Asthma Control Assessment Tools

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Both the National Asthma Education and Prevention Program Expert Panel Report 3 and the 2015 Global Initiative for Asthma guidelines identify achieving and maintaining asthma control as goals of therapy, and they emphasize periodic assessment of asthma control once treatment is established. Accurate assessment of asthma control is difficult due to the complexity of asthma control and due to the limitations in the traditional methods of assessment, such as lung function tests, physician assessment, and patients' self-assessment. Relying solely on the role of lung function tests is insufficient to reflect the status of asthma control, since patients with asthma may have normal spirometry between exacerbations. Clinicians often overestimate the level of asthma control. Similarly, it is not uncommon for patients to overestimate how well their asthma is controlled, and, therefore, they under-report asthma symptoms and fail to recognize the impact that asthma has on their daily life. As a result, several tools have been developed to quantify the level of asthma control, identify patients at risk, and evaluate the effect of asthma management. This review examines the commonly

used asthma control assessment tools in terms of content, psychometric properties, methods of administration, limitations, and ability to reflect the overall status of asthma control, which can aid clinicians in selecting the most appropriate tool for their needs. *Key words: asthma; asthma control; questionnaire; outcome assessment; Asthma Control Test; Asthma Control Questionnaire; Asthma Therapy Assessment Questionnaire.* [Respir Care 2016;61(1):106–116. © 2016 Daedalus Enterprises]

Introduction

Asthma continues to be a common disease associated with high mortality and high economic and social tolls despite the advances in the understanding of the pathophysiology of asthma, the availability of effective preventive therapy, and the availability of international treatment guidelines. It is estimated that 300 million people of all ages and diverse ethnicities suffer from asthma, and about 1 in every 250 is estimated to die from asthma worldwide.[1,2]

Most of the burden of asthma is attributed to treating patients with uncontrolled asthma.[3] Thus, the concept of asthma control is increasingly recognized as a critical aspect of the evaluation and management of the disease. Similar to other diseases, control of asthma involves control of (1) current impairment, including daily/nocturnal symptoms, reliever use, level of activity, and quality of life, and (2) future risk, including the risk of exacerbations, permanent impairment of lung function, and the adverse effects of treatment. Once treatment is established, achieving asthma control by reducing both impairment and risk is defined as the goal of asthma therapy according to the National Asthma Education and Prevention Program (NAEPP) Expert Panel Report 3(EPR-3)[4] and the 2015 Global Initiative for Asthma (GINA) guidelines.[1] These goals require periodic assessment and ongoing monitoring to ensure that they are met and to determine whether adjustments to therapy are required.[1,4]

Clinician assessment, patient self-assessment, and minimal invasive markers, such as spirometry and fractional exhaled nitric oxide (F_{ENO}), are the established methods for monitoring asthma.[1,4,5] However, discordance between the patient's and clinician's assessment of the patient's level of asthma control were reported in several studies.[1,6] Also, both clinicians and patients often overestimate the level of asthma control.[7-9] Thus, clinicians suboptimally manage asthma, and patients under-report asthma symptoms and may fail to recognize the impact that asthma has on their daily life.[8,9] Furthermore, the findings of lung function testing are insufficient to reflect the adequacy of asthma control despite being widely used in clinical care.[10] Other physiological markers, such as sputum eosinophils and F_{ENO}, require further evaluation before they can be recommended as assessment tools for routine asthma management.[4]

Several standardized self-administered asthma control assessment tools have been developed to quantify the level of asthma control. These tools are simple and easily completed by patients to facilitate an objective assessment of asthma management. This review examines the tools that have established psychometric properties and have been extensively studied in terms of their content or domains, methods of administration, and ability to reflect the overall status of asthma control. The tools included are the Asthma Control Test (ACT), Childhood Asthma Control Test (cACT), Asthma Control Questionnaire (ACQ), Asthma Therapy Assessment Questionnaire (ATAQ), and Lara Asthma Symptom Scale (LASS).

The review below addressed the validity, reliability, accuracy, and responsiveness of each tool. Validity is the extent to which a tool measures what it is intended to measure. Reliability concerns whether a tool is internally consistent or reproducible and, therefore, whether it consistently measures what it is intended to measure. Accuracy is the ability of the tool to distinguish between different patients' categories (ie, different levels of asthma control) against a criterion measure. Finally, responsiveness is the tool's ability to detect important changes over time.

