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The Pulmonary Function and Respiratory Muscle Strength in Thai Obese Children

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ABSTRACT

Objective: This study was to compare the pulmonary function, respiratory muscle strength, and physical activity level between obese and non-obese children and to determine the correlation between pulmonary function, respiratory muscle strength and physical activity level in both child groups.

Methods: 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 non-obese 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), and 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.

Results: The results showed that FVC, FEV_1 and VC of the obese group were statistically higher than the non-obese group ($p<0.05$). FEV_1/FVC ratio of the obese group was statistically lower than the non-obese group ($p<0.05$). MIP and MEP were not significantly different between the groups ($p > 0.05$). Physical activity levels were not significantly different between the 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 non-obese 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 non-obese group showed no correlation with MIP and MEP ($r = 0.202$ and 0.006 respectively; $p > 0.05$).

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 non-obese group. In addition, FEV_1/FVC ratio of the obese group was lower than the non-obese 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 non-obese 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.

Keywords: Obese children; pulmonary function; maximal inspiratory pressure; maximal expiratory pressure; physical activity

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Childhood obesity is a common pediatric chronic illness in developing countries.[1,2] 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.[3] From 1996 to 2001, obese children had increased 15-36%.[4] 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. There are three major components to treat obesity which consist of dietary therapy, behavior therapy and increased physical activity.

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

A few studies have investigated pulmonary function and respiratory muscle strength in obese children and the results of these are controversial.[6] Nevertheless these studies were conducted in other countries. The standard pulmonary

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function and respiratory muscle strength depend on many factors such as gender, age, weight, height and nationality.[7] However, the respiratory muscle strength in Thai obese children have not been investigated. Therefore, a study on the pulmonary function and respiratory muscle strength in Thai obese children by comparing with normal children is interesting. The result of this study might be used to evaluate pulmonary abnormalities in obese children and to promote pulmonary related health among 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.[8] Additionally, this study investigated the physical activity of children by determination the correlation pulmonary function, respiratory muscle strength and physical activity level in both children groups.

MATERIALS AND METHODS

Thai healthy children aged between 10-12 years voluntarily participated in this study. The subjects were classified into two groups: obese group and non-obese group, according to the National Growth References for children under 20 years of age, Nutrition Division, Department of Health, Ministry of Public Health, Thailand.[9] The obese group consisted of children who had body weight more than 3 standard deviations whereas the non-obese group consisted of children who had body weight between -1.5 to +1.5 standard deviations by children who had the same height. The classification of subject used weight for height criteria because it is more reliable and better parameter to evaluate the growth of children.[10] The subjects met the inclusion criteria as follows: 1) healthy children both gender; 2) ability to understand verbal instruction and cooperate to test; and, 3) no prior experience with the procedures.

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), patent ductus arteriosus (PDA);
- Have structural abnormalities of upper airways including oral cavity, severe enough to interfere pulmonary function test;
- Have a history of thoracic, back or abdominal surgery.

Exclusion criteria evaluated from demographic information, medical history and all subjects were interviewed by examiners.

Instrumentations

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. The spirometer was calibrated by using a 3-liter calibration syringe (Cosmed, INC., Italy) daily before testing.

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 is expressed 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.

A bathroom scale was used to measure the subject's weight. It was calibrated daily before testing. A measurement tape that was attached the wall room and heighten from the floor 15 centimeters was used for height measurement.

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 subject' 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 were interviewed about a physical activity questionnaire for children aged 10-14 years old.[11] Then, the procedures of testing were clearly explained and demonstrated to each subject prior to data collection until the subject tried to perform accurately. The order of testing including VC, FVC, FEV_1, ratio of FEV_1/FVC, MIP and MEP would be randomized. The measurements of pulmonary function and respiratory muscle strength are described below.

