
Reliability and factor analysis of the Spanish version of the Asthma Control Test

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Background: The Asthma Control Test (ACT) has been developed to evaluate asthma control and to reflect its nature. A Spanish version of the test has been widely disseminated to physicians, but it has not yet been validated.

Objectives: To examine the psychometric properties of the Spanish version of the ACT.

Methods: A total of 322 asthmatic patients with a mean (SD) age of 43.8 (17.3) years (range, 12–84 years) with appropriate criteria for inclusion completed the ACT. Spirometric variables were measured and asthma severity was rated by physicians.

Results: Internal consistency reliability was 0.79. The ACT showed weak correlation coefficients with forced expiratory volume in 1 second (FEV₁) ($\rho = 0.27$; $P = .01$) and asthma severity ($\rho = -0.19$; $P = .01$). Almost 40% of patients with an FEV₁ less than 60% of predicted rated their asthma as well or totally controlled; conversely, 70% of patients with asthma well or totally controlled showed an FEV₁ less than 80% of predicted. The factor analysis revealed a 2-factor solution: the first component included the 5 items of the ACT (subjective component), and the second component included the spirometric measures (objective component). The 2-factor solution accounted for 66.2% of the total variance.

Conclusions: These data reveal a unidimensional structure of the ACT and do not support the use of this test without spirometry in the management of asthma. Spirometry provides important complementary information about asthma severity that may be used in conjunction with clinical assessments of control to provide optimal management in many patients.

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INTRODUCTION

Asthma is a multifaceted chronic inflammatory disorder of the airways associated with episodes of hyperresponsiveness, airflow obstruction, and respiratory symptoms.¹ Recently, current guidelines have emphasized the concept of asthma control. Thus, the goal of asthma management should be to achieve and maintain control of the disease. In a wide sense, asthma control refers to clinical manifestations (symptoms and quality of life), functional variables (spirometry), and biomarkers of inflammation. Thus, an adequate evaluation of asthma control should include subjective and objective data, such as daytime and nocturnal symptoms, limitation of activities and quality of life, need for rescue medication, lung function, exacerbations, emergency department visits, patients' perception of control, and adverse effects. This

multidimensionality of asthma control agrees with previous data on chronic and acute asthma evaluation.^{2,3}

Different studies^{4–7} suggest that many asthmatic patients are undertreated and uncontrolled. Hence, this deficiency points to the need for a simple method for assessing asthma control. The level of asthma control constitutes a relevant measure because the objective of treatment will be to control symptoms and minimize the impact of the disease on patient functioning. In the past few years, several measures have been developed for quantifying asthma control.^{8–11} Not all of these instruments include a measure of lung function, and they are being promoted for use not only in research but for patient care. In particular, the Asthma Control Test (ACT) (QualityMetric Corp, Lincoln, Rhode Island) has been designed for patient self-evaluation, and it is available in many languages (including Spanish) on the Internet (<http://www.asthmacontrol.com>). The ACT was developed (as a 5-item questionnaire) to evaluate asthma control and to reflect the multidimensionality of asthma control.¹¹ The reliability and content validity of the English version are supported by 2 studies.^{11,12} Nevertheless, data from these studies do not necessarily support the dimensionality of the test. Thus, the aim of the present study is to examine the psychometric properties of the Spanish version of the ACT; reliability and construct validity, including factor structure, were evaluated. In particular, we performed factor analysis, a relevant technique for evaluating construct test validity^{13,14} that has not been used previously in any version of the test.

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METHODS

Patients

We recruited consecutive adolescents and adults (≥ 12 years) with asthma who attended 4 outpatient pulmonary medicine clinics in Uruguay and Argentina. Patients were eligible if they had a diagnosis of asthma according to the Global Strategy for Asthma Management and Prevention report,¹⁵ were literate in Spanish, and expressed their consent to participate in the study. Patients were excluded if they had evidence of chronic obstructive pulmonary disease, cardiac disease, or recurrent chest infections. Data were collected during an 8-week period. Local ethics committees approved the study.

Measures

The ACT is a self-report questionnaire with 5 items assessing the effect of asthma on daily functioning, symptoms, and use of rescue medication.¹¹ Each item is rated on a 5-point Likert scale. A total score is obtained by summing responses for the 5 items (ranging from 5 points for poor control to 25 points for complete asthma control). The Spanish version used in this study was obtained from the Internet (<http://www.asthmacontrol.com>).

