



## Original article

## Association between the effects of body mass index on lung volumes among students in Jiangsu Province

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## ABSTRACT

**Introduction:** Obesity has been reported to develop lung problems and causes a significant medical health problem for the future of student's health.

**Material and methods:** This is a cross-sectional study among 255 581 students aged 7–22 years-old. Electronic spirometer device was used for diagnose of lung conditions, and ultrasonic scale machine (SY133) was used to measures body weight and height. BMI was calculated based on Chines Working Group on Obesity in China (WGOC) standard.

**Results:** Mean of lung capacity volume (mL), and the ratio of vital lung capacity and BMI (mL/kg) in males were significantly more than females ( $P < 0.001$ ), also the differences in lung volumes by gender was reported within the 13 cities in Jiangsu Province. Lung capacity (mL) was showed significant positive association with height ( $r = 0.70, P < 0.001$ ), weight ( $r = 0.60, P < 0.001$ ) in males and body height in females ( $r = 0.54, P < 0.001$ ), respectively. The significantly low, moderate positive association was reported in males lung capacity volume ( $P < 0.001$ ) compare with the negative association in females within the ratio of vital lung capacity and BMI ( $P < 0.001$ ). BMI, as reported, lowers association values of lung volume.

**Conclusions:** We found that age gender has significant effects on lung capacity volumes, and obese students were noticed lower lung volumes. Therefore, comprehensive intervention measures dominant by physical exercise should be adopted towards student's health.

## 1. INTRODUCTION

Obesity increases at an alarming rate in the world's population, including the Chinese communities.<sup>1–3</sup> It is estimated that 150 million adults and 15 million children are obese, and almost 30.4 million overweight or obese children and adolescents of China in 2010.<sup>4</sup>

Some studies show increasing of obesity incidents in China, owing to rapid economic development and dramatic transitions in lifestyle of Chinese populations.<sup>1–3,5</sup>

However, its cure has remained mostly ineffective, followed by the poor physical activities among students which reported causing numerous health problems, such as damaged lung function in children and adolescents.<sup>6</sup>

Lately, obesity reports cause a significant change in the respiratory system, resulting in loss on thoracoabdominal synchronism.<sup>7</sup> Despite the fact that other studies reported that obesity has a clear potential direct effect on respiratory function, since it increases oxygen consumption and carbon dioxide production,<sup>8</sup> and also appeared in causes of an adverse impact on lung volume and capacity, decreases the lung volumes and increase the incidence of asthma.

Recently, other data also showed that higher BMI is associated with increased forced lung capacity and forced expiratory volume during one second in females and males.<sup>9</sup> Furthermore, there was the exponential association between BMI and lung capacity had been reported in children at overweight and obese level.<sup>10,11</sup> Others researchers showed an inverse association between anthropometric variables with pulmonary values among fat adolescent boys in Baroda city, Gujarat.<sup>12</sup>

There is substantial evidence that the spirometric variables were an essential factor to identify the respiratory diseases. The reports show forced expiratory volume in one second and forced vital capacity, tend to decrease with increasing BMI,<sup>9,10</sup> however, there was a small, remarkable effect which has usually presented within the normal range in healthy people, children and obese adults.<sup>13</sup>

Moreover, such a strong association between lung capacities has been reported in decline by an average of the national level among students in Shandong University. Owing to the lack of adequate physical fitness activities among student, such as long-distance running, cycling, swimming, and another endurance exercise, etc.<sup>14</sup>

In spite of, the overwhelming number of published articles on influence of obesity on pulmonary function in worldwide.<sup>6–11,14</sup> More recently Musa et al. reported results increasing of BMI levels among students aged 7–22 years in Jiangsu province, which may have further future health consequences to student health status.<sup>3</sup>

However, studies investigating lung capacity in obese children and adolescent is few.<sup>14</sup> Hence, the present study was aimed to investigate the association between BMI and the lung capacity volumes in school children and adolescent in Jiangsu province, China.