Measurement of pulmonary function

Pulmonary function was tested following the guidelines recommended by the American Thoracic Society (ATS).[12] The subjects were asked to sit comfortably and wear a nose clip during the test. They will perform each test for three trials. Between each trial, the subjects rested at least 1 minute. A tester was verbally encouraging the subjects to achieve their 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 no Thai reference. Dejsomritrutai et al. in 2002 concluded the pulmonary function in Thai people was very much similar to the Chinese in Hong Kong. Normative data in this study preferred according to ATS.[13]

Measurement of respiratory muscle strength

The subject rested on a comfortable chair and the MIP or MEP was tested. MIP was determined from residual volume following a maximum expiration, called Muller maneuver. MEP also determined at total lung capacity following maximum inspiration, called Valsalva maneuver. MIP and MEP were measured 3 times per test. Each maneuver was separated by one minute resting period until the subject recover from exhaustion. The value of MIP and MEP was acceptable when the subject sustained breathing for at least 1 second. The highest value of MIP and MEP was chosen.

Assessment and evaluation of physical activity

Physical activity questionnaire for children aged 10-14 years old was used to evaluate physical activity level.

The self-report questionnaire consisted of seven questions that asked about physical activity. Level of physical activity was classified in three, namely: inactive, insufficiently active and sufficiently active.

Statistical analysis

Statistical analysis was calculated with the SPSS for Windows 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 muscles strength between the obese and the non-obese groups.

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 muscles strength and physical activity level in both groups.

RESULTS

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 non-obese 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 1. Both groups were similar in age but significantly different in height, weight and BMI ($p<0.05$).

The 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 non-obese 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 non-obese group showed no correlation with MIP and MEP ($r = 0.202$ and 0.006, respectively; $p > 0.05$).

DISCUSSION

Demographic data of sixty healthy children 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 non-obese group. In the present study, subjects in the obese group were usually more hypersthenic than the non-obese 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.[14] In the present study, subjects never performed pulmonary function and respiratory muscle strength before they were recruited in order to normalize learning effects which might not be equal among the subjects.

The results of pulmonary function test in Thai obese and non-obese children aged 10-12 years are shown in Table 2. The studies of Mallory et al, Marcus et al, and Li et al. found that FVC in obese children was higher than normal. However, Susiva et al. found that FVC in Thai obese children decreased when compared with predicted values but Inselman et al showed that FVC in obese children was normal and similar to this study. The present study found that FVC and VC in obese children were significantly higher than non-obese children but the values of FVC and VC of both groups were normal according to the interpretation of American Thoracic Society (ATS).

As for the FEV_1 value, Inselman et al. found that obese children had a low FEV_1 when compared to the normal group but the study of Mallory et al. showed that the FEV_1 was not changed. On the contrary, Marcus et al. and Li et al. 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 non-obese group. However, FEV_1 in both groups were within the 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. Therefore, the results in the present study did not show any pulmonary abnormality in obese children.

The normal value of FVC, FEV_1 and VC depends on the subject's stature, age, gender and race. Stature is best estimated with body height.[15] Nevertheless height should not be different between the groups because height is one of many factors which affect pulmonary function and respiratory muscle strength.[16,17] Taller subjects have higher lung volume and flows. However, in the present study

TABLE 1. Characteristics of subjects.

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

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

*; significant difference at $p<0.05$

TABLE 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 non-obese group.

Pulmonary function	Obese group Mean ± SD	Non-obese 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

TABLE 3. Comparison of means and standard deviations of absolute maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) between the obese and non-obese group.

Respiratory muscle strength	Obese group Mean ± SD (cmH_2O)	Non-obese 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

subjects' height in the obese group was higher than those in the non-obese group with the same age. Therefore, it is possible that the high FVC, FEV_1 and VC values are caused by height and not weight difference.

When the researcher arranged both groups of children to have the same heights, which consisted of ten children per group, 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 the non-obese children (p<0.05) but other pulmonary function parameters were not different between the two groups.

VC in the obese children was statistically higher than the non-obese children. It would be possible that the obese children in this study were usually stronger than normal children. Although, obese children had higher VC than normal children, it did not 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.

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.

