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Original Article

The Relationship between Obesity and Lung Function in Adults: A Systematic Review

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ABSTRACT

Background: The purpose of this study was to systematically evaluate studies assessing the association between obesity and lung function in adult individuals.

Methods: This systematic review conducted a comprehensive search of databases, including PubMed, Scopus, ScienceDirect, EMBASE, ProQuest, and Google Scholar, up to 30 June 2021. Keywords used were: "obesity," "overweight," "breathing function," "respiratory function," "breathing physiology," and "breathing disorders." Study selection, data extraction, and quality assessment were conducted independently by two reviewers.

Results: Sixteen articles met the inclusion criteria: eight cohort studies, four case-control studies, and four cross-sectional studies.

Conclusion: Based on the Critical Appraisal Skills Programme (CASP) quality assessment tools, all included studies were rated as high quality, except for one cohort study (approximately 6% of the total), which was rated as moderate quality. According to the results of these 16 studies, there is a strong inverse correlation between obesity severity and certain lung volumes and capacities in adults.

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Introduction

Respiratory function reflects the coordinated activity of the lungs, chest wall, and respiratory musculature [1]. Parameters such as lung volumes and capacities, measured using various devices including spirometers and plethysmographs, are used to assess respiratory function. Several factors, including obesity, can affect respiratory function [2–4]. Obesity increases oxygen demand and carbon dioxide production while reducing respiratory compliance, thereby increasing the mechanical effort required for breathing [4]. Today, obesity is recognized as one of the growing public health problems worldwide [5–7].

Obesity, defined as the abnormal accumulation of body fat, is a rising global public health concern [5,7,8]. In individuals with obesity, alterations in thoracoabdominal mechanics impede diaphragm descent and rib cage movement, both essential components of effective ventilation [8]. Consequently, lung volumes decrease, chest wall mechanics are altered, and airway resistance may increase [9,10]. Previous studies have shown that obesity is associated with reduced static lung volumes, whereas spirometric pulmonary volumes and airflow remain within the normal range except in cases of severe obesity [2–4]. Commonly reported respiratory changes in overweight and obese adults include reductions in functional residual capacity (FRC), expiratory reserve volume (ERV), total lung capacity (TLC), residual volume (RV), and respiratory system compliance [11], along with decreases in forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) [12–14], and maximal voluntary ventilation (MVV) [6,15,16].

Obesity is also associated with sleep-disordered breathing, cardiometabolic disease, and elevated risks for certain cancers [6,8,14,17,18]. Chronic lung disease can be fatal; even mild pulmonary dysfunction, which may not be clinically apparent, predicts both respiratory and all-cause mortality [19–22]. The mechanisms through which lung diseases contribute to early mortality from other conditions are not fully understood. Still, researchers suggest that muscle wasting, autonomic dysfunction, systemic inflammation, and oxidative stress may play important roles [20]. Studies also indicate that both underweight and overweight individuals exhibit reduced ventilatory performance [10].

Effective lung function relies on the coordinated activity of all components of the respiratory system. The worldwide rise in obesity has become a major public health concern, particularly in developed countries [23]. Numerous studies have demonstrated that higher body mass index (BMI) is associated with reduced lung volumes [24–28]. In 2014, a systematic review examined the relationship between obesity and alterations in lung volumes and capacities among children and adolescents [8]. The findings indicated that obese participants exhibited lower lung volumes and capacities compared with their healthy counterparts. Despite this, no systematic review has yet specifically focused on the association between obesity and pulmonary function in obese adults. This underscores the need for a comprehensive review to assess obesity-related respiratory impairments, highlight the importance of understanding their effects, and critically evaluate the existing evidence. Accordingly, the present systematic review investigates the relationship between obesity and lung function in adults and identifies the respiratory parameters most affected by excess body weight.

Methods and Materials

Data Source and Search Strategy

This systematic review adhered to the PRISMA reporting guidelines [30] (Fig. 1). Articles published in English up to 30 June 2021 were considered. Searches were conducted in PubMed/MEDLINE, Scopus, ScienceDirect, EMBASE, ProQuest, and Google Scholar. Reference lists of included studies were screened to identify additional relevant publications. Search terms included combinations of "obesity," "central obesity," "visceral obesity," "overweight," "lung function," "pulmonary function," "respiratory function," "breathing function," "breathing physiology," and "breathing disorders." The study protocol was prospectively registered in PROSPERO (CRD42021238652).

