

Is the correct use of a dry powder inhaler (Turbohaler) age dependent?

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Background: The metered-dose inhalers are the most commonly used devices in the treatment of asthma, but dry powder inhalers (eg, Turbohaler) are being increasingly used. Studies evaluating how well children can use a Turbohaler are lacking.

Objective: We assessed whether the correct use of a Turbohaler could be easily taught to unselected stable asthmatic children.

Methods: One hundred sixty-one asthmatic children aged 5 to 17 years (mean, 9.8 years) consecutively attending the outpatient clinic were included in study. After a demonstration and 10 minutes of training, the inhalation technique was checked in a standardized way (yes/no response). Keeping the device upright, proper preparation of the drug dose and inspiratory flow on inhalation were measured by the Turbohaler trainer. **Results:** One hundred thirty-three children (83%) performed every step correctly (ie, 96% of children older than 8 years but only 55% of children between 5 and 8 years; $P < .001$). Of 28 children incorrectly using the Turbohaler-trainer, 20 generated insufficient inspiratory flow through the device. There was no significant difference in airway obstruction (expressed as percent of predicted forced vital capacity, FEV_1 , and Tiffeneau index) between correct and incorrect users, but when measured through the pneumotachograph, mean peak inspiratory flow (expressed as percent predicted) was significantly lower in those children incorrectly using the device. Turbohaler use was reevaluated after 4.7 ± 2.0 months in a subset of 64 patients. Fifty-three of 64 (83%) children again used the device correctly. Only 3 of 13 who used the device incorrectly at the first evaluation used it correctly at the second evaluation.

Conclusions: We conclude that the correct use of the Turbohaler can be easily taught to asthmatic children older than 8 years. Those who use the device correctly after initial instructions continue to do so afterwards. (*J Allergy Clin Immunol* 1999;103:763-7.)

Key words: Asthma, dry powder inhaler, children, Turbohaler

Inhalation is the most direct route for drug delivery in asthma therapy and leads to a rapid response to bronchodilators.¹ It enables lower doses of drugs to be used and reduces the risk of systemic side-effects. Metered-dose inhalers (MDIs) are the most commonly used devices, but dry powder inhalers, such as the Turbohaler, are increasingly used.

Abbreviations used

FVC: Forced vital capacity
LED: Light-emitting diode
MDI: Metered-dose inhaler
PIF: Peak inspiratory flow

Several articles have highlighted the poor performance of children using an MDI.^{2,3} Even in adults, as many as 75% to 89% are reported to make at least 1 error during inhalation from these devices.^{4,5} Breath-actuated devices, such as the Turbohaler, are easier to use and preferred by children and their parents.⁶⁻⁸ Van Der Palen et al⁹ reported that 46% of patients with chronic obstructive pulmonary disease use the Turbohaler device correctly. However, a large study evaluating how well children can prepare the drug dose and inhale through a Turbohaler is lacking.

The purpose of this study was therefore to assess whether the correct use of the dry powder inhaler Turbohaler (Astra Draco, Sweden) could be easily taught to nonselected asthmatic children.

METHODS

Patients

All children attending the asthma outpatient clinic were consecutively included in this study, provided that they had never used a dry powder inhaler and were 5 years of age or older.

Study design

The Turbohaler-trainer is a device simulating the Turbohaler and allowing a semiquantitative measurement of peak inspiratory flow (PIF). Activation of 0, 1, 2, and 3 light-emitting diodes (LEDs) are reported to correspond to flows less than 20, 21 to 40, 41 to 60, and more than 60 L·min⁻¹, respectively. This report was validated by performing 134 inspiratory maneuvers through the Turbohaler-trainer connected to the MasterScreen spirometer (Jaeger GmbH, Würzburg, Germany). One hundred seventeen of the 134 (87%) inspiratory maneuvers were correctly classified as below or above 40 L·min⁻¹ by using the cut-off of at least 2 LEDs being lit. All inhalations resulting in 1 or 3 LEDs being lit were below and above 40 L·min⁻¹, respectively. Thirteen of 17 inhalations "wrongly" resulting in 1 or 2 LEDs being lit were borderline values between 35 and 45 L·min⁻¹. Therefore it was decided that the Turbohaler-trainer was sufficiently accurate to classify the patients' inspiratory efforts as adequate or inadequate by using a cut-off of 40 L·min⁻¹. Turbohaler use was thus evaluated in a manner that approximated home use of the device as closely as possible.