Asthma severity was classified according to the Global Initiative for Asthma (GINA) criteria.¹ Thus, asthmatic patients were subdivided into 4 categories based on the level of symptoms, airflow limitation, and lung function variability: intermittent, mild persistent, moderate persistent, and severe persistent. This classification is expert opinion based, and it has not been standardized. Pulmonary function was determined using spirometric measures. The spirometers and the procedure for testing fulfilled the American Thoracic Society criteria.¹⁶

Procedure

Participants completed the ACT during a routine clinic visit. After this, each patient underwent spirometry. Finally, the asthma severity of each patient was classified by the asthma specialist using the GINA criteria. Physicians were blinded to ACT scores and pulmonary function test results.

Statistical Analysis

Mean $\pm$ SD values were calculated for continuous variables. The reliability of the ACT was evaluated by using a measure of internal consistency (Cronbach α coefficient).¹⁷ Correlations between different variables were evaluated using Spearman ρ coefficients. One-way analysis of variance was used to test the significance of differences in mean ACT scores across different subgroups of patients. The χ^2 test with Yates correction or the Fisher exact test was used for categorical variables. Responses to the 5 ACT items and the spirometric measures were factor analyzed initially through the method of principal components. To determine the number of factors to extract, the Kaiser criterion was used (only factors with an eigenvalue, or the sum of squared factor loadings, of ≥ 1.0 should be retained in the factor analysis).¹⁴ The χ^2 test of

Bartlett¹⁸ was used to evaluate the amount of information in the correlation matrix given the relation between the number of observations and the number of variables. A statistically significant test result represented a minimum requirement for performing a factor analysis. Factors extracted were then rotated orthogonally using the Varimax procedure. All the data were analyzed using a software package (SPSS 12.0 for Windows; SPSS Inc, Chicago, Illinois). $P < .05$ using a 2-tailed test was taken as being of significance for all statistical tests.

RESULTS

A total of 322 asthmatic patients with a mean (SD) age of 43.8 (17.3) years (range, 12–84 years) with the appropriate criteria for inclusion participated in the study. Approximately 10% of the patients were 65 years or older, and 11% were younger than 20 years; they were predominantly female (almost 70%). The sample characteristics are given in Table 1. The mean FEV₁ for asthmatic patients was less than 60% of predicted for 29.2% of patients. Only 22.4% of patients had an ACT score of 20 or greater (controlled asthma). However, almost 40% of the patients believed that their asthma was well or totally controlled (ACT item 5 score of 4 or 5). Regarding asthma severity, 64.0% of patients were classified as moderate persistent or severe persistent according to the GINA criteria. Pulmonary function and asthma severity did not present significant differences by sex ($P > .05$). On the

Table 1. Characteristics of the 322 Study Patients

Variable	Value
Age, mean (SD), y	43.8 (17.3)
Sex, M/F, No. (%)	98/224 (30.4/69.6)
Height, mean (SD), m	1.62 (0.10)
Weight, mean (SD), kg	69.0 (17.2)
FVC, mean (SD), L	2.87 (0.94)
FVC, mean (SD), % of predicted	81.8 (17.1)
FEV ₁ , mean (SD), L	2.09 (0.88)
FEV ₁ , mean (SD), % of predicted	70.5 (20.4)
FEV ₁ /FVC, mean (SD)	71.4 (14.9)
Oral corticosteroid use, No. (%)	77 (23.9)
β_2 -agonists use, No. (%)	242 (75.1)
FEV ₁ , No. (%)	
<60% of predicted	94 (29.2)
60–79% of predicted	100 (31.1)
80–100% of predicted	89 (27.6)
>100% of predicted	39 (12.1)
ACT score, No. (%)	
<20	250 (77.6)
≥ 20	72 (22.4)
Asthma severity, No. (%)	
Intermittent	44 (13.7)
Mild persistent	72 (22.4)
Moderate persistent	114 (35.4)
Severe persistent	92 (28.6)

Abbreviations: ACT, Asthma Control Test; FEV₁, forced expiratory volume in 1 second; FVC, forced expiratory volume.

