Research Article

Factors Affecting Respiratory Function of Rice Millers in Anuradhapura District

Wickramage SP[1]✉, Rajaratne AAJ[2], Udupihille M[1]
[1] Department of Physiology, Faculty of Medicine and Allied Sciences, Rajarata University of Sri Lanka, Saliyapura, Sri Lanka
[2]Department of Physiology, Faculty of Medicine, University of Peradeniya, Peradeniya, Sri Lanka

Abstract

Introduction

Rice is the most important crop cultivated in Sri Lanka and rice milling is the largest agro-based industry in the country.

Objectives

To compare lung functions of rice millers and controls with predicted normal values for Sinhalese and to determine the effects of rice husk dust on lung functions of rice millers in relation to length (years) of exposure.

Methods

Rice millers (male: 84, female: 84) and controls (male: 84, female: 84) were selected and matched for determinants of lung functions. Data were collected via a validated questionnaire and spirometry. Observed mean lung functions were compared with lung function norms published for non-smoking Sinhalese.

Results

Most of the male millers and controls were smokers while none of the females were. All mean lung functions tested FVC, FEV_1, PEFR and $FEF_{25-75\%}$, were significantly lower than the predicted values among male millers. While some lung functions were significantly reduced in female millers and male controls, all were comparable with predicted values in female controls. Duration of employment in rice mills was significantly and inversely related to FVC and FEV_1 of millers.

Conclusions

Observed deficiencies in lung functions of rice millers were probably caused by occupational exposure to rice husk dust and tobacco smoke. The cumulative effect of the two were found to be more harmful than each alone. Wearing face masks, worker education and adequate ventilation in mills are recommended. Advantages of cessation of smoking should be further stressed to communities of lower socioeconomic and educational backgrounds.

Key words: Rice millers, Lung functions, Occupational lung disease, Spirometry, Lung function norms

Funding: Financial assistance provided by the Rajarata University research grants RJT/R&P/2009/Med/R/04, RJT/RP&HDC/2012/Med.&Alli.Sci./R/04 and RJT/RP&HDC/2013/Med.&Alli.Sci./R/01 and National Research Council (Grant 06/67) are gratefully acknowledged.
Competing interest: None
Correspondence: sujanthi.wickramage@gmail.com
DOI: http://doi.org/10.4038/amj.v11i1.7644

Introduction

Respiratory diseases associated with agriculture were among the first recognized occupational health hazards in the world (1). Olaus Magnus, as early as in 1555, warned about the dangers of inhaling grain dusts (1). This risk was again noted in 1713 by the Italian Physician Bernardino Ramazzini in his seminal work *De Morbis Artificum Diatriba (Diseases of Workers*) (1). According to Buchan and Kramer (1980) (2) Ramazzini found that nearly all the workers engaged in sifting and measuring grain developed shortness of breath and rarely reached old age.

Although respiratory health hazards were first recognized in the early ages, it has only been in the 20th century that this problem has been carefully studied and documented. In general, the investigation of agricultural health hazards in the world has always got secondary treatment when compared to the investigation of hazards in mining and other heavy metal industries. Nevertheless, these agricultural health hazards are of serious concern (1).

Rice (*Oryza sativa*) is the major staple food in the Sri Lankan diet (3) and also of more than one quarter of the world's population (4). At present, rice occupies about 34% (780,000 hectares) of the total cultivated area in Sri Lanka (5). It is grown as a wetland crop in all the districts in the country in irrigated paddy fields. Rice milling is the process by which paddy is converted to rice. The main steps in rice milling include air and sun drying of the paddy, cleaning, hulling/de-husking, separating, polishing and grading (6). All these steps generate dust, especially hulling, polishing and air and sun drying of the paddy. Rice milling in Sri Lanka is primarily a small to medium scale industry with very little formal control of working conditions by the government. Therefore, almost no protective measures are taken by these paddy mill workers against inhalation of rice husk dust. Furthermore, the average mill worker, with his low level of education, is ignorant of potential harmful effects of inhalation of various dust particles and is reluctant to adopt safety precautions (7).