Before being examined at the asthma clinic, children performed pulmonary function tests with the MasterScreen (Jaeger GmbH) according to 1994 American Thoracic Society criteria.¹⁰ Forced vital capacity (FVC), FEV_1 , and Tiffeneau index were measured and expressed as the percentage of predicted values for height and

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TABLE I. Demographic and pulmonary function values for the total group and for individuals using the Turbohaler correctly and incorrectly

	Total group (n = 161)	Correct use (n = 133)	Incorrect use (n = 28)	P values*
Age (y)	9.8 ± 2.8 (5.7-16.8)	10.4 ± 2.7 (5.7-16.8)	7.0 ± 1.2 (5.8-10.3)	<.000017
Sex (M/F)	94/67	77/56	17/11	.78
FVC (% predicted)	103 ± 14 (57-137)	104 ± 13 (70-137)	100 ± 16 (57-134)	.19
FEV ₁ (% predicted)	100 ± 17 (38-134)	100 ± 16 (51-134)	99 ± 20 (38-123)	.86
Tiffeneau (%)	82 ± 10 (43-100)	81 ± 9 (43-100)	84 ± 11 (55-98)	.22
PIF (% predicted)	77 ± 20 (26-132)	79 ± 20 (26-131)	67 ± 20 (45-132)	<.007

Values are means ± SD, with ranges in parentheses.

*P values determined by means of 2-tailed *t* tests.

sex according to Zapletal.¹¹ For PIF, predicted values from Soly-mar¹¹ were used.

After being examined at the asthma clinic, each child individually received verbal instructions on how to use the Turbohaler and a demonstration by the well-experienced research asthma nurse (GW) in a patient- and age-appropriate manner. The patients were then allowed to practice for 10 minutes during which corrections and encouragements were given by the nurse if necessary. Subsequently, the child was asked to perform all parts of the inhalation independently, and his or her technique was assessed by the investigator by using a standardized scoring system as follows: keeping the device upright (yes/no response), proper preparation of the drug dose (yes/no response), and inspiratory flow on inhalation measured by the Turbohaler-trainer. At least 2 LEDs being lit on the Turbohaler-trainer was considered as adequate.

Children correctly using the device were prescribed the Turbohaler as maintenance therapy. Those incorrectly using the device were supplied with a placebo canister and asked to practice daily. At the follow-up asthma visit, pulmonary function was again measured. Turbohaler use was again demonstrated, and 10 minutes of practice and corrections were again allowed. Finally, correct use was evaluated in the manner specified above.

Statistical analysis was done with StatSoft Statistica for Windows version 4.5. For continuous variables with a normal distribution, *t* tests were used. As nonparametric tests, chi-square tests, Fisher exact tests, and Spearman rank correlations were used. Probability (*P*) values less than .05 were considered as statistically significant.

RESULTS

First assessment

A first assessment of Turbohaler use was done in 166 children attending the asthma clinic. Of them, 5 could not perform pulmonary function tests and therefore were excluded from further evaluation. The mean age of these patients was 6.8 years (range, 6.3 to 7.4 years). One hundred sixty-one children (94 boys and 67 girls), ranging in age from 5 to 17 years (Table I), comprised the study group. One hundred thirty three of these 161 (83%) children could perform every step correctly. Of 28 children incorrectly using the device, 20

could not generate a sufficient inspiratory flow, and 19 could not correctly prepare the drug dose; 10 could do neither.

