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Mobile-based asthma action plans for adolescents

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Abstract

Purpose—To examine feasibility and utilization of a mobile asthma action plan (AAP) among adolescents.

Methods—Adolescents (aged 12–17 years) with persistent asthma had their personalized AAP downloaded to a smartphone application. Teens were prompted by the mobile application to record either daily symptoms or peak flow measurements and to record medications. Once data were entered, the application provided immediate feedback based on the teen's AAP instructions. Asthma Control Test (ACT®) and child asthma self-efficacy scores were examined pre- and post-intervention.

Results—Adolescents utilized the mobile AAP a median 4.3 days/week. Participant satisfaction was high with 93% stating that they were better able to control asthma by utilizing the mobile AAP. For participants with uncontrolled asthma at baseline, median (interquartile range) ACT scores improved significantly from 16 (5) to 18 (8) [$p = 0.03$]. Median asthma attack prevention self-efficacy scores improved from 34 (3.5) to 36 (5.3) [$p = 0.04$].

Conclusions—Results suggest that personalized mobile-based AAPs are a feasible method to communicate AAP instructions to teens.

Keywords

Adolescent; asthma; asthma action plan; high risk; teen

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Declaration of interest
The authors report no conflict of interest. The authors alone are responsible for the content and writing of this article.

Introduction

Asthma is the most common chronic illness of childhood, and adolescents represent a group that is typically difficult to engage in self-management strategies [1]. Adolescent asthmatics have poor perception of symptoms and a higher rate of asthma deaths compared to younger children [2,3]. In addition to these risk factors, adolescence is a time of increasing autonomy, and adolescents are more likely to be responsible for their own self-care [4]. The National Asthma Education and Prevention Program (NAEPP) recommends use of a written AAP for all patients with asthma [5]. Unfortunately, the use of paper action plans may not be relevant for today's technology-savvy adolescent patient population. The use of mobile technology is ubiquitous among adolescents with nearly 80% of today's adolescents stating that they have a mobile device, and three of four stating that they use a mobile device to access the internet [6]. Several studies have demonstrated acceptance of mobile phone-based self-monitoring of asthma by patients, but few have examined feasibility in a predominantly rural, medically underserved US region [7,8].

We examined the feasibility of implementing a mobile phone-based AAP to deliver instructions to adolescents with persistent asthma. Participants were adolescent children attending outpatient visits for asthma at Arkansas Children's Hospital, the only tertiary care hospital in this underserved, rural state. We examined frequency of utilization of the application, patient satisfaction with the application and the effects of application usage on asthma self-efficacy and asthma control after an eight-week study period. The mobile AAP delivered individualized instructions and prompts for daily and acute asthma management and positive feedback for appropriate usage via the adolescent's mobile device.

Methods

We conducted a single arm, feasibility and proof-of-concept study to examine the utilization of a mobile AAP by adolescents (12–17 years of age) who fit diagnostic criteria for persistent asthma per NAEPP guidelines [5]. Furthermore, an important objective of this study was to determine the direction of the intervention effect rather than testing for the efficacy of intervention or determining the effect size. Thus, a sample size calculation for the purpose of detecting a significant effect was not done *a priori*. Twenty subjects were recruited from pediatric specialty clinics at Arkansas Children's Hospital, the state's only tertiary pediatric care center, *via* convenience sampling. The application was developed by asthma sub-specialists, including an allergist and pulmonologist with expertise in guidelines-based asthma care, a respiratory therapist, asthma and community-based researchers and experienced mobile application developers.

After informed consent was obtained, participants were given access to a mobile smartphone application for a period of eight weeks. The mobile application was available for download on both iOS and Android platforms. Participants were able to download the application on his/her smartphone device. If the participant did not have access to a compatible smartphone, a loaned smartphone was provided for the eight-week study period. At enrollment, all participants were given instructions and demonstrated proper peak flow meter use during the baseline visit, and those who did not have their own meter were provided one. The AAP mobile application replicated the participant's instructions exactly as prescribed on his/her paper AAP by the child's physician. Participants were asked to record either asthma symptoms or peak flow measurements daily on the mobile application. Participants were encouraged to enter these data as per their preference (i.e. no emphasis was placed on recording peak flow rate over symptoms or vice versa). Participants received once daily prompts *via* push notification from the mobile AAP to record asthma symptoms or peak flow measurements and a separate push notification reminding him/her to take his/her prescribed controller medications. If the participant chose to enter a peak flow reading, the application navigated to a screen allowing the participant to enter his/her reading. If the participant chose to enter a symptom profile, the application navigated to a screen with symptoms, and the participant chose from a menu of items such as coughing a little, coughing a lot, wheezing, short of breath, etc.

