Reference Spirometric Values for Healthy Lifetime Nonsmokers in Thailand†

WANCHAI DEJSOMRITRUTAI, M.D.*,
KHUN NANTA MARANETRA, M.D.*,
KITTIPONG MANEECHOTESUWAN, M.D.*,
NITIPATANA CHIERAKUL, M.D.*,
JAMSAK TSCHEIKUNA, M.D.*,
TASNEEYA SUTHAMSMAI, M.Sc.*,
ARTH NANA, M.D.*,
BENJAMAS CHUAYCHOO, M.D.*,
PHUNSUP WONGSURAKIAT, M.D.*,
SUCHAI CHAROENRATANAKUL, M.D.*,
WILAWAN JUENGPRASERT, M.D.**,
CHANA NARUMAN, M.Sc.*

Abstract

The normal spirometric reference values for Thai people are still not yet available. The aim of this study was to establish standard spirometric equations for Thai people. Subjects 10 years of age and over were selected and their demographic distributions represented that of the population of the whole country. Inclusion criteria were strictly lifetime nonsmokers, no history of chronic cardiopulmonary disease (using a modified ATS - DLD 78 respiratory adult questionnaire), normal standard chest radiograph and unremarkable physical examination. They had to be without respiratory symptoms at the time of the study. Spirometric values were obtained by 5 turbine system 'Pony graphic' (Cosmed, Italy) spirometers which met ATS recommendations. A normal group of 2299 women and 1655 men were selected. Regression analyses using sex, height and age as independent variables were used to provide equations for predicted values. The results were:

	Equations	r2	SEE
FVC(L)	: M -2.601+0.122A-0.00046A^2+0.00023H^2-0.00061AH	0.669	0.434
	: F -5.914+0.088A-0.0003A^2+0.056H-0.0005AH	0.618	0.324
FEV1(L)	: M -7.697+0.123A+0.067H-0.00034A^2-0.0007AH	0.70	0.371
	: F -10.603+0.085A-0.00019A^2+0.12H-0.00022H^2 -0.00056AH	0.681	0.275

* Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700,
* Ministry of Public Health, Nonthaburi 11000, Thailand.

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		Equations	r2	SEE
$FEF_{25-75\%}$(L/S)	:	M -19.049+0.201A+0.207H-0.00042A^2-0.00039H^2 -0.0012AH	0.42	0.882
	:	F-21.528+0.11A-0.00017A^2+0.272H-0.0007H^2-0.00082AH	0.456	0.664
PEFR(L/S)	:	M -16.859+0.307A+0.141H-0.0018A^2-0.001AH	0.443	1.543
	:	F -31.355+0.162A-0.00084A^2+0.391H-0.00099H^2 -0.00072AH	0.29	1.117
FEV1/FVC(%)	:	M 19.362+0.49A+0.829H-0.0023H^2-0.0041AH	0.24	5.364
	:	F 83.126+0.243A+0.002A^2+0.08H-0.0036AH	0.22	4.986

M = male, F = female, A = age (years), H = height (cms)

FVC and FEV1 from this study are close to the Chinese but are 8-20 per cent lower than the Caucasians. These predicted equations are recommended to be used for future reference values in the Thai population.

Key word : Spirometry, Reference, Standard, Thailand, Pulmonary Function Test

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Spirometry is widely available and is the most useful pulmonary function test. It includes measurements of both volume and flow, which provide valuable data for the diagnosis of respiratory diseases and assessment of their severity. The standard values of spirometry depend on many factors including sex, age, height and ethnic origin. It is well recognized that there are racial variations in lung function[1-3]. Lung function equations derived from Caucasian populations usually over-estimate values in non-Caucasian subjects. Therefore, the study of reference spirometric values obtained from subjects belonging to the same ethnic group is recommended. The prediction equations widely used are based on different study populations, including smokers[4,5]. Recent recommendations have proposed reference values based on cross sectional studies of only healthy, lifetime nonsmokers[5,6]. Since the reference values for Thai people are not yet available, this study was conducted among lifetime nonsmokers in Thailand to establish standard spirometric equations for Thai people. This study used techniques and equipment that meet the recommendations of the American Thoracic Society[7].