Asthma Control Test

The ACT is a multidimensional, standardized, and validated tool and the most widely used tool for assessing asthma control in patients with asthma older than 12 y.[8] Similar to most asthma assessment tools, the ACT quantifies asthma control as a continuous variable and provides a numeric value to distinguish between controlled and uncontrolled asthma. The ACT is a patient-centered/completed questionnaire that recalls the patient's experience of 5 items: asthma symptoms (nocturnal and daytime), the

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use of rescue medications, the effect of asthma on daily functioning, and the patient's perception of asthma control over the previous 4 weeks.[9] Each item includes 5 response options corresponding to a 5-point Likert-type rating scale. Subsequently, responses for each of the 5 items are summed to yield a score ranging from 5 (poor asthma control) to 25 (complete asthma control).[9]

Validity

Overall validity of the ACT has been assessed more than any other asthma control assessment tool. Thus, the ACT has been designated as a core measure for National Institutes of Health (NIH)-initiated clinical research in adults. Alpaydin et al[11] reported a statistically significant association between ACT and the Asthma Quality of Life Questionnaire (AQLQ).[12] Another study[13] reported a strong correlation between the ACT and the ACQ.[14] In contrast, moderate to low correlations were observed between the ACT score and FEV_1, F_{ENO}, and specialists' rating of control according to NAEPP EPR-3 guidelines.[9,15,16] The substantially low correlations between the ACT scores and physiologic measures of asthma, such as FEV_1 values and F_{ENO}, support the notion that asthma control cannot be inferred from physiologic measures alone.[14,17] Furthermore, the ACT has been validated in many languages[18-23] and in different settings, including in asthma specialist consultations,[9] in primary care,[13] in pharmacies,[24] by mail,[25] by speech-recognition telephone calls,[26] and over the internet.[27]

Reliability

Nathan et al[9] reported high internal consistency of the ACT score with specialists' ratings among subjects with controlled asthma as well as subjects with uncontrolled asthma (0.79 and 0.83, respectively). Alvarez-Gutiérrez et al[15] assessed the test-retest reliability of the ACT on subjects who remain stable at baseline and follow-up visits; they had the same specialist ratings of asthma control on both visits. The authors reported a test-retest reliability of 0.77.

Accuracy

According to 2008 GINA guidelines,[28] which have the same definition and criteria of asthma control as the 2015 GINA guidelines, an ACT score of $\geq$23 and a score $\leq$19 indicates well-controlled asthma[29] and uncontrolled asthma, respectively.[9,13,25,30] A cutoff score of $\leq$19 was associated with higher risk of adverse asthma outcomes, such as asthma exacerbation[17,31] and urgent health-care utilization.[17,32] With regard to NAEPP EPR-3 guidelines, a score of $\geq$20 indicates well-controlled asthma, a score of 16–19 indicates not well-controlled asthma, and a score of $\leq$15 indicates very poorly controlled asthma.[13,33] An ACT score of $\leq$15 predicted future asthma exacerbations in multiple studies.[26,33,34] The variations in the ACT performance against the 2008 GINA and NAEPP EPR-3 guidelines could be attributed to the slight differences between the components of asthma control in the 2 guidelines.

Responsiveness

Schatz et al[13] reported that changes in ACT scores were strongly correlated with changes in ACQ scores, moderately correlated with changes in specialist control ratings, and weakly correlated with change in percent-of-predicted FEV_1 values. The minimum clinically important difference for a tool is the smallest change in score that can be considered clinically important.[35] The minimum clinically important difference enhances the ability of clinicians and researchers to evaluate the effectiveness of interventions. For the ACT, a difference of 3 points has been shown to be a significant minimum clinically important difference.[35]

