Original paper

Demographic and medical factors affecting short-term changes in subjective evaluation of asthma control in adolescents

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Abstract

Introduction: Asthma control is an important measure of disease stabilization, which is linked to the treatment and lifestyle recommendations.
Aim: To assess the impact of selected factors on asthma control in adolescents, as assessed using the Asthma Control Test (ACT™).
Material and methods: The prospective study included 100 asthma patients aged between 12 and 19. Asthma was assessed in three consecutive follow-up visits spaced 3 months apart, using the standardized ACT™ questionnaire.
Results: Asthma was fully controlled (ACT score = 25 points) in more than half of the patients in all follow-up visits (53.0%, 54.0%, and 56.0%, respectively). More than one third of the participants scored between 20 and 24 points (37.0% vs. 39.0% vs. 40.0%). A minority of patients had uncontrolled asthma (scores below 20), and the group consistently diminished in subsequent visits (10% vs. 7% vs. 4%). Uncontrolled asthma was found significantly more often in female patients (33.33%; $p < 0.001$) and those living in rural areas (20.59%; $p < 0.01$). Treatment with a combination of inhaled corticosteroids (ICS) and LABAs was associated with worse asthma control (14.81%; $p < 0.05$). Better asthma control was found in patients with a family history of allergies (73.85% vs. 75.38% vs. 78.46%; $p < 0.001$) and in those with concurrent allergies (66.67% vs. 68.00% vs. 70.67%; $p < 0.001$).
Conclusions: Asthma control in adolescents differs by sex and residence. Concurrent allergies and family history of allergies improve asthma self-control in adolescents.

Key words: asthma, adolescents, asthma control, Asthma Control Test.

Introduction

Asthma is the most common chronic respiratory disease in children and adolescents in most developed countries [1]. International studies indicate that asthma affects between 5% and 15% of population in the developing age, with numerous reports of a high incidence of asthma and allergic rhinitis in the last several decades [2–4]. An ECAP study (Epidemiology of Allergies in Poland) conducted between 2007 and 2008 in 9 regions of Poland showed that asthma affects 2–7% of children aged 6 and 7, and 4–10% of children aged 13 and 14. Findings included significant differences between regions in terms of asthma severity and a higher prevalence in children living in urban areas, compared to those living in rural areas. The increase in asthma diagnoses is estimated at 0.4–0.7 annually, which allows one to estimate the rise in asthma prevalence in Poland at 5% per decade [5–7].

The complex etiology of asthma, as well as its long-term and unpredictable clinical course, necessitate constant monitoring of its symptoms, as well as modifying treatment to prevent disease progression and permanent damage. The identification of factors affecting asthma control and the risk of hospitalization, as well as the ability to live an active life, are key measures of management effectiveness [8–11].

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Guidelines on asthma education and prevention highlight asthma control as a matter of special importance. Asthma control is the optimum criterion for asthma grading, which is mainly linked to treatment recommendations. The current Global Initiative for Asthma (GINA) 2016 guidelines define, based among other factors on clinical parameters and forced expiratory volume in 1 s (FEV_1) or FEV_1/forced vital capacity (FCV)%, three asthma control levels: full control, partial control, and no control. In healthy children, the obtained values of FEV_1/FCV% and FEV_1% should be within the range of 80–120% predicted, between –1.645 SD and +1.645 SD from the predicted or between 5 and 95 percentile [12–17].

In daily practice, asthma control tests are especially useful, quickly providing vital information on the patient's health. Until recently, most questionnaires in use were very extensive and required assistance from qualified medical personnel to complete them. In 2004, the standardized Asthma Control Test (ACT™) was proposed for evaluating asthma control in patients above 12 years of age. The questionnaire enables adequate evaluation of asthma control as it is reliable, accurate, and multidimensional, and is still easily completed by the patient [18]. The ACT comprises 5 questions regarding limitations in the activity imposed by the illness, shortness of breath, sleep disorders, and the need for rescue medication. Each answer is rated from 1 to 5 points. A score of 25 indicates fully controlled asthma, scores of 20–24 indicate partially controlled asthma, and scores of 19 or lower – uncontrolled asthma. The test results should be considered in subsequent treatment interventions and recommendations regarding the patient's daily functioning [19, 20].

