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Validity and Reliability Evidence of the Asthma Control Test – Act in Greece

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Background. The dimensionality of the Asthma Control Test (ACT) was examined in two counterview studies. Up to now, the ACT has not been validated for the Greek asthma patients. *Objective.* The present study was designed to examine the validity and reliability of the ACT responses in Greek asthma outpatients under a specialist's care. *Study design.* Following evidence for sample-specific validity, the ACT ($n = 100$) was examined through construct, cross-sectional, convergent, and discriminant validity as well as internal consistency and test–retest reliability [root mean squared error of approximation (RMSEA)]. *Results.* A one-factor solution fit the data [χ^2 (chi-square) = 3.899, *df* (degrees of freedom) 5, ns, RMSEA <0.001]. The ACT showed a high internal consistency (Cronbach alpha = 0.72) and a high 2 months test–retest reliability (IR = 0.85) for the total sample. Significant differences were found between the five categories of asthma control patients (not controlled at all, poorly controlled, somewhat controlled, well controlled, and completely controlled), according to the specialists' rating, for the ACT ($p < .001$). Significant differences were found between patients with and without asthma control ($p = .001$), patients of different gender ($p = .05$), educational status ($p = .05$), mean year income ($p = .01$), body mass index ($p = .05$), follow-up visits ($p = .01$), as well as among patients of different age ($p < .001$) and severity ($p < .001$). An ACT score of 19 or less provided optimum balance of sensitivity (98.46) and specificity (88.57) for screening 'not controlled' asthma. Cross-sectional validity testing showed moderate correlation of the ACT score with FEV1% predicted ($r = 0.57$, $p < .001$) and disability ($r = –0.42$, $p < .001$) and moderately high correlation with dyspnea ($r = –0.71$, $p < .001$). Convergent validity testing showed that the ACT score was correlated with the specialists' rating ($r = 0.89$, $p < .001$). *Conclusion.* The ACT is valid and reliable in Greek outpatients with asthma under a specialist's care.

Keywords asthma control, Asthma Control Test, reliability, validity

INTRODUCTION

The cornerstone of asthma management is to achieve and maintain the control of the disease (1). Asthma control is of major clinical importance, as the management approach and adjustments to treatment are based on it (1).

In Europe, the prevalence of self-reported 'not controlled' asthma was 48%, while the cost of healthcare services for asthma was high (2). In Greece, more than 40% of the patients under a specialist's care reported that their asthma was not well controlled (3).

Several valid and reliable questionnaires have been developed to evaluate asthma control, such as the Asthma Control Test (ACT) (4), the Asthma Therapy Assessment Questionnaire (ATAQ) (5), the Asthma Control System (ACSS) (6), and the Asthma Control Questionnaire (ACQ) (7). The assessment of asthma control with the ACT does not require FEV1, which is often not available in the primary care setting (8). The ACT is suggested as a predictor of Global Initiative for Asthma (GINA) guideline-defined asthma control (9) and has been validated in a variety of populations in different countries (2, 4, 8, 10–13). The dimensionality of the ACT was examined in two counterview studies (12, 13). Rodringo et al. (12) demonstrated the unidimensionality of the ACT, whereas Hasnaoui et al. (13) revealed a two-factor model for the ACT. Up to now, the ACT has not been validated for the Greek patients with asthma.

The theory of sample-specific validity and reliability (14–18) indicates the importance of presenting validity and reliability evidence for each instrument used in every study. Further, according to the relativism, an orientation in the cross-cultural psychology, the role of culture in behavior variation is very important so it is not feasible to use standard instruments across cultures; only local instruments may be used (18).

Based on the above, the present study was designed to provide validity and reliability evidence for the ACT in a Greek sample of asthma patients through construct, cross-sectional, convergent, and discriminant validity, as well as internal consistency and test–retest reliability (19).

METHODS

Study Population

Participants were recruited from the outpatients of the Asthma Department of the 'Amalia Fleming' General Hospital in Athens, Greece, from January to July 2009.

