

Checklists for dry powder inhaler technique: a review and recommendations

Iman A Basheti, PhD

Associate Professor in Clinical Pharmacy

Faculty of Pharmacy, University of Applied Sciences, Amman, Jordan

Sinthia Z Bosnic-Anticevich, PhD

Associate Professor in Pharmacology

Sydney Medical School and Woolcock Institute of Medical Research, University of
Sydney, NSW, Australia

Carol L Armour, PhD

Professor in Pharmacology

Sydney Medical School and Woolcock Institute of Medical Research, University of
Sydney, NSW, Australia

Helen K Reddel, PhD

Respiratory Physician and Associate Professor

Woolcock Institute of Medical Research and University of Sydney, NSW, Australia

Correspondence to: Iman Basheti; Email: dr_iman@asu.edu.jo

Keywords: Inhalers, checklists; technique, pharmacists, scoring systems.

Abstract

Turbuhaler and Diskus are commonly-used dry powder inhaler devices for patients with respiratory disease. Their effectiveness is limited in part by the patient's ability to use them correctly. This has led to numerous studies being conducted over the last decade to assess the correct use of these devices by patients and health care professionals. These studies have generally used device-specific checklists to assess technique, this being the most feasible and accessible method for assessment. However, divergence between the checklists and scoring systems for the same device in different studies makes direct comparison of results difficult and at times inappropriate. Little evidence is available to assess the relative importance of different criteria; however, brief patient training based on specific inhaler technique checklists leads to significant improvement in asthma outcomes. This paper reviews common checklists and scoring systems used for Turbuhaler and Diskus, discusses the problem of heterogeneity between different checklists, and finally recommends suitable checklists and scoring systems for these devices, based on the literature and previous findings. Only when similar checklists are used across different research studies will accurate comparisons and meta-analysis be possible.

Introduction

Dry powder inhaler (DPI) devices have been developed over the last two decades for treatment of asthma and chronic obstructive pulmonary disease (COPD). These small portable devices contain micronised powdered medication, often with a carrier, with the particles dispersed during inhalation. These devices were developed for use in adults and older children, and have been shown to deliver drugs safely and effectively.^{1,2} Several types of DPIs are available, some as single dose, capsule based inhalers such as the Rotahaler, Aeroliser, or Handihaler. More commonly, DPIs are multi-dose inhalers, either reservoir type inhalers, such as the Turbuhaler (similar to Flexhaler), Clickhaler, Easyhaler and Novolizer, or based on pre-filled blisters, such as the Diskus (Accuhaler), or blister disks such as the Diskhaler.

The acceptance of DPIs has been driven in large part by the enormous success in recent years of combination treatment with a corticosteroid and a long-acting β_2 -agonist.³ The combination of budesonide and formoterol fumarate in the Turbuhaler (TH) (AstraZeneca, Sweden) (Symbicort®), and fluticasone propionate and salmeterol xinafoate in the Diskus (DIS) (GlaxoSmithKline, UK) (Seretide®), reflects current treatment guidelines for moderate to severe asthma and COPD. These devices have been found to be the most efficient and commonly used of the DPI devices.^{4,5}

Many factors play a role in the overall performance of the TH⁶ (Figure 1) and DIS⁷ (Figure 2), from their pharmaceutical formulations, to their mechanical and aerodynamic properties, to the way they are used by people with airways disease. Correct device use is critical to the delivery of medication to the airways. Many studies have been conducted to

assess and improve the way people use the TH and the DIS. Some studies have used specific devices for assessing individual components of inhaler technique. For example, devices such as the Turbutest measure the patient's inspiratory flow through a placebo TH.^{8,9} Portable devices for assessing some components of inhaler technique were recently reviewed.¹⁰ One example is the "Inhalation Manager" which measures inspiratory flow through inhalation devices - including a stylized dry powder inhaler - using a pneumotachometer; this system also predicts drug delivery mass and particle deposition based on *in vitro* data.¹¹ This instrument is proposed as a tool for assessing and training patients on correct inhaler technique and for identifying the most suitable inhaler for an individual patient,¹¹ but it is not feasible on a wide scale and requires technical support. The Turbuhaler whistle (AstraZeneca International, London, UK) is a simple device that whistles if the patient inhales above 35L/sec.¹²

However, by far the most common, feasible and accessible method of assessing inhaler technique is through the use of device-specific inhaler technique checklists. The validity of inhaler technique checklists was initially established by Appel,¹³ who showed that trained personnel were able to achieve a 98% success rate in predicting the bronchodilator response for asthma patients using their reliever inhaler devices by observing their inhaler technique. More recently, inhaler technique checklists have been shown to be feasible tools for assessment of technique. The clinical utility of inhaler checklists has been confirmed by studies with dry powder inhalers¹⁴ and with pressurized metered dose inhalers¹⁵ which have shown that, when brief patient training was based on a standardised inhaler technique checklist, there were significant improvements in asthma outcomes. Hence, it can be concluded that assessment and correction of asthma patients'

inhaler technique against a checklist is a valid measurement of the effectiveness of the inhalation devices in terms of delivering improved clinical outcomes.

A systematic review of the effectiveness of different inhaler devices in asthma and COPD noted problems in comparisons between studies because of variation in the relevant inhaler technique checklists.¹⁶ The objective of the present review was therefore to describe and compare the inhaler technique checklists and scoring systems reported for TH and DIS, and to recommend uniform checklists and scoring systems for use in future studies and in clinical practice.

Review of the literature

Search strategy

The search strategy included PUBMED, EMBASE, and International Pharmacy Abstracts to 2012. Keywords used for the search included ‘Inhaler technique’, plus ‘checklists’, ‘Turbuhaler’, ‘Turbohaler’, ‘Accuhaler’, ‘Diskus’, or ‘incorrect use’. The titles and abstracts of all articles produced by this search were assessed for inclusion before retrieval of full articles. These articles were then subsequently reassessed for inclusion, and only those presenting checklists for the TH and/or DIS and meeting the inclusion criteria were included in the review. No blinding of authors’ names or institutions was done, and no scoring system for study quality was used. The inclusion criteria were: studies of TH or DIS usage, involving patients with asthma or COPD and/or health care professionals. Only publications in the English language were

included. Letters to editors, commentaries, cost-analyses and surveys were excluded. Instructions packaged with the inhaler devices themselves were also included.

Published inhaler technique checklists and reporting systems

Twenty six research articles were included in the analysis of inhaler technique checklists for the TH and DIS. Table 1 lists these checklists, together with the list of steps in the manufacturers' instructions.

Number and categorization of steps

Table 1 includes 24 different checklists for the TH, and 16 for the DIS. It shows substantial variation between checklists in the number of steps listed, ranging from three to fourteen steps for TH and three to thirteen steps for DIS. Most checklists included removing the TH cap (19/24) or opening the DIS cover (14/16), and all checklists included steps for loading a dose and inhaling the dose. However, first exhaling away from the mouthpiece was listed in fewer than half of checklists for both devices. The speed of inhalation, most often described as needing to be strong and forceful, was not mentioned in 4/24 TH and 3/16 DIS checklists. Almost all checklists included holding the breath after inhalation (21/24 for TH, 13/16 for DIS). Some checklists also included an item for waiting a specified time between doses,¹⁷⁻¹⁹ and one, rinsing and spitting out after use of the inhaler.¹⁷

Some checklists (ten for TH, six for DIS) further identified a subset of steps as being “essential” or “critical”; these are indicated with bold text in Table 1. The number of these essential steps varied, most commonly four for TH and three for DIS. For TH the essential steps were usually holding the device upright during loading, twisting the base

around and back to load a dose, exhaling away from the device, and inhaling strongly and forcefully, and for DIS, the most common essential steps were opening the mouthpiece, pushing the lever to load a dose, and inhaling. However, the essential items varied substantially between checklists. In most cases, the authors stated that the selection of an item as essential or critical was based on their evaluation that if this step was incorrectly performed, little or no medication would reach the lung.

Other authors classified some steps as “common problem steps”.²⁰ van Beerendonk²¹ divided the checklist into skilled and non-skilled items, stating that non-skilled items such as exhaling to residual volume required only information, whereas skilled items such as inhaling forcefully and deeply also required physical training.

