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Obstructive Sleep Apnea Risk, Body Fat, and BMI in Pulmonary Tuberculosis Patients

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Abstract:

Background: Obstructive sleep apnea (OSA) is a common sleep-related breathing disorder significantly associated with body composition abnormalities. Pulmonary tuberculosis (TB) causes structural lung damage that may predispose patients to sleep disturbances, yet the relationship between OSA and body composition in TB populations remains inadequately explored. **Aim:** This study aimed to investigate the association between OSA severity and body composition measures including total body fat, visceral fat, subcutaneous fat, and body mass index (BMI) among pulmonary TB patients.

Methods: A cross-sectional analytical observational study was conducted at RS Ibnu Sina YW-UMI Makassar from August to November 2025. Eighty-five pulmonary TB patients were selected through purposive sampling. OSA risk was assessed using the STOP-BANG questionnaire, while body composition was measured using bioelectrical impedance analysis. Chi-square tests were performed to examine associations between variables with significance set at $p<0.05$.

Results: Significant associations were found between OSA severity and all body composition parameters: total body fat ($p=0.004$), visceral fat ($p=0.000$), subcutaneous fat ($p=0.005$), and BMI ($p=0.000$). Severe OSA showed highest prevalence of very high total body fat (46.4%), elevated visceral fat (60.7%), high subcutaneous fat (57.1%), and obesity grade 1 (35.7%). Moderate OSA occurred predominantly in underweight patients (50.0%), revealing a U-shaped BMI-OSA relationship.

Conclusions: Visceral fat demonstrated the strongest association with OSA severity in pulmonary TB patients. Comprehensive body composition assessment provides superior clinical utility compared to BMI alone for OSA risk stratification.

Implementation. These findings support integrating body composition monitoring into TB management protocols and provide foundation for personalized interventions addressing both infectious disease treatment and metabolic health optimization.

Keywords: Obstructive sleep apnea, body composition, visceral fat, body mass index, pulmonary tuberculosis

INTRODUCTION

Sleep is a fundamental physiological process that plays a crucial role in restoring physical and mental functions. Disturbances in sleep quality may significantly impair health status and quality of life(Cahaya et al., 2019; Mukhlis & Bakhtiar, 2021). One of the most common sleep-related breathing disorders is Obstructive Sleep Apnea (OSA), characterized by recurrent episodes of partial or complete upper airway obstruction during sleep, leading to intermittent hypoxia and sleep fragmentation(Cahaya et al., 2019; Mukhlis & Bakhtiar, 2021). The epidemiology of tuberculosis indicates that this disease remains one of the greatest global health burdens, with a high prevalence in developing countries, including Indonesia. According to WHO reports, approximately 10.6 million TB cases occurred globally in 2022, with the largest proportion affecting adults (90%), while 10% occurred in children. Global case distribution shows that men have a higher incidence of TB than women, with a ratio of approximately 2:1; however, women infected with TB, particularly those with HIV comorbidity, have a higher risk of mortality. In Indonesia, TB remains a priority public health problem, ranking second in the world for the highest number of TB cases after India. Differences in incidence by sex, variations in vulnerable age groups, as well as social, economic, and biological factors, contribute to the spread of TB (Fitrah Ahmad et al., 2025).

OSA has been associated with various systemic comorbidities, including cardiovascular disease, diabetes mellitus, hypertension, dyslipidemia, stroke, cognitive impairment, and chronic respiratory diseases. Anthropometric parameters such as body mass index (BMI), neck circumference, and body fat distribution have been widely investigated and shown to be significantly associated with the risk of OSA. Excess body fat, particularly central and upper-body fat accumulation, can contribute to upper airway narrowing, reduced pharyngeal muscle tone, and impaired ventilatory control during sleep, thereby increasing the likelihood of airway collapse(Locke et al., 2022).

Pulmonary tuberculosis (TB) remains a major global health problem, particularly in developing countries, including Indonesia. TB can cause long-term structural and functional alterations of the lungs, such as fibrosis, airway obstruction, and reduced lung capacity, which may predispose patients to sleep-related breathing disorders. Several studies have demonstrated that patients with pulmonary TB experience poorer sleep quality and greater nocturnal hypoxemia compared to healthy individuals. In addition, a history of pulmonary TB has been associated with an increased risk of airflow limitation, which may further exacerbate the occurrence of OSA(Shah & Kaltsakas, 2023).

Despite substantial evidence linking obesity and OSA in the general population, the interaction between OSA, body fat composition, and BMI in patients with pulmonary TB remains insufficiently explored, particularly in low- and middle-income countries. Existing studies have primarily focused on OSA in relation to obesity or chronic respiratory diseases separately, while data examining the combined influence of pulmonary TB and adiposity on OSA risk are limited. This lack of evidence represents an important research gap, especially in regions with a high burden of TB(Kim et al., 2024).