One hundred four of 108 (96%) children older than 8 years and 29 of 53 (55%) children younger than 8 years could use the inhaler properly (*P* < .001, as determined by chi-square test). Only 1 of 6 5-year-old children performed every step of the inhalation correctly, but as many as 13 of 24 6-year-old children (54%) could do so. Fifteen of 23 (65%) 7-year-old children, 13 of 14 (93%) 8-year-old children, 19 of 20 (95%) 9-year-old children, 50 of 52 (96%) 10- to 13-year-old children, and all of the children 13 years old or older were scored as using the Turbohaler correctly (*P* < .001; Spearman rank correlation) (Fig 1). Thus older children were more likely to correctly perform every step of the procedure.

There was no difference in proper Turbohaler use between boys and girls when considering children below 8 years of age or children above 8 years of age (chi-square test). There was also no significant difference in severity of airway obstruction expressed as Tiffeneau index, percent of predicted FVC, or percent of predicted FEV₁ between correct and incorrect Turbohaler users (*t* test, Table I) for the whole group or when considering only children below 8 years. Mean PIF (expressed as percent predicted) measured by pneumotachograph was significantly lower in those using the device incorrectly (Table I).

Second assessment

The second evaluation comprised 64 patients (39 boys and 25 girls). The mean interval between both evaluations was 4.7 ± 2.0 (SD) months. Their mean age was 10.4 ± 2.9 years. Fifty-three of sixty-four (83%) children used the Turbohaler correctly. Of those using the Turbohaler incorrectly, 8 were not able to properly prepare the drug, and 5 did not get 2 LEDs to light with the Turbohaler-trainer. Seven of 18 (39%) children below 8 years of age used the device correctly, and all children older than 8 years (*n* = 46) used the device correctly. There was thus again a significant age difference between those using the device correctly and those using it incorrectly (11.1 ± 0.3 [SEM] years vs 6.7 ± 0.2 [SEM] years; *P* < .00001). All but 1 patient correctly using the Turbohaler at the first evaluation used it correctly at the second evaluation (*P* < .001, Fisher's exact test). Only 3 of 13 patients incorrectly using the device learned to use it correctly. All 3 were among the older patients who used the device incorrectly at the first evaluation (the upper half for age distribution).

DISCUSSION

Nearly all children 8 years of age and older could be easily taught to correctly use a Turbohaler device; in about half of the children below that age we were able to do so. Those who used the device correctly continued to do so on follow-up. The restrictions to optimal use were

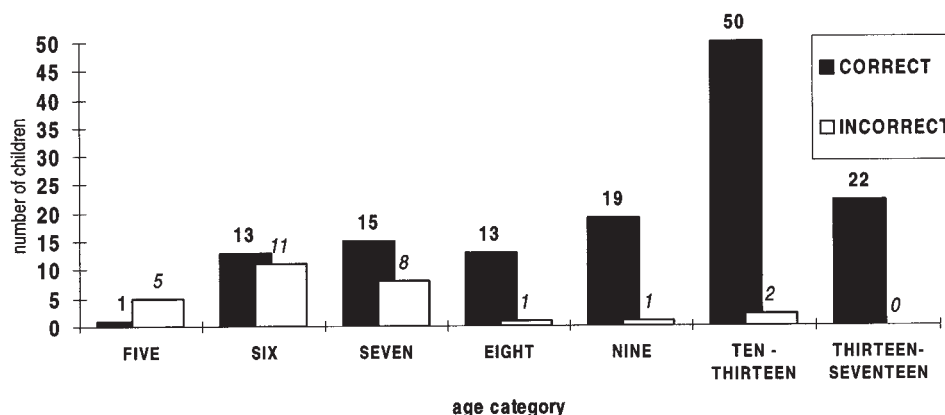


FIG 1. Correct use of the Turbohaler according to age.

