Original Article

Pulmonary function of adolescents from Tripura, a North-eastern state of India

Dipayan Choudhuri, Balaram Sutradhar

Department of Human Physiology, Tripura University (A Central University), Agartala, Tripura, India

ABSTRACT

Objective: Spirometric evaluation of pulmonary function has been evolved as clinical tool in diagnosis, management, and follow-up of respiratory disorders. There are very few studies on normative reference values of pulmonary function parameters for adolescents from Tripura, a North-eastern state of India. The present study was aimed to evaluate pulmonary function and their predictors in male and female adolescents of Tripura. **Materials and Methods:** A total of 640 (320 from tribal and 320 non-tribal) healthy, non-smoking male and female school children (age 10-14 years) from four different districts of Tripura were randomly sampled for the study. The pulmonary function parameters analysed included forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), peak expiratory flow rate (PEFR), forced expiratory flow between 25% and 75% expired volume ($FEF_{25-75\%}$), ratio of FEV_1/FVC and maximum voluntary ventilation (MVV). **Results:** The results revealed that body weight, body mass index (BMI), PEFR, $FEF_{25-75\%}$ and MVV are significantly high among male tribal children in comparison to non-tribal children. Height, weight, waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), PEFR and MVV were found to be significantly more in tribal girls. In case of adolescents from Tripura, most of the pulmonary function parameters correlated with anthropometric parameters of the subject like height, weight, BMI, WHR, and WHtR. **Conclusion:** From the present study, it can be concluded that both anthropometric and pulmonary function status of tribal and non-tribal adolescents from Tripura are comparable. The computed regression norms may be used to predict pulmonary function of adolescents from Tripura by using anthropometric indices.

KEY WORDS: Anthropometric indices, correlation, prediction equation, pulmonary function, tribal and nontribal adolescents

Address for correspondence: Dr. Dipayan Choudhuri, Department of Human Physiology, Tripura University (A Central University), Suryamaninagar, Agartala - 799 022, Tripura, India. E-mail: dipayanchoudhuri@gmail.com

INTRODUCTION

Spirometric evaluation of pulmonary function is the most important tool for clinical assessment of respiratory functions in individuals.[1,2] Population specific reference values are necessary for maintaining the reliability of pulmonary function evaluation.[3,4] Till now, several studies have reported reference values for pulmonary function from different corners of the world, including India.[5-8] There is significant difference in these values owing to genetic, environmental and ethnic differences of the population studied.[9,10]

Access this article online

Quick Response Code:

Website: www.lungindia.com

DOI: 10.4103/0970-2113.159568

The normal standards for pulmonary function measurements among the tribal adolescents of Tripura, a North eastern state of India is not reported yet. Moreover, the difference between tribal and nontribal adolescents residing in Tripura is also not reported. Since, ethnicity and environment plays important role in influencing pulmonary function, and in view of paucity of pertinent data, evaluation of pulmonary function of adolescents from Tripura seemed important.

The present study was, therefore, aimed to evaluate pulmonary functions of both tribal and non tribal adolescents from Tripura. The study also aimed to evaluate association of pulmonary function parameters with various physical and anthropometric parameters of the subject from both the groups.

MATERIALS AND METHODS

This cross sectional study was conducted among adolescents from eight schools covering four different districts of Tripura. From each district one rural and one urban school was included for the study. The study was conducted between February to June 2013. Total number of subjects included in the study were six hundred and forty (640). Out of which 320 were from tribal and another 320 were from nontribal community of the state. In each group equal number of male (160) and female (160) were included for the study. The sample size was calculated according to World Health Organisation method for sample size calculation in health studies taking 95% confidance.[11]

All the students with in the age group of 10-14 years were requested to participate in the study, irrespective of their sex, ethnicity or socioeconomic status. A pre validated questionnaire that was used in INSEARCH studies across India was administered to the parents to identify children with any respiratory symptoms.[12] One hundred and eighty seven (187) subjects having the history or existing pulmonary disorders were excluded from the study. Informed consent to participate in the study was obtained from the parents of each children. The study protocol was approved by the Human Ethical Committee of the University.

Demographic information of the subject including age, sex, and ethnicity were recorded.[13] Anthropometric parameters like weight, height, chest circumference, hip and waist circumference were recorded using standardized procedure.[14] Height was measured with subject standing barefoot on a stadiometer (Bio + Plus R. Sl. No. 51392) and rounded to the nearest 10^{th} of a centimetre. Weight was recorded with the subjects wearing school uniforms to an accuracy of ± 0.1 kg by using a standard spring balance (Libra, India). Waist circumference was measured at the level of umbilicus and hip circumference was measured across the greater trochanter with legs and feet together by using a tailors measuring tape. The body mass index and waist hip ratio were calculated.[10]

A complete spirogram was performed according to American Thoracic Society (ATS) guidelines[15] by using an expirograph (Helios 702, RMS, India). The test was carried out in a private and quiet room in a standing position with the nose clip held in position on the nose. Data from two hundred and fifty three (253) subjects were not included for analysis as they could not perform spirometry according to ATS standard. The flow, volume/timed graph were taken out in accordance to the criteria based on the ATS. The subject was instructed to take a deep breath until the lung were full and then blow out through mouth as forcibly and as fast and as long as possible till the maximum capacity, sealing the lips tightly around a clean mouth piece. Best of the three acceptable curves was selected as the recording.