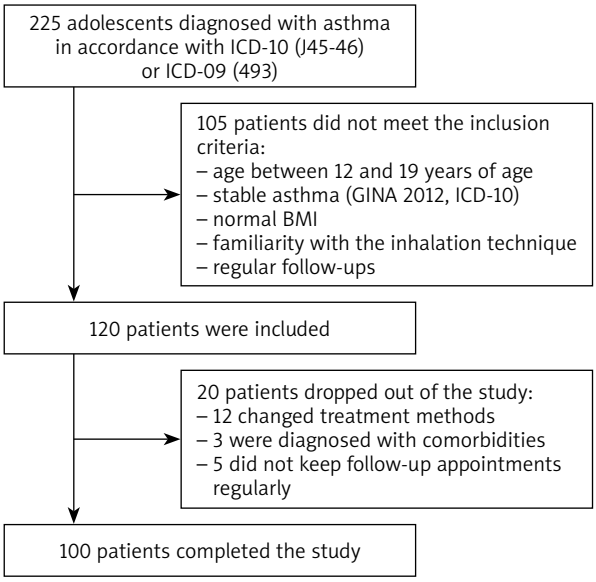

Figure 1. Study group selection process

Aim

The purpose of the study was to assess the impact of selected factors on asthma control in adolescents, based on ACT scores.

Material and methods

The study was performed at the allergy clinic of the Independent Public Hospital in Lesko, Podkarpackie Province, Poland. The Asthma Control Test (ACT™) is increasingly administered as a standard procedure for follow-up visits for patients aged 12 and above, including adults.

At the preparatory stage, the medical records of 225 asthma patients were reviewed in September 2013. One hundred and twenty patients meeting all the inclusion criteria were selected to participate in the 9-month prospective study. The inclusion criteria were: age between 12 and 19; stable asthma diagnosed at least 1 year beforehand, in accordance with ICD-10 (J45-46) or ICD-9 (493) and the GINA 2012 criteria; familiarity with the medication inhalation technique; keeping follow-up appointments; and normal body weight (body mass index (BMI) between 18.5 and 24.9 kg/m^2, and percentile rank between 10 and 90). The patients were evaluated in 3 follow-up visits, spaced 3 months ±7 days apart. Of the 120 participants, 20 dropped out of the study: 12 due to a change in treatment methods, 3 due to comorbidities, and 5 due to irregularities in follow-up appointment keeping. The final analysis included 100 patients who completed the study (Figure 1). The study was approved by the Bioethics Committee of the Lublin Medical University and the Allergy Clinic Director. Consent was obtained from the patients and their parents.

Statistical analysis

The research instrument used was the standardized ACT™ questionnaire. In addition, during each visit, spirometry examination was performed. The parameter values analyzed were shown as numbers and percentages. The relationships between the studied characteristics were evaluated using the χ^2 test for independence. For FEV/FCV% ratio, the following were calculated: the range of values (min., max.), arithmetic mean (M), standard deviation (SD), median (Me) and percentiles (25%, 75%). Normal distribution of FEV/FCV% was estimated with Shapiro-Wilk W test. The significance of differences between individual visits was assessed with Friedman ANOVA test, and the significance of differences for FEV/FCV% depending on asthma control on the basis of the ACT was assessed with Kruskal-Wallis ANOVA test. Differences at $p < 0.05$ were considered statistically significant. Statistical analyses were performed using Statistica 10.0 software (StatSoft, Inc., USA).

