Reference Values and Related Factors for Peak Expiratory Flow in Middle-aged and Elderly Chinese

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Abstract

Background: Peak expiratory flow (PEF), as an essential index used for screening and monitoring asthma, chronic obstructive pulmonary disease, and respiratory mortality especially in elderly, is recommended especially for low resource settings in low- and middle-income countries. However, few reports have focused on the reference of PEF in China, especially in the middle-aged and elderly. Thus, the aim of this study was to determine age- and sex-specific reference values of PEF in the middle-aged and older Chinese population.

Methods: There were 11,717 participants included for reference value analysis and 11,340 participants were included for risk factor analysis. The PEF was measured using a peak flow meter in L/min. The distribution of PEF terciles stratified by sex and age were reported. Multiple linear regression analysis was used to determine the associations between risk factors and PEF.

Results: The PEF was higher in men than women across all age subgroups. The value of PEF decreased with age in both men and women. Height, weight, handgrip strength, and household air pollution were positively associated with PEF, and age, waist circumference smoking status were negatively associated with PEF significantly in both men and women (all $P<0.05$). The mean values were 9.38 L/min and 64.12 L/min for men and women. Meanwhile, the prevalence of low PEF was 1.62% and 2.16% for men and women, respectively.

Conclusions: Age- and sex-specific centiles of PEF for the middle-aged and older Chinese population were estimated. The reference values for low PEF were provided for epidemiological studies and clinical practice in the future. Interventions on lung function or respiratory disease should be pay more attention on factors associated with PEF.

Background

Asthma and chronic obstructive pulmonary disease (COPD), as two of the most common obstructive airway diseases [1], are serious public health problems worldwide [2-4], especially in China [5-8]. From 1990 to 2015, the prevalence of COPD and asthma globally increased by 44.2% and 12.6%, respectively [3]. In 2015, disability-adjusted life years caused by COPD were 15,389,017 in China and 1,797,438 by asthma [3]. Thus, it is important to seek a convenient, fast and feasible method for early screening and disease surveillance. Peak expiratory flow (PEF), as an essential index used to assess response to asthma treatment, short- or long-term monitoring of asthma [4, 9], or to evaluate triggers for worsening symptoms and for screening of COPD [10], is recommended by the World Health Organization especially for low resource settings in low- and middle-income countries [11].

There are nearly 1.4 billion Chinese in the world, indicating a huge medical need, however, the researches on the reference value of PEF are rarely reported. At present, reference values of spirometry for the Chinese population are calculated using Southeast Asians and Northeast Asians by adjusting with fixed ethnic conversion factors, which were mainly established with Caucasian data and did not include PEF

[10, 12]. Moreover, several studies have shown that reference values, derived from different ethnic populations, are not applicable to the national population [12, 13]. For example, a study of Chinese aged 5–14 years suggested that Greece and Ireland references were inappropriate for Chinese children [14].

Most previous studies in China have focused on children and adolescents [14, 15] with few reports on adults [10, 16], especially for the middle-aged and older. Although one study [10] included 7115 subjects aged 4–80 years in China, the middle-aged and older people accounted for only a small proportion and relevant variables were not included. Another study based on elderly was conducted in Jinan [16], a city of eastern China, which means that it could not represent the elderly population of the whole of China.

Previous studies showed that age was one of the most important determinants of predicted PEF, that decreased with increasing age [9, 13]. In addition, PEF was an independent predictor of health status, and physical and cognitive function [17], hospitalization, frailty development [18], mortality from respiratory and other causes in elderly [18, 19]. Household air pollution from inefficient cooking and heating with solid fuels will discharge particulate matter and gases, which will cause adverse health effects in human subjects [20] and associated with infant [21], middle-aged adults [22] lung function. However, this association has not been explored in elderly adults.

Thus, the present study aimed to investigate age- and sex-specific reference values of PEF in the middle-aged and older Chinese population based on the China Health and Retirement Longitudinal Study (CHARLS), which involves 17,708 middle-aged and elderly participants from 28 provinces in China. Moreover, we explored the factors associated with PEF including household air pollution, which was rarely shown in previous studies. Cut-off values were assumed to define low PEF.

Methods

Study population

The CHARLS is a longitudinal survey collecting data on demographics, socioeconomic status, biomedical measurements and self-reported health status in China [23]. This cross-sectional study used data from the baseline of CHARLS, which was conducted between June 2011 and March 2012. In total, 17,708 participants were included. The participants were selected using a four-stage, stratified, cluster random sampling method from 450 counties of 28 provinces and the response rate was 80.5%. During the research period, 13,249 participants received the PEF test. For this study, 48 participants younger than 40 years were excluded. Additionally, we excluded those who had chronic lung diseases such as chronic bronchitis and emphysema (n = 1,370), cancer or malignant tumor (n = 114). Thus, 11,717 participants were included for reference value analyses. Furthermore, participants who did not provide information on body mass index (BMI) (n = 176), smoking status (n = 9), waist measurement (n = 26), handgrip strength (n = 180) or heating or cooking source (n = 986) were also excluded. Thus, 10,340 participants were included for risk factor analyses (**Figure 1**). The CHARLS was conducted by Peking University. The protocol was approved by the ethics committee of Peking University and written informed consent was provided from all participants in the present study. The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki.