Childhood Asthma Control Test

The cACT was developed in 2006 to assess asthma control in children 4–11 y old.[36] The cACT is a self-administered tool that integrates the child's and the child's caregiver's perspectives on asthma control over the previous 4 weeks.[36] The cACT is composed of 7 questions (4 child-reported and 3 caregiver-reported). The child-reported questions, rated on 4-point Likert scale, include daytime and activity limitation due to asthma symptoms, nocturnal awakenings due to asthma, and self-perceptions of asthma; the caregiver-reported questions, rated on 6-point Likert scale, include asking about the child's daytime and nocturnal symptoms. The responses summed to an overall score that ranges from 0 (poor control of asthma) to 27 (complete control of asthma).[36]

Validity

The cACT has been validated more than any other asthma control assessment tool for children with asthma, and, therefore, it has been designated as a core outcome for NIH-initiated participant characterization and for observational studies.[37-40] In the developmental study, Liu et al[36] reported that the cACT overall score discriminated between patients who differ in the specialists' rating of asthma control. Similarly, Chen et al[37] reported that mean cACT scores were significantly lower among patients with poor asthma control as compared with those who were well controlled according to specialists' rating.

The cACT has a strong correlation with the asthma control classification based on GINA guidelines[41] as well

as with other asthma assessment tools, such as the Pediatric Asthma Quality of Life Questionnaire,[42] the Pediatric Asthma Caregiver's Quality of Life Questionnaire,[43] and the Child Asthma Short Form.[36,44,45] On the contrary, the correlations between the cACT scores and the physiologic tests of asthma, lung function measures and F_{ENO}, were not substantial.[36,37,39,46]

Reliability

The Cronbach α of .79 indicated good internal consistency of the cACT in the developmental study.[36] Also, the cACT had a good test-retest reliability among subjects with the same level of asthma control according to the specialists' rating ($r = 0.55$).[37]

Accuracy

Liu et al[38] found that 66% of children who were classified as having "very poorly controlled" asthma according to NAEPP EPR-3 guidelines scored 12 or less on the cACT. Those children had a lower mean percent-of-predicted FEV_1, had more frequent prescriptions to step-up therapy, and were more frequently rated as having severe asthma compared with those who scored 13–19. On the other hand, another study reported that a cACT score of ≥ 22 indicated well-controlled asthma, according to the 2008 GINA guidelines.[28,29]

Responsiveness

Changes in the cACT scores correlated well with changes in specialists' ratings of asthma control but correlated poorly with changes in peak expiratory flow rate.[37] A score change of 2 points was recently identified as the minimum clinically important difference for cACT.[29]

Asthma Control Questionnaire

The ACQ is another multidimensional, standardized, patient-centered test and is the most widely used asthma control assessment tool in clinical trials.[14,40,47] The ACQ was developed specifically to quantify levels of asthma control defined by international guidelines (ie, the British Thoracic Society 1990 guidelines for management of asthma in adults,[48] the National Heart, Lung, and Blood Institute 1992 international consensus report on diagnosis and treatment of asthma,[49] and the Thoracic Society of Australia and New Zealand 1989 asthma management plan).[50] The ACQ involves asking patients to recall their experiences in the previous week and to respond to 6 questions on a 7-point scale about 5 asthma symptoms (nighttime waking, symptoms on waking, activity limitations, shortness of breath, and wheezing) and about the frequency of using short-acting β_2 agonists. The seventh item is the percent-of-predicted FEV_1 before bronchodilator, which is recorded by a clinician. The ACQ score is the mean of the 7 items, which gives all items equal weight. An ACQ score has a range from 0 (totally controlled) to 6 (severely uncontrolled).[47]

Ideally, the complete 7-item ACQ should be used. However, performing lung function testing or collecting data about the use of short-acting β_2 agonist bronchodilators is not always feasible. Therefore, 3 shortened versions of the ACQ were developed and validated: symptoms only (ACQ-5); symptoms plus FEV_1 (ACQ-6a); and symptoms plus β_2 agonist (ACQ-6b).[51] Juniper et al[52] conducted a study to determine whether the questions concerning β_2 agonist use and lung function testing can be removed from the ACQ for large studies without altering the validity and the measurement properties of the tool. The authors reported no evidence of a difference in scores between the complete ACQ (which is here referred to as the ACQ) and ACQ-6a. However, significant differences were noted between the ACQ and ACQ-5 and between the ACQ and ACQ-6b. Thus, omitting FEV_1 as in ACQ-6b and in ACQ-5 could affect the possibility of using those 2 versions interchangeably with other versions of the ACQ.

