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ORIGINAL ARTICLE
IN PNEUMOLOGY

Prediction of spirometry parameters using chest circumference in Sri Lankan boys aged 8-16 years

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Abstract

Introduction: Most normative standards for spirometry are established based on height, weight and body mass index. We have investigated chest circumference as an alternative to height for interpretation when accurate height measurements cannot be obtained.
Methods: This is a cross-sectional study conducted in Sri Lankan boys aged 8-16. Spirometry measurements were taken adhering to American Thoracic Society/European Respiratory Society 2005 recommendations. Data analysis was performed with SPSS Version 18 for Windows. Correlations (Pearson correlation coefficient) between lung volumes and chest circumference were evaluated. Subsequently, multiple regression analysis was performed between lung volumes and the predictor variables.
Results: Six hundred and eighty-two (n = 682) boys with acceptable spirograms were included in the final analysis. Chest circumference was significantly correlated to height as well as spirometry parameters. Therefore, reference equations were established based on chest circumference and age.
Discussion and Conclusions: Chest circumference could be considered as competent as height in predicting lung flows and volumes in Sri Lankan males aged 8 to 16, and it could be used as an alternative parameter in situations where height cannot be measured precisely.

KEY WORDS: Chest circumference; reference standards; spirometry; Sri Lanka.

Riassunto

Introduzione: La maggior parte dei criteri normativi per la spirometria sono stabiliti in base all'altezza, al peso ed all'indice di massa corporea. Noi abbiamo studiato la circonferenza toracica come alternativa all'altezza per l'interpretazione della spirometria quando accurate misure dell'altezza non possono essere ottenute.
Metodi: Questo è uno studio trasversale condotto in ragazzi dello Sri Lanka dell'età di 8-16 anni. I test di funzionalità respiratoria sono stati eseguiti secondo le raccomandazioni del 2005 dell'American Thoracic Society/European Respiratory Society. L'analisi dei dati è stata eseguita con il software SPSS Versione 18 per Windows. Sono state valutate le correlazioni tra i volumi polmonari e la circonferenza toracica con il coefficiente di correlazione di Pearson. Quindi, è stata eseguita l'analisi di regressione multipla tra i volume polmonari e le variabili predittori.
Risultati: 682 ragazzi con spirometrie accettabili sono stati inclusi nell'analisi finale. La circonferenza toracica è risultata essere correlata in modo significativo all'altezza cosi come ai parametri respiratori. Pertanto, sono state ottenute le equazioni di riferimento sulla base dell'età e della circonferenza toracica.
Discussione e Conclusioni: La circonferenza toracica potrebbe essere considerata idonea quanto l'altezza nel predire i flussi ed i volumi polmonari nei maschi dello Sri Lanka di età compresa tra 8 e 16 anni e potrebbe essere utilizzata come parametro alternativo in situazioni in cui l'altezza non può essere misurata con precisione.

TAKE-HOME MESSAGE

In this Sri Lanka-based study carried out on boys aged 8-16 years, chest circumference resulted as competent as height in predicting lung flows and volumes in males, and it could be used as a substitute for height for interpretation of spirometry parameters when accurate height measurements cannot be obtained.

Competing interests - none declared.

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INTRODUCTION

Spirometry interpretation needs reference values for comparison. Most reference values are formulated based on age, weight and standing height from healthy non-smoking subjects, as the independent variables [1–4]. In patients with deformities or disabilities, whose height cannot be measured precisely, interpretation of spirometry becomes a challenge. Chest circumference, arm span or chest volume are independent measures of body size that may be considered instead of height in such situations. Golshan et al. have shown that arm span is a substitute for height when height cannot be measured accurately [5].

Chest circumference is an independent measure of body size and not affected by limb deformities, and we hypothesized that it might be a better alternative to formulate prediction equations in children whose height cannot be assessed correctly.