Spirometric parameters recorded for analysis were forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), FEV_1/FVC ratio, peak expiratory flow rate (PEFR), forced expiratory flow $FEF_{25-75\%}$. The maximum voluntary ventilation (MVV) was determined by fast, deep breathing for a 10 second period and reported as liters/minute.

Statistical analysis was performed using SPSS 16.0 (statistical Program for the Social Sciences) for Windows. Continues variables (e.g. age) were reported as mean ± standard deviation (SD). The mean for age, height, weight, BMI, WHR, FVC, FEV_1, PEFR, $FEF_{25-75\%}$ and MVV were stratified by gender and ethnicity. The t-test was used to test for the difference in measurements between various groups at the level of significance $P < 0.05$. Pearson's correlation coefficients between spirometric parameters (FVC, FEV_1, FEV_1/FVC, PEFR, $FEF_{25-75\%}$ and MVV) and age, height, weight, BMI and WHR were calculated. Linear regression analysis was performed to establish the relationship between pulmonary function parameter and physical parameters.

RESULTS

Table 1 shows the comparison of mean values for anthropometric and pulmonary function characteristics between tribal and non tribal male subjects. Among different anthropometric and pulmonary function parameters mean values for weight, BMI, PEFR, $FEF_{25-75\%}$ and MVV were found to be significantly higher in tribal male than their non-tribal counterpart.

Table 2 represents anthropometric and pulmonary function parameters in female subjects. Mean values for WHtR, WHR, PEFR, and MVV of the subjects were significantly higher in tribal female and mean values height and weight were found to be higher in non tribal female subjects.

Table 3 represents comparison of various pulmonary function parameters recorded in different groups of Indian children recently.[16-20] It shows that various parameters recorded in our study is comparable with that from other groups of children. The variations in values may be due

Table 1: Recording of anthropometric and pulmonary function parameter of tribal and nontribal male subject

Parameters	Tribal (160)	Non-tribal (160)	*P* value
Age (years)	11.99±1.26	11.95±1.23	0.8051
Height (cm)	143.41±8.78	143.64±8.63	0.8154
Weight (kg)	35.40±3.97	32.76±3.39	<0.0001***
BMI	17.20±1.14	15.95±1.78	<0.0001***
WHtR	0.44±0.04	0.44±0.04	0.2798
WHR	0.89±0.06	0.88±0.06	0.1781
FVC (L)	1.69±0.07	1.69±0.07	0.8941
FEV_1(L)	1.51±0.10	1.52±0.09	0.6584
FEV_1/FVC %	89.72±5.99	89.95±5.82	0.7315
PEFR (L/sec)	4.57±0.79	4.22±0.90	0.0003***
FEF25-75%	2.93±0.46	2.70±0.44	<0.0001***
MVV (L/min)	61.34±10.81	57.55±11.83	0.0030**

Values are in mean±SD, *significant *P* values. BMI: Body mass index, WHtR: Waist-to-height ratio, WHR: Waist-to-hip ratio, FEV_1/FVC: Forced expiratory volume in 1 second/Forced vital capacity, PEFR: Peak expiratory flow rate, MVV: Maximum voluntary ventilation, ***Strongly Significant, **Moderately Significantly variation in age group included and method and sensitivity of study protocol employed.

In male subjects PEFR and $FEF_{25-75\%}$ is correlated positively with age of the subject. Height of the subject correlated positively with $FEV_1/FVC_{\%}$, PEFR, $FEF_{25-75\%,}$ and negatively with FVC. Weight of the subjects shows significant positive correlation with PEFR, $FEF_{25-75\%,}$ and negative correlation with FVC of the subject. BMI of the subjects positively correlated with FVC, PEFR, and MVV and negative correlation was found between BMI and $FEV_1/FVC_{\%}$ of the subjets. WHtR of the subject correlated negatively with $FEV_1/FVC_{\%}$, and positively with FVC, and MVV of the subjects. WHR of the subjects exhibited significant positive correlation with FVC, MVV and negative correlation with $FEV_1/FVC_{\%}$ of the male subjects [Table 4].