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Specified exclusion criteria were chronic obstructive pulmonary disease (COPD), cardiovascular disease, neurological disorders, physical disability, and inability to comprehend or complete questionnaires in Greek. Data from 100 ($n = 100$ asthma outpatients (21 men and 79 women), aged from 18 to 80 years (Mean = 49.98, SD = 16.87), were used for the purposes of the present study. All patients, clinically diagnosed according to the GINA (1), had at least a 12% improvement in FEV1 after inhalation of 200–400 μg of salbutamol (1) and were symptomatic during the past 12 months, under a specialist's care, and under controlled medications including inhaled glucocorticosteroids, long-acting inhaled β_2-agonists, and other medication according to GINA (1). With reference to asthma severity (1), 58 patients suffered from mild asthma, 32 patients had moderate asthma, and 10 patients had severe asthma. Twenty patients aged 20–47 years were current smokers, 72 patients aged 18–80 years were non-smokers, and 8 patients aged 28–74 years were ex-smokers. Sixty-three patients had asthma for more than 8 years whereas 37 patients had asthma for less than 8 years. According to BMI, 44 patients were normal/underweight (BMI < 25 kg/m^2), 34 were overweight, and 22 were obese.

The study protocol was approved by the Research Ethics Committee of the 'Amalia Fleming' General Hospital while the informed consent form was signed by all participants.

Data Collection

Patients were assessed at two scheduled specialist office visits in 0 and 2 months with the following measures: (1) a questionnaire regarding the demographic information, (2) the ACT (4), (3) the pulmonary function test (FEV1 % predicted values), and (4) the Medical Research Council (MRC) breathlessness scale (20).

Asthma control. The ACT (4) consists of five items regarding the frequency of (a) activity limitations in work or school, (b) night awareness due to asthma symptoms, (c) perceived breathlessness, (d) consumption of rescue medications, and (e) perceived asthma control. It evaluates asthma control during the previous 4 weeks. The total ACT score ranges from 5 (poorly controlled) to 25 (completely controlled). The ACT score $\leq$19 indicates the ideal discriminant cut-off score for the 'not controlled' asthma (4, 8, 11). The validity and the reliability of the ACT have been tested in many populations (2, 4, 8, 10–13). The ACT showed high internal consistency (Cronbach alpha = 0.85) and test–retest reliability (IR = 0.77). The Greek version used in the present study was obtained from GlaxoSmithKlein (GSK) under permission. It is the translated Greek version of ACT with the approval of the Hellenic Thoracic Society.

Pulmonary function testing. Pulmonary function tests (FEV1% predicted values) were performed based on the 1987 American Thoracic Society recommendations (21). The participants indicated no use of bronchodilators, at least 4 hours before the spirometry test (1) [Spiro sense spirometry system (Burdick Inc., Deerfield, WI, USA.)]. FEV1% predicted was measured at the end of each measurement's procedure.

Disability. The MRC breathlessness scale (20) quantifies the disability associated with dyspnea and ranges from 1 to 5 (the higher the score, the higher the disability level). The MRC score has shown validity and reliability evidence [98% agreement between raters and high correlation with other breathlessness scales, with lung function (22) and with direct measurements of disability (walking distance) (22)].

Severity classification was based on established GINA (1) criteria (intermittent, mild, moderate, and severe asthma). *With respect to the BMI calculation (kg/m^2)*, participants were classified into normal: <25.0, overweight: 25.0–29.9, and obese: $\geq$30.0 groups (23). *Standing height* was measured with a Raven Minimeter (Raven Equipment Limited, Essex, UK) to the nearest 0.1 cm, without shoes (24). *Weight* was measured to the nearest 0.1 kg with a Seca weighting scale (Seca, Hanover, MD, USA), without shoes, in light clothing (24).

A specialist rated asthma control based on the five categories recommended by NIH (25) are as follows: (a) not controlled at all, (b) poorly controlled, (c) somewhat controlled, (d) well controlled, and (e) completely controlled. According to Nathan et al. (4), the five categories of asthma control grouped in two categories: (a) not controlled asthma, which included the categories of not controlled at all, poorly controlled, and somewhat controlled; and (b) controlled asthma, which included the categories of well controlled and completely controlled asthma. The specialist was blinded to each patient's ACT score.

The administration as well as data collection for the ACT and MRC was conducted by the primary researcher of the present study.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) (version 13) was used for data analysis.