A cross sectional study carried out among Malaysian rice millers showed significantly higher prevalence of respiratory symptoms among rice millers than the controls. These symptoms included chest tightness (34.9%), morning phlegm (31.7%), shortness of breath (31.7%) and morning cough (19%) (8). Meanwhile, of a group of 150 Pakistani rice millers 18.7% had lung function changes attributable to obstructive lung disease, while 4% had features of restrictive lung disease (9). Furthermore, Indian rice millers were found to have significantly lower Forced Vital Capacity (FVC), Forced Expiratory Volume in the first second (FEV_1) and Peak Expiratory Flow Rate (PEFR) when compared with controls (10). Similar findings were observed in another Indian study with 42.6% of the studied rice mill workers showing evidence of respiratory morbidity and 10.7% having decreased PEFR (11).

While rice is the single most important crop cultivated in Sri Lanka (5) and rice milling is the largest agro-based industry in the country (12), the occupational health of the Sri Lankan rice millers has not been adequately studied. The present study was carried out with the aim of gaining better understanding of the impact of the rice husk dust exposure on the Sri Lankan rice millers. It was carried out in the mainly agricultural Anuradhapura district of Sri Lanka where 64.2% of the district's labour force is employed in the agricultural sector (13). The objective of this study was to compare the lung function variables of the rice millers and controls with the predicted normal values for the Sinhalese population and to determine the effects of rice husk dust on lung functions of rice millers in relation to length (years) of exposure.

Materials and Methods

The study was carried out in Anuradhapura district. Anuradhapura is primarily an agricultural district with most of the resident people are engaged in rice farming activities. It is estimated that 182,834media to large scale rice farmers are living in Anuradhapura district currently. Rice production from the area during Yala season 2017 was nearly 30,000 MT. In the current study, the subject group comprised of 84 male and 84 female rice millers selected from rice mills in 11 out of the 22 divisional secretariat divisions in Anuradhapura district through convenient sampling. Each selected rice miller was employed in rice mills for a total period of 2 years or more. The control group was made up of 84 males and 84 females employed as security guards and cleaners in Rajarata University of Sri Lanka.

The millers were excluded from the study if they were found to have acute respiratory tract infection, or were on treatment for acute respiratory tract infection, at the time of testing. The exclusion criteria also included having had a prior history of respiratory disease with lasting complications or frequent exacerbations affecting current respiratory function, or a history of cardiac illness with complications affecting current respiratory function. The millers were also left out of the study if, at the time of testing, they were found to suffer from respiratory or cardiovascular disease not possibly related to occupational dust exposures. The millers with dental abnormalities with difficulties in sealing lips around the mouth piece to perform spirometry, and the millers who were not actively

involved in the milling process, such as cooks and clerical staff of the larger mills, were also excluded from the study.

Data was collected via an interviewer administered validated respiratory symptom and occupational history questionnaire and spirometry. Each participant's respiratory function was assessed via spirometry. A Spirolab II (Medical International Research, Rome, Italy) portable spirometer was used for this purpose, and the measurements were taken according to the guidelines published by the American Thoracic Society (14). Spirometry was performed twice on each individual. On the rice millers, it was performed once in the morning, before the start of day's work, and once in the afternoon, after the workers had been exposed to the rice husk dust for over 4 hours. Data was collected from the rice millers fulfilling the selection criteria employed in 43 rice mills. Similarly, in the controls too spirometry was performed once in the morning and once in the afternoon. Of the lung function measurements recorded by the spirometer, FVC, FEV_1, FEV_1/FVC ratio, PEFR and $FEF_{25-75\%}$ (Average Mid-expiratory Flow Rate) were used in the comparisons. The spirometer was calibrated using a fixed volume 3-liter calibration syringe (A-M systems, USA). This calibration was done following its use on 2 or 3 mills.

The data gathered in the lung function assessment were entered in a computerized data base (Excel, ™Microsoft). The entered data sheet was double checked comparing with the questionnaires to ensure correct data entry. The data analysis was carried out using SPSS™ version 17.0 (Statistical Product and Service Solutions, Chicago) software. Prior to analyses, the normal distribution of the data sets were ascertained by applying statistical tests of normality such as Anderson-Darling, Ryan-Joiner and Kolmogorov-Smirnov.