In spite of, many articles have been published on influence of obesity on pulmonary function in the worldwide.<sup>10–12</sup> Even though, obesity has reported increasing among student

in Jiangsu Province,<sup>3</sup> furthermore, BMI was reported had reported effects on lung function that can reduce respiratory well-being, while others numerous studies have reports of the relationship between BMI and lung capacity in many areas, but yielded inconsistent results.<sup>1–3,13,14</sup>

But up-to-date there has never been a large study showing the association between BMI and the lung volumes among of students in Jiangsu Province, China, we consider more studies were required for the future of student's health.

## 2. AIM

This study aims to determine whether there is a relationship between lung capacity volumes values and BMI levels, height, weight among students aged 7–22 years old.

## 3. MATERIAL AND METHODS

### 3.1 Design

This study utilized cross-sectional analysis based on four-wave students' physical fitness and health surveillance database for years 2010–2013.

### 3.2 Study area

The study is conducted in Jiangsu province Jiangsu, the 3rd smallest province, which is located in the eastern-central coastal of the People's Republic of China, but the 5th most populous the most densely populated of the 23 provinces of the People's Republic of China (PRC), covering 102 600 km<sup>2</sup> with an approximate population of 74.058 million.

### 3.3 Participants

Participants were male and female students aged 7–22-year-old, who were participated voluntary in student's physical fitness and health survey. The exclusion criteria included students did not take part in lung capacity test and complete anthropometric measurements tests. Finally, a total of 127 866 males and 127 715 females students from 82 schools and 10 universities were participated in the study and completed the demographic characteristics of the study population as presented by Musa et al. (2017).<sup>3</sup>

### 3.4 Procedures

Ethical approval for the study was provided by from the Ethics Committee of Student's Health Literacy Promotion and Research, Jiangsu Province, China and Institutional Review Board of School of Public Health, Southeast University. Verbal informed consent was obtained from all surveillance before the study was conducted.

Before conducted lung capacity test, participants were requested to fill the basic demographic information.

Measurements of maximum breathing capacity were made on 255 581 Chinese students used the electronic spirometer to obtain the vital lung capacity and a ratio of lung capacity and BMI volumes for each subject. The overall measurement was performed by and well-trained physicians during the physi-

cal fitness and health survey. The lung capacity test was conducted by measuring how much air subjects can breathe out in one forced breath. While vital lung capacity per BMI refers to the ratio of vital capacity to body weight. The relative value of the ratio of lung capacity and body weight is reflected by reflecting the relative value of vital function per kilogram of body weight. Measurement of lung capacity (mL) and a ratio of lung capacity and BMI (mL/kg) was taken for the overall sample by following the guideline of student's health promotion activities and sport universal protocols.

Ultrasonic scale machine (Chines, SY133) was used to the height of the subject nearest 0.1 cm, while weight was measured to the nearest 0.1 kg with subjects wearing light school uniform, with empty pockets and without shoes. The BMI was calculated as body weight in kilograms divided by the square of height ( $\text{kg}/\text{m}^2$ ). All anthropometric equipment was calibrated before the assessment. BMI index cut-off points were calculated based on the Chinese Working Group on Obesity standard.<sup>15,16</sup> Well-trained health staff completed overall body measurements including height and weight during the period.

### 3.5 Data analysis

Data for the continuous variable are presented as mean  $\pm$  standard deviations. Comparison of the differences variables was tested using Student *t*-test or one-way analysis of variance. Pearson's correlation coefficient (*r*) was used or correlation test for the relationship between anthropometrics variables and lung capacity. All statistical analyses were performed using Statistical Package for Social Sciences (SPSS, v. 19.0, Chicago, Illinois, USA) with the level of significance set at 0.05 for all tests.

