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ORIGINAL ARTICLE

Asthma control test via text messaging: could it be a tool for evaluating asthma control?

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Abstract

Introduction: Originally, the Asthma Control Test (ACT) was designed for English-speaking patients using a paper-and-pencil format. The Turkish version of the ACT was recently validated. This article compares the paper-and-pencil and web-based texting formats of the Turkish version of the ACT and evaluates the compatibility of these ACT scores with GINA-based physician assessments of asthma control. *Methods*: This multicentre prospective study included 431 asthma patients from outpatient clinics in Turkey. The patients were randomized into a paper-and-pencil group ($n = 220$) and a text messaging group ($n = 211$). Patients completed the ACT at Visit 1, after 10 ± 2 days, and at 5 ± 1 week to demonstrate the reliability and responsiveness of the test. At each visit, physicians assessed patients' asthma control levels. *Results*: The ACT administered via texting showed an internal consistency of 0.82. For the texting group, we found a significant correlation between the ACT and physician assessments at Visit 1 ($r = 0.60$, $p < 0.001$). The AUC was 0.87, with a sensitivity of 78.0% and a specificity of 77.5% for a score of ≤ 19 for screening "uncontrolled" asthma in the texting group. *Conclusion*: When the Turkish version of the ACT was administered via either the paper-and-pencil or text messaging test, scores were closely associated with physician assessments of asthma control.

Keywords

Control, management, quality of life

History

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Introduction

The Asthma Control Test (ACT) assesses a patient's perspective of his or her asthma control level, which clinicians can then use when evaluating the overall status of asthma control [1]. The original version of the ACT was evaluated among English-speaking patients and found to be internally consistent, reproducible, valid, and responsive to clinical changes [2,3]. The ACT has subsequently been translated into many languages and has been evaluated in various cultural settings, including in Turkey [4–11].

Schatz et al. administered the ACT by telephone using speech recognition technology and found this method of delivery to be comparable to the paper form in terms of reliability and predictive validity [12]. Another study found that ACT scores from a telephone interview are reliable and comparable to those obtained via the paper-and-pencil format [13].

Text messaging, or ''texting,'' is an innovative method of communication that is often quicker and cheaper than voice calling and is convenient in circumstances where answering

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a call is inappropriate [14]. Although previous reviews have suggested that text messaging could be a useful tool in the healthcare field, few studies have examined texting in specific settings. Preliminary data suggest that health care providers are using text messaging in novel ways. Some studies report that texting can be used to schedule and confirm appointments, thereby reducing the costs associated with non-adherence [15,16].

MacDonell et al. evaluated asthma medication use and symptoms via automated text messaging among African Americans aged 18–25 years. They suggested that text messaging might be a useful method to measure medication use and symptoms in ''real time'' [17].

Another recent study by Vasbinder et al. assessed children with asthma with insufficient asthma control who were sent real-time text-messages. They found that text-messages increase the adherence to inhaled corticosteroids (ICS) and help achieve better asthma control and better quality of life [18].

The present study compares the paper-and-pencil and web-based texting formats of the Turkish version of the ACT to evaluate the compatibility of the resulting ACT scores with physician assessments of asthma control using the Global Initiative for Asthma (GINA) guidelines [19].

The purpose of this comparison was to determine whether text messaging provided a practical, time-saving, and user-friendly method of delivering the ACT to asthma patients.

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Methods

The Turkish version of the ACT

The ACT is a self-administered questionnaire that includes 5 items that assess the frequency of shortness of breath, nighttime awakenings, the use of rescue medications, the impact of asthma on daily functioning, and overall self-assessment of asthma control. Each item includes five response options with values ranging from one to five. Responses from each of the five items are summed to yield a score ranging from 5 (*poor control of asthma*) to 25 (*complete control of asthma*). An ACT score of <20 indicates uncontrolled asthma [11].