Results

The study group included patients between 12 and 19 years of age (mean age: 15.07 ±2.17 years), 76% were males and 24% females (Table 1). Sixty-six percent of participants lived in rural areas. 70% were found to have IgE-dependent asthma, based on a positive skin allergy test for one or more of the following allergens: mold, mixed grass pollens, hazel pollen, birch pollen, alder pollen, cat and dog hair. Family history was positive for atopy in 65% of patients. Fifty-eight percent of participants had concurrent allergic rhinitis, and 17% – atopic dermatitis. Seventy-three percent were treated with inhaled corticosteroids (ICS), 27% with a combination of ICS and long-acting β_2 adrenoceptor agonists (LABAs), and 35% were additionally undergoing allergen immunotherapy. All patients used short-acting β_2 adrenoceptor agonists (SABAs) as rescue medication. Patients were treated without changes throughout the analysis period.

More than half of the patients achieved ACT scores of 25 points, indicating fully controlled asthma, at each follow-up visit (V1 vs. V2 vs. V3) (Table 2). More than one third of the participants scored between 20 and 24 points (37.0% vs. 39.0% vs. 40.0%). A minority of patients had uncontrolled asthma (scores below 20 points). Asthma self-control did not significantly change in the analysis period.

The results of the spirometry test (Table 3) showed that teenagers with mild asthma (FEV_1/FCV% between 70–80% predicted) were participating in the study. The highest average value of FEV_1/FCV% was recorded on visit 2, while the lowest on visit 1 ($p < 0.001$). At the time of enrollment in 53 respondents who scored 25 points in ACT test and in 37 with a score of 20–24 points, the FEV_1/FCV% ratio remained as 78.07–80.18%; in further 10 with ACT < 20 points this ratio was 78.07%.

Table 1. Asthma patients' characteristics

Parameter	Result
Age (min.–max.) [years]	12–19
12–15, *n* (%)	57 (57)
> 15–19, *n* (%)	43 (43)
Gender, *n* (%):	
Male	76 (76)
Female	24 (24)
Residence, *n* (%):	
Urban	34 (34)
Rural	66 (66)
Family history of allergies, *n* (%):	
Yes	65 (65)
No	35 (35)
Asthma phenotype, *n* (%):	
IgE-dependent	70 (70)
Non-IgE-dependent	30 (30)
Concurrent allergies, *n* (%):	
Allergic rhinitis	58 (58)
Atopic dermatitis	17 (17)
Asthma treatment, *n* (%):	
Inhaled GCs	73 (73)
SABAs	100 (100)
Inhaled GCs + LABAs	27 (27)

Table 2. Overall ACT result for the asthma patients

Score: asthma control	Visit			Statistical parameters
	V1	V2	V3	
25 points	53 (53%)	54 (54%)	56 (56%)	$p = 0.4594$ $\chi^2 = 1.56$
20–24 points	37 (37%)	39 (39%)	40 (40%)	
< 20 points	10 (10%)	7 (7%)	4 (4%)	
Mean score ± SD	22.73 ±3.33	23.18 ±2.96	23.42 ±2.52	

Table 3. The value of FEV_1/FCV% ratio on subsequent visits

Visit	*N*	Min.	Max.	Mean	SD	Median	25%	75%	*P*-value
V1	100	78.07	80.18	78.47	0.83	78.07	78.07	78.07	< 0.001
V2	100	78.07	82.29	79.97	1.67	80.18	78.07	82.29	
V3	100	77.02	84.40	79.42	2.85	78.07	77.02	80.18	

During visit V2 in 54 patients who scored 25 points in ACT test, FEV_1/FVC% of 78.07–82.29% was observed, while in 7 patients with a score of ACT < 20 points the FEV_1/FVC% ratio was 79.13%. When analyzing the results of spirometry tests on visit V3 it was noted that in subjects with ACT equal to 25 points, Tiffeneau index was slightly higher and amounted to 78.07–84.4%, while in adolescents with ACT < 20 points the values reached 77.02%. These differences were statistically significant ($p < 0.001$).

A statistically significant correlation was found (Table 4) between patients' sex and overall ACT results in visits V1 ($\chi^2 = 22.32$; $p < 0.01$) and V2 ($\chi^2 = 11.42$; $p < 0.01$). At these visits, significantly more girls than boys had uncontrolled asthma. During the third visit, no significant differences in ACT results were found between male and female patients. No statistically significant correlations were found between patient age and the overall ACT results in the three follow-up visits. A statistically significant correlation was, however, found between the patients' residence and the overall ACT result — at V1 only. Uncontrolled asthma was more common in youths from rural areas. In the two remaining visits, residence did not determine the overall ACT result.