Although the ACQ was initially developed for adult patients with asthma, its ability to quantify asthma control level in children was evaluated as well. Recent studies found that the ACQ is valid for use in children 6–17 y old. However, a trained interviewer is required to administer the questionnaire to children 6–10 y old.[53,54]

Validity

The extensive validation data of the ACQ resulted in the ACQ being designated as a core measure for NIH-initiated clinical research in adults.[40] The ACQ has been validated for use as a self-administered tool in-person, at home, or by telephone.[40] Moderate to strong correlations resulted from comparing the ACQ with the AQLQ ($r = 0.76$),[54] Mini Asthma Quality of Life Questionnaire ($r = 0.72$ and 0.74),[55] the Medical Outcomes Survey Short Form-36 (SF-36) ($r = 0.19–0.55$),[56] and the ACT ($r = -0.82$ to -0.89).[13,14,19]

The correlations between the ACQ and the shortened versions were high ($r = 0.87$ with ACQ-5, 0.98 with ACQ-6a, and 0.92 with ACQ-6b).[57] A post hoc analysis of 2 large clinical trials showed that all versions of the ACQ were strongly correlated with each other and with the overall score from the AQLQ for both baseline and change scores.[57] In another study, Juniper et al[58] reported that these 3 shortened versions can be used in large clinical trials without loss of validity or change in interpretation. Also, when the 4 versions were compared with each other, substantial concordances in both cross-sectional and longitudinal va-

lidity were noted. However, the 4 versions of ACQ had variable agreement when compared with the 2008 GINA and the NAEPP EPR-3 criteria for asthma control. Thus, although each version is valid in its own right, the lack of consistent agreement between them and the guidelines may make it invalid to use them interchangeably.

In children with asthma, the ACQ demonstrates a good construct validity, as indicated by its strong correlation with the Mini Pediatric Asthma Quality of Life Questionnaire,[59] Asthma Control Diary,[60] the ACT and cACT, the Pediatric Asthma Quality of Life Questionnaire,[42] and the Asthma Symptom Utility Index.[53,54,61] Also, the ACQ discriminates between groups of children with asthma based on the presence or absence of clinical events related to asthma control.[53,54]

Reliability

The ACQ has shown high reliability in adult subjects who remained clinically stable between consecutive visits to the clinic (an intraclass correlation coefficient of 0.90).[14] Also, the mean reliability data provided by the 3 shortened versions of the ACQ were very concordant with the original ACQ at baseline measurement (intraclass correlation coefficient >0.94).[58] The children's version of the ACQ demonstrated fair to good internal consistency (Cronbach α of .42–.82) and moderate test-retest reliability (intraclass correlation coefficient = 0.53).[54]

Accuracy

Juniper et al[62] have established the ACQ cutoff points for controlled asthma (≤ 0.75 points) and not well-controlled asthma (≥ 1.5 points). However, a more recent study by Olaguibel et al[63] reported poor correlation between these cutoff points and the GINA guidelines' classification of asthma control. Olaguibel et al[63] argued that Juniper et al[62] utilized a composite of GINA/NAEPP EPR-3 guidelines for the data collected in the clinical trial diaries and clinic records to define the level of asthma control. Instead, Olaguibel et al[63] proposed cutoff points of <0.5 for controlled asthma, 0.5–0.99 for partly controlled asthma, and ≥ 1 for uncontrolled asthma.[64] For the children's version of ACQ, a cutoff value of 1.25 for distinguishing between well-controlled and poorly controlled asthma was reported.[54]

To assess the ability of the ACQ to predict future exacerbations, Bateman et al[64] reported a marked increase in the risk of future exacerbations in subjects with ACQ-5 scores of ≥ 0.75 compared with subjects with ACQ-5 scores of <0.05. In another study, Meltzer et al[65] reported that with each point increase in the ACQ score, there is a 50% higher risk of exacerbations.