Therefore, this study aims to investigate the occurrence of OSA among patients with pulmonary TB, to describe body fat composition and BMI in TB patients with OSA, and to analyze the relationship between OSA and body fat composition as well as BMI in individuals with pulmonary TB treated at RS Ibnu Sina YW-UMI Makassar. It is hypothesized that higher body fat percentage and increased BMI are significantly associated with a greater risk of OSA in patients with pulmonary tuberculosis. Global research shows a strong link between OSA and obesity, specifically visceral fat. However, studies integrating OSA, body composition, and pulmonary tuberculosis are still limited, especially in developing countries.

State of the Art

Obstructive Sleep Apnea (OSA) and Body Composition.

Current research demonstrates that OSA is strongly associated with obesity and abnormal fat distribution, especially visceral and upper-body fat. Studies in the general population confirm that:

1. Visceral adiposity is a stronger predictor of OSA severity than BMI. Total and subcutaneous fat contribute mechanically to upper airway obstruction. Body composition assessment using BIA or imaging provides better risk stratification than BMI alone. Recent international studies (2021–2025) emphasize that metabolic and inflammatory effects of adipose tissue play a central role in OSA pathophysiology.
2. OSA in Chronic Respiratory Diseases. Research on OSA in chronic lung diseases (COPD, fibrosis, asthma) shows that: Structural lung damage increases airway instability. Reduced lung volume worsens nocturnal hypoxemia. OSA prevalence is

higher in patients with respiratory impairment. However, most studies focus on COPD and obesity-related respiratory disorders.

3. Pulmonary Tuberculosis (TB) and Sleep Disorders. Existing literature indicates that TB patients often experience: Poor sleep quality, Nocturnal hypoxemia, Persistent airflow limitation after treatment. Some studies suggest increased OSA risk in TB survivors, but they mainly assess sleep quality rather than objective OSA risk or body composition.
4. Integration of OSA, Body Composition, and TB
   a. Before this study, most research: Examined OSA + obesity (general population), or Examined TB + sleep disturbance, separately.
   b. Very few studies combined: Pulmonary TB history, Detailed body fat parameters, OSA risk assessment,
   c. Especially in low- and middle-income countries.

LITERATURE REVIEW

Obstructive Sleep Apnea (OSA) is a sleep-related breathing disorder characterized by recurrent episodes of partial or complete upper airway obstruction during sleep, resulting in intermittent hypoxia, hypercapnia, and sleep fragmentation. These pathophysiological disturbances trigger sympathetic overactivity, systemic inflammation, and oxidative stress, which contribute to various cardiometabolic and respiratory complications. The severity of OSA is influenced by multiple factors, including anatomical characteristics of the upper airway, neuromuscular control, and body composition, particularly fat distribution in the neck and trunk region.

Body fat composition plays a pivotal role in the development of OSA. Excess adipose tissue, especially visceral and upper-body fat, can promote airway narrowing through mechanical compression of the pharyngeal structures and reduction of lung volumes. Visceral fat is metabolically active and associated with increased production of pro-inflammatory cytokines such as TNF-α and IL-6, which may impair respiratory muscle function and ventilatory control. Several studies have demonstrated that individuals with higher body fat percentage and visceral fat levels exhibit a significantly greater risk of moderate to severe OSA, independent of overall body weight.

Body Mass Index (BMI) is widely used as a simple indicator of nutritional status and obesity; however, its interpretation in pulmonary tuberculosis (TB) patients is often complex. TB is commonly associated with weight loss, muscle wasting, and altered body composition due to chronic inflammation, increased energy expenditure, and decreased appetite. Nevertheless, a subset of TB patients may present with normal or elevated BMI, particularly those with metabolic comorbidities or during the recovery phase after anti-tuberculosis treatment. Both undernutrition and obesity have potential implications for OSA risk: underweight status may reflect reduced respiratory muscle strength, whereas overweight and obesity contribute to upper airway collapsibility.

Pulmonary tuberculosis can induce long-term structural and functional changes in the respiratory system, including fibrosis, bronchiectasis, airflow limitation, and reduced lung compliance. These alterations may predispose TB survivors to sleep-related breathing disorders. Chronic lung damage can increase upper airway resistance and impair ventilatory stability during sleep, thereby facilitating the occurrence of OSA even in the absence of classical obesity. Previous studies have reported a higher prevalence of nocturnal hypoxemia and poor sleep quality among TB patients compared to the general population.

The interaction between OSA, body fat composition, and BMI in pulmonary TB represents a unique clinical context. Unlike the general population where obesity is the dominant risk factor, TB patients may experience a dual burden of malnutrition and abnormal fat redistribution. Visceral adiposity may persist despite low BMI, leading to an underestimated risk of OSA when BMI alone is used as a screening parameter. Therefore, assessment of body fat percentage and visceral fat may provide better insight into OSA risk stratification in this population.

