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Impact of educational intervention for correct inhaler technique on the quality of life of children with asthma

Uticaj sprovođenja edukacije za pravilnu inhalatornu tehniku na kvalitet života dece sa astmom

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Abstract

Background/Aim. Asthma is the most common chronic disease in children and adolescents and has shown an apparent increase in incidence in recent years. The first purpose of the study was to evaluate the influence of education about proper use of inhalers on quality of life in children with asthma. Secondly, we aimed to understand which aspects of quality of life in children with asthma can be significantly improved after education and to identify factors that may affect the level of that improvement. **Methods.** In this prospective, before-and-after interventional study, a total of 147 children with asthma were enrolled. The Pediatric Asthma Quality of Life Questionnaire (PAQLQ) was used to measure the functional problems that are most troublesome to children with asthma. We used the Asthma Control Test (ACT), based on a series of question about symptoms and daily functioning, to identify patients with poorly controlled asthma. Forced expiratory volume in one second (FEV1) and peak expiratory flow (PEF) were also determined. Trained educators estimated patients' inhaler technique and collected questionnaire information. **Results.** Multivariate analysis of covariance indicated significant differences between PAQLQ and ACT scores which all were significantly higher after education about proper use of inhalers ($p < 0.001$). A number of children demonstrating a correct inhalation technique improved from 28 (19%) to 127 (86.4%) ($p < 0.001$). Asthma severity accounted for the largest proportion of variability PAQLQ and ACT scores (38.4%). **Conclusion.** Inhaler technique improvement contributes to better asthma control in children with asthma rather than to their quality of life. Asthma severity proved to be a major contributor to variations in PAQLQ and ACT scores and significant obstacle for quality of life improvement in children with asthma.

Key words:
asthma; child; nebulizers and vaporizers; quality of life; education, medical; respiratory function tests.

Apstrakt

Uvod/Cilj. Astma je najčešće hronično oboljenje kod dece i adolescenata čija se incidencija stalno povećava u poslednje vreme. Pimarni cilj ovog rada bio je da se utvrdi uticaj edukacije o pravilnoj upotrebi inhalatora na kvalitet života dece sa astmom. Drugi cilj je bio razumevanje koji aspekti kvaliteta života mogu biti značajno unapređeni posle edukacije i identifikacija faktora koji utiču na nivo tog unapređenja. **Metode.** Ukupno 147 dece sa astmom je bilo uključeno u ovu prospektivnu i intervencijsku (pre - posle), studiju. Za merenje funkcionalnih problema koji se najčešće javljaju kod dece sa astmom korišćen je *The Pediatric Asthma Quality of Life Questionnaire* (PAQLQ). Test za kontrolu astme (ACT), koji se bazira na nizu pitanja u vezi sa simptomima i dnevnim funkcionisanjem, korišćen je za utvrđivanje loše kontrolisane astme. Takođe, mereni su i forsirani ekspiratorni volumen u 1 sekundi (FEV1) i vršni ekspiratorni protok (PEF). **Rezultati.** Multivarijantna analiza kovarijanse pokazala je da postoje statistički značajne razlike u vrednosti PAQLQ i ACT skorova pre i nakon sprovedene edukacije o pravilnoj upotrebi inhalatora ($p < 0,001$). Broj dece koja su pravilno koristila inhalator povećao se sa 28 (19%) na 127 (86,4%) ($p < 0,001$). Stepen astme identifikovan je kao faktor koji je najviše doprinosio varijabilnosti u vrednostima skorova (38,4%). **Zaključak.** Bolja inhalaciona tehnika kod dece sa astmom više doprinosi boljoj kontroli astme u odnosu na unapređenje kvaliteta života. Najveći uticaj na vari-

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jacije u ACT i PAQLQ skorovima ima stepen astme koji se pokazao kao najveća prepreka za unapređenje kvaliteta života kod dece sa astmom.

Ključne reči:
astma; deca; nebulizatori i vaporizatori; kvalitet života; edukacija, medicinska; respiratorna funkcija, testovi.

Introduction

Asthma is the most common chronic disease in children and adolescents and has shown an apparent increase in incidence in recent years [1]. Health professionals are challenged to find effective responses to the influence of chronic disease such as asthma on the health and quality of life of children and their families. It is known that asthma manifests emotional and social effects on children. In addition to regular visits to the doctor, children need education to understand the disease, avoid triggers and to manage medication.

