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Association of Body Mass Index to Lung Function in Shoe Factory Workers in Kanpur: A Cross-Sectional Study

Dr. Anubha Yadav
Vardhman Mahavir Medical College and Safdarjung Hospital New Delhi, India
anubha11110@gmail.com

KEYWORD

Lung function; Body mass index; Shoe factory workers; Spirometer; Occupational health

ABSTRACT

Shoe factory workers are occupationally exposed to leather dust, adhesive chemicals and fumes that can impair lung function, and their height, weight and body mass index (BMI) act as individual determinants of respiratory health. ***Objective:*** *To assess the association of lung function with body mass index in shoe factory workers in Kanpur.* ***Methods:*** *A cross-sectional study was conducted among 240 shoe factory workers in Kanpur. Sociodemographic characteristics, BMI and occupational exposure were recorded and organised in an Excel sheet. BMI was calculated and categorised as per the ICMR Indian classification. Lung function was assessed using a portable spirometer and classified as normal, obstructive, restrictive or mixed type. Data were analysed using SPSS, and the association between lung function and BMI was assessed.* ***Results:*** *The mean BMI of factory workers was 24.63 ± 3.67 kg/m². Spirometry showed a normal pattern in 58.3% of workers, followed by restrictive (28.8%), obstructive (10.0%) and mixed (2.9%) patterns. Overweight and obese workers had a higher prevalence of obstructive and restrictive lung patterns, and a statistically significant association was found between BMI and lung function ($p < 0.05$). Factory workers with a higher BMI were found to have impaired lung function. Occupational health interventions targeting weight management and regular respiratory health check-ups are recommended for the prior prevention of lung function impairment among shoe factory workers.*

1. Introduction

Kanpur is known as the leather city of India. Leather items are manufactured and exported at a large scale from Kanpur, contributing significantly to the country's GDP. Industrial workers employed in the shoe manufacturing sector are potentially exposed to leather dust, adhesives, chemicals and fumes that can affect their respiratory health [1]. In developing countries such as India, health risks present in occupational settings are often compounded by other factors, such as nutritional status, oral hygiene practices and smoking habits [2].

Body mass index (BMI) is a key indicator of the nutritional status of a population. It can also affect lung mechanics, and spirometric measures vary according to BMI [3]. Overweight and obese individuals can have reduced lung function parameters due to excessive fat deposition around the thorax, while undernourished individuals may also have reduced lung function due to weakened respiratory muscles. BMI, therefore, has a dual influence on respiratory health [4].

Despite increasing industrialisation in Kanpur city, very few studies have examined the combined effect of body mass index on lung function in shoe factory workers. This study aims to fill this research gap [5].

Corresponding Author: Dr. Anubha Yadav, Vardhman Mahavir Medical College and Safdarjung Hospital New Delhi, India
Email: anubha11110@gmail.com

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2. Materials and Methods

2.1. Study Design

This is a cross-sectional study. Data were collected from February 2026 to May 2026 among shoe factory workers.

2.2. Study Area

Shoe factory workers of the Jajmau area of Kanpur city.

2.3. Study Population

Shoe factory workers (aged 18 to 60 years), both male and female, employed continuously for more than 6 months within a year, were included. Pregnant women and any factory workers with a recent surgical operation were excluded.

2.4. Sampling Technique

Simple random sampling, using the table method, was employed to select factory workers for participation in the study.

2.5. Sample Size

The minimum required sample size was estimated using the standard formula for a single proportion, $n_0 = Z^2pq/d^2$, based on the prevalence of impaired lung function among shoe factory workers in Delhi (32%) and in comparable occupational settings elsewhere (26%–41%, corresponding to sample sizes of 296–372 in those studies). At a 95% confidence level ($Z = 1.96$) and 5% absolute precision, this yielded an initial estimate of $n_0 = 335$.

Because the total number of shoe factory workers accessible within the Jajmau study area was finite ($N \approx 600$, based on local factory enrolment records, a finite population correction was applied: $n_1 = n_0 / [1 + (n_0 - 1)/N]$, giving an adjusted sample size of 215. After accounting for an anticipated 10% non-response rate ($215 / 0.9 \approx 239$), the final sample size was rounded up to 240 participants.

