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ORIGINAL RESEARCH

Chronic airflow limitation in a rural Indian population: etiology and relationship to body mass index

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Purpose: Respiratory conditions remain a source of morbidity globally. As such, this study aimed to explore factors associated with the development of airflow obstruction (AFO) in a rural Indian setting and, using spirometry, study whether underweight is linked to AFO.

Methods: Patients > 35 years old attending a rural clinic in West Bengal, India, took a structured questionnaire, had their body mass index (BMI) measured, and had spirometry performed by an ancillary health care worker.

Results: In total, 416 patients completed the study; spirometry was acceptable for analysis of forced expiratory volume in 1 second in 286 cases (69%); 16% were noted to exhibit AFO. Factors associated with AFO were: increasing age (95% confidence interval (CI) 0.004–0.011; $P = 0.005$), smoking history (95% CI 0.07–0.174; $P = 0.006$), male gender (95% CI 0.19–0.47; $P = 0.012$), reduced BMI (95% CI 0.19–0.65; $P = 0.02$), and occupation (95% CI 0.12–0.84; $P = 0.08$). The mean BMI in males who currently smoked (n = 60; 19.29 kg/m^2; standard deviation [SD] 3.46) was significantly lower than in male never smokers (n = 33; 21.15 kg/m^2 SD 3.38; $P < 0.001$). AFO was observed in 27% of subjects with a BMI <18.5 kg/m^2, falling to 13% with a BMI ≥18.5 kg/m^2 ($P = 0.013$). AFO was observed in 11% of housewives, 22% of farm laborers, and 31% of cotton/jute workers ($P = 0.035$).

Conclusion: In a rural Indian setting, AFO was related to advancing age, current or previous smoking, male gender, reduced BMI, and occupation. The data also suggest that being underweight is linked with AFO and that a mechanistic relationship exists between low body weight, smoking tobacco, and development of AFO.

Keywords: airflow obstruction, risk factors, BMI, spirometry, measurement, questionnaire, smoking, body weight

Introduction

The global burden of respiratory disease is felt particularly in developing countries. Furthermore, in less affluent rural populations living in countries such as India, access to adequate health care resources may be limited.[1,2] Lung functions of people in India have been detailed in epidemiological studies, although there remains a relative paucity of data concerning the rural regions of West Bengal.[3–5] Moreover, studies in India often base the diagnosis of airflow obstruction (AFO) solely on questionnaire data without spirometry.[3] Therefore, there remains a need to study respiratory symptoms and define lung function in people residing in such areas. It would also be useful to define population-based predictors of AFO in a rural Indian setting where clinicians may lack access to lung function testing.

There is a growing body of literature in India regarding the impact of biomass fuels and tobacco smoking on the development of AFO.[6–9] Studies conducted in

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predominantly urban Indian settings have highlighted a relationship between low body mass index (BMI), tobacco consumption, and AFO.[10] Data from urban populations in India have shown reduced forced expiratory volume in 1 second (FEV_1) to correlate positively with low BMI.[11] This contrasts with findings in industrialized developed countries, where the rising incidence of obesity has been linked to the development of respiratory disease.[12,13] This paper investigates the hypothesis that being significantly underweight, a common finding in less affluent rural populations of developing countries, can be linked to the finding of AFO.

Materials and methods

All patients >35 years old attending the primary care outpatient clinic (Moitri Swasthya Kendra) in Chengail, West Bengal, India, were invited to participate in the study over a 12-month period commencing February 2009.

After subjects gave informed consent, they underwent:

- Completion of a structured questionnaire (Appendix). Patients completed questionnaires with the assistance of one investigator in all cases. The questionnaire was developed by a focus group comprising a general physician based at the Moitri Swasthya Kendra clinic (PG) and consultant respiratory physicians based at University Hospital Aintree, Liverpool, UK (BC, PMAC, CJW), and Birmingham Heartlands Hospital, UK (RM). The questionnaire was then translated from English into Bengali, the language local to the area of India in which the study was conducted, by two investigators (RM and PG) – this version being used for the study. "Bidis" were defined as hand-rolled cigarettes comprising tobacco wrapped with the temburni plant.
- Measurement of body weight and height and the calculation of BMI. Underweight was defined as BMI <18.5 kg/m^2 according to the World Health Organization.[14]
- Measurement of spirometry using a portable spirometer (Medikro® SpiroStar DX; Medikro®, Kuopio, Finland) using validated criteria.[15] The investigator, an ancillary health worker affiliated to Moitri Swasthya Kendra, participated in two training workshops focusing on performing spirometry. The ancillary health care worker had no prior experience in performing spirometry but assisted a general physician on a weekly basis at the primary care clinic. Each workshop, conducted by two consultant respiratory physicians (BC and RM), lasted 3 hours. The training included theoretical and practical aspects of spirometry, diagnosis of AFO according to the Global initiative for chronic Obstructive Lung Disease (GOLD) criteria, and an assessment to ensure that the health care worker could perform spirometry independently.[16] Calibration of the spirometer was performed daily during the study period.

The spirometry data were independently analyzed by a respiratory clinical physiologist (VM) blinded to the questionnaire results and graded into three categories:

1. Good quality. Explosive start on flow-volume curve producing acceptable peak expiratory flow (PEF); met end of test criteria of <25 mL exhaled in 1 second; back extrapolation volume <150 mL/5% of forced vital capacity (FVC); FVC duration $\geq$ 6 seconds; no coughs, leaks or extra breaths. Reproducibility criteria could not be assessed as only the best maneuver was available on the spirometry report.
2. Adequate shape of the expiratory curve. Explosive start on flow-volume curve; back extrapolation volume < 150 mL/5% of FVC; no coughs, leaks or extra breaths allowing accurate and valid estimation of FEV_1.
3. Poor quality. All other spirometry that failed to meet criteria for groups 1 or 2.

Only those data in categories 1 and 2 were deemed acceptable for further analysis and further categorized as "acceptable" spirometry. AFO was defined as an FEV_1/FVC ratio < 0.7.[16] Cases of "acceptable" spirometry exhibiting AFO were stratified according to severity using GOLD criteria as "normal" values for the local population have not been established.[17] Formal ethical approval to conduct the study was granted by the Board of the Moitri Swasthya Kendra Hospital.

Statistical analysis

Analysis was performed using SPSS (v 18.0; IBM, Armonk, NY). Data are presented as mean and standard deviation (SD) unless otherwise stated. Predicted values for lung function were based on the European Coal and Steel Community (ECSC) reference values.[17] Statistical significance was defined as a P value of <0.05. Chi-square testing was used to examine differences between categorical variables. Analysis of variance was used to compare the mean of normally distributed variables between two groups. Spearman's rank coefficient was used to measure correlation between two sets of data. Logistic regression analysis was used to identify candidate variables associated with the presence of airflow obstruction.

Results

During the study period, 416 patients attending the clinic consented and were recruited to the study and all successfully completed the questionnaire. None were excluded from the analysis at this point. Of those recruited, 111 with adequate spirometry were deemed to be of "good quality" (category 1); the shape was deemed to be "satisfactory" in a further 175 (category 2) – hence, 286 spirometry traces (69% of the overall sample) were categorized as "acceptable" (ie, suitable for analysis of FEV_1). These 286 subjects who had complete questionnaire data and valid spirometry were used in the analysis (see Table 1 for key demographics of study population). All but two subjects in employment had "blue collar" occupations. All 140 subjects in the "housewife" occupation category cooked with an indoor stove, the cooking fuel being liquid petroleum gas distributed by government subsidy.

Relationship between respiratory symptoms and lung function

Forty-seven subjects (16%) were noted to exhibit AFO: GOLD "mild" stage 1 in seven (15%), "moderate" stage 2 in 23 (49%), "severe" stage 3 in twelve (26%), "very severe" stage 4 in five (10%). The incidence of AFO was significantly higher in males (22% [30/105]) than in females (11% [17/151]) (chi-square analysis, $P = 0.01$).