Measurement of PEF

The PEF was measured using a peak flow meter (Everpure, Shanghai, China) in L/min. Each participant was asked to stand up, take a deep breath, place his or her lips around the disposable mouthpiece and blow at maximum strength and speed. The trained technician recorded the readings indicated by the pointer and reset the flow meter, and then waited for 30 seconds before the next measurement. The measurement was repeated three times and the mean value was used in analysis.

Assessment of other variables

The demographic variables and health status functioning in the present study were collected by standardized questionnaires which included sex, age, education level (no formal education, elementary school or middle school and above), smoking status (current non-smoker or smoker), place of residence (urban or rural) and number of comorbidities, clean heating energy use, clean cooking fuel use, clean energy use. Weight, height, and waist circumference were measured in the morning before breakfast. Participants wore light indoor clothes for weight measurement, using a health meter (Omron HN-286, Yangzhou, China) with accuracy of 0.1 kg. Height was measured without shoes to the nearest 0.1 cm with a stadiometer (Seca 213, Hangzhou, China). Waist circumference was measured by a trained technician using an inelastic tape midway between the last rib and the top of the iliac crest, on the midaxillary line. The BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2). Handgrip strength was measured with a hand-held dynamometer (Yuejian WL-1000, Nantong, China) in kilograms (kg). Each hand was tested twice, alternating hands between tests, and the greatest force was used in the final analyses. Household air pollution was assessed by questionnaire. Clean heating status was assessed through question “Does your residence have heating?” and “What is the main heating energy source?”. No heating or heating source from solar, natural gas, liquefied petroleum gas, electric was seemed as clean heating energy use. Heating source from coal, crop residue/wood burning was seemed as solid fuel use. Source from natural gas, marsh gas, liquefied petroleum gas, electric, or other was defined as clean cooking fuel use.

Statistical analyses

Data were shown according to sex and age. The Kolmogorov–Smirnov test was used to evaluate the normal distribution of the variables. The continuous variables were reported as mean ± standard deviation (SD). Sex-specific centiles for PEF using the Box-Cox Cole and Green (BCCG) distribution, Lambda-Mu-Sigma (LMS) method implemented in the GAMLSS (Generalized Additive Models for Location, Scale and Shape) package[24] in the statistical software R (version 3.6.3, www.r-project.org).

Considering of unnecessary over-fitting, the optimal degrees of freedom for the cubic spline curve were chosen by selecting the model with the smallest Schwarz Bayesian Criterion. We modelled the mean and SD of grip at each age using the normal distribution in GAMLSS.

Multiple linear regression analysis was used to adjust for the effects of sex, age, BMI, weight, waist circumference, handgrip strength, education level, smoking status, place of residence and number of comorbidities, and to identify those associated with PEF independently. Stepwise method was used to select independent variables. In addition, significance level for entry into the model was 0.10, and significance level for staying in the model is 0.15. Furthermore, a cut-off value was defined to identify persons with a “Low” PEF. Which was expressed as 1 SD and 2SD lower than sex-specific mean value derived from people younger than 65 years old.

Data management and statistical analyses were conducted using SAS 9.3 edition (SAS Institute Inc., Cary, NC, USA). Percentiles estimation was conducted using GAMLSS package in the statistical software R. All reported *P*-values were two-sided, and $P < 0.05$ was considered significant.

Results

Reference values for PEF

Total of 11,717 observations of PEF from 17,708 participants was used to produce the centiles values as shown in **Table 1** and **Figure 2**.

Percentiles 5, 10, 25, 50, 75, 90 and 95 were calculated for PEF according to sex and age bracket as shown in **Table 1**. The PEF was higher in men than in women for all age subgroups. The value of PEF decreased with age onwards in both men and women. By age of 40~45, the median of PEF in men was 1.5 times of that in women, and the ratio decreased slightly to 1.3 at the age of 80 and above. The peak of median PEF in men was 443.66 at 40~45 years in men and 291.71 in women. The predicted percentiles of PEF had a downward trend with age for both men and women (**Figure 2**). Percentiles of PEF were also calculated separated by household clean heating energy use (Table 1s and Figure 1s) and clean cooking fuel use (Table 2s and Figure 2s). Higher PEF was seen in Clean heating energy use (314.6 ± 124.5 vs 296.5 ± 122.4, t=6.04, $P<0.0001$), clean cooking energy use (304.7 ± 123.7 vs 296.5 ± 122.5, t=3.36, $P<0.001$).