The construct validity of the ACT measurements was tested through factor analysis and the difference between groups (19). *Preliminary tests of exploratory factor analysis* included (a) the Bartlett's test of sphericity and (b) the KMO (Kaiser–Meyer–Olkin measure of sampling adequacy) (26).

Exploratory factor analysis was conducted through principal axis factoring with an oblimin rotation (delta = 0) (27). The consideration of the number of factors was based on (1) the scree plot test, (2) the eigenvalue-greater-than-one rule, (3) the percentage of explained variance for every factor, (4) the percentage of total explained variance for the extracted factors, and (5) the number of factors that conceptually may be explained (26). Further, specific criteria were used for the acceptance of the factor construction of the ACT: (1) factor loading >0.30 (26) and (2) item communality (h^2) >0.30 (28). For the exploratory factor analysis, the responses of the first measurement were used (29).

Preliminary tests of confirmatory factor analysis included testing of the (a) univariate skewness, (b) univariate kurtosis, and (c) multivariate normality (kurtosis) (Mardia's index) (30, 31).

For the confirmatory factor analysis, conducted with the EQS software (32), specific indices were used for the assessment of the goodness of fit such as (a) χ^2 (chi-square), *df*, χ^2/df ratio, Satorra–Bentler χ^2; (b) comparative fit index (CFI); (c) incremental fit index (IFI); (d) adjusted goodness of fit index (AGFI); (e) standardized root mean squared residual (SRMR); and (f) root mean squared error of approximation (RMSEA) and 90% CI of RMSEA (26). For the confirmatory factor analysis, the responses of the second measurement were used.

Differences between groups were performed with ANOVAs, *t*-tests with Bonferroni adjustment (27), and Pearson χ^2 statistics (33).

The reliability testing of the ACT measurements. (a) *the internal consistency* of the ACT was tested through Cronbach alpha reliability coefficients whereas (b) *test–retest reliability* was tested based on intraclass correlation coefficient (IR) between the two measurements (0, 2 months) for the 'stable' patients with asthma, as well as, for the total sample (29, 34).

The cross-sectional construct validity was tested through the correlation of the ACT score with the (a) FEV1% predicted, (b) Borg scale, and (c) MRC with the Pearson's *r* correlation coefficient.

The convergent validity was examined through the correlation of the ACT score with the specialist's rating with the Pearson's *r* correlation coefficient.

The discriminant validity was examined through the receiver operating characteristic (ROC) analysis as well as *the responsiveness* (35, 36). The criterion used for the *ROC curve analysis* was the specialist's rating (4). Sensitivity and specificity statistics, positive and negative predictive values were estimated at each cut-off score (4). *The responsiveness* was examined in a repeated measures design (2 months apart) (19). The total sample ($n = 100$) was divided into three groups according to the change in FEV1% predicted between the two measurements (2 months apart): (a) 'stable,' (b) 'improved,' and (c) 'deteriorated' (30). The responsiveness in the present study referred to the discriminant property of the ACT among 'stable,' 'improved,' and 'deteriorated' patients with asthma (29).

RESULTS

Construct Validity of the ACT: A. Factor Analysis

Exploratory factor analysis. The value of the Bartlett's test of sphericity (149.928, $p < .00001$) led to the rejection of the null hypothesis (26) for the independency of the variables. The criterion KMO (0.782) was at the appropriate range (26). The anti-image correlation matrix for each one of the five items ranged from 0.719 to 0.859, supporting the ability of their analysis. Further, kurtosis [–1.346 to –0.841 ($M = –1.180$)] and skewness [–0.687 to 0.114 ($M = –0.352$)] were in appropriate range (31), supporting the normality of the items' distribution.

Factor analysis through principal axis factoring revealed one factor with eigenvalue of 2.275, explaining a 45.494% of the total variance. Loadings and item communalities ranged from 0.470 to 0.914 ($M = 0.656$) and from 0.221 to 0.836 ($M = 0.455$), respectively. The results of exploratory factor analysis are presented in (Table 1).