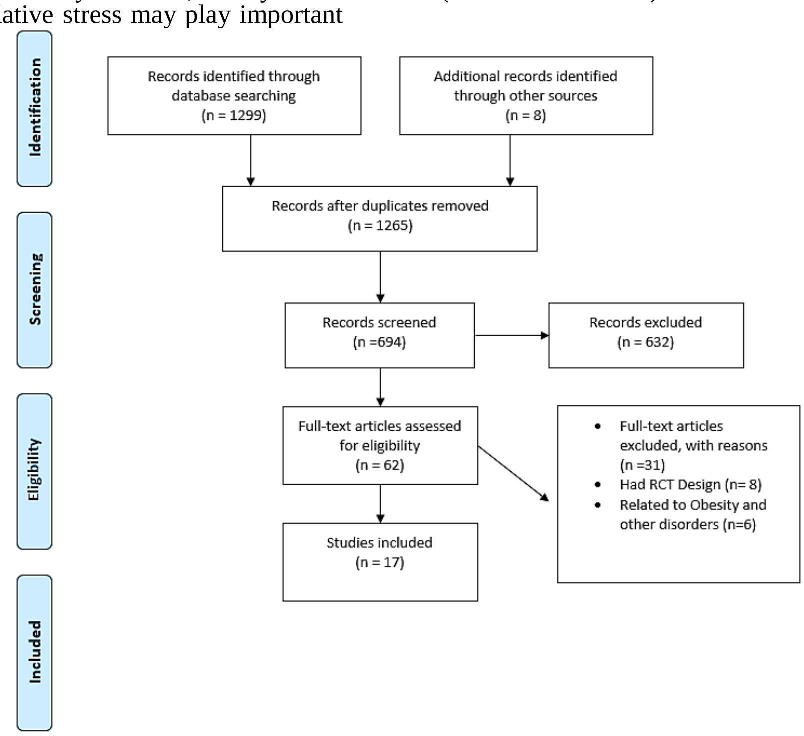

Figure 1: Search Strategy Flowchart

Study Selection

The inclusion criteria for this review specified that only studies published in English were considered. Eligible studies involved adult participants aged 18 years or older who were classified as obese and did not present with major underlying diseases. Additionally, studies were required to report at least two pulmonary function outcomes, such as vital capacity (VC), tidal volume (VT), functional residual capacity (FRC), total lung capacity (TLC), residual volume (RV), expiratory reserve volume (ERV), forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), or maximal voluntary ventilation (MVV). Only observational designs—including cohort, cross-sectional, and case-control studies—were included.

The PEO framework was applied as follows: P: obese adults; E: pulmonary function tests; O: pulmonary function parameters such as VC, VT, FRC, TLC, RV, ERV, total respiratory system compliance, FVC, FEV_1, and MVV.

Exclusion criteria were applied to studies that did not meet these conditions. Specifically, studies published in languages other than English and randomized controlled trial protocols were excluded. Abstracts published solely in conference or seminar proceedings were also excluded, along with studies that assessed pulmonary function exclusively during physical activity.

Data Extraction and Methodological Quality

Two reviewers (FR, KHK) independently extracted data. A third reviewer (NP) verified the extracted information and removed duplicates. Disagreements regarding the eligibility of publications for inclusion were resolved through group consensus.

The quality of the selected studies was assessed using the Critical Appraisal Skills Program (CASP) tool. A discussion panel comprising all authors was convened to resolve any inconsistencies in the evaluation outcomes. The CASP checklists, freely available under a Creative Commons License on the CASP UK website, were used to guide this appraisal [31].

The tool includes 11 questions for case–control and cross-sectional designs and 12 questions for cohort studies. The first two items serve as rapid screening questions; if both are answered "yes," reviewers proceed to the remaining items. Most questions can be answered with "yes," "no," or "can't tell," and some items overlap.

Studies achieving at least 75% of the total possible score were classified as "high quality," those scoring between 50% and 75% as "moderate quality," and those scoring below 50% as "low quality" [32]. A summary of the CASP evaluations is presented in Tables 1–3.