Current evidence regarding OSA in TB patients remains limited, particularly in low- and middle-income countries with high TB prevalence. Most available studies have examined OSA in relation to obesity or chronic respiratory diseases separately, while data integrating pulmonary TB history with detailed body composition parameters are scarce. Understanding this relationship is essential because unrecognized OSA may worsen clinical outcomes, delay TB recovery, and reduce quality of life.

Based on these considerations, evaluating OSA risk together with body fat composition and BMI in pulmonary TB patients is clinically relevant. Identification of modifiable factors such as excess visceral fat could support early preventive strategies and comprehensive management of TB patients. This study therefore focuses on analyzing the association between OSA risk, body fat parameters, and BMI among pulmonary tuberculosis patients treated at RS Ibnu Sina YW-UMI Makassar.

This study is the first study in Indonesia to analyze the relationship between OSA and total, visceral, and subcutaneous fat in TB patients, as well as identify a non-linear pattern of BMI–OSA relationships.

Research Gap

Despite its contributions, several gaps remain in this research field:

1. Diagnostic Gap: This study uses STOP-BANG screening rather than polysomnography (PSG). Lack of Apnea–Hypopnea Index (AHI) data limits diagnostic accuracy. Gap: Absence of gold-standard objective OSA diagnosis in TB populations.
2. Design Gap: Cross-sectional design prevents causal inference. Gap: No longitudinal evidence showing whether body fat changes lead to OSA progression in TB patients.
3. Mechanistic Gap: Inflammatory markers (IL-6, TNF-α, CRP) were not measured. Lung function parameters (FEV_1, FVC) were not included. Gap: Limited understanding of biological mechanisms linking TB damage, fat distribution, and OSA.
4. Intervention Gap: No evaluation of weight management, nutrition therapy, or fat-reduction interventions. Gap: Lack of evidence on whether modifying body composition improves OSA outcomes in TB patients.
5. Population Gap: Single-center study with purposive sampling, Limited ethnic, regional, and socioeconomic diversity. Gap: Limited generalizability to other TB populations in Indonesia and globally.
6. Anatomical Gap: ENT examinations and airway imaging were not conducted. Gap: Insufficient data on structural airway abnormalities contributing to OSA in TB patients.

Summary Table

Aspect	Current Evidence	This Study	Remaining Gap
OSA & Obesity	Well established	Extended to TB patients	Causal mechanisms unclear
Body Composition	Studied in general population	Applied to TB population	No imaging/biomarkers
Diagnosis	Mostly PSG-based	STOP-BANG screening	No AHI confirmation
Design	Mostly cross-sectional	Cross-sectional	No longitudinal studies
Intervention	Limited	Not studied	No clinical trials

Although previous studies have established strong associations between obesity and obstructive sleep apnea in the general population, evidence integrating pulmonary tuberculosis, detailed body composition parameters, and OSA risk remains limited. Existing studies predominantly rely on cross-sectional designs and screening tools without objective polysomnographic confirmation. Moreover, the biological mechanisms linking visceral adiposity, TB-related lung damage, and airway instability have not been adequately explored. Longitudinal and interventional studies incorporating objective sleep assessment, inflammatory biomarkers, and pulmonary function testing are therefore required to clarify causal pathways and optimize clinical management strategies in this vulnerable population.

METHOD

Study Design

This study used an analytical observational cross-sectional design to evaluate the association between the risk of Obstructive Sleep Apnea (OSA), body fat composition, and Body Mass Index (BMI) among patients with pulmonary tuberculosis. The design enabled simultaneous assessment of OSA risk, body fat parameters, and BMI within a single period without any intervention.

Population and Sample

The population consisted of 560 patients diagnosed with pulmonary tuberculosis who received inpatient or outpatient care at Ibnu Sina YW UMI Hospital, Makassar, between January and December 2024. A purposive sampling technique was applied based on predefined eligibility criteria. The minimum required sample size was 85 respondents, calculated using the Slovin formula with a margin of error of 10%. Data collection continued until the minimum sample size was fulfilled.

Inclusion and Exclusion Criteria

Inclusion criteria were patients diagnosed with pulmonary tuberculosis, receiving treatment at Ibnu Sina YW UMI Hospital, willing to participate, and providing informed consent. Exclusion criteria included structural abnormalities of the upper airway (nasal cavity, tongue, uvula, or pharynx), presence of implanted metallic devices or orthopedic hardware, history of upper airway surgery, and incomplete clinical or anthropometric data.

Operational Definition of Variables

The independent variables were body fat composition and Body Mass Index. Body fat composition included total body fat percentage, visceral fat level, and subcutaneous fat percentage measured using Bioelectrical Impedance Analysis (BIA) and categorized according to manufacturer reference standards (ordinal scale). BMI was calculated as kg/m² and classified as underweight (<18.5), normal (18.5–22.9), overweight (23.0–24.9), obesity class I (25.0–29.9), and obesity class II (≥30.0) (ordinal scale). The dependent variable was the risk of Obstructive Sleep Apnea measured using the STOP-BANG questionnaire and categorized as low (0–2), intermediate (3–4), or high risk (5–8) (ordinal scale).