There are guidelines that address asthma management in children: the Practical Allergy (PRACTALL) consensus report, the Global strategy for asthma (GINA) and the International consensus on (ICON) pediatric asthma [2–4]. Despite all, asthma is a disease that is still poorly controlled. The reasons for poor control of asthma are numerous, but one of the main reasons is the poor inhalation technique [5]. Regardless of the type of inhaler, the importance of proper application, regular education and training of medical staff are the most effective strategy for the reduction of errors in the application of an inhalation technique. Also, the regular control technique of taking the drug in each subsequent visit to the doctor is of particular importance. Considering that errors in the inhalation process are very frequent and that may affect the availability of the drug to lungs, correct inhalation technique is essential for the adequate bronchodilatory effect.

Possible errors include those which do not depend on an inhaler type (an inadequate exhalation just before the inhalation or by inhalation through the nose) and errors originating from a device itself (inadequately prepared inhaler) [6]. It has been shown that the improper use of different inhalers is associated with poor control of the asthma [7]. Incorrect inhalation technique may lead to decrease of lung deposition of inhaled drug up to 50% [8]. When a bronchodilator is applied, the increase in FEV 1 (forced expiratory volume in one second) may be lower for a third if the drug has not been adequately taken. Also, incorrect inhaler technique correlates with a poorer control of asthma in patients treated with inhaled corticosteroids [9].

Parents frequently report being unsure and confuse on how to manage the child's asthma. Also, the family caregiver's perception of managing asthma has been shown to affect child health outcomes, including hospitalizations and emergency department visits [10]. The impact of asthma on children's daily activities, including sports and play as well as their emotional status is very significant. Studies have shown that incorporation of asthma education plans can be quite beneficial [11]. Appropriate education has proved to be very useful for both individual and group programming to improve asthma self-management skills in children and their parents [12]. One of the main tasks for asthma educators is to determine what is preventing the patient from achieving asthma control. When an educator understands where the patient make a mistake, he or she should teach him or her to use the inhaler in such a way that all steps are correct. The aim of this study was to evaluate the influence of education about proper use of inhalers in children on their quality of life. The specific objective was to understand which aspects of the quality of life in children with asthma can be significantly improved after education and to identify factors that may affect the level of that improvement.

Methods

Study design and participants

Between January 2016 and June 2017, interventional study was performed in 147 juvenile patients with mild, moderate and severe persistent asthma aged between 7 and 17 years. It was a prospective, before-and-after, interventional study in which each patient was his/her own control. Exclusion criteria were enrollment in education program in the past and chronic disease in addition to asthma.

The diagnosis of asthma was accepted when a patient with common clinical symptoms of the disease and airflow limitation had a positive bronchodilator test or a daily peak expiratory flow variability > 20% or a positive methacholine challenge test documented in the medical record. The level of severity of asthma was defined according to the Global Initiative for Asthma criteria which was based on asthma symptom frequency, medication use, FEV1 and PEF values. Uncontrolled asthma was defined as the Asthma Control Test (ACT) score < 20. The duration of the study was 18 months; during the first 6 months data were collected and all patients included were consecutively enrolled from the primary care center. Next, during one year, education which lasted for three months, was conducted. Education on inhalation technique was performed by certified nurses in three stages: in first session, children were taught about importance of proper inhaler use and inhaled medications. Also, demonstration of the proper use of different types of inhalers was performed. Second session was consisted of workshops and training for proper use of inhalers. In the third phase of the education checking of inhalation techniques was carried out. All participants received theoretical lessons with audiovisual aids, practical exercise and written instructions containing important guidelines for the treatment of asthma. Although education was referred to different types of inhalers, it was standardized because nurses were equally trained for each inhaler used in the study and training was conducted according to manufacturer's instructions. The study was conducted in accordance with the Declaration of Helsinki principles and was approved by the Ethics Committee of the

Health Center Rakovica. Written informed consent was obtained from child's parents. Personal identification data were anonymous.

