

# Acquisition and short-term retention of inhaler techniques require intact executive function in elderly subjects

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## Abstract

**Background:** patients with dementia are almost invariably unable to use any form of inhaler. Some elderly patients are unable to learn to use a metered dose inhaler or Turbohaler\* despite a normal abbreviated mental test score. Studies have shown that in many people this is due to unrecognised cognitive impairment and/or dyspraxia. The executive domains of cognition are particularly important in planning and sequencing; it might be expected therefore that disordered frontal (executive) function could be a predictor of poor inhaler technique in subjects with no overt features of dementia.

**Objective:** to explore the relationship between cognitive, and executive, function and the ability to acquire metered dose inhaler and Turbohaler technique in old age.

**Design:** a prospective randomised observational study with blinded evaluation.

**Subjects:** 30 inhaler-naïve inpatients (21 female) with a mean age of 85 (range 75–94) and having a normal (8–10) abbreviated mental test score.

**Methods:** subjects received standardised metered dose inhaler and Turbohaler training and were scored on an analogue scale (for metered dose inhaler) or for competence (Turbohaler) the following day. The Mini-Mental State Examination and EXIT25 (for executive function) were performed by separate observers.

**Results:** significant correlation was found between the metered dose inhaler score and Mini-Mental State Examination ( $r\ 0.540$ ,  $P < 0.002$ ) and EXIT25 ( $r\ -0.702$ ,  $P < 0.0001$ ). Threshold effects emerged for the metered dose inhaler in that 18/19 with a competent score compared to 2/11 scored as incompetent had a Mini-Mental State Examination of  $> 23$  ( $P < 0.01$ ) and 19/19 compared to 0/11 had an EXIT25 of  $< 15$  ( $P < 0.01$ ). Similarly, for the Turbohaler 21/21 of the competent subjects had a Mini-Mental State Examination of  $> 23$  compared with 3/9 incompetent subjects ( $P < 0.01$ ), with 21/21 competent compared with 0/9 incompetent having an EXIT25  $< 15$  ( $P < 0.01$ ).

**Conclusion:** acquisition and short-term retention of metered dose inhaler and Turbohaler techniques is unlikely to be successful in frail elderly people who have an abnormal Mini-Mental State Examination and/or EXIT25 test. The latter test, when abnormal, is probably the superior predictor of inability to learn inhaler techniques.

**Keywords:** elderly, inhaler, cognitive function, executive function, asthma

## Introduction

Delivery of drugs to the airways by means of inhaler devices is essential for the optimal management of asthma in patients of all ages [1], and also confers benefit in an important proportion of people with chronic obstructive pulmonary disease (COPD) [2]. An adequate

therapeutic effect depends upon sufficient deposition of drugs in the medium and small airways [3, 4], for which a competent inhaler technique is essential irrespective of the design and relative complexity of the device. Most asthmatic patients receive their medication either by metered dose inhaler (MDI), often attached to a large volume spacer, or from one of a number of dry powder systems. All inhalers require a degree of dexterity and co-ordination to obtain a consistent delivery to the target

\*Turbohaler is a trademark (AstraZeneca)

airways. Many older patients have been shown to have a poor inhaler technique [5–7], which might be one of the factors underlying the observation that death rates from asthma have not fallen in the older age group as they have in children and young adults in England and Wales [8].

Cognitive function was shown to be an important determinant of inhaler technique in a community setting [5], and of the ability to acquire [9] and retain [10] a competent technique. Most patients with an Abbreviated Mental Test (AMT) [11] score of <8 could not use an MDI [5, 9]. However, cognitive screening tests did not always identify patients who were unable to learn to use an MDI; some individuals with a normal AMT score of 8 or more, and who were neurologically intact on clinical examination, were nevertheless unable to achieve an adequate MDI technique despite training and reinforcement [12]. Some such patients had evidence of cognitive impairment when tested with the more sensitive screening tool, the Mini-Mental State Examination (MMSE) [13, 14], and abnormal ideo-motor praxis on formal testing was strongly associated with an inadequate MDI technique [14]. An alternative possibility is that elderly people with a normal AMT and no apparent dementia, who are unable to use a MDI, might have abnormalities of frontal (executive) brain function. This can be an early manifestation of a dementing process [15], vascular brain disease [16], or brain ageing [15]. It can be argued that good executive function is a prerequisite for understanding, planning and correctly sequencing the administration of a dose from a MDI. Indeed, executive function tests have been shown to correlate with other task competencies, and with overall functional performance [15, 17]. The study reported here was performed to explore that contention, for the MDI and the Turbohaler, the latter being a relatively simple device to operate.