Table 2. Asthma Control Test (ACT) Scores by Sex

ACT item	ACT score, mean (SD)			P value
	Males	Females	Total	
1	3.51 (1.31)	3.46 (1.23)	3.47 (1.26)	.7
2	3.34 (1.34)	2.72 (1.51)	2.91 (1.49)	<.001
3	3.14 (1.50)	3.03 (1.53)	3.06 (1.52)	.5
4	3.12 (1.51)	2.62 (1.55)	2.77 (1.55)	.007
5	3.06 (1.20)	3.08 (1.21)	3.08 (1.21)	.8
Total	16.17 (4.96)	14.91 (5.12)	15.29 (5.10)	.04

other hand, females displayed worst asthma control than males (Table 2). Thus, females were more short of breath (item 3) and used more rescue medication in the past 4 weeks (item 4) than males. However, there was no significant difference in self-rated asthma control between females and males (item 5). Finally, females and males did not display differences in the severity of asthma ($P = .6$).

Reliability and Construct Validity

The internal consistency reliability of the 5 items of the Spanish version of the ACT was 0.79. Table 3 gives the correlation coefficients (ρ) among the ACT, asthma severity, and the spirometric measures. As has been previously demonstrated,¹¹ patients with lower lung function had significantly lower mean $\pm$ SD ACT total scores than patients with better lung function (FEV₁ <60% of predicted: ACT score, 13.7 ± 4.88 ; FEV₁ of 60%–79% of predicted: ACT score, 15.8 ± 4.95 ; FEV₁ of 80%–100% of predicted: ACT score, 15.6 ± 5.03 ; and FEV₁ >100% of predicted: ACT score, 16.6 ± 2.47 ; $F = 3.71$; $P = .01$). However, the positive correlation between ACT total score and FEV₁ was weak ($\rho = 0.27$; $P = .01$). In the same way, there was a low and inverse correlation between ACT total score and asthma severity ($\rho = -0.19$; $P = .01$). Thus, more severe patients tended to have worse control of their asthma. Finally, asthma severity correlated inversely with FEV₁ ($\rho = -0.47$; $P = .01$).

A close inspection of the correlations matrix showed that only 3 (items 1, 2, and 4) of the 5 ACT items presented

significant correlation coefficients with FEV₁, forced vital capacity (FVC), and asthma severity; item 4 (“How often have you used your rescue inhaler or nebulizer medication?”) showed the highest correlation. The remaining 2 items, item 3 (“How often did your asthma symptoms wake you up at night or earlier than usual in the morning?”) and item 5 (“How would you rate your asthma control during the past 4 weeks?”), did not seem to have any relation with pulmonary function and asthma severity.

Of the 128 patients who rated their asthma as well or totally controlled (item 5 score of 4 or 5), 26.6% showed some degree of everyday functioning impairment (item 1 score of 1–3), 35.9% reported some degree of shortness of breath (item 2 score of 1–3), 29.7% woke up at night or earlier in the morning 2 or more times per day (item 3 score of 1–3), and 40.6% used rescue medication 2 or more times per day (item 4 score of 1 or 2). In contrast, of the 94 patients who had an FEV₁ less than 60% of predicted, 37.6% rated their asthma as well or totally controlled (item 5 score of 4 or 5). Also, 70% of patients with asthma well or totally controlled (ACT total score ≥ 20) had an FEV₁ less than 80% of predicted (Fig 1).

Finally, we analyzed the ACT to understand how its items are structured. First, we performed a factors analysis including the 5 items of the Spanish adaptation. Only 1 component or factor was extracted ($\chi^2 = 0.0001$). This solution explained 52.3% of the total variance. Because only 1 component was obtained, the solution could not be rotated. When we performed a second analysis including all ACT items and 2 spirometric measures (FVC and FEV₁), a 2-factor solution seemed to be clinically and statistically appropriate ($\chi^2 = 0.0001$) (Table 4). These 2 factors accounted for 66.2% of the total variance. Factors extracted using this method were then rotated. The first extracted factor from the data set included the 5 items of the ACT, and it accounted for approximately 36% of the total variance, and the second factor contained the 2 spirometric measures (FEV₁ and FVC), with approximately 30% of the total variance.