METHOD

Study population

This cross-sectional study was performed from January 1996 to December 1997 and was designed to include a population of all ages over 10 years old and distributed to all parts of the country. Male and female subjects included were volunteers from all walks of life for example, civil servants, farmers, military personnel, students from schools and colleges and businessmen. These subjects were recruited by different means such as advertisement *via* the media, school directors, health care workers, village chiefs (kamnan), chief executive officers of private firms etc. Subjects included had to fulfill the following criteria: a. a lifetime nonsmoker (total smoking less than 0.5 pack-year and did not smoke within the last 6 months) 2. no history of chronic cardiopulmonary disease 3. normal chest radiograph 4. unremarkable physical examination of respiratory and cardiovascular system 5. no respiratory symptom at the time of the study 6. not pregnant. ATS DLD-78 Respiratory Adult Questionnaire was used by trained interviewers to obtain the respiratory health information. Subjects were excluded if they had a his-

tory of chronic cardio-pulmonary diseases or acute respiratory symptoms. Standard chest radiographs were done and independently interpreted by three respiratory specialists and only subjects whose chest radiographs were normal with unanimous opinions were included. Physical examinations were performed by respiratory physicians and subjects with a neck mass, chest wall deformities (e.g. kyphosis or scoliosis), an abnormal cardiopulmonary system (e.g. murmur, wheeze, crackles) were excluded.

Spirometry measurement

Spirometric values were obtained by 5 turbine system spirometers (Pony Graphic, Cosmed, Italy) which met ATS requirements. The machines were calibrated with a 3-litre syringe every morning before use and after 4 hours of the tests. The measurement of volume and flow were BTPS corrected. Standing height (cm) was recorded. Subjects performed spirometry in a sitting position wearing noseclips by trained and experienced technicians. Acceptability and reproducibility criteria were applied according to ATS recommendations[7] until three acceptable and two reproducible curves were obtained. The largest FVC and FEV1 from the three acceptable maneuvers were recorded while other spirometric parameters e.g. FEV1/FVC%, FEF25-75% were chosen from best curve (largest sum of FVC and FEV1).

Statistical Method

Multiple linear regression was used to develop equations to predict FEV1, FVC, FEV1/FVC%, FEF25-75% and PEFR using the SPSS 7.0 program for both females and males. In each analysis, the physical predictors significantly associated with lung function were selected from among: age (A) years, age squared (A^2); height (H), height squared (H^2), age x height (AH).

The prediction equations of each spirometric values were established using the models which gave the best coefficient of determination (r^2) and the standard error of the estimate (SEE) was used as an estimate of error variation.

Table 1. Demographic data of reference samples.

	Women	Men	Total
Number	2299	1655	3954
Age(years)			
Mean (SEE)	43.24 (0.4)	36.73 (0.44)	40.35 (0.30)
Range	10-92	10-87	10-92
Height (centimetres)			
Mean (SEE)	153.5 (0.13)	163.6 (0.22)	157.7 (0.14)
Range	121-184	125-185	121-185
Weight (kilograms)			
Mean (SEE)	53.7 (0.22)	59.7 (0.29)	56.23 (0 18)
Range	21-115	22-109	21-115

Table 2. The distribution of residences of the subjects.