Marcus et al.[17,22] 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

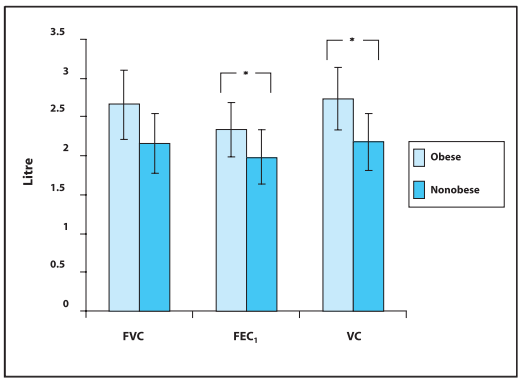


Fig 1. Comparison of means and standard deviations of absolute forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and vital capacity (VC) between the obese and non-obese group (* statistically significant at p < 0.05).

decreased from normal. In the present study, FEV_1/FVC ratio in the obese group was lower than the non-obese 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. Therefore, the obese children in the present study who had a low FEV_1/FVC ratio tend to observe airway obstruction higher than the non-obese children.

According to a review of the literature, there has not been any study on respiratory muscle strength in Thai children especially Thai obese children. However, studies on normal respiratory muscle strength from other countries can be roughly used to compare with the respiratory muscle strength in Thai children. The results of MIP and MEP in Thai children were lower than the results from other countries.[18,19] 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 non-obese children. With similar to Inselman et al., it was suggested that obesity with fat deposit did not involve respiratory muscle strength.[20] VC might also be improving 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 did not change from normal range. Therefore, the possible cause of a remained MIP and MEP was a normal VC.

Physical activity level between both groups was reportedly not different. 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 be different between the groups. Watching television is the most common leisure-time activity involving both physical inactivity and inappropriate food intake.[2,28]

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. Additionally, physical activity level had no correlation with MIP and MEP in both groups.

In the present study, the pulmonary function in both groups was significant difference but they were in normal ranges. Furthermore, the respiratory muscle strength in both groups was not differences.

TABLE 4. Comparison of physical activity level between the obese and non-obese groups.

Level group	Inactive	Insufficiently active	Sufficiently active	Total (n)	p-value[b]
Obese	6	13	11	30	0.725
Non-obese	9	10	11	30	

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

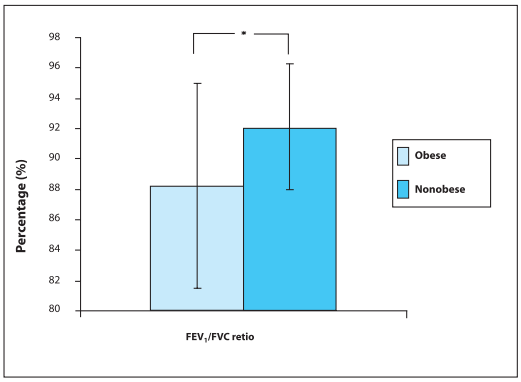


Fig 2. Comparison of means and standard deviations of absolute FEV_1/FVC ratio the obese and non-obese group (* statistically significant at $p < 0.05$).

Therefore, physical activity level between both groups was not different. This finding is similar to the Tang and colleague's study that both groups did not show a difference in lung function because they 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 used in the study might not be sufficient to detect the correlation.[21]

The data of this study provided the 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 important to provide 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 demonstrate more accurately the 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 because obesity is one of the strongest risk factors for these conditions in order to assess respiratory complications and risk factors in obese children.

Although, all parameters including pulmonary function of both groups were in normal range, obese children tend to have airway obstruction higher than non-obese children. Therefore, pediatricians should not only manage body weight but also be concerned of pulmonary abnormalities in obese children.