Responsiveness

The ACQ was found to be more responsive to changes in asthma control status than the 2008 GINA classification of asthma control.[28,51] Furthermore, changes in the ACQ score agreed well with the changes in AQLQ and SF-36.[14] No evidence of difference in responsiveness between the original ACQ and the 3 shortened versions was reported.[51]

The minimum clinically important difference for the ACQ was found to be 0.5 for the original ACQ and slightly variable for the other versions (0.52 for ACQ-5, 0.46 for ACQ-6a, and 0.49 for ACQ-6b).[58] For the children's version, a similar minimum clinically important difference was reported (0.52) in the initial validation study with a sample of 35 children.[53] However, a study with a larger sample size ($n = 305$) reported a change of 0.40 as the minimum clinically important difference among children.[54]

Asthma Therapy Assessment Questionnaire

The ATAQ is a brief, self-administered tool, developed to identify individuals (18 y and older) with possible asthma control problems. The questionnaire assesses the level of asthma control during the prior 4 weeks by asking the patient about: (1) self-perception of asthma control; (2) missed work, school, or normal daily activities due to asthma; (3) nighttime waking due to asthma symptoms; and (4) use of short-acting β_2 agonist bronchodilators. Respondents are graded as either having or not having a control problem in each one of these 4 items; the item scores are then summed to provide a total, which ranges from 0 (no asthma control problems) to 4 (4 asthma control problems).[8,40,66,67] Skinner et al[71] developed a parent completed ATAQ version to identify children and adolescents (5–17 y old) with current problems in asthma control. This version was derived from the adult version developed by Vollmer et al.[66]

Validity

Cross-sectional and longitudinal correlation between ATAQ and health-care utilization has qualified the ATAQ as a supplementary measure for NIH-initiated clinical research in adults.[40] Vollmer et al[66] reported that only 2% of those with an ATAQ score of 0 had been hospitalized for asthma in the past year, versus 24% of those with an ATAQ score of 4. In a 12-month prospective study,[67] subjects with ATAQ scores of 3 or 4 (ie, 3 or 4 control problems) were 5 times more likely to be hospitalized, 5.4 times more likely to be seen in an emergency department, and twice as likely to have routine asthma care visits compared with subjects with no control problems.

The ATAQ was also used to assess the economic burden of uncontrolled asthma. Sullivan et al[68] reported that

the costs for uncontrolled asthma, as indicated by the ATAQ score, were more than double those with scores indicating controlled asthma. Also, a higher ATAQ score (more control problems) was associated with lower quality of life in subjects with asthma, indicated by generic and disease-specific quality of life measures, such as the SF-36, the standardized version of the Asthma Quality of Life Questionnaire,[12] and the Mini Asthma Quality of Life Questionnaire.[55,68] Furthermore, a strong correlation and similar performance were reported between the ATAQ and the ACT at home and in clinical settings ($r = -0.73$).[25,69,70]

Reliability

The reliability of the ATAQ has not been evaluated for the adult version. However, in the developmental study of the children and adolescent ATAQ, the Cronbach α of .75 indicated good internal consistency of the ATAQ.[71]

Accuracy

An ATAQ score of 1 or greater was used as an established cutoff value for uncontrolled versus controlled asthma. Also, the ATAQ score of 3 or greater is the defined cutoff for the NAEPP EPR-3 category of "very poorly controlled" asthma.[4]

Responsiveness

In a prospective study,[72] subjects' ATAQ scores at baseline were significantly associated with asthma-specific health-related quality of life at follow up (Mini Asthma Quality of Life Questionnaire: $r = -0.49$), where a higher number of control problems was associated with an incremental reduction in quality of life. The minimum clinically important difference for ATAQ has not yet been established.

Lara Asthma Symptom Scale

The LASS has been developed to measure asthma control in both children[73] and adults[74] with asthma. Initially, the LASS was developed as an English and Spanish symptom scale to measure asthma control in children of non-English-speaking populations. Later, an adult version was developed. The LASS is composed of 8 items that assess the frequency of cough, wheezing, shortness of breath, asthma attacks, chest pain, nocturnal symptoms, and overall perception of asthma severity over the previous 4 weeks. Each item is scored on a 5-point scale with the descriptors: never, a few days, some days, most days, and every day. Subsequently, responses for each of the 8 items are summed to yield total scores that range from 8 to 40, with higher scores representing more severe asthma symptoms.[73] The adult version of the LASS is completed by the patient, and the children's version is completed by the parents of the child with asthma.