A statistically significant difference was found between the treatment used and the overall ACT results during visits V2 and V3 (Figure 2). Patients treated with

Table 4. Selected demographic characteristics (age, sex, residence) and asthma control as assessed using the ACT

Sex	**ACT score (points)**	**Boys *n* (%)**	**Girls *n* (%)**	**Statistical parameters**
V1	25	40 (52.63)	13 (54.17)	$\chi^2 = 22.32$ $p < 0.001$
	20–24	34 (44.74)	3 (12.5)	
	< 20	2 (2.63)	8 (33.33)	
V2	25	40 (52.63)	14 (58.33)	$\chi^2 = 11.42$ $p < 0.01$
	20–24	34 (44.74)	5 (20.83)	
	< 20	2 (2.63)	5 (20.83)	
V3	25	40 (52.63)	16 (66.67)	$\chi^2 = 3.90$ $p = 0.1422$
	20–24	34 (44.74)	6 (25)	
	< 20	2 (2.63)	2 (8.33)	
Age	**ACT score (points)**	**≤ 15 years old *n* (%)**	**> 15 years old *n* (%)**	**Statistical parameters**
V1	25	33 (57.89)	20 (46.51)	$\chi^2 = 1.28$ $p = 0.5209$
	20–24	19 (33.33)	18 (41.86)	
	< 20	5 (8.77)	5 (11.63)	
V2	25	34 (59.65)	20 (46.51)	$\chi^2 = 3.25$ $p = 0.1969$
	20–24	18 (31.58)	21 (48.84)	
	< 20	5 (8.77)	2 (4.65)	
V3	25	36 (63.16)	20 (46.51)	$\chi^2 = 2.77$ $p = 0.2509$
	20–24	19 (33.33)	21 (48.84)	
	< 20	2 (3.51)	2 (4.65)	
Residence	**ACT score (points)**	**Rural *n* (%)**	**Urban *n* (%)**	**Statistical parameters**
V1	25	33 (50.00)	20 (58.82)	$\chi^2 = 9.86$ $p < 0.01$
	20–24	30 (45.45)	7 (20.59)	
	< 20	3 (4.55)	7 (20.59)	
V2	25	33 (50.00)	21 (61.76)	$\chi^2 = 4.34$ $p = 0.1954$
	20–24	30 (45.45)	9 (26.47)	
	< 20	3 (4.55)	4 (11.76)	
V3	25	33 (50.00)	23 (67.65)	$\chi^2 = 2.84$ $p = 0.2422$
	20–24	30 (45.45)	10 (29.41)	
	< 20	3 (4.55)	1 (2.94)	

