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ORIGINAL ARTICLE

The Asthma Control Test, Japanese Version (ACT-J) as a Predictor of Global Initiative for Asthma (GINA) Guideline-Defined Asthma Control: Analysis of a Questionnaire-Based Survey

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ABSTRACT

Background: The 2006 Global Initiative for Asthma (GINA 2006) guidelines emphasize the importance of evaluating the control rather than the severity of asthma. The Asthma Control Test (ACT) is well known to be an excellent tool for evaluating asthma control in the clinical setting. This study aimed to evaluate the ACT, Japanese version (ACT-J) as a predictor of asthma control as defined by the GINA 2006 guidelines in actual clinical practice.

Methods: A cross-sectional analysis comparing the ACT-J score and GINA classification of asthma control among 419 patients of primary care physicians and specialists was performed using the data from a 2010 questionnaire-based survey conducted by the Niigata Asthma Treatment Study Group.

Results: The optimal cut-off point of the ACT-J score for predicting GINA-defined asthma control was 23, with ACT-J scores of ≥23 and ≤22 predicting controlled and uncontrolled asthma with area under the receiver operating characteristics curve values of 0.76 [95% confidence interval (CI): 0.72-0.81] and 0.93 [95% CI: 0.90-0.97], respectively.

Conclusions: ACT scores of ≥23 and ≤22 are useful for identifying patients with controlled and uncontrolled asthma, respectively, as defined by GINA 2006, and the latter is more strongly predictive than the former. The reason for the higher cut-off point of the ACT-J relative to other versions of the ACT is unclear and warrants further investigation.

KEY WORDS

ACT, asthma control, cut-off point, GINA, ROC curve

ABBREVIATIONS

ACT, Asthma Control Test; ACT-J, Japanese version of the Asthma Control Test; AUC, area under the curve; CI, confidence interval; GINA, Global Initiative for Asthma; ICS, inhaled corticosteroid; IQR, interquartile range; LABA, long-acting beta agonist; LTRA, leukotriene receptor antagonist; OCS, oral corticosteroid; OSRT, oral sustained-release theophylline; PEFM, peak-flow meter; ROC, receiver operating characteristic; %PEF, the PEFM value as a percentage of the predicted PEFM value.

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INTRODUCTION

The Global Initiative for Asthma (GINA) and other asthma management guidelines based on the GINA guidelines have promoted remarkable improvement in asthma management.[1-3] These guidelines, including the 2006 GINA guidelines (GINA 2006), require the clinician to achieve current control of asthma and decrease the risk for future asthma exacerbation rather than merely evaluate the severity of asthma.[4,5] Therefore, it is extremely important to evaluate asthma control in each patient in order to use these guidelines appropriately, and the GINA guidelines provide the criteria for such evaluations.

As asthma is one of the most common diseases,[6-8] asthma management requires not only specialists but also general physicians, with the role of general physicians being extremely important. Studies of actual clinical care have indicated that lung function tests, including the forced expiratory volume in 1 second at peak expiratory flow and peak flow, both of which are required under most circumstances for proper evaluation of asthma control under the guidelines, are only poorly used.[3,9-11] Therefore, in actual clinical care, it is more realistic to use criteria other than lung function parameters, instead of the GINA criteria, to evaluate asthma control.

The Asthma Control Test (ACT), which was developed in 2004, is a simple, self-administrated, and rapidly completed assessment tool comprising 5 questions.[12] This tool is recognized as better for achieving asthma control[13-15] despite requiring no lung function tests. Several studies have shown that the ACT can be an excellent predictor of asthma control as defined by the GINA guidelines.[16-19] Although the Japanese version of the ACT (ACT-J) was introduced in 2006, no similar analysis of the ACT-J has yet been performed.

In 1998, the Niigata Asthma Treatment Study Group began conducting annual or biennial surveys to investigate various asthma control and management problems.[20-28] We analyzed data from the questionnaire-based 2008 survey and reported that the ACT-J is both reliable and valid.[29] In order to allow evaluation of the ACT-J as a predictor of GINA 2006-defined asthma control in actual clinical practice, the questions in the 2010 survey concerning the criteria for asthma control were based on the GINA 2006 guidelines. Therefore, the present study used data from the 2010 questionnaire-based cross-sectional survey to compare the ACT-J score and GINA classification of asthma control and analyze the usefulness of the ACT-J as a predictor of GINA 2006-defined asthma control.