The characters of participants

The characteristics of participants included for the reference analyses were show in **Table 2**. The mean values of PEF were 354.10 ± 132.40 and 254.10 ± 94.98 L/min for men and women, respectively. Men had a higher age, height, weight, PEF, education level, prevalence of smoking and drinking status, chance of living in rural, and number of comorbidities than women ($P<0.05$). Compare to women, men had a lower level of BMI ($P<0.05$).

Risk factors correlated with PEF

The multiple stepwise linear regression associations between PEF and age, height, weight, BMI, waist circumference, handgrip strength, education level, smoking status, place of residence and number of comorbidities, clean heating energy use, clean cooking fuel use and clean energy use among the middle-aged and older men and women in China are presented in **Table 3**. In both men and women, height, weight, handgrip strength, residence in urban, and clean heating energy use were positively associated with PEF significantly. And age, waist circumference smoking status were negatively associated with PEF significantly. Different from women, however, higher education level was positively associated with PEF in men. And the number of comorbidities was associated with PEF in women.

Reference for low PEF

The mean value of PEF was 354.09 ± 132.35 L/min for men, and 254.09 ± 94.98 L/min for women in younger reference adult (≤65 years). Thus, as defined 1 SD below the sex-specific mean value, the cut-off values of Low PEF were 221.73L/min and 159.11 L/min for men and women, respectively. Therefore, the prevalence of Low PEF in men and women were 18.53%, 15.37% separately. When the reference was set as 2 SD below sex-specific mean value, the cut-off values of Low PEF were 89.38 L/min and 64.12 L/min for men and women. Meanwhile, the prevalence of low PEF was 1.62% and 2.16% for men and women separately.

Discussion

In the present study, we established the reference values for PEF using data from 11,717 healthy middle-aged and elderly Chinese adults according to age and sex. The mean values of PEF were 354.10 ± 132.40 and 254.10 ± 94.98 L/min for men and women, respectively. The PEF was higher in men than in women for all age subgroups. The PEF value was decreased with age in both men and women. Our data also suggested that, in both men and women, age, height, weight, waist circumference, handgrip strength, residence in urban, smoking status were significantly associated with PEF. Besides, education level, clean heating energy use were associated with PEF only in men, and number of comorbidities and clean energy use were associated with PEF only in women significantly. The cut-off values of low PEF (mean – 2 SD) were 89.38 L/min and 64.12 L/min for men and women, respectively. And the prevalence of low PEF in men and women were 1.62%, 2.16% separately.

As a physiologic measure and an important index, PEF, has been proposed to estimate airflow obstruction, which could be used to help the management of asthma [11] and screening COPD [10]. Compared with formal spirometry, which is usually unavailable in primary care settings, especially in developing countries [10], PEF test is much cheaper and easier, although it is a crude measure. In addition, considering its rapid and easy-to-get results, it is also feasible for use in large-scale surveys [25]. In recent years, some researchers found that PEF was not only related to respiratory disease, but also demonstrated strong relationships with some poor outcomes [19, 25, 26], especially in older adults. Thus, the measurement of PEF has an important effect in clinical practice and is of practical significance in public health. And it is essential and urgent to establish a unique reference for Chinese.

Global Lung Function Initiative has recommended multi-ethnic spirometry reference values for Northeast Asians, which were established based on largely urban Caucasian data in 2012 [27]. However, the reference value did not include PEF. Previous to our study, PEF reference values for Chinese were estimated. However, several disadvantages limited the national wide usage, for example, based on children and adolescence, or small local regions, or small samples [15, 16, 28-31]. Jian estimated the reference value for 7,115 healthy Han nationality people aged 4~80 years old. Parameters and equations for low limit of normal for PEF in separate age segment were shown in their study. However, that is not convenient for clinical practice in screening the people who are abnormal in lung function. Moreover, potential factors associated lung function were not taken into account. Household air pollution, for example, has been found with respiratory disease, cardiovascular disease, and lung functions. And the association between PEF and household air pollution has not been explored in elderly. Therefore, our study based on the CHARLS, which involves 17,708 middle-aged and elderly participants from 450 counties of 28 provinces in China. And cut-off points for men and women were estimated respectively. Those would make the clinical screening for patients who are abnormal very simple and practical.