Research Instruments and Data Collection Procedures

OSA risk was assessed using the STOP-BANG questionnaire. Body weight and body composition were measured using a OneMed Bioelectrical Impedance Analysis device, while height was measured using a microtoise. Participants were instructed to fast for 2–3 hours, avoid strenuous activity for 12 hours, and remove metallic objects before measurement. After informed consent, participants completed the STOP-BANG questionnaire followed by anthropometric and BIA assessment. All data were verified for completeness and accuracy prior to analysis.

Data Analysis

Data were analyzed using SPSS. Univariate analysis was performed to present frequencies and percentages of demographic characteristics, BMI, body fat composition, and OSA risk in tables and figures. Bivariate analysis using the Chi-square test was conducted to assess the association between OSA risk and body fat composition as well as BMI. A p-value <0.05 was considered statistically significant.

DISCUSSION

This chapter presents the analysis results examining the relationship between obstructive sleep apnea (OSA) and body composition measures (body fat and body mass index) among pulmonary tuberculosis patients at RS Ibnu Sina YW-UMI Makassar. The study enrolled 85 patients from both outpatient and inpatient settings, focusing on total body fat composition, visceral fat, subcutaneous fat, and BMI. The limited study of OSA in TB patients with objective diagnosis, longitudinal design, and a body composition-based intervention approach suggests the need for more comprehensive follow-up research

Frequency Distribution of Respondent Characteristics and Research Variables

The study population comprised predominantly male patients (56.5%, n=48) compared to females (43.5%, n=37). Age distribution revealed elderly patients (≥65 years) as the largest group (24.7%, n=21), followed by early elderly (46-55 years, 22.4%, n=19), late adults (36-45 years, 17.6%, n=15), late elderly (56-65 years, 16.5%, n=14), late adolescents (17-25 years, 12.9%, n=11), and early adults (26-35 years, 5.9%, n=5) (Table 1).

Table 1. Gender and Age Distribution of Respondents

Variable	Frequency (n=85)	Percentage (%)
Gender		
Male	48	56.5%
Female	37	43.5%
Age Groups		
Late Adolescent (17-25 years)	11	12.9%
Early Adult (26-35 years)	5	5.9%
Late Adult (36-45 years)	15	17.6%
Early Elderly (46-55 years)	19	22.4%
Late Elderly (56-65 years)	14	16.5%
Elderly (≥65 years)	21	24.7%

Source: Primary Data, 2025

Table 2. Risk Level Distribution Based on OSA, Body Fat, Visceral Fat, Subcutaneous Fat and BMI Among TB Patients at RS Ibnu Sina YW-UMI Makassar 2025

Research Variable	Frequency (n=85)	Percentage (%)
OSA Severity		
Mild	29	34.1%
Moderate	28	32.9%
Severe	28	32.9%
Total Body Fat		
Low	18	21.2%
Normal	34	40.0%
High	14	16.5%
Very High	19	22.4%
Visceral Fat		
Normal	62	72.9%
High	23	27.1%
Very High	0	0%
Subcutaneous Fat		
Low	19	22.4%
Normal	38	44.7%
High	28	32.9%
BMI		
Underweight	34	40.0%
Normal	26	30.6%
Overweight	12	14.1%
Obesity 1	12	14.1%
Obesity 2	1	1.2%

Source: Primary Data, 2025

Regarding research variables, OSA severity was distributed relatively evenly across categories: mild OSA (34.1%, n=29), moderate OSA (32.9%, n=28), and severe OSA (32.9%, n=28). Total body fat showed normal levels in the majority (40.0%, n=34), followed by very high (22.4%, n=19), low (21.2%, n=18), and high (16.5%, n=14). Visceral fat was predominantly normal (72.9%, n=62) with high levels in 27.1% (n=23). Subcutaneous fat distribution showed normal levels in 44.7% (n=38), high in 32.9% (n=28), and low in 22.4% (n=19). BMI classification revealed underweight as the dominant category (40.0%, n=34), followed by normal (30.6%, n=26), overweight (14.1%, n=12), obesity grade 1 (14.1%, n=12), and obesity grade 2 (1.2%, n=1) (Table 2).

Associations Between OSA and Body Composition Measures OSA and Total Body Fat Composition

Association Between OSA and Total Body Fat in Pulmonary TB Patients

This study demonstrated a significant association between OSA severity and total body fat composition (p=0.004). Severe OSA showed the highest proportion of very high body fat (46.4%), while mild OSA predominantly occurred in patients with normal body fat (58.6%). This progressive relationship supports the hypothesis that adipose tissue accumulation contributes to upper airway obstruction through cervical and thoracic fat deposition, which compresses airways and reduces tissue elasticity (Avishek Layek & Tejas Menon Suri, 2025).