the inability to generate sufficient inspiratory flow through the Turbohaler and the inability to correctly prepare a drug dose. The latter could be performed by a parent, thereby increasing the proportion of possible correct Turbohaler use to 88% (Fig 2). This study is the only true field study that we know of in which teaching the correct use of a Turbohaler is evaluated in a nonselected stable asthmatic pediatric population with the wide range of airway obstruction seen in asthma. We chose an instruction period of 10 minutes because that time period can be reasonably applied in a routine asthma clinic or in any doctor's office for instructing the use of a simple device. In our opinion the quality of the instruction was very good. A friendly, well-trained, and patient asthma nurse gave all explanations and instructions to each child individually in an age-appropriate manner.

Since dry powder inhalers were introduced, several studies have documented the efficacy of their use with short-acting bronchodilators in adults⁴ and children.^{12,13} Efficacy of this device has been demonstrated also in children, but always the evaluation concerned a small number of children or a selected group. Fuglsang and Pedersen¹² only studied 13 children, all over the age of 7 years. Hansen and Pedersen¹³ studied only 14 children, all over the age of 8 years. Goren et al¹⁴ assessed 59 children and judged correct use of the Turbohaler solely by visually inspecting the holes in the dosing unit. In that study efficacy was evaluated by a clinical score before and after drug administration. Placebo administration or a control group were not studied. Oldaeus et al⁷ studied children known to correctly perform pulmonary function tests at a very early age. A more thorough study was performed by Laberge et al.¹⁵ They looked at 10 children between 3 and 6 years of age, and documented that all 10 children could generate a PIF above 39 L·min⁻¹. However, similar to the study by Ståhl et al,¹⁶ children were selected because they were known to have a correct inhalation technique, and PIF was measured by using a pneumotachograph.

As a cut-off for sufficient inspiratory flow, we have chosen 2 LEDs on the Turbohaler-trainer (corresponding

to a PIF above 40 L·min⁻¹). This cut-off is commonly used for dry powder inhalers.¹⁷ Other authors have claimed efficient use of the Turbohaler with inspiratory flows as low as 30 L·min⁻¹.¹⁸ If this is correct, in our study a larger proportion of young children are able to correctly use a Turbohaler.

Hill and Slater¹⁹ showed in their *in vitro* study that the emitted dose of budesonide from the Turbohaler device at an inspiratory flow of 60 L·min⁻¹ reached 46.0% ± 14.6% of the nominal dose. In another *in vitro* study Meakin et al²⁰ found flow dependency of drug doses (terbutaline) released from the Turbohaler; at 30 L·min⁻¹ it fell to two thirds of those achieved at 60 L·min⁻¹. The *in vivo* study of Borgström et al²¹ showed that budesonide inhaled by means of the Turbohaler with a flow of 58 L·min⁻¹ leads to a lung deposition of 28% ± 10%. At a flow of 36 L·min⁻¹ the deposition is only 15% ± 3% ($P < .001$). Thus lung deposition from the Turbohaler is dependent on inspiratory effort, and when lower inspiratory flows are accepted as sufficient, the benefit of an increased bronchial deposition is lost. This finding was confirmed in asthmatic children by Hirsch et al.²²

As could be expected, the mean spirometric PIF measurement was significantly higher in those patients correctly using the Turbohaler than in those using it incorrectly. Other authors¹⁶ have concluded that about 50% of children less than 6 years of age can achieve a PIF around 40 L·min⁻¹. Indeed, in our study, when measuring PIF with the IOS MasterScreen, all children did generate inspiratory flows of at least 40 L·min⁻¹. This was not the case in our evaluation by Turbohaler-trainer, as only 2 of 6 children younger than 6 years of age could cause 2 LEDs to activate (Fig 2). The differences in inspiratory flows measured with Jaeger IOS MasterScreen or Astra Turbohaler-trainer are best explained by the added Turbohaler resistance, as demonstrated in the *in vitro* study by Richards and Saunders.²³ The Turbohaler-trainer probably assesses the situation more realistically and closer to the conditions of Turbohaler use in the home situation.