There are some differences between our study and the previous study [12]. First, our study focuses on the middle-aged and elderly, including 11,717 Chinese people aged over 40 years. In the previous study, there was a wide range of age of 4–80 years for 7,115 subjects but the middle-aged and older accounted for only a small proportion. PEF is very important for screening and treatment for asthma and COPD, especially for adults and elderly those who declined in lung function with age. Second, one of the key inclusion criteria in the previous study was life-long non-smokers; however, smokers were not excluded from our study. On one hand, we believe that smokers also represented a considerable part of the “healthy” population; on the other hand, logically, we want to consider the effect of smoking on the value of PEF. Third, limitations in the previous article did not include the factors influencing pulmonary function, such as economic conditions, residential environment, and nutrition. However, in the present study, we explored the relationship between PEF and BMI, weight, waist circumference, handgrip strength, education level, smoking status, place of residence and number of comorbidities, in addition to sex and age.

Our data suggested that height, weight, handgrip strength, residence in urban, and clean heating energy use were positively associated with PEF, and age, waist circumference, smoking were negatively associated with PEF significantly in both men and women. Besides, education level was associated with PEF only in men, and number of comorbidities was associated with PEF only in women significantly. In addition, cut-off point was defined as 2 SD below mean value from subjects under 65 years. a diagnose criteria from fixed value are very practical in clinical practice[32].

There are several limitations should be considered. First, the study population only comprised the middle-aged and elderly in China, which limits the generalizability of the results to other populations. Second, we did not consider the influence of some risk factors, such as nationality, environmental pollution, and physical activity, because such information was unavailable. Third, the impact of risk factors on PEF in the present study was based on a cross-sectional study, which limits the inferences of causality.

Conclusions

PEF was declined with age from 40 years in both men and women. This study estimated the age- and sex-specific centiles of PEF for the middle-aged and older Chinese population using LMS method. Interventions on lung function or respiratory disease should be pay more attention on factors associated with PEF. Evidence were provided for epidemiological studies and clinical practice in the future.

Abbreviation

PEF: Peak expiratory flow; COPD: Chronic obstructive pulmonary disease; CHARLS: Chinese Health Retirement Longitudinal Study; BMI, Body mass index; SD: Standard deviation; BCCG: Box-Cox-Cole and Green; LMS: Lambda-Mu-Sigma; GAMLSS: Generalized Additive Models for Location, Scale and Shape;

Declarations

Ethics approval and consent to participate

The protocol was approved by the ethics committee of Peking University and written informed consent was provided from all participants in the present study.

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are openly available in China Health and Retirement Longitudinal Study at http://charls.pku.edu.cn/index.html.

Competing interests

The authors declare that they have no competing interests.

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Competing interests

The authors declare that they have no competing interests

Author contributions

XY had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: JC, XY. Acquisition of data: TCL, XHZ. Analysis and interpretation of data: SHT, ZYZ Drafting of the manuscript: JC, DHX. Statistical analysis: JC, XY. All authors read and approved the final manuscript.

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References

1. Song P, Zha M, Xia W, Zeng C, Zhu Y: **Asthma-chronic obstructive pulmonary disease overlap in China: prevalence, associated factors and comorbidities in middle-aged and older adults**. *Curr Med Res Opin* 2020, **36**(4):667-675.
2. Lopez-Campos JL, Tan W, Soriano JB: **Global burden of COPD**. *Respirology* 2016, **21**(1):14-23.
3. Collaborators GBDCRD: **Global, regional, and national deaths, prevalence, disability-adjusted life years, and years lived with disability for chronic obstructive pulmonary disease and asthma, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015**. *Lancet Respir Med* 2017, **5**(9):691-706.
4. **The global asthma report 2018.** Available from http://www.globalasthmareport.org. Accessed 20 May 2020.
5. Yang G, Wang Y, Zeng Y, Gao GF, Liang X, Zhou M, Wan X, Yu S, Jiang Y, Naghavi M *et al*: **Rapid health transition in China, 1990-2010: findings from the Global Burden of Disease Study 2010**. *Lancet* 2013, **381**(9882):1987-2015.
6. Yin P, Wang H, Vos T, Li Y, Liu S, Liu Y, Liu J, Wang L, Naghavi M, Murray CJ *et al*: **A Subnational Analysis of Mortality and Prevalence of COPD in China From 1990 to 2013: Findings From the Global Burden of Disease Study 2013**. *Chest* 2016, **150**(6):1269-1280.
7. Huls A, Schikowski T: **Ambient particulate matter and COPD in China: a challenge for respiratory health research**. *Thorax* 2017, **72**(9):771-772.
8. Lin J, Wang W, Chen P, Zhou X, Wan H, Yin K, Ma L, Wu C, Li J, Liu C *et al*: **Prevalence and risk factors of asthma in mainland China: The CARE study**. *Respir Med* 2018, **137**:48-54.
9. Kodgule RR, Singh V, Dhar R, Saicharan BG, Madas SJ, Gogtay JA, Salvi SS, Koul PA: **Reference values for peak expiratory flow in Indian adult population using a European Union scale peak flow**

meter. *J Postgrad Med* 2014, **60**(2):123-129.