Measurements and questionnaires

On inclusion in the study, a record was made of the patients' general and socio-demographic characteristics (age, gender, anthropometric data, type of habitat environment, exposure to tobacco smoke, financial status, type of asthma inhaler). At the visit to a pediatrician, results of functional respiratory tests (FRT), FEV1 and peak expiratory flow (PEF), were obtained. The children included in the study used some of the following inhalers: MDI (metered-dose inhaler with a spacer or without it), Autohaler, Accuhaler/Diskus and Turbohaler (dry powder inhaler). Trained educators in presence of pediatrician requested children to demonstrate their inhaler technique and if any of the steps was missing or done wrong according to the checklist, it was assigned as incorrect inhaler use. Also, as a relative inhaler technique improvement measurement, we calculated the percentage of correct steps for each patient and his/her inhaler. The limitations in daily life (physical, emotional and social) associated with asthma were assessed using the Serbian version of the Pediatric Asthma Quality of Life Questionnaire (PAQLQ) [13]. Translation into Serbian and linguistic validation of PAQLQ(S) was made by the MAPI Research Institute (1996) in Lyon, France. To determine if patients'asthma symptoms are well controlled we used the ACT. The children were accompanied with parents but the first author of this article conducted all the interviews. After the first data collection, the patients have attended education and were followed-up for a period of one-year at the primary care center.

Statistics

The Kolmogorov-Smirnov test was used to determine if the distribution of variables was normal. Equality of variances was controlled by the Levene's test. The estimated sample size of the study was 111 patients with a confidence interval of 95% and a random error of 5%. The PEF and emotional status score – were not normally distributed ($p < 0.05$) for the pooled samples. Therefore, logarithmic transformations were performed for both of these variables. After logarithmic transformations, both variables, PEF and emotional status score, were tested for normality of distribution. As they achieved normal distribution, these transformed values were used in all subsequent analyses. The χ^2-test was used to determine distributions of type of environment, exposure to tobacco smoke and financial status towards FEV1 and PEF (less or more than 80%) and absolute inhaler technique improvement. To determine whether there was a statistically significant difference in quality of life and asthma control after training and education we used the general linear model of analysis of variance. Multivariate analysis of covariance (MANCOVA, Wilks' lambda) was performed to test the hypotheses that education (fixed factor), asthma severity, FEV1 and relative inhaler technique improvement (covariates) have a significant effect on the normally distributed scores for symptoms, activity limitation, emotional function, overall PAQLQ and ACT (dependent variables). Univariate ANCOVA was then performed for each of the individual parameters. Partial eta-squared (η^2) values, which describe the proportion of variability attributable to a factor, were included to provide an intuitive measure of effect size. Pearson's correlation was employed to establish possible relationships between scores for symptoms, activity limitation, emotional function, overall PAQLQ and ACT and covariates. Differences were considered statistically significant at $p < 0.05$. All analyses were performed using Statgraphics 4.2 software (STSC, Inc. & Statistical Graphics Corporation 1985–1989) and CBstat 4.3.2 version software (K. Linnet, Risskov, Denmark).

Results

Anthropomorphological data of the patients are shown in Table 1.

Table 1
Anthropomorphological and demographic characteristics of patients before education

Characteristics	Values
Age (years), median (interquartile range)	9 (8.0–13.0)
Height (cm), median (interquartile range)	139 (129.0–160.0)
Weight (kg), median (interquartile range)	32.0 (36.0–52.0)
Gender, n (%)	
males	90 (61)
females	57 (39)
Type of environment, n (%)	
urban	99 (67)
rural	48 (33)
Exposure to tobacco smoke, n (%)	
no	97 (66)
yes	50 (34)
Financial status, n (%)	
very bad	15 (10)
bad	66 (45)
good	55 (37)
very good	11 (7)
Asthma severity, n (%)	
mild	92 (63)
moderate	45 (31)
severe	10 (7)

n (%) – number (%) of patients.

ANOVA indicated significant differences between the PAQLQ (symptoms, activity limitation, emotional function and overall PAQLQ) and ACT scores which all were significantly higher after patient education conducted ($p < 0.001$) (Table 2).

Also, FEV1 ($p = 0.048$) and relative inhaler technique improvement ($p < 0.001$) were significantly higher after patient education conducted. A number of children demonstrating a correct inhalation technique improved from 28 (19%)

to 127 (86.4%) ($p < 0.001$). When we tested the distribution of type of environment, exposure to tobacco smoke and financial status according to FEV1 and PEF no significant differences were found (Figure 1).

