Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/bbe

Original Research Article

Verification of the new 'all ages' spirometric reference values for use in young Polish children of Caucasian origin

Waldemar Tomalak [a,1], Jakub Radliński [a,*], Halina Bańka [a], Bożena Myszkal [a], Krzysztof Żarnowski [a], Zbigniew Doniec [a], Jaroslav Fabry [b]

[a] Department of Physiopathology of Respiratory System, Institute for Tuberculosis and Lung Diseases, Pediatric Division, Rabka-Zdrój, Poland

[b] Srobar's Institute of Children Tuberculosis and Respiratory Diseases, Dolný Smokovec, Vysoké Tatry, Slovak Republic

ARTICLE INFO

Article history:
Received 26 November 2015
Received in revised form
22 August 2016
Accepted 2 September 2016
Available online 20 January 2017

Keywords:
Spirometry
Children
Reference values
Impulse oscillometry

ABSTRACT

Interpretation of the spirometric results in young children aged 3 years and onward was a difficult task, because existing reference values usually covered age range of 7–18 years. Recently two big studies concerning 'all ages' reference equations were published: the study of The Asthma UK Initiative (Stanojevic et al. AJRCCM 2009) and the so called GLI2012 values (Quanjer et al. ERJ 2012); both providing equations with LMS approach for spirometric reference values for age range of 3–95 years. The aim of the study was to test the applicability of the new sets of equations in a group of healthy Polish children of Caucasian descent.

The analysis was performed on a data gathered from children admitted to outpatient department for diagnostic reasons. Children performed impulse oscillometry (IOS) measurements and spirometry. Elevated value of oscillometric resistance at 5 Hz (R5) eliminated children from analysis as well as forced expiratory time less than 1.5 s. Final analysis was performed on results obtained from 142 children aged 4–10 years.

Z-scores and percent of predicted values were calculated for FEV1, FVC and FEV1/FVC using both sets; additionally z-score and percent predicted was also calculated for FEV0.75/FVC using Stanojevic's equation. The distribution of all calculated z-scores was normal. For FEV1/FVC mean ± SD of z-score was 0.01 ± 0.80 using GLI2012 and -0.15 ± 0.79 using Stanojevic's set. Mean value of percent predicted values using GLI2012 was $100.2 \pm 5.5\%$ for FEV1/FVC, $107.4 \pm 9.4\%$ for FEV1 and $106.6 \pm 10.1\%$ for FVC. Our results confirm applicability of the new sets of reference values in young Caucasian children from Poland and point out the potential diagnostic value of FEV0.75/FVC.

* *Corresponding author at*: Department of Physiopathology of Respiratory System, Institute for Tuberculosis and Lung Diseases, Pediatric Division, Jan Rudnik str 3b, 34-700 Rabka-Zdrój, Poland.

E-mail addresses: wtomalak@igrabka.edu.pl (W. Tomalak), jradlins@igrabka.edu.pl (J. Radliński), hbanka@igrabka.edu.pl (H. Bańka), bmyszkal@igrabka.edu.pl (B. Myszkal), kzarnowski@igrabka.edu.pl (K. Żarnowski), zdoniec@igrabka.edu.pl (Z. Doniec), fabry@sudtarch.sk (J. Fabry).

[1] Deceased.

http://dx.doi.org/10.1016/j.bbe.2016.09.006

1. Introduction

Spirometry is a first line diagnostic technique used in respiratory medicine. This test is primarily but not exclusively used to diagnose the most frequent obstructive lung diseases. The indications for spirometry cover wide scope of situations including diagnostics, monitoring, evaluation of disability or impairment and public health [1]. Although the recommendations for spirometry [2] state that "with appropriate coaching children as young as 5 years of age are often able to perform acceptable spirometry" there are attempts to perform spirometry in the children as young as 3 years of age. This is a challenging task, however may be successful.

There are two main problems when dealing with spirometry in younger children. The first is the ability of the child to cooperate in performing properly forced respiratory manoeuver, the second is interpretation of the results. There are studies showing that in preschool children the cooperation rate increases with age: Loeb et al. reported that the percentage of acceptable and repeatable spirometry increased with age rising above 50% by age of 6 and reached a plateau with approximately 85% success at the age of 10 [3]. In a study from our laboratory [4] in the group of 233 children half of them were able to perform acceptable spirometry. The ability to cooperate also increased with age. The analysis revealed, that the most important problem was to reach forced expiratory time longer than recommended 3 s.