METHODS

The target population was 'healthy' boys. We only considered boys due to measurement difficulties anticipated with girls and measurement errors that could occur as a result of breast size around puberty. The sample was recruited from the latter part of a cross-sectional study which was conducted to formulate spirometry reference equations for Sri Lankan children aged 8-16 years [6]. For the main study, recruitment was carried out through stratified multistage cluster sampling from 5 districts in Sri Lanka. The enrolled children were given a questionnaire which was formulated based on International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire with an intention to select 'healthy' non-smoking children [7]. A physical examination was carried out by an investigator and excluded if any of them had previous or concurrent cardio-respiratory diseases, spinal or limb deformities, frequent respiratory symptoms during the previous year, upper respiratory tract infections (URTI) like symptoms in the previous 2 weeks, and a history of chest, abdominal or nasal surgery. Errors encountered in measurement of chest circumference (CC) were additional exclusion criteria for this study. Written and verbal consent were gathered from the caregiver separately for measurement of chest circumference. Assent was taken from children for participation. Ethical clearance was obtained from Ethics committee, Faculty of Medical Sciences, University of Sri Jayewardenepura. The standing height was measured to the nearest centimeter and weight was measured with a spring balance. When measuring the chest circumference a non-stretchable tape was passed just above the lower angle of scapula behind, above the nipples in front and over the armpits at sides [8]. During the process the arm should rise a little when the tape is being passed round the chest returned to the resting position when the measurement is taken. All efforts were taken to obtain the measurements in expiration. The boys were asked to remove clothing above the waist. If a child did not allow taking an accurate measurement, still measurement was made over the clothes. Such measurements were subsequently rejected.

Spirometry measurements were recorded by two trained technicians with Vitelograph Alpha Touch spirometer. Volume calibration was performed daily by using a 3-litre standard syringe. The measurement protocol fulfilled the American Thoracic Society/European Respiratory Society 2005 (ATS/ERS) recommendations [9].

The child was seated and wore a nose clip. A minimum of 3 and a maximum of 8 manoeuvers were performed to obtain at least two acceptable trials. The largest Forced vital capacity (FVC) and Forced expiratory volume in one second (FEV1) values were required to be within 5% of each other. From the maneuver with the largest sum FVC+FEV1, peak expiratory flow (PEFR) and forced expiratory flow between 25% and 75% (FEF 25-75%) were taken.

Statistics

Data analysis was performed with SPSS Version 18 for Windows. Correlations (Pearson correlation coefficient) between lung volumes and chest circumference were evaluated. Subsequently, multiple regression analysis was performed between lung volumes and the predictor variables. Different regression models (transformed and untransformed) were attempted. Fitness of the models was assessed by DW (Durbin Watson) statistic and coefficient of multiple determinations for multiple regressions (R^2). Comparisons among mean measured (observed) values versus predicted values from equations of this study based on CC and age were done with t-test. Further comparisons were performed between measured and predicted values (based on height and height derived from CC) obtained from equations of the main study.

RESULTS

Six hundred and eighty-two (n = 682) boys with acceptable spirograms were included in the final analysis. Nine hundred and nineteen (n = 919) boys were excluded from all the subjects who were invited (n = 1601) at the beginning due to various reasons. Presence of chronic cardiac and respiratory diseases (n = 189), absence on the day of spirometry (n = 198), recent acute illness (n = 58), spirograms not meeting ATS/ERS standards (n = 258) and incomplete questionnaires (n = 138) were some of them. Seventy-eight boys were excluded due to difficulties encountered when measuring chest circumference. Demographic and anthropometric data are summarized in Table 1.

Correlation between chest circumference and height was significant (r = 0.74, P < 0.001). Further, there was significant correlation between chest circumference and FVC (r = 0.77, P < 0.001), FEV1 (r = 0.74, P < 0.001), FEF 25-75% (r = 0.54, P < 0.001), PEFR (r = 0.62, P < 0.001). Subsequently, we performed multiple regression analysis between independent (chest circumference and age) and dependent variables (FVC, FEV1, FEF 25-75% and FVC) to evaluate the best fit for the model. Coefficient for determination (R^2) ranged from 64.7 to 85.9 (Table 2).