Study population

Our prospective, observational, cross-sectional study involved 14 tertiary hospitals in different geographic regions of Turkey. A total of 478 asthma patients over the age of 16 were recruited from the outpatient clinics between February and April 2011. Asthma diagnosis was based on patient history and GINA guidelines [18]. Participants had a history of recurrent wheezing, shortness of breath, and cough, and objective signs of reversible airway obstruction with at least a 12% increase in the forced expiratory volume in one second (FEV_1) after 15 min of inhalation of 200 mcg of salbutamol. To be included in the study, patients had to comply with the study protocol and have a mobile phone with texting capabilities and the ability to write texts. We excluded patients with coexisting pulmonary diseases such as pneumonia, bronchiectasis, or empyema and those having an asthma attack at the time of enrolment. Each patient provided written, informed consent.

Study design

Of the 478 eligible asthma patients, 47 were dropped from the study because of missing data in their case report forms, and the remaining 431 cases were randomized into two groups: about half completed the paper form of the ACT ($n = 220$), and half replied to text messages sent from a website to their mobile phones ($n = 211$). The patients completed the ACT at their first admission (Visit 1), after 10 ± 2 days (Visit 2), and again after 5 ± 1 weeks (Visit 3; Figure 1). Because of technical errors on the data server, 21 patients were dropped from the study, leaving a total of 190 patients in the texting group at Visit 1 (Figure 1). During the first visit, socio-demographic variables such as age, gender, and education were recorded. Using the GINA criteria, a physical examination, and a patient history, physicians classified each patient's asthma control status as totally controlled, partly controlled, or uncontrolled.

At the second and third visits, all variables except socio-demographic data were collected again. Pulmonary function tests were administered at every visit. Patients in both groups completed the ACT themselves. For those in the texting group, a nurse or office secretary was available to answer questions about the mobile phone interface to avoid possible errors resulting from patients' inexperience and to be sure that patients focused on the questions without feeling anxiety about the technology. Afterwards, a physician assessed each patient's asthma control status blinded to the ACT outcomes.

All patients received asthma treatment (inhaled corticosteroids with or without long-acting beta agonists and short-acting beta agonists PRN) between Visit 1 and Visit 3.

Text messaging application design

A computer interface for each center was designed by the text messaging provider. The physician added the patient's phone number to the system, and the number was then sent to the text messaging provider via the Internet. When the provider received the number, the software was triggered to send the first question of the ACT via the mobile operator, Turkcell™. The first question included response options on the screen, and participants were told to press the number that best described their asthma status. The answer was transmitted to the text messaging provider via the mobile network and was recorded into a database. After receiving the first answer, the system sent the second question automatically. The process continued until the patient responded to the last question. The algorithm was similar to that used by Huang et al. [15].

Statistical analyses

Reliability

In both the paper-and-pencil and texting groups, we determined internal consistency and test–retest reliability. We computed Cronbach's alpha coefficients to estimate the internal consistency reliability of the ACT scores at each visit. We determined the test–retest reliability of the ACT scores by computing the intra class correlation (ICC) between Visit 1 and Visit 2 in stable patients (those whose control status was the same at Visits 1 and 2) in both groups.