In female, age of the subject shows significant positive correlation with FVC, FEV_1, FEV_1/FVC%, PEFR and significant negative correlation with MVV of the subjects. Height of the subjects correlated positively with FEV1, $FEF_{25-75\%}$ and negatively with MVV of the subjects. Weight of the female subjects exhibits significant positive correlation with FVC, FEV_1, $FEV_1/FVC_{\%}$ and PEFR of the subjects but here is no significant negative correlation between weight and pulmonary function parameters of the subjects. BMI shows significant positive correlation with PEFR and significant negative correlation with FEV_1, $FEV_1/FVC_{\%}$, and $FEF_{25-75\%}$ of the subjects. WHtR of the subjects' exhibit significant positive correlation with FVC and MVV of the subjects and negative correlation with FEV_1, FEV_1/FVC, $FEF_{25-75\%}$ of the subjects. WHR of the subjects positively correlated with FVC and MVV and negatively correlated with FEV_1, $FEV_1/FVC_{\%}$ of the subjects [Table 5].

Table 2: Recording of anthropometric and pulmonary function parameter of tribal and nontribal female subject

Parameters	Tribal (160)	Non-tribal (160)	*P* value
Age (years)	11.84±1.29	11.97±1.29	0.3757
Height (cm)	137.1±7.71	140.67±9.01	0.0002***
Weight (kg)	32.36±3.37	33.53±3.91	0.0042**
BMI	17.26±1.77	16.99±1.70	0.1527
WHtR	0.47±0.04	0.44±0.04	<0.0001***
WHR	0.90±0.06	0.88±0.06	<0.0001***
FVC (L)	1.70±0.08	1.69±0.07	0.1335
FEV_1(L)	1.51±0.09	1.51±0.09	0.9951
FEV_1/FVC %	88.51±6.06	88.97±7.07	0.5281
PEFR (L/sec)	4.74±0.63	4.36±0.87	<0.0001***
FEF 25-75%	2.81±0.43	2.75±0.43	0.1938
MVV (L/min)	64.28±11.79	58.68±11.15	<0.0001***

Values are mean±SD, *significant *P* values. BMI: Body mass index, WHtR: Waist-to-height ratio, WHR: Waist-to-hip ratio, FEV_1/FVC: Forced expiratory volume in 1 second/Forced vital capacity, PEFR: Peak expiratory flow rate, MVV: Maximum voluntary ventilation, FEF: Forced expiratory flow, ***Strongly Significant, **Moderately Significant

Table 3: Recent reports on pulmonary function measurements by different authors

Author's	Subjects	Age range (years)	FVC (L)	FEV_1 (L)	FEV_1/ FVC%	PEFR (L/sec)	FEF 25-75%	FEF 50%	MVV (L/min)
Singh *et al.* (2014)[16]	Boys (*n*=109)	10-14	2.53	2.39	-	5.80	-	-	-
	Girls (*n*=158)	10-14	2.31	2.18	-	5.29	-	-	-
Thakare *et al.* (2014)[17]	Rural boys (*n*=110)	5-15	1.891±0.93	1.752±0.805	-	3.962±1.762	-	-	-
	Urban boys (*n*=110)	5-15	1.446±0.737	1.353±0.657	-	3.162±1.708	-	-	-
	Rural girls (*n*=110)	5-15	1.604±0.666	1.586±0.622	-	3.953±1.496	-	-	-
	Urban girls (*n*=110)	5-15	1.399±0.635	1.240±0.548	-	3.475±1.312	-	-	-
Tahere *et al.* (2010)[18]	Boys (*n*=408)	8-14	2.01±0.46	1.76±0.38		4.74±0.96	-	-	-
	Girls (*n*=247)	8-14	1.91±0.47	1.688±0.403	-	4.47±1.15	-	-	-
Vijayan *et al.* (2000)[19]	Boys (*n*=246)	7-19	2.05	1.79	-	3.64	-	2.32	68.0
	Girls (*n*=223)								
Budhiraja *et al.* (2010)[20]	Male (*n*=57.1% of 600)	6-15	2.16	1.95	-	3.3663	-	2.68	72.91
	Female (*n*=42.9% of 600)	6-15	1.80	1.66	-	3.056	-	2.37	62.97
Present study	Tribal (rural and urban *n*=320)	10-14	1.70±0.08	1.51±0.09	88.51±6.06	4.74±0.63	2.81±0.43	-	64.28±11.79
	Non-tribal (rural and urban *n*=320)	10-14	1.69±0.07	1.51±0.09	88.97±7.07	4.36±0.87	2.81±0.43	-	58.68±11.15

FEV_1/FVC: Forced expiratory volume in 1 second/Forced vital capacity, PEFR: Peak expiratory flow rate, MVV: Maximum voluntary ventilation, FEF: Forced expiratory flow

Table 4: Pearson's correlation coefficient between different anthropometric and pulmonary function parameter of male subject