Scoring and reporting systems for inhaler technique checklists

As with checklist items, scoring systems varied greatly between publications. The most common approach was to give a score of one for each correctly/satisfactorily performed step and a score of zero for each skipped or incorrectly/unsatisfactorily performed step.^{14,17,18,20,22-24} Kesten *et al* graded pharmacists’ TH skills as good, fair, adequate or skipped, with a score of zero for skipped/not adequate and a score of 1 for good/fair.¹⁹ Ronmark *et al* allocated a score of 2 for correct, 1 for not completely correct, and 0 for incorrect.²⁵

Some checklists had a more complicated scoring system. Steier *et al* gave a total score of zero if “a step was left out that was necessary for successful inhalation (e.g., opening of the cap, loading) or if the patient exhaled into the device”, and “all other attempts were

rated from 1-9 points”.²⁶ Sestini *et al* gave a score of 1 for each item of the checklist considered as “minor”, and a score of 3 for each one considered as “major”.²⁷

For reporting a patient’s overall inhaler technique, most authors reported the inhaler technique score as the sum of the scores for each step, or as the proportion of checklist items that were performed correctly. More complicated systems were used by some authors. Ronmark *et al* assigned “overall correct use” of the device if no step was performed “incorrectly” (score 0) and if no more than two of four specific steps (steps 2, 3, 5, and 7 in Table 1) were “not completely correct” (score 1).²⁵ Lenney *et al* provided 3 checklists for each device: the first (A, called “Optimal Technique”) included all steps required to use the device correctly; the second (B, called “Some Delivery”) included 2-3 common errors relevant to the device, and the third (C, called “Little or No Delivery”) included more substantial errors.²⁸ Each patient’s technique was graded as A, B or C according to the checklist to which it best corresponded.

For summarising population results, the most common approaches were to report the average per-patient score and/or the proportion of patients who demonstrated all checklist steps correctly or who had any errors.²⁹⁻³² van der Palen *et al*²⁹ and Basheti *et al*^{30,32,33} also reported the proportion of patients with “correct essential technique” (all essential steps in Table 1 correct), and Melani *et al* reported the proportion of patients with any “critical errors”.³⁴ Some authors also reported data for each individual checklist step, reporting the proportion of patients performing each step correctly³¹ or incorrectly.³⁴

Source of information for checklists

It was not always possible to determine the source of a published checklist (Table 1). Authors often stated that they had based their checklists on the manufacturers' leaflets,^{23,25,27,35,36} previously published checklists,^{37,38} national and international asthma foundation guidelines,^{17,29} and/or developed their own. Personal or expert opinion was often used to justify the checklist items; for example Nimmo *et al* stated that the TH checklist steps were those "identified as necessary for correct inhalation technique for the purpose of the study".³⁹

SUMMARY

The above body of literature demonstrates that there is no defined standard for assessment of inhaler technique with TH or DIS, with regard to the number and content of steps in the relevant checklists. Not all studies stated the source of their checklists, and even when the source of the checklists was stated, there were many different sources. Scoring systems used to present the results of the assessments were very different as well, making it unfeasible to compare the results in many cases. Therefore, while overall similar processes are described in each checklist, the range of content and format presents a challenge with regard to drawing comparisons between the checklists and validation of the individual steps.

A recent review has called for standardization of the way inhaler device studies are conducted and the way they are reported to physicians and health authorities.⁴⁰ Considering the above findings, the most obvious questions at this stage would be: which checklists are most appropriate to be used for future studies assessing and/or educating patients on correct TH and/or DIS technique? Which steps should be weighed more, i.e.

which steps can be considered essential steps? How should inhaler technique data be scored and reported? To answer these questions, we examined evidence for the clinical importance of each of the steps commonly included in checklists for the TH and DIS.

Evidence for inclusion of individual technique steps into device checklists

Each checklist deals with three overall processes: preparation of the device/loading of the dose, delivery of the dose and preparation of the device for storage. Within these three overall processes, we identified published evidence that supports individual checklist steps. It is not possible to find evidence for some of the steps that are included in the manufacturers' instructions for a particular device; these recommendations may have been developed in-house, with various options tested and some perhaps abandoned, and the evidence not necessarily available in the public domain.

A. Preparation of the device

Most checklists describe the preparation of the device to include i) removing the cover (TH) or opening the cover (DIS) and ii) loading a dose for delivery.

i) While there is no published evidence on the importance, necessity or impact of removing the cover (TH) or opening the cover (DIS), the design of the devices means that it would be physically impossible for any medication to be delivered if this step was not performed. This may seem so obvious as to be unnecessary to check, but a small proportion of patients fail to complete this step.⁴¹

ii) Loading (or preparing) a dose for delivery is described for both TH and DIS. For the TH, (Figure 1) the medication powder is stored in bulk in a reservoir (“Storage unit for drug”), above a dose well (“Dosing unit”) and prior to drug administration a single dose of dry power needs to be aliquotted (“loaded”).⁴² This is achieved by holding the device upright and rotating the grip at the base of the TH in one direction and back again. While early TH instructions specified starting with an anti-clockwise rotation, the manufacturer later clarified that the direction of initial rotation was irrelevant provided the base was rotated in both directions and a click was heard. If the device is upright, the drug falls by gravity from the reservoir into the Dosing unit, and excess powder is scraped off to make the measured dose available.^{6,43,44} This is an important step as without it, an appropriate dose of medication will not be available for delivery.

In contrast, the DIS contains a “Coiled strip” containing metered doses of dry powder (Figure 2). When the “Lever” is pulled to the right, the two foil strips are peeled apart, and the dose is aligned with and exposed to the mouthpiece. Without the lever being pulled across, it is physically impossible for any medication to be inhaled.

B. Delivery of the dose

This process involves all of the breathing manoeuvres required to move the drug from the device and into the body. Typically, the checklists involve a description of i) how to exhale the air from the lungs (how much and where), ii) how to place the mouthpiece of the device into the mouth, iii) how to inhale the medication from the device, and iv) breath holding after inhalation.

i) Exhaling air prior to inhalation is a physiological process. While some checklists do not include this step on the basis that it does not affect clinical outcomes,⁴⁵ other checklists specify “exhaling to residual volume”, based on clinical experience that this ensures that the patient can make a deep and forceful inhalation.^{32,33} For both TH and DIS, it is important to exhale away from the mouthpiece as there is evidence that exhalation into the device may reduce the dose delivered to the lung.⁴⁶⁻⁴⁸ Exhalation into or near the device compromises the integrity of the dry powder dose: for both the TH^{12,42,44,46,49,50} and the DIS,⁵¹ it can displace the already-loaded dose of powder and introduce moisture, potentially causing aggregation of dry powder particles.

ii) Placing the mouthpiece between teeth and lips before inhalation (TH and DIS) may also influence clinical outcomes.⁵¹ A tight seal between the lips and the mouthpiece avoids air leakage that would otherwise reduce the inspiratory flow rate; having the mouthpiece passing the lips and the teeth is important, otherwise a portion of the aerosol particles may deposit onto the teeth and tongue decreasing the amount of medication reaching the lung.⁵¹

iii) Inhaling forcefully and deeply i.e. generating sufficient inspiratory flow, has been shown to be important for optimal drug delivery for TH and DIS,^{6,28,52} as it ensures de-aggregation of the metered dose⁵³ and deep lung deposition.^{51,54} Inspiration should be forceful from the beginning of inhalation rather than increasing gradually.⁵⁰ Failure to do so results in partial delivery of the medication to the lungs,²⁸ and increased drug deposition in the mouth and pharynx.^{50,53, 55,56} Maintaining a forceful and deep inhalation from the start of the inhalation maneuver, and for as long as possible, can ensure that

most patients can use a DPI (TH and DIS) irrespective of the resistance of the device or their disease severity.⁵⁷ However, while most patients can achieve the required flow rate,^{58,59} flow rate is more likely to be a problem for the TH than for the lower resistance DIS.^{60,61}

iv) Breath holding following inhalation (TH and DIS) is included in most of the published checklists and the Global Initiative for Asthma (GINA) web site checklists for both the TH and the DIS (www.ginasthma.com/inhalers/slide_11.html, *Accessed April 19, 2012*). This is one of the most discussed items about inhaler technique checklists.⁴⁵