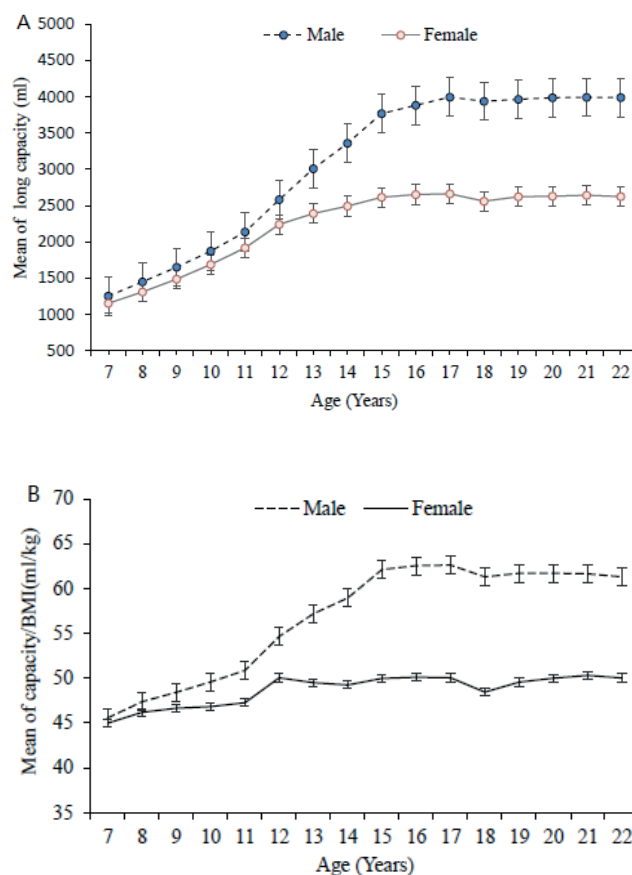
## 4. RESULTS

A total of 255 581 schoolchildren and adolescents aged 7–22-year-old were involved in the study with male 127 866 and female 127 715, respectively. Males groups had a higher mean of lung capacity (A) and ratio of lung capacity and BMI (B) when compared with the female's student (Figure 1).

The relationship between anthropometrics and lung capacity regarding Pearson correlation is shown in Table 1.

**Table 1. Correlation between anthropometrics and lung capacity volume by gender.**

Study variables	Pearson correlation		<i>P</i> value
	Males	Females	
<b>Lung capacity (mL)</b>			
Height, m	0.70	0.54	<0.001
Weight, kg	0.60	0.49	<0.001
BMI, $\text{kg}/\text{m}^2$	0.30	0.29	<0.001
<b>Ratio of lung capacity and BMI (mL/kg)</b>			
Height, m	0.03	0.06	<0.001
Weight, kg	-0.08	-0.20	<0.001
BMI, $\text{kg}/\text{m}^2$	-0.32	-0.31	<0.001



**Figure 1. Mean of Lung capacity (A) and Lung capacity/BMI (B) values in male and female.**

There was the strong positive correlation between body height and lung capacity (mL) in male compared with moderate positive associations with female students ( $P < 0.001$ ). Furthermore, significant weak negative correlations between BMI and ratio of lung capacity and BMI with males and females ( $P < 0.001$ ).