Parameters	Male											
	Age (years)		Height (cm)		Weight (kg)		BMI		WHtR		WHR	
	R	*P*	*R*	*P*	*R*	*P*	*R*	*P*	*R*	*P*	*R*	*P*
FVC (L)	−0.068	0.222	−0.280**	0.000	−0.139*	0.013	0.198**	0.000	0.256**	0.000	0.252**	0.000
FEV_1 (L)	0.066	0.237	0.035	0.536	0.020	0.725	−0.040	0.471	−0.047	0.405	−0.092	0.099
FEV_1/FVC%	0.102	0.069	0.198**	0.000	0.100	0.074	−0.156**	0.005	−0.195**	0.000	−0.241**	0.000
PEFR (L/sec)	0.158**	0.005	0.115*	0.040	0.241**	0.000	0.133*	0.017	−0.044	0.431	0.065	0.243
$FEF_{25-75\%}$	0.375**	0.000	0.228**	0.000	0.338**	0.000	0.098	0.082	−0.046	0.408	0.056	0.314
MVV (L/min)	0.073	0.193	−0.052	0.355	0.103	0.066	0.179**	0.001	0.122*	0.029	0.122*	0.029

FVC: Forced vital capacity, FEV_1: Forced expiratory volume in one second, FEV_1/FVC %: Forced expiratory volume in 1 sec as percentage of FVC, PEFR: Peak expiratory flow rate, $FEF_{25-75\%}$: Mid expiratory flow rate, MVV: Maximum ventilator volume, FEF: Forced expiratory flow, *$P<0.05$;**$P<0.01$;***$P<0.001$

Table 5: Pearson's correlation coefficient between different anthropometric and pulmonary function parameter of female subject

Parameters	Female											
	Age (years)		Height (cm)		Weight (kg)		BMI		WHtR		WHR	
	R	*P*	*R*	*P*	*R*	*P*	*R*	*P*	*R*	*P*	*R*	*P*
FVC (L)	0.149**	0.008	0.087	0.120	0.145**	0.009	0.053	0.345	0.149**	0.008	0.350**	0.000
FEV_1 (L)	0.331**	0.000	0.363**	0.000	0.251**	0.000	−0.189**	0.001	−0.306**	0.000	−0.201**	0.000
FEV_1/FVC%	0.212**	0.000	0.292	0.000	0.206**	0.000	−0.138*	0.014	−0.329**	0.000	−0.337**	0.000
PEFR (L/sec)	0.262**	0.000	0.072	0.198	0.221**	0.000	0.140*	0.012	−0.032	0.571	−0.002	0.975
$FEF_{25\text{-}75\%}$	−0.008	0.892	0.124*	0.026	−0.002	0.971	−0.159**	0.004	−0.023	0.683	0.068	0.222
MVV (L/min)	−0.115*	0.040	−0.137*	0.014	−0.043	0.440	0.106	0.059	0.196**	0.000	0.191**	0.001

FVC: Forced vital capacity, FEV_1: Forced expiratory volume in one second, FEV_1/FVC %: Forced expiratory volume in 1 sec as percentage of FVC, PEFR: Peak expiratory flow rate, FEF: Forced expiratory flow, MVV: Maximum ventilator volume, WHR: Waist hip ratio, WHtR: Waist height ratio, BMI: Body mass index, *$P<0.05$;**$P<0.01$;***$P<0.001$

Table 6: Multiple regression norms for the prediction of pulmonary function measurements in male adolescent of Tripura

Dependent variable	Sex	Regression equation	*R*	R^2	*P* value
FVC (L)	Male	FVC (L) =1.576+0.01881*BMI−0.8585*WHtR+0.4981*WHR−0.007627*Weight	0.3466	0.1201	<0.0001***
FEV_1(L)	Male	FEV_1 (L) =1.595−0.01202*BMI+1.006*WHtR−0.5681*WHR+0.005260*Weight	0.1531	0.0234	0.1119
FEV_1/FVC%	Male	FEV_1/FVC% =100.57−1.729*BMI+108.46 *WHtR−61.821WHR+0.7257*Weight	0.3395	0.1152	<0.0001***
PEFR (L/sec)	Male	PEFR (L/sec) =1.261+0.08070*BMI−7.474*WHtR+4.955*WHR+0.02096*Weight	0.2862	0.0819	<0.0001***
$FEF_{25\text{-}75\%}$	Male	$FEF_{25\text{-}75\%}$ =0.05245−0.1052*BMI+5.496*WHtR−0.6873WHR+0.07909*Weight	0.4003	0.1608	<0.0001***
MVV (L/min)	Male	MVV (L/min) =18.863−0.1146*BMI+76.117*WHtR−14.309*WHR+0.6350*Weight	0.2127	0.0453	0.0055**

FEV_1/FVC: Forced expiratory volume in 1 second/Forced vital capacity, PEFR: Peak expiratory flow rate, MVV: Maximum voluntary ventilation, FEF: Forced expiratory flow, BMI: Body mass index, WHtR: Waist-to-height ratio, WHR: Waist-to-hip ratio, *$P<0.05$;**$P<0.01$;***$P<0.001$