In contrast to our findings, Ståhl et al¹⁶ found a mean PIF through Turbohaler of 58 L·min⁻¹ even in children

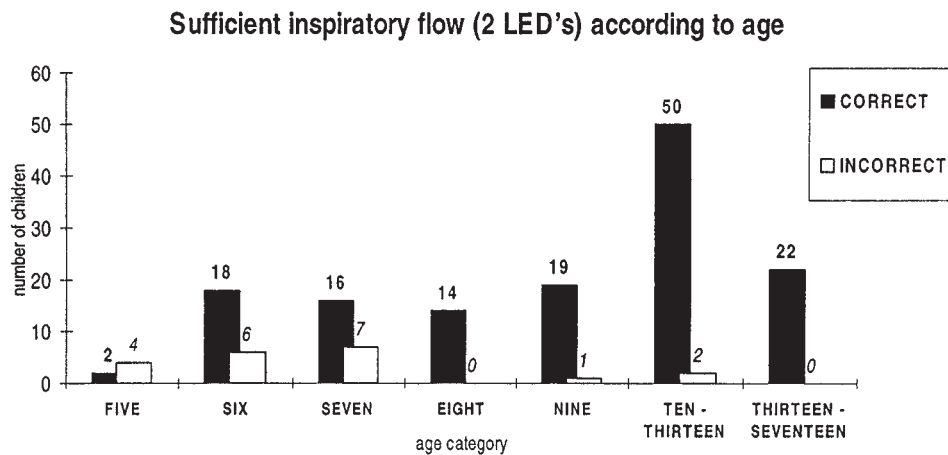


FIG 2. Sufficient inspiratory flows through the Turbohaler-trainer according to age.

from 3 to 6 years of age. However, they measured PIF through a Vitalograph spirometer connected to the Turbohaler device, and children were selected for the study because they could use the mini-Wright peak flow meter properly and because they had a good inhalation technique through the Turbohaler.

Direct comparative studies between dry powder inhalers and MDIs in children are rare. However, some studies have shown that the Turbohaler is easier to use and preferred by both parents and children.^{6,8} Hultquist et al²⁴ confirmed that the majority of children with asthma consider the Turbohaler to be easier to use and more effective than an MDI. Warner and Chetcuti²⁵ showed that children prefer Turbohaler to another dry powder inhaler, the Ventolin Rotahaler. Agertoft and Pedersen²⁶ showed that budesonide inhaled by means of the Turbohaler is more effective than budesonide inhaled by means of an MDI with a spacer in the treatment of childhood asthma.

Our evaluation of Turbohaler use in children is far more satisfactory than any MDI evaluation reported in children³ or adults.^{27,28} The majority of children have problems correctly timing and inhaling from an MDI; in this study correct use of the Turbohaler is documented in 83% of the included nonselected patients, and 88% of the children generate a sufficient inspiratory flow.

In our study an equal proportion of patients scored correctly at the first and second evaluation (both 83%). Only a few patients (ie, the older subjects who did not initially use the device correctly) switch from incorrect to correct use. However, we did not monitor compliance with home training. If children cannot be easily taught to use a Turbohaler, we suggest waiting until they are older to use this device or use it with their parents' help.

We clearly show that in a nonselected group of asthmatic children that nearly all above age 8 years can use the device, thereby confirming previous data. However, in contrast to a selected patient group, we show that only half of the children below age 8 years can use the device properly. Therefore the use in these youngsters should be individualized.

We conclude that age is the main restriction for proper use of the Turbohaler. Fifty-five percent of children younger than 8 years can be taught to use this inhaler correctly, but nearly 100% of children older than 8 years can learn correct use. Severity of airway obstruction (as judged by pulmonary function tests) does not play a role in correct Turbohaler use. Children who correctly use the Turbohaler after a single instruction continue to do so afterwards.

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