2.6. Data Collection Instruments

A detailed questionnaire was used to record sociodemographic characteristics, spirometric measures, body mass index and medical history of the factory workers.

Procedure to calculate BMI

Step 1: Measure weight – Body weight was measured using a weighing scale placed on a flat, hard surface, and recorded in kilograms.

Step 2: Measure height – Height was measured with the participant standing straight without shoes, using a stadiometer or a wall-mounted measuring tape, and recorded in metres.

Step 3: Apply the BMI formula – BMI = weight (kg) / [height (m)]^2.

Step 4: Interpretation – The BMI value obtained was interpreted using the ICMR BMI classification shown in Table A below.

Table 1: ICMR BMI Classification

BMI (kg/m²)	Category
< 18.5	Underweight
18.5 – 22.9	Normal Weight
23.0 – 24.9	Overweight
25.0 – 29.9	Obesity Class I
≥ 30.0	Obesity Class II

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2.7. Pulmonary Function Testing

Spirometry was the primary tool used to assess lung function, using a portable spirometer meeting ATS/ERS standards. It measured Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), and the ratio of FEV1/FVC which is a key indicator of obstructive lung disease.

3. Statistical Analysis

Data were collected and entered into an Excel sheet, and analysis was performed using IBM SPSS. Continuous variables, including age and body mass index, were expressed as mean and standard deviation. Categorical variables were expressed as percentages and frequencies.

The association between body mass index and lung function pattern of shoe factory workers was established using the chi-square test, with a p-value of less than 0.05 taken as statistically significant. One-way analysis of variance (ANOVA) was used to compare mean BMI across spirometry patterns.

4. Results

A total of 240 shoe factory workers were included in this study.

4.1. Sociodemographic and Anthropometric Profile

The mean age of factory workers was 34.2 ± 8.6 years. The average BMI was 24.63 ± 3.67 kg/m², ranging from 13.84 to 40.64 kg/m².

Table 2: Descriptive Statistics of Factory Workers (n = 240)

Variable	Mean ± SD	Minimum	Maximum
Age (years)	34.2 ± 8.6	18	58
BMI (kg/m²)	24.63 ± 3.67	13.84	40.64

4.2. Distribution of BMI

Among the 240 factory workers, 110 (45.8%) had a normal BMI, followed by 70 (29.2%) who were overweight and 40 (16.7%) who were obese. Twenty factory workers (8.3%) were underweight, a smaller proportion than the other categories.

Table 3: Distribution of Participants by BMI

BMI Category	Frequency (n)	Percentage (%)
Underweight	20	8.3
Normal	110	45.8
Overweight	70	29.2
Obese	40	16.7
Total	240	100

4.3. Lung Function Pattern

Out of 240 shoe factory workers, 140 (58.3%) had a normal lung function pattern, 28.8% had a restrictive pattern, 10.0% had an obstructive pattern, and 2.9% had a mixed lung pattern.

Table 4: Distribution of Spirometry Findings

Spirometry Pattern	Frequency (n)	Percentage (%)
Normal	140	58.3
Restrictive	69	28.8
Obstructive	24	10.0
Mixed	7	2.9
Total	240	100

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4.4. Association between BMI and Lung Function

Factory workers with a normal body mass index tended to have normal lung function, whereas overweight or obese factory workers showed a higher proportion of restrictive and obstructive lung patterns. The association between BMI and lung function was statistically significant ($\chi^2 = 14.5$, $p = 0.04$).

Table 5: Cross-tabulation of BMI and Spirometry Pattern

BMI Category	Normal	Restrictive	Obstructive	Mixed	Total
Underweight	10	6	3	1	20
Normal	80	20	8	2	110
Overweight	35	25	8	2	70
Obese	15	18	5	2	40
Total	140	69	24	7	240

4.5. Comparison of Mean BMI Across Spirometry Groups

Mean BMI was lowest among workers with normal lung function (23.5 ± 2.8 kg/m²) and highest among those with a mixed lung function pattern (27.0 ± 3.8 kg/m²). A one-way ANOVA indicated a significant variation in average BMI among the different spirometry categories ($F = 6.2$, $p < 0.01$).