METHODS

Participation in this study was open to all medical institutions in Niigata Prefecture, Japan, that intended to join the Niigata Asthma Treatment Study Group. The study was performed with the approval of the Ethics Committee at the School of Medicine of Niigata University (approval #1090) in Niigata Prefecture, Japan, in accordance with the Ethical Principles for Medical Research Involving Human Subjects (Declaration of Helsinki). Written informed consent to participate was obtained from all patients. The questionnaire was written in Japanese. The questionnaire survey was administered between September and October 2010. The subjects comprised patients aged 16 or more years with bronchial asthma who regularly visited the participating institutions for asthma management (typically once or twice per month). The recruited patients were asked to complete the questionnaire without assistance and were thus expected to understand the technical terms such as "attack" used in the questionnaire.

This questionnaire included questions concerning daytime symptoms, limitation of activities, and nocturnal symptoms/awaking during the 4 weeks prior to the survey; this information is required for the definition of asthma control under the GINA 2006 guidelines. Subjects were also asked about their use of peak-flow meters (PEFMs), most recent PEFM reading, and smoking status. Furthermore, subjects were asked a series of questions to evaluate their frequency of asthma attacks (classified as few attacks, seasonal attacks, and persistent attacks) during the year prior to the survey. Five ACT-J questions were also included in the questionnaire. Physicians were asked to monitor the subjects' completion of the questionnaire and to supply details on their current treatment, medication used for primary control, and the type of asthma (atopic or non-atopic) as indicated by the total serum IgE level or the detection of allergen-specific IgE and the overall severity of disease.

Our survey definitions of GINA asthma control are summarized in Table 1. The presence of daytime symptoms was determined from our original survey data, and the ACT-J questions were used to gauge the limitations of activities and need for reliever/rescue treatment. The presence of nocturnal symptoms/awaking was derived from both our original survey data and the ACT-J question. The decline in lung function was determined from the PEFM value. Patients who reported few attacks during the last year and no attacks during the 2 weeks prior to the survey were judged to have no asthma exacerbation, while patients reporting seasonal or persistent attacks with no attacks during the 2 weeks prior to the survey were considered to have had 1 or more exacerbations in the last year. Patients who reported asthma attacks during the 2 weeks prior to the survey were judged as having had 1 or more exacerbations in the last 2 weeks. Based on these criteria, patients were classified as having controlled, partly controlled, or uncon-

Table 1 The working definition of the GINA-defined asthma control used in this study

Levels of asthma control			
Characteristic	Controlled (All of the following)	Partly controlled (Any measure present *during the 4 weeks prior to the survey*)	Uncontrolled
Daytime symptoms †	None (twice or less/week)	More than twice/week	Three or more features of partly controlled asthma present *during any of the last 4 weeks*
Limitations of activities ‡	None	Any	
Nocturnal symptoms/awakening †, ‡	None	Any	
Need for reliever/rescue treatment ‡	None (twice or less/week)	More than twice/week	
Lung function (PEF)*	Normal	<80% predicted	
Exacerbations §	None	One or more in the last year	One or more *in the last 2 weeks*

GINA, Global Initiative for Asthma; PEFM, peak expiratory flow.

† Data derived from the survey questions.

‡ Data derived from the asthma control test questions.

§ "None" indicates the subject reported few attacks during the last year and no attacks during the 2 weeks prior to the survey. "One or more in the last year" indicates that the subject reported seasonal or persistent attacks during the last year and no attacks during the 2 weeks prior to the survey. "One or more in the last 2 weeks" indicates that the subject reported 1 or more attacks present during the 2 week prior to the survey.

trolled asthma.