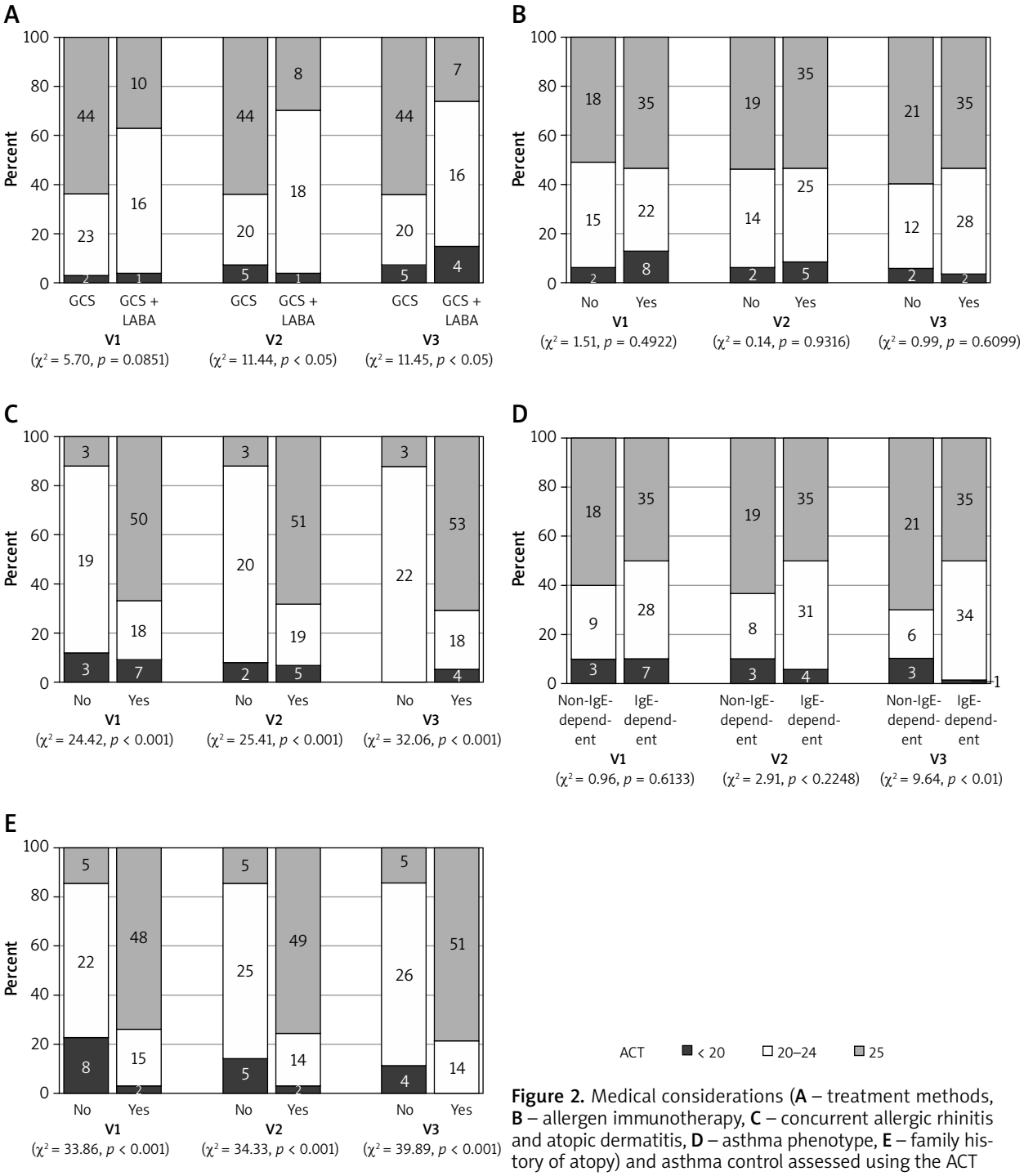

Figure 2. Medical considerations (**A** – treatment methods, **B** – allergen immunotherapy, **C** – concurrent allergic rhinitis and atopic dermatitis, **D** – asthma phenotype, **E** – family history of atopy) and asthma control assessed using the ACT

inhaled corticosteroids (ICS) only had better asthma control than those treated with a combination of inhaled corticosteroids (ICS) and LABAs. During the first follow-up, no significant differences were found in this respect. Neither were any significant differences found between allergen immunotherapy in youths with asthma and their overall ACT results in any of the three visits (V1: $p = 0.4922$; V2: $p = 0.9316$; V3: $p = 0.6099$). A statistically significant ($p < 0.001$) correlation was shown between concurrent allergic diseases and the ACT results throughout the follow-up period. Patients reporting other allergic diseases had fully controlled asthma significantly more often.

The analysis of asthma phenotypes showed a statistically significant difference ($p < 0.01$) in ACT results at V3. Significantly more patients with non-IgE-dependent asth-

ma than patients with IgE-dependent asthma achieved full asthma control ($p < 0.01$). In the first two follow-up visits, no statistically significant differences were found in this respect. The overall ACT results in all follow-up visits were at the same time significantly correlated ($p < 0.001$) with family history of allergies. Patients whose family history was positive for allergies had fully controlled asthma significantly more often than those with a negative family history for atopy.