Table 1: Critical Appraisal Skills Program (CASP) Assessment of the Methodological Quality of Cohort Studies

Study Criterion	Chen 1993	Lazerus 1997	Canoy 2004	Jones 2006	Thyagarajan 2008	Saliman 2008	Saxena 2009	Sutherland 2016	Choe 2018
Clearly focused issue	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Acceptable recruitment	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exposure accurately measured to minimize bias	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Outcome accurately measured to minimize bias	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Confounding factors identified	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Confounding factors in the design and/or analysis accounted	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Complete follow-up	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes
Follow-up duration	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes
Results	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Precision of the results	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Reliability of the results	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ability to generalize results	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Interpretation related to the existing evidence	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Practical implication	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total score	14	14	14	10	14	12	12	14	12
Quality Level	High	High	High	Moderate	High	High	High	High	High

Table 2: Critical Appraisal Skills Program (CASP) Assessment of the Methodological Quality of Cross-Sectional Studies

Study Criterion	Wei 2010	Gabrielsen 2011	Rasool 2012	Pekkarinen 2012
Clearly focused questions/issues	Yes	Yes	Yes	Yes
Appropriate method	Yes	Yes	Yes	Yes
Clearly described the method of subject selection	Yes	Yes	Yes	Yes
Sample selection bias	Yes	Yes	Yes	Yes
Ability to generalize to the population	Yes	Yes	Yes	Yes
Satisfactory response rate	Yes	Yes	Yes	Yes
Validity and reliability of measurements	Yes	Yes	Yes	Yes
Assessment of statistical significance	Yes	Yes	Yes	Yes
Explanation of confidence interval	Yes	Yes	No	No
Confounding factors accounted	Yes	Yes	Yes	No
Ability to generalize results	Yes	Yes	Yes	Yes
Total score	11	11	10	9
Quality Level	High	High	High	High

Table 3: Critical Appraisal Skills Program (CASP) Assessment of the Methodological Quality of Case–Control Studies

Study Criterion	Naimark 1960	Zerah 1993	Ceylan 2009	Steier 2014
Clearly focused issue	Yes	Yes	Yes	Yes
Appropriate method	Yes	Yes	Yes	Yes
Acceptable recruitment	Yes	Yes	Yes	Yes
Acceptable control	Yes	Yes	Yes	Yes
Exposure accurately measured to minimize bias	Yes	Yes	Yes	Yes
Groups treated equally	Yes	Yes	Yes	Yes
Confounding factors accounted	Can't tell	Can't tell	Can't tell	No
Treatment effect	Yes	Yes	Yes	Yes
Precision of treatment effect	Yes	Yes	Yes	Can't tell
Reliability of the results	Yes	Yes	Yes	Yes
Ability to generalize results	Yes	Yes	Yes	Yes
Interpretation related to the existing evidence	Yes	Yes	Yes	Yes
Total score	11	11	12	10
Quality Level	High	High	High	High

The initial search yielded 1,307 records. After removing duplicates, 1,265 unique records were screened. Based on the title and abstract review, 637 studies were excluded. A full-text review identified 17 studies meeting the inclusion criteria: nine cohort studies, four case-control studies, and four cross-sectional studies.

CASP evaluations indicated that all but one cohort study were rated as high quality (Tables 1–3); the remaining study was categorized as moderate quality (≈6% of included studies) [12].

Body mass index (BMI) was the most commonly used marker of adiposity [9,12,13,16,24,25,28,33–36]. Additionally, one case-control study used body surface area as an indicator of obesity [11]. Two cohort studies and one case-control study assessed obesity using trunk body fat, subtotal body fat, skinfold thickness, total adipose tissue, and visceral adipose tissue [6,15,18,36]. Two cohort studies and one cross-sectional study measured hip circumference (HC), waist circumference (WC), waist–hip ratio (WHR), and BMI to evaluate adiposity [14,27,36–38]. Moreover, one cohort study and one cross-sectional study measured HC, WC, WHR, BMI, and body fat in obese individuals [1,10,17,26,38].

A summary of all included studies—including objectives, populations, and main outcomes—is presented in Table 4.