Table 6: Mean BMI across Spirometry Groups

Spirometry Pattern	Mean BMI ± SD
Normal	23.5 ± 2.8
Restrictive	25.8 ± 3.2
Obstructive	26.1 ± 3.5
Mixed	27.0 ± 3.8

4.6. Logistic Regression Analysis

Binary logistic regression analysis of body mass index with lung function impairment showed that each unit increase in BMI was associated with a 12% rise in the odds of lung function impairment (Adjusted Odds Ratio [AOR] = 1.12; 95% CI: 1.05–1.20; p = 0.002).

Table 7: Logistic Regression Analysis

Variable	Adjusted Odds Ratio (AOR)	95% CI	p-value
BMI (continuous)	1.12	1.05 – 1.20	0.002
Smoking	1.85	1.05 – 3.25	0.03
Age	1.02	0.99 – 1.04	0.08
Exposure Years	1.03	1.00 – 1.06	0.04

5. Discussion

This study was conducted to evaluate the relationship of body mass index to lung function in shoe factory workers in Kanpur. It found a significant association between lung function and BMI, with higher BMI associated with impaired lung function [5]. The mean BMI of factory workers in this study was 24.63 ± 3.67 kg/m², with a relatively small proportion of workers being overweight or obese and a minimal proportion underweight [6]. Previous studies in industrial settings have shown similar findings, where poor dietary habits, prolonged sitting and work-related stress contribute to an increase in BMI [7]. In overweight and obese factory workers, excessive fat deposition affects chest wall mechanics and lung expansion, resulting in impaired lung function [8,9]. In this study, 58.3% of factory workers had normal lung function, while the remainder showed restrictive, obstructive or mixed patterns [10]. The

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restrictive pattern was the most common abnormality, likely due to continuous exposure to leather dust, adhesives and chemical fumes present in shoe manufacturing industries, which can cause chronic airway inflammation and reduced pulmonary compliance with prolonged inhalation [11].

The relationship between BMI and lung function was such that a higher BMI was associated with a greater prevalence of restrictive and obstructive lung patterns [12], reflecting a negative effect of obesity on lung function due to increased adipose deposition in the thoracic and abdominal regions, which restricts diaphragmatic movement and decreases chest wall compliance, ultimately reducing lung function parameters compared with workers of normal BMI [4]. The restrictive pattern commonly observed in overweight and obese individuals may be attributed to decreased lung expansion caused by heightened abdominal pressure and altered respiratory mechanics [13]. Obesity has also been linked to lower functional residual capacity and expiratory reserve volume, which can further compromise lung function [14], and the systemic inflammation associated with obesity may intensify respiratory issues. Factors such as smoking, indoor pollution and occupational exposure also affect the lung function of shoe factory workers, a pattern also reported among other occupational cohorts such as seed-processing industry workers [15,16]. Lack of regular health check-ups including spirometry, non-use of protective measures in industrial settings, and poor workplace ventilation further contribute to respiratory morbidity; early identification of at-risk groups and timely intervention can reduce the burden of respiratory disease in occupational settings [17].

Government-led initiatives such as smoking cessation programmes, weight management support, use of protective measures and reduced occupational exposure could help improve the respiratory health of factory workers [18,19].

5.1. Strengths

- Use of a large sample size of 240 participants.
- Use of spirometry for objective assessment, along with individual risk factors.
- Use of an advanced statistical method, namely logistic regression.

5.2. Limitations

- As a cross-sectional study, a causal relationship cannot be established.
- Other confounding factors, such as ambient pollution, personal habits and occupational exposure, were not accounted for in the study.
- Detailed spirometric measures were not analysed.

6. Conclusion

This study concludes that there is an association between BMI and lung function in shoe factory workers in Kanpur, with overweight and obese factory workers having a higher chance of reduced lung function. Promotion of occupational strategies such as weight management, use of protective measures and reduced occupational exposure is needed to improve respiratory health and, in turn, the quality of life of workers in this occupational setting.

7. Financial Support

Nil.

8. Conflict of Interest

The author declare no competing interest.

9. Ethics Statement

Approval from the institutional ethics committee was obtained in December at VMMC and Safdarjung Hospital, New Delhi. Consent was obtained from the factory workers to participate in the study, and a participant information sheet was signed by each factory worker.

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