Discussion

Achieving full asthma control through patient education and promotion of self-control is an important component in asthma treatment strategies. For an adolescent patient, achievement of full asthma control involves not only better health, but also, and more importantly, normal functioning at home, at school, and in the peer group [18–20].

GINA 2006 introduced a unified classification of asthma symptoms, defining three grades of asthma control: controlled asthma, partially controlled asthma, and uncontrolled asthma [21]. The ACT is a useful screening instrument enabling the identification of patients with uncontrolled disease [22–24]. Since 2008, GINA has been recommending the use of the Asthma Control Test (ACT™) for asthma control assessment. It is particularly useful in long-term assessment, and its results are correlated with clinical parameters as evaluated by specialists, the results of pulmonary function tests, and the development of inflammatory processes [8].

The definition of asthma control proposed by GINA 2016 includes reduction of asthma symptoms during the day and/or night, unrestricted physical activity, exacerbation prevention, maintenance of normal pulmonary function, reduced use of β-agonists, and no medication side effects [25].

Asthma is a chronic inflammatory respiratory disease, whose effective treatment requires in-depth knowledge on the illness and ongoing cooperation with the therapeutic team [3, 8]. Both the patient and their caregivers should be familiar with the symptoms, factors aggravating the course of the disease, and the appropriate measures for managing exacerbations. The subjective assessment of asthma using the ACT criteria should prompt the patient to consult a physician or to intensify treatment based on a specialist's recommendations. Therefore, the use of ACT contributes to improved patient knowledge and better cooperation with the physician. Waibel *et al.* [19] also highlight the educational value of the test, contributing to patient awareness of symptoms indicating exacerbation.

The present study showed that the result of the ACT, used as a standard procedure in all patient visits, was significant in subsequent diagnosis and treatment. In all three follow-ups, more than half of the youths obtained perfect scores, indicating fully controlled asthma, and approximately one third obtained satisfactory scores. In consecutive visits, the number of patients with good test results steadily increased, while the number of patients with uncontrolled asthma decreased steadily, which suggests an improvement in patient education, as well as good cooperation between medical personnel and the patients and their parents.

To make clinical evaluation objective, on every visit spirometry examination was conducted. Literature data show, however, that the Tiffeneau and FEV_1% rate does not fully reflect the degree of asthma control in both adults and children. Even in children with uncontrolled asthma the parameters FEV_1/FVC% for a long time can be within the range of predicted values. On the other hand, it was demonstrated that Tiffeneau index < 60% is an independent predictor of asthma exacerbations, regardless of the degree of control of the disease [8, 26]. While observing the mean FEV_1/FVC% on individual visits, it was found that they were within the normal and in most cases correlated with the subjective good asthma control in ACT test. In children with very good asthma control (ACT = 25), the highest value of FEV_1/FCV% was confirmed.

Sex may be a significant factor in subjectively assessed asthma control. Research points to the fact that female asthma patients report more symptoms, and that their negative experiences are more frequent and lasting. Weiner *et al.* suggest that the difference in subjective asthma control assessment between the sexes may be due to differences in perceived intensity of symptoms, as women and men react to episodes of dyspnea differently [27, 28]. However, Dursun *et al.*, comparing asthma self-control in adult male and female patients, reported no statistically significant differences in ACT scores or clinical characteristics [20]. Meanwhile, in the present study, sex was a statistically significant factor differentiating asthma control assessed using the ACT, with worse asthma control at V1 and V2 in female patients. This can be due to factors specific to adolescence, including higher emotional lability in girls, which might have affected the ACT self-control scores [29].

Asthma has a variable course – hence the importance of ongoing clinical evaluation and adjustment of treatment, also affected by subjective factors reflecting asthma control. Patients' physical and psychological functioning, as well as disease self-control, typically worsen with age [30]. In the case of younger adolescents, parents/caregivers typically participate in disease treatment and monitoring. Older youths typically show worse control of chronic disease [31]. This is due to their having gained more experience and authority, experiencing the need to become independent from their parents' authority, and developing an inclination for risky behaviors. However, in the present study, age was not a significant factor with regard to ACT scores.