Table 4: Summary of Details of All Included Studies

Author/ year (Study design)	Purpose	Population &Sample size	Outcome measure	Conclusion
1. Naimark 1960 (Case-control)	To assess the elastic properties of the total respiratory system and its components in a group of obese subjects and to compare them to those of a group of normal individuals.	36 (13 F., 23 M.) 19-46 y	VC, Max. Breathing Capacity, Alveolar N2 After 7 min. O2, TLC, BSA	A significant correlation between vital capacity and total respiratory compliance in normal and obese subjects.
2. Chen 1993 (Cohort)	To examine the effects of body weight at baseline and subsequent weight gain on the decline of pulmonary function test variables in both men and women.	709 adults 25-59 y	BMI, FVC, FEV1, MMFR	Increases in body weight were linearly associated with reductions in lung function measures—specifically FVC, FEV_1, and MMFR in men, and FVC and FEV_1 in women. Overall, weight gain had a more pronounced impact on pulmonary function in men than in women.
3. Zerah 1993 (Case-control)	To assess the effects of obesity on pulmonary function.	46 (31 F., 15 M.) 16 - 63 y	Respiratory resistance , Airway (nasal and oral) resistance, TLC, VC, ERV, RV, IC, expiratory flows, and BMI	Respiratory and airway resistance increased markedly with increasing obesity. TLC, VC, FRC, ERV, and expiratory flow rates were reduced and showed significant inverse correlations with BMI. A significant linear relationship was also observed between airway conductance and FRC.
4. Lazarus 1997 (Cohort)	To assess the effect of overall obesity and fat distribution on ventilatory function.	507 Subjects 30-79 y	BMI, FEV1, FVC, FEV1/FVC, MMEF, Subscapular skin fold, WC, HC, WHR	There was a positive correlation between BMI and FEV1/FVC, and a negative correlation between BMI and FVC and MMEF (40-60 y), between WC and FVC and FEV1 (50-59 y), and between subscapular skin fold and FVC and FEV1.
5. Canoy 2004 (Cohort)	To examine the relation between respiratory function and abdominal obesity in a large free-living population of men and women	9,674 M., 11,876 F. 45-79 y	FEV1, FVC, WC, BMI, WHR	An inverse relation between respiratory function and abdominal obesity was observed in this population. Both FEV1 and FVC mean values were lower among persons in the higher quintiles of WHR.
6. Jones 2006 (Cohort)	To show the correlation between body mass index (BMI) and the various lung volumes.	373(215 F., 158 M.) >18 y	FEV1/FVC%, VC, TLC, RV, RV/TLC, FRC, FRC/TLC, ERV, DLCO, BMI	BMI significantly influences all lung volumes, with the most pronounced reductions seen in FRC and ERV, even at BMI levels below 30 kg/m².
7. Thyagarajan 2008 (Cohort)	To quantify age-related changes in FVC, FEV1, and the FEV1/ FVC ratio according to BMI.	5,115 black and white M. and F.. 18–30 y	BW, BMI**,** FVC, and FEV1	Greater and increasing body fat were associated with notable declines in lung function. Changes in BMI strongly predicted FVC, FEV_1, and the FEV_1/FVC ratio, indicating that rising obesity poses a serious risk to population respiratory health.
8. Saliman 2008 (Cohort)	To delineate the pulmonary function tests and respiratory physiology of morbidly obese subjects.	136(102 F, 34 M) 45 ± 10 y	FEV1, FVC, FEV1/FVC, PaCO2 , BMI	Restrictive ventilatory defects were less common than obstructive ventilatory patterns and were most prominently associated with obesity hypoventilation syndrome.
9. Sexana 2009 (Cohort)	To assess the association of FEV1, FVC, and BMI, WC, and WHR as the markers of relative and abdominal obesity, respectively.	80 subjects (40 F., 40 M.) 20-40y	BMI, WC, HC, WHR, FVC, and FEV1	WC was strongly associated with lower FVC and FEV_1 in obese women, while WHR showed the greatest difference between obese and non-obese men. In both sexes, WC and WHR had significant inverse correlations with FVC and FEV_1, with WC showing the strongest overall association.
10. Ceylan 2009 (Case-control)	To determine the predominant pulmonary function abnormality in overweight and moderately obese subjects and to evaluate the correlation between the severity of lung function impairment and the degree of	51 subjects 31 F., 22 M. 18-66 y	Skin fold , FEV1, FVC, FEV1/FVC, PEF, FEF%25–75, MVV, DLCO, DLCO/VA	Reductions in FRC and ERV were the most frequent abnormalities among overweight and obese individuals. In women, the subscapular skinfold was the strongest predictor of FRC. In men, triceps skinfold thickness showed negative correlations with FEV_1 and