While the manufacturer's instructions for the TH do not include this step, many clinicians advise inclusion of a breath-hold for DPIs to avoid confusion with pressurized metered dose inhalers (pMDIs), for which a breath-hold is necessary.⁶² For pMDIs, the original suggestion of a 10-second breath-hold was based on lung deposition studies,⁶² but the general recommendation for clinical practice is that the breath should be held only as long as is comfortable. A 5-second breath-hold is a realistic target for most patients.⁶³

C. Preparation of the device for storage

Replacing the cap after use of a TH or closing the lid of the DIS are the final steps articulated in inhaler checklists. While this step is post drug delivery, it serves to keep the device clean, prevent foreign objects from entering the mouthpiece and minimize absorption of moisture from the ambient environment.^{51,64} Therefore these steps are important in maintaining the drug integrity for subsequent doses. For the TH, replacing the cap is included in the manufacturer's instructions, but in fewer than half of published TH checklists.

Evidence for additional steps

There does not appear to be any published evidence to support a 30 second delay between doses, and it is not included in manufacturers' instruction leaflets in countries such as Jordan, Canada, Australia, and the United States. This step would only be relevant to patients prescribed two or more inhalation doses on each occasion. Likewise, an instruction to rinse the mouth after taking a dose, while important for patients using inhaled corticosteroids to reduce the risk of oropharyngeal side-effects, is not relevant to those using TH or DIS for delivery of short- or long-acting β_2 -agonists.

Nevertheless, if the perspective of Appel *et al*,¹³ is adopted i.e. that the better the inhaler technique (the more correct steps performed) by the patient, the better the clinical response expected,^{14,32} these additional steps should be considered while delivering a complete TH and DIS technique education. Patients for whom a second dose or mouth rinsing is relevant may need to be asked about these steps, as they may not necessarily think to perform them when asked to demonstrate their technique.

Essential steps for TH and DIS

As previously mentioned, in some published checklists a series of steps have been identified as "essential". Considering the evidence above, it becomes clear that, without the completion of certain steps, it is unlikely that any medication would be delivered to the airways. It is these steps that could be considered "essential". They include: opening/removing the cover, loading the device,⁴² which in the case of the TH should be completed while holding the device upright^{29,43} and inhaling through the mouthpiece forcefully and deeply.^{50,55} Failure to perform these steps will result in no medication

being available either because of the physical barrier of the cap of lid or the unavailability of the drug; or the drug failing to be transported out of the inhaler.

From the literature, the published checklists for TH and DIS that best describe all of the steps recommended are those published by van der Palen *et al*²⁹ and Basheti *et al*¹⁴ (Table 2).

Reporting TH/DIS technique data

In order to allow comparison of data from different studies, we recommend that inhaler technique data should be presented as

- 1) the proportion of patients with correct technique (all steps in the checklist correct)
- 2) the proportion of patients with correct essential technique (all essential steps identified in each checklist correct)
- 3) the mean of inhaler technique scores (\pm S.D.)
- 4) for more detailed studies, the proportion of patients with correct technique for each individual step in the technique checklist.

If all of these metrics were reported (or at least recommendations 1-3), appropriate comparison of populations would be possible in different locations and over time. In addition, effectiveness of interventions designed to improve inhaler technique and thus clinical outcomes could be established.

Clinical impact of using inhaler technique checklists

In the literature and in clinical practice, there is broad acceptance that poor inhaler technique is a substantial contributor to poor asthma control and to increased health care

costs.⁴² For pMDIs, Giraud *et al* showed a strong relationship between poor technique, assessed with a standardized checklist, and a composite asthma instability index.⁶⁵ A subsequent study by the same authors¹⁵ showed that assessment and correction of inhaler technique using a standardized checklist led to a significant improvement in asthma control, particularly in patients whose inhaler technique was sub-optimal at the start.¹⁵ Although there have been many studies evaluating dry powder inhaler technique, a review by Lavorini *et al*⁴⁹ found that few studies had documented the relationship between incorrect technique and clinical outcomes; however, there is no reason to suppose that this would be any different than for pMDIs. The concept of essential steps is supported by the finding of Melani *et al* that patients with one or more critical errors on the TH or DIS checklist had significantly worse asthma control, impaired quality of life, activity limitation and sleep disturbance.³⁴ The strongest confirmation of the value of inhaler checklists comes from studies in which inhaler assessment and skills training was associated with significantly improved asthma outcomes.¹⁴ Again, there are few, but in young children, Goren *et al* showed that improved TH technique with a rudimentary child-specific checklist was associated with greater bronchodilator effect.⁶⁶ In the 6-month study by Basheti *et al*,¹⁴ a brief pharmacy intervention, with assessment and correction of inhaler technique and checklist-based inhaler labels, led to significant improvement in asthma outcomes compared with a control group.¹⁴ In this study, changes in asthma control measures over time seemed to relate more to the proportion of patients with all steps correct than to average inhaler technique scores.^{14,32}

Considering the difference in steps between TH and DIS checklists, another important practical recommendation that this review can add is that, where possible, only one type

of inhaler device should be used per patient. Previous studies have shown that use of different devices predisposes patients to inhaler misuse compared with using only one type of inhaler.^{12,67,68} In addition, substituting a different DPI for that previously used by the patient can cause confusion for the patient.⁶⁹ Skilled health care professionals have an essential role in evaluating patients' inhalation technique and ensuring they are using the inhalers properly.^{12,50,61} Avoiding multiple inhaler devices for a patient can also lead to fewer steps to teach/learn and hence less confusion in demonstrating/performing the individual steps per inhaler device for health care professionals and patients.

Conclusion

Inhaler technique checklists have been used in the majority of studies investigating the inhaler technique performance of patients and of health care professionals such as pharmacists. This literature review demonstrates considerable heterogeneity in inhaler technique checklists for the same dry powder devices in different studies, which makes direct comparison of results difficult. This may cause confusion for both patients and health care professionals, and ultimately contribute to poor technique. The issue of inhaler technique checklist heterogeneity was first raised more than a decade ago,¹⁶ but more work clearly needs to be done to ensure standardization of checklists for clinical and research contexts.

Checklists are feasible for use in clinical research and clinical practice, with no equipment costs, and with minimal time required. Unlike existing inhaler technique assessment devices which are only able to check some components of inhaler use, use of a checklist ensures that *every* step required for delivery of medication is assessed.

However, the differences between the various checklists and scoring systems in the literature make the direct comparison of results difficult and at times inappropriate. Hence, in this review we have recommended checklists and scoring systems for the most commonly used DPIs, TH and DIS, based on the literature and previous findings. If future studies in this area use common checklists and scoring systems, the problem of inhaler technique assessment heterogeneity between different studies will be resolved allowing for more accurate comparisons between the results.

From the literature, the published checklists for TH and DIS that best describe all of the steps recommended above are those published by van der Palen *et al*²⁹ and Basheti *et al*.¹⁴ The validity of these checklists is supported by evidence for significant improvement in asthma outcomes when technique is assessed and improved.¹⁴ It is recommended that future studies use these checklists so direct comparison between studies can assess the efficacy of specific interventions.

Figure legends

Figure 1. An image of a Turbuhaler device (Image provided by AstraZeneca plc).

Figure 2. An image of a Discuss device (Image provided by GlaxoSmithKline plc).