Residence	Women		Men		Total		% Distribution of Thai population: National report(1996)
	No	%	No	%	No	%	
North-Eastern	581	25.3	547	33.1	1128	28.5	32
Central	544	23.7	337	20.4	881	22.3	22
North	428	18.6	349	21.1	777	19.6	20
Bangkok	477	20.7	226	13.6	703	17.8	13
South	269	11.7	196	11.8	465	11.8	13
Total	2299	100	1655	100	3954	100	100

RESULTS

Two thousand two hundred and ninety-nine women and 1,655 men who were healthy lifetime nonsmokers were recruited. The demographic data of the subjects are shown in Table 1. The distribution of residences of the subjects and number of subjects selected from each part of the country were proportional to the distribution of the general population (Table 2). Data showed an overrepresentation of women over 50 years of age because women were more likely to be nonsmokers than men of the same age group (Table 3). Fig. 1 (A-D) shows the age dependency of the distributions of FVC and FEV1 among men and women of reference samples. In each of these plots, dots represent individual subjects. They all showed some degree of curvature with the maximum of most spirometric values at the age range of 20-24 years in males and 15-19 years in females. The derived prediction equations are given in Table 4. Values of r^2 and SEE for the present study and from six previous studies[4,8-12] are shown in Table 5-6. The comparison of the predicted spirometric values for adult non smokers (at the mean height in the present study) using the equations from the present study and the equations developed by Lam in Chinese from Hong Kong[10] with the corresponding values predicted for Caucasians by Quanjer[4] and Crapo[9] are shown in Fig. 2-5. In order to

Table 3. Age distribution of the subjects.

	Age (years)							
	10-19	20-29	30-39	40-49	50-59	60-69	≥ 70	Total
male (n)	363	316	313	274	161	150	78	1655
female (n)	290	371	359	362	284	427	206	2299
Total	653	687	672	636	445	577	284	3954

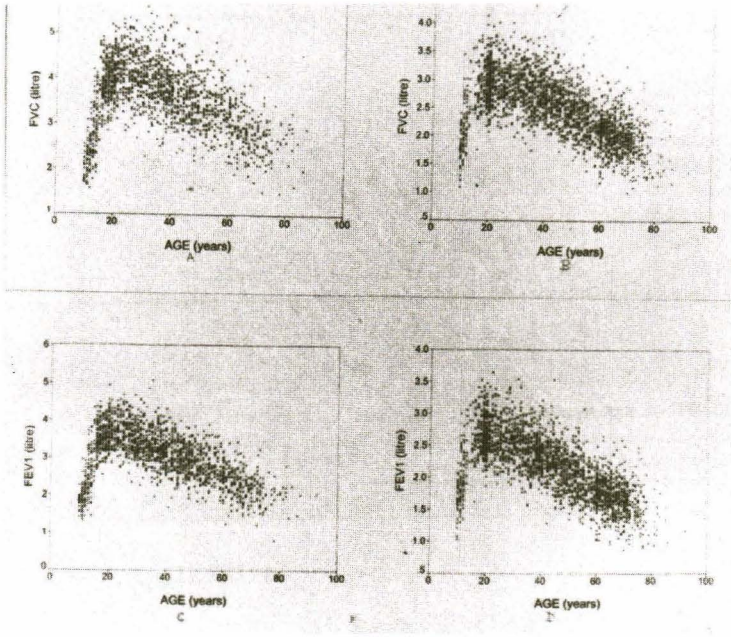

Fig. 1. Figure A-D shows the age dependency of the distributions of FVC in (A) men and (B) women and of FEV1 in (C) men and (D) women.

Table 4. Derivation of the prediction equations.

		Equations	r^2	SEE
FVC(L)	:	M -2.601+0.122A-0.00046A^2+0.00023H^2-0.00061AH	0.669	0.434
	:	F -5.914+0.088A-0.0003A^2+0.056H-0.0005AH	0.618	0.324
FEV1(L)	:	M -7.697+0.123A+0.067H-0.00034A^2-0.0007AH	0.70	0.371
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M = male, F = female, A = age (years), H = height (cms)

Table 5. Comparison of spirometric equations among various studies (male).