10. Tian J, Zhou Y, Cui J, Wang D, Wang X, Hu G, Tian Y, Jiang Y, Zheng J, Wang J *et al*: **Peak expiratory flow as a screening tool to detect airflow obstruction in a primary health care setting**. *Int J Tuberc Lung Dis* 2012, **16**(5):674-680.
11. **Global Strategy for Asthma Management and Prevention.** Available from https://ginasthma.org/gina-reports. Accessed 20 May 2020.
12. Jian W, Gao Y, Hao C, Wang N, Ai T, Liu C, Xu Y, Kang J, Yang L, Shen H *et al*: **Reference values for spirometry in Chinese aged 4-80 years**. *J Thorac Dis* 2017, **9**(11):4538-4549.
13. Rebacz-Maron E: **The multi-ethnic global lung initiative 2012 and Third National Health and Nutrition Examination Survey reference values do not reflect spirometric measurements in Black boys and men from Tanzania**. *Clin Physiol Funct Imaging* 2018, **38**(1):76-86.
14. Lu Y, Zheng J, Liu C, Ai T, Wang N, Meng N, Li S, Luo R, Ren X, Jiang W *et al*: **Peak expiratory flow among healthy children aged 5-14 years in China**. *J Thorac Dis* 2018, **10**(3):1377-1385.
15. Jiang M, Gao Y, Zhong NS, Chen WQ, Guan WJ, Zheng JP: **Spirometric reference values for healthy Han children aged 5-15 years in Guangzhou, southern China**. *Pediatr Pulmonol* 2015, **50**(10):1009-1016.
16. Tian XY, Liu CH, Wang DX, Ji XL, Shi H, Zheng CY, Xie MS, Xiao W: **Spirometric Reference Equations for Elderly Chinese in Jinan Aged 60-84 Years**. *Chin Med J (Engl)* 2018, **131**(9):1016-1022.
17. Trevisan C, Rizzuto D, Maggi S, Sergi G, Welmer AK, Vetrano DL: **Cross-Sectional and Longitudinal Associations between Peak Expiratory Flow and Frailty in Older Adults**. *J Clin Med* 2019, **8**(11).
18. Roberts MH, Mapel DW: **Limited lung function: impact of reduced peak expiratory flow on health status, health-care utilization, and expected survival in older adults**. *Am J Epidemiol* 2012, **176**(2):127-134.
19. Smith M, Zhou M, Wang L, Peto R, Yang G, Chen Z: **Peak flow as a predictor of cause-specific mortality in China: results from a 15-year prospective study of ~170,000 men**. *Int J Epidemiol* 2013, **42**(3):803-815.
20. Balmes JR: **Household air pollution from domestic combustion of solid fuels and health**. *J Allergy Clin Immunol* 2019, **143**(6):1979-1987.
21. Lee AG, Kaali S, Quinn A, Delimini R, Burkart K, Opoku-Mensah J, Wylie BJ, Yawson AK, Kinney PL, Ae-Ngibise KA *et al*: **Prenatal Household Air Pollution Is Associated with Impaired Infant Lung Function with Sex-Specific Effects. Evidence from GRAPHS, a Cluster Randomized Cookstove Intervention Trial**. *Am J Respir Crit Care Med* 2019, **199**(6):738-746.
22. Devien L, Giovannelli J, Cuny D, Matran R, Amouyel P, Hulo S, Edmé JL, Dauchet L: **Sources of household air pollution: The association with lung function and respiratory symptoms in middle-aged adult**. *Environ Res* 2018, **164**:140-148.
23. Zhao Y, Hu Y, Smith JP, Strauss J, Yang G: **Cohort profile: the China Health and Retirement Longitudinal Study (CHARLS)**. *Int J Epidemiol* 2014, **43**(1):61-68.