References

1. Kemp JP, Hill MR, Vaughan LM, Meltzer EO, Welch MJ, Ostrom NK. Pilot study of bronchodilator response to inhaled albuterol delivered by metered-dose inhaler and a novel dry powder inhaler. *Ann Allergy Asthma Immunol* 1997;79(4):322-326.
2. Richter K. Successful use of DPI systems in asthmatic patients--key parameters. *Respir Med* 2004;98(Suppl B):S22-27.
3. Atkins PJ. Dry powder inhalers: an overview. *Respir Care* 2005;50(10):1304-1312.
4. Roche N, Huchon GJ. Rationale for the choice of an aerosol delivery system. *J Aerosol Med* 2000;13(4):393-404.
5. Muller V, Galffy G, Eszes N, Losonczy G, Bizzi A, Nicolini G, et al. Asthma control in patients receiving inhaled corticosteroid and long-acting beta2-agonist fixed combinations. A real-life study comparing dry powder inhalers and a pressurized metered dose inhaler extrafine formulation. *BMC Pulm Med* 2011;11:40.(doi):10.1186/1471-2466-1111-1140.
6. Wetterlin K. Turbuhaler: A new powder inhaler for administration of drugs to the airways. *Pharm Res* 1988; 5(8):506-508.
7. Chrystyn H. The Diskus (TM) inhaler: A review of its pharmaceutical and clinical performance. *Clin Drug I* 1999;18(4):287-296.

8. Engel T, Heinig JH, Madsen F, Nikander K. Peak inspiratory flow and inspiratory vital capacity of patients with asthma measured with and without a new dry-powder inhaler device (Turbohaler). *Eur Respir J* 1990;3(9):1037-1041.
9. Hawksworth GM, James L, Chrystyn H. Characterization of the inspiratory manoeuvre when asthmatics inhale through a Turbohaler pre- and post-counselling in a community pharmacy. *Respir Med* 2000;94(5):501-504.
10. Lavorini F, Levy ML, Corrigan C, Crompton G, on behalf of the ADMIT Working Group. The ADMIT series - issues in inhalation therapy. 6) Training tools for inhalation devices. *Prim Care Respir J* 2010;19(4):335-341.
11. Kamin WE, Genz T, Roeder S, Scheuch G, Cloes R, Juenemann R, et al. The inhalation manager: a new computer-based device to assess inhalation technique and drug delivery to the patient. *J Aerosol Med* 2003;16(1):21-29.
12. Haughney J, Price D, Kaplan A, Chrystyn H, Horne R, May N, et al. Achieving asthma control in practice: understanding the reasons for poor control. *Respir Med* 2008;102(12):1681-1693.
13. Appel D. Faulty use of canister nebulizers for asthma. *J Fam Pract* 1982;14(6):1135-1138.
14. Basheti IA, Armour CL, Bosnic-Anticevich SZ, Reddel HK. Evaluation of a novel educational strategy, including inhaler-based reminder labels, to improve asthma inhaler technique. *Patient Educ Couns* 2008;72(1):26-33.
15. Giraud V, Allaert FA, Roche N. Inhaler technique and asthma: feasibility and acceptability of training by pharmacists. *Respir Med* 2011;105(12):1815-1822.

16. Brocklebank D, Ram F, Wright J, Barry P, Cates C, Davies L, et al. Comparison of the effectiveness of inhaler devices in asthma and chronic obstructive airways disease: a systematic review of the literature. *Health Technol Assess* 2001;5(26):1-149.
17. Garcia-Cardenas V, Sabater-Hernandez D, Garcia-Corpas JP, Faus MJ, Martinez-Martinez F, Benrimoj SI. Errors in Turbuhaler technique in a Spanish population of asthmatic patients (letter). *Respir Care* 2012;57(5):817-818; author reply 818-819.
18. Hanania NA WR, Kesten S, Chapman KR. Medical Personnel's knowledge of and ability to use inhaling devices; metered-dose inhalers, spacing chambers, and breath-actuated dry powder inhalers. *Chest* 1994;105(1):111-116.
19. Kesten S, Zife K, Chapman KR. Pharmacist knowledge and ability to use inhaled medication delivery systems. *Chest* 1993;104(6):1737-1742.
20. Nelson P, Young HN, Knobloch MJ, Griesbach SA. Telephonic monitoring and optimization of inhaler technique. *Telemed J E Health* 2011;17(9):734-740.
21. van Beerendonk I, Mesters I, Mudde AN, Tan TD. Assessment of the inhalation technique in outpatients with asthma or chronic obstructive pulmonary disease using a metered-dose inhaler or dry powder device. *J Asthma* 1998;35(3):273-279.
22. Serra-Batlles J, Plaza V, Badiola C, Morejon E. Patient perception and acceptability of multidose dry powder inhalers: a randomized crossover comparison of Diskus/Accuhaler with Turbuhaler. *J Aerosol Med* 2002;15(1):59-64.

23. Cain WT, Cable G, Oppenheimer JJ. The ability of the community pharmacist to learn the proper actuation techniques of inhaler devices. *J Allergy Clin Immunol* 2001;108(6):918-920.
24. Martin MA, Mosnaim GS, Rojas D, Hernandez O, Sadowski LS. Evaluation of an asthma medication training program for immigrant Mexican community health workers. *Prog Community Health Partnersh* 2011;5(1):95-103.
25. Ronmark E, Jogi R, Lindqvist A, Haugen T, Meren M, Loit HM, et al. Correct use of three powder inhalers: comparison between Diskus, Turbuhaler, and Easyhaler. *J Asthma* 2005;42(3):173-178.
26. Steier J, Trammer T, Cloes RM, Petro W. Optical feedback training of inhalation with Autohaler and Turbuhaler in COPD patients. *Lung* 2003;181(4):183-192.
27. Sestini P, Cappiello V, Aliani M, Martucci P, Sena A, Vaghi A, et al. Prescription bias and factors associated with improper use of inhalers. *J Aerosol Med* 2006;19(2):127-136.
28. Lenney J, Innes JA, Crompton GK. Inappropriate inhaler use: assessment of use and patient preference of seven inhalation devices. *Respir Med* 2000;94(5):496-500.
29. van der Palen J, Klein JJ, Schildkamp AM. Comparison of a new multidose powder inhaler (Diskus/Accuhaler) and the Turbuhaler regarding preference and ease of use. *J Asthma* 1998;35(2):147-152.
30. Basheti IA, Qunaibi E, Bosnic-Anticevich SZ, Armour CL, Khater S, Omar M, et al. User error with Diskus and Turbuhaler by asthma patients and pharmacists in Jordan and Australia. *Respir Care* 2011;56(12):1916-1923.

31. Sleath B, Ayala GX, Gillette C, Williams D, Davis S, Tudor G, et al. Provider demonstration and assessment of child device technique during pediatric asthma visits. *Pediatrics* 2011;127(4):642-648.
32. Basheti IA, Reddel HK, Armour CL, Bosnic-Anticevich SZ. Improved asthma outcomes with a simple inhaler technique intervention by community pharmacists. *J Allergy Clin Immunol* 2007;119(6):1537-1538.
33. Basheti IA, Reddel HK, Armour CL, Bosnic-Anticevich SZ. Counseling about turbuhaler technique: needs assessment and effective strategies for community pharmacists. *Respir Care* 2005;50(5):617-623.
34. Melani AS, Bonavia M, Cilenti V, Cinti C, Lodi M, Martucci P, et al. Inhaler mishandling remains common in real life and is associated with reduced disease control. *Respir Med* 2011;105(6):930-938.
35. Chopra N, Oprescu N, Fask A, Oppenheimer J. Does introduction of new "easy to use" inhalational devices improve medical personnel's knowledge of their proper use? *Ann Allergy Asthma Immunol* 2002;88(4):395-400.
36. Molimard M, Raheison C, Lignot S, Depont F, Abouelfath A, Moore N. Assessment of handling of inhaler devices in real life: an observational study in 3811 patients in primary care. *J Aerosol Med* 2003;16(3):249-254.
37. Epstein S, Maidenberg A, Hallett D, Khan K, Chapman KR. Patient handling of a dry-powder inhaler in clinical practice. *Chest* 2001;120(5):1480-1484.
38. Lareau SC, Hodder R. Teaching inhaler use in chronic obstructive pulmonary disease patients. *J Am Acad Nurse Pract* 2012;24(2):113-120.