Table 3. Correlation Coefficients (ρ) Among the ACT, the Spirometric Measures, and Asthma Severity

	FVC, L	FEV ₁ , L	GINA severity	ACT item					Total
				1	2	3	4	5	
FVC, L		0.87 ^a	−0.31 ^a	0.20 ^a	0.22 ^a	0.11	0.36 ^a	0.00	0.26 ^a
FEV ₁ , L			−0.47 ^a	0.24 ^a	0.22 ^a	0.11	0.37 ^a	0.02	0.27 ^a
Asthma severity				−0.19 ^a	−0.15 ^a	0.0	−0.22 ^a	−0.08	−0.19 ^a
ACT item 1					0.45 ^a	0.41 ^a	0.41 ^a	0.39 ^a	0.70 ^a
ACT item 2						0.57 ^a	0.52 ^a	0.36 ^a	0.80 ^a
ACT item 3							0.46 ^a	0.34 ^a	0.78 ^a
ACT item 4								0.21 ^a	0.73 ^a
ACT item 5									0.59 ^a

Abbreviations: ACT, Asthma Control Test; FEV₁, forced expiratory volume in 1 second; FVC, forced vital capacity; GINA, Global Initiative for Asthma.

^a $P = .01$.

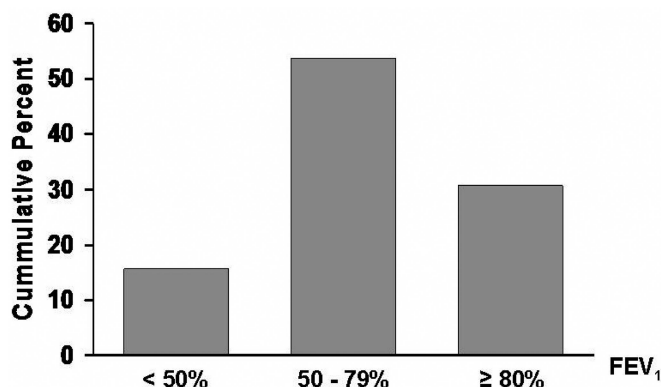


Figure 1. Cumulative percentage of patients with well or totally controlled asthma (Asthma Control Test total score ≥ 20) stratified by forced expiratory volume in 1 second (FEV₁) (percentage of predicted).

DISCUSSION

The ACT is a patient-administered tool designed to evaluate asthma control. The reliability and validity of the English version were evaluated in several studies.^{11,12} Although a Spanish version of the test has been widely disseminated for physician use, this version has not yet been validated. Thus, the aim of the present study was to examine the psychometric properties of the Spanish version of the ACT. Particularly, we applied the factor analysis technique, which has not been used previously in the validation process of any version of the test.

Several studies⁴⁻⁷ have shown that the goals of asthma treatment are not achieved. Even more, many patients who reported totally controlled asthma simultaneously also reported symptoms and frequent use of rescue medication. An important difficulty has probably been the lack of distinction between the concepts of control and severity of the disease. Thus, whereas severity represents a relatively stable characteristic of the individual that reflects the underlying disease process, level of control refers to current asthma status or adequacy of treatment.¹⁹ Although both concepts are conceptually distinct, they display a certain degree of correlation. Thus, ACT scores are not totally independent of severity; more severely asthmatic patients tended to have worse control of their asthma. Recently, guidelines have emphasized the notion that the goal of asthma treatment consists of achieving and maintaining its clinical control.¹ The ACT has been developed to meet these needs and to provide a more simplified evaluation of asthma control without the use of lung function testing. Nevertheless, the use of spirometry along with the ACT has not been clearly defined by its authors. Initially, because ACT scores and FEV₁ together explained more variance in the specialist's rating of control (a measure not validated) than either alone, they considered that the best measure of control would be a combination of both.¹¹ Later, the same authors changed their opinion and stated "we feel that the absence of spirometry is acceptable because the ACT predicts asthma control as determined by a specialist

Table 4. Rotated (Varimax) Factor Loading Matrix From a Factor Analysis of ACT Items and Spirometric Measures in 322 Asthmatic Patients

	Factor 1	Factor 2
ACT item 1	0.70 ^a	0.21
ACT item 2	0.78 ^a	0.20
ACT item 3	0.81 ^a	0.02
ACT item 4	0.61 ^a	0.41
ACT item 5	0.66 ^a	0.21
FEV ₁ , L	0.07	0.95 ^a
FVC, L	0.07	0.95 ^a
Eigenvalues	2.56	2.09
Total variance explained, %	36.4	29.8
Trace (common variance), %	55	45

Abbreviations: ACT, Asthma Control Test; FEV₁, forced expiratory volume in 1 second; FVC, forced vital capacity.