Study	Age	n	Variable			
			FVC		FEV1	
			r^2	SEE	r^2	SEE
Morris (8)	20-84	517	0.42	0.74	0.53	0.55
Crapo (9)	18-91	125	0.54	0.64	0.64	0.49
Lam (10)	5-85	1778	0.7	0.22	0.8	0.19
Quanjer (4)	18-70	189	0.85	0.56	0.86	0.51
Gore (11)	18-78	165	0.57	0.62	0.62	0.48
Brandli (12)	18-60	1267	0.4	0.4	0.44	0.44
Siriraj	10-87	1655	0.67	0.43	0.7	0.37

Table 6. Comparison of spirometric equations among various studies (female).

Study	Age	n	Variable			
			FVC		FEV1	
			r^2	SEE	r^2	SEE
Morris (8)	20-84	471	0.50	0.52	0.53	0.47
Crapo (9)	18-91	126	0.74	0.39	0.80	0.33
Lam (10)	5-85	1712	0.65	0.19	0.76	0.17
Quanjer (4)	18-70	514	0.86	0.42	0.88	0.38
Gore (11)	18-78	249	0.66	0.38	0.69	0.34
Brandli (12)	18-60	1890	0.38	0.50	0.47	0.41
Siriraj	10-87	2299	0.62	0.32	0.68	0.28

compare the differences between various predicted equations, spirometric data of each subject recruited (of the same height, age, and gender) were calculated using the present equations as well as the equations of Crapo(9), Quanjer(4) and Lam(10). The difference in per cent between the results were recorded for each data point. The mean of those differences is shown in Table 7. In general, most parameters in Thais from the present study are lower than the Caucasians in the Crapo(9) and Quanjer studies(5). FEV1 values in Thais are approximately 20.8 per cent and 16.0 per cent lower than those

found in Crapo's study of Caucasians from North America in males and females respectively[9], while the results of Quanjer's study from European subjects showed that FEV1 in Thais are 12.5 per cent and 7.8 per cent lower in males and females respectively. For FVC in male subjects the Thais have 19.4 per cent lower FVC compared to Crapo's study and 11.0 per cent lower than Quanjer's study[5,9]. The same comparison was made with Lam's study with variability in the results of approximately 3 per cent difference for the age range between 20-74 years of age.

DISCUSSION

Almost all previously published reference spirometric standards were carried out in Caucasians from North America or Europe with only scanty reports from Asian countries. Lam's equa-

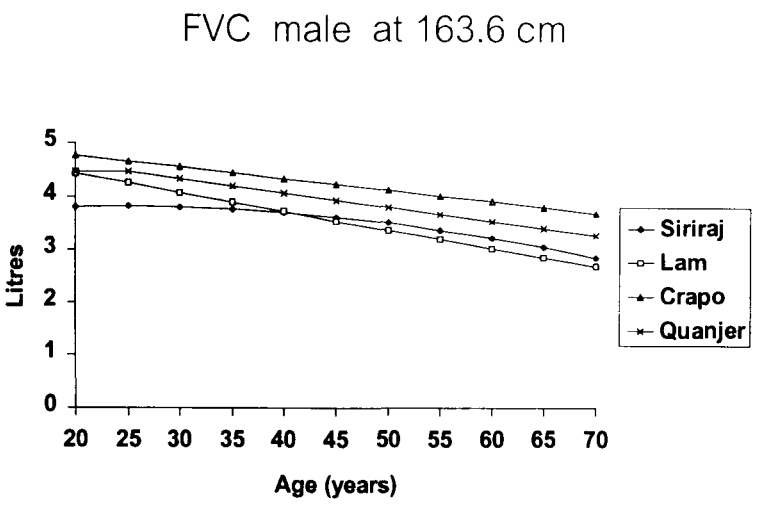

Fig. 2. The comparison of the predicted spirometric values – FVC, male.