Because we assumed that some other parameters could potentially moderate the impact of the education about proper inhaler use on quality of life, we used multivariate analysis of covariance (MANCOVA). We used the MANCOVA test to establish whether the groups of independent variables (before and after education) were significantly different in relation to dependent variables (symptoms, activity limitation, emotional function, overall PAQLQ and ACT scores, collectively), after controlling for covariates: asthma severity and FEV1, as well as relative inhaler technique improvement. MANCOVA revealed that education ($p = 0.004$), FEV1 ($p = 0.019$), asthma severity ($p < 0.001$) and relative inhaler technique improvement (< 0.001) were significant covariates (Table 3). Based upon η^2 values, asthma severity accounted for the largest proportion of variability of the PAQLQ and ACT scores (38.4%). Less but significant proportion of variability of the PAQLQ and ACT scores was accounted by relative inhaler technique improvement (23.7%). Age, gender, type of habitat environment, exposure to tobacco smoke, financial status, type of asthma inhaler were not significant as covariates.

Table 2
Values of scores for quality of life, asthma control test, FEV1, PEF and correct inhaler technique during inhaler use

Parameters	Before education	After education
PAQLQ scores		
Activity limitation	22.1 ± 4.5	23.5 ± 4.0**
Symptoms	44.8 ± 8.8	48.0 ± 8.1**
Emotional function	35.0 (32.0–40.0)	39.0 (34.0–42.0)**
Overall PAQLQ	102.5 ± 18.2	109.7 ± 18.2**
ACT score	19.4 ± 2.1	21.8 ± 1.8**
FEV1 (%)	83.7 ± 7.6	85.2 ± 7.4*
PEF (L/min)	335.0 (290.0–385.0)	345.0 (294.0–386.0)
Correct steps (%)	76.0 ± 11.0	97.6 ± 1.6**
Incorrect / Correct inhaler technique†, n (%)	119 (81) / 28 (19)	20 (13.6) / 127 (86.4)**

Data following the normal distribution were presented as means ± standard deviation, and data not following the normal distribution were presented as median (interquartile range).
PAQLQ – Pediatric Asthma Quality of Life Questionnaire; ACT – Asthma Control Test; FEV1 – forced expiratory volume in one second; PEF – peak expiratory flow; n (%) – number (%) of patients.
***$p < 0.05$; **$p < 0.001$; †χ^2 test.**

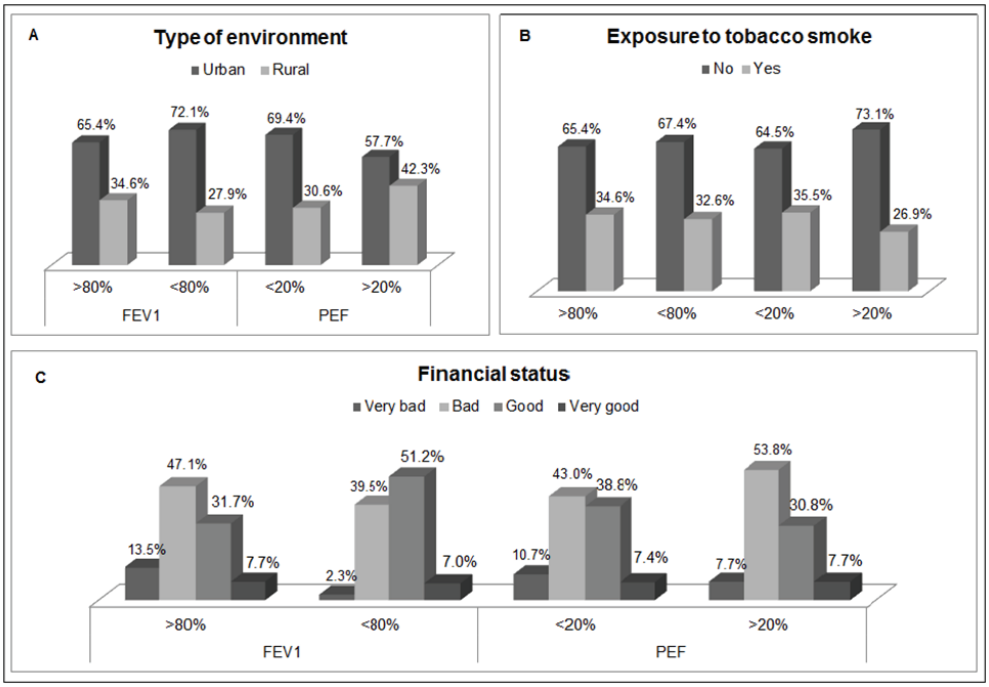

Fig. 1 – Distribution of type of environment (A), exposure to tobacco smoke (B), and financial status (C) according to forced expiratory volume in one second (FEV1) and peak expiratory flow (PEF).