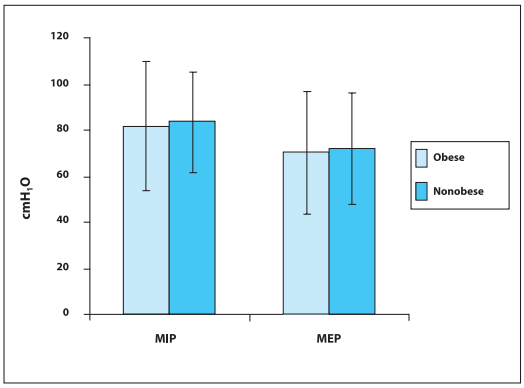


Fig 3. Comparison of means and standard deviations of absolute maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) between the obese and non-obese group.

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บทคัดย่อ

การศึกษาค่าสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจในเด็กไทยที่มีภาวะอ้วน

นพวรรณ จารุสุสินธ์ วท.บ.*, สุวรรณี จรูงจิตรอารี วท.ม.*, พิภพ จิรภิญโญ พ.บ., สายพิณ ประเสริฐสุขดี Ph.D.***

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วัตถุประสงค์: การศึกษาครั้งนี้มีจุดประสงค์เพื่อเปรียบเทียบค่าสมรรถภาพปอด, ความแข็งแรงของกล้ามเนื้อหายใจและระดับกิจกรรมในเด็กไทยที่มีภาวะอ้วนกับเด็กไทยที่มีน้ำหนักตัวปกติ รวมทั้งศึกษาความสัมพันธ์ระหว่างค่าสมรรถภาพปอด, ความแข็งแรงของกล้ามเนื้อหายใจกับระดับกิจกรรมของเด็กทั้งสองกลุ่ม

วิธีการ: เด็กไทยสุขภาพดีอายุระหว่าง 10-12 ปีเข้าร่วมการศึกษา 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

ผลการศึกษา: พบว่าค่า FVC, FEV_1 และ VC ในกลุ่มเด็กที่มีภาวะอ้วนมีค่าสูงกว่ากลุ่มเด็กที่มีน้ำหนักตัวปกติอย่างมีนัยสำคัญทางสถิติ ค่า FEV_1/FVC ratio ในกลุ่มเด็กที่มีภาวะอ้วนมีค่าต่ำกว่ากลุ่มเด็กที่มีน้ำหนักตัวปกติอย่างมีนัยสำคัญทางสถิติ ความแข็งแรงของกล้ามเนื้อหายใจเข้าและกล้ามเนื้อหายใจออกไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติระหว่างสองกลุ่ม ระดับกิจกรรมของเด็กทั้งสองกลุ่มไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ นอกจากนี้พบว่าไม่มีความสัมพันธ์กันอย่างมีนัยสำคัญทางสถิติระหว่างค่าสมรรถภาพปอด, ความแข็งแรงของกล้ามเนื้อหายใจกับระดับกิจกรรมในเด็กทั้งสองกลุ่ม

สรุป: การศึกษาครั้งนี้ทำให้ทราบข้อมูลของค่าสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจในเด็กไทยที่มีภาวะอ้วน โดยค่า FVC, FEV1 และ VC ในกลุ่มเด็กที่มีภาวะอ้วนมีค่าสูงกว่ากลุ่มเด็กที่มีน้ำหนักตัวปกติ ค่า FEV_1/FVC ratio ในกลุ่มเด็กที่มีภาวะอ้วนมีค่าต่ำกว่ากลุ่มเด็กที่มีน้ำหนักตัวปกติ โดยเด็กทั้งสองกลุ่มนั้นมีค่าสมรรถภาพปอดอยู่ในเกณฑ์ปกติ ซึ่งพบว่าเด็กอ้วนมีแนวโน้มที่จะเกิดภาวะทางเดินหายใจอุดกั้นได้มากกว่าเด็กที่มีน้ำหนักตัวปกติ ส่วนค่าความแข็งแรงของกล้ามเนื้อหายใจและระดับกิจกรรมระหว่างเด็กทั้งสองกลุ่มไม่มีความแตกต่างกัน นอกจากนี้ยังไม่พบความสัมพันธ์ระหว่างระดับกิจกรรมกับค่าสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจในเด็กทั้งสองกลุ่ม