Residence, as a demographic factor, may determine the accessibility of specialists. Patients in rural environ-

ments typically experience more obstacles in access to medical care than those living in urban environments [32]. In the present study, nearly two-thirds of the group (65 patients) lived in rural areas. These patients were shown to have significantly worse asthma control, as assessed using the ACT, at the first follow-up, compared to urban residents.

Due to its complex etiopathogenesis, asthma management should be comprehensive, aiming to achieve full control of symptoms while minimizing the risk of adverse effects. Treatment standards recommend that all patients receive an individual treatment plan, in writing, including guidelines for managing exacerbations. The primary treatment, viewed as the most effective in terms of symptom control, respiratory inflammation prevention, pulmonary function maintenance, and patient lifestyle improvement, is to use inhaled corticosteroids (ICS) [21, 25]. Most patients were treated with ICS only, which resulted, in nearly all cases, in full or good control of asthma, as assessed by the ACT in all follow-up visits. LABAs are often used in combination with inhaled GCs as first-line therapy in chronic treatment of moderate and severe asthma in children and adolescents. Combination treatment may result in better symptom control than an increased dosage of ICS alone [27]. The present study did not corroborate the correlation, which is likely to be due to the disease severity observed in the patients studied.

One component of asthma management other than pharmaceutical treatment is allergen immunotherapy, modifying the course of atopic disease development [28]. Studies by other authors indicate that allergen immunotherapy in asthma significantly reduces symptoms and exacerbations. It also improves patients' functioning, physical performance, and quality of life [29]. In the present study, allergen immunotherapy did not significantly affect subjective asthma control as assessed by the ACT.

Epidemiological studies consistently report that allergic rhinitis and asthma are two atopic respiratory diseases constituting a substantial medical and socio-economic issue, due to their significant impact on patients' quality of life, restriction of daily activity, interference with sleep, and increased absence from school and work. Research conducted so far has demonstrated that treatment of rhinitis improves asthma control, while effective treatment of asthma positively affects the course of rhinitis [2].

Studies by other authors indicate that the presence of numerous allergy symptoms in various organs decreases asthma control [13, 29]. In the present study, 75 patients experienced symptoms of other allergic diseases, including 58 cases of allergic rhinitis and 17 cases of atopic dermatitis, which is consistent with the literature data [3, 6]. Moreover, youths with concurrent allergic symptoms were found to have better ACT results in all follow-up visits analyzed, which may be due to the relatively small size of the study group, the large proportion of patients with a family history of atopy (which typically results in a trend for prevention, self-control, and chronic disease treatment in the family), and the large proportion of younger adolescents whose treatment is in most cases supervised by their parents.

Allergies involve genetic factors to a great extent. The familial background of asthma and allergies in the general population was the subject of multiple studies, which indicated that paternal factors contribute to the incidence of these diseases in children more than maternal ones [33]. In the present study, nearly two-thirds of the group (65 patients) had a family history of allergies. Moreover, youths with a positive family history for atopy significantly more often had fully controlled asthma than those with a negative family history. Chronic allergic disease in the family typically affects how other family members function, especially those who also have symptoms of the same or another allergic disease triggering adaptive mechanisms and promoting self-control [34, 35].

The positive result of ACT obtained by most patients in all the analyzed follow-up visits is the desired outcome of optimum asthma control, and affects youths' health-related behaviors, including improved perception of one's health, as well as their functioning in the family and social environment.

The present findings require further verification in a multi-center analysis, with a larger study group, as well as an evaluation of the actual effects of asthma patient education with regard to treatment monitoring.

Conclusions

Asthma control in adolescents differs by sex and residence. Concurrent allergies and family history of allergies improve asthma self-control in adolescents.

Acknowledgments

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Conflict of interest

The authors declare no conflict of interest.

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