The average normal predicted lung function values published by Udupihille (1995) (15) for the healthy non-smoking Sinhalese adults of similar age and height were utilized to compare the observed values. The predicted lung functions were calculated for each individual using the published equations (15) and the means of the predicted values were obtained. To calculate the predicted FEV_1 the equation used was: FEV1 = (0.02) Height (cm) + (- 0.023) Age (years) + (- 0.139)

These means of the predicted values were compared with the means of the observed values by using one sample t tests. Multiple linear regression analyses were carried out to assess the contributory factors to the lung functions of the rice millers.

Ethical clearance for the study was obtained from the Research, Ethics and Higher Degrees Committee of the Faculty of Medicine & Allied Sciences, Rajarata University of Sri Lanka. All the millers and the controls recruited for this study were given explanations about the aims of the study and the extent of the participants' contribution, by the principal investigator, and their written informed consent was taken prior to their participation.

Results

Means age of the males and the females from rice miller group was 44.8 ± 11.1 and 44.7 ± 8.7 years respectively (Table 1).

Table 1: Comparison of factors determining lung volumes and capacities of rice millers and controls

Factors			*Male*			*Female*		
			Millers	*Controls*	*p-value*	*Millers*	*Controls*	*p-value*
Age (years)* (mean ± SD)			44.8 ± 11.1	41.6 ± 11.4	0.063	44.7 ± 8.7	42.3 ± 8.6	0.074
Height (cm)* (mean ± SD)			165.4 ± 6.4	167.1 ± 5.6	0.294	151.0 ± 7.6	152.7 ± 6.9	0.282
Weight (kg)* (mean ± SD)			59.7 ± 9.8	62.6 ± 11.1	0.69	53.0 ± 10.8	55.3 ± 9.9	0.143
Tobacco smoking status (pack year index)* (mean ± SD)			5.7 ± 7.9	4.3 ± 7.3	0.247	0	0	-
Passive smoking status**	None to mild % (n)		61.9% (52)	83.3% (70)	0.002	82.1% (69)	89.3% (75)	0.186
	Moderate to severe % (n)		38.1% (32)	16.7% (14)		17.9% (15)	10.7% (9)	
Exposure to other agricultural dusts**	Exposed % (n)		63% (53)	52% (44)	0.160	37% (31)	31% (26)	0.415
	Non-exposed % (n)		37% (31)	48% (40)		63% (53)	69% (58)	
Socioeconomic status**	Education standard	No/Primary education % (n)	20.2% (17)	3.6% (3)	0.001	29.8% (25)	14.3% (12)	0.016
		Secondary education % (n)	79.8% (67)	96.4% (81)		70.2% (59)	85.7% (72)	
	Marital status	Single/divorced/separated/ widowed % (n)	10.7% (9)	14.3% (12)	0.484	26.2% (22)	9.5% (8)	0.005
		Married % (n)	89.3% (75)	85.7% (72)		73.8% (62)	90.5% (76)	

Table 2: Comparison of the mean lung functions of male rice millers with lung function norms predicted for healthy non-smoking Sinhalese population of similar age and height

Lung function variable	*Predicted values for Sinhalese males of similar age & height*	*Time of the day test was performed*	*Observed mean values in male millers ± SD*	*p value***
FVC (Liters)	3.317	Morning	2.82 ± 0.65	< 0.01*
		Afternoon	2.82 ± 0.60	< 0.01*
FEV_1 (Liters)	2.698	Morning	2.54 ± 0.56	0.01*
		Afternoon	2.53 ± 0.54	< 0.01*
PEFR (Liters/sec)	9.126	Morning	8.15 ± 2.41	< 0.01*
		Afternoon	8.17 ± 2.17	< 0.01*
$FEF_{25-75\%}$ (Liters)	2.916	Morning	3.38 ± 1.10	< 0.01*
		Afternoon	3.34 ± 1.08	< 0.01*