The analyses evaluated the relationship between the ACT-J score and GINA-defined asthma control, taking the GINA classification as the "true" classification and the ACT-J score as the "predictor." Our analyses evaluated the relationships between the ACT-J score and GINA-defined partly controlled/uncontrolled versus controlled asthma and between the ACT-J score and GINA-defined partly controlled/controlled versus uncontrolled asthma. For the analysis, receiver operating characteristic (ROC) curves (sensitivity vs. [1 - specificity]) were plotted for the full range of ACT-J score cut-off points. The Youden index, indicating the effectiveness of the ACT-J, was calculated (The Youden index = sensitivity + specificity - 1), and used in this study. This ranges between 0 and 1, with values close to 1 indicating that the effectiveness is relatively large and value close to 0 indicating limited one. Sensitivity and specificity were used to determine the area under the curve (AUC) values with 95% confidence intervals (CI). The AUC summarizes the relationship between the 2 measures by incorporating information from all ACT-J values. If the ACT score was a perfect predictor, this area would equal 1; if it were no better than random chance, it would equal 0.5 (the straight line drawn on the ROC curves). The performance levels of the ACT-J at different cut-off points were calculated and the ROC curves drawn with the appropriate ranges of the 2 measures to make this relationship clear (Fig. 1A, B and Table 4A, B). The kappa statistic, a means of measuring agreement beyond that due to chance alone between 2 sets of categorical observations and is interpreted as follows: 0.81-1.00, almost perfect; 0.61-0.80, substantial; 0.41-0.60, moderate; 0.21-0.40, fair; 0.00-0.20, slight; and <0, poor agreement[30]; was also used for the optimal cut-off point of the ACT-J score.

Representative results for all continuous variables except the ACT scores were expressed as arithmetic means with standard deviations. ACT scores were expressed as median values with interquartile ranges (IQRs). Intergroup differences in continuous variables were evaluated using the Kruskal-Wallis test and Mann-Whitney U test with the Bonferroni correction. A $\chi 2$ test with the Bonferroni correction was used to assess the significance levels of differences in proportions between groups. All statistical analyses except the calculation of the AUC were performed with the statistical software package StatView 5.0 PowerPC version (SAS Institute, Inc., Cary, NC, USA), and the AUC was calculated using SPSS version 17 (IBM SPSS Statistics, Inc., Chicago, IL, USA). A p-value of <0.05 was considered to indicate statistical significance.

RESULTS

PATIENT CHARACTERISTICS

The study included patients from 24 large hospitals (200 beds or more), 16 small hospitals (fewer than 200 beds), and 56 clinics (no beds). A total of 4,662 questionnaires were prepared, and 2,762 responses were received (response rate: 59.2%). The rate of PEFM use in this study was 23.7%, and we analyzed data from the 419 patients with asthma who answered the questionnaire and completed the 5 questions from the ACT-J questionnaire and whose asthma control could be classified according to the GINA criteria (Table 1). The patients' characteristics, including the number of cases, age, sex, duration of disease, type of

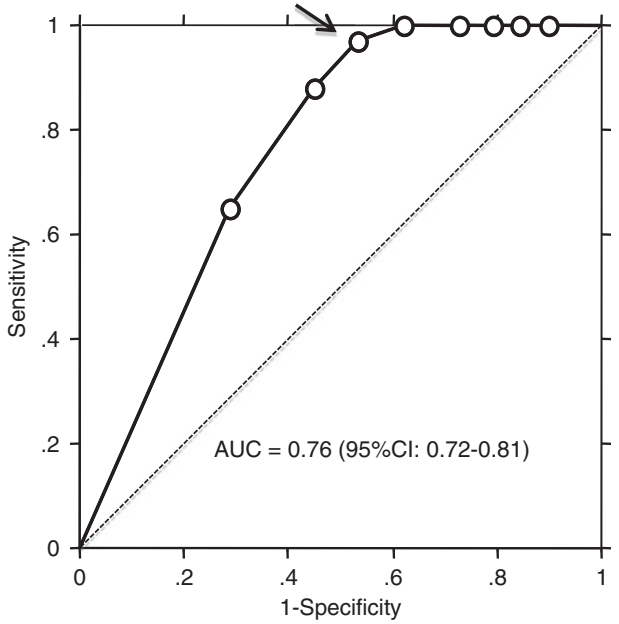

Fig. 1A Receiver operating characteristic curve for identifying controlled asthma as defined by the 2006 Global Initiative for Asthma guidelines using the Asthma Control Test. 95%CI: 95% confidence interval, °: cut-off points, arrow: cut-off point of 23.