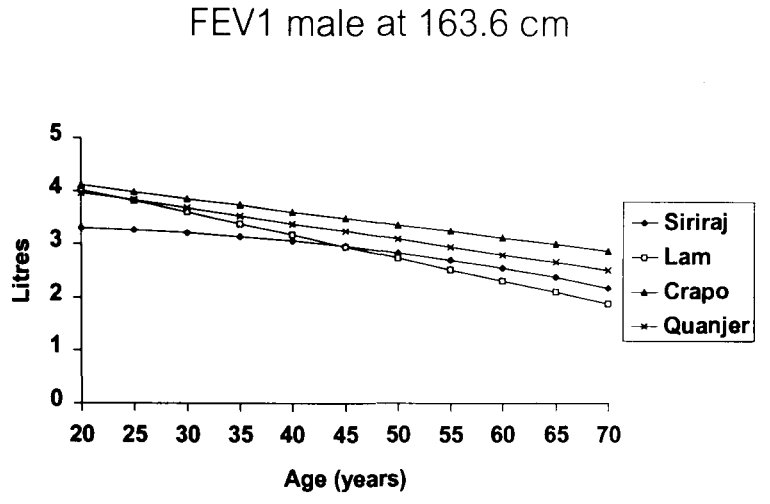

Fig. 3. The comparison of the predicted spirometric values – FEV1, male.

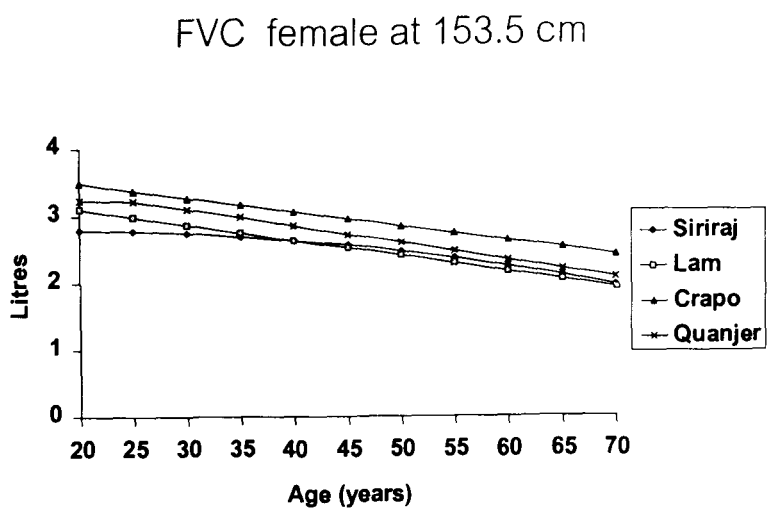

Fig. 4. The comparison of the predicted spirometric values – FVC, female.

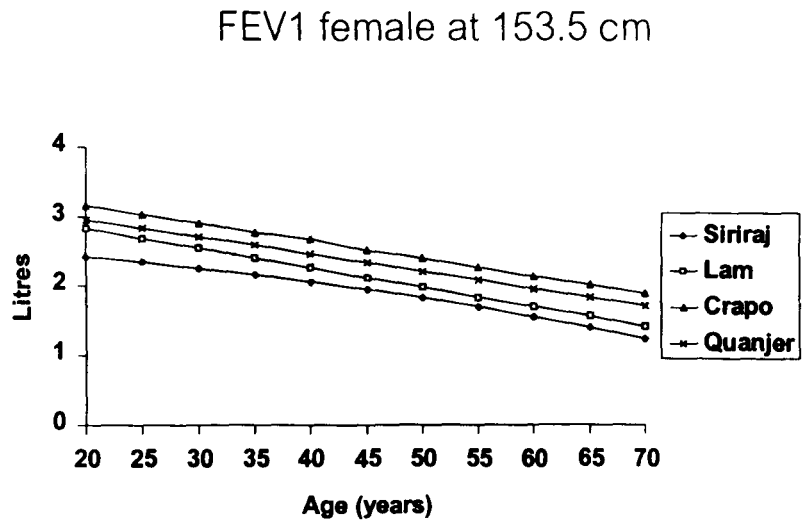

Fig. 5. The comparison of the predicted spirometric values – FEV1, female.

Table 7. Mean percentage differences between three previous studies and the present study.