After the participant entered symptoms, peak flow or medication data on his/her mobile device, he/she received immediate, interactive feedback from the application. This feedback included positive messaging when a controller medication dose, symptom profile or peak flow measurement was entered by the adolescent (e.g. "Way to Go!", "Great job!", "You Rock!", etc.) if no further actions were required. However, if the teen's input (symptom or peak flow measurement) indicated a yellow or red zone value, the application screen automatically navigated to a yellow or red zone screen. The yellow and red zone screens instructed the teen regarding his/her prescribed rescue medication(s) dosages and timing of doses as well as when to seek medical assistance for severe symptoms. These features exactly replicated the instructions as prescribed by the child's physician on the participant's paper AAP.

The mobile AAP also provided weekly asthma education tips *via* push notification such as information about asthma triggers, the importance of taking daily controller medications and reminders to use a spacer device with inhaled medications. Participant data entered by the adolescent on his/her mobile device was automatically transmitted to a secure, web-based portal for data compilation.

Mobile application usage rates and adolescent satisfaction as well as pre- and post-intervention Asthma Control Test (ACT), and child asthma self-efficacy scores were examined [9,10]. The ACT is a validated, self-report questionnaire that includes five items to assess each of the following in the past four weeks: impact of asthma on daily functioning, frequency of shortness of breath, frequency of nocturnal asthma symptoms, frequency of rescue medication use and general asthma control. Responses to each item range from 1 to 5, and the items are summed to yield a total score ranging from 5 to 25. An ACT score>19 is an indicator of controlled asthma [9]. The child asthma self-efficacy questionnaire is a 14-item validated questionnaire designed to measure the child's self-efficacy with regard to attack prevention (eight items) and attack management (six items) [10]. The child was required to select one of five responses ranging from "Not at all sure" (1 point) to "Completely sure" (5 points) in response to questions designed to assess self-management behaviors. The child self-efficacy score range is 14–70 points. The Cronbach's α reliability = 0.75 [10]. This study was approved by University of Arkansas for Medical Sciences' Institutional Review Board.

Analysis

Continuous outcomes were summarized using median and interquartile range (IQR; lower and upper quartiles) or mean and standard deviation (SD); categorical variables were summarized as frequency and percent. Analyses were stratified based on ACT score at baseline. Participants with baseline ACT scores ≤19 were considered to have uncontrolled asthma at baseline [9]. Location differences in pre- and post-intervention ACT scores, total asthma self-efficacy and the subscales for prevention and management were compared using a Wilcoxon signed-rank test. All tests conducted were two-sided assuming a significance level of 5%. The data analysis for this paper was generated using SAS software, Version 9.3 of the SAS System for Windows (SAS Institute Inc., Cary, NC).

Results

Of the 20 adolescent participants, mean age was 13.5 (SD 3.47) years, 60% were minority, and 90% had state-issued medical insurance. Adolescents utilized the mobile AAP a median 4.3 days/week to record peak flow rates and/or asthma symptoms. Although participants were instructed that they could enter either asthma symptoms or peak flow readings, participants more commonly recorded peak flow measurements compared with symptoms profile (median 4.3 days/week vs. <1 day/week, respectively). When questioned regarding the preferred method of obtaining his/her asthma zone instructions, the majority of participants (13/20) reported that they preferred to log either their peak flow measurement or both the peak flow measurement and symptoms as compared with just logging symptoms. One participant preferred logging symptoms, and six participants either had no preference or did not respond. Adolescent satisfaction was high with 93% stating that they thought they were better able to control their asthma by utilizing the mobile AAP.

Both pre- and post-ACT and self-efficacy scores were available for 18 participants; two participants did not have post-intervention scores due to being lost to follow-up. Median (IQR) ACT score for all participants ($n = 18$) was 20 (16–23) pre-intervention and 21.5 (16–23) post-intervention ($p = 0.53$; Figure 1). However, for participants with uncontrolled asthma at baseline ($n = 9$), median ACT scores increased significantly from 16 (13–17) at baseline to 18 (16–23) post-intervention ($p = 0.03$; Figure 1). Median total self-efficacy score was 60.5 (54–64) pre-intervention and 62 (56–64) post-intervention ($p = 0.13$; Table 1). For the asthma attack prevention domain, median scores significantly improved post-intervention from 34 (33–36) to 36 (33–38; $p = 0.04$; Table 1). Among adolescents with uncontrolled asthma at baseline, median scores for the asthma attack prevention domain were 33 (32–36) at baseline and 35 (33–36) post-intervention; however, this increase was not statistically significant ($p = 0.36$; Table 1).

