INTRODUCTION

Bronchial asthma is one of the most common public health problems, with still increasing prevalence, affecting about 5-10% of children in industrialized countries (1). Lung function measurements, like bronchoplethysmography (2) and spirometry play a pivotal role in early diagnosis and in follow-up measurements of individual patients. However, these reference values are calculated based on measurements performed in groups of mostly older children and young adults two or three decades ago. In the present, cross-sectional study, lung function measurements were performed in 518 children (241 boys and 277 girls; mean age 6.0±0.3 years) at a regular medical check prior to school enrolment. Spirometry was done using the MasterScreen IOS (Cardinal Health, Wurzburg). We recorded forced vital capacity (FVC), forced expiratory volume in one second (FEV1), maximal expiratory flow (PEF), and maximal expiratory flow at 75, 50, and 25% of vital capacity (MEF75, MEF50, MEF25). We found that FEV1 and FVC corresponded to reference values (101.0±14.9% and 95.4±13.6%, in boys and girls, respectively). In maneuvers satisfying ATS/ERS criteria (TE >1 sec), forced expiratory (parameters (PEF, MEF50) reached only 68.9±13.6 and 75.9±26.6% of reference values, in boys and girls, respectively). There was no significant correlation of lung function parameters to BMI. In conclusion, the hitherto reference values largely overestimate the maximal flow rates of preschool children performing a forced spirometry with TE >1 sec. At the age of 6, forced expiratory flow values are not (yet) impaired by an increased BMI. Standardized spirometry starting in preschool children allows closely evaluating the individual development of lung function during follow-up measurements.

Key words: children, cross-sectional study, spirometry, reference values, forced vital capacity, maximal expiratory flow

MATERIAL AND METHODS

After informal parental consent and with approval of an institutional Ethics Committee, lung function measurements were performed in 518 children (241 boys and 277 girls; mean age 6.0±0.3 years) during an obligatory medical check-up prior to school enrolment. Body mass index (BMI; kg/m²) was calculated. Anthropometric data were compared to the usual German reference system for children and to the data recently gathered in the German health interview and examination survey for children and adolescents (9, 10).

Spirometry was done with a MasterScreen IOS (Cardinal Health, Wurzburg, Germany), according to ATS/ERS statements (6). We recorded forced vital capacity (FVC), forced expiratory volume in on second (FEV1), maximal (peak) expiratory flow (PEF), and maximal expiratory flow at 75, 50 and 25% of vital capacity (MEF75, MEF50, MEF25); only measurements with more than one second time for expiration (TE) were accepted for analysis. For each individual, the measurements were compared to 'predicted values', calculated according to reference values according to Zapletal et al. (11), often used for children in Europe. Calculation of statistical values and development of figures was carried out using Excel (Microsoft Corp.).

RESULTS

Anthropometric data

The children’s mean height was 118.0±5.2 cm and body weight was 22.5±4.0 kg; the mean BMI was 16.0±2.0 (range 12.7-27.6). Based on the percentiles of BMI in the Kromeyer-
Hauschild reference system (9), the proportion of overweight was 9-10% and 3% of the children were obese (Table 1; Fig. 1).

Standardized spirometry

Both, FEV₁ and FVC closely corresponded to calculated reference values (101±14.9% and 95.4±13.6%). The linear regression analysis shows a slight tendency (not significant) of FEV₁ and FVC to increase with increasing BMI (Fig. 2A and B). On the other hand, during maneuvers with Tₑ >1sec, parameters characterizing forced expiratory flow (PEF, MEF₅₀) reached only 68.9±13.6 and 75.9±26.6% of reference values calculated according to Zapletal et al. (11) (Fig. 3A and B).

Obesity and spirometry

In this young age group, with only about 9% of overweight children, we could not discern an impaired performance in forced spirometry associated with overweight or obesity (Fig. 2 and Fig. 3).

DISCUSSION

Our anthropometrical data are in close agreement with present anthropometrical development in Germany, where the proportion of overweight was found to be 9% and the proportion of obesity about 3% in 3-6-year-olds (the rise of this proportion exceeding reference data has been demonstrated to start after the age of 6, reaching a proportion of 15% overweight in 7-10 year-olds) (10). This finding supports the assumption that our data were collected in a group quite representative for pre-school children aged 6 in Germany.

The ideal spirometry in preschool children is one that is applicable to later ages as well, so that longitudinal studies can be performed, monitoring individual development of lung function from infancy (6) to adulthood (12). Moreover, reference data used to evaluate individual spirometric data should adequately describe lung growth and pulmonary function in this age group (13). Our finding of a high rate of acceptable and repeatable spirometry in six year old children using updated ATS/ERS criteria is in accordance with recent observations (14).

**Fig. 1.** Frequency distribution of body mass index presenting data of 518 preschool children. Vertical dotted lines indicate 3%, 10%, 90% (overweight) and 97% (obesity) percentiles of the BMI based on the Kromeyer-Hausschild reference system of BMI in German children (11).

**Fig. 2.** Correlation between FEV₁ in absolute values (Panel A) and as % predicted values (Panel B) and BMI in 518 preschool children. Linear regression lines were calculated for boys (——) and girls (-----).
As lung volume and data for volume-dependent maneuvers mostly depend on anthropometric data (e.g., height), we were not surprised to find a close concordance of IVC and FEV1 with often used reference data for children (11). In contrast, data characterizing expiratory flow during the forced expiration were found to be substantially lower than those calculated according to reference values. One possible explanation is that a forced expiratory maneuver in some preschool children would spontaneously be shorter than one second. Thus, the training to reach a longer duration of forced expiration (exceeding one second) in some individuals might be associated with a decrease in expiratory flow for a given expiratory volume.

Recent cross-sectional and prospective studies in children (and adults) support an association between obesity and asthma; most longitudinal studies suggest that obesity precedes the development of asthma. The mechanisms proposed to explain this link include airway inflammation, mechanical factors, changes in diet, and decreased physiological activity (8). In preschool children, BMI is known slightly to increase with age and height. Thus, higher BMI per se can be expected to be associated with somewhat higher values for spirometry in preschool children. Our data collected in a relatively small proportion of overweight and obese preschool children at the age of 6 did not sustain the assumption, presented in other studies, that overweight increases the risk for significantly impaired lung function (7, 15).

We conclude that reference values often used for spirometry, most pre-school children should be able to perform representative lung function measurements, which is a valuable diagnostic tool to early identify respiratory diseases. Furthermore, early standardized spirometry may offer an option to evaluate the individual development of lung function (4, 12), using serial measurements during follow-up in childhood and adolescence.

Conflict of interests: None declared.

REFERENCES

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