Table 7: Multiple regression norms for the prediction of pulmonary function measurements in female adolescent of Tripura

Dependent variable	Sex	Regression equation	*R*	R^2	*P* value
FVC (L)	Female	FVC (L) =1.166−1.415×Weight+0.002807×BMI−0.9983×WHtR+1.048×WHR	0.4495	0.2021	<0.0001
FEV_1 (L)	Female	FEV_1 (L) =1.576+0.01093×Weight−0.01980×BMI+0.5109×WHtR−0.3641×WHR	0.3933	0.1547	<0.0001
FEV_1/FVC%	Female	FEV_1/FVC% =109.90+0.8649×Weight−1.415×BMI+93.416WHtR−76.212×WHR	0.4234	0.1792	<0.0001
PEFR (L/sec)	Female	PEFR (L/sec) =2.634+0.05266×Weight+0.01147×BMI+2.240×WHtR−1.164×WHR	0.2343	0.0549	0.0013
$FEF_{25\text{-}75\%}$	Female	$FEF_{25\text{-}75\%}$ =2.404+0.009159×Weight−0.05583×BMI−0.3821×WHtR+1.352×WHR	0.2219	0.0492	0.0031
MVV (L/min)	Female	MVV (L/min) =28.926−0.02856×Weight+0.2116×BMI+24.094×WHtR+21.305×WHR	0.2023	0.0409	0.0103

FEV_1/FVC: Forced expiratory volume in 1 second/Forced vital capacity, PEFR: Peak expiratory flow rate, MVV: Maximum voluntary ventilation, FEF: Forced expiratory flow, BMI: Body mass index, WHtR: Waist-to-height ratio, WHR: Waist-to-hip ratio

The regression equation for FVC, FEV_1, $FEV_1/FVC_{\%}$, PEFR, $FEF_{25\text{-}75\%}$ and MVV based on weight, BMI, WHtR, and WHR are presented in Table 6 for male subjects and [Table 7] for female subjects. A comparison of recently reported regression equations among Indian children is represented in Table 8.[17-22] Most of these equations used age, height, weight of the subject as predictors of pulmonary function. Pulmonary function in our subjects showed positive correlation with markers of obesity like BMI, WHtR, and WHR, for this reason, we utilized these parameters in regression equation.

DISCUSSION

In the present study we evaluated pulmonary function and their anthropometric predictors in school children 10-14 years of age from Tripura, a North eastern state of India. The pulmonary function and anthropometric parameters of ethnic tribal children and non-ethnic Bengali children residing in the state of Tripura, evaluated in our study, are found to be comparable. The bodyweight and BMI of tribal children were significantly higher. Both height and weight of non-tribal female were found to be higher. The waist to hip ratio (WHR) and waist to height ratio (WHtR) of tribal female were significantly higher.

The tribal population of the country is generally at risk of under nutrition owing to different factors affecting their health status.[23] Most of the earlier studies have reported poor health condition of tribal children.[24] Comparable nutritional status of tribal children from Tripura indicates improved health status of the children owing to improved health care and other facilities.[25]

The lung function parameters like PEFR, PEF50%, and MVV were found to be significantly higher in tribal children than the non-tribal Bengal children. Other lung function parameters like FVC, FEV_1, FEV_1/FVC% were found to be comparable between the children of both the groups. Singha and Nag also reported a higher value of FVC, FEV_1, among the urban male tribal children of Tripura than the non-tribal children.[26] PEFR recorded by them was less in tribal male than non-tribal male children. Gupta *et al*. reported a better peak expiratory flow rate for children living at high altitude than the low landers.[27]

However, Kasyap *et al*. did not find any difference in PEFR values between highlander tribal children and children from West or lowlanders urban North Indian children.[28] Comparable nutritional status of tribal children might