24. Stasinopoulos DM, Rigby RA: **Generalized Additive Models for Location Scale and Shape (GAMLSS) inR**. *Journal of Statistical Software* 2007, **23**(7).
25. Trevisan C, Rizzuto D, Ek S, Maggi S, Sergi G, Fratiglioni L, Welmer AK: **Peak Expiratory Flow and the Risk of Injurious Falls in Older Adults: The Role of Physical and Cognitive Deficits**. *J Am Med Dir Assoc* 2020:ahead of print.
26. Cook NR, Evans DA, Scherr PA, Speizer FE, Taylor JO, Hennekens CH: **Peak expiratory flow rate and 5-year mortality in an elderly population**. *Am J Epidemiol* 1991, **133**(8):784-794.
27. Quanjer PH, Stanojevic S, Cole TJ, Baur X, Hall GL, Culver BH, Enright PL, Hankinson JL, Ip MS, Zheng J *et al*: **Multi-ethnic reference values for spirometry for the 3-95-yr age range: the global lung function 2012 equations**. *Eur Respir J* 2012, **40**(6):1324-1343.
28. Leung TF, Liu TC, Mak KK, Su X, Sy HY, Li AM, Lau JT, Lum S, Wong GW: **Reference standards for forced expiratory indices in Chinese preschool children**. *Pediatr Pulmonol* 2013, **48**(11):1119-1126.
29. Jeng MJ, Chang HL, Tsai MC, Tsao PC, Yang CF, Lee YS, Soong WJ, Tang RB: **Spirometric pulmonary function parameters of healthy Chinese children aged 3-6 years in Taiwan**. *Pediatr Pulmonol* 2009, **44**(7):676-682.
30. Tsai MC, Jeng MJ, Chang HL, Tsao PC, Yang CF, Peng YY, Lee YS, Soong WJ, Tang RB: **Spirometric reference equations for healthy children aged 6 to 11 years in Taiwan**. *J Chin Med Assoc* 2010, **73**(1):21-28.
31. Ma YN, Wang J, Dong GH, Liu MM, Wang D, Liu YQ, Zhao Y, Ren WH, Lee YL, Zhao YD *et al*: **Predictive equations using regression analysis of pulmonary function for healthy children in Northeast China**. *PLoS One* 2013, **8**(5):e63875.
32. Neve V, Hulo S, Edme JL, Boileau S, Baquet G, Pouessel G, Thumerelle C, Deschildre A, Matran R: **Utility of measuring FEV0.75/FVC ratio in preschoolers with uncontrolled wheezing disorder**. *Eur Respir J* 2016, **48**(2):420-427.

Tables

Table 1. Reference values for PEF (L/min) stratified by age and sex

Age (year)	*n*	P5	P10	P25	P50	P75	P90	P95	Mean ± SD
Men									
40−45	39	232.61	282.96	361.99	443.66	520.38	586.13	624.24	459.10 ± 119.43
45−50	1001	206.40	255.35	334.12	417.68	497.87	567.73	608.65	412.00 ± 121.89
50−55	862	182.24	230.15	309.08	394.76	478.56	552.63	596.43	394.14 ± 126.33
55−60	1138	157.80	205.15	283.98	370.06	454.48	529.24	573.49	368.59 ± 125.44
60−65	966	137.16	181.70	257.37	341.63	425.56	500.77	545.63	341.91 ± 123.76
65−70	614	118.60	158.40	228.09	308.47	391.00	466.74	512.63	313.60 ± 119.40
70−75	427	98.93	133.51	196.43	272.22	353.06	429.52	476.79	276.41 ± 112.23
75−80	240	80.22	109.96	166.68	238.78	319.39	398.60	448.83	243.50 ± 117.14
80+	132	64.69	90.21	141.06	209.03	288.51	369.51	422.17	227.05 ± 107.35
Women									
40−45	228	141.17	175.83	231.92	291.71	349.33	399.67	429.22	285.36 ± 87.57
45−50	1367	139.68	172.30	226.92	287.52	348.00	402.31	434.77	285.50 ± 90.61
50−55	959	132.77	164.38	218.29	279.36	341.37	397.86	431.93	282.98 ± 90.48
55−60	1289	116.10	147.57	201.44	262.52	324.53	380.99	415.02	263.03 ± 90.68
60−65	976	100.37	129.54	180.69	240.20	301.93	359.09	393.95	238.46 ± 89.36

65–70	650	89.98	115.68	162.36	218.99	279.99	338.25	374.51	221.30 ± 88.80
70–75	391	80.56	103.46	146.08	199.28	258.11	315.53	351.82	203.42 ± 81.72
75–80	270	67.80	88.75	128.68	179.81	237.63	295.09	331.83	188.77 ± 78.31
80+	168	52.34	71.23	108.64	158.51	216.83	276.35	315.10	163.02 ± 88.21

Table 2. Demographic characteristics of the participates

Variables	Total (n = 11717)	Men (n = 5419)	Women (n = 6298)	t /	*P*
Age *, years	65.00 ± 11.78	59.02 ± 9.34	57.86 ± 9.80	6.57	<0.0001
Height *, cm	158.25 ± 8.59	164.33 ± 6.63	153.01 ± 6.33	93.60	<0.0001
Weight *, kg	59.23 ± 11.74	62.57 ± 11.67	56.36 ± 11.02	29.35	<0.0001
BMI *, kg/m^2	23.58 ± 3.89	23.10 ± 3.65	24.00 ± 4.03	12.52	<0.0001
Waist Circumference *, cm	84.40 ± 12.59	84.30 ± 12.42	84.49 ± 12.73	0.84	0.3993
PEF *, L/min	300.34 ± 124.24	354.10 ± 132.40	254.10 ± 94.98	46.30	<0.0001
Education (%)					
No formal education	20.48	33.70	9.08		<0.0001
Elementary school	35.35	33.26	37.15		
Middle school and above	44.16	33.03	53.77		
Smoking (%)					
Yes	30.45	59.15	5.69	3797.59	<0.0001
No	69.55	40.85	94.31		
Drinking (%)					
Yes	25.06	46.21	6.81	2325.60	<0.0001
No	74.94	53.79	93.19		
Place of residence (%)					
Urban	37.50	36.41	38.44	4.95	<0.05
Rural	62.50	63.59	61.56		
Number of comorbidities, median (Q1, Q3)	1 (0, 2)	1 (0, 2)	1 (0, 2)	6.87	<0.0001
Clean heating energy (%)					
Yes	20.20	19.98	20.38	0.26	0.6130
No	79.80	80.02	79.62		
Clean cooking fuel (%)					

