonobese group

Pred = predicted value

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Table G.4 Maximal respiratory pressure of obese and nonobese subjects

Subj. No.	MIP (cmH_2O)	MEP (cmH_2O)	Subj. No.	MIP (cmH_2O)	MEP (cmH_2O)
O1	129	116	**N1**	49	31
O2	100	81	**N2**	48	59
O3	113	70	**N3**	102	86
O4	108	84	**N4**	106	119
O5	73	25	**N5**	91	45
O6	67	47	**N6**	115	102
O7	83	76	**N7**	81	70
O8	75	85	**N8**	63	66
O9	85	76	**N9**	58	57
O10	90	81	**N10**	80	45
O11	129	55	**N11**	121	127
O12	71	70	**N12**	101	108
O13	80	38	**N13**	98	98
O14	27	36	**N14**	78	29
O15	35	29	**N15**	73	78
O16	75	93	**N16**	95	68
O17	52	59	**N17**	83	87
O18	73	30	**N18**	97	87
O19	58	33	**N19**	67	71
O20	129	92	**N20**	89	63
O21	69	87	**N21**	75	78
O22	85	63	**N22**	64	52
O23	53	69	**N23**	69	46
O24	77	46	**N24**	62	81
O25	51	96	**N25**	105	85
O26	98	113	**N26**	42	60
O27	117	118	**N27**	102	65
O28	82	78	**N28**	66	43
O29	40	64	**N29**	121	81
O30	124	100	**N30**	98	66

O = subject in the obese group

N = subject in the nonobese group

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Table G.5 Physical activity level of obese and nonobese subjects

Obese group	Physical activity level	Nonobese group	Physical activity level
O1	Sufficiently active	**N1**	Inactive
O2	Inactive	**N2**	Inactive
O3	Sufficiently active	**N3**	Inactive
O4	Sufficiently active	**N4**	Insufficiently active
O5	Inactive	**N5**	Insufficiently active
O6	Insufficiently active	**N6**	Inactive
O7	Inactive	**N7**	Sufficiently active
O8	Insufficiently active	**N8**	Insufficiently active
O9	Inactive	**N9**	Insufficiently active
O10	Insufficiently active	**N10**	Inactive
O11	Insufficiently active	**N11**	Insufficiently active
O12	Insufficiently active	**N12**	Insufficiently active
O13	Inactive	**N13**	Insufficiently active
O14	Sufficiently active	**N14**	Sufficiently active
O15	Inactive	**N15**	Insufficiently active
O16	Sufficiently active	**N16**	Sufficiently active
O17	Inactive	**N17**	Sufficiently active
O18	Insufficiently active	**N18**	Sufficiently active
O19	Insufficiently active	**N19**	Insufficiently active
O20	Sufficiently active	**N20**	Insufficiently active
O21	Sufficiently active	**N21**	Insufficiently active
O22	Sufficiently active	**N22**	Sufficiently active
O23	Sufficiently active	**N23**	Insufficiently active
O24	Insufficiently active	**N24**	Inactive
O25	Sufficiently active	**N25**	Sufficiently active
O26	Insufficiently active	**N26**	Sufficiently active
O27	Inactive	**N27**	Sufficiently active
O28	Insufficiently active	**N28**	Insufficiently active
O29	Inactive	**N29**	Sufficiently active
O30	Sufficiently active	**N30**	Sufficiently active

O = subject in the obese group

N = subject in the nonobese group

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