Table 8: Predictive equation derived from different recent studies

Author	Subject	Respiratory parameter studied	Anthropometric variable studied	Predictive equation derived
Thakare *et al.* (2014)[17]	Rural children	FVC, FEV_1, PEFR	Age, height, weight, arm span, BSA	FVC= −0.546+0.208 (age)+0.001 (height)+0.04 (weight)+0.016 (arm span)+1.99 (BSA) FEV_1= −0.759+0.175 (age)+0.007 (height)+0.017 (weight)+0.006 (arm span)+1.052 (BSA) PEFR= −1.577+0.359 (age)+0.024 (height)+0.031 (weight)+0.018 (arm span)+2.206 (BSA)
	Urban children	FVC, FEV_1, PEFR	Age, height, weight, arm span, BSA	FVC= −0.388+0.159 (age)+0.023 (height)+0.04 (weight)+0.016 (arm span)−1.99 (BSA) FEV_1= −0.255+0.147 (age)+0.018 (height)+0.04 (weight)+0.011 (arm span)−2.151 (BSA) PEFR= −0.989+0.361 (age)+0.031 (height)−0.026 (weight)+0.031 (arm span)+1.496 (BSA)
Budhiraja *et al.* (2010)[20]		FVC, FEV_1, PEFR, MVV	Age, sex, height, weight	FVC= −2.8916+0.0254 (Age years)+0.1257 (Sex)+0.0271 (Ht cm)+0.0172 (Wt kg) FEF_1= −2.3666+0.021 (Age years)+0.0906 (Sex)+0.0236 (Ht cm)+0.0141 (Wt kg) PEFR= −214.587+3.2039 (Age years)+17.451 (Sex)+2.2489 (Ht cm)+1.1375 (Wt kg) MVV= −90.2014+2.3332 (Sex)+0.966 (Ht cm)+0.5332 (Wt kg)
Taksande *et al.* (2008)[21]	Female	PEFR	Height, weight	PEFR=3.64 height (cm)−257.86 PEFR=4.27 weight (kg)+124.42
	Male	PEFR	Height, weight	PEFR=4.7 height (cm)−364.51 PEFR=5.6 weight (kg)+159.37
Mittal *et al.* (2013)[22]	Boys	PEF	Age, height, weight	PEF (boys)= −150.38+9.19×Age (years)+1.75×Ht (cm)+1.74×Wt (kg) R2=0.969, standard error of estimate= ±14.43
	Girls	PEF	Age, height, weight	PEF (girls)= −177.06+0.86×Age (years)+2.59×Ht (cm)+1.49×Wt (kg) R2=0.949, standard error of estimate=±15.66
Present study (2014)	Male	FVC, FEV_1, FEV_1/FVC%, PEFR, $FEF_{25-75\%}$, MVV	Weight, BMI, WHR, WHtR	FVC (L) =1.576+0.01881×BMI−0.8585×WHtR+0.4981×WHR-0.007627×weight FEV_1 (L) =1.595−0.01202×BMI+1.006×WHtR−0.5681×WHR+0.005260×weight FEV_1/FVC% =100.57−1.729×BMI+108.46×WHtR−61.821WHR+0.7257×weight PEFR (L/sec) =1.261+0.08070×BMI−7.474×WHtR+4.955×WHR+0.02096×weight $FEF_{25-75\%}$ =0.05245−0.1052×BMI+5.496×WHtR−0.6873WHR+0.07909×weight MVV (L/min) =18.863−0.1146×BMI+76.117×WHtR−14.309×WHR+0.6350×weight
	Female	FVC, FEV_1, FEV_1/FVC%, PEFR, $FEF_{25-75\%}$, MVV	Weight, BMI, WHR, WHtR	FVC (L) =1.166-1.415×weight+0.002807×BMI−0.9983×WHtR+1.048×WHR FEV_1 (L) =1.576+0.01093×weight-0.01980×BMI+0.5109×WHtR−0.3641×WHR FEV_1/FVC% =109.90+0.8649×weight−1.415×BMI+93.416WHtR−76.212×WHR PEFR (L/sec) =2.634+0.05266×weight+0.01147×BMI+2.240×WHtR−1.164×WHR $FEF_{25-75\%}$ =2.404+0.009159×weight−0.05583×BMI−0.3821×WHtR+1.352×WHR MVV (L/min) =28.926−0.02856×weight+0.2116×BMI+24.094×WHtR+21.305×WHR

FVC: Forced vital capacity, FEV_1: Forced expiratory volume in one second, PEFR: Peak expiratory flow rate, FEF: Forced expiratory flow, MVV: Maximum voluntary ventilation, WHR: Waist hip ratio, WHtR: Waist height ratio, BMI: Body mass index

contribute to better pulmonary function status among the tribal children from Tripura.[29]

Variables like ethnicity, age, weight, and height, are reported to be the prime predictors of lung function in different groups of population.[30,31] In our study, parameters like height, weight, BMI, WHR and WHtR correlated positively in different groups of subjects. Meng-chiao Tasi, *et al*. observed that standing height was the factor with highest correlation with the pulmonary function parameters in growing children aged 6-11 years in Tiawn city.[32] Ya-Nan Ma, *et al*. recently developed predictive equation of lung function for 9-15 years old children from North east china following ATS/ERS Task force guidelines and using predictor variable like age, height, and weight.[33] Doctor *et al*. in their study with Gujarati school children of 8-14 years of age found, for FVC and FEV highest correlation was presented with age in girls and height in boys. For FEV1% significant negative correlation was present with age and height in both sexes, but positive correlation was found with surface area. Similarly, PEFR showed highest correlation with surface area in boys and girls.[18] Various earlier studies on children from India mostly used age, height and weight as predictor for pulmonary function.[34-36]

Number of recent studies have observed that pulmonary function shows an inverse relationship with various markers of obesity and fat distribution in children and adolescent.[37-39] Markers of both general and visceral obesity like BMI, WC, WHR are reported to influence pulmonary function in children and adolescent.[40,41] Some of the recent studies showed that respiratory mechanics can be affected by fat distribution pattern and central obesity, estimated by WC and WHR, independent of BMI. In view of these findings and depending on results of correlation analysis we utilized marker of obesity like weight, BMI, WHR, and WHtR in multiple regression analysis for prediction of pulmonary function measurements in both male and female adolescents from Tripura.