Author/ year (Study design)	Purpose	Population &Sample size	Outcome measure	Conclusion
	obesity.			FRC, and suprailiac skinfold thickness was inversely related to FEV_1, FVC, FRC, ERV, and TLC.
11. Wei 2010 (Cross-sectional)	To determine the prevalence of pulmonary function abnormality in obese Chinese patients before bariatric surgery, and to clarify the relationship between the various anthropometric measurements of obesity and the impairment of pulmonary function.	150 obese subjects 89 F., 61 M. 18-59 y	BW, BMI, WC, HC, WHR, Waist-Height ratio(WHtR), FVC, FEV1, VC, ERV, RV, TLC, DLCO.	Body weight, BMI, WC, HC, and WHtR were all significantly negatively associated with FVC and FEV_1. BMI, WC, and WHtR also showed inverse correlations with ERV, while HC was the only positive predictor of DLCO/VA.
12. Gabrielson 2011 (Cross-sectional)	To investigate how various measures of obesity are related to arterial blood gases and pulmonary function.	149 morbidly obese subjects 115 F., 34M. 43 ± 11 y	BMI, NC, WC, HP, Blood gas, FVC, FEV1, FEV1/FVC, DLCO, DLCO/VA, TLC, VC, IC, ITGV, ERV, and RV	BMI, neck circumference (NC), and WC were negatively correlated with ERV, and NC showed a significant negative correlation with VC. ERV and RV were significantly associated with PaO_2 and $PaCO_2$. Higher levels of BMI, WC, and NC were linked to lower PaO_2 and higher $PaCO_2$, indicating that both central and general obesity contribute to unfavorable blood gas values and reduced ERV.
13. Pekkarinen 2012 (Cross-sectional)	To examined how Body composition and abdominal obesity are associated with lung function in healthy individuals. population	284 adults (110 M., 174 F.) > 18 y	FVC, FEV1, FEV1 ⁄ FVC, PEF, FEF50%, FEF75%, DLCO, DLCO ⁄ VA, VC, ERV, WC, BMI, Abdominal sagittal diameter, Body fat, lean body, and muscle mass.	Muscle mass and lean body mass correlated positively with DLCO. Abdominal sagittal diameter and WC correlated inversely with FEV1/*FVC*.
14. Rasool 2012 (Cross-sectional)	To assess the association of BMI with lung volumes	225 >20 y (Normal, Overweight, and Obese) 48 F, 180 M	FVC, FEV1, FEV1/ FVC, BMI	Obese individuals had significantly lower FVC% and FEV_1% than those of normal weight. Clear linear relationships were observed between obesity and pulmonary function parameters. BMI was negatively and linearly associated with FVC% in overweight and obese individuals and with FEV_1% specifically in obese subjects.
15. Steier 2014 (Case-control)	To investigate factors influencing lung function disorder in obese individuals	9 normal weight (5M, 4F) 38 ± 11 y 9 obese (4 M, 5F) 45 ± 13 y	BMI, Neck circumference, Waist: hip ratio, MRC Dyspnoea Score, FEV1, FEV1 (%predicted), FVC, FVC (%predicted), FEV1 /FVC (%), Sagittal abdominal diameter/SAD, Delta SAD $_{inspiration}$, Double skinfold abdomen	In obese individuals, elevated intra-abdominal pressure—and the resulting increase in intrathoracic pressure—leads to reduced FRC and ERV.
16. Sutherland 2016 (Cohort)	To explore the relationship between adiposity measured and respiratory function tests	361 healthy subjects 32-38 y (51% M)	Body fat, BMI, WC, TLC, FEV1, FVC, FRC, RV, sGaw, TLCO, and VA.	Adiposity affected lung volumes more strongly in men than in women, although its association with the FEV_1/FVC ratio appeared only in women. Overall, changes in adiposity and lung function were generally more pronounced in men.
17. Choe 2018 (cohort)	to assess the association of obesity indices and forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) in asymptomatic non-smokers	1,145 subjects (428 M, mean age 52.3 y)	TAT, VAT, FEV1 and FVC	Higher total adipose tissue (TAT) and visceral adipose tissue (VAT) were significantly associated with lower FEV_1 and FVC. At the same time, reductions in TAT and VAT corresponded to improvements in these measures in both men and women.