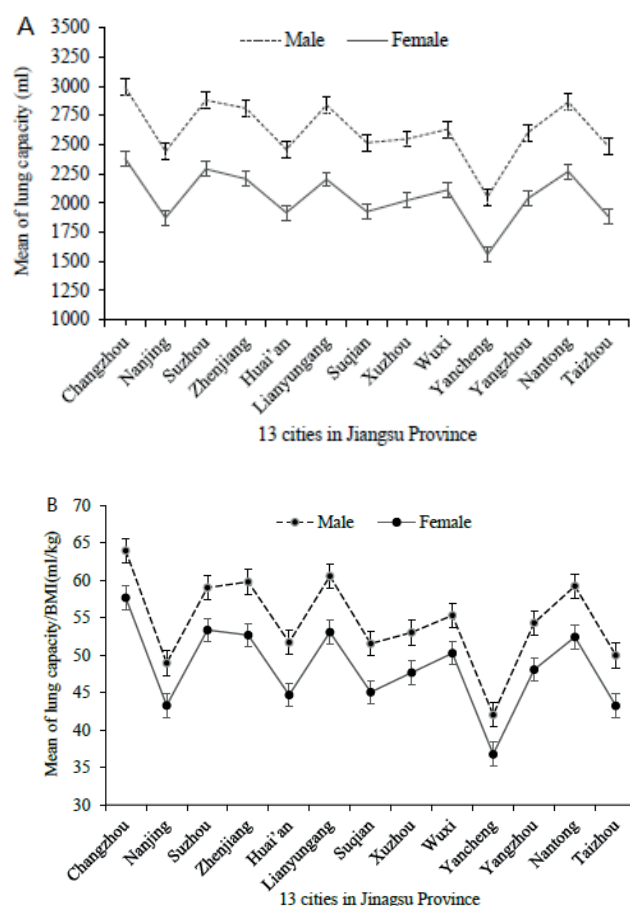
The stratification of lung volume by age groups shows in Table 2. The reported average of lung capacity measurement in male groups had the higher significant average mean of

**Table 2. The effect of age groups (years) on lung capacity by gender.**

Variables	Males (127866)	Females (127715)	<i>P</i> value
	Mean $\pm$ SD	Mean $\pm$ SD	
<b>Lung capacity (mL) by age groups</b>			
7–11	1671.84 $\pm$ 485.17	1510.77 $\pm$ 450.18	<0.001
12–14	2981.43 $\pm$ 745.81	2373.79 $\pm$ 579.69	<0.001
15–17	3880.34 $\pm$ 798.53	2642.25 $\pm$ 596.24	<0.001
18–22	3972.67 $\pm$ 772.30	2615.18 $\pm$ 543.80	<0.001
<b>Lung capacity/BMI (mL/kg) by age groups</b>			
7–11	48.35 $\pm$ 14.86	46.38 $\pm$ 14.19	<0.001
12–14	56.92 $\pm$ 14.27	48.31 $\pm$ 12.99	<0.001
15–17	62.41 $\pm$ 13.27	50.04 $\pm$ 11.73	<0.001
18–22	61.52 $\pm$ 12.21	56.38 $\pm$ 15.59	<0.001

**Table 3. Effect of BMI level on lung capacity by gender.**

Variables, BMI groups	Mean ± SD	F value	P value
<b>Males, lung capacity (mL), BMI level</b>			
Normal weight	3605.39 ± 988.21	275.87	<0.001
Over weight	3672.08 ± 1142.20		
Obesity	3277.32 ± 1233.73		
Total	3589.52 ± 1044.03		
<b>Females lung capacity (mL), BMI level</b>			
Normal weight	2469.44 ± 657.31	85.41	<0.001
Over weight	2557.35 ± 724.20		
Obesity	2305.74 ± 828.54		
Total	2472.53 ± 674.28		
<b>Males, lung capacity/BMI (mL/kg)</b>			
Normal weight	62.23 ± 13.149	6.87	<0.001
Over weight	52.59 ± 11.571		
Obesity	43.287 ± 11.06		
Total	58.93 ± 14.06		
<b>Females, lung capacity/BMI (mL/kg)</b>			
Normal weight	50.12 ± 11.79	1.80	<0.001
Over weight	42.52 ± 9.93		
Obesity	36.49 ± 9.75		
Total	48.72 ± 12.03		

**Figure 2. Mean differences in lung capacity (A) and lung capacity/BMI (B) values in 13 cities in Jiangsu Province, by gender.**

lung capacity and ratio of lung capacity and BMI compared with female groups within the different age groups.