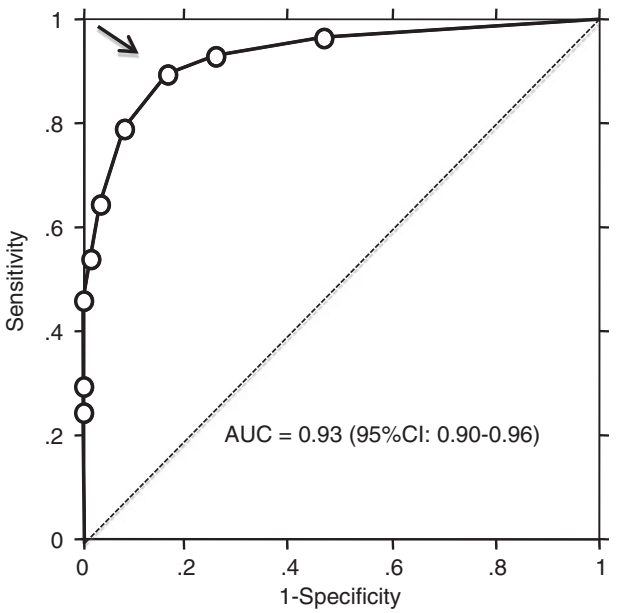

Fig. 1B Receiver operating characteristic curve for identifying uncontrolled asthma as defined by the 2006 Global Initiative for Asthma guidelines using the Asthma Control Test. 95%CI: 95% confidence interval, °: cut-off points, arrow: cut-off point of 22.

Table 2 Characteristics of patients with controlled, partly controlled and uncontrolled asthma according to the GINA definitions

GINA classification	Controlled	Partly controlled	Uncontrolled
Number od cases	168	166	85
Age (years, mean ± SD)	62.5 ± 15.0	60.3 ± 16.6	56.5 ± 16.4*
Sex (%, male/female)	34.5/65.5	45.2/54.8	42.2/57.6
Duration (years, mean ± SD)	17.5 ± 14.7	17.7 ± 15.9	19.1 ± 17.6
Type (%, atopic/non-atopic)	70.8/25.6	68.7/26.5	67.0/24.7
Smoking status			
non-smoker (%)	66.7	56.0	49.4*
ex-smoker (%)	20.8	34.9*	35.3*
current smoker (%)	11.3	9.0	15.3
Medication			
rate of ICS use (%)	89.3	95.2	91.8
rate of OCS use (%)	4.8	4.8	11.8
rate of LABA use (%)	39.3	61.5***	62.3**
rate of LTRA use (%)	49.9	60.2	64.7
rate of OSRT use (%)	32.5	46.4***	49.9***

GINA, Global Initiative for Asthma; ICS, inhaled corticosteroid; LABA, long-acting beta agonist; LTRA, leukotriene receptor antagonist; OCS, oral corticosteroid; OSRT, oral sustained-released theophylline.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ vs. controlled asthma.

disease, smoking status and medication are summarized by asthma control classification (controlled, partly controlled, or uncontrolled asthma) in Table 2. None of these characteristics differed significantly among the 3 classifications except for the age of patients with uncontrolled asthma ($p < 0.05$). The proportion of non-smokers was significantly lower ($p < 0.05$) among patients with uncontrolled asthma and the proportions of ex-smokers significantly higher ($p < 0.05$) among those with partly controlled and uncontrolled asthma than among those with controlled asthma. The rates of LABA and OSRT use were sig-

Table 3 Indicators of asthma control in patients with controlled, partly controlled and uncontrolled asthma according to the GINA definition

GINA classification	Controlled	Partly controlled	Uncontrolled
Frequency of asthma attacks in the year prior to the survey			
Few attacks (%)	94.0	48.2***	20***, #
Seasonal attacks (%)	0.0	44.6***	37.6***
Persistent attacks (%)	0.0	1.8	30.6***, #
Not described	6.0	5.4	11.8
Asthma attacks in the 2 weeks prior to questionnaire			
Attacks (%)	0.0	0.0	60.1***, ###
No attacks (%)	97.6	94.6	34.1***, ###
Not described (%)	1.2	5.4	5.8
%PEF (mean +/- SD)	101.2 ± 16.6	84.6 ± 27.6***	76.4 ± 21.1***
ACT (median, [IQR])	25 [24-25]	24 [23-25]***	19 [17-21]***, ###

GINA, Global Initiative for Asthma; ACT, asthma control test; IQR, interquartile range; %PEF, peak expiratory flow as a percentage of the predicted peak-flow value.