Table 3

Multivariate and univariate analysis of covariance (ANCOVA) results depended on education

Multivariate ANCOVA					
Effect		Wilks' Lambda	F	Partial η^2	*p*
Asthma severity		0.616	44.599	0.384	< 0.001
FEV1 (%)		0.96	3.013	0.04	0.019
Relative inhaler technique improvement		0.763	22.227	0.237	< 0.001
Education		0.948	3.947	0.052	0.004
Univariate ANCOVA					
Dependent variable	Parameter	B	Observed power	Partial η^2	*p*
Activity	Asthma severity	-4.574	1	0.354	< 0.001
	FEV1 (%)	0.06	0.529	0.014	0.042
	Education	1.31	0.634	0.018	0.022
Symptoms	Asthma severity	-9.165	1	0.363	< 0.001
	FEV1 (%)	0.14	0.678	0.02	0.016
	Education	2.488	0.605	0.017	0.026
Emotions	Asthma severity	-6.938	1	0.329	< 0.001
	Education	2.593	0.811	0.027	0.005
Total score	Asthma severity	-20.677	1	0.373	< 0.001
	FEV1 (%)	0.275	0.575	0.016	0.032
	Education	6.39	0.735	0.023	0.010
Asthma control score	Asthma severity	-1.594	1	0.247	< 0.001
	FEV1 (%)	0.041	0.871	0.032	0.002
	Relative inhaler technique improvement	0.067	1	0.177	< 0.001
	Education	0.986	0.971	0.049	< 0.001

PAQLQ – Pediatric Asthma Quality of Life Questionnaire; ACT – Asthma Control Test; FEV1 – forced expiratory volume in one second.

Table 4

Pearson's correlations between parameters of quality of life and asthma control test and FEV1, asthma severity and relative inhaler technique improvement

Parameters	Correlations, rho (*p*)				
	Activity limitation	Symptoms	Emotional function[a]	Overall PAQLQ	ACT
Before education					
FEV1	0.224** (0.006)	0.208* (0.011)	0.227** (0.006)	0.226** (0.006)	0.163* (0.049)
Relative inhaler technique improvement	0.227** (0.006)	0.276** (0.001)	0.234** (0.004)	0.260** (0.001)	0.595** (< 0.001)
Asthma severity	-0.628** (< 0.001)	-0.631** (< 0.001)	-0.587** (< 0.001)	-0.637** (< 0.001)	-0.554** (< 0.001)
After education					
FEV1	0.224** (0.006)	0.224** (0.006)	0.246** (0.003)	0.238** (0.004)	0.126 (0.128)
Relative inhaler technique improvement	0.056 (0.502)	0.064 (0.438)	0.039 (0.638)	0.055 (0.507)	0.222** (0.007)
Asthma severity	-0.617** (< 0.001)	-0.624** (< 0.001)	-0.626** (< 0.001)	-0.639** (< 0.001)	-0.494** (< 0.001)

PAQLQ – Pediatric Asthma Quality life Questionaire; ACT – Asthma Control Test; FEV1 – forced expiratory volume in one second.
***p* < 0.05, ***p* < 0.01; [a]logarithmic transformed variable.**

ANCOVA, however, found that asthma severity and FEV1were significant for all the PAQLQ and ACT scores but relative inhaler technique improvement was significant only for asthma control score. Relative inhaler technique improvement and FEV1 provided positive model coefficients (B) and this equated to positive relationships between covariates and the PAQLQ and ACT scores.

The education positive model coefficient was equated to higher score values after patient education relative to values before education was conducted. The negative model coefficient for the asthma severity implied a negative relationship between this covariate and dependent variables (PAQLQ and ACT scores).

FEV1 was positively correlated with activity limitation, symptoms, emotional function and overall the PAQLQ and ACT scores before and after education was conducted (Table 4). The ACT score positively correlated with FEV1 only before education was conducted but not after it. Asthma sever-

ity was negatively correlated with all dependent variables before and after education was conducted. Relative inhaler technique improvement was positively correlated with all parameters of quality of life and the ACT score before education was conducted but after education the only significant correlation was with the ACT score.