The study included both ethnic and non ethnic population of the state for comparison. This provides overall picture of pulmonary function of different groups of children in the state. However cross sectional nature of the study is a limitation. Longitudinal studies are needed to investigate the effect of various anthropometric predictors on pulmonary function of the studied subjects.

CONCLUSION

In conclusion, our study determined the normative values for pulmonary function parameters in children from Tripura and proposed predictive equation with anthropometric markers like BMI, WHR, WHtR. These normative reference values can be utilized for evaluating pulmonary function of children living in Tripura.

ACKNOWLEDGEMENT

Financial assistance for the project by Indian Council of Medical Research (ICMR), New Delhi, is acknowledged.

REFERENCES

1. Barreiro TJ, Perillo I. An approach to interpreting spirometry. Am Fam Physician 2004;69:1107-14.
2. Ferguson GT, Enright PL, Buist AS, Higgins MW. Office spirometry for lung health assessment in adults: A consensus statement from the National Lung Health Education program. Chest 2000;45:513-30.
3. Budhiraja S, Singh D, Pooni PA, Dhooria GS. Pulmonary function in normal school children in the age group of 6-15 years in North India. Iran J Pediatr 2010;20:82-90.
4. Pellegrino R, Viegi G, Brusasco V, Crapo RO, Burgos F, Casaburi R, *et al*. Interpretative strategies for lung function tests. Eur Respir J 2005;26:948-68.
5. Maiolo C, Mohamed EI, Carbonelli MG. Body composition and respiratory function. Acta Diabetol 2003;40(Suppl 1):S32-8.
6. Van Sickle D, Magzamen S, Mullahy J. Understanding socioeconomic and racial differences in adult lung function. Am J Respir Crit Care Med 2011;184:521-7.
7. Feng K, Chen L, Han SM, Zhu GJ. Spirometric standards for healthy children and adolescents of Korean Chinese in northeast China. J Korean Med Sci 2011;26:1469-73.
8. Vijayan VK, Reetha AM, Kuppurao KV, Venkatesan P, Thilakavathy S. Pulmonary function in normal south Indian children aged 7 to 19 years. Indian J Chest Dis Allied Sci 2000;42:147-56.
9. Trabelsi Y, Tabka Z, Richalet JP, Gharbi N, Bienvenu A, Guenard H, *et al*. Spirometric values in Tunisian children: Relationship with pubertal status. Ann Hum Biol 2007;34:195-205.
10. Chen Y, Rennie D, Cormier YF, Dosman J. Waist circumference is associated with pulmonary functions in normal-weight, overweight, and obese subjects. Am J Clin Nutr 2007;85:35-9.
11. Naing NN. Determination of sample size. Malays J Med Sci 2003;10:84-6.
12. Jindal SK. Indian Study on Epidemiology of Asthma, Respiratory Symptoms and Chronic Bronchitis (INSEARCH). A Multicentre Study (2006-2009) Sponsored by Indian Council of Medical Research (Final Report). ND: Indian Council of Medical Research (ICMR); p. 1-332.
13. Harik-Khan RI, Wise RA, Fleg JL. The effect of gender on the relationship between body fat distribution and lung function. J Clin Epidemiol 2001;54:399-406.
14. Ochs-Balcom HM, Grant BJ, Muti P, Sempos CT, Freudenheim JL, Trevisan M, *et al*. Pulmonary function and abdominal adiposity in general population. Chest 2006;129:853-62.
15. Salome CM, King GG, Berend N. Physiology of obesity and effects on lung function. J Appl Physol 2010;108:206-11.
16. Singh V, Kurrey VK, Khandawal O, Phulijhele S. Evaluation of lung function by spirometry in 12-14 years adolescents in school of Raipur city, Chattisgarh. Int J Med Sci Res Pract 2014;1:9-15.
17. Thakare AE, Tajne VD, Hulke SM. PFT prediction equations in rural and urban school children: Need for separate equations. Research and reviews. J Med Health Sci 2014;3:78-92.
18. Doctor TH, Trivedi SS, Chudasama RK. Pulmonary function test in healthy school children of 8 to 14 years age in south Gujarat region, India. Lung India 2010;27:145-8.
19. Vijayan VK, Reetha AM, Kuppurao KV, Vekatesan P, Thilakavathy S. Pulmonary function in normal south Indian children aged 7-19 years. Indian J Chest Dis Allied Sci 2000;42:147-56.
20. Budhiraja S, Singh D, Pooni PA, Dhooria GS. Pulmonary functions in normal school children in the age group of 6-15 years in North India. Iran J Pediatr 2010;20:82-90.