***$p < 0.001$ v.s. controlled asthma, #$p < 0.05$, ###$p < 0.001$ vs. partly controlled asthma.

nificantly higher ($p < 0.001$ or $p < 0.01$) among patients with partly controlled and uncontrolled asthma than among those with controlled asthma.

INDICATORS OF ASTHMA CONTROL

The indicators of asthma control are individually summarized in Table 3. The proportions of patients with few, seasonal, and persistent attacks during the year prior to the survey in the controlled, partly controlled, and uncontrolled asthma groups were 94.0, 0.0, and 0.0%; 48.2, 44.6, and 1.8%; and 20.0, 37.6, and 30.6%; respectively. The proportions of subjects with few attacks were significantly lower ($p < 0.001$) in the partially and uncontrolled asthma groups than in the controlled asthma group, and the proportion with few attacks was significantly lower ($p < 0.05$) in the uncontrolled asthma group than in the partially controlled asthma group. The proportions of subjects with seasonal attacks were significantly higher ($p < 0.001$) in the partly controlled and uncontrolled asthma groups than in the controlled asthma group, and the proportion with persistent attacks was significantly higher in the uncontrolled asthma group than in the controlled ($p < 0.001$) and partially controlled ($p < 0.05$) asthma groups.

The proportions of subjects reporting attacks and no attacks during the 2 weeks prior to the survey in the controlled, partially controlled, and uncontrolled asthma groups were 0.0 and 97.6%; 0.0 and 94.6%; and 60.1 and 34.1%; respectively. The proportions of those reporting attacks and no attacks were significantly higher and lower ($p < 0.001$), respectively, in the uncontrolled asthma group than in the controlled and partially controlled asthma groups.

The peak expiratory flow (PEF) values as percentages of the predicted PEF (%PEF, mean ± SD) in the controlled, partly controlled, and uncontrolled asthma groups were 101.2 ± 16.6, 84.6 ± 27.6, and 76.4 ± 21.1%, respectively. The %PEF values were significantly lower ($p < 0.001$) in the partly controlled and uncontrolled asthma groups than in the controlled asthma group. The ACT-J scores (median [IQR]) of the controlled, partly controlled, and uncontrolled asthma groups were 25 [24-25], 24 [23-25], and 19 [17-21], respectively. The ACT-J scores were significantly lower ($p < 0.001$) in the partly controlled and uncontrolled asthma groups than in the controlled asthma group, and the ACT-J score was significantly lower ($p < 0.001$) in the uncontrolled asthma group than in the partly controlled asthma group.

ACCURACY OF ACT-J SCREENING DETERMINATION OF THE OPTIMAL ACT CUT-OFF POINT

The performance of the ACT-J score for identifying patients with controlled asthma is summarized in Table 4A, which shows the performance levels of the ACT-J score at different proposed cut-off points. A cut-off point of <18 yielded poor ACT-J classification accuracy and was therefore dismissed. An ACT cut-off score of 23 produced the maximum value of the Youden index (0.44); accordingly, we used an ACT score of 23 as the optimal cut-off point for identifying patients with controlled asthma. As shown on the ROC curve, a cut-off point of 23 represents the point closest to the top-left corner (Fig. 1A), which yields the lowest rates of false-positive and false-negative screening results. The AUC value was 0.76 (95%CI: 0.72-0.81); this was calculated using not only the data shown in Table 4A but also the full ranges of the 2 measures including the data in Table 4A. An ACT-J score of ≥23 predicted GINA-defined controlled asthma with 54.9% accuracy, while an ACT-J score of ≤22 predicted GINA-defined uncontrolled/partly con-

Table 4A Performance of the ACT-J score at different cut-off points for predicting the GINA category of asthma control (controlled vs. partly controlled/uncontrolled) in all patients (n = 419)

Cut-off point	% sensitivity	% specificity	% positive predicitive value	% negative predictive value	Youden index
25	64.9	71.3	60.2	75.2	0.362
24	88.1	55.0	56.7	87.3	0.431
23	97.0	46.6	54.9	95.9	0.436
22	100.0	37.8	51.9	100.0	0.378
21	100.0	27.1	47.9	100.0	0.271
20	100.0	20.7	45.8	100.0	0.207
19	100.0	15.9	44.3	100.0	0.159
18	100.0	10.4	42.7	100.0	0.104

ACT-J, Asthma Control Test Japanese version; GINA, Global Initiative for Asthma.