## Methods

We studied 30 inhaler-naïve subjects with a mean age of 85 years (range 75–94). All were inpatients receiving active rehabilitation after a variety of acute medical or surgical illnesses. To obtain a sample which was virtually random, all patients who met the study criteria were invited consecutively to consent to take part in the study, until the target number was reached. All had stable, reproducible, AMT scores of 8–10 when tested 3–9 days apart. None had previously used any type of inhaler. All were able to read newsprint, with or without glasses, and hear a voice at conversational level with or without a hearing aid. Patients were excluded if there was evidence of focal neurological loss on clinical examination, a confusional state, or a painful condition of the hands or shoulders.

The subjects received training in the use of a placebo MDI and Turbohaler on separate days in random order, using the National Asthma Campaign recommendations. In each case the subject's MDI technique was scored

immediately after the training (day 1) and again the following day (day 2), without further demonstration or training, by an experienced observer, on an analogue scale [14] of 0–10, where 0 represented the worst possible technique, 10 a perfect technique and the threshold for adequate competence [3–5] was 5/6 [5 just incompetent, 6 just competent (defined as actuating the MDI near the start of inhalation and continuing to inhale after actuation)]. The scale is shown in Table 1, along with typical observations of technique. Similarly, the subject's Turbohaler technique was scored as competent or incompetent, with the minimum performance for competence defined as operating the scraper then inhaling through the device.

Separate observers performed the MMSE and a test of frontal executive function, validated for use in frail elderly subjects, known as EXIT25 [18].

Statistical analysis for correlation was performed using Excel software, and categorical data were tested with Fisher's test.

## Results

The results are summarised in Tables 2–4. A significant correlation was found between the MDI score and the MMSE on day 1 and day 2, and a closer correlation between the MDI score and EXIT25 on days 1 and 2. A reasonably clear threshold effect was found in the relationship between MDI competence (score > 5) and MMSE in that 9 of the 11 subjects with an incompetent score (<6) had an MMSE of <24, whereas 18/19 with a competent score had an MMSE of >23, this being similar to the findings in a previous study [14]. An MMSE score of <24 is regarded as evidence of probable cognitive impairment [13]. A clear threshold emerged for EXIT25 in that all 11 subjects with an incompetent MDI score had an EXIT25 of >14 (definite impairment) and all 19 with a competent score had an EXIT25 score of <15, 13 of whom had

**Table 1.** The metered dose inhaler (MDI) score. The score was made by an experienced clinician on an analogue scale of 0 to 10, and with the threshold between 5 and 6 defined as separating bare competence (6) from incompetence.

Typical errors observed	MDI score
A perfect technique	10
Breath hold <5 s	9
No breath hold	8
Actuates inhaler slightly late in inspiration	7
Actuates late but well before full inspiration	6
Actuates too late/too early	5
Poor inspiratory effort with late/early actuation	4
Very poor coordination of inspiration/actuation	3
Failure to actuate or no inspiration	2
Little idea how to use the inhaler	1
No idea what to do with the inhaler	0

**Table 2.** Correlation between the MDI score and MMSE and EXIT25 on days 1 and 2

MDI score <i>versus</i> MMSE	r	P
Day 1	0.482	<0.007
Day 2	0.540	<0.002
MDI score <i>versus</i> EXIT25		
Day 1	-0.661	<0.0001
Day 2	-0.702	<0.0001

**Table 3.** Threshold relationship between day 2 MDI score (5/6 threshold) and MMSE (23/24 threshold) and EXIT25 (14/15 threshold)

	MDI score < 6	MDI score > 5	P
MMSE < 24	9	1	<0.01
MMSE > 23	2	18	<0.01
EXIT25 < 15	0	19	<0.01
EXIT25 > 14	11	0	<0.01

**Table 4.** Threshold relationship between day 2 Turbohaler technique (competent/incompetent threshold) and MMSE (23/24 threshold) and EXIT25 (14/15 threshold)

	Competent	Incompetent	P
MMSE > 23	21	3	<0.01
MMSE < 24	0	6	<0.01
EXIT25 < 15	21	0	<0.01
EXIT25 > 14	0	9	<0.01

a score of <10 (associated with normal executive function, with 10–14 regarded as a borderline score).