Table 1 Demographics of study population (n = 286)

Age (median)		
50 (range 35) years		
Body mass index		
21.38 (4.08)		
Smoking status		
Never smoker	178 (62%)	35 (56%) bidis only
Ex-smoker	46 (16%) ex	2 (3%) cigarettes only
Current smoker	62 (22%) current	25 (41%) bidis and cigarettes
Sex		
Male	135 (47%) male	33/135 (24%) never smokers
Female	151 (53%) female	145/151 (96%) never smokers
Occupation		
Housewife	140 (49%) (0% male; 1 (0.7%) current/previous smoker)	
Cotton/Jute worker	26 (9%) (96% male; 21 (81%) current/previous smoker)	
Farm labourer	60 (21%) (95% male; 34 (73%) current/previous smoker)	
Other	60 (21%) (88% male; 42 (70%) current/previous smoker)	
History of childhood chest complaints		
Yes	18 (6%)	
No	268 (94%)	
History of treatment for tuberculosis		
Yes	26 (9%)	
No	260 (91%)	

Twenty-four percent (15) of current smokers and 26% (12) of ex-smokers were found to exhibit AFO on spirometry compared with 11% (20) of never smokers (chi-square test; $P = 0.006$). Thus, never smokers comprised 43% (20/47) of all AFO cases. The percentage predicted values of FEV_1 and FEV_1/FVC were significantly lower in current and ex-smokers compared with never smokers (see Table 2).

Presence of cough, wheeze, morning phlegm, phlegm at any time of day, and breathlessness on the flat was significantly higher in subjects with AFO (see Table 3). Twenty-nine percent (52/178) of never smokers reported the presence of wheeze compared with 44% (21/45) and 45% (28/62) of ex- and current smokers (ANOVA; $P = 0.027$). Forty-four percent (27/62) of current and 33% (15/46) of ex-smokers reported presence of morning phlegm compared with 23% (41/178) of never smokers (ANOVA; $P = 0.007$). No significant differences were noted between the never, ex-, and current smokers in terms of reporting breathlessness either on a gradient (78% versus 87% versus 79%) or on the level (50% versus 53% versus 57%).

Factors associated with the development of AFO

On logistic regression analysis, factors associated with the development of AFO were:

- increasing age (95% confidence interval [CI] 0.004–0.011; $P < 0.005$)
- smoking status: those "current" or "ex-smokers" (95% CI 0.07–0.174; $P = 0.006$)
- male gender (95% CI 0.19–0.47; $P = 0.012$)
- reduced BMI (95% CI 0.19–0.65; $P = 0.02$)
- occupation: those not belonging to the "housewife" category (95% CI 0.12–0.84; $P = 0.08$).

A history of childhood chest complaints, use of an indoor stove when cooking, or a known history of prior treated tuberculosis was not associated with AFO.

Table 2 Association of smoking status and lung function on spirometry

	Current smoker (N = 62)	Ex-smoker (N = 46)	Never smoker (N = 178)	*P* value (ANOVA)
FEV_1 (L) % predicted	2.19 (0.68) 71.85 (20.43)	2.14 (0.79) 71.52 (19.51)	1.85 (0.63) 79.80 (21.60)	$P = 0.008$
FVC (L) % predicted	2.93 (0.71) 77.87 (16.60)	2.76 (0.88) 74.96 (17.57)	2.25 (0.76) 81.27 (21.10)	$P = 0.117$ (NS)
FEV_1/FVC ratio	0.73 (0.12)	0.75 (0.11)	0.83 (0.11)	$P < 0.001$

Abbreviations: FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; NS, nonsignificant.