^a The highest loadings.

evaluation better than does the FEV₁."²⁰ Finally, a new study²¹ found that the ACT and spirometry were equally effective methods for identifying patients with not well-controlled asthma. Although in this study we found small but statistically significant differences in mean ACT total scores across patients differing in pulmonary function, the ACT showed low correlation coefficients with spirometric measures. This observation is consistent with previous studies^{11,12,22} and suggests that spirometry and the ACT do not evaluate the same components of asthma. Therefore, a considerable proportion of patients (38%) with severe airway obstruction (FEV₁ < 60% of predicted) reported their asthma to be well or totally controlled; conversely, 70% of patients well or totally controlled according to the ACT criteria had an FEV₁ less than 80% of predicted. Only ACT item 4 (about the use of rescue medication) showed a moderate correlation with FEV₁.

These findings are consistent with previous studies that have shown that many asthmatic patients have poor recognition of their symptoms and poor perception of symptom severity, especially if their disease is long-standing.^{23,24} Retrospective analysis of asthma deaths has emphasized the failure of patients to appreciate the severity of attack as a risk factor.²⁵ Magadle et al²⁶ observed a direct association between blunted perception of dyspnea and more emergency department visits, hospitalizations, near-fatal attacks, and deaths. Also, psychiatric and psychological mechanisms may interfere with normal behavior during asthma exacerbations and may lead to poor recognition of the severity of crisis.²⁷ Hence, spirometry provides important complementary information about asthma severity that may be used in conjunction with clinical assessments of control to provide optimal management in many patients.

In addition, this study presents data stratified by sex. Overall, males showed a higher level of asthma control than females (females had more shortness of breath and use of rescue medication). Only 2 studies^{9,20} reported data stratified

by sex indicating that men and women did not differ on the number of control problems or ACT scores. However, previous published studies^{11,12} using the English version of the ACT did not report sex characteristics in the evaluated samples. So, these differences are difficult to explain, and we do not know whether they will have some impact on the recommendation of the use of this version of the ACT. Finally, these differences cannot be explained by asthma severity because males and females were equivalent in this factor.

Earlier evidence has demonstrated that the severity of asthma constitutes a multidimensional concept. Thus, factor analysis has indicated that a description of asthma severity should include at least 3 components.² In the same way, the ACT has been designed as a questionnaire that reflects the multidimensionality of asthma control (its items refer to asthma symptoms, use of rescue medication, and impact of asthma on everyday functioning). Nevertheless, ACT multidimensionality has not been formally tested. Internal consistency evaluates the extent to which different items of a test measure the same ability or trait. They all will give low estimates of reliability if the test is designed to measure several traits (multidimensional), and they will be most reliable if they are unidimensional. The high internal consistency of ACT reliability (Cronbach coefficient) suggests the last possibility. However, to test the hypothesis of ACT multidimensionality, we initially performed a factor analysis of the 5 items of the Spanish version of the test. Because lung function measures provide important information about asthma evaluation,¹ FEV₁ and FVC were included in a second analysis. The result of the first analysis demonstrated an obvious 1-factor solution. This factor or trait included the 5 ACT items, with 52.3% of the total variance. Such a general or global factor is difficult to interpret because it represents a construct that is found to include a rather large proportion of every one of the variables analyzed. Because the common aspect in these 5 items was that all were based on patient self-report, it was denominated as "subjective control." In contrast, the second analysis showed a 2-factor solution, with 66.2% of the total variance explained. The first component included the 5 items of the ACT (subjective control), and the second the 2 spirometric measures (objective measures of airflow obstruction). These data do not support ACT multidimensionality; instead, the test showed a unidimensional structure as a global factor, and mostly independent of pulmonary function. As has been noted previously,¹¹ ACT scores and lung function measures explained more variance than either alone. So, these findings again suggest that a combination of both measures would be considered the best measure of asthma control.

In summary, this evaluation of the Spanish version of the ACT confirmed its adequate reliability. However, the data suggested that the ACT is mostly independent of lung function; a considerable proportion of patients with severe airway obstruction reported that their asthma is well or totally controlled, and conversely, many patients well or totally controlled had considerable airway obstruction. In addition, the

use for the first time of the factor analysis technique did not support its multidimensional configuration. These findings do not support the use of this test without spirometry in the management of asthma; physicians should be skeptical about substituting the ACT for objective measures of airway obstruction, such as spirometry, in the evaluation and management of asthmatic patients, and particularly in those who predominantly speak Spanish.

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