These findings align with (Gao et al., 2025), who reported that increased fat percentage significantly correlates with elevated AHI scores, emphasizing that body composition not just total weight plays critical roles in OSA pathogenesis. (Chuang et al., 2025) demonstrated that each unit increase in fat percentage directly correlates with OSA severity, providing more specific predictive value than BMI. (Yetim et al., 2025) corroborated this, identifying fat mass as a strong OSA predictor even after BMI adjustment.

In TB patients, this relationship becomes multifactorial. Excessive body fat causes decreased pharyngeal muscle tone and increased airway pressure, while TB-related inflammation causes lung fibrosis and ventilatory impairment. This combination creates a "two-hit" mechanism that substantially elevates OSA risk beyond either condition alone (Messineo et al., 2024).

Table 3. Association Between OSA and Total Body Fat Among TB Patients at RS Ibnu Sina YW-UMI Makassar 2025

OSA Severity	Total Body Fat Distribution				Total	Sig
	Low	Normal	High	Very High		
Mild	5 (17.2%)	17 (58.6%)	3 (10.3%)	4 (13.8%)	29 (100%)	0.004
Moderate	8 (28.6%)	11 (39.3%)	7 (25.0%)	2 (7.1%)	28 (100%)	
Severe	5 (17.9%)	6 (21.4%)	4 (14.3%)	13 (46.4%)	28 (100%)	
Total	18 (21.2%)	34 (40.0%)	14 (16.5%)	19 (22.4%)	85 (100%)	

Source: Primary Data, 2025 Chi-Square Test Note: Body fat percentage categories differ by gender (Female: Very High ≥35%, High 30-<35%, Normal 20-<30%, Low <20%; Male: Very High ≥25%, High 20-<25%, Normal 10-<20%, Low <10%)

Chi-square analysis revealed a significant association between OSA severity and total body fat composition (p=0.004). Mild OSA predominantly occurred in patients with normal body fat (58.6%, n=17), while severe OSA showed the highest proportion of very high body fat (46.4%, n=13). Moderate OSA demonstrated a more balanced distribution across body fat categories (Table 3).

Association Between OSA and Visceral Fat in Pulmonary TB Patients

A highly significant association emerged between OSA severity and visceral fat (p=0.000). Severe OSA demonstrated the strongest association with elevated visceral fat (60.7%), while mild OSA predominantly occurred with normal visceral fat (93.1%). This clear gradient confirms visceral adiposity's independent role in OSA pathogenesis.

These findings align with (Xu et al., 2024), who identified that visceral fat scores increased OSA risk 2.4-fold independent of BMI. The mechanism involves visceral fat accumulation increasing intra-abdominal pressure, compressing the diaphragm, and reducing lung capacity. (Sekizuka et al., 2021) demonstrated that visceral fat area provides additional predictive information beyond BMI. (Kundel et al., 2021) showed that visceral fat's metabolic activity not just volume correlates with OSA severity through proinflammatory cytokine production .

In TB patients, elevated visceral fat produces dual effects: mechanical diaphragmatic compression reduces lung volume while metabolic inflammation impairs respiratory muscle function. This combination with TB-related structural damage creates particularly severe OSA phenotypes.

Table 4. Association Between OSA and Visceral Fat Among TB Patients at RS Ibnu Sina YW-UMI Makassar 2025

OSA Severity	Visceral Fat Distribution		Total	Sig
	Normal	High	Very High	
Mild	27 (93.1%)	2 (6.9%)	0 (0%)	29 (100%)
Moderate	24 (85.7%)	4 (14.3%)	0 (0%)	28 (100%)
Severe	11 (39.3%)	17 (60.7%)	0 (0%)	28 (100%)
Total	62 (72.9%)	23 (27.1%)	0 (0%)	85 (100%)

Source: Primary Data, 2025 Chi-Square Test Note: Visceral fat categories (Normal: 0.5-9.5, High: 10-14.5, Very High: 15-30)

A highly significant association was found between OSA severity and visceral fat levels (p=0.000). Severe OSA showed the strongest association with elevated visceral fat (60.7%, n=17), while mild OSA predominantly occurred in patients with normal visceral fat levels (93.1%, n=27) (Table 4).

OSA and Subcutaneous Fat

Subcutaneous fat demonstrated a significant relationship with OSA severity (p=0.005). Severe OSA was predominantly associated with high subcutaneous fat (57.1%, n=16), whereas mild OSA showed the highest proportion of normal subcutaneous fat (65.5%, n=19). Moderate OSA exhibited a more distributed pattern across categories (Table 5).