39. Nimmo CJ, Chen DN, Martinusen SM, Ustad TL, Ostrow DN. Assessment of patient acceptance and inhalation technique of a pressurized aerosol inhaler and two breath-actuated devices. *Ann Pharmacother* 1993;27(7-8):922-927.
40. Haughney J, Price D, Barnes NC, Virchow JC, Roche N, Chrystyn H. Choosing inhaler devices for people with asthma: current knowledge and outstanding research needs. *Respir Med*;104(9):1237-1245.
41. Melani AS, Zanchetta D, Barbato N, Sestini P, Cinti C, Canessa PA, et al. Inhalation technique and variables associated with misuse of conventional metered-dose inhalers and newer dry powder inhalers in experienced adults. *Ann Allergy Asthma Immunol* 2004;93(5):439-446.
42. Fink JB. Inhalers in asthma management: is demonstration the key to compliance? *Respir Care* 2005;50(5):598-600.
43. Ekstrom T, Andersson AC, Skedinger M, Lindbladh C, Stahl E. Dose potency relationship of terbutaline inhaled via Turbuhaler or via a pressurized metered dose inhaler. *Ann Allergy Asthma Immunol* 1995;74(4):328-332.
44. Meakin BJ, Cainey JM, Woodcock PM. Simulated 'in-use' and 'mis-use' aspects of the delivery of terbutaline sulphate from Bricanyl Turbohaler™ dry powder inhalers. *Int J Pharm* 1995;119(1):103-108.
45. Hansen OR, Pedersen S. Optimal inhalation technique with terbutaline Turbuhaler. *Eur Respir J* 1989;2(7):637-639.
46. Meakin BJ, Cainey JM, Woodcock PM. Drug delivery characteristics of bricanyl Turbohaler(TM) dry powder inhalers. *Int J Pharm* 1995;119(1):91-102.

47. Engel T SB, Skovsted B, Heining JH. Effects, side effects and plasma concentrations of terbutaline in adult asthmatics after inhaling from a dry powder inhaler device at different inhalation flows and volumes. *Br J Clin Pharmacol* 1992;33:439-444.
48. Broeders ME, Molema J, Hop WC, Vermue NA, Folgering HT. The course of inhalation profiles during an exacerbation of obstructive lung disease. *Respir Med* 2004;98(12):1173-1179.
49. Lavorini F, Magnan A, Dubus JC, Voshaar T, Corbetta L, Broeders M, et al. Effect of incorrect use of dry powder inhalers on management of patients with asthma and COPD. *Respir Med* 2008;102(4):593-604.
50. Laube BL, Janssens HM, de Jongh FH, Devadason SG, Dhand R, Diot P, et al. What the pulmonary specialist should know about the new inhalation therapies. *Eur Respir J* 2011;37(6):1308-1331.
51. Borgstrom L, Asking L, Thorsson L. Idealhalers or realhalers? A comparison of Diskus and Turbuhaler. *Int J Clin Pract* 2005;59(12):1488-1495.
52. Newman SP. A comparison of lung deposition patterns between different asthma inhalers. *J Aerosol Med* 1995;8(Suppl 3):S21-26.
53. De Boer AH, Bolhuis GK, Gjaltema D, Hagedoorn P. Inhalation characteristics and their effects on in vitro drug delivery from dry powder inhalers: Part 3: the effect of flow increase rate (FIR) on the in vitro drug release from the Pulmicort 200 Turbuhaler. *Int J Pharm* 1997;153(1):67-77.
54. Persson G, Olsson B, Soliman S. The impact of inspiratory effort on inspiratory flow through Turbuhaler in asthmatic patients. *Eur Respir J* 1997;10(3):681-684.

55. Devadason SG, Everard ML, MacEarlan C, Roller C, Summers QA, Swift P, et al. Lung deposition from the Turbuhaler in children with cystic fibrosis. *Eur Respir J* 1997;10(9):2023-2028.
56. Abdelrahim ME, Assi KH, Chrystyn H. Dose emission and aerodynamic characterization of the terbutaline sulphate dose emitted from a Turbuhaler at low inhalation flow. *Pharm Dev Technol* 2013;18(4):944-949.
57. Azouz W, Chrystyn H. Clarifying the dilemmas about inhalation techniques for dry powder inhalers: integrating science with clinical practice. *Prim Care Respir J* 2012;21(2):208-213.
58. Borgstrom L. On the use of dry powder inhalers in situations perceived as constrained. *J Aerosol Med* 2001;14(3):281-287.
59. Nsour WM, Alldred A, Corrado J, Chrystyn H. Measurement of peak inhalation rates with an in-check meter to identify an elderly patient's ability to use a turbuhaler. *Respir Med* 2001;95(12):965-968.
60. Chrystyn H. Effects of device design on patient compliance: comparing the same drug in different devices. . In: Dalby RN, Byron PR, Peart J, Suman JD, editors. *Respiratory drug delivery Europe*. Virginia Commonwealth University: Davis Healthcare International Publishing, 2009:105-116.
61. Capstick TG, Clifton IJ. Inhaler technique and training in people with chronic obstructive pulmonary disease and asthma. *Expert Rev Respir Med* 2012;6(1):91-101.

62. Newman SP, Pavia D, Garland N, Clarke SW. Effects of various inhalation modes on the deposition of radioactive pressurized aerosols. *Eur J Respir Dis Suppl* 1982;119:57-65.
63. Goodman DE, Israel E, Rosenberg M, Johnston R, Weiss ST, Drazen JM. The influence of age, diagnosis, and gender on proper use of metered-dose inhalers. *Am J Respir Crit Care Med* 1994;150(5 Pt 1):1256-1261.
64. Borgstrom L, Asking L, Lipniunas P. An in vivo and in vitro comparison of two powder inhalers following storage at hot/humid conditions. *J Aerosol Med* 2005;18(3):304-310.
65. Giraud V, Roche N. Misuse of corticosteroid metered-dose inhaler is associated with decreased asthma stability. *Eur Respir J* 2002;19(2):246-251.
66. Goren A, Noviski N, Avital A, Maayan C, Stahl E, Godfrey S, et al. Assessment of the ability of young children to use a powder inhaler device (Turbuhaler). *Pediatr Pulmonol* 1994;18(2):77-80.
67. van der Palen J, Klein JJ, van Herwaarden CL, Zielhuis GA, Seydel ER. Multiple inhalers confuse asthma patients. *Eur Respir J* 1999;14(5):1034-1037.
68. Price D, Chrystyn H, Kaplan A, Haughney J, Roman-Rodriguez M, Burden A, et al. Effectiveness of same versus mixed asthma inhaler devices: a retrospective observational study in primary care. *Allergy Asthma Immunol Res* 2012;4(4):184-191.
69. Williams AE, Chrystyn H. Survey of pharmacists' attitudes towards interchangeable use of dry powder inhalers. *Pharm World Sci* 2007;29(3):221-227.

70. AL-Doghim I. Evaluation of Inhalation Technique of Metered Dose Inhaler (MDI) and Dry Powder Inhaler-Turbuhaler[®] (DPI) among Pediatric Patients with Asthma. *J J Appl Sci* 2007;9(1):53-66.
71. Kamps AW, Brand PL, Roorda RJ. Determinants of correct inhalation technique in children attending a hospital-based asthma clinic. *Acta Paediatr* 2002;91(2):159-163.
72. Khassawneh BY, Al-Ali MK, Alzoubi KH, Batarseh MZ, Al-Safi SA, Sharara AM, et al. Handling of inhaler devices in actual pulmonary practice: metered-dose inhaler versus dry powder inhalers. *Respir Care* 2008;53(3):324-328.
73. Smith IJ, Parry-Billings M. The inhalers of the future? A review of dry powder devices on the market today. *Pulm Pharmacol Ther* 2003;16(2):79-95.
74. Newman SP. Inhaler treatment options in COPD. *Eur Respir Rev* 2005;14(96):102-108.
75. Moore AC, Stone S. Meeting the needs of patients with COPD: patients' preference for the Diskus inhaler compared with the Handihaler. *Int J Clin Pract* 2004;58(5):444-450.
76. Rootmensen GN, van Keimpema AR, Jansen HM, de Haan RJ. Predictors of incorrect inhalation technique in patients with asthma or COPD: a study using a validated videotaped scoring method. *J Aerosol Med Pulm Drug Deliv* 2010;23(5):323-328.