Yes	44.75	44.19	45.24	1.1655	0.2803
No	55.25	55.81	54.76		
Clean energy use (%)					
Yes	13.67	13.45	13.85	0.3407	0.5594
No	86.33	86.55	86.15		

* presented as means ± standard deviation. PEF, peak expiratory flow.

Table 3 Multiple linear regression of PEF

Variables	*β*	SE	*t*	*P*
Men				
Intercept	221.08	51.85	4.26	<0.0001
Age (years)	-3.85	0.21	-18.45	<0.0001
Height	1.38	0.32	4.37	<0.0001
Weight (kg)	1.60	0.23	6.95	<0.0001
Waist circumference (cm)	-0.47	0.18	-2.70	<0.01
Hand grip strength (kg)	1.54	0.16	9.70	<0.0001
Education level				
No formal education	Reference			
Elementary school	8.21	4.13	1.99	<0.05
Middle school and above	4.57	4.34	1.05	0.2925
Smoking status (Yes vs No)	-7.35	3.52	-2.09	<0.05
Place of residence (Urban vs Rural)	13.63	3.80	3.59	<0.001
Clean heating energy use	14.99	4.38	3.42	<0.001
Women				
Intercept	132.17	35.27	3.75	<0.001
Age (years)	-2.15	0.14	-15.63	<0.0001
Height	1.14	0.23	5.03	<0.0001
Weight (kg)	0.95	0.16	5.94	<0.0001
Waist circumference (cm)	-0.31	0.11	-2.70	<0.01
Hand grip strength (kg)	1.61	0.16	9.92	<0.0001
Smoking status (Yes vs No)	-11.38	5.07	-2.25	<0.05
Place of residence (Urban vs Rural)	8.88	2.55	3.48	<0.001
Number of comorbidities	-3.87	0.96	-4.02	<0.0001
Clean heating energy use	7.47	3.00	2.49	<0.05

PEF, peak expiratory flow; SE, standard error.