Confirmatory factor analysis. The examination of the distributional properties of the ACT showed that skewness ranged from –1.08 to –0.42 ($M = –0.69$), kurtosis ranged from –1.11 to –0.38 ($M = –0.73$), and Mardia's index (normalized estimate) was 3.060, all at the appropriate range (30). The results supported the one-factor structure of the ACT whereas the indices exceeded the appropriate limits for the goodness of fit. Specifically, the CFA indices of the ACT were $\chi^2 = 3.899$, *df* 5, ns, Satorra-Bentler $\chi^2 = 2.560$, ns, χ^2/df ratio = 0.780, CFI = 1.000, IFI = 1.000, AGFI = 0.952, SRMR = 0.045, RMSEA < 0.001 (90% CI of RMSEA = 0.000–0.122). The item loadings were acceptable and ranged from 0.34 to 0.97 (Figure 1). The average off-diagonal standardized residual was 0.028 and supported the good fit of the model.

Differences Between Groups

Based on the specialist's rating (25), participants were classified into five groups: 19 patients had 'not controlled at all' asthma, 24 patients had 'poorly controlled' asthma, 22 patients had 'somewhat controlled' asthma, 28 patients had 'well controlled' asthma, and 7 patients had 'completely controlled' asthma. Significant differences were found between the five categories of asthma control, according to the specialists' rating for the ACT ($F = 91.957$, $p < .001$) (Table 2).

According to Nathan et al. (4) the aforementioned categories were divided into two groups: (a) 65 patients with 'not controlled asthma' (categories of not controlled at

TABLE 1.—Loadings and item communalities of the ACT.

Items	Item loadings	Item communalities
5	0.914	0.836
2	0.737	0.544
1	0.621	0.386
3	0.537	0.289
4	0.470	0.221
Eigen value	2.275	
% explained variance	45.494	

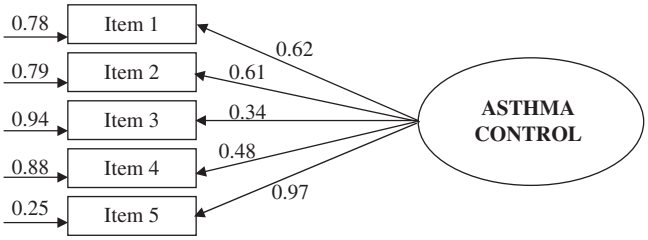

FIGURE 1.—Item loadings and errors of the ACT.

TABLE 2.—Means, SD, and *p*-values for the ACT score between the five categories of asthma control, according to the specialists' rating.

	Mean	(SD)	Categories	*p*
'Not controlled at all' asthma (category 1) ($n = 19$)	11.89	(1.85)	1–2	.05
			1–3	.001
			1–4	.001
			1–5	.001
'Poorly controlled' asthma (category 2) ($n = 24$)	14.13	(2.54)	2–3	.001
			2–4	.001
			2–5	.001
'Somewhat controlled' asthma (category 3) ($n = 21$)	17.76	(1.70)	3–4	.001
			3–5	.001
'Well controlled' asthma (category 4) ($n = 29$)	21.83	(2.63)	4–5	.05
'Completely controlled' asthma(category 5) ($n = 7$)	24.86	(0.38)		

TABLE 3.—Means, SD, and *p*-values for the ACT score between patients of different gender, duration of asthma, asthma control, residence, educational status, mean year income, body mass index, emergency department visits, and follow-up visits.

Variables	*N*	Mean (SD)	*t*	*p*
Gender				
Men	21	19.81 (3.84)	2.62	.05
Women	79	16.82 (4.82)		
Duration of asthma				
≤8 years	37	17.95 (4.73)	0.80	*ns*
>8 years	63	17.16 (4.81)		
Asthma control				
Controlled asthma	35	22.43 (2.69)	11.91	.001
Not controlled asthma	65	14.77 (3.25)		
Residence				
City	68	17.84 (4.70)	1.19	*ns*
Province	32	16.63 (4.91)		
Educational status				
≤12 years	34	16.09 (4.98)	−2.08	.05
≥13 years	66	18.15 (4.54)		
Mean year income				
≤20.000 €	58	16.41 (4.53)	−2.63	.01
>20.000 €	42	18.88 (4.78)		
Body mass index (BMI)				
Normal/underweight	44	18.64 (4.98)	2.25	.05
Obese/overweight	56	16.52 (4.43)		
Emergency department visits				
None	66	17.93 (4.77)	1.44	*ns*
More than one	34	16.50 (4.70)		
Follow-up visits				
Regular	45	18.82 (4.83)	−2.68	.01
Deterioration of symptoms	55	16.33 (4.46)		