21. Taksande A, Jain M, Vilhekar K, Chaturvedi P. Peak expiratory flow rate of rural school children from Wardha district, Maharashtra in India. World J Pediatr 2008;4:211-4.
22. Mittal S, Gupta S, Kumar A, Singh KD. Regression equation for peak expiratory flow in healthy children aged 7-14 years from Punjab, India. Lung India 2013;30:183-6.
23. Mungreiphy NK, Kapoor S, Sinha R. Association between BMI, blood pressure, and age: Study among Tangkhul Naga Tribal males of Northeast India. J Anthropol 2011;2011:1-6.
24. Divakar SV, Balaji PA, Poornima S, Varne SR, Ali SS, Puttaswamy M. A comparative assessment of nutritional and health status between tribal and nontribal under five children of Mysore, India. Muller J Med Sci Res 2013;4:82-5.
25. Navaneethan P, Kalaivani T, Rajesekaran C, Sunil N. Nutritional status of children in rural India: A case study from Tamil Nadu, first in the world to initiate the mid-day meal scheme. Health 2011;3:647-55.
26. Sinha U, Nag SK. A comparative study of pulmonary function of urban tribal and non-tribal boys of Tripura. Indian J L Sci 2012;1:25-8.
27. Gupta S, Mittal S, Kanar A, Singh KD. Peak expiratory flow rate of healthy School children living at high altitude. N Am J Med Sci 2013;5:422-6.
28. Manjareeka M, Mishra J, Nanda S, Mishra S, Mishra J. Assessment of peak expiratory flow rate in preadolescent children of sub-tribal communities in Odisha. Int J Clin Exp Physiol 2014;1:120-4.
29. El-Baz FM, Abdelaziz EA, Abdelaziz AA, Kamel TB, Fahmy A. Impact of obesity and body fat distribution on pulmonary function of Egyptian children. Egypt J Bronchol 2009;3:49-58.
30. Swaminathan S, Diffey B, Vaz M. Evaluating the suitability of prediction equations for lung function in Indian children: A practical approach. Indian Pediatr 2006;43:680-98.
31. Oloyede IP, Ekrikpo UE, Ekanem EE. Normative values and anthropometric determinants of lung function indices in rural Nigerian children: A pilot survey. Niger J Paed 2013;40:406-11.
32. Tasi MC, Jeng MJ, Chang HL, Taso PC, Yang CF, Peng YY, *et al*. Spirometric reference equations for healthy children aged 6 to 11 years in Taiwan. J Chin Med Assoc 2010;73:21-8.
33. Ma YN, Wang J, Dong GH, Liu MM, Wang D, Liu YQ, *et al*. Predictive equations using linear regression analysis of pulmonary function for healthy children in Northeast China. PLoS One 2013;8:e63875.
34. Dikshit MB, Raje S, Agrawal MJ. Lung functions with spirometry: An Indian perspective–I. Peak expiratory flow rates. Indian J Physiol Pharmacol 2005;49:8-18.
35. Sitalakshmi R, Ravi Shankar P, Padmavathi R, Subhashini AS, Thanasekaran MV. Predicted equations for pulmonary function in normal adolescent South Indian population. Indian J Physiol Pharmacol 2014;58:290-3.
36. Raju PS, Prasad KV, Ramana YV, Ahmed SK, Murthy KJ. Study on lung function tests and prediction equations in Indian male children. Indian Pediatr 2013;40:705-1.
37. Gundogdu Z, Eryilmaz N. Correlation between peak flow and body mass index in obese and non-obese children in Kocaeli, Turkey. Prim Care Respir J 2011;20:403-6.
38. Fahmy WA, Khairy SA, Anwar GM. The effects of obesity on pulmonary function tests among children and adolescents. Researcher 2013;5:55-9.
39. Paralikar SJ, Kathrotia RG, Pathak NR, Jani MB. Assessment of pulmonary functions in obese adolescent boys. Lung India 2012;29:236-40.
40. Soundariya K, Neelambika N. Influence of anthropometric indices on pulmonary function tests in young individuals. World J Med Sci 2013;9:157-61.
41. Choudhuri D, Choudhuri S. Effect of gender and body mass index on pulmonary function tests in adolescents of tribal population of a north eastern state of India. Indian J Physiol Pharmacol 2014;58:170-3.

How to cite this article: Choudhuri D, Sutradhar B. Pulmonary function of adolescents from Tripura, a North-eastern state of India. Lung India 2015;32:353-8.

Source of Support: This work is supported by Indian Council of Medical Research, New Delhi, through an *ad hoc* project sanctioned to the corresponding author. **Conflict of Interest:** None declared.