Table 1. Checklists used in the assessment of inhaler technique in clinical studies for Turbuhaler and Diskus*

The manufacturers' instructions are listed first, followed by other authors in alphabetical order.

TH=Turbhualer, DIS=Diskus (Accuhaler)

Author	Turbuhaler (TH) instructions	Diskus (DIS) instructions	Stated source
Manufacturer instructions	<p>†</p> <ol style="list-style-type: none"> 1-Unscrew the cover and lift it off. 2-Hold your TH upright with the red grip at the bottom. 3-Turn the red grip as far as it will go in one direction. Then turn it as far as it will go in the other direction. You should hear a click sound. 4-Hold your TH away from your mouth. Breathe out gently (as far as is comfortable). 5-Place the mouthpiece gently between your teeth. Close your lips. 6-Breathe in as deeply and as hard as you can through your mouth. 7-Remove your TH from your mouth. 8-Then breathe out gently. 9-If you are to take a second inhalation, repeat steps 2 to 6. 10-Replace the cover tightly after use. 11-Rinse your mouth with water after your daily morning and/or evening doses, and spit it out. 	<ol style="list-style-type: none"> 1-Hold the DIS in one hand and put the thumb of your other hand on the thumbgrip. 2-Push your thumb away from you as far as it will go until the mouthpiece appears and snaps into position. 3-Hold the DIS in a level, horizontal position with the mouthpiece towards you. 4-Slide the lever away from you as far as it will go until it clicks 5-Before inhaling your dose, breathe out as far as is comfortable, holding the DIS level and away from your mouth. 6-Put the mouthpiece to your lips. Breathe in quickly and deeply through the DIS, not through your nose. 7-Remove the DIS from your mouth. Hold your breath for about 10 seconds, or for as long as is comfortable. 8-Breathe out slowly. 9-Close the DIS when you are finished taking a dose so that the DIS will be ready for you to take your next dose. 10-Put your thumb on the thumbgrip and slide the thumbgrip back towards you as far as it will go. The DIS will click shut. The 	<p>Manufacturer instructions for the Symbicort™ TH (AstraZeneca; (http://www.medicines.org.uk/emc/medicine/14249, Accessed November 17, 2012)</p> <p>and</p> <p>DIS (GlaxoSmithKline; http://usgsk.com/products/assets/us_advair_instructions.pdf, Accessed november 23, 2012)</p>

		lever will automatically return to its original position.	
Al-Doghim ⁷⁰	<p>1- Remove Cap 2- Hold the inhaler upright and turn the grip to the right as far as it will go, and then turn the grip back again to the left until it clicks. 3- Exhale slowly. 4- Place the mouthpiece between your teeth and lips. 5- Inhale forcefully and deeply. 6- Remove the inhaler from your mouth before breathing out.</p>		Checklist based on previous studies
Basheti et al ¹⁴	<p>1-Remove the cap from the inhaler 2-Keep inhaler upright 3-Rotate grip anti-clockwise then back until a click is heard 4-Exhale to residual volume 5-Exhale away from the mouthpiece 6-Place mouthpiece between teeth and lips 7-Inhale forcefully and deeply 8-Hold breath for 5 seconds 9-Exhale away from mouthpiece</p>	<p>1-Open inhaler 2-Push lever back completely 3-Exhale to residual volume 4-Exhale away from mouthpiece 5-Mouthpiece between teeth and lips 6-Inhale forcefully and deeply 7-Hold breath for 5 seconds 8-Exhale away from mouthpiece 9-Close inhaler</p>	Checklist was based on previous published study by van der Palen ²⁹
Basheti et al ³³	<p>1-Remove the cap from the inhaler 2-Keep inhaler upright, on a flat surface 3-Rotate grip anti-clockwise then back until a click is heard 4-Exhale to residual volume 5-Exhale away from the mouthpiece 6-Place mouthpiece between teeth and lips 7-Inhale forcefully and deeply 8-Hold breath for 5 seconds</p>		Checklist was based on previous published study by van der Palen ²⁹

	9-Exhale away from mouthpiece		
Cain et al ²³	<p>1-Remove the cover</p> <p>2-Turn the bottom clockwise until it clicks while keeping the inhaler upright</p> <p>3-Turn the bottom counter-clockwise to the maximum while keeping the inhaler upright</p> <p>4-Turn head away from the inhaler and exhale to FRC or RV</p> <p>5-Place the mouthpiece between lips horizontally or vertically and inhale deeply and forcefully</p> <p>6-Hold breath in full inspiration for 5-10 seconds and exhale.</p>	<p>1-Put thumb on the thumb grip and push the grip away from you as far as it will go until the mouthpiece appears and snaps into position.</p> <p>2-Slide the lever away from you as far as it will go until it clicks while keeping the DIS horizontally.</p> <p>3-Holding the DIS horizontally and away from mouth, breathe out to FRC or RV</p> <p>4-Put the mouthpiece to lips and breath in steadily and deeply</p> <p>5-Remove the DIS from mouth. Hold breath in full inspiration for 5-10 seconds and exhale</p> <p>6-Put thumb on the grip and slid the thumb grip back towards you as far as it will go to click it shut</p>	Manufacturer's instructions
Chopra and Oprescu ³⁵	<p>1-Remove the cover</p> <p>2-Turn the bottom clockwise until it clicks while keeping the inhaler upright</p> <p>3-Turn the bottom anticlockwise to the maximum while keeping the inhaler upright</p> <p>4-Turn your head away from the inhaler and exhale to FRC or RV</p> <p>5-Place the mouthpiece between your lips horizontally or vertically and inhale deeply and forcefully</p> <p>6-Hold your breath in full inspiration for 5-10 seconds, exhale</p>	<p>1-Put the thumb of your hand on the thumb grip and push your thumb away from you as far as it will go until the mouthpiece appears and snaps into position</p> <p>2-Slide the lever away from you as far as it will go until it clicks while keeping the DIS horizontally</p> <p>3-Holding the DIS horizontally and away from your mouth, breathe out to FRC or RV</p> <p>4-Put the mouthpiece to your lips and breathe in steadily and deeply</p> <p>5-Remove the DIS from your mouth. Hold your breath in full inspiration for 5-10</p>	Manufacturer's instructions

		seconds and exhale 6-Put your thumb on the thumb grip and slide the thumb grip back towards you as far as it will go to click it shut	
Gracia-Cardenas ¹⁷	<ol style="list-style-type: none"> 1- Unscrew and lift off the cover 2- Hold the inhaler upright 3- Twist the red grip fully to the right as far as it will go and twist it back again to the left. A 'click' will be heard 4- Breathe out gently taking care not to breathe into the TH 5- Place mouthpiece between teeth and lips 6- Inhale forcefully and deeply 7- Remove inhaler from mouth, hold breath for 8 seconds, and exhale away from the mouthpiece 8- If further doses are needed, wait 30 seconds, and repeat steps from 2 to 7 9- Replace white cap 10- Rinse mouth with water. Do not swallow 		Spanish guide for asthma management guidelines
Epstein et al ³⁷	<ol style="list-style-type: none"> 1-Removing the cover before the first puff 2-Not shaking the inhaler 3-Holding the inhaler upright for priming 4-Turning the wheel correctly to the right 5-Turning the wheel correctly to the left until there is a click. 6-Breathing out 7-Breathing away from the inhaler prior to inhalation 8-Putting the mouthpiece between the lips 		Manufacturer's recommendation and previous published studies by Hanania et al ¹⁸ and Kesten et al ¹⁹

