UNIVERSITI SAINS MALAYSIA
PROJEK PENYELIDIKAN JANGKA PENDEK
LAPORAN AKHIR

KAJIAN SPIROMETER DAN ANTROPOMETRIK KE ATAS KANAK-KANAK BERUMUR DIANTARA 7 DAN 12 TAHUN

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(SPIROMETRIC AND ANTHROPOMETRIC STUDIES IN NORMAL CHILDREN AGED BETWEEN 7 AND 12 YEARS)

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ABSTRAK

Data spirometrik untuk 1183 orang kanak-kanak sekolah yang sihat (551 lelaki dan 632 perempuan) yang berumur antara 7 hingga 12 tahun telah dianalisa untuk memperolehi persamaan ramalan untuk FVC (kapasiti paksaan mutlak), FEV_1 (isipadu ekspirasi paksaan dalam masa satu saat), $FEF_{25-75\%}$ (aliran maksima semasa pertengahan FVC), $Vmax_{50\%}$ (kadar aliran selepas menghembuskan 50% FVC) dan PEFR (kadar aliran ekspirasi kemuncak). Untuk semua parameter fungsi peparu, kanak-kanak perempuan mempunyai nilai yang lebih rendah daripada lelaki. Dengan menggunakan analisa regresi, ketinggian semasa berdiri merupakan petunjuk (penjangka) yang paling penting untuk fungsi pulmonari, dalam semua kelas umur. Persamaan regresi yang dibentuk dengan pembolehubah bersandar secara logaritma memberi jangkaan yang tepat. Nilai FVC ramalan yang diperolehi daripada persamaan yang berasaskan pada populasi lain adalah lebih tinggi daripada purata yang didapati dalam kajian ini. Oleh sebab itu, kajian ini menegaskan betapa pentingnya untuk berhati-hati apabila menggunakan formula yang diperolehi daripada satu populasi ke populasi yang lain. Kesimpulan ralat yang besar mungkin dicapai sekiranya persamaan ramalan untuk parameter peparu untuk sesuatu populasi tertentu tidak diperolehi daripada kajian yang berasaskan pada kumpulan populasi yang sama.

Kata Kunci: spirometrik paksaan, kanak-kanak sekolah, nilai rujukan, kajian keratan lintang, warga Malaysia

ABSTRACT

Spirometric data on 1183 healthy school children (551 boys and 632 girls) ranging in age from 7 to 12 years were analysed to derive predicted equations for FVC (forced vital capacity), FEV_1 (forced expiratory volume in one second), $FEF_{25-75\%}$ (maximal flow over the mid-portion of FVC), $Vmax_{50\%}$ (flow rate after expiring 50% of FVC), and PEFR (peak expiratory flow rate). For all lung function parameters, girls have lower values than boys. Using regression analysis, standing height appeared to be the most important predictor of pulmonary function across the age group. Regression equations constructed with logarithmically transfered dependent variables provided accurate predictions. Predicted FVC values derived from equation based on other population were higher than the observed mean in this study. This study therefore, reemphasises the need to be cautious when applying formulae derived from one population to another. Grossly erroneous conclusions may be reached unless predicted equations for lung parameters for a given population group are derived from studies based upon the same population group.

Keywords: forced spirometry, school children, reference values, cross-sectional study, Malaysian

INTRODUCTION

Pulmonary function testing in children has become an important method of monitoring lung growth. It also provide an objective documentation of the nature, presence and severity of an abnormality, and as well the therapeutic response and progress of chronic disease(1,2).

Many reports of various lung function parameters in apparently healthy children of North American (3-10), Australian (11,12), Europeans (13,14) and Asian (15-19) populations have been reported. However, there have been few reports of similar studies in the Malaysian children population, which comprises of three main races namely Malays, Chinese and Indians. These studies have been limited to one particular race or to one aspect of lung function test (18.19). In view of the paucity of normal data availability on Malaysian children a further statistically analysed study of pulmonary functions in healthy Malaysian children seemed relevant as very little can be gleaned from studies of Omar and Henry (18) and Ismail et al. (19) in terms of forming a reliable reference standard for Malaysian children.

It is increasingly recognised that population specific reference values developed with consideration of racial, ethnic origins and gender for children are also important (20). Furthermore, prediction equations for ventilatory function developed in particular population may not be appropriate for another population.

The present study therefore aims to determine the lung function parameters in normal healthy Malaysian children and to ascertain whether there are differences between the lung function measurements of Malaysian and those of other population groups. An attempt is also made to derive reliable prediction formulae for ventilatory function in the Malaysian children. A comparison of the predicted values for Malaysian children using formulae derived from this study and those derived from other studies is also made.

METHODS

Subjects

Seven to 12 years-old primary school children from eight schools in Kota Bharu area were subjects in this cross-sectional study.

Tests

Testing consisted of the administration of a simplified respiratory symptom questionnaire which was written in Bahasa Malaysia, Mandarin and Tamil. The questionnaires were distributed to parents of 1490 randomly selected children through the class teachers. A total of 1455 children who returned the completed questionnaire were asked to participate in spirometry and anthropometric measurements which were performed at the respective schools. From the questionnaire, all children who had a history of bronchiolitis, bronchitis and asthma were eliminated from the study. These deletions reduced the size of the population studied to 1338 (92%) of the 1455 selected.