all, poorly controlled, and somewhat controlled) and (b) 35 patients with 'controlled asthma' (categories of well controlled and completely controlled asthma). Significant differences were found between patients with and without asthma control ($p = .001$), for the ACT score, as well as between patients of different gender ($p = .05$), educational status ($p = .001$), mean year income ($p = .01$), body mass index ($p = .05$), and follow-up visits ($p = .01$) (Table 3).

Significant differences between patients with controlled and not controlled asthma were found regarding each one of the five ACT items separately: (a) activity limitations in work or school ($\chi^2 = 29.955$, $p < .001$), (b) night awareness due to asthma symptoms ($\chi^2 = 32.515$, $p < .001$), (c) perceived breathlessness ($\chi^2 = 24.802$, $p < .001$), (d) consumption of rescue medications ($\chi^2 = 21.688$, $p < .001$), and (e) perceived asthma control ($\chi^2 = 60.767$, $p < .001$). Specifically, the number of patients with controlled asthma compared to those with not controlled asthma was higher for each one of the five ACT items separately.

The ANOVA analysis showed significant differences ($F = 18.06$, $p < .001$) among patients with mild, moderate, and severe asthma, regarding ACT score. Post hoc analysis with independent sample *t*-test and Bonferonni adjustment ($0.05/3 = 0.0165$) showed significant differences for the ACT score only between patients with mild ($p < .001$) and those with severe asthma ($p < .001$). Specifically, patients with mild asthma had significantly higher ACT score than patients with moderate and severe asthma. Regarding smoking, no significant differences ($F = 0.373$, $p = .69$) were found among smokers, non-smokers, and ex-smokers. Further, ANOVA analysis showed significant differences for the ACT score

TABLE 4.—Means, SD, *F*-values, and *p*-values for the ACT score among patients of different age, severity, and smoking behavior.

			Age			
	≤30 years Mean (SD) $n = 19$	31–50 years Mean (SD) $n = 32$	51–64 years Mean (SD) $n = 23$	≥65 years Mean (SD) $n = 26$	*F*	*p*
ACT	19.26 (4.17)	18.47 (4.84)	18.04 (5.03)	14.35 (3.50)	5.959	.001
			Severity of asthma			
	Mild Mean (SD)	Moderate Mean (SD)	Severe Mean (SD)	*F*	*p*	
ACT	19.43 (4.40)	15.44 (3.93)	12.40 (2.63)	18.06	<.001	
			Smoking			
	Smokers Mean (SD)	Non-smokers Mean (SD)	Smokers Mean (SD)	*F*	*p*	
ACT	16.75 (4.73)	17.50 (4.77)	18.75 (5.20)	0.373	*ns*	

among patients of different ages ($F = 5.959$, $p < .001$). Post hoc analysis with independent sample t-test and Bonferonni adjustment ($0.05/8 = 0.006$) showed that only patients over 65 years had the lowest ACT score among all the other levels of age ($p < .001$). (Table 4) presents the responses of patients regarding age, severity, and smoking.

Discriminant Validity of the ACT

ROC curve analysis. The ROC analysis was used to define the ideal cut-off score to discriminate patients with controlled asthma from those with not controlled asthma. (Table 5) presents the responses of patients with and without asthma control, starting from point 13, as cut-off score. ACT cut-off points below 13 showed low screening accuracy. Specifically, low cut-off points have low sensitivity and high specificity, whereas high cut-off points have high sensitivity and low specificity.

Based on the ROC curve analysis, point 19 was defined as the ideal cut-off score and as the nearest point to the upper left corner (Figure 2). This means that points below 19 are false negative and false positive and point 19 is the ideal cut-off score.

The area under the ROC curve (AUC) was 0.956, significant at level 0.001. The AUC in the present study was significantly different from AUC = 0.05, providing evidence of discriminant accuracy to the ACT. In conclusion, the ACT with a cut-off score of 19 can discriminate patients with controlled asthma from those with not controlled asthma.