	<p>9-Breathing in deeply 10-Breathing forcefully through the mouth 11-Removing the inhaler from the mouth 12-Holding the breath for more than 5 seconds before exhaling 14-Replacing the cover after the second puff</p>		
Hanania et al ¹⁸	<p>1-Remove cover 2-Hold inhaler upright 3-Turn bottom clockwise then anticlockwise 4-Exhale away from inhaler to functional residual capacity or residual volume 5-Insert mouthpiece between lips 6- Breathe in forcefully and deeply 7- Don't exhale, remove inhaler from mouth 8-Hold breath to comfort (5-10 seconds) 9-Exhale, wait 20-30 seconds before a second inhalation 10-Hold upright 11-Rotate bottom again before a second inhalation</p>		Not stated (justifications given)
Kamps et al ⁷¹	<p>1-Rotate TH counter-clockwise and back while keeping it upright 2-Place mouthpiece between teeth and lips 3-Inhale forcefully and deeply</p>	<p>1-Open DIS and push back handle completely 2-Place mouthpiece between teeth and lips 3-Inhale forcefully and deeply</p>	Netherlands Asthma Foundation
Khassawneh et al ⁷²	<p>1-Unscrew and lift off the cover 2-Hold the inhaler upright with the grip downwards 3-Turn the grip until it clicks 4-Breathe in rapidly and deeply</p>	<p>1-Open the device 2-Slide the lever until it clicks 3-Breathe in rapidly and deeply</p>	Checklist was derived from medication leaflet and previous studies ^{36,28, 73}

Kesten et al ¹⁹	1-Remove the cover 2-Hold inhaler upright 3-Turn bottom completely to the right then left until click 4-Exhale away from inhaler to functional residual capacity or residual volume 5-Put mouthpiece between lips 6- Breathe in forcefully and deeply 7-Don't exhale, remove inhaler from mouth 8-Hold breath according to comfort 9-Exhale, wait a minimum of 20-30 seconds before second inhalation 10-Hold upright 11-Rotate bottom correctly		Not stated (justifications given)
Lareau et al ³⁸	<i>Steps to prepare for inhalation after unscrewing/removing/opening the cap</i> Twist grip as far as possible in one direction Twist grip back until it clicks <i>Other steps given as critical errors:</i> Failure to remove cap Holding inhaler upside down Failure to load dose Blowing into device Failure to make tight seal with lips Inhalation too weak or too slow		Checklist was derived from instructions in the package inserts, and adapted from previous work ⁷⁴

Lenney et al ²⁸	<p>1-Remove mouthpiece cover 2-Prime inhaler by twisting base until it clicks with device vertical $\pm 45^\circ$ 3-Breathe out gently 4-Place inhaler between lips and breathe in quickly and deeply until full 5-Hold breath for 10 seconds.</p>	<p>1-Rotate cover to expose mouthpiece 2-Prime device by pushing back lever until it pops. 3-Continue as for TH</p>	Not stated (justifications given)
Melani et al ³⁴	<p>1-Remove the cover 2-Hold inhaler upright 3-Load the dose 4-Place mouthpiece between lips 5-Inhale by mouth 6-Breathe out the device mouthpiece 7-Inhale deeply and quickly 8-Forceful and deep inhalation 9-Hold breath 10-Breathe out the device mouthpiece</p>	<p>1-Turn the cover 2-Load the dose 3-Inhale by mouth 4-Breathe out the device mouthpiece 5-Inhale deeply and quickly 6-Place mouthpiece between lips 7-Forceful and deep inhalation 8-Hold breath 9-Breathe out the device mouthpiece</p>	Checklist is a translation from the original Italian format in supplementary data file prepared by the Educational Group members
Melani et al ⁴¹	<p>1-Correct removal of the cap 2-Successful loading 3-Hold the device in the upright 4-After loading, never exhale through the mouthpiece 5-Exhale until the residual volume before inhalation 6-Place the mouthpiece into the mouth, sealing the lips 7-Inhale forcefully 8-Inhale by mouth and not by nose 9-Continue to inhale for as long as possible 10-Hold breath for 4 to 6 seconds/Hold breath for 8 to 10 seconds</p>	<p>1-Correct removal of the cap 2-Successful loading 4-After loading, never exhale through the mouthpiece 5-Exhale until the residual volume before inhalation 6-Place the mouthpiece into the mouth, sealing the lips 7-Inhale forcefully 8-Inhale by mouth and not by nose 9-Continue to inhale for as long as possible 10-Hold breath for 4 to 6 seconds/Hold breath for 8-10 seconds 11-Replace the mouthpiece cover</p>	GINA Guidelines, The GOLD Executive Committee, and manufacturer's instructions.

	<p>11- Never exhale into the mouthpiece after inhalation</p> <p>12-Replace the mouthpiece cover</p>		
Molimard et al ³⁶	<p>1-Hold inhaler upright (tolerance of $\pm 45^\circ$)</p> <p>2-Rotate grip and back until "click"</p> <p>3-Exhale before inhalation</p> <p>4-Exhale away from mouthpiece</p> <p>5-Inhale through the mouthpiece</p> <p>6-Hold breath a few seconds</p>	<p>1-Hold mouthpiece towards them</p> <p>2-Slide the lever as far as possible</p> <p>3-Exhale before inhalation</p> <p>4-Exhale away from mouthpiece</p> <p>5-Inhale through the mouthpiece</p> <p>6-Hold breath a few seconds</p>	Manufacturer's instructions
Moore et al ⁷⁵	<p>1-Correct removal of the cap</p> <p>2-Successful loading</p> <p>3-Hold the device in the upright</p> <p>4-After loading, never exhale through the mouthpiece</p> <p>5-Exhale until the residual volume before inhalation</p> <p>6-Place the mouthpiece into the mouth, sealing the lips</p> <p>7-Inhale forcefully</p> <p>8-Inhale by mouth and not by nose</p> <p>9-Continue to inhale for as long as possible</p> <p>10-Hold breath for 4 to 6 seconds/Hold breath for 8 to 10 seconds/Do not hold breath</p> <p>11- Never exhale into the mouthpiece after inhalation</p> <p>12-Replace the mouthpiece cover</p>	<p>1-Correct removal of the cap</p> <p>2-Successful loading</p> <p>4-After loading, never exhale through the mouthpiece</p> <p>5-Exhale until the residual volume before inhalation</p> <p>6-Place the mouthpiece into the mouth, sealing the lips</p> <p>7-Inhale forcefully</p> <p>8-Inhale by mouth and not by nose</p> <p>9-Continue to inhale for as long as possible</p> <p>10-Hold breath for 4 to 6 seconds/Hold breath for 8-10 seconds/Do not hold breath</p> <p>11-Replace the mouthpiece cover</p>	Not stated
Nelson et al ²⁰		<p>1.Open inhaler</p> <p>2.Push lever</p> <p>3.Inhaler level and flat (after dose activated)</p> <p>4.Exhale (away from mouthpiece)</p> <p>5.Put mouthpiece in mouth</p>	Food and Drug Administration -approved product package inserts

		6. Inhaler level and flat (when inhaling) 7. Inhale through mouth 8. Inhale fast and deep 9. Hold breath 10. Exhale (away from mouthpiece) 11. Close inhaler	and guidelines from American College of Chest Physicians
Nimmo et al ³⁹	1- Remove mouthpiece cover 2- Hold upright 3- Load dose 4- Twist grip back to original position 5- Exhale fully 6- Place mouthpiece between teeth and lips 7- Breathe in through TH quickly and deeply 8- Hold breath for 10 seconds 9- Breath out slowly		Not stated (justifications given)
Ronmark et al ²⁵	1-release of the dose (i.e. holding the inhaler in a correct position) 2- Number of released dose (i.e. correctly releasing one dose) 3- Exhalation before use 4-Exhalation away from mouthpiece before inhalation 5- Lips tightly around mouthpiece 6-Inhalation 7- Holding the breath after inhalation 9-Exhalation away from mouthpiece after inhalation		Manufacturer's instructions with justifications of highlighted steps (self medication steps) given.