Discussion

Our results revealed high participant satisfaction with the mobile-based AAP, and findings suggest that a personalized mobile-based AAP can be integrated into the regular routine of adolescents. Innovative solutions are needed to address disparate asthma outcomes experienced by adolescents. Portable tablets, smart phones, MP3 players and the Internet are just a few of the electronic resources that many adolescents use every day [5–7,11]. Recent reports have revealed a substantial and steady increase in smartphone use by adolescents [6,12,13]. It is estimated that nearly 80% of US adolescents have a mobile phone (increased from 36% in 2011), and 23% have a computer tablet [6–8]. Smartphone and mobile application use is also growing substantially with adolescents representing the fastest growing sector to adopt smartphone technology.

Because the uptake among adolescents has been so widespread, mobile application technology represents a potentially socially acceptable and feasible alternative to paper AAPs to assist adolescents in improving asthma self-care, yet further investigations are needed. In a recent Cochrane review, authors concluded that the current scientific evidence is insufficient to advise providers, policy makers and patients to use mobile applications for long-term asthma self-management [14]. The studies reviewed included a heterogeneous study population, and findings were inconsistent. Authors concluded that future investigations were needed given the potential benefits and availability of technology; however, investigators need to consider the contribution of each component of the intervention and should minimize differences in the clinical management of intervention and control arms [14]. Ryan et al. published results showing no difference in asthma control and self-efficacy between mobile-based and paper AAPs [15]. However, the study by Ryan et al. compared a group utilizing a mobile-based application plus intensive education sessions to a group receiving intensive education and paper AAPs only. While this study demonstrated no difference in asthma outcomes between groups, both groups received an intense, prospective intervention by a study nurse, which may not be easily replicated in other populations. This is especially true in rural, medically underserved states such as Arkansas where our study was conducted. Furthermore, the median age of this group was ≥46 years; therefore, result may not be indicative of findings in an adolescent population since adolescents are more likely to accept and utilize mobile-based technology compared with older populations [6,12,13].

Among patients with uncontrolled asthma at baseline, improved asthma symptom control was suggested by a significant increase in ACT score of three points from the pre- to post-intervention time points. A previous investigation to examine the minimally important difference in ACT score suggests that a change of three points is likely clinically significant, and differences less than two are likely not clinically significant [16]. Our study suggests that a mobile AAP may be a feasible way to help adolescents achieve better asthma control as they transition from child to adulthood, particularly for adolescents with uncontrolled asthma. A statistically significant improvement in the ACT score of the overall study population was not achieved likely due to the fact that the mean ACT score at baseline for the overall group was 20. This finding suggests little room for improvement since a score > 19 is an indicator of adequate asthma control [9]. In the overall study group, we did find a modest increase in self-efficacy scores with a statistically significant improvement in asthma attack prevention scores. While only a modest effect was observed in this short feasibility study, this is an important finding as asthma self-efficacy is key to successful asthma self-management skills, especially as adolescents become increasingly independent from their caregivers. Furthermore, due to the small sample size considered in this study, the effect sizes seen may not be an accurate estimate of the true effect, and a future large scale study is warranted.

Our study was limited by a relatively short study period. A longer study period may have resulted in even greater improvements in asthma control and self-efficacy, as participants would have had more time to benefit from daily medication reminders and weekly education tips. Conversely, a longer study period may have demonstrated diminished utilization of the application over time. Future studies are needed to assess the long-term feasibility, usage rates and long-term behavior changes associated with the use of a mobile AAP among adolescents with persistent asthma. Adolescents in this study rated satisfaction as high and utilized the application a median 4.3 days/week. Our findings and current trends in mobile health and remote monitoring [17], suggest that a mobile AAP may be a feasible intervention to engage adolescents in asthma self-management. In the future, investigators should consider designing applications that incorporate adolescent-friendly designs and graphics, virtual status updates or rewards, and other interactive features to increase usage and to keep adolescents engaged over a long timeframe.

Conclusions

We have shown that personalized mobile-based AAPs are a feasible method to communicate AAP instructions and have the potential to improve asthma control and self-efficacy in adolescents with uncontrolled asthma. With high rates of smartphone and tablet usage among adolescents, mobile application technology represents a potentially socially acceptable alternative to paper AAPs to assist adolescents in improving asthma self-care. Adolescents, especially those from rural and medically underserved regions of the United States, are a group at significant risk for poor asthma outcomes, and our findings suggest that mobile technology may be an effective tool to improve asthma control in this population. For these reasons, further large-scale, long-term randomized studies in this population are warranted.

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