Abreviation

FEV1= forced expiratory volume in one second, FVC = forced vital capacity, PEF = Peak expiratory flow, LV= Lung volumes, TLC= total lung capacity, FRC= functional residual capacity, RV= residual volume, ERV=expiratory reserve volume, BSA= Body surface area, TLCO = Carbon monoxide gas transfer, $PaCO_2$= arterial carbon dioxide pressure, PaO_2= arterial oxygen pressure, VC= vital capacity, $V_{Emax=}$ Predicted minute ventilation at maximum exercise, VO_2=maximum O_2, Hbo_2= O_2 saturation of hemoglobin in arterial blood, $VO_{2\ max}$= maximal O_2 consumption, DLCO =carbon monoxide diffusing capacity of the lung, FEF 50%-75% = forced expiratory flow at 50% and 75% vital capacity; FRC = function residual capacity, IC = inspiratory capacity, MVV = maximum voluntary ventilation, PEmax = maximum static expiratory mouth pressure, PFT = pulmonary function test, PTmax = maximum static inspiratory mouth pressure, RMS = respiratory muscle strength, SVC = slow vital capacity, PImax= Maximum static inspiratory mouth pressure, PEmax= Maximum static expiratory mouth pressure, WHR = waist to hip ratio, BMI= body mass index, WC= waist circumference, HC= hip circumference, NC= neck circumference, WHtR=Waist-Height ratio, DEXA= dual energy x ray absorptiometry, , MMEFR= maximum mid-expiratory flow rate, FM= fat mass, FFM = fat-free mass, and BF%= body fat percentage, PAEE = physical activity energy expenditure, EELV= end expiratory lung volume, IGTV= intra-thoracic gas volume, sGaw= specific airway conductance adjusted for thoracic gas volume, VA= alveolar volume, BW= bodyweight, T_I= inspiratory time, T_{TOT}= total time of the respiratory cycle, FR= respiratory frequency, *W*rest= inspiratory power of breathing at rest, *W*crit= critical inspiratory power, IRV: inspiratory reserve volume, TAT: total adipose tissue, VAT: visceral adipose tissue.

Outcome Measures

Lung volumes are generally classified as static and dynamic. Static lung volumes include tidal volume (VT), inspiratory reserve volume (IRV), expiratory reserve volume (ERV), and residual volume (RV). Four subdivided static lung capacities are total lung capacity (TLC), vital capacity (VC), functional residual capacity (FRC), and inspiratory capacity (IC). Dynamic lung volumes are derived from VC and include forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), the FEV_1/FVC ratio, forced expiratory flow at 25–75% (FEF25–75%), and maximal voluntary ventilation (MVV) [39,40].

Among the included studies, most (n = 14) assessed dynamic lung volumes [1,6,10,12–18,22,24–27,33,35,37–39], while six studies evaluated static lung volumes [1,9,10,12,15–17,25,27,28,34,37,39].

Other variables examined in approximately half of the included studies (n = 7) were the carbon monoxide diffusion capacity of the lung (DLCO) and the DLCO-to-alveolar volume ratio (DLCO/VA) [1,6,9,10,12,15–18,25,27,37].

Discussion

This systematic review highlights a robust and consistent relationship between increased adiposity and diminished pulmonary function. Findings across diverse study designs and populations indicate that obesity adversely affects lung mechanics, gas exchange, and respiratory muscle efficiency.

BMI

The findings of the included studies indicate that obesity, regardless of severity, significantly impairs respiratory function. Changes in BMI are strong predictors of FVC and FEV_1, and higher BMI values are associated with reductions in FEV_1/FVC and $FEF_{25–75}$%/FVC ratios, independent of respiratory symptoms or pre-existing pulmonary disease [33,35]. BMI influences all pulmonary function parameters, with particularly notable effects on functional residual capacity (FRC) and expiratory reserve volume (ERV) [12,36]. Restrictive ventilatory patterns were also associated with higher BMI, especially among individuals with obesity hypoventilation syndrome [13].

One study reported a significant negative correlation between BMI and several lung volumes—total lung capacity (TLC), vital capacity (VC), functional residual capacity (FRC), and expiratory reserve volume (ERV)—and a significant linear association between airway conductance and FRC, while noting that residual volume (RV) did not change significantly with increasing obesity. Specific airway conductance was also found to be unaffected by the degree of obesity [28]. Another study highlighted sex-related differences, reporting that the impact of obesity on pulmonary function was more pronounced in men than in women. In men, increases in body weight were linearly associated with declines in FVC, FEV_1, and maximum mid-expiratory flow rate (MMFR). In contrast, in women, weight gain was associated with reductions in FVC and FEV_1 [24].