Responsiveness. The results of the present study showed 76 'stable' patients, 24 'improved,' and none 'deteriorated.' The repeated measures design conducted was 2 × 2 ANOVA. Significant interaction was found between clinical status ('stable,' 'improved') and time (two measurements) ($F = 117.602$, $p < .001$, $\eta^2 = 0.545$) for the ACT score (Figure 3). Post hoc analysis with repeated

TABLE 5.—Screening accuracy of the ACT based on different cut-off points.

Cut-off points	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
≤10	13.85	100.00	100.00	38.5
≤11	23.08	100.00	100.00	41.2
≤12	29.23	100.00	100.00	43.2
≤13	35.38	100.00	100.00	45.5
≤14	46.15	100.00	100.00	50.0
≤15	56.92	94.29	94.9	54.1
≤16	66.15	94.29	95.6	60.0
≤17	76.92	91.43	94.3	68.1
≤18	84.62	91.43	94.8	76.2
≤19	93.85	88.57	93.8	88.6
≤20	98.46	77.14	88.9	96.4
≤21	98.46	74.29	87.7	96.3
≤22	100.00	65.71	84.4	100.0
≤23	100.00	48.57	78.3	100.0
≤24	100.00	17.14	69.1	100.0
≤25	100.00	0.00	65.0	100.0

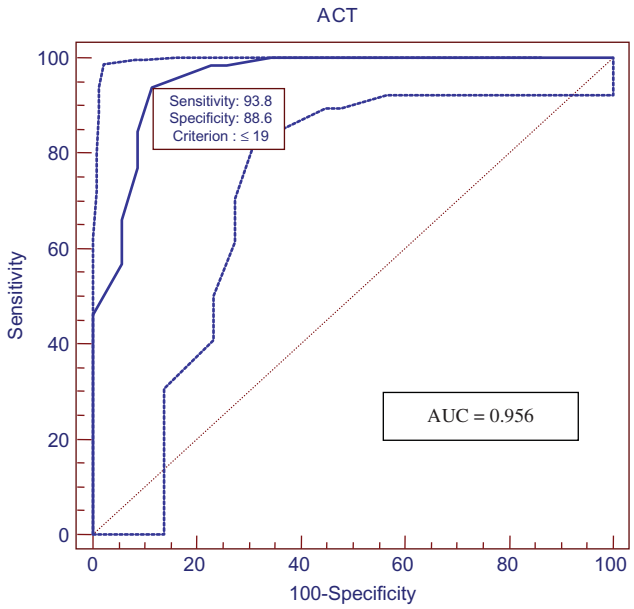

FIGURE 2.—ROC curve for the ACT.

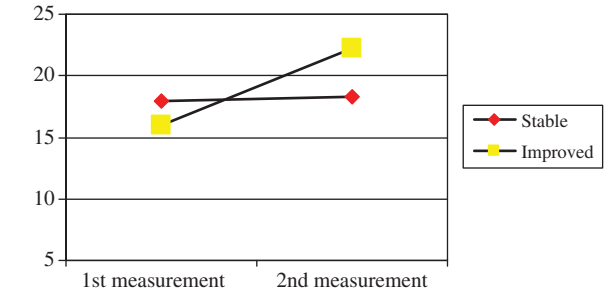

FIGURE 3.—Interaction between clinical status and time for the ACT score.

t-tests and Bonferonni adjustment ($0.05/4 = 0.0125$) examined the differences between the two groups separately for the first and second measurement. Regarding the first measurement, no significant differences were found between groups for the ACT score ($t = 1.724$, $p = .088$) ('stable': mean = 17.91, SD = 4.80, 'improved': mean = 16.00, SD = 4.49). On the contrary, referring to the second measurement, significant differences were found between the two groups ($t = -5.349$, $p < .001$) ('stable': mean = 18.24, SD = 4.61, 'improved': mean = 22.21, SD = 2.55).

Cross-sectional validity testing showed moderate correlation of the ACT score with FEV1% predicted ($r = 0.57$, $p < .001$) and disability (MRC) ($r = -0.42$, $p < .001$) and moderately high correlation with dyspnea (Borg scale) ($r = -0.71$, $p < .001$).