Table 3 Respiratory symptoms in relation to presence of airflow obstruction

Symptom (%/number of subjects)	All subjects (N = 286)	Subjects with airflow obstruction (N = 47)	Subjects without airflow obstruction (N = 239)	*P* value (chi-square test)
Cough	62 (177)	79 (37)	59 (140)	0.006
Wheeze	52 (148)	62 (29)	30 (71)	$<$0.005
Morning phlegm	29 (83)	45 (21)	26 (62)	0.003
Phlegm at any time of the day	43 (122)	55 (26)	40 (96)	0.042
Breathlessness on flat	52 (149)	70 (33)	49 (116)	0.009
Breathlessness on gradient	79 (226)	87 (41)	77 (185)	0.30

Relationship between occupation, symptoms, and lung function

Twenty-one percent of housewives reported the presence of morning phlegm; this rose to 30% in farm laborers, 35% in cotton/jute workers, and 43% in "other" occupations (mean square = 13.68; F = 9.24; $P = 0.003$). A significant relationship was noted between occupation and AFO on spirometry; an FEV_1/FVC ratio < 0.7 was found in 11% (15/140) of housewives compared with 18% (11/60) of "other occupations," 22% (13/60) of farm laborers, and 31% (8/26) of cotton/jute workers ($P = 0.035$).

Relationship between BMI, respiratory symptoms, and lung function

Twenty-three percent (66/286) of subjects were classified as "underweight" (ie, BMI $<$18.5 kg/m^2). The mean BMI was significantly lower in the 47 patients with AFO diagnosed on spirometry (20.11 [SD 4.02] versus 21.62 [SD 4.01] kg/m^2; $P = 0.02$). Current smokers were found to have a significantly lower BMI compared to never smokers (19.36 [SD 3.46] versus 22.35 [SD 4.12] kg/m^2; $P < 0.001$) and males were found to have a significantly lower BMI when compared with females (20.03 [SD 3.51] versus 22.59 [SD 4.19] kg/m^2; $P < 0.001$). The mean BMI in male current smokers (n = 60; 19.29 [SD 3.46] kg/m^2) was significantly lower than in male never smokers (n = 33; 21.15 [SD 3.38] kg/m^2 $P < 0.001$).

A significant association was observed between BMI and AFO on spirometry (coefficient = –0.137; $P = 0.02$), percentage predicted FEV_1 (coefficient = 0.14; $P = 0.02$), FVC (coefficient = 0.13; $P = 0.03$), and peak expiratory flow (coefficient = 0.14; $P = 0.02$), with a nonsignificant trend noted between BMI and FEV 25%–75% (coefficient = 0.1; $P = 0.09$). Of the 286 subjects, 23% (66) were noted to have a BMI of $<$18.5 kg/m^2, with AFO being observed in 27% (18/66) of such cases, falling to 13% (29/220) of subjects with a BMI of $\geq$18.5 kg/m^2 ($P = 0.013$).

Discussion

This study showed that within a rural Indian population, tobacco smoking, advanced age, and male gender were factors linked with an increased incidence of AFO, in keeping with studies conducted in Western industrialized settings. However, in the cohort discussed, the BMI was found to be $<$18.5 kg/m^2 in 23% of subjects reflecting a higher proportion of underweight subjects compared with subjects in studies conducted in Western populations. A survey of adults in Mumbai by Pednekar et al found a strong relationship between tobacco consumption and a low BMI, seen particularly in bidi smokers, although spirometry was not performed in their study.[18] Pedneker et al found that a BMI of $<$18.5 kg/m^2 was twice as prevalent in bidi smokers – 32% of male bidi smokers had a BMI of $<$18.5 kg/m^2 compared with 13.5% of male never smokers and the authors suggested that tobacco use, particularly bidis, represented an independent risk factor for low BMI. These findings are comparable to the data in the present study, where the mean BMI was significantly lower in current smokers when compared with never smokers, with 97% of current tobacco users smoking bidis. However, the present study expands further on this hypothesis, suggesting that, as well as tobacco smoking, being underweight in a rural Indian population is associated with the finding of AFO on spirometry. The mean BMI was significantly lower in subjects with AFO in this study, with the incidence of AFO doubling in those with a BMI of $<$18.5 kg/m^2. In a Belgian study of steelworkers, a correlation was observed between BMI and AFO in current smokers.[19] However, the BMI in the current smokers group was 26.84 kg/m^2 compared with 28.26 kg/m^2 in nonsmokers, substantially higher values than those seen in the group discussed in this paper, reflecting the two entirely different populations studied. In a study of 202 chronic obstructive pulmonary disease (COPD) patients and 136 controls from New Delhi, India, FEV_1 positively correlated with BMI.[11] However, the mean BMI in the COPD population was 21.7 kg/m^2, again higher than in the present study, suggesting that underweight was less relevant within this urban Indian population compared with a rural one as seen in the cohort discussed. Low body weight has been shown to correlate with degree of emphysema seen on computerized tomography in COPD patients and has been implicated as a predictor of the development of COPD in longitudinal studies.[20,21] Such data suggest a mechanistic relationship between low body weight, smoking tobacco, and loss of lung function leading to the development of AFO.