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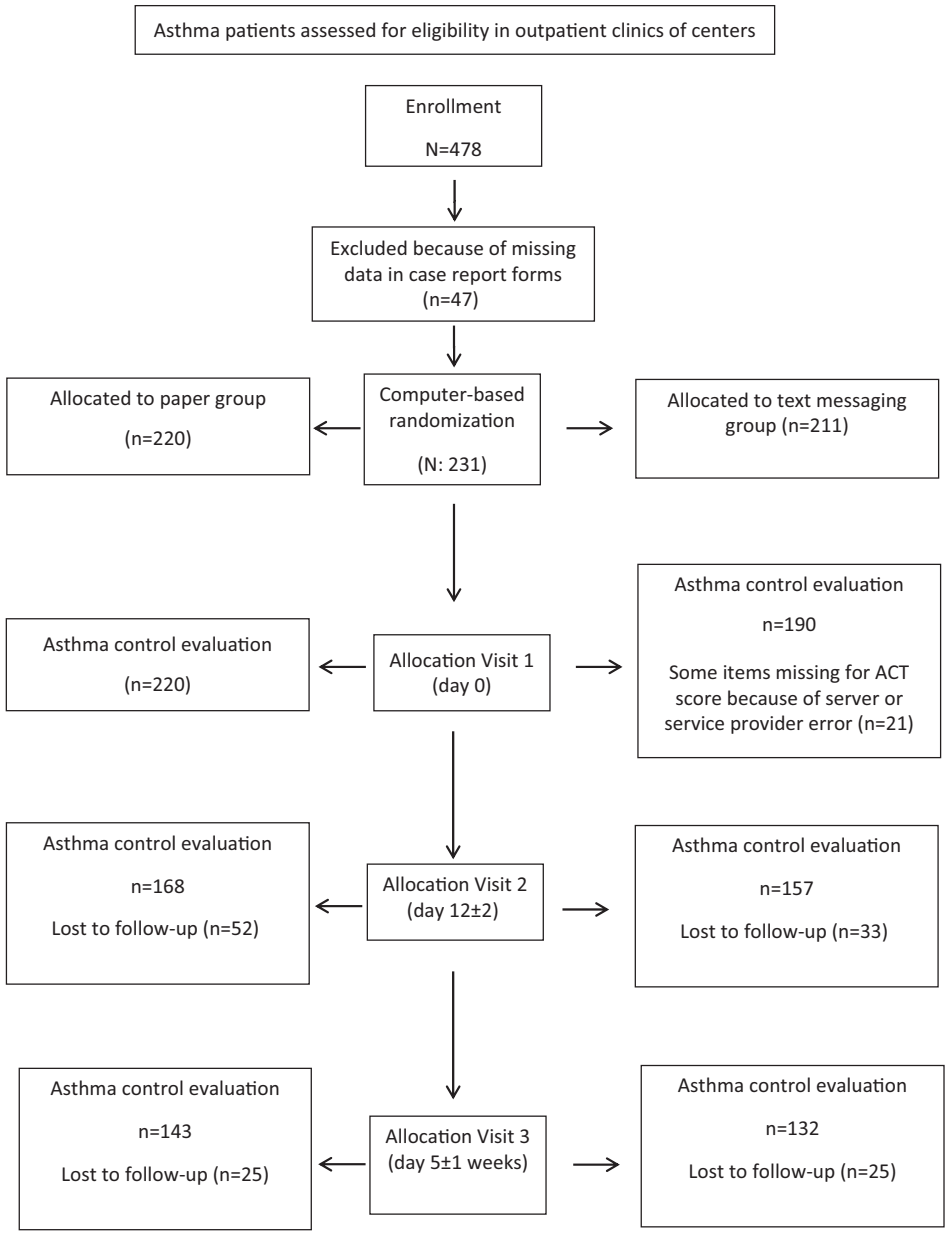

Figure 1. Flowchart and timeline of the study.

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Validity

We examined *convergent validity* through the correlation of the ACT score with the physician's assessment of the patient's control status at Visit 1, using the Spearman correlation coefficient.

Discriminant validity

For both groups, we used a one-way ANOVA test to determine known-groups validity by comparing mean ACT scores at Visit 1 of patients grouped into the three categories according to the physician-administered GINA assessments (controlled, partly controlled, and uncontrolled asthma). The second measure was predicted FEV_1% values. Patients were categorized into four groups based on their predicted FEV_1% values: <30–59%, 60–79%, 80–100% or >100%. This stratification of FEV_1% was roughly based on severity as defined by the GINA classification (one-way ANOVA test).

Screening accuracy

We used receiver operating characteristic (ROC) analysis to examine discriminant validity. The criterion used for the ROC curve analysis was physician assessment of asthma control. We conducted two different ROC curve analyses: one for identifying uncontrolled asthma and one for identifying completely controlled asthma. We calculated sensitivity, specificity, the percentage of patients' correctly classified, positive predictive values (PPV), and negative predictive values (NPV).

Responsiveness

We grouped patients according to their levels of change in asthma control between Visit 1 and Visit 3, as determined by

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physician assessment (worse, no change, improvement). We used the Jonckheere–Terpstra test to compare the changes in ACT scores across these patients groups.