*p < 0.05 **One sample t test

Table 3: Comparison of the mean lung functions of female rice millers with the lung function norms predicted for healthy non-smoking Sinhalese population of similar age and height

Lung function variable	*Predicted values for Sinhalese females*	*Time of the day test was performed*	*Observed mean values in female millers*	*p* **
FVC (Liters)	2.067	Morning	1.96 ± 0.48	0.054
		Afternoon	1.87 ± 0.43	< 0.01*
FEV_1 (Liters)	1.852	Morning	1.76 ± 0.38	0.03*
		Afternoon	1.71 ± 0.39	< 0.01*
PEFR (Liters/sec)	6.227	Morning	5.53 ± 1.50	< 0.01*
		Afternoon	5.62 ± 1.52	< 0.01*
$FEF_{25-75\%}$ (Liters)	2.406	Morning	2.36 ± 0.73	0.56
		Afternoon	2.42 ± 0.74	0.91

None of the females were smokers while 66% from the male rice miller group and 64% from the male control group were smokers with 5.7 ± 7.9 and 4.3 ± 7.3 pack years respectively. Controls had a higher educational level than the millers in both the male and female groups (Table 1).

The outcomes obtained for male millers, female millers, male controls and female controls are shown in tables 2, 3, 4 and 5 respectively. All mean lung functions tested FVC, FEV1, PEFR and FEF25-75%, were significantly lower than the predicted values among male millers. While some lung functions were found to be significantly reduced in the female millers and male controls, all the lung functions tested were compatible with the predicted values among female controls.

Contributory factors to lung functions of millers as identified from multiple linear regression are shown in Table 4. The significant contributions of the already recognized determinants such as age, gender, height and weight on lung functions were confirmed by the analysis. The duration of employment in rice mills was significantly and inversely related to the FVC and FEV1 values of the millers. Among other factors tested, the mean pack year index of smoking was significantly associated with FEV1 and PEFR, while the exposure to other agricultural dusts was significantly associated wit FEV1 of the millers.

Discussion

The present study has confirmed that the cardiorespiratory health of the rice millers employed in Anuradhapura district, irrespective of gender, is adversely affected. In the current study, for comparisons, the lung function norms published for the Sinhalese by Udupihille in 1995 (15) were used. These norms predict the expected lung function values for normal, healthy, non smoking, Sinhalese individuals, depending on their age, height and sex. Most of the lung functions of female as well as male millers used in the current study were lower than the respective norms.

Table 4: Comparison of the mean lung functions of male and female controls with the lung function norms predicted for healthy non-smoking Sinhalese population of similar age and height

Lung function variable	*Predicted values*	*Time of the day test was performed*	*Observed mean values*	*p value***
Males				
FVC (Liters)	3.435	Morning	3.14 ± 0.54	< 0.01*
		Afternoon	3.15 ± 0.58	< 0.01*
FEV_1 (Liters)	2.821	Morning	2.76 ± 0.48	0.23
		Afternoon	2.72 ± 0.45	0.04*
PEFR (Liters/sec)	9.283	Morning	8.91 ±1.84	0.07
		Afternoon	9.13 ± 1.86	0.46
$FEF_{25-75\%}$ (Liters)	3.088	Morning	3.37 ± 0.88	< 0.01*
		Afternoon	3.31 ± 1.24	0.11
Females				
FVC (Liters)	2.155	Morning	2.12 ± 0.41	0.43
		Afternoon	2.15 ± 0.39	0.9
FEV_1 (Liters)	1.942	Morning	1.93 ± 0.38	0.74
		Afternoon	1.93 ± 0.36	0.77
PEFR (Liters/sec)	6.375	Morning	6.43 ± 1.77	0.77
		Afternoon	6.38 ± 1.59	0.99
$FEF_{25-75\%}$ (Liters)	2.559	Morning	2.79 ± 1.04	0.05
		Afternoon	2.78 ± 1.34	0.14

These norms which were published over twenty years ago, could be expected to have changed to a certain degree over the two decades due to changes in environmental factors including air pollution, socioeconomical factors, the changes in people's dietary habits, exercise etc. Further, Udupihille has used the data collected from non-smoking Sinhalese individuals to establish the lung function norms. However, in the current study, the majority of the male subjects and controls were smokers and as such, the results could have been adversely affected.