Results showed significantly different effects in lung capacity and ratio of lung capacity and BMI among male and females students with different BMI levels ( $P < 0.001$ ) and higher average mean were reported in males compared with female. Moreover, the average of lung capacity and ratio of lung capacity and BMI was significantly lower among male and female in obese group (Table 3).

There is significant difference in lung capacity and ratio of capacity and BMI values in males and females student within 13 cities in Jiangsu province as showed presented in (Figure 1).

## 5. DISCUSSION

An increase in the rate of obesity among the population has been observed around the world. Also, the recent reports estimate that increasing of overweight and obesity among students in Jiangsu Province,<sup>3</sup> however, there is no doubt that might be a reasons of lack of physical inactivity among student have a direct effect on respiratory well-being,<sup>8</sup> furthermore have a strong association in effecting the lung volume.<sup>9</sup>

There is the significant difference in mean lung capacity in males and females of detected from age 7 to 22 year-old in Jiangsu Province, and males student has better lung capacity volume than females. However, the previous study has reported the total lung capacity volume was lower in males, and females compare with body weight.<sup>6</sup>

Our study is unique in that it shows the influence of BMI on lung capacity by age, gender and different BMI level.

The study outcome also proves the results of many other studies on lung capacities carried out in the worldwide. Such as among a Mediterranean population,<sup>16</sup> Malaysian students in university students in Malaysia,<sup>17</sup> and among different parts of the Indian subcontinent,<sup>18</sup> and among healthy Chinese subjects,<sup>19</sup> and among non-smoking student in Aga University in Pakistan,<sup>20</sup> whereas indicate that there is a significant difference in lung capacity volume and ratio of lung capacity and BMI with anthropometric parameters in males and females within different ethnic groups at school aged. While the effects of obesity on spirometric values are not consistent with most of the studies, some studies showing no results,<sup>10,21</sup> some additional showing significant effects and variation between the averages mean of lung capacity volumes.<sup>11,13</sup> Our study is set as one that shows the effects BMI on lung capacity among the participants by age, gender and different BMI level. However, the results show that lung capacity is linked to a declining in physical fitness and reported decreased with an increased average of body weight.<sup>22</sup> The finding of current reports indicated that the mean of; lung capacity volume decreased by an increase in BMI, which is in agreement with previous studies, which showed the significantly reducing of lung volumes by increased of BMI.<sup>10</sup> A comparable findings were obtained by other studies that, the increases in BMI in adolescents was associated with decreased pulmonary function rate.<sup>21</sup>



The current endeavor discovered that there is an essential correlation coefficient of lung capacity volume with body weight and BMI between both male and female adolescents. Similar findings have been reported previously.<sup>23,24</sup>

The difference between the rates of lung capacity is most likely support the lung capacity score in college students in Shandong Province.<sup>14</sup>

Although the study measured the lung capacity score for students from the diverse geographical site, regions, gender, age groups, and differences BMI level, it may be necessary some limitations. The study did not include all pulmonary function tests in children and adolescent students such as lung-forced vital capacity, forced expiratory flow 25% to 75%, peak expiratory flow, vial residual capacity volume, maximum voluntary ventilation, functional residual capacity, and expiratory reserve volume during the follow-up programme. Therefore, further investigations are still required to establish the association of gender, age, height and weight with lung capacity in a more detailed manner and including additional variables to assess the effect of obesity on lung capacity.

## 6. CONCLUSIONS

The study found BMI has significant effects on lung volumes; obesity causes a significant decrease of the lung volumes among schoolchildren and adolescents. Furthermore, obese students have low vital lung capacity volumes. Thus, increasing physical fitness activities may further avoid the decline rate of lung capacity volume, while more studies on BMI and lung should continue among students, followed by comprehensive intervention measures for student's physical exercise.

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## Conflict of interest

The authors declare that do not have any conflict of interest to declare.

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