All 21 subjects who retained a competent Turbohaler technique on day 2 had an MMSE of >23, and 6/9 of those with an incompetent technique had an MMSE of <24, whereas all 21 competent subjects had an EXIT25 of <15. All 9 of those incompetent with a Turbohaler had an EXIT25 of >14.

A strong concordance was observed between MDI competence and Turbohaler competence in that all 19 of those able to learn to use an MDI were also competent with a Turbohaler, with two additional subjects able to master the Turbohaler.

The commonest errors of MDI technique in the incompetent subjects on day 2 were failure to actuate the device during inhalation, stopping inhalation upon actuation and exhaling after actuation. For the Turbohaler the most frequent errors were failure to operate the scraper and exhaling through the device.

## Discussion

This study confirmed the previous finding [14] that the majority of elderly subjects with a normal AMT who cannot learn to use an MDI or Turbohaler have an

abnormal MMSE. It also showed that all such subjects had evidence of impaired frontal executive function. This suggests that the executive domains are important determinants of an adequate inhaler self-administration technique in subjects with or without overt cognitive impairment on MMSE screening. Of course, memory will clearly be an important limiting factor for the patient learning to use an inhaler for the first time. The subjects in this study were physically frail inpatients, so it could be argued that the findings might not be applicable to the majority of elderly people living in the community.

However, studies of elderly subjects living in retirement homes with minimal support found evidence of executive dysfunction in a large proportion, which suggests that our findings could have a wider application [15]. A similar study now needs to be conducted on older people living independently, with family or in residential homes, to shed further light on this issue.

We studied short-term retention of inhaler techniques, this being the first step for long-term inhaler competence. Other studies have shown the importance of cognitive function and age in determining inhaler technique over a longer time scale [5, 7, 10, 12]. The role of executive function in the long-term responses to training and reinforcement requires further research.

The correlation between the MDI score and MMSE or EXIT25 provided evidence for the thesis that global cognitive function and executive function are important determinants of an effective MDI technique, and indicate a progressive decremental effect of worsening cognitive/executive impairment on the successful acquisition of an adequate MDI technique, though this is not likely to be of direct clinical utility. On the other hand, the observed threshold effects could be of use in clinical practice to help identify subjects who are unlikely to learn to use an MDI or Turbohaler correctly. This contention was reinforced by finding an MMSE threshold of around 23 for adequate acquisition of both types of inhaler technique, which is similar to the threshold of 22 found in an earlier study [14]. Furthermore, an apparently more robust EXIT25 threshold of 14 was observed for the MDI and Turbohaler. This finding indicates that EXIT25 might be a more reliable test than MMSE for predicting the adequate acquisition of inhaler technique.

The AMT remains a helpful quick screening test for the likelihood of being able to use inhaler devices, because an abnormal score is reliably associated with an inadequate technique [9]. There will be some patients with a normal AMT who cannot use an MDI or Turbohaler properly so the AMT alone cannot be relied upon for screening. Our findings suggest that the MMSE is likely to be more sensitive for that purpose. Furthermore, because executive dysfunction is a frequent finding in frail elderly people [15, 17], our results suggest that if such patients require self-administered inhaled therapy they should have a test of frontal executive function, such as EXIT25 before deciding to proceed. The EXIT25

takes about 15–20 min to conduct, so might be considered to be somewhat lengthy in this context. Further work is now required to explore the usefulness of abbreviated forms of executive function testing for quick screening in elderly patients requiring inhaled therapy. Until firm evidence is available clinicians should bear in mind the importance of executive function in this context and take into account any clinical manifestations of executive dysfunction, such as deteriorating organisational skills, when planning inhaler therapy in elderly patients.

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### Key points

- Many older patients are unable to learn to use a metered dose inhaler.
  - Learning metered dose inhaler and Turbohaler techniques requires intact executive function.
  - EXIT25, a test of executive function, can be used to identify patients who are not likely to learn inhaler techniques successfully, the Mini-Mental State Examination is also useful in this context.
  - A normal Abbreviated Mental Test is not reliably predictive of ability to acquire inhaler skills, though an abnormal (<7) score will identify most subjects who will not be successful.
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### Conflict of interest

This study was unfunded and there are no conflicts of interest.

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Received 21 May 2002; accepted in revised form 6 December 2002