Since the correlation between chest circumference and height was significant, we formulated an equation (see below) to predict height from chest circumference with a coefficient of determination of 87.9. Thus, predicted height could be used to interpret the spirometry parameters.

$$\text{Height}_{\text{pred.}} = 60.29 + 0.57 \times \text{Chest Circum.} + 4.9 \times \text{Age } (R^2 - 87.9)$$

Mean measured values did not show a significant difference from predicted values from equations derived from this study (Figure 1a and 1b). Comparison between predicted values based on CC of this study and predicted values based on height from the main study did not differ significantly either. Close resemblance between measured versus predicted values based on height derived from CC is also shown in Figure 1a and 1b.

DISCUSSION AND CONCLUSIONS

This study has shown that chest circumference is useful in interpreting spirometry in special situations. It is a potential substitute for height in situations where measurement of the actual height cannot be performed. Chest circumference had been incorporated into lung function reference equations by Raju and co-workers as a predictor variable. They have shown that height, CC and fat free mass can be considered as good predictors of spirometry parameters that are included in their reference equations [10, 11]. Equations derived based on CC in our study have not included height or Body Mass Index (a derivative of height and weight) and could be used when height cannot be measured.

We compared spirometry predictions directly through CC with measured standards for comparability. In addition, values derived through height predicted from CC were compared with measured ones. There could be potential errors in deriving height from CC. Even minor differences in predicted height through chest circumference, may give errors in interpretation of spirometry especially when the readings are borderline. However, it is still could be better than predicting with an inaccurate height measurement.

Having a healthy sample of boys with strict

Table 1. Baseline characteristics of the study subjects.

Parameter	Mean ± SD	Range
Mean age (years)	11.80 ±2.30	08-16
Mean BMI (kgm-2)	16.64 ±3.37	10-31
Mean height (cm)	147.85 ±14.83	115-186
Mean chest circumference (cm)	68.97 ± 9.49	051-104
Weight (kg)	37.30 ±12.86	17-98

Table 2. Prediction equations for spirometry parameters.

Parameter	Constant (α)	Age coefficient (β^1)	CC coefficient (β^2)	R^2	DW statistic
FVC	-2.02	0.16	0.04	85.9	1.797
FEV1	-1.57	0.14	0.28	84.4	1.701
FEF 25-75%	-1.04	0.17	0.22	64.7	1.743
PEFR	-2.67	0.36	0.04	76.3	1.881

Note: Chest circumference in cm, Age in years, R^2: coefficient of determination

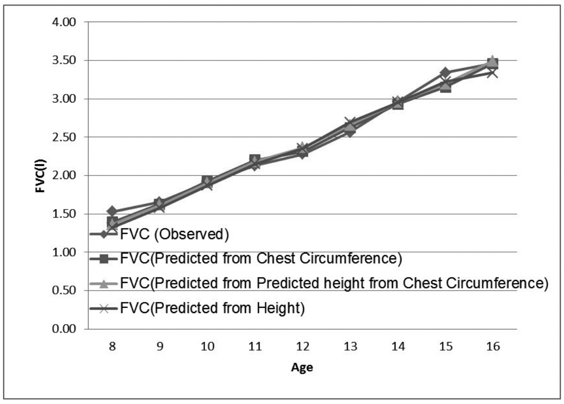

Figure 1a. Comparison of observed/measured FVC values vs predicted values from eqautions based CC (P = 0.38), height derived from CC (P = 0.21) and height (P = 0.83).