The cohort discussed displayed a high prevalence of respiratory symptoms with just over half reporting breathlessness while walking on the flat. A report of 2400 rural households in the neighboring state of Orissa found that one third of males had symptoms of a cough in the preceding 30 days. Twelve percent of males and 10% of females were classified as having AFO by spirometry, with half of all males displaying a BMI of <19 kg/m^2.[22] Regarding occupational factors, the deleterious effects of jute and cotton exposure on the respiratory system are well documented.[23,24] This study found that, in comparison to cotton/jute workers and farm laborers, housewives had a significantly lower prevalence of AFO (at 31% and 11%, respectively) and morning phlegm production. One reason for this may be because the chief cooking fuel used by the cohort here discussed was liquid petroleum gas rather than biomass, with users of the latter historically exhibiting an increased prevalence of respiratory symptoms and abnormal lung function.[25] This study also found that 43% of all cases of AFO were seen in never smokers. Data from the Third National Health and Nutrition Examination Survey revealed that "never smokers" comprised 23% of all cases of AFO with those authors reporting low BMI as a factor associated with AFO in addition to male gender, allergy history, and increasing age.[26]

The present study has limitations. Subjects were drawn from a population attending a clinic treating patients with "unselected" medical problems, making extrapolation difficult in a general Indian population. Further, the lung function technician received training and reinforcement in performing spirometry from respiratory consultants, which may not be possible in all rural areas of India. The use of the GOLD definition for AFO has been controversial, with opponents arguing that it will lead to overdiagnosis of AFO in the elderly.[27,28] However, the difficulty in using proposed alternative definitions of AFO (ie, "lower limit of normal") is that the normal values and prediction equations defined for Caucasian populations may not always reflect those seen in rural Indian settings.[29] The authors' data did not assess atopic status, IgE level, or bronchodilator reversibility, so it was not possible to accurately distinguish asthma from COPD.

In rural Indian settings, the data in this study suggest that clinicians should maintain a high index of suspicion to consider AFO in underweight individuals, particularly in the presence of the other relevant risk factors observed in the study. Whilst a BMI of ≤ 21 kg/m^2 has been shown to represent an adverse prognostic indicator in the multidimensional BODE index (Body mass index, Obstruction, Dyspnea, Exercise capacity), additional study is required to determine whether indicators such as the BODE index would be as informative within Indian populations diagnosed with COPD.[30] In view of the proportion of patients exhibiting a BMI of <18.5 kg/m^2 in the cohort discussed, further studies are also needed within rural Indian settings, exploring the role of nutritional factors and any link to respiratory disease and AFO.

Conclusion

This study demonstrates that, in a rural Indian setting, AFO was related to advancing age, a history of current or previous smoking, male gender, occupation, and a reduced BMI.

Disclosure

The authors report no conflicts of interest in this work.

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Appendix: Respiratory questionnaire

Name

Gender

Age

Occupation: Current:
Previous:

Smoker (Current/Ex/Never): what smoked?

Number of years you have been smoking

Have you ever been diagnosed or treated for tuberculosis?

Did you have chest trouble when you were young?

Do you cook with a stove indoors?

Do you usually have a cough or have you ever had a cough in the last 12 months?

Have you ever had an attack of wheezing or tightness in your chest during the last 12 months?

Do you usually bring up phlegm from your chest first thing in the morning?

Do you usually bring up phlegm from your chest at any time of the day?

Do you feel breathless on walking at your own pace on the level?

Do you feel breathless on walking fast on the level or climbing up a slight hill?

How often is your sleep disturbed by cough, breathlessness, chest tightness or wheezing?