Age was recorded to the nearest year and standing height was measured in stocking feet. Sitting height was measured with the child seated in a straight-backed chair, head upright with shoulders square. Weight, without shoes, was measured with the subjects fully clothed in school uniform after removing objects from their pockets. The Quetelet body mass index (BMI) was calculated by dividing weight (kg) by height square (m^2).

After anthropometric measurements, testing was performed on all subjects by the same two of the authors who are trained in spirometry. Spirometry was performed using a Vitalograph Model R spirometers which were calibrated with a 1-L syringe and checks for leaks were performed by the technologists before use. Each child was tested while standing with the nose clipped. Forced vital capacity (FVC) manoeuvre was demonstrated and a practice blow was allowed after which forced expiratory curves were recorded until three "acceptable" FVC manoeuvres were obtained using conventional criteria of acceptability (20-22) or in which two highest FVCs did not vary by more than 5%. If two reproducible error-free trials were not obtained or those that produced no stable tracings were excluded from the study. Those deletions further reduced the size of the reference population by 12% from 1338 to the final sample of 1183 children, of which 551 were boys and 632 were girls.

The largest FVC and forced expiratory volume at one seconds (FEV_1) were recorded even if they came from different tracings. Values for forced expiratory flow between 25% and 75% of vital capacity ($FEF_{25\%-75\%}$), flow at 50% expiratory volume ($V_{max50\%}$) were obtained from the tracing with the largest sum of FVC and FEV_1. All spirometry readings were converted to body temperature and pressure saturated (BTPS). Peak expiratory flow rates (PEFR) were measured using a Vitalograph peak expiratory flow meter. After a couple of practice blows, the best of three blows were recorded.

Data Analysis

Mean values and standard deviations (SD) were calculated for the whole group and for all the six age categories. Statistical analysis was performed using Student's t-test and analysis of variance (ANOVA). Analysis of variance was performed using a regression approach as both raw and logarithimically transformed data. Prediction equations were calculated using a stepwise multifactorial regression analysis. Statistical significance was accepted at $p<0.05$ or less.

RESULTS

One thousand one hundred eighty three children of 7 to 12 years of age living in the state of Kelantan constituted the potential study population. Of these 492 (41.6%) were Malays, 479 (40.5%) Chinese and 212 (17.9%) Indian.

Anthropometric data together with the ethnic breakdown for boys and girls are presented in Table 1. Table 1 also shows that for each age group, the girls generally have similar heights, sitting heights and weight to their male counterparts. Girls have slightly higher BMI than boys but this difference was not significant.

Pulmonary function as assessed by FVC, FEV_1, $FEF_{25-75\%}$, $Vmax_{50\%}$ and PEFR are shown in Table 2. Boys exhibited higher values than girls for all pulmonary function measurements, however significant differences between sexes were only seen for some of the parameters (see Table 2). These parameters increased progressively with age in both sexes. Mean FVC in the boys are 9.5% higher than that of the girls. Similarly, the mean FEV_1 in the boys are 7.5% higher compared to the girls. $FEF_{25-75\%}$ and $Vmax_{50\%}$ again were generally higher in the boys except at age 11 years, they were about 8% lower compared to the girls. PEFR too was generally higher in the boys compared to their female counterparts, but significant differences were seen below the age of 10 years. Mean PEFR in the boys was about 3% higher than the girls.

TABLE 1

Mean values and standard deviation for height, sitting height, weight and body mass index (BMI) including ethnic group distribution by age in boys and girls.

				BOYS			
Age Group (years)	7	8	9	10	11	12	7-12 Total
n	126	87	85	97	85	71	551
Ethnic group							
Malay	58	32	27	41	32	28	218
Chinese	48	42	43	39	35	29	236
Indian	20	13	15	17	18	14	97
Height	116.24	122.94	127.54	132.39	138.26	143.88	129.13
(cm)	±5.81	±5.69	±5.78	±6.57	±6.85	±7.07	±11.53
Sitting Ht.	61.56	64.64	66.95	70.13	72.02	74.06	67.78
(cm)	±3.25	±3.49	±3.74	±4.53	±3.85	±3.86	±5.90
Weight	19.99	24.02	25.87	29.48	33.81	38.69	27.51
(kg)	±3.57	±6.46	±6.11	±8.43	±9.78	±12.26	±9.59
BMI	14.73	15.69	15.77	16.64	17.44	18.50	16.28
(kg/m^2)	±1.87	±2.91	±2.73	±3.70	±3.68	±4.95	±3.51
				GIRLS			
Age Group (years)	7	8	9	10	11	12	7-12 Total
n	115	113	117	108	110	69	632
Ethnic group							
Malay	49	49	38	55	53	30	274
Chinese	48	44	52	33	42	24	243
Indian	18	20	27	20	15	15	115
Height	115.47	122.14	126.56	134.16	140.31	144.21	129.37
(cm)	±5.47	±5.70	±5.62	±7.8	±7.66	±7.73	±11.78
Sitting Ht.	61.42	64.91	66.27	70.13	73.17[a]	74.80	67.94
(cm)	±3.34	±3.42	±3.50	±4.71	±4.21	±4.49	±6.00
Weight	19.22	22.72	24.68	30.15	34.66	36.51	27.31
(kg)	±3.27	±4.66	±5.14	±9.08	±9.49	±8.78	±9.25
BMI	14.36	15.15	15.31	16.52	17.40	17.38	15.90
(kg/m^2)	±1.72	±2.42	±2.25	±3.70	±3.57	±3.09	±3.06