Results

Our final sample consisted of 410 patients with a mean age of 37 in each of the 2 groups. At the baseline visit, physicians rated asthma control as totally controlled in 21.05% of the 190 texting patients, partly controlled in 43.15%, and uncontrolled in 35.80%. For the paper-and-pencil group, physicians rated asthma as totally controlled in 22.30% of the 220 patients, partly controlled in 38.60%, and uncontrolled in 39.10%. The difference between the two groups was not significant ($p > 0.05$). Mean ACT scores for the texting group were 21.98 ± 2.97, 16.56 ± 4.49, and 13.06 ± 4.39 for patients classified as having controlled, partly controlled, and uncontrolled asthma, respectively, according to GINA-based physician assessments. In the paper-and-pencil group, mean ACT scores were 22.65 ± 2.87, 18.32 ± 4.30, and 13.23 ± 4.23 in controlled, partly controlled, and uncontrolled asthma patients, respectively. The differences between the texting and paper-and-pencil groups were significant in the controlled and partly controlled groups ($p < 0.05$ and $p < 0.01$, respectively). Only in the uncontrolled group were the differences between the texting and paper-and-pencil groups not significant ($p > 0.05$; Table 1).

Table 1. Socio-demographic and clinical characteristics of the study population.

	Texting (*N*:190)	Paper (*N*:220)	Significance
Age, mean ± SD	37 ± 11	37 ± 12	$p > 0.05$
Males, %	30	28.2	$p > 0.05$
Education,%	43.70	47.70	$p > 0.05$
Primary, ≤8 yrs.			
Body Mass Index (BMI), mean ± SD	26.68 ± 5.33	26.45 ± 5.21	$p > 0.05$
FVC, L, mean ± SD	3.58 ± 1.00	3.49 ± 0.94	$p > 0.05$
FVC, %, mean ± SD	98.52 ± 20.63	95.73 ± 17.23	$p > 0.05$
FEV_1, L, mean ± SD	2.76 ± 0.84	2.75 ± 0.99	$p > 0.05$
FEV_1, %	88.88 ± 20.59	87.40 ± 18.85	$p > 0.05$
% predicted FEV1 categories, %			
<30–59	7.30	6.80	$p > 0.05$
60–79	23.30	23.70	
80–100	31.60	45.80	
>100	37.80	23.70	
PEF, $Lsec^{-1}$, mean ± SD	6.46 ± 5.24	6.47 ± 5.87	$p > 0.05$
PEF, %, mean ± SD	80.10 ± 23.4	75.21 ± 22.82	$p > 0.05$
ACT at baseline, mean ± SD	16.45 ± 5.32	17.30 ± 5.37	$p > 0.05$
GINA, %			
Controlled	21.05	22.30	$p < 0.05$
Partly controlled	43.15	38.60	$p < 0.01$
Uncontrolled	35.80	39.10	$p > 0.05$
ACT scores according to GINA classification, mean ± SD			
Controlled	21.98 ± 2.97	22.65 ± 2.87	$p < 0.05$
Partly controlled	16.56 ± 4.59	18.32 ± 4.30	$p < 0.01$
Uncontrolled	13.06 ± 4.39	13.23 ± 4.23	$p > 0.05$
Patients' medications,%			
Short-acting B2 agonists	68	70	$p > 0.05$
Inhaled corticosteroids alone	35	33	$p > 0.05$
Combination therapy	73	69	$p > 0.05$

SD, standard deviation; FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 s; PEF, peak expiratory flow.

Reliability

The Turkish ACT had an internal consistency of 0.82 at Visit 1 in both the texting and paper-and-pencil groups. The test–retest reliability between Visit 1 and Visit 2 showed an ICC of 0.84 (SEM: 95% CI: 0.74–0.89) among the 119 stable patients in the texting group. The test–retest reliability between Visit 1 and Visit 2 showed an ICC of 0.85 (95% CI:0.77–0.88) among the 128 stable patients in the paper-and-pencil group. The Cronbach's alphas were 0.86 and 0.86 at Visit 2 and Visit 3 in the texting group, respectively. The Cronbach's alphas for the paper-and-pencil group were 0.87 and 0.82 at Visit 2 and Visit 3, respectively.