Rootmensen et al ⁷⁶	<ol style="list-style-type: none"> 1-Keep inhaler in upright position 2-Twist the grip to the right and twist back until the “click” sound 3-Place inhaler in horizontal position 4-Sit upright or stand 5-Breathe out to residual volume 6-Tilt head back (hyperextend) 7-Close lips on inhaler 8-Inhale forcefully and deeply 9-Hold breath for at least 5 sec 10-Breathe out away from mouthpiece 	<ol style="list-style-type: none"> 1-Activate inhaler 2-Sit upright or stand 3-Breathe out to residual volume 4-Tilt head back (hyperextend) 5-Close lips on inhaler 6-Inhale forcefully and deeply 7-Hold breath for at least 5 sec 8-Breathe out away from mouthpiece 	Based on van Beerendonk ²¹ and van der Palen ²⁹ . Scoring system agreed by three investigators
Serra-Battles et al ²²	<ol style="list-style-type: none"> 1-Remove cover 2-Keep upright 3-Twist grip forward 4-Twist grip backward 5-Put to mouth 6-Breathe from the inhaler 7-Replace cover and close the device 	<ol style="list-style-type: none"> 1-Open inhaler 2-Slide the lever 3-Put to mouth 4-Breathe in the inhaler 5-Close the device 	Not stated

Sestini et al ²⁷	<ol style="list-style-type: none"> 1- Opening the device 2- Loading the device 3- Keeping the inhaler less than 45 degrees from the vertical axis during loading 4- Exhaling away from the mouthpiece of the device after loading 5- Sealing the lips around the mouthpiece during inhalation 6- Inhaling to Total Lung Capacity 7- Inhaling by mouth and not by nose 8- Exhaling away from the mouthpiece of the device after inhalation 9- Holding breath after inhalation 10- Closing the device properly 	<ol style="list-style-type: none"> 1- Opening the device 2- Loading the device 3- Exhaling away from the mouthpiece of the device after loading 4- Sealing the lips around the mouthpiece during inhalation 5- Inhaling to Total Lung Capacity 6- Inhaling by mouth and not by nose 7- Holding breath after inhalation 8- Closing the device properly 	Manufacturer's instructions
Sleath et al ³¹	<ol style="list-style-type: none"> 1-Lift off white cover to reveal mouthpiece 2-Hold device with mouthpiece up and twist the grip at the base back and forth 1 time to load dose 3-Hold device horizontal and exhale gently away from mouthpiece 4-Place mouthpiece between lips 5-Take a forceful breath in steadily and deeply 6-Hold breath for 10 s 7-Replace white cover 	<ol style="list-style-type: none"> 1-Open device until it clicks 2-To load a dose, hold device horizontal and slide the lever away from you until it stops (there should be a second click) 3-Exhale gently away from mouthpiece 4-Place mouthpiece in lips 5-Take a forceful breath in steadily and deeply 6-Hold breath for 10 s 7-Close device by sliding thumb grip toward self until it clicks 	Not stated
Steier et al ²⁶	<ol style="list-style-type: none"> 1-Open the cap 2-Hold the device vertically 3-Screw the wheel 4-Screw the wheel back until you hear a click 5-Exhale deeply 		Not stated

	6-put the mouthpiece into the mouth 7-Inhale deeply and strongly 8-Hold the breath 9-Close the cap		
van Beerendonk et al ²¹	1-Prepare the inhaler before usage 2-Keep inhaler horizontal 3-Exhale to residual volume 4-Place mouthpiece between lips and teeth 5-Inhale forcefully and deeply 6-Take inhaler out of mouth 7-Hold breath for 5 seconds 8-Exhale and repeat from item 3		The Dutch Asthma Foundation
van der Palen et al ²⁹ van	1-Remove the cap from the inhaler 2-Keep inhaler upright 3-Rotate grip until click 4-Exhale to residual volume 5-Exhale away from mouthpiece 6-Place mouthpiece between teeth and lips 7-Inhale forcefully and deeply 8-Hold breath for 5 seconds 9-Exhale away from mouthpiece 10-Replace cap	1-Open inhaler 2-Push lever back completely 3-Exhale to residual volume 4-Exhale away from mouthpiece 5-Mouthpiece between teeth and lips 6-Inhale forcefully and deeply 7-Hold breath for 5 seconds 8-Exhale away from mouthpiece 9-Close inhaler	The Dutch Asthma Foundation

* Studies are listed in alphabetical order according to authors' surname. Highlighted steps are those stated by the relevant author to be 'important', 'essential' or 'critical'. † There are additional instructions for first use of Symbicort.

Table 2. Recommended checklists for assessment of Turbuhaler and Diskus (Accuhaler) technique.

Checklist for Turbuhaler technique	Checklist for Diskus technique
<ol style="list-style-type: none"> 1. Remove the cap from the inhaler* 2. Keep inhaler upright* 3. Rotate grip anti-clockwise then back until a click is heard* 4. Exhale to residual volume 5. Exhale away from the mouthpiece 6. Place mouthpiece between teeth and lips 7. Inhale forcefully and deeply* 8. Hold breath for 5 seconds 9. Exhale away from mouthpiece† 	<ol style="list-style-type: none"> 1. Open inhaler* 2. Push lever back completely* 3. Exhale to residual volume 4. Exhale away from mouthpiece 5. Mouthpiece between teeth and lips 6. Inhale forcefully and deeply* 7. Hold breath for 5 seconds 8. Exhale away from mouthpiece 9. Close inhaler

* Bold steps are 'Essential Steps' (i.e. steps if not performed correctly by the patients, little or no medication would reach their lung). † The patient should also, of course, replace the Turbuhaler cap after use. These published checklists were standardized to 9 items each in order to allow comparison of scores between the two devices.

Figure 1. An image of a Turbuhaler device (Image provided by AstraZeneca plc).

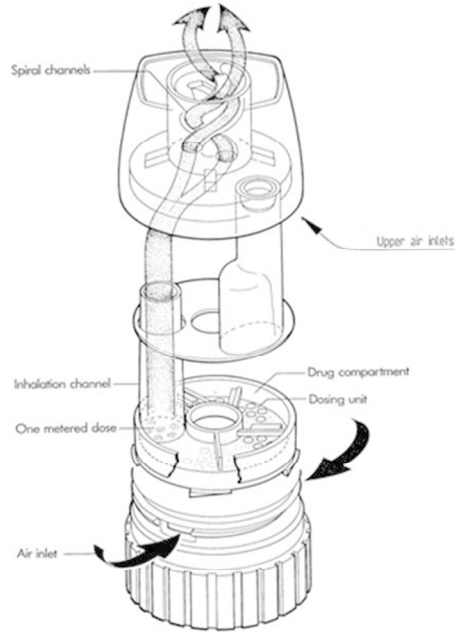


Figure 1. An image of a Turbuhaler device (Image provided by AstraZeneca plc).
254x190mm (96 x 96 DPI)

Figure 2. An image of a Discuss device (Image provided by GlaxoSmithKline plc).

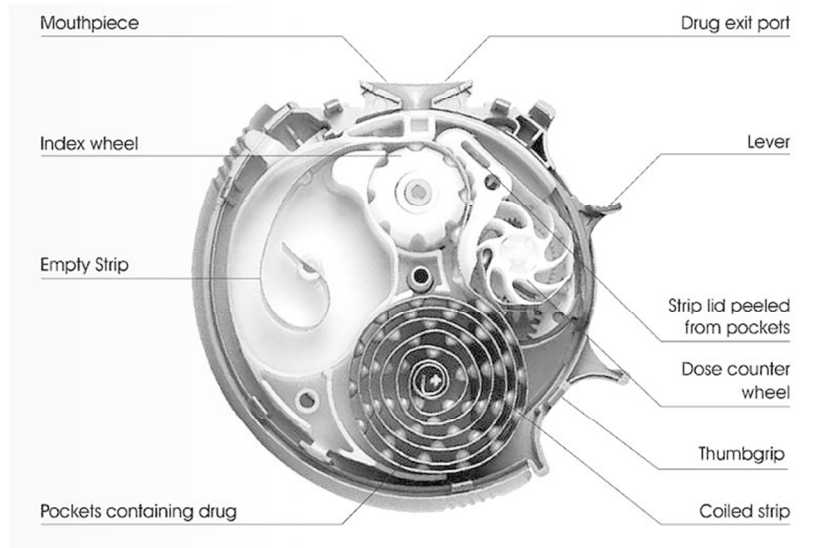


Figure 2. An image of a Discuss device (Image provided by GlaxoSmithKline plc).
254x190mm (96 x 96 DPI)