Obesity may adversely affect the respiratory system through alterations in gas exchange, respiratory mechanics, respiratory muscle endurance, and the neural control of breathing [18]. One study further demonstrated that increases in BMI were associated with changes in variables such as total lung capacity (TLC) and arterial carbon dioxide pressure ($PaCO_2$) [13]. Functional residual capacity (FRC) and expiratory reserve volume (ERV) appear to be most significantly affected when BMI exceeds 30 kg/m² [6]. Additionally, excess intra-abdominal fat can restrict full diaphragmatic movement and alter the mechanical properties of the rib cage. In obese individuals, the diaphragm tends to assume a higher resting position within the thoracic cavity, thereby reducing lung function and impairing rib cage mobility and compliance [24,28,34,41].

Hip, Waist Circumference, and Waist-Hip Ratio, BMI, and Body Fat

One of the included studies reported significant associations between BMI, body weight, muscle mass, lean body mass, waist circumference, and abdominal sagittal diameter with predicted FVC%. Notably, BMI was correlated with FVC only in men, whereas this relationship was absent in women. In contrast, lean body mass, muscle mass, and waist circumference were related to FVC in women, while BMI was not. Lean body mass and muscle mass were also associated with predicted FEV_1% when both sexes were analyzed together; however, these correlations disappeared when men and women were examined separately.

Abdominal sagittal diameter showed an inverse relationship with the predicted FEV_1/FVC ratio across men, women, and the combined sample. Waist circumference was negatively correlated with the FEV_1/FVC ratio in women and in the combined analysis. Overall, measures of abdominal obesity appeared to exert the greatest influence on FEV_1/FVC ratios. In men, lean body mass and muscle mass were positively associated with the FEV_1/FVC ratio.

Lean body mass, muscle mass, weight, and BMI were identified as the most important determinants of predicted DLCO%. However, BMI was not a significant predictor when women were analyzed separately. DLCO also showed a weak association with waist circumference when both sexes were considered together [10]. Additional evidence indicated that higher body fat levels were associated with reduced lung function across dynamic and static lung volumes, with consistent effects across multiple adiposity measures. Furthermore, increases in body fat between ages 32 and 38 were linked to declines in FEV_1/FVC ratios among women, suggesting that body fat negatively affects airway function in this group. Although body fat did not directly impair gas transfer, longitudinal decreases in transfer factors were associated with increased body fat, likely due to reductions in alveolar gas volume [1].

Obesity represents an excessive accumulation of body fat, and both sex and fat distribution play key roles in obesity-related alterations in pulmonary function [17]. Sex-specific patterns of fat deposition can modify the relationship between adiposity indicators and lung function. Additionally, abdominal fat may influence pulmonary mechanics by restricting downward diaphragmatic movement and limiting lung expansion [14].

Hip, Waist Circumference, and Waist-Hip Ratio and BMI

One of the included studies examined the relationship between abdominal obesity and lung function in both men and women. The study found an inverse association between abdominal fat accumulation and pulmonary function among healthy older adults of both sexes. Individuals in the higher waist–hip ratio (WHR) quintiles exhibited lower mean FEV_1 and FVC values. Among all obesity indicators assessed, WHR demonstrated the strongest and most consistent negative independent association with respiratory performance. Additionally, the independent effect of BMI on lung function in men may reflect greater muscle mass or higher respiratory strength than in women [37].

Findings from other included studies indicated that average dynamic pulmonary parameters were reduced in obese individuals (BMI ≥ 30 kg/m²) of both sexes. BMI, WHR, and waist circumference (WC) each showed inverse correlations with lung function in men and women. Visceral fat may impair lung function by altering interleukin and cytokine levels, contributing to systemic inflammation. WC may also adversely affect pulmonary function through mechanisms related to insulin resistance. Abdominal adiposity can reduce expiratory reserve volume by compressing the diaphragm and lungs, thereby decreasing FVC. A lower WC may be a more meaningful indicator in men than BMI, as individuals with similar BMI values may differ substantially in abdominal fat by sex. These findings suggest that abdominal adiposity can impair lung function even when BMI values are within normal or non-obese ranges (BMI <30 kg/m²) [14].

Another study investigating the prevalence of lung function abnormalities in obese Chinese patients before bariatric surgery evaluated several obesity indices—including body weight (BW), BMI, waist circumference (WC), hip circumference (HC), waist-to-height ratio (WHtR), and waist–hip ratio (WHR)—in relation to pulmonary impairment. The results indicated that BW, BMI, WC, HC, and WHtR (but not WHR) were negatively correlated with FEV_1, FVC, TLC, and VC, whereas DLCO/VA was positively correlated with these variables. After adjusting for confounders such as age, sex, and smoking status, only WC retained a significant negative effect on FEV_1, FVC, TLC, and VC. These findings suggest that all anthropometric obesity measures, except WHR, are associated with a restrictive pattern of lung dysfunction [27,36].