Table 5. Association Between OSA and Subcutaneous Fat Among TB Patients at RS Ibnu Sina YW-UMI Makassar 2025

OSA Severity	Subcutaneous Fat Distribution		Total	Sig
	Low	Normal	High	
Mild	5 (17.2%)	19 (65.5%)	5 (17.2%)	29 (100%)
Moderate	9 (32.1%)	12 (42.9%)	7 (25.0%)	28 (100%)
Severe	5 (17.9%)	7 (25.0%)	16 (57.1%)	28 (100%)
Total	19 (22.4%)	38 (44.7%)	28 (32.9%)	85 (100%)

Source: Primary Data, 2025 Chi-Square Test Note: Subcutaneous fat categories differ by gender (Female: Low <20%, Normal 20-29.9%, High ≥30%; Male: Low <10%, Normal 10-19.9%, High ≥20%)

This study identified significant associations between OSA severity and subcutaneous fat (p=0.005). Severe OSA showed the highest proportion of elevated subcutaneous fat

(57.1%), while mild OSA predominantly occurred with normal levels (65.5%). This gradient suggests that subcutaneous fat, particularly in anatomically critical regions, contributes to airway obstruction.

(Molnár et al., 2022) reported that neck and chest subcutaneous fat thickness correlates with OSA risk through pharyngeal compression. (Zaffanello et al., 2025) emphasized that neck subcutaneous fat exerts greater influence than extremity accumulation. However, (Kritikou et al., 2013) noted that subcutaneous fat shows weaker associations than visceral fat, though cervical accumulation remains important.

In TB patients, cervicothoracic subcutaneous fat adds external airway pressure to existing TB-related structural damage, creating a "compression from outside" mechanism that synergizes with internal airway changes.

OSA and Body Mass Index

A highly significant association emerged between OSA severity and BMI classification (p=0.000). Severe OSA showed the highest proportion of obesity grade 1 (35.7%, n=10), while moderate OSA was predominantly associated with underweight status (50.0%, n=14). Mild OSA occurred most frequently in patients with normal BMI (41.4%, n=12). The distribution pattern indicates increasing OSA severity correlates with higher BMI categories, particularly in the overweight to obese range (Table 6).

Table 6. Association Between OSA and BMI Among TB Patients at RS Ibnu Sina YW-UMI Makassar 2025

OSA Severity	BMI Distribution					Total	Sig
	Underweight	Normal	Overweight	Obesity 1	Obesity 2		
Mild	1 (3.4%)	12 (41.4%)	1 (3.4%)	1 (3.4%)	0 (0%)	29 (100%)	
Moderate	14 (50.0%)	8 (28.6%)	5 (17.9%)	1 (3.6%)	0 (0%)	28 (100%)	0.000
Severe	5 (17.9%)	6 (21.4%)	6 (21.4%)	10 (35.7%)	1 (3.6%)	28 (100%)	
Total	34 (40.0%)	26 (30.6%)	12 (14.1%)	12 (14.1%)	1 (1.2%)	85 (100%)	

Source: Primary Data, 2025 Chi-Square Test Note: BMI categories (Underweight: <18.5 kg/m², Normal: 18.5-22.9 kg/m², Overweight: 23-24.9 kg/m², Obesity 1: 25-29.9 kg/m², Obesity 2: ≥30 kg/m²)

These findings demonstrate significant associations between OSA severity and all measured body composition parameters in TB patients. The strongest associations were observed with visceral fat and BMI, suggesting these measures may serve as important clinical indicators for OSA risk stratification in this population.

A highly significant association existed between OSA severity and BMI (p=0.000). Severe OSA showed highest prevalence in obesity grade 1 (35.7%), while moderate OSA occurred predominantly in underweight individuals (50.0%). This U-shaped pattern indicates complex bidirectional relationships in TB populations.

In obese individuals, adipose tissue compresses pharyngeal structures and increases airway resistance. Evidence shows 10% weight gain increases AHI by 32%, while 10% weight loss reduces AHI by 26%. These findings align with (Liao et al., 2024), Syarifah (2023), and (Esmaeili et al., 2025), confirming BMI's strong correlation with OSA risk.

However, moderate OSA's prevalence in underweight TB patients reveals non-obesity mechanisms: pulmonary tissue damage, respiratory muscle weakness from malnutrition, and chronic hypoxia disrupting pharyngeal neuromuscular control (Qian et al., 2025). This demonstrates that in TB populations, both extremes of nutritional status influence OSA through different pathophysiological pathways.

Novelty of This Study

This research provides several important novel contributions:

1. Contextual Novelty (Population-Based): First comprehensive study in Indonesia examining OSA risk in pulmonary TB patients using body composition analysis. Focuses on a high-TB-burden, underrepresented population.
2. Methodological Novelty: Uses Bioelectrical Impedance Analysis (BIA) to assess: Total body fat, Visceral fat, Subcutaneous fat. Integrates BIA data with STOP-BANG screening, which is rarely applied in TB populations.
3. Conceptual Novelty: Demonstrates that visceral fat is the strongest predictor of OSA severity in TB patients. Shows that BMI alone is insufficient for OSA risk assessment in this group.
4. Empirical Novelty: Identifies a U-shaped relationship between BMI and OSA, where: Obese patients show severe OSA, Underweight patients also show moderate OSA. This finding challenges conventional obesity-centered OSA models.
5. Clinical Novelty: Proposes integrating body composition monitoring into TB management. Supports personalized metabolic and respiratory risk assessment.