Despite these obvious limitations, many lung functions of the millers were found to be significantly lower than the predicted norms. While the female controls had mean lung functions comparable to norms, the mean FVC and FEV1 of the male controls were significantly lower, probably owing to tobacco smoking. The female millers' lung functions were likely to have been affected due to the exposure to rice husk dust while the male millers were probably affected due to the combined effect of rice husk dust and tobacco smoke.

When air pollutants are breathed into the lungs, the harmful particles which bypass the lung defense mechanisms such as hairs in nostrils, mucus membrane lining the nasal passage and pharynx and ciliary action, may get trapped in the alveoli, causing a localized inflammatory response. Enzymes such as elastase are released during this inflammatory response, causing alveolar septal disintegration. The inflammatory response also causes impairment of lung defense mechanisms and disruption of lung tissue repair mechanisms. This may lead to significant deformities in lung architecture, including loss of lung elastic recoil, leading to functional consequences. A similar chronic inflammatory response in the lungs can be expected due to long term exposure to rice husk dust. This may play a role in chronic reductions in lung functions in those exposed to rice husk dust.

Smokers are known to develop prominent restrictive changes in lungs with the tobacco smoke destroying lung elastic tissue and preventing full expansion of lungs, thus leading to emphysema. They may also develop chronic obstructive airway changes as tobacco smoke causes inflammation driven pathologies in the lungs, giving rise to progressive airflow limitation. Both active and passive smoking can cause damage to the lungs. It has been shown that smokers are affected by the exposure to rice husk dust far worse than non smokers (16)(17).

Tobacco smoke contains more than 7000 chemicals, most of which are toxic to cilia, the tiny hair-like processes lining the airways (18). The toxins in the inhaled smoke would slow down the ciliary action, paralyze them, and finally destroy them, thereby hindering their sweeping action of mucus. This would cause the mucus to build up in the airways, giving rise to long standing cough and phlegm in the chest.

A multiple regression analysis confirmed the significant contributions from the already recognized determinants such as age, gender, height and weight on lung functions. The total number of years employed in rice mills were significantly inversely correlated with FVC and FEV_1 of the rice millers.

Table 5: Factors contributing to the variations in lung functions of rice millers

Lung functions		Factors tested (p value)**						
		Age	Gender	Height	Weight	Smoking pack years	Exposure to other agricultural dusts	Total number of years
FVC	Before exposure	<0.001*	<0.001*	0.005*	0.001*	-	-	-
	After exposure	<0.001*	<0.001*	0.001*	0.002*	-	-	0.019*
FEV_1	Before exposure	<0.001*	<0.001*	<0.001*	-	0.02*	-	-
	After exposure	<0.001*	<0.001*	<0.001*	-	-	0.034*	0.038*
FEV_1/FVC ratio	Before exposure	0.032*	-	-	<0.001*	-	-	-
	After exposure	0.006*	-	0.033*	<0.001*	-	-	-
PEFR	Before exposure	0.007*	<0.001*	<0.001*	-	0.034*	-	-
	After exposure	0.002*	<0.001*	<0.001*	-	-	-	-
$FEF_{25-75\%}$	Before exposure	<0.001*	<0.001*	-	-	-	-	-
	After exposure	<0.001*	<0.001*	-	-	-	-	-

This study has shown that rice millers employed in Anuradhapura district, Sri Lanka, irrespective of gender, have significantly reduced lung functions when compared with the norms predicted for the healthy, non-smoking Sinhalese individuals. These adversities were probably caused by the occupational exposure to rice husk dust, and the combined effect of rice husk dust and tobacco smoke.

Duration of employment in rice mills was inversely related to the FVC and FEV_1 values of the millers. The present study has reconfirmed the harmful effects of tobacco smoke on the lung functions. The cumulative effect of grain dust and tobacco smoke was found to be more harmful than each alone.