Study	Male				Female				Age
	FVC		FEV1		FVC		FEV1		
	Mean	95%CI	Mean	95%CI	Mean	95%CI	Mean	95%CI	
Crapo	19.4	19.1-19.7	20.8	20.5-21.1	19.7	19.5-19.9	16.0	15.8-16.2	18-89
Quanjer	11.0	10.8-11.3	12.5	12.3-12.7	9.7	9.4-10.0	7.8	7.5-8.1	18-70
Lam	1.3	1.0-1.7	3.4	2.8-4.0	0.6	0.4-0.8	-3.1	(-3.5) - (-2.7)	20-74

(-) = lower than the present study

tions[10] were previously used as reference values for interpreting spirometric results in Thailand. The present study reports normal values for spirometric parameters in healthy lifetime nonsmokers in Thailand. The equipment and techniques used meet ATS criteria and recommendations. The geographical distributions of the subjects correspond to the distribution of the general population in the country. All age groups that may encounter clinical spirometric testing were included. All subjects were judged healthy by various screening processes that include a standard respiratory questionnaire, physical examination and chest X-ray. So the equations derived should leave no doubt about accuracy and acceptability.

Comparisons of coefficient of determination (r^2) and standard error of estimations (SEE) for the present and past predictive equations (Table 5-6) revealed superiority of the present equations. The population in Lam's study comprised of a mixed group of smokers, ex-smokers and nonsmokers while in this study only lifetime nonsmokers were included. The studies from North America and Europe were smaller in sample sizes and also with a lower coefficient of determination. This result lends strength to the assertion that the present equations are preferable to equations derived in the past for predicting the lung function of Thai subjects.

Comparisons of predicted values for FEV1 and FVC using the equations from the present study, those of Lam, Crapo and Quanjer were made both in males and females. Not surprisingly, present equations predicted values lower than Crapo and Quanjer in all age groups both in males and females. In males less than 40 years of age the results were comparable with Lam but with increasing age the present study showed higher values. This discrepancy may be the effect of inclusion of the smoking population in Lam's study. In average, the mean of all spirometric parameters from the present study is 8-20 per cent lower than Crapo and Quanjer's results and almost equivalent to Lam's (Table 7). The present practice of 10 or 15 per cent deduction from the Caucasian reference values for all spirometric parameters can either overestimate or underestimate the results depending on the prediction equations that were used. Another observation that can be made from this study is that this difference did not show uniformity over the entire range of age and height. An error can easily be made by fixing the discrepancy to either 10 or 15 per cent over the entire range of subjects with varying age and height. These practices should be substituted by using the local equations in order to avoid those errors.

In conclusion, this study confirmed that Thai people have FEV1, FVC values lower than Caucasians (8-20%) of the same height, age and gender. These parameters are very much similar to the Chinese in Hong Kong. These predicted equations are recommended to be used for future reference values in the Thai population.

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ค่ามาตรฐานสมรรถภาพการทำงานของปอดในประชากรไทย

วันชัย เดชสมฤทธิ์ฤทัย, พ.บ., อรรถ นานา, พ.ด.*, คุณนันทา มาระเนตร์, พ.ด.*, เบญจมาศ ช่วยชู, พ.บ.*, กิตติพงศ์ มณีโชติสุวรรณ, พ.บ.*, พูนทรัพย์ วงศ์สุรเกียรติ์, พ.บ.*, นิธิพัฒน์ เจียรกุล, พ.บ.*, สุชัย เจริญรัตนกุล, พ.บ.*, แจ่มศักดิ์ ไชยคุณา, พ.บ.*, วิลาวัณย์ จึงประเสริฐ, พ.บ.**, ทัศนียา สุธรรมสมัย, วท.ม.*, ชนะ นฤมาน, วท.ม.**

