Original Article

# Overweight, Obesity, and Lung Function in Children and Adults—A Meta-analysis

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***What is known about the topic?*** Overweight and obesity are associated with changes in lung function in children, adolescents, and adults. However, there is some conflicting evidence on whether these changes differ by age group, sex, or asthma status.

***What does this article add to our knowledge?*** We provide comprehensive pooled estimates of the effect of obesity on lung function, stratified by age group (pediatrics vs adults) and asthma status. Moreover, we use meta-regression to evaluate the role of age and gender in these associations.

***How does this study impact current management guidelines?*** Detrimental changes in lung function constitute yet another complication of obesity. These changes differ by age, sex, and asthma status; clinicians should take these characteristics into account when evaluating obesity and lung function.

**BACKGROUND: There is conflicting evidence on the effect of obesity on lung function in adults and children with and without asthma. We aimed to evaluate the relation between overweight or obesity and lung function, and whether such relationship varies by age, sex, or asthma status.**
**METHODS: We searched PubMed, Scopus, CINAHL, Cochrane, and EMBASE for all studies (in English) reporting on obesity status (by body mass index) and lung function, from 2005 to 2017. Main outcomes were forced expiratory volume in 1 second ($FEV_1$), forced vital capacity (FVC), $FEV_1$/FVC, forced expiratory flow between 25th and 75th percentile of the forced vital capacity ($FEF_{25-75}$), total lung capacity (TLC), residual volume (RV), and functional residual capacity (FRC). Random-effects models were used to calculate the pooled risk estimates; each study was weighed by the inverse effect size variance. For each outcome, we compared overweight or obese ("obese") subjects with those of normal weight.**
**RESULTS: All measures of lung function were decreased among obese subjects. Obese adults showed a pattern (lower $FEV_1$, FVC, TLC, and RV) different from obese children (more pronounced $FEV_1$/FVC deficit with unchanged $FEV_1$ or FVC). There were also seemingly different patterns by asthma status, in that subjects without asthma had more marked decreases in $FEV_1$, TLC, RV, and FRC than subjects with asthma. Subjects who were obese (as compared with overweight) had even further decreased $FEV_1$, FVC, TLC, RV, and FRC.**
**CONCLUSIONS: Obesity is detrimental to lung function, but specific patterns differ between children and adults. Physicians should be aware of adverse effects of obesity on lung function, and weight control should be considered in the management of airway disease among the obese.**  **(J Allergy Clin Immunol Pract 2017;■:■-■)**

***Key words:*** *Obesity; Childhood obesity; Lung function; Asthma; Meta-analysis*

The worldwide epidemic of obesity is a major public health problem, particularly in industrialized countries. Obesity is associated with numerous complications, including multiple detrimental effects on the respiratory system.[1] Several plausible mechanisms have been proposed to explain the observed association between obesity and respiratory symptoms, such as decreased total respiratory system compliance, increased airway resistance, reduced lung volumes, and altered ventilation and gas exchange.[2,3] Overweight and obesity have also been associated with higher incidence of asthma,[4] asthma morbidity, and resistance to therapy.[5] Evidence shows that weight gain precedes the development of asthma symptoms[6] and that obese individuals have later decreases in lung function.[7] Conversely, weight loss results in improvement of asthma-related health outcomes in adults.[8,9]

In adults, an inverse association between body mass index (BMI) and lung volumes indicates that obesity leads to a

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*Abbreviations used*
- *BMI- Body mass index*
- *CI- Confidence interval*
- *$FEF_{25-75}$- Forced expiratory flow between 25th and 75th percentile of the forced vital capacity*
- *$FEV_1$- Forced expiratory volume in 1 second*
- *FRC- Functional residual capacity*
- *FVC- Forced vital capacity*
- *RV- Residual volume*
- *TLC- Total lung capacity*
- *WC- Waist circumference*
- *WHR- Waist-to-hip ratio*
- *WMD- Weighted mean difference*

restrictive lung deficit.[10,11] However, some studies have also reported slightly lower forced expiratory volume in 1 second/forced vital capacity ($FEV_1$/FVC) in adults with asthma.[12] On the other hand, several studies in children have reported that increased BMI is associated with normal, or even increasing, $FEV_1$ and FVC but low $FEV_1$/FVC, consistent with either an obstructive deficit or airway dysanapsis,[13,14] with some reports showing differences by sex.[15] Yet other studies have shown findings in children that may be suggestive of a restrictive deficit, which may be more similar to findings reported in adults.[16-18] Such inconsistencies may partly be due to differences among study populations and outcome measures. More importantly, they suggest that the association between obesity and lung function may differ between children and adults. In this meta-analysis, we aim to further elucidate the relationship between overweight or obesity and lung function, and whether such relationship differs by age group or by asthma status.