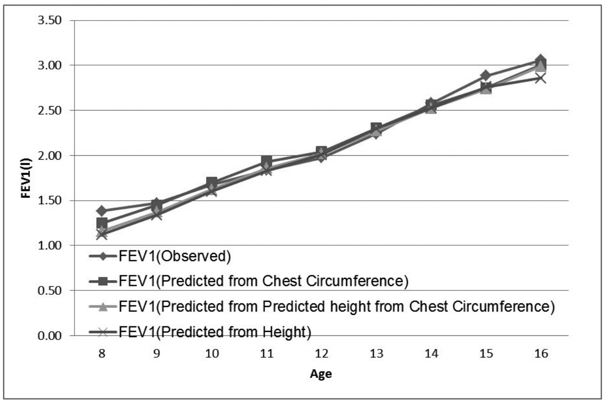

Figure 1b. Comparison between observed/measured FEV1 values vs predicted values from eqautions based CC (P = 0.93), height derieved from CC (P = 0.11) and height (P = 0.24).
A P value of less than 0.01 was considered significant since there are multiple comparisons. Age is a common variable for all above prediction eqautions. Ht: Height, CC: Chest circumference.

inclusion criteria was a strength in our study. The main study recruited a sample which was socio-demographically representative of children between 8-16 years in Sri Lanka. However, only a section of that sample was taken into this study. Thus, this needs more verification with a larger sample size to represent all ethnic groups (Sinhalese, Tamils & Muslims) and geographic areas in the country. Another limitation of this study was having only males in the sample, and obviously, results are not applicable in other countries and races. However, this study could pave the way to further research to confirm our results within other age groups and people of other races and countries using the chest circonference as substitute of height in order to perform spirometry in special conditions.

In conclusion, chest circumference could be considered as competent as height in predicting lung flows and volumes in males, and it could be used as a substitute for height for interpretation of spirometry parameters whan a accurate height measurements cannot be obtained.

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References

1. Rosenthal M, Bain SH, Cramer D, Helms P, Denison D, Bush A, et al. Lung function in white children aged 4 to 19 years. Thorax. 1993;48:794–802.
2. Quanjer PH, Borsboom GJ, Brunekreff B, Zach M, Forche G, Cotes JE, et al. Spirometric reference values for white European children and adolescents: Polgar revisited. Pediatr Pulmonol. 1995;19:135–142.
3. Wang X, Dockery DW, Wypij D, Fay ME, Ferris BG Jr. Pulmonary function between 6 and 18 years of age. Pediatr Pulmonol. 1993;15:75–88.
4. Chinn DJ, Cotes JE, Martin AJ. Modelling the lung function of Caucasians during adolescence as a basis for reference values. Ann Hum Biol. 2006;33:64–77.
5. Golshan M, Crapo RO, Amra B, Jensen RL, Golshan R. Arm span as an independent predictor of pulmonary function parameters: validation and reference values. Respirology. 2007;12:361–366. doi:10.1111/j.1440-1843.2007.01070.x.
6. Liyanage G. Spirometry in children: Meeting the unmet need. Sri Lanka J Child Health. 2016;45(3):151–62.
7. Lai CKW, Beasley R, Crane J, Foliaki S, Shah J, Weiland S. Global variation in the prevalence and severity of asthma symptoms: Phase Three of the International Study of Asthma and Allergies in Childhood (ISAAC). Thorax. 2009;64:476–483. doi:10.1136/thx.2008.106609.
8. Vallios HV. Anthropometric Techniques. Current Anthropology.1965;6:127–143.
9. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of spirometry. Eur Respir J. 2005;26:319–338.
10. Raju PS, Prasad KVV, Venkata Ramana Y, Ahmed SK, Murthy KJR. Study on lung function tests and prediction equations in Indian male children. Indian Pediatr. 2003 Aug;40(8):705–711.
11. Raju PS, Prasad KVV, Venkata Ramana Y. Murthy KJR. Pulmonary function tests in Indian girls - Prediction equations. Indian J Pediatr. 2004;71:893–897. doi:10.1007/BF02830828.