ในปัจจุบันยังไม่มีรายงานค่ามาตรฐานการตรวจสมรรถภาพการทำงานของปอดที่สมบูรณ์ในประชากรไทย จำเป็นต้องใช้ค่าของต่างประเทศเพื่อเปรียบเทียบและแปลผล ซึ่งอาจทำให้การแปลผลคลาดเคลื่อนได้ วัตถุประสงค์ของการศึกษาวิจัยนี้เพื่อหาค่ามาตรฐานของสมรรถภาพการทำงานของปอดในประชากรไทยที่ไม่สูบบุหรี่ ได้แก่ค่า FVC, FEV1, FEV1/FVC%, $FEF_{25-75\%}$, PEFR จำนวนประชากรที่ศึกษา จำนวน 3,954 ราย เป็นชาย 1,655 ราย หญิง 2,299 ราย อายุตั้งแต่ 10 ปีขึ้นไป ไม่สูบบุหรี่ ไม่มีประวัติการเป็นโรคหัวใจและโรคระบบหายใจมาก่อนและไม่มีอาการผิดปกติทางระบบหายใจในขณะทำการศึกษา โดยใช้แบบสัมภาษณ์โรคระบบหายใจในผู้ใหญ่ของสมาคมโรคทรวงอกอเมริกา (ATS-DLD-78) ผลการตรวจร่างกายและภาพรังสีทรวงอกขนาดมาตรฐานปกติ ตัวอย่างประชากรที่ศึกษานี้ได้สัดส่วนกับประชากรภาคต่างๆ ของประเทศ เครื่องมือที่ใช้ตรวจสมรรถภาพปอด คือ turbine spirometer "Pony graphic" (Cosmed, ประเทศอิตาลี) ซึ่งได้มาตรฐานตามสมาคมโรคทรวงอกอเมริกา ทำการตรวจโดยผู้ชำนาญทางการตรวจสมรรถภาพปอด ได้สมการของศิริราชสำหรับค่าปกติมาตรฐานของประชากรไทย ดังนี้

		Equations	r^2	SEE
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$FEF_{25-75\%}$(L/S)	:	M $-19.049+0.201A+0.207H-0.00042A^2-0.00039H^2$ $-0.0012AH$	0.42	0.882
	:	F $-21.528+0.11A-0.00017A^2+0.272H-0.0007H^2-0.00082AH$	0.456	0.664
PEFR(L/S)	:	M $-16.859+0.307A+0.141H-0.0018A^2-0.001AH$	0.443	1.543
	:	F $-31.355+0.162A-0.00084A^2+0.391H-0.00099H^2$ $-0.00072AH$	0.29	1.117
FEV1/FVC (%)	:	M $19.362+0.49A+0.829H-0.0023H^2-0.0041AH$	0.24	5.364
	:	F $83.126+0.243A+0.002A^2+0.08H-0.0036AH$	0.22	4.986

M = male, F = female, A = age(years), H = height (cms)

จากสมการของศิริราชนี้ ค่า FVC และ FEV1 จะต่ำกว่าสมการของชาวตะวันตกร้อยละ 8-20 แต่ใกล้เคียงกับของฮ่องกง คณะผู้วิจัยเชื่อว่าค่าปกติจากการศึกษานี้เชื่อถือได้ และครอบคลุมกลุ่มอายุของผู้ป่วยที่มารับการตรวจในโรงพยาบาล จึงควรเป็นค่าปกติที่นำไปใช้ในการแปลผลการตรวจสมรรถภาพการทำงานของปอดในประชากรไทย

คำสำคัญ : สไปโรเมตรีย์, ค่ามาตรฐาน, ประชากรไทย, สมรรถภาพการทำงานของปอด

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* สาขาวิชาโรคระบบการหายใจและวัณโรค, ภาควิชาอายุรศาสตร์, คณะแพทยศาสตร์ศิริราชพยาบาล, มหาวิทยาลัยมหิดล, กรุงเทพ ฯ 10700

** กองอาชีวอนามัย, กรมอนามัย, กระทรวงสาธารณสุข, นนทบุรี 11000