Beside the performance problems there is a problem with interpretation of the results. Commonly used children's reference values of Zapletal and Samanek [5] were constructed many years ago. The equations are valid for the age range of 7–8 to 18 years and should not be used outside the age range for which they had been developed. Also the group studied was not too big, moreover results were obtained with volume measuring spirometers according to procedures and quality standards that had changed many times since then.

Recently two big projects oriented on new reference values have been completed, presenting quite new approach: to evaluate reference values for the whole range of ages. In 2009 [6] the report of The Asthma UK Initiative was published, presenting new reference values for young children constructed with 3777 results of spirometry from 15 centers in Europe and USA obtained in 3–7 years old children and combined with NHANES III data to give transient equations for FEV1 (forced expiratory volume in one second), FVC (forced vital capacity) and FEV1/FVC from 3 to 85 years of age. As it was mentioned above, as there is a problem with reaching appropriate forced expiratory time, the paper contains also equations for FEV0.75/FVC which can be used in case FEV1 is not reliable because of short expiration time and/or abrupt end of expiratory manoeuver. The second study [7] was accomplished within an ERS Task Force "Global Lung Function Initiative" and yielded to the new reference values equations for FEV1, FVC and FEV1/FVC constructed for Caucasian subjects from the data gathered from more than 57,000 spirometries. They cover age range from 2.5 to 95 years and are known as GLI2012.

Both analyses were done using the most modern approach to reference values constructing known as LMS method which is described in detail by Cole and Green [8]. The fitted models provide sex-specific, height- and age-adjusted values for the median, the coefficient of variation (CV), and skewness. The median (M) is the predicted value for the individual, which together with (S), the CV, and (L), the skewness allows the individual's measurement to be converted to a z-score or percent predicted value.

The general form of the equation is:

$$Y = a + b\times H + c\times A + \text{age-spline} + d1\times\text{group} + d2\times\text{group}\times A$$

where Y is the dependent variable, H is the standing height (cm), A is age (years), and a, b, c, d1 and d2 are coefficients which vary for ethnic group, and spline is an age-specific contribution from the spline function. Group is a dummy variable with values of 0 or 1 indicating ethnicity, where Caucasians are the reference.

The recommendations for interpretative strategies [9] advise to choose reference values thoroughly, this should include "matching age-range, anthropometric, race/ethnic, socio-economic and environmental characteristics between the subjects investigated by the laboratory". Additionally, it is suggested to compare selected normal values equations with measurements performed on a representative sample of healthy subjects tested in the laboratory.

The aim of the present study was to verify the applicability of new all-ages reference values in a population of the youngest Polish children of Caucasian origin.

2. Material and methods

This is a retrospective study. The analysis was performed on a data of children aged 4–10 years being admitted to Outpatient Department of the Institute for TBC & Lung Diseases in Rabka during 6 months period mainly for diagnostic purposes. In those children impulse oscillometry (IOS) and spirometry were performed. Prior to the admission the parents or the legal guardians signed informed consent. Measurements were done using MasterLab setup (Jaeger, Germany) calibrated according to the recommendation [10]; the flow channel with a 3-liter syringe, the oscillometric measurement setup was tested with known impedance.

The tests were done in the morning. Impulse oscillometry was performed as the first to avoid possible spirometry induced bronchoconstriction. Briefly, the child breathed tidally through the pneumotachograph during 60 s, while the system superimposed triangular pressure pulses on natural breathing [10]. At least three tests were performed to get reproducible results. The value of R5 (resistance at 5 Hz) was used to judge the presence of obstruction in the respiratory system. Spirometry was performed according to ERS/ATS standard [1]. It is obvious, that in part of the children spirometry was not successful, while there was no problem with performing impulse oscillometry tests. When performing spirometry 3 to 8 manoeuvers were necessary to get acceptable and repeatable measurements.

The analysis brought results from more than 400 children. Exclusion criteria were as follows: asthma or other chronic respiratory disease diagnosed in the past; active infection at