Both abdominal and subcutaneous chest-wall adiposity may contribute to pulmonary impairment [6]. Fat accumulation between the ribs and intercostal muscles can reduce chest wall compliance and increase the metabolic demands and workload of breathing, even at rest [37]. Moreover, this fat deposition may limit full chest wall expansion and movement, either through direct mechanical loading or by altering intercostal muscle function [22].

Trunk Body Fat, Subtotal Body Fat, Skinfold, Total and Visceral Adipose Tissue

The included studies showed that functional residual capacity (FRC) and expiratory reserve volume (ERV) were significantly reduced in overweight or moderately obese individuals. In contrast, residual volume (RV) did not differ between groups. Patterns of body fat distribution may independently influence lung function. Individuals with upper-body obesity tend to have lower FVC, FEV_1, and total lung capacity (TLC). Fat accumulation in the abdomen and along the abdominal and chest walls can reduce lung volumes by exerting direct mechanical loading on the rib cage, diaphragm, and lungs.

In men, FVC was negatively associated with all measures of adiposity and positively associated with fat-free mass (FFM), whereas in women, FVC showed no relationship with adiposity indicators. Waist–hip ratio (WHR) was inversely correlated with FVC, TLC, and FRC. Moreover, subscapular skinfold thickness was negatively correlated with both FVC and ERV in men. No associations were found between forced expiratory flow at 25–75% ($FEF_{25–75}$%) and measures of relative adiposity, suggesting that small airways were not affected. In men, triceps skinfold thickness was negatively related to FEV_1 and FRC, and suprailiac skinfold thickness showed inverse correlations with FEV_1, FVC, FRC, ERV, and TLC.

One study also demonstrated that BMI, waist circumference (WC), and neck circumference (NC) were significantly associated with lower arterial oxygen pressure (PaO_2) and higher $PaCO_2$ in obese individuals with otherwise normal lung function. BMI, NC, and WC were also negatively correlated with ERV [18].

Overall, body fat distribution adversely affects pulmonary function tests [1]. Abnormalities in lung function cannot be attributed solely to abdominal adiposity (e.g., BMI or WHR); subcutaneous fat deposition also plays an important role in impaired respiratory function [6,36].

Weight/ Body Surface Area/ Body Surface Area and BMI

Findings from the included studies indicated that obesity is associated with reduced rib cage compliance, likely due to increased elastic resistance of the thoracic cage. A significant relationship between vital capacity (VC) and total respiratory system compliance was observed in both normal-weight and obese individuals [11]. The added weight of abdominal contents and the rib cage may increase ventilatory load. In obese individuals, rib cage compliance is reduced because diaphragmatic movement and rib cage expansion are restricted, resulting in increased energy expenditure and higher oxygen demand during breathing [11,18,43]. Obesity also contributes to inadequate lung ventilation, which can impair effective coughing and hinder the clearance of secretions from the tracheobronchial tree—factors that increase the risk of severe and prolonged respiratory infections [44–46].

During the COVID-19 pandemic, obesity has been associated with an increased likelihood of hospitalization, the need for mechanical ventilation, ICU admission, and mortality [47]. These observations underscore the importance of raising awareness about the impact of obesity on respiratory function.

This review was unable to perform a meta-analysis due to heterogeneity in study designs and outcome measures. Additionally, variations in obesity severity were not distinguished. Further controlled studies are needed to clarify dose–response relationships between adiposity levels and pulmonary impairment.

Conclusion

Obesity negatively influences multiple aspects of pulmonary function. Across the reviewed studies, higher levels of adiposity—particularly central fat accumulation—were consistently associated with reductions in lung volumes, diminished ventilatory capacity, and alterations in respiratory mechanics.

A clear inverse relationship exists between obesity and several key indicators of respiratory function, underscoring the importance of early recognition, prevention, and intervention strategies to reduce obesity-related respiratory compromise.

Author Contributions

Concept/idea/research design: Kh. Kazemi, F. Rahimi, N. Rahmani,

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Project management: N. Pirayeh, N. Rahmani.

All authors met the International Committee of Medical Journal Editors (ICMJE) criteria for authorship, contributed to the revision of intellectual content, took responsibility for the integrity of the work, and approved the final version for publication. All authors had full access to the study data.

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