Convergent validity

In both groups, the ACT scores correlated well with the physicians' GINA-based assessments at Visit 1 ($r = 0.60$, $p < 0.001$ and $r = 0.69$, $p < 0.001$ for the texting and paper-and-pencil groups, respectively). The ACT scores also correlated with the physicians' GINA-based assessments at Visits 2 and 3 (0.61, $p < 0.001$ and 0.62, respectively, for texting and 0.73, $p < 0.001$ and $p < 0.001$, respectively, for the paper-and-pencil format).

Discriminant validity

ACT scores were significantly different among the three GINA classifications of patients based on physician assessments for both the texting and paper-and-pencil groups ($p < 0.001$ and $p < 0.001$, respectively). Moreover, patients with poorer lung function (predicted FEV_1%) scored significantly lower on the ACT than patients with better lung function in the paper-and-pencil group ($p < 0.001$), but this result was not significant in the texting group ($p > 0.05$; one-way Anova test; Table 2).

Screening accuracy of the texting group

Patients in the texting group with an ACT score of 19 or less had a sensitivity of 78.0% and a specificity of 77.5% and were correctly classified 78% of the time (i.e. matched the physicians' GINA assessments) as having uncontrolled asthma. A cut-point score of 19 yielded an area under the curve (AUC) of 0.89 (Table 3).

When we evaluated a cut point for patients in the texting group with totally controlled asthma versus those with partly controlled/uncontrolled asthma, those with an ACT score of 19 or less showed a sensitivity of 94% and a specificity of 94% and were correctly classified 65% of the time as having uncontrolled asthma. A cut-point score of 19 also yielded an AUC of 0.78 (Table 4).

Responsiveness

For the texting group, we determined the responsiveness of the ACT by evaluating mean changes in ACT scores across groups of patients who differed in the level of change in the physicians' assessments of asthma control. We found that the

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Table 2. Discriminant validity tests on mean ACT scores at Visit 1*.

	Texting group		Paper-and-pencil group	
	ACT score, mean ± SD		ACT score, mean ± SD	
GINA classification				
Controlled	21.98 ± 2.97	$p < 0.001$	22.65 ± 2.87	$p < 0.001$
Partly controlled	16.56 ± 4.59		18.32 ± 4.30	
Uncontrolled	13.06 ± 4.39		13.23 ± 4.23	
FEV_1 predicted, %				
>100	15.78 ± 5.53	$p > 0.05$	18.53 ± 5.47	$p < 0.001$
<80–100	17.24 ± 5.23		17.91 ± 4.93	
<60–79	16.14 ± 5.50		15.44 ± 5.05	
<30–59	12.71 ± 5.13		14.71 ± 6.09	

*One-way ANOVA test within the groups.

Table 3. In the texting group, performance on the ACT at various cut points in screening for uncontrolled asthma (sensitivity, specificity, predictive value, and percentage of patients correctly classified based on the GINA-based physician assessments) at Visit 1.

ACT	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Correctly classified (%)
≤5	2.0	100.0	100.0	21.4	22.6
≤6	4.7	100.0	100.0	21.9	24.7
≤7	5.3	100.0	100.0	22.0	25.3
≤8	10.7	100.0	100.0	23.0	29.5
≤9	12.7	100.0	100.0	23.4	31.1
≤10	19.3	100.0	100.0	24.8	36.3
≤11	26.0	100.0	100.0	26.5	41.6
≤12	33.3	100.0	100.0	28.6	47.4
≤13	40.7	100.0	100.0	31.0	53.2
≤14	48.0	100.0	100.0	33.9	58.9
≤15	53.3	95.0	97.6	35.2	62.1
≤16	62.7	92.5	96.9	39.8	68.9
≤17	66.7	92.5	97.1	42.5	72.1
≤18	70.0	90.0	96.3	44.4	74.2
≤19	78.0	77.5	92.9	48.4	77.9
≤20	87.3	70.0	91.6	59.6	83.7
≤21	92.0	60.0	89.6	66.7	85.3
≤22	94.7	47.5	87.1	70.4	84.7
≤23	96.7	37.5	85.3	75.0	84.2
≤24	98.7	35.0	85.1	87.5	85.3
≤25	100.0	0.0	78.9	0.0	78.9