a = significantly different from the boys at $p<0.05$

TABLE 2

Mean values and standard deviations for lung parameters by age in boys and girls

BOYS							
Age Group (years)	7	8	9	10	11	12	7-12 Total
n	126	87	89	97	85	71	551
FVC	1.13	1.38	1.54	1.77	1.96	2.22	1.62
(l)	±0.28	±0.30	±0.28	±0.30	±0.36	±0.47	±0.49
FEV_1	0.98	1.22	1.38	1.56	1.73	1.97	1.43
(l)	±0.26	±0.27	±0.27	±0.27	±0.29	±0.40	±0.44
$FEF_{25-75\%}$	1.23	1.57	1.80	1.94	2.10	2.50	1.80
(l/s)	±0.43	±0.44	±0.54	±0.50	±0.49	±0.60	±0.64
$Vmax_{50\%}$	1.41	1.81	2.09	2.27	2.41	2.95	2.08
(l/s)	±0.51	±0.51	±0.63	±0.63	±0.59	±0.73	±0.77
PEFR	206.07	242.99	267.41	285.15	302.94	332.00	266.34
(l/min)	±32.25	±30.92	±34.92	±40.73	±49.92	±48.71	±57.29

GIRLS							
Age Group (years)	7	8	9	10	11	12	7-12 Total
n	115	113	117	108	110	69	632
FVC	1.00[c]	1.26[b]	1.34[c]	1.65[a]	1.85[a]	2.00[b]	1.48
(l)	±0.26	±0.29	±0.28	±0.37	±0.37	±0.44	±0.47
FEV_1	0.88[b]	1.12[b]	1.21[c]	1.49	1.67	1.80[a]	1.33
(l)	±0.25	±0.27	±0.25	±0.33	±0.36	±0.42	±0.44
$FEF_{25-75\%}$	1.22	1.49	1.64[a]	1.94	2.28[a]	2.39	1.79
(l/s)	±0.62	±0.51	±0.47	±0.62	±0.68	±0.78	±0.73
$Vmax_{50\%}$	1.38	1.70	1.88[a]	2.24	2.62[a]	2.73	2.05
(l/s)	±0.75	±0.60	±0.55	±0.71	±0.75	±0.88	±0.84
PEFR	195.48[a]	228.98[b]	247.86[c]	279.68	305.95	320.36	258.52
(l/min)	±31.99	±36.62	±40.12	±41.58	±45.39	±47.36	±58.27

Definition of abbreviations: FVC = forced vital capacity; FEV_1 = forced expiratory volume in one second; $FEF_{25-75\%}$ = maximal flow over the mid-portion of FVC; $Vmax_{50\%}$ = flow rate after expiring 50% of FVC; PEFR = peak expiratory flow rate.
Significant differences from the boys are indicated by a ($p<0.05$); b ($p<0.01$); c ($p<0.001$).

Zero-order correlation between the various anthropometric and lung parameters were also carried out (Table 3). All lung parameters were significantly correlated ($p<0.001$) with the anthropometric variables for both sexes. Correlations for all lung parameters were highest when correlated with height.

Analysis of covariance to determine the relationship between the various pulmonary variables (with and without natural logarithm) and anthropometric measurements are shown in Table 4. All the covariants showed highly significant correlation ($p<0.001$) with all lung function variables. The F values was highest for covariant age for each lung function variable.

TABLE 3

Correlation coefficients between the pulmonary and anthropometric variables in boys and girls.

	FVC	FEV_1	$FEF_{25-75\%}$	$Vmax_{50\%}$	PEFR
BOYS					
Height	0.87	0.87	0.68	0.68	0.77
Sitting Ht.	0.84	0.82	0.62	0.62	0.72
Age	0.74	0.75	0.62	0.62	0.73
Weight	0.81	0.76	0.54	0.55	0.66
GIRLS					
	FVC	FEV_1	$FEF_{25-75\%}$	$Vmax_{50\%}$	PEFR
Height	0.84	0.83	0.65	0.66	0.78
Sitting Ht.	0.81	0.80	0.60	0.62	0.74
Age	0.71	0.70	0.56	0.57	0.73
Weight	0.79	0.76	0.55	0.58	0.69

All the coefficients were significant at $p<0.001$

Multiple regression analysis were carried out for each lung function variable using the anthropometric measurements as independent variables and dealing with each sex separately. For all pulmonary function variables, linear regression analysis or logarithmic model were used to determined reference equations using standing height, age and weight or sitting height, age and weight (Tables 5 and 6). The regression coefficient on height or sitting height were greatest and R^2 values were higher for males than for females. All the variables in Tables 5 and 6 were highly significant ($p<0.001$). For all pulmonary function variables, regression equation constructed with logarithmically transformed data provided slightly more accurate prediction than did the untransformed data.