## METHODS

We prospectively registered the protocol for this meta-analysis on July 10, 2015, at http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42015023193.

### Search and selection criteria

We searched PubMed, Scopus, CINAHL, and the Cochrane Database for all studies reporting obesity status and lung function in human subjects, published in English from 2005 (standardization of spirometry[19]) to January 2017, using the following keywords: ("Body Mass Index" OR "BMI" OR "percent body fat" OR "body fat distribution" OR "Waist Circumference" OR "Obesity" OR "Overweight" OR "Waist-hip ratio" OR "Adiposity" OR "abdominal obesity") AND [("FEV1" OR "FVC" OR "$FEV_1$/FVC" OR "FEF2575" OR "PEFR" OR "TLC" OR "RV/TLC" OR "FRC" OR "lung function" OR "spirometry") NOT ("cystic fibrosis" OR "COPD" OR "cancer")].

Inclusion criteria were: (1) observational studies of children or adults with assessments of obesity and lung function; or (2) baseline data from experimental studies focused on obesity and lung function. Exclusion criteria were: (1) studies focused on cystic fibrosis or chronic obstructive pulmonary disease; (2) studies that included diseases or therapies that may affect the lung function of subjects (eg, cancer, radiotherapy); and (3) obesity secondary to specific diseases (eg, hypothyroidism, hypertension) or medical treatments. Our primary outcomes were spirometry measures ($FEV_1$, FVC, $FEV_1$/FVC, and forced expiratory flow between 25th and 75th percentile of the forced vital capacity

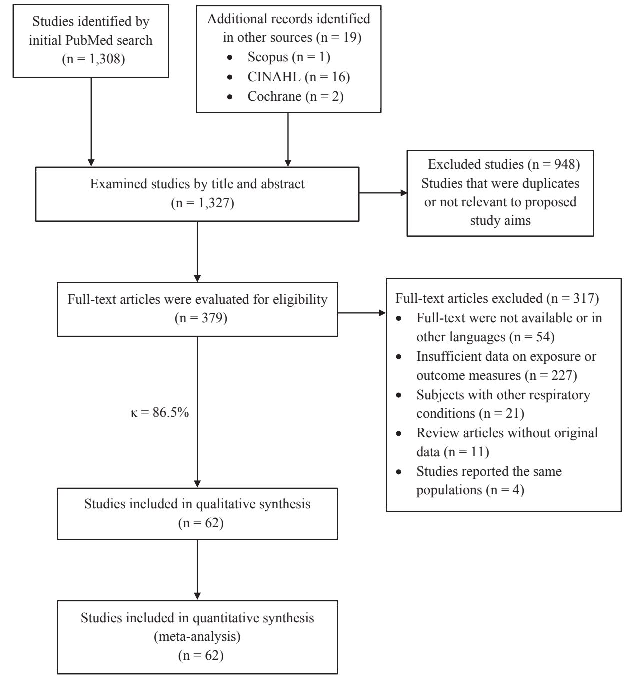


**FIGURE 1.** Study selection flowchart. $\kappa$ = kappa agreement coefficient.

[$FEF_{25-75}$]). Secondary outcomes were measures of lung volume (total lung capacity [TLC], residual volume [RV], RV/TLC, and functional residual capacity [FRC]). Study subjects were classified as "normal weight (reference group)," "overweight," or "obese" by BMI (*z*-score in children and $kg/m^2$ in adults). Central or abdominal obesity was defined by waist circumference (WC) or waist-to-hip ratio (WHR).

### Data abstraction and data analysis

The study was performed following the recommendations for reporting meta-analyses of observational studies by the Meta-analysis of Observational Studies in Epidemiology group[20] and the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines.[21] Titles, abstracts, contexts, and citations were independently assessed and analyzed by 2 investigators (Y-YH and JM). Disagreements were resolved through a mediator (EF).

For all outcomes analyzed, we calculated the pooled $\beta$ coefficients (weighted mean difference [WMD]) and 95% confidence intervals (CI) using random-effects models to address the heterogeneity across the included studies. Each study was weighted by its inverse effect size variance. Some studies were included more than once when they had several comparisons (eg, overweight vs normal weight, and obese vs normal weight) or strata (eg, males and females, children [$\leq$18 years] and adults [$>$18 years]). Egger's test and funnel plots with pseudo 95% CI were used to examine small-study effects and publication bias. When possible, meta-regression was performed to explore potential sources of heterogeneity and test whether certain characteristics (eg, age-group, sex distribution) modify the effect of obesity on lung function; meta-regression was performed only when $\geq$10 studies reported a specific characteristic. All analyses were performed using STATA v13 (StataCorp, College Station, Tex).