PPV, positive predictive value; NPV, negative predictive value.

mean change in ACT scores was 4.4 ± 4.6 for those patients who improved by one level according to the GINA physician assessments (i.e. moved from uncontrolled to partly controlled or from partly controlled to totally controlled) and was 9.0 ± 3.7 for those who improved by two levels according to the GINA physician assessments (i.e. moved from uncontrolled to totally controlled). However, we found that the ACT change was 0 for patients whose physicians classified them as having a decreased level of control based on the GINA criteria (i.e. moving from totally controlled to partly controlled or from partly controlled to uncontrolled). We found that the ACT change was 0 ± 11.31 for patients whose physicians classified them as having a decreased level of control based on the GINA criteria (i.e., moving from totally controlled to partly controlled or from partly controlled to uncontrolled). Between Visit 1 and Visit 3, there was a significant difference in mean (SD) score changes among the various groups of patients ($p < 0.001$) (Table 5).

Table 4. In the texting group, performance of the ACT at various cut points in screening for uncontrolled (uncontrolled and partly controlled) asthma versus controlled asthma (sensitivity, specificity, predictive values, numbers and percentage of patients correctly classified based on the GINA-based physician assessments) at Visit 1.

ACT	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Correctly classified (%)
≤5	2.9	2.9	66.7	64.706	64.7
≤6	8.8	8.8	85.7	66.120	66.8
≤7	10.3	10.3	87.5	66.484	67.4
≤8	19.1	19.1	81.3	68.391	69.5
≤9	22.1	22.1	78.9	69.006	70.0
≤10	29.4	29.4	69.0	70.186	70.0
≤11	38.2	38.2	66.7	72.185	71.1
≤12	45.6	45.6	62.0	73.571	70.5
≤13	52.9	52.9	59.0	75.194	70.0
≤14	61.8	61.8	58.3	77.966	70.5
≤15	70.6	70.6	58.5	81.481	71.6
≤16	77.9	77.9	54.6	83.871	68.9
≤17	83.8	83.8	55.3	87.356	70.0
≤18	85.3	85.3	53.2	87.654	67.9
≤19	94.1	94.1	50.8	93.750	65.3
≤20	97.1	97.1	46.2	95.745	58.4
≤21	97.1	97.1	42.9	94.444	52.6
≤22	97.1	97.1	40.5	92.593	47.9
≤23	100.0	100.0	40.0	100.000	46.3
≤24	100.0	100.0	39.1	100.000	44.2
≤25	100.0	100.0	35.8	0.000	35.8

PPV, positive predictive value; NPV, negative predictive value.

Discussion

Our results demonstrate that the reliability, validity, and responsiveness of the Turkish of version of the ACT via texting is comparable to that of the paper-and-pencil form for evaluating asthma control in Turkish adult patients.

In terms of validity, we found a good correlation between GINA-based physician assessments and ACT scores in both the paper-and-pencil and texting groups. ACT scores were significantly different for each of the three GINA classifications of patients in the texting group. On the ACT at Visit 1, each of the three asthma control classifications—controlled, partly controlled, and uncontrolled asthma—conformed to the MID of three points of change, as suggested by Schatz et al. [3]. Classification of asthma control status via ACT scores was comparable between the texting- and paper-and-pencil-administered questionnaires in this study.

In a previous validation study using the paper-and-pencil of the Turkish ACT, 84.5% of patients were correctly classified according to GINA-based physician assessments [11]. In this study, the ACT correctly classified 77% of the patients in the texting group according to the physician assessments.

Patients in the texting group with an ACT score of 19 or less showed a sensitivity and specificity for uncontrolled asthma of 78.0% and 77.5%, respectively. We suggest that a cut point of 19 on the ACT to determine uncontrolled asthma in a patient should be used with caution because 22% of the patients were not classified correctly at this cut point. If we were instead to use a cut point of 18, the specificity increases to 90%, but sensitivity drops to 70%, with 74.2% of patients being correctly classified. If we accept a cut-off point of 20, the specificity decreases to 70%, but the sensitivity increases

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Table 5. Mean changes in ACT scores as a function of changes in physicians' assessments of asthma control between Visit 1 and Visit 3.