TABLE 4

Analysis of covariance between normal and natural logarithms of spirometric parameters and anthropometric measurements in boys and girls

ANALYSIS OF COVARIANCE

BOYS

Covariates	Variance Ratios, F: FVC	FEV_1	$FEF_{25-75\%}$	$Vmax_{50\%}$	PEFR
Height	33.4	30.0	9.3	9.4	16.3
Sitting Ht.	47.9	41.6	13.5	13.3	22.0
Age	89.6	92.9	47.4	47.1	85.1
Weight	32.9	24.7	7.4	7.9	14.0

Covariates	lnFVC	$lnFEV_1$	$lnFEF_{25-75\%}$	$lnVmax_{50\%}$	lnPEFR
Height	29.0	20.8	6.7	7.4	13.4
Sitting Ht.	42.7	35.3	12.5	13.2	22.1
Age	90.8	88.7	43.7	45.6	89.0
Weight	32.8	24.5	7.3	7.8	13.8

GIRLS

Covariates	Variance Ratios, F: FVC	FEV_1	$FEF_{25-75\%}$	$Vmax_{50\%}$	PEFR
Height	28.6	28.0	9.7	9.7	18.2
Sitting Ht.	45.1	40.7	13.3	14.3	27.2
Age	109.0	107.3	48.6	50.0	120.7
Weight	31.8	26.2	8.6	9.3	17.8

Covariates	lnFVC	$lnFEV_1$	$lnFEF_{25-75\%}$	$lnVmax_{50\%}$	lnPEFR
Height	25.3	23.8	8.7	9.3	16.9
Sitting Ht.	39.8	35.5	12.8	14.0	25.1
Age	111.6	109.3	49.2	53.3	117.7
Weight	26.5	22.1	7.8	8.7	16.0

All the ratios were significant at $p<0.001$

TABLE 5

Linear Regression equations of pulmonary function as a function of physiologic variables in children (7 to 12 years of age) with coefficient of determination (R^2) and the level of significance (p) for boys and girls

	Equation	R^2	p
BOYS			
FVC	0.024Ht + 0.016W + 0.024Age - 2.117	0.77	<0.001
FEV_1	0.023Ht + 0.009W + 0.028Age - 2.105	0.73	<0.001
$FEF_{25-75\%}$	0.030Ht + 0.065Age - 2.630	0.44	<0.001
$Vmax_{50\%}$	0.036Ht + 0.077Age - 3.255	0.45	<0.001
PEFR	1.838Ht + 0.989W + 10.447Age - 93.614	0.62	<0.001
FVC	0.031SHt + 0.018W + 0.064Age - 1.575	0.76	<0.001
FEV_1	0.028SHt + 0.012W + 0.071Age - 1.481	0.70	<0.001
$FEF_{25-75\%}$	0.039SHt + 0.125Age - 1.954	0.42	<0.001
$Vmax_{50\%}$	0.033SHt + 0.010W + 0.151Age - 1.776	0.43	<0.001
PEFR	2.178SHt + 1.223W + 13.852Age - 41.871	0.62	<0.001
GIRLS			
FVC	0.024Ht + 0.015W - 1.977	0.72	<0.001
FEV_1	0.024Ht + 0.010W - 2.067	0.68	<0.001
$FEF_{25-75\%}$	0.040Ht - 3.447	0.42	<0.001
$Vmax_{50\%}$	0.041Ht + 0.010W - 3.490	0.44	<0.001
PEFR	1.943Ht + 1.086W + 10.127Age - 116.252	0.60	<0.001
FVC	0.028SHt + 0.018W + 0.055Age - 1.427	0.70	<0.001
FEV_1	0.028SHt + 0.013W + 0.056Age - 1.495	0.67	<0.001
$FEF_{25-75\%}$	0.037SHt + 0.012W + 0.101Age - 1.985	0.40	<0.001
$Vmax_{50\%}$	0.041SHt + 0.018W + 0.109Age - 2.214	0.43	<0.001
PEFR	2.662SHt + 1.313W + 13.430Age - 82.466	0.57	<0.001

Ht= Height in cm, SHt = Sitting height in cm, W = Weight in kg, and Age in years.

TABLE 6

Regression equations for the logarithm of pulmonary function as a function of physiologic variables in children (7 to 12 years of age) with coefficient of determination (R^2) and the level of significance (p) for boys and girls