Table 4B Performance of the ACT-J at different cut-off points for predicting the GINA category of asthma control (uncontrolled vs. partly controlled/controlled) in all patients (n = 419)

Cut-off point	% sensitivity	% specificity	% positive predicitive Value	% negative predictive Value	Youden Index
16	24.7	99.7	95.5	83.9	0.244
17	29.4	99.7	96.2	84.7	0.291
18	45.9	99.7	97.5	87.9	0.456
19	54.1	98.2	88.5	89.4	0.523
20	64.7	96.1	80.9	91.5	0.608
21	78.8	91.6	70.5	94.4	0.704
22	89.4	86.2	62.3	97.0	0.756
23	92.9	76.3	50.0	97.7	0.693
24	96.5	53.3	34.5	98.3	0.498

ACT-J, Asthma Control Test Japanese version; GINA, Global Initiative for Asthma.

Table 5 Number and percentage of patients with each asthma control status among the patients with ACT-J scores of ≥23 and ≤22

GINA classification	ACT-J score ≥23 number of cases (%)	ACT-J score ≤22 number of cases (%)
Controlled	163 (54.9)	5 (4.1)
Partly controlled	125 (42.1)	41 (33.6)
Uncontrolled	9 (3.0)	76 (62.3)

ACT-J, Asthma Control Test Japanese version; GINA, Global Initiative for Asthma.

trolled asthma with 95.9% accuracy. A cut-off point of ≥23 for controlled asthma yielded a kappa level of agreement for the entire patient population of 0.39.

The performance of the ACT-J score for identifying patients with uncontrolled asthma is summarized in Table 4B. A cut-off point of <16 yielded poor ACT classification accuracy and was therefore dismissed. The Youden index reached a maximum of 0.76 with an ACT score of 22, making this the optimal cut-off point for identifying patients with uncontrolled asthma. A cut-off point of 22 is also the point closest to the top-left corner of the ROC curve (Fig. 1B). The AUC value was 0.93 (95% CI: 0.90-0.97), which was also calculated using the full ranges of the 2 measures. An ACT-J score of ≤22 predicted GINA-defined uncontrolled asthma with 62.3% accuracy, while an ACT-J score of ≥23 predicted GINA-defined controlled/partially controlled asthma with 99.1% accuracy. The cut-off point of ≤22 for uncontrolled asthma produced a kappa level of agreement for the entire patient population of 0.63. The rates of controlled, partly controlled, and uncontrolled asthma among subjects with ACT-J scores of ≥23 were 54.9, 42.1, and 3.0%, respectively, while the rates of controlled, partly controlled, and uncontrolled asthma among subjects with ACT-J scores of ≤22 were 4.1, 33.6, and 62.3%, respectively (Table 5).

DISCUSSION

This study aimed to evaluate the ACT-J score as a predictor of GINA 2006 guidelines-defined asthma control in actual clinical practice; this was of interest because the ACT-J evaluation of asthma control requires no lung function tests and is suitable for use by general physicians, who play an important role in asthma management and whose use of lung function testing is not high.[3,9-11] To our knowledge, this study was the first such evaluation of the ACT-J.