Convergent validity testing showed high correlation of the ACT score with the specialists' rating ($r = 0.89$, $p < .001$).

Reliability of ACT Measures

The internal consistency. The internal consistency of the ACT showed appropriate Cronbach alpha values (a) for the total sample (first measurement alpha = 0.72, second measurement alpha = 0.79), (b) for patients with

controlled asthma (first measurement alpha 0.75, second measurement alpha = 0.76), and (c) patients with not controlled asthma (first measurement alpha = 0.65, second measurement alpha = 0.75).

Test–retest reliability of ACT measures. The results of the present study showed high reliability of the repeated measures for the total sample (IR = 0.85).

Discussion

The present study examined the validity and reliability of the ACT (GSK) in a Greek sample of asthma outpatients under a specialist's care.

The exploratory factor analysis revealed a single-factor ACT model. The specific model, according to the suggested statistical criteria, explains adequately the total variance (26) and supports the unidimensional structure of the ACT. According to Nathan et al. (4), asthma control is a multidimensional structure. The dimensionality of the ACT was supported by two studies with counterview findings (12, 13). The unidimensionality of the ACT founded in the present study is in line with the findings of the exploratory factor analysis conducted by Rodringo et al. (12). In the same study, Rodringo et al. (12) did a second analysis while they added two more items regarding pulmonary function (FEV1 and FVC). The researchers found a two-factor model including the five items of the ACT (first factor) and the two items of the pulmonary function (second factor). The findings of Rodringo et al. (12) demonstrated the unidimensionality of the ACT as a distinct factor separate from pulmonary function. The principal component analysis conducted by Hasnaoui et al. (13) revealed a two-factor model for the ACT: the first factor included four items (first, second, third, fifth) with 40% of explained variability, whereas the second factor comprised the fourth item of the ACT (use of rescue treatment) with 20% of explained variability. According to Stevens (26), at least three variables are needed to describe one factor with confidence.Further, Cronbach's alpha coefficient cannot be computed for a single item (37). The findings of the exploratory and confirmatory factor analysis in the present study revealed high item loadings on the unique factor supporting the unidimensionality and overall validity of the ACT in Greece. The reliability testing, based on the reliability indices, showed that the ACT measures are reliable (27) and in line with previous studies (4, 8, 11). However, the fourth item of the ACT (use of rescue treatment) had a communality value below the cut-off score 0.30. This may be explained by the fact that the majority of the participants (58%) had never used rescue treatment/nebulizer for the past 4 weeks. Specifically, only 8 patients reported frequent use (3 or more times/day), 24 patients used rescue treatment/nebulizer once or twice/day, 4 participants reported two or three times/week, whereas 6 patients only one or less than one time/week. What is more, the fourth ACT item was problematic in the study of Hasnaoui et al. (13) because it exhibited low correlation with other ACT item scores and its removal lead to an increase in overall internal consistency.

With regard to differences between groups, more patients with 'not controlled' asthma compared to those with 'controlled' asthma, rated by a specialist, reported activity limitations in work or school, night awareness due to asthma symptoms, perceived breathlessness, and consumption of rescue medications. Further, patients with 'controlled' asthma compared to those with 'not controlled' asthma, according to the specialist's rating, had better asthma control regarding total ACT score, which is in line with previous studies (4, 8).

Further, among participants, the males, the young people, the educated, those with high income, normal BMI, and mild asthma had better asthma control (ACT score). The observation that women, compared to the men, had poorer asthma control may be due to the fact they suffer from more severe asthma, perceive dyspnea more readily which is consistent with the higher reported use of short-acting β_2-agonists (38, 39). It is, however, interesting to note that in the present study among the 100 participants the 10 patients with severe asthma were all women.

Regarding age, our finding is in line with Laforest et al. (38). The elder patients have poor perception of the control of their disease (40). Poor perception of asthma control in turn has an impact on asthma management exposing their lives to danger (41). Further, elder patients seem to have a high prevalence of noncompliance (>50%) in asthma medication (42), due to (a) their beliefs on health problems (43), (b) depression, and (c) the duration of asthma (44). Moreover, aging is associated with physical activity limitations (45), particularly for the asthmatics (46).