	Equation	R^2	p
BOYS			
lnFVC	1.796lnHt + 0.316lnW + 0.189lnAge - 9.702	0.80	<0.001
$\ln FEV_1$	2.037lnHt + 0.210lnW + 0.254lnAge - 10.829	0.77	<0.001
$\ln FEF_{25-75\%}$	2.193lnHt + 0.407lnW - 11.026	0.47	<0.001
$\ln Vmax_{50\%}$	2.260lnHt + 0.421lnAge - 11.239	0.47	<0.001
lnPEFR	0.691lnHt + 0.144lnW + 0.403lnAge + 0.850	0.62	<0.001
lnFVC	1.222lnSHt + 0.364lnW + 0.379lnAge - 6.733	0.78	<0.001
$\ln FEV_1$	1.279lnSHt + 0.288lnW + 0.487lnAge - 7.087	0.74	<0.001
$\ln FEF_{25-75\%}$	1.584lnSHt + 0.678lnAge - 7.643	0.44	<0.001
$\ln Vmax_{50\%}$	1.645lnSHt + 0.696lnAge - 7.794	0.44	<0.001
lnPEFR	0.404lnSHt + 0.175lnW + 0.487lnAge + 2.219	0.62	<0.001
GIRLS			
lnFVC	1.708lnHt + 0.325lnW + 0.169lnAge - 9.349	0.74	<0.001
$\ln FEV_1$	1.941lnHt + 0.251lnW + 0.202lnAge - 10.462	0.71	<0.001
$\ln FEF_{25-75\%}$	2.638lnHt + 0.279lnAge - 12.944	0.43	<0.001
$\ln Vmax_{50\%}$	2.681lnHt + 0.293lnAge - 13.049	0.44	<0.001
lnPEFR	0.884lnHt + 0.144lnW + 0.386lnAge - 0.086	0.63	<0.001
lnFVC	1.131lnSHt + 0.393lnW + 0.371lnAge - 6.526	0.72	<0.001
$\ln FEV_1$	1.290lnSHt + 0.331lnW + 0.436lnAge - 7.248	0.69	<0.001
$\ln FEF_{25-75\%}$	1.411lnSHt + 0.216lnW + 0.597lnAge - 7.477	0.40	<0.001
$\ln Vmax_{50\%}$	1.384lnSHt + 0.258lnW + 0.588lnAge - 7.351	0.42	<0.001
lnPEFR	0.591lnSHt + 0.179lnW + 0.490lnAge + 1.369	0.62	<0.001

Ht= Height in cm, SHt = Sitting height in cm, W = Weight in kg, and Age in years.

DISCUSSION

The purpose of this study was to determine lung function parameters with the aim of establishing population norms for Malaysian children, covering most racial and socioeconomic groups. Population sample was drawn from schoolchildren living in and around Kota Bharu and could be considered to represent a sample of a typical Malaysian population.

In this study lung function parameters were studied in "healthy" children as all children suffering from any respiratory symptoms were removed from the analysis. Boys and girls were studied separately as was suggested by the group for standardisation of lung function in children (20). Moreover, there is physiologic evidence that the pulmonary function does not grow in the same way in boys and girls (23).

Analysis of lung function data showed that mean forced vital capacity for each age group in the boys in this study is similar to that observed in Thai boys (17) but somewhat higher than that of the Indian boys (15). It is generally lower than observed in North-American (6-10), Australian (12) and European (14) boys. In girls, mean FVC of Malaysians are higher than that of the Indian (15) and Thai (17) girls. Again it is lower than that in girls from North-America (6-10), Australia (12) and Europe (14). Similar trends were also noted for the other lung parameters. The precise reason for the marked difference in lung parameters between Asians (Malaysia included) and North-American or European children is uncertain although it has been attributed to both genetic and environmental factors (24). Anthropometric variations may explain some of these differences as the physical build of Westerners on average is somewhat larger than that of Asians.

Numerous regression models have been used by investigators to relate pulmonary function variables to anthropometric measurements. The common approach in children has been to use linear, curvilinear or natural logarithmic regression equations to relate lung function to body growth. The discussion on which regression model is 'best' has been reviewed by Michealson et al. (25) and Polgar and Weng (26). In common with other investigators (7-9,11,12,27) we found higher correlation coefficients when a natural logarithmic regression was used (Table 6). However, to ease the handling in a daily clinical routine, we have also derived linear prediction formulae for the ages 7 to 12 years (Table 5) which has also been used by other investigators (28-31) using the standing height as independent variables. Hsi and associates (32) have found that sitting height was useful when comparing black children with other races. Therefore, in Malaysian children we have similarly produced linear and logarithmic equations using sitting height as the independent variable (see Tables 5 and 6).

The validity of our logarithmic equations was studied by comparing the predicted values with those found by other investigators, although such a comparison is often complicated by differences in equipment, methodology, choice of "normal" subjects, and age range and spirometric study results for young populations show considerable discrepancies. Tables 7 and 8 compares our predicted values for a standard boy or girl (age 9 years, measuring 129 cm. and weighing 27 kg.) using age, standing height and weight standardised equations from data of other populations. The predicted values were 1% to 25% greater than the observed means in the present study except for the study of Black American children by Schwartz et al. (9) which showed a lower predicted values for both sexes. Thai girls (17) too showed a lower predicted mean. Black American girls of the study of Dockery et al. (10) showed similar predicted values to our observed mean. The biggest differences were found using formulae based on data of North-American, European or Australian populations (7-10,12,14). It is interesting to note that although the formulae were correlated for age, height and weight. the predicted values for a given age, height and weight were higher than the observed mean in our study. The differences observed between populations maybe related to genetic factors that may in turn lead to the formation of airways of a different size or different elastic recoil (33-35).

The large difference between the observed mean and that predicted from formulae based on data from European, North-American or even Australian population reemphasises the need to be cautious when applying formulae derived from one population to another. Besides, it also further reinforces the need for population groups to form their own population norms for the various physiological parameters.

In conclusion, this study shows that all lung parameters are lower in Malaysian as compared to their Caucasian comtempories. This difference is present even when the effects of variation in age, height and weight are

TABLE 7

Comparison of predicted values using regression equations with coefficient of determination (R^2) or correlation coefficient (r) from other studies with the observed mean in the present study for a boy aged 9 years (Age), measuring 129 cm in height (H) and weighing 27 kg (W).