When the ACT-J score was used to identify controlled asthma, we found that an ACT-J score of ≤22

predicted partly controlled or uncontrolled asthma as defined by the GINA criteria with 95.9% accuracy (Table 5). The AUC, the single most-informative measure of the ability of the ACT-J score to predict GINA-defined asthma status, was 0.76 (95% CI: 0.72-0.81) for identification of controlled asthma using this cut-off (Fig. 1). However, the AUC for identification of controlled asthma was lower than previously found for other disease categories.[31-33] Moreover, an ACT-J score of ≥23 predicted GINA-defined controlled asthma with 54.9% accuracy (Table 5), and the kappa statistic (0.39) suggested fair agreement when the cut-off point of ≥23 was used for identifying controlled asthma. On the other hand, when the ACT-J score was used to identify uncontrolled asthma, an ACT-J score of ≤22 predicted GINA-defined uncontrolled asthma with 62.3% accuracy (Table 5). The AUC for identification of uncontrolled asthma was 0.93 (95% CI: 0.90-0.97), which is higher than previously found for other disease categories.[31-33] The kappa statistic (0.63) also indicated substantial agreement for the identification of uncontrolled asthma when the cut-off point of ≤22 was used. These indicate that the ACT-J was useful for predicting the patient's GINA-defined asthma control status and was particularly useful for confirming that a patient's asthma was uncontrolled according to the GINA classification. When the cut-off point 23 in the ACT-J for predicting GINA-defined controlled asthma is used, we should pay an attention to the fact that there are some patients with some partly controlled asthma and a few patients with uncontrolled asthma among subjects with ACT-J scores of ≥23. The under-treatment may occur on such patients. To avoid this, we should manage the asthmatic patients using other clinical information as well as the ACT-J.

There are several explanations for the low value of the kappa statistic for the use of the cut-off point of ≥23 to identify controlled asthma. One of these is simply that substantial numbers of patients with an ACT-J score of ≥23 had GINA-defined partly controlled asthma (42.1%) and a few had uncontrolled asthma (3.0%). Some of the discrepancy could be explained by the different criteria for the timing of exacerbations between the ACT-J and the GINA definitions. Of patients with GINA-defined partly controlled asthma and an ACT-J score of ≥23, 25.6% failed to meet the GINA definition of controlled asthma despite having only seasonal attacks. The ACT-J lists more specific symptoms than the GINA definition, as was pointed out by Thomas *et al*..[16] On the other hand, only a few patients with ACT-J scores of ≥23 (10.3%) had GINA-defined uncontrolled asthma, resulting in a substantial kappa statistic when the cut-off point of ≤22 was used to identify uncontrolled asthma.

Another important result of this study is that the optimal cut-off point was higher than in previous studies that were performed outside Japan using non-Japanese versions of the ACT rather than the ACT-J.[16-19] The cause of this difference is unknown. The nature of asthma does not differ fundamentally among races; however, as the ACT-J relies on self-reported answers, this difference might stem from differences in how the symptoms of asthma are perceived and expressed. The intensity levels of dyspnea symptoms as experienced by individuals with asthma do not correlate well with their degrees of airway obstruction as determined by spirometry.[34,35] While patients with stable asthma always experience dyspnea after inhalation of a bronchoconstrictive agent, the degree of dyspnea associated with any fixed decline (e.g., 20%) in the forced expiratory volume in 1 second during peak expiratory flow varies widely.[36] Somatosensory amplification has recently been introduced as an explanation of the dissociation of subjective and objective symptoms in various diseases.[37,38] Somatosensory amplification has been reported to play an important role in patients with asthma.[39] Further investigation, e.g., of race-specific differences in somatosensory amplification, might be required to explain the different cut-off point of the ACT-J score.

This study has several limitations. First, there is some possibility of patient selection bias; the enrolled subjects were regular visitors at one of the participating institutes, meaning that patients with recent-onset asthma might not have been included in this study. Second, some patients with seasonal asthma might not visit medical institutes during asymptomatic periods. Therefore, there was no evidence of the efficacy of the ACT-J score in such patients. A third limitation relates to our selection of the GINA 2006 asthma control classification as the gold standard assessment of asthma control, as has previously been pointed out by Nguyen *et al*..[17] In truth, there is no real gold standard for measuring asthma control; the GINA classification is described as a "working scheme based on current opinion, which has not been validated.[17]"

In summary, this study showed that ACT scores of ≥23 and ≤22 are useful for identifying patients with controlled and uncontrolled asthma, respectively, as defined by the GINA 2006 guidelines. The AUC values of the ROC curves indicate that the latter is more strongly predictive than the former. The reason for the unusually high cut-off point of the ACT-J is unclear and warrants further investigation.

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