Validity

Lara et al[73] assessed the construct validity of the children's version of the LASS score in a sample of Latino parents of children with asthma. The authors reported moderate to strong association between both English and Spanish LASS scores and other measures of functional status, such as asthma-related school days lost ($r = 0.53$) and asthma-related activity days lost ($r = 0.50$). Weak correlations were observed between the LASS scores and the use of a bronchodilator ($r = 0.21$), asthma-related emergency department visits ($r = 0.18$), and hospitalization ($r = 0.19$).[73] The correlation between LASS scores and the lung function tests was weak with percent-of-predicted FEV_1 ($r = -0.20$) and insubstantial with percent-of-predicted peak flow.[73] Similarly, LASS scores of the adult version showed strong correlation with AQLQ and weak correlation with FEV_1, asthma-related emergency department visits, and hospitalizations.

Reliability

The LASS had a high internal consistency in both adult and child populations. The Cronbach α was .84 in the children's version[73] and .84 in the adult version.[74] A Chinese version of the LASS showed high internal consistency as well (Cronbach $\alpha = .87$).[75]

Accuracy

Although the design of the LASS specifies that a higher score indicates more symptoms, the cutoff values that distinguish between patients' different levels of asthma control have not been established.

Responsiveness

In the developmental study,[73] the responsiveness of the LASS was assessed by measuring the changes in the total scores related to the changes in the health status. The total scores were lower after resolution of asthma exacerbation compared with the scores during the exacerbation. Also, the changes in the adult LASS scores had a weak correlation with the changes in the AQLQ scores ($r = -0.70$) and with the changes in percent-of-predicted FEV_1 ($r = -0.14$).[74]

The minimum clinically important difference for the LASS scores was defined for the adult population only.[40] Wood et al[74] compared the changes in LASS scores with the predetermined clinically important changes in FEV_1

Table 1. Characteristics of Asthma Control Assessment Tools

Questionnaire	No. of Items	Target Age, y	Recall Window, wks	Scoring System	Validated Methods /Settings of Administration	Questionnaire Content						Validity	Reliability	Responsiveness
						Symptom Frequency	Reliever Use	Activity Limitation	Nocturnal Symptoms	Exacerbation	Additional Measures			
ACT	5	>12	4	Score ranges from 5 to 25: >19 = controlled; 16–19 = not well controlled; <16 = very poorly controlled. Minimum clinically important difference = 3 points.	Clinical settings, Home, Phone, Mail, Internet	Yes	Yes	Yes	Yes	No	Self-perception of control	Nathan et al[9]; Schatz et[13]; Alpaydin et al[11]; Alvarez et al[15]; Schatz et al[25]; Zhou et al[19]	Nathan et al[9]; Schatz et al[13]	Schatz et al (2006), Schatz et al[35]
cACT	7	4–11	4	Score ranges from 0 to 27: ≥22 = well-controlled; <19 = uncontrolled. Minimum clinically important difference = 2 points.	Clinical settings, mail, home	Yes	No	Yes	Yes	No	Self-perception of control	Liu et al[36]; Chen et al[37]; Yu et al[41]; Yoon et al[46]	Liu et al[36]; Chen et al[37]	Chen et al[37]
ACQ	6	>12 or 6–17	1	Score ranges from 0 to 6: <0.5 = controlled; 0.5-<1 = partially controlled; >1 = uncontrolled. Minimum clinically important difference = 0.5 points for adults or 0.4 points for children.	Clinical settings, home, phone, mail	Yes	Yes	Yes	Yes	No	FEV_1	Juniper et al[14]; Juniper et al[60]; Juniper et al[58]; Schatz et al[13]; Juniper et al[53]; Nguyen et al[54]; Wyrwich et al[57]	Juniper et al[14]; Juniper et al[58]; Nguyen et al[54]; Wyrwich et al[57]	Juniper et al[14]; O'Byrne et al[51]
ATAQ	4	≥18	4	Number of control problems: 0 = controlled; 1–2 = not well controlled; 3–4 = very poorly controlled. Minimum clinically important difference not identified.	Clinical settings, mail, home	No	Yes	Yes	Yes	No	Self-perception of control	Vollmer et al[66]; Vollmer et al[67]; Sullivan et al[68]; Ozoh et al[69]	Skinner et al[71] (children and adolescents ATAQ)	Chen et al[72]