Ref	n	Race	Equation	R^2	r	Predicted mean	Observed mean	Difference bet. mean	% differ
Namihira et al. (7)	433	Mexican	lnFVC =0.646 + 1.621(Ht(m) - 1.35)			1.73	1.62	0.11	6.8
Coultas et al. (8)	237	Hispanic	lnFVC =2.9247lnHt - 6.6863	0.91		1.86	1.62	0.24	14.8
Schwartz et al. (9)	329	White Americam	lnFVC =2.00lnHt + 0.177lnAge + 0.232ln(BMI) - 1.15	0.64		1.75	1.62	0.13	8.0
		Black American	lnFVC =2.00lnHt + 0.177lnAge + 0.232ln(BMI) - 1.285	0.64		1.53	1.62	-0.08	-5.5
Dockery et al. (10)	6300	White American	lnFVC =1.8886lnHt(m) + 0.1957lnW + 0.0751lnAge - 0.6787	0.78		1.84	1.62	0.22	13.6
	526	Black American	lnFVC =1.8886lnHt(m) + 0.1957lnW + 0.0751lnAge - 0.8108	0.78		1.62	1.62	0.00	0.0
Hibbert et al (12)		Australian	lnVC =1.4096Ht(m) + 0.0119Age.Ht(m) - 0.2581		0.92	1.97	1.62	0.35	21.6
Solymar et al. (14)	75	Swedish	logVC =2.695logHt(m) + 0.008		0.94	2.02	1.62	0.4	24.7
Suwanjutha et al. (17)	229	Thai	VC =1.08560 - 0.04707Age + 0.01154Age^2			1.60	1.62	-0.02	-1.23
Neukirch et al. (27)	180	Polynesians	FVC =ln(0.010Ht + 0.007W + 0.028A + 3.432)		0.92	1.64	1.62	0.02	1.2
	202	Europeans	FVC =ln(0.013Ht + 0.005W + 0.029A + 3.095)		0.93	1.64	1.62	0.02	1.2
	135	Chinese	FVC =ln(0.013Ht + 0.005W + 0.024A + 3.152)		0.93	1.64	1.62	0.02	1.2
Present study	551	Malaysian	lnFVC =1.796lnHt + 0.316lnW + 0.189lnAge - 9.702	0.77		1.62	1.62	-	-

BMI = 0.00161 kg/cm^2

TABLE 8

Comparison of predicted values using regression equations with coefficient of determination (R^2) or correlation coefficient (r) from other studies with the observed mean in the present study for a girl aged 9 years (Age), measuring 129 cm in height (H) and weighing 27 kg (W).

Ref	n	Race	Equation	R^2	r	Predicted mean	Observed mean	Difference bet. mean	% differ
Namihira et al. (7)	433	Mexican	InFVC =0.646 + 1.621(Ht(m) - 1.35)			1.73	1.48	0.25	16.9
Coultas et al (8)	271	Hipanic	InFVC =2.8016InHt - 6.1478	0.86'		1.75	1.48	0.27	18.2
Schwartz et al. (9)	302	White Americam	InFVC =2.00InHt + 0.177InAge + 0.232In(BMI) - 1.2087	0.64		1.64	1.48	0.16	10.8
		Black American	InFVC =2.00InHt + 0.177InAge + 0.232In(BMI) - 1.3437	0.64		1.44	1.48	-0.04	-2.7
Dockery et al. (10)	5958	White American	InFVC =1.8592InHt(m) + 0.1957InW + 0.0751InAge - 0.7432	0.78		1.72	1.48	0.24	16.2
	515	Black American	InFVC =1.8592InHt(m) + 0.1957InW + 0.0751InAge - 0.8753	0.78		1.50	1.48	0.02	1.4
Hibbert et al (12)		Australian	InFVC =1.4393Ht(m) + 0.0221Age - 1.4500		0.92	1.83	1.48	0.35	23.6
Solymar et al. (14)	65	Swedish	logVC =2.875logHt(m) - 0.052		0.92	1.84	1.48	0.36	24.3
Suwanjutha et al. (17)	229	Thai	VC =-0.67509 + 0.30238Age - 0.00577Age^2			1.58	1.48	0.10	6.7
Neukirch et al. (27)	190	Polynesians	FVC =In(0.015Ht + 0.021A + 3.110)		0.77	1.66	1.48	0.18	12.2
	179	Europeans	FVC =In(0.013Ht + 0.029A + 3.378)		0.83	1.67	1.48	0.19	12.8
	121	Chinese	FVC =In(0.016Ht + 0.026A + 2.799)		0.76	1.63	1.48	0.15	10.1
Present study	632	Malaysian	InFVC =1.708InHt + 0.325InW + 0.169InAge - 9.349	0.74		1.48	1.48	-	-

BMI = 0.00159 kg/cm^2

eliminated. It is unlikely this is due to poor nutrition or health as all the subjects in this study were adequately nourished and healthy. Genetic, racial and environmental factors could possibly influence these lung parameters (24, 33-35). The difference notwithstanding, this study provides useful norms based on a large sample derived from the local population for clinical practice and epidemological studies of comparable populations. In addition, it appears that for purpose of predicting lung function parameters for an individual it is always better to use equations derived from the same race or population sample.