	Texting Group ACT score (Mean±SD)	Significance*	Paper-and-pencil group ACT score (Mean±SD)	Significance*
Worse	0.00 ± 11.31	$p < 0.001$	-2 ± 2.84	$p < 0.001$
No change	1.16 ± 4.37		1.00 ± 3.67	
Improvement by 1	4.47 ± 4.67		4.11 ± 3.56	
Improvement by 2	9.00 ± 3.74		9.90 ± 4.77	

SD, standard deviation.
*Jonckheere–Terpstra test, $p < 0.001$.

to 87.3%, with 83.7% of patients being correctly classified. Thus, the optimal cut-off score could vary depending on the physician's perspective and how the ACT scores will be used (Table 3).

Our findings show that the ACT via texting might be useful for screening uncontrolled asthma as well as for monitoring changes in asthma control, as ACT scores were responsive to changes in physician ratings among improving patients' asthma status. We note that our study period was only 5 weeks, which is very short for a longitudinal study. In addition, patients only used this innovative method during the five-week period, which did not allow us to observe long-term outcomes in patients' health and compliance.

Although the ACT was designed as a paper-and-pencil test, it has been administered in a variety of formats, including phone interviews and speech recognition via telephone. These methods have both advantages and disadvantages. The paper-and-pencil format allows doctors to clarify questions and avoid misunderstandings, which can also enhance data quality and allow for the immediate validation or verification of issues. One possible disadvantage to this format is physician fatigue. In addition, use of the ACT can be low in a busy practice [12,13].

Kosinski et al. discussed the psychometric properties and comparability of ACT scores between paper-and-pencil administered questionnaires and telephone-interview administered questionnaires. The authors reported that ACT scores from a telephone interview were reliable and comparable to ACT scores from a paper-and-pencil format, suggesting that ACT scores could be equally applicable without adjustment [13].

Text messaging is another method of gathering patient data that offers both advantages and disadvantages. Texting has become ubiquitous in many countries and is widely used across Europe. Average text message usage (the number of text messages sent per active mobile connection per month) in Europe was 81.2 in 2011. Five countries had levels of text message usage per connection above 150 messages per month, and Ireland and Turkey had an average of more than 200. In addition, text messaging is inexpensive and user-friendly; messages can be stored, retrieved, and answered at the user's convenience; and transmission is as quick or almost as quick as a phone call. Across Europe, the average price per text in 2011 was a mere €0.022 [20].

Because of high rates of ownership and frequency of use, mobile phones show great promise as a communication tool in every arena of modern life including health care. In many situations, a person might be more comfortable sending a text message than talking on the phone. Physicians are also using texting as a means of supporting patients, such as those receiving treatment for chronic diseases [21,22]. In a recent study, text messaging was used to improve asthma control. Lv et al. compared a traditional asthma control plan to the traditional plan plus daily texting reminders via mobile phone. The authors found that texting improved the patients' perceived control of asthma. The texting group had an increased follow-up rate and improved asthma-specific quality of life compared to the group receiving only the traditional asthma education program [23].

This study has two primary limitations. First, the text messaging platform was used in office, and some patients needed help using the system. A nurse or secretary was available to answer questions about the format only and did not interfere with the patients' ratings in any way. As a result, we were not able to determine these patients' ability to use the text messaging system in their homes or at work. In addition, we did not measure how many patients needed such help. This issue limits the external validity of our text messaging results and is an important consideration for future studies.

Conclusion

This study demonstrated that scores obtained via the paper-and-pencil format and web-based texting format of the ACT in Turkey were closely associated with the physician assessments of asthma control. Moreover, the texting version was able to detect improvement in a patient's asthma control level. Our study suggests that administration of the ACT via texting is comparable to the paper-and- pencil format and has the potential to enable the evaluation of asthma control via a mobile phone. However, the use of texting for assessing asthma control should be tested further before application in real life.

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Declaration of interest

An unrestricted grant from GlaxoSmithKline, Turkey supported this research. The authors report no conflicts of interest.

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The authors alone are responsible for the content and writing of this article.

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