Figures

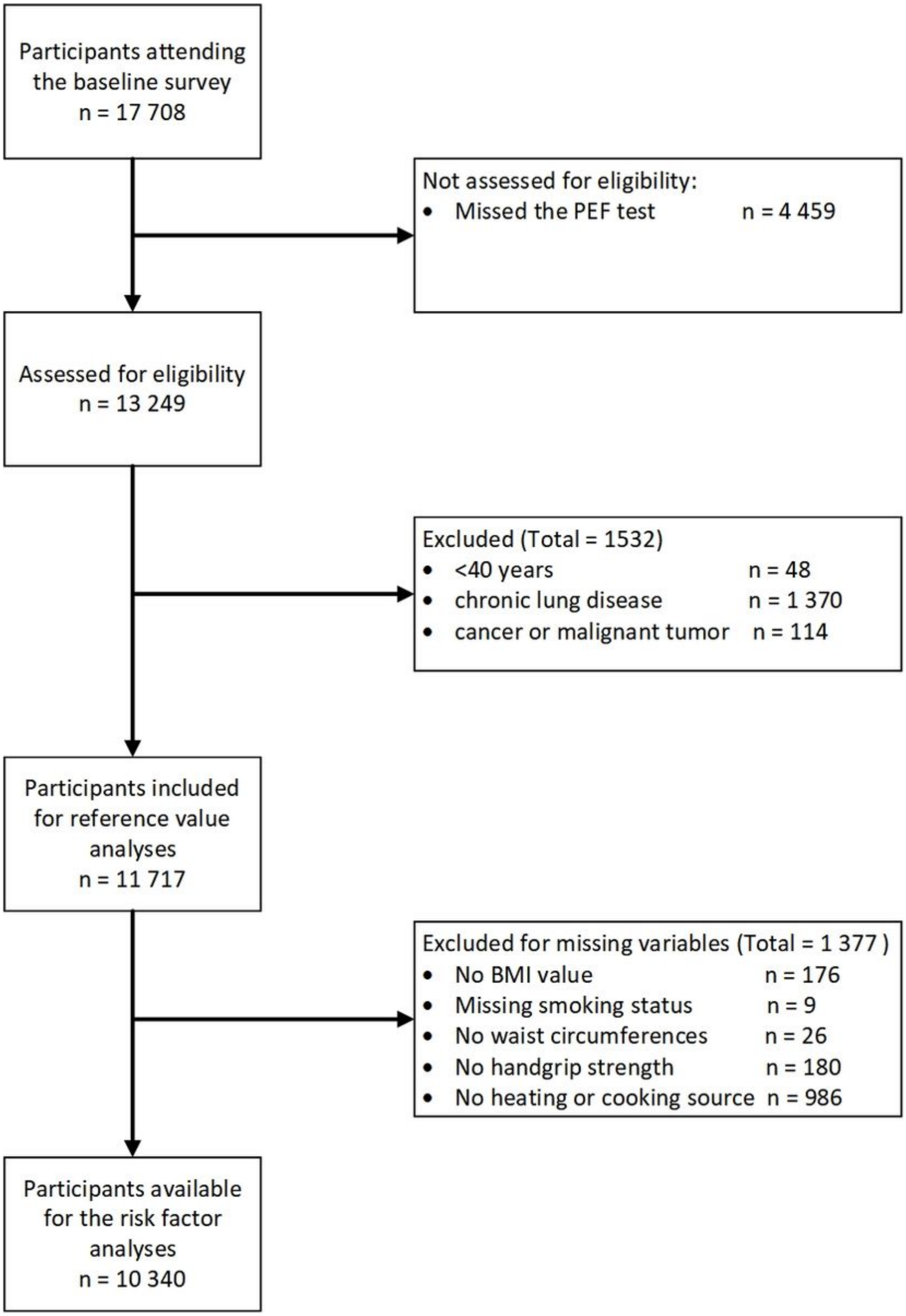

Figure 1

The flow chart of the PEF study

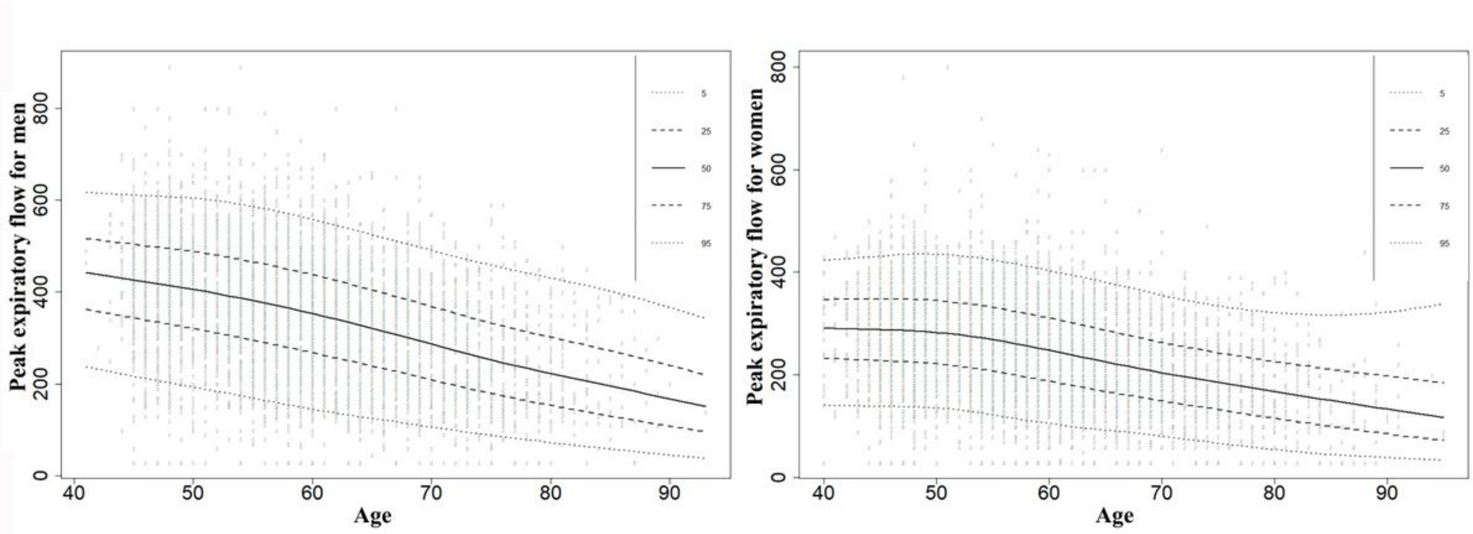

Figure 2

Centiles curve for PEF men (left) and women (right). Centiles were estimated by LMS method.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Figure2s.jpg
- supplementmaterial.docx
- Figure1s.jpg