CONCLUSION

This study demonstrates that obstructive sleep apnea (OSA) severity increases progressively with elevated body composition parameters in patients with pulmonary tuberculosis (TB). Severe OSA was most prevalent among individuals with very high total body fat (46.4%), elevated visceral fat (60.7%), high subcutaneous fat (57.1%), and obesity grade I (35.7%). These findings confirm that adipose tissue accumulation plays a substantial role in upper airway obstruction through combined mechanical compression and metabolic–inflammatory pathways.

Visceral fat emerged as the strongest independent risk factor for OSA severity. Its effects appear to operate through dual mechanisms, including diaphragmatic compression that reduces lung volumes and increased production of proinflammatory cytokines that impair respiratory function. These processes likely interact synergistically with TB-related pulmonary damage, contributing to particularly severe OSA phenotypes in this population.

The association between body mass index (BMI) and OSA revealed important complexity. While severe OSA predominated in obese patients, moderate OSA was also frequently observed among underweight individuals, resulting in a U-shaped relationship. This finding indicates that both extremes of nutritional status influence OSA risk through distinct mechanisms and challenges traditional obesity-centered models, especially in patients with chronic pulmonary disease.

Based on these findings, comprehensive body composition assessment particularly evaluation of visceral fat should be incorporated into routine clinical management of TB patients to improve OSA risk stratification. Body composition analysis provides clinically meaningful information beyond BMI alone and supports the development of more precise assessment frameworks in chronic pulmonary disease populations.

Future research should employ objective diagnostic approaches rather than relying solely on screening questionnaires such as STOP-BANG. Confirmation of OSA using direct measurement of the Apnea–Hypopnea Index (AHI) with gold-standard diagnostic tools, including overnight polysomnography, is recommended to ensure greater diagnostic accuracy and reliability. Additionally, comprehensive otorhinolaryngological (ENT) physical examinations should be performed to identify anatomical and functional factors predisposing to OSA, with findings correlated to polysomnographic results.

Interventions targeting visceral fat reduction may provide dual benefits by improving both OSA severity and pulmonary outcomes in TB patients. At the same time, underweight individuals require tailored nutritional strategies that promote lean mass preservation while avoiding excessive fat accumulation. Overall, this study supports integrating body composition monitoring, objective sleep assessment, and individualized metabolic and nutritional interventions into TB management protocols to optimize respiratory and overall health outcomes in this vulnerable population.

Implication

The The findings of this study have important practical and academic implications. Practically, the results indicate that a large proportion of medical students exhibit low to moderate physical activity levels accompanied by varied BMI profiles, including underweight and obesity. This highlights the need for targeted health promotion programs within the medical faculty to encourage regular physical activity, balanced nutrition, and healthy lifestyle behaviors. Universities may consider implementing structured exercise programs, campus sports facilities, health education seminars, and routine BMI monitoring to support students in maintaining optimal nutritional status and preventing long-term health risks.

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BIBLIOGRAPHY

Avishek Layek, & Tejas Menon Suri. (2025). Tuberculosis and sleep – An underexplored association? *Indian Journal of Tuberculosis*, *27*(1), S91–S93.

Cahaya, G., Berawi, K. N., & Mustofa, S. (2019). Obesitas Meningkatkan Risiko Obstructive Sleep Apnea pada Laki-laki Dewasa. *Majority*, *8*(2), 161.

Chuang, Y. M., Liu, W. Te, Tsai, C. Y., Lin, Y. C., Ho, K. F., Chuang, K. J., & Chuang, H. C. (2025). Associations between body composition, hydration status, and sleep architecture in obstructive sleep apnea. *Frontiers in Endocrinology*, *16*. https://doi.org/10.3389/fendo.2025.1666026

Esmaeili, N., Gell, L., Imler, T., Hajipour, M., Taranto-Montemurro, L., Messineo, L., Stone, K. L., Sands, S. A., Ayas, N., Yee, J., Cronin, J., Heinzer, R., Wellman, A., Redline, S., & Azarbarzin, A. (2025). The relationship between obesity and obstructive sleep apnea in four community-based cohorts: an individual participant data meta-analysis of 12,860 adults. *EClinicalMedicine*, *83*. https://doi.org/10.1016/j.eclinm.2025.103221

Fitrah Ahmad, I., Pandu Wiriansya, E., Puspa Ratu, A., & Kasim, S. (2025). Tuberculosis Infection In Women. In *International Journal of Health and Pharmaceutical*. https://ijhp.net

Gao, L., Wen, Y., Guo, K., Li, R., Mao, M., Feng, S., & Wang, X. (2025). Research trends and hot spots in obesity-induced pain: A bibliometric analysis of the last 20 years. In *IBRO Neuroscience Reports* (Vol. 18, pp. 311–322). Elsevier B.V. https://doi.org/10.1016/j.ibneur.2025.02.001