Measures employed by the mill workers during work to avoid direct contact with dust, such as wearing of face masks, are recommended. Also, measures need to be taken to standardize, implement and maintain adequate ventilation in mills (i.e. fixing of dust extraction fans) and also to educate Sri Lankan rice millers regarding this preventable harm they are unknowingly exposing themselves to. Introduction of a rice mills hygiene protocol should prove to be beneficial. The advantages of cessation of smoking should be further stressed to communities of lower socioeconomic and educational backgrounds.

Acknowledgements

The authors sincerely thank Prof D.J. Weilgama and Dr B.T.B. Wijerathne for their contribution in manuscript preparation and Ms K.D.N. Karunarathne and the Temporary Lecturers and the non-academic staff of the Department of Physiology for their assistance during data collection.

References

1. Respiratory health hazards in agriculture. Am J Respir Crit Care Med. 1998;158(5):2.
2. Buchan RM, Kramer GD. A Field Test of a Procedure for the Identification of Protein-Bearing Particles in Grain Elevator Air. 1980.
3. Palipane KB. Milling and quality improvement in rice, Institute of Post Harvest Technology, Anuradhapura. 2003.
4. Lim HH, Domala Z, Joginder S, Lee SH, Lim CS, Abu Bakar CM. Rice millers' syndrome: a preliminary report. Br J Ind Med. 1984 Nov;41(4):445–9.
5. International Rice Research Institute. Sri Lanka Rice Knowledge Bank. International Rice Research Institute. 2007.
6. Hathurusinghe CP. Paddy Milling Survey 2006. Colombo: Hector Kobbekaduwa Agrarian Research and Training Institute; 2007.
7. Dassanayake BK, Ratnatunga KC, Karunaratne KI, Nandadeva D, Nanayakkara SDI, Rajaratne AAJ. The effect of occupational exposure to paddy husk dust on the respiratory health of paddy mill workers in Sri Lanka. Proc Perad Univ Res Sess Sri Lanka. 2007;12(1):146–7.
8. Musa R, Naing L, Ahmad Z, Kamarul Y. Respiratory health of rice millers in Kelantan, Malaysia. Southeast Asian J Trop Med Public Health. 2000 Sep;31(3):575–8.
9. Singh SK, Nishith SD, Tandon GS, Shukla N, Saxena SK. Some observations on pulmonary function tests in rice mill workers. Indian J Physiol Pharmacol. 1988;32(2):152–7.
10. Bhat MR, Ramaswamy C. A comparative study of lung functions in rice mill and saw mill workers. Indian J Physiol Pharmacol. 1991;35(1):27–30.

11. Prakash S, Manjunatha S, Shashikala C. Morbidity patterns among rice mill workers: A cross sectional study. Indian J Occup Environ Med. 2010;14(3):91–3.
12. Rafeek MIM, Mahrouf ARM, Samaratunga PA. Rice marketing system: implication for rice quality improvement and issue of affordability. 2003.
13. Department of Census and Statistics. Sri Lanka labour force survey. Annual Report - 2010 (with Provincial and District Level Data), Ministry of Finance and Planning. 2010.
14. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of spirometry. Eur Respir J. 26:319–38.
15. Udupihille M. Spirometric and flow standards for healthy adult non-smoking Sri Lankans belonging to the Sinhalese ethnic group. Ann Hum Biol. 1995;22(4):321–36.
16. Cotton DJ, Graham BL, Li KY, Froh F, Barnett GD, Dosman JA. Effects of grain dust exposure and smoking on respiratory symptoms and lung function. J Occup Med. 1983;25(2):131–41.
17. Ye TT, Huang JX, Shen YE, Lu PL, Christiani DC. Respiratory symptoms and pulmonary function among Chinese rice-granary workers. Int J Occup Environ Health. 1998;4(3):155–9.
18. American Cancer Society. Harmful chemicals in tobacco products [Internet]. 2017. Available from: https://www.cancer.org/cancer/cancer-causes/tobacco-and-cancer/carcinogens-found-in-tobacco-products.html