(*Continued*)

Table 1. Continued

Questionnaire	No. of Items	Target Age, y	Recall Window, wks	Scoring System	Validated Methods /Settings of Administration	Questionnaire Content: Symptom Frequency	Reliever Use	Activity Limitation	Nocturnal Symptoms	Exacerbation	Additional Measures	Validity	Reliability	Responsiveness
LASS	8	>3	4	Score ranges from 8 to 40, with higher scores representing more severe asthma symptoms. Minimum clinically important difference = 7 points.	Clinical settings	Yes	No	No	Yes	Yes	Parental perception of child's control	Lara et al[73]; Wood et al[74]	Lara et al[73]; Wood et al[74]; Chia and Li (2007)	Lara et al[73]; Wood et al[74]

ACT = Asthma Control Test
cACT = Childhood Asthma Control Test
ACQ = Asthma Control Questionnaire
ATAQ = Asthma Therapy Assessment Questionnaire
LASS = Lara Asthma Symptom Scale

(12% change)[76] and AQLQ (a change of 0.5 points).[77] The authors reported that a change of 7 points in the LASS would represent a clinically important difference.

Summary

To facilitate an accurate and objective assessment of asthma control, tools that are multidimensional, simple, and relatively short and easy to administer have been developed. The most commonly utilized tools are the ACT, cACT, ACQ, and ATAQ. Because those tools were designed to capture the overall level of asthma control, there are many similarities in their content. Nonetheless, considerable differences between them still exist. For instance, they use different ranges for their scoring systems. Whereas the ACQ is scored using a 7-point scale, from 0 (totally controlled) to 6 (extremely poorly controlled), the ACT total score ranges from 5 (poor control of asthma) to 25 (complete control of asthma). The targeted patient age is another difference among tools. The LASS, for instance, has been developed for patients of all ages[73] The cACT, however, has been developed for patients 4–11 y old.[36] Table 1 features the similarities and differences between the reviewed asthma control assessment tools.

Despite the reported merits of these tools, they are not without shortcomings. A recent study conducted by Vermeulen et al[78] reported that only moderate agreement (r = 0.41–0.6) exists between the ACT, ACQ, ATAQ, and 2009 GINA levels of asthma control. This finding limits the ability to use these tools interchangeably. Also, a review by Halbert et al[10] highlighted the discrepancy between the content of most of the tools and the national and international guidelines. Whereas the ACQ and ACT are closely aligned with the 2015 GINA and NAEPP EPR-3 guidelines, neither tool assesses the risk of asthma exacerbations, which is an integral part of both guidelines' criteria of asthma control. Nevertheless, the LASS was the only tool reviewed above that evaluated the risk of asthma exacerbations as part of its assessment. Furthermore, the ACQ is the only tool included in the above review that comprises lung function as part of the asthma control measure. Despite the fact that measures of lung function are infrequently performed because spirometry equipment is costly and is not always available,[79] these measures are considered an essential criterion of asthma control in both the 2015 GINA and NAEPP EPR-3 guidelines.[10] On the other hand, some of these tools evaluate asthma control concepts not included in the guidelines, such as the patient's perception of asthma control in the ACT, cACT, and ATAQ and specific asthma symptoms, such as shortness of breath in ACT, wheezing in the ACQ, and coughing and chest pain in the LASS.

Knowledge of the psychometric properties of asthma control assessment tools is critical to ensure that the tool

selected will measure the desired outcome. Among the tools reviewed, the ACQ has been used in the majority of clinical trials, and the ACT has the most published validation data. Both tools have been validated for use as self-administered tools in person, at home,[40] or by telephone[26] and in different languages.[18-20] For children, the cACT has more validation data than other tools that target children with asthma.[37-39] Also, the populations used in the validation studies vary between tools. For instance, in the United States, studies have included mostly white patients. Furthermore, the modes and settings in which those tools can be administered vary as well (ie, in-person, at home, over the telephone, in various clinical settings, or over the internet). Thus, clinicians not only need to review the results of the psychometric properties of tools, but they need to also consider whether the tool was evaluated with a similar population and in a similar setting as their intended use.

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