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PUBLICATIONS ARISING FROM THE STUDY

The preparation of cognitive maps and their use in teacher/teaching, learner/learning functions and assessment will be highlighted.

1. DP Ausubel. Educational Psychology: A Cognitive View 1968.
2. Rine Hart Holt, INC. Winston. New York.

ANTHROPOMETRIC AND SPIROMETRIC VOLUMES OF PRIMARY SCHOOL GIRLS.

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There have been no reports of spirometric volumes and related anthropometric studies in Malaysian girls by which norms could be established. The purpose of this preliminary study, therefore, is to determine lung and anthropometric parameters in normal healthy Malaysian schoolgirls.

Four hundred and sixty-five Malay and Chinese primary school girls (standards 1 to 6) participated in a cross-sectional study of anthropometric, spirometric and peak expiratory flow measurements. Spirometry was performed using Vitalograph Model R spirometers. Peak expiratory flow rates (PEFR) were measured using Vitalograph peak expiratory flow meters.

Summary of results (Mean ± SD).

	Standard					
	1	2	3	4	5	6
FVC (L)	1.06	1.27	1.39	1.63	1.83	2.05
	0.28	±0.28	±0.31	±0.31	±0.40	±0.40
FEV_1 $Lmin^{-1}$	0.94	1.12	1.48	1.48	1.63	1.84
	±0.28	±0.04	±0.23	±0.28	±0.40	±0.36
PEFR $Lmin^{-1}$	187.2	230.3	246.9	278.5	300.3	236.4
	±31.5	±37.7	±40.9	±32.2	±48.8	±57.2

FVC correlated significantly ($p<0.001$) with age and standing height ($r = 0.65$ and $r = 0.82$, respectively). Similarly, PEFR correlated significantly ($p<0.001$) with age and standing height ($r = 0.71$ and $r = 0.76$, respectively). Regression analysis revealed an age-related increase in FVC of 178 ml per year. Multiple stepwise regression of the data for the prediction of FVC and PEFR gave the following equations: FVC (L) = 0.024 Ht + 0.013 Wt – 1.973; RSD = 0.70; PEFR (L/min) = 2.77 Ht + 9.31 Age – 189.96; RSD = 0.61, respectively.

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CORRELATION OF STANDING AND SITTING HEIGHTS ON SPIROMETRIC MEASUREMENTS IN GIRLS. *R Singh, HJ Singh, AS Dharap[†], BS Quah[§]. Departments of Physiology, [†]Anatomy and [§]Pediatrics, School of Medical Sciences, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia.*

This study determines the relationship between standing and sitting heights and spirometric measurements in healthy primary school girls.

Four hundred and sixty five primary school girls participated in a cross-sectional study of anthropometric, spirometric and peak expiratory flow measurements. Forced vital capacity (FVC) and forced expiratory volume in 1 sec (FEV_1), were measured, using dry wedge spirometers (Vitalograph, Model R). Peak expiratory flow rates (PEFR) were measured, using Vitalograph peak expiratory flow meters. FVC, FEV_1, and PEFR correlated significantly ($p<0.001$) with standing height and sitting height, but the correlation was better with standing height as shown below:-

	FVC	FEV_1	PEFR
Standing Height (Ht)	0.82	0.80	0.77
Sitting Height (SHt)	0.78	0.76	0.72

Stepwise multiple regression of the data, using either standing height or sitting height to predict FVC and PEFR, gave better residual standard deviations (RSD) with standing height in the equation:.

FVC = 0.024 Ht + 0.013 Wt - 1.973; RSD=0.70.
FVC = 0.031 SHt + 0.018 Wt + 0.003 Age = 1.461; RSD=0.67.
PEFR = 2.77 Ht + 9.31 Age = a.89.96; RSD=0.61.
FEFR = 3.04 SHt + 13.71 Age + 1.00 Wt - 108.09; RSD=0.59.

In conclusion, standing height appeared to be a better predictor of spirometric volumes in primary school girls.

Supported by USM Short-Term Grant.

OBSERVATIONS OF ACUTE POISONING IN IN-PATIENTS AT HOSPITAL UNIVERSITI SAINS MALAYSIA AND KOTA BHARU GENERAL HOSPITAL. *SA Sulaiman, SSJ Mohsin. Department of Pharmacology, School of Medical Sciences Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia.*

The most frequent group of substances involved in cases of acute poisoning admitted to the Government Unit in the Kuala Lumpur General Hospital in 1987 was pharmaceutical products, followed by household items and insecticides/herbicides (1). A retrospective survey was done to determine the trend of acute poisoning cases admitted to the Hospital Universiti Sains Malaysia (HUSM) and the Kota Bharu General Hospital (KBGH) for the period of 1987 to 1991. The purpose of this survey was to compare the trend of acute poisoning occurring in these parts of the country. The observations were based on patient medical records obtained from the Medical Record Department of HUSM and the Medical and Paediatric admission records of the KBGH. There was a slow increase in the total number of cases of acute poisoning admitted to both hospitals. Sixty-one percent to 71.3% of the acute poisoning cases were due to poisonous bites. Acute poisoning with pharmaceutical products ranged from 11.4% to 14.4%. Acute poisoning with constituted insecticides and herbicides constitute 4.8% to 11.6%.

BMI was calculated as weight in kg/(height in m)^2 after Quetelet (2). Statistical analysis was performed using 2-way ANOVA.