Kim, S. H., Sim, J. K., Choi, J. Y., Moon, J. Y., Lee, H., & Min, K. H. (2024). Prevalence of and factors associated with likely obstructive sleep apnea in individuals with airflow limitation. *Frontiers in Medicine*, *11*. https://doi.org/10.3389/fmed.2024.1343372

Kritikou, I., Basta, M., Tappouni, R., Pejovic, S., Fernandez-Mendoza, J., Nazir, R., Shaffer, M. L., Liao, D., Bixler, E. O., Chrousos, G. P., & Vgontzas, A. N. (2013). Sleep apnoea and visceral adiposity in middle-aged male and female subjects. *European Respiratory Journal*, *41*(3), 601–609. https://doi.org/10.1183/09031936.00183411

Kundel, V., Lehane, D., Ramachandran, S., Fayad, Z., Robson, P., Shah, N., & Mani, V. (2021). Measuring visceral adipose tissue metabolic activity in sleep apnea utilizing hybrid18f-fdg pet/mri: A pilot study. *Nature and Science of Sleep*, *13*, 1943–1953. https://doi.org/10.2147/NSS.S327341

Liao, Z., Chen, Y., Wu, L., Huang, Y., Li, S., Liu, J., Zong, X., Tai, J., & Chen, F. (2024). Associations of Obstructive Sleep Apnea Risk with Obesity, Body Composition and Metabolic Abnormalities in School-Aged Children and Adolescents. *Nutrients*, *16*(15). https://doi.org/10.3390/nu16152419

Locke, B. W., Lee, J. J., & Sundar, K. M. (2022). OSA and Chronic Respiratory Disease: Mechanisms and Epidemiology. In *International Journal of Environmental Research and Public Health* (Vol. 19, Number 9). MDPI. https://doi.org/10.3390/ijerph19095473

Messineo, L., Bakker, J. P., Cronin, J., Yee, J., & White, D. P. (2024). Obstructive sleep apnea and obesity: A review of epidemiology, pathophysiology and the effect of weight-loss treatments. In *Sleep Medicine Reviews* (Vol. 78). W.B. Saunders Ltd. https://doi.org/10.1016/j.smrv.2024.101996

Molnár, V., Lakner, Z., Molnár, A., Tárnoki, D. L., Tárnoki, Á. D., Kunos, L., & Tamás, L. (2022). The Predictive Role of Subcutaneous Adipose Tissue in the Pathogenesis of Obstructive Sleep Apnoea. *Life*, *12*(10). https://doi.org/10.3390/life12101504

Mukhlis, M., & Bakhtiar, A. (2021). *Obstructive Sleep Apneu (OSA), Obesitas Hypoventilation Syndrome (OHS) dan Gagal Napas*.

Qian, Y., Perret, J. L., Hamilton, G. S., Abramson, M. J., Lodge, C. J., Bui, D. S., Ali, G. B., De Silva, A. P., Adams, R. J., Thompson, B. R., Erbas, B., Walters, E. H., Senaratna, C. V., & Dharmage, S. C. (2025). Early-to-Midlife Body Mass Index Trajectories and Obstructive Sleep Apnoea Risk 10 Years Later. *Respirology*, *30*(5), 435–445. https://doi.org/10.1111/resp.70002

Sekizuka, H., Ono, Yoshiaki, Saitoh, T., & Ono, Yoshitaka. (2021). Visceral fat area by abdominal bioelectrical impedance analysis as a risk of obstructive sleep apnea a single-clinic retrospective case study. *International Heart Journal*, *62*(5), 1091–1095. https://doi.org/10.1536/ihj.21-219

Shah, N. M., & Kaltsakas, G. (2023). Respiratory complications of obesity: from early changes to respiratory failure. In *Breathe* (Vol. 19, Number 1). European Respiratory Society. https://doi.org/10.1183/20734735.0263-2022

Xu, X., Xu, J., & Zhang, M. (2024). Association between metabolic score for visceral fat and obstructive sleep apnea: a cross-sectional study. *Frontiers in Medicine*, *11*. https://doi.org/10.3389/fmed.2024.1480717

Yetim, M., Kalçık, M., Bekar, L., Karavelioğlu, Y., & Yılmaz, Y. A. (2025). Body Composition Analysis in Obstructive Sleep Apnea: A Cross-Sectional Study Using Bioelectrical Impedance Analysis. *Clinical Respiratory Journal*, *19*(9). https://doi.org/10.1111/crj.70123

Zaffanello, M., Pietrobelli, A., Piacentini, G., Zoller, T., Nosetti, L., Guzzo, A., & Antoniazzi, F. (2025). Mapping the Fat: How Childhood Obesity and Body Composition Shape Obstructive Sleep Apnoea. In *Children* (Vol. 12, Number 7). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/children12070912