As regards BMI, Greek patients with normal BMI had better asthma control compared to the overweight/obese, which is in accordance with previous studies (38, 47, 48). This finding might be explained by the fact that the obese/overweight patients with asthma compared to those with normal BMI have higher activity limitations and dyspnea (49). This is due to their low fitness which results from their wrong beliefs, behavior, and attitude to the disease (50) and not because of the disease itself. Specifically, Greek overweight/obese asthma patients compared to those with normal BMI have better asthma control, lower level of physical activity in leisure time, and higher disability impact of dyspnea on daily activities (47).

Although a high percentage of Greek asthma patients prefer to consult an asthma specialist (78%) rather than any other (3), in the present study only 55% of the participants had regular follow-up visits. Further, patients with regular follow-up visits had better asthma control compared to those with follow-up visits in emergency only. This finding is in line with Soriano et al. (39) and may support that the frequency of follow-up visits to the asthma specialist is a predictor variable of asthma control.

The findings of discriminant, cross-sectional, and convergent validity testing provided further validity support. The ROC curve analysis showed that the point 19 of ACT

was the ideal cut-off score between Greek patients with and without controlled asthma, supporting the results of previous studies (4, 8, 11). Further, the responsiveness testing showed the ability of the ACT to detect clinical changes. The ideal cut-off score is an important tool: (a) in clinical practice, because it helps healthcare providers identify rather than miss patients with true 'not controlled' asthma as well as provide additional treatment (4), and (b) in research studies, to assess the effectiveness of intervention programs on asthma control (7). Overall, based on the measurement of asthma control with valid and reliable tools for each population sample (17) as well as on the ideal cut-off score, asthma professionals can improve the standards of asthma treatment in Greece reducing morbidity and direct and social costs of healthcare (51).

The correlation of ACT with FEV1% predicted was lower than the ACT with specialist's rating, which is in line with previous studies (4–7, 11). This finding supports that the specialist's rating is not concluded solely from the airway function (4, 7, 8, 11). Further, Sorkens et al. (52) stated that ACT is of higher predictive value than FEV1% and asthma control should be predicted by both variables. As regards ACT correlation with the Borg scale and the MRC, the present study showed that the lower the dyspnea and its impact on daily activities, the higher the asthma control. It should be pointed out that dyspnea was the main symptom to discriminate Greek patients with or without asthma control. Besides, dyspnea is reported as the most important and frequent symptom (70%) for Greek asthma patients (3).

Finally, the prevalence of 'not controlled' asthma in the present study (65%) is in accordance with the 65% reported by Soriano et al. (39) as well as with the global percentage reinforcing the aspect that the optimal asthma has been not achieved yet (2). The authors of the present study should expect a low prevalence of 'not controlled' asthma because the specific sample used was under a specialist's care (4). Unfortunately, this did not happen, a fact that may be explained by the high percentage (55%) of patients who used to visit the specialist in deterioration of asthma symptoms and not regularly (45%) (39). In addition, the high prevalence of 'not controlled' asthma in Greece is due to the non-compliance to asthma medications as well as to the lack of asthma education for patients or continuing medical education programs (3).

The present study has some potential limitations: (a) the sample was not random, due to the absence of Greek asthma patient records, and (b) up to now, there is no gold standard for asthma control measurements hence we used the experienced specialist's rating based on GINA (1) recommendations.

Despite the above limitations, the present study is the first that (a) examined the reliability and validity of a questionnaire regarding asthma control in Greece, (b) conducted confirmatory factor analysis of the ACT worldwide, and (c) examined the prevalence of asthma control in Greece, measured by NIH (23) criteria. The methodological power of the present study lies in the valid and standardized measures used. Further, the diagnosis and severity of asthma was not self-reported but based on GINA (1).

Conclusion

The present study showed that the ACT is valid and reliable in Greek outpatients with asthma under a specialist's care. Therefore, we may recommend it as a clinical and research tool measuring asthma control for the Greek asthmatics. The ACT may improve the partnership between Greek asthma patients and physicians, which in turn may help the screening of patients at risk, the adjustment of asthma treatment, and the patient's compliance with the guided asthma self-management.

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Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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