Summary of results (Mean ± SD)

	Malays		Chinese	
age	n	BMI	n	BMI
7	58	14.9±2.3	43	15.2±2.2
8	39	14.8±3.3	44	15.7±2.9
9	35	15.3±3.7	41	17.3±2.4
10	49	16.6±2.7	46	16.8±3.4
11	35	16.4±3.1	46	18.7±3.8
12	45	18.1±3.0	46	20.5±3.5

Statistical analysis revealed significant differences in the BMI with age and race ($p<0.001$). The BMI was significantly higher in the Chinese boys. The reason for this is not immediately apparent, but may be related to socio-economic differences between the two races.

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Supported by USM Short-Term Grant.

DETECTION OF HEPATITIS B VIRUS DNA IN HEPATITIS B SURFACE ANTIGEN POSITIVE SERA USING THE POLYMERASE CHAIN REACTION: A BETTER METHOD FOR MEASURING INFECTIVITY. *KK Phua, PK Das[†], KE Choo[§], M Nazim[¶], E Gowans[‡]. Departments of Immunology, [†]Pathology and [¶]Medicine, School of Medical Sciences, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan. [§]Department of Paediatrics, General Hospital Kota Bharu. [‡]Hepatitis Laboratory, Division of Medical Virology, Institute of Medical and Veterinary Science, Adelaide, South Australia.*

Although conventional serological markers, such as hepatitis B surface antigen (HBsAg), have been shown to be sensitive and convenient for the detection of Hepatitis B virus (HBV) infection, they are not always good indicators of viral activity. Viral DNA and Hepatitis B e antigen (HBeAg) detection have been reported to be superior as they offer direct evidence of the presence and activity of the virus in the patients. Recently, a polymerase chain reaction (PCR) method has been developed that offers high sensitivity and specificity for the detection of HBV-DNA. We report here the preliminary findings of our PCR method for the measurement of infectivity and sensitivity in comparison with the ELISA method for HBeAg detection, using sera from 1119 healthy volunteers in the State of Kelantan.

We found that of the 79 subjects that were HBsAg positive (7.1% carrier rate), 36 (45.6%) were HBeAg positive by ELISA, compared with 66 (83.5%) HBV-DNA positive by PCR. In the HBeAg positive group, all 36 (100%) subjects were positive for HBV-DNA but, in the HBeAg negative group, 37 (85%) were also positive for HBV-DNA. The PCR for HBV-DNA detection appears to be a better method than the ELISA for HBeAg detection for the assesssment of hepatitis B infectivity.

Seventeen deaths were reported over the 5 year period and 53% of these were due to paraquat poisoning. We concluded that poisonous bites remained the most important cause of acute poisoning and paraquat was an important cause of death due to poisoning in this part of the country.

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DEVELOPMENT OF COMPUTER-AIDED-LEARNING SOFTWARE FOR THE STUDY OF AUTONOMIC PHARMACOLOGY. *PN Yeoh, Y Khairuddin[†]. Department of Pharmacology and [†]Social Obstetrics and Gynaecology Unit, Faculty of Medicine, University of Malaya, 59100 Kuala Lumpur, Malaysia.*

Computer-aided-learning has several advantages. To the teacher, a well-constructed software can save time from repetitive teaching. To the student, softwares created based on the topics in the curriculum and placed in readily accessible workstations will enable more flexible and effective learning.

The ANS package consists of a series of stacks, developed for self-learning of autonomic pharmacology. It is targetted for the medical and dental undergraduates in the University of Malaya. Developed on HypercardTM for the Macintosh computer, it utilizes the ease of the Macintosh user interface to navigate from stack to stack, enabling the user to access different parts of the software at will. ANS can be used by any other student in the health sciences, including pharmacy and nursing students, as well as post-graduate students in the clinical disciplines doing their Part I post-graduate examinations. Each topic consists of a text and evaluation part. The text portion is illustrated with graphics, animation, sound and visual effects to make learning more interesting and effective. Certain concepts are enhanced by simulated animal experiments with built-in questions, hints and answers. The evaluation portion consists of questions constructed, based on material in the text, with hints available to the student on the questions being asked. An ongoing score table records the current score. Sound and text feedback to the user's answer to a question to enhance attention. At the end of the evaluation, the user is presented with an analysis of his/her performance. A cumulative record, accessible by password, is available to the teacher or supervisor. The student's performance can be printed out when required.

ANS was well accepted by students in the medical and dental classes in a student survey.

ETHNIC DIFFERENCES IN BODY MASS INDEX IN MALE SCHOOL CHILDREN IN KELANTAN. *HJ Singh, R Singh, BS Quah[†], AS Dharap[§]. Departments of Physiology, [†]Pediatrics and [§]Anatomy, School of Medical Sciences, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia.*

Body Mass Index (BMI) or obesity index is often used in the diagnosis of chronic energy deficiency (1). Data in weight tables drawn from selected ethnic and socioeconomic groups are not universally applicable, since such weights are by definition normative and not necessarily desirable weights. We measured BMI of male school children in Kelantan from the two main races in Malaysia, Malays and Chinese.

Children were randomly selected from various schools in and around Kota Bharu. Height and weight were measured with subjects standing barefooted and attired in school uniforms. The