Discussion

Maintaining control of asthma in children continues to be a problem, despite the advancements in its therapy. Individual factors such as genetics, smoking, type of inhaler, improper compliance, as well as family and environmental factors such as pets in the home, air pollution, and pollen exposure were identified as important factors that determine poorly controlled asthma [14, 15]. In many cases, asthma is poorly controlled due to incorrect use of inhaler, especially in children. Considering that children with asthma depend on their caregivers for help in managing their illness, participation in training programs for better asthma control was proved to be very useful for both children and parents [16]. Also, it is worth mentioning that asthma management improvement could result in decreasing asthma medication costs [17].

Numerous studies have focused on the importance of proper training for an inhaler use [18–20]. Few have examined the additional impact of age, obesity and limited parental health literacy [21–23]. Considering that relatively high rate of incorrect handling of inhalers has been reported in asthmatic children [24], we intend to examine the potential of education in improving inhaler technique and, consequently, better asthma control. Also, we aimed to investigate whether quality of life of children, in addition to asthma control, depend on other factors such as FEV1 values, asthma severity and relative inhaler technique improvement given as the percentage of correct steps. We initiated our study using an ethnically homogenous group of asthmatic children who were under different life circumstances (type of environment, exposure to tobacco smoke and financial status) and we found that profile of the study participants was equally distributed towards FEV1 and PEF values. At the beginning of the study children with asthma demonstrated a number of errors in device use. We revealed that 81.0% of the patients used the inhaler incorrectly, which means that only 19.0% of children were treated properly. Such a large number of errors occured most likely because the proper use of an inhaler was not well understood by patients. Also, physicians often have limited time to properly educate patients during regular medical check-up. All the patients in the study had received training program including practical demonstration and re-check of inhaler technique. After the training was completed correct inhaler technique was found to be present in 86.4% (n = 127) and incorrect inhaler technique was recorded in 13.6% (n = 20) of the patients included in the study. Our results showed that training reduced errors and improved outcomes. All scores of quality of life, determined in this study, asthma control and FEV1were significantly higher after educational interventions were performed. These results were in accordance with a review of controlled trials that demonstrated that a broad range of inhaler devices are very effective in delivering therapy when patients use them properly [6].

Education program contributed 5.2% to variability of quality of life with the largest single influence in the asthma control score (4.9%). When we look at differences observed among parameters of quality of life, as well as asthma control, before and after education, it is clear that the improvement of the disease management is accomplished. Although significant, the impact of education on 4.9% of the asthma control score variability suggests that training program had a relatively modest influence in asthma control improvement. However, it should be noted that the main effect of education was significant improvement of inhaler technique, which contributed to 23.7% variability of the quality of life and ACT scores. The positive model coefficient (B = 0.067) for the percentage of correct steps implied a positive relationship to the ACT score with contribution of 17.7%. On the other hand, when ANCOVA was performed, the relative inhaler technique improvement did not have a direct impact on quality of life scores. Based on these findings we could conclude that education improved asthma control, which is, in turn, positively affect quality of life.

Further analysis of physical, emotional and social issues and overall PAQLQ and ACT scores in asthmatic children as dependent variables, revealed a significant, but negative effect of asthma severity on quality of life (38.4%). This actually means that the level of asthma severity was major factor that affected quality of life of these children and to those with severe asthma we could expect only slight or no increase in scores after education regardless of inhaler technique improvement. Several studies have demonstrated that poorly controlled asthma was found to be associated with lower quality of life and ACT scores [25, 26]. It is not surprising that significant negative relationship was found between the level of asthma severity and activity limitation, symptoms and emotional function. When asthma is well controlled, symptoms are rare, activity is not limited, and sleep is not interrupted. At the same time the positive relationship between the PAQLQ and ACT scores and FEV1 and percentage of correct steps indicates an increase in quality of life, which is, at least partly, a consequence of the education and inhaler technique improvement.

Strategies to decrease the impact of asthma on quality of life in children should be focused on both, choosing an appropriate inhaler device and patient education for its proper use. It would certainly be useful not only for the patient's health but it would also have positive economic consequences.

Limitations of the study were relatively small number of children and having no information whether the level of proper use was followed after the study. Also, it is important to note that there was difference in age among children who took part in this study.

Conclusion

Education apparently plays a significant role in processes that lead to the PAQLQ and ACT scores increase in

asthmatic children. Correct use of an inhaler contributes to better asthma control rather than quality of life. Asthma severity proved to be a significant contributor to variations in the PAQLQ and ACT scores and major obstacle for quality of life improvement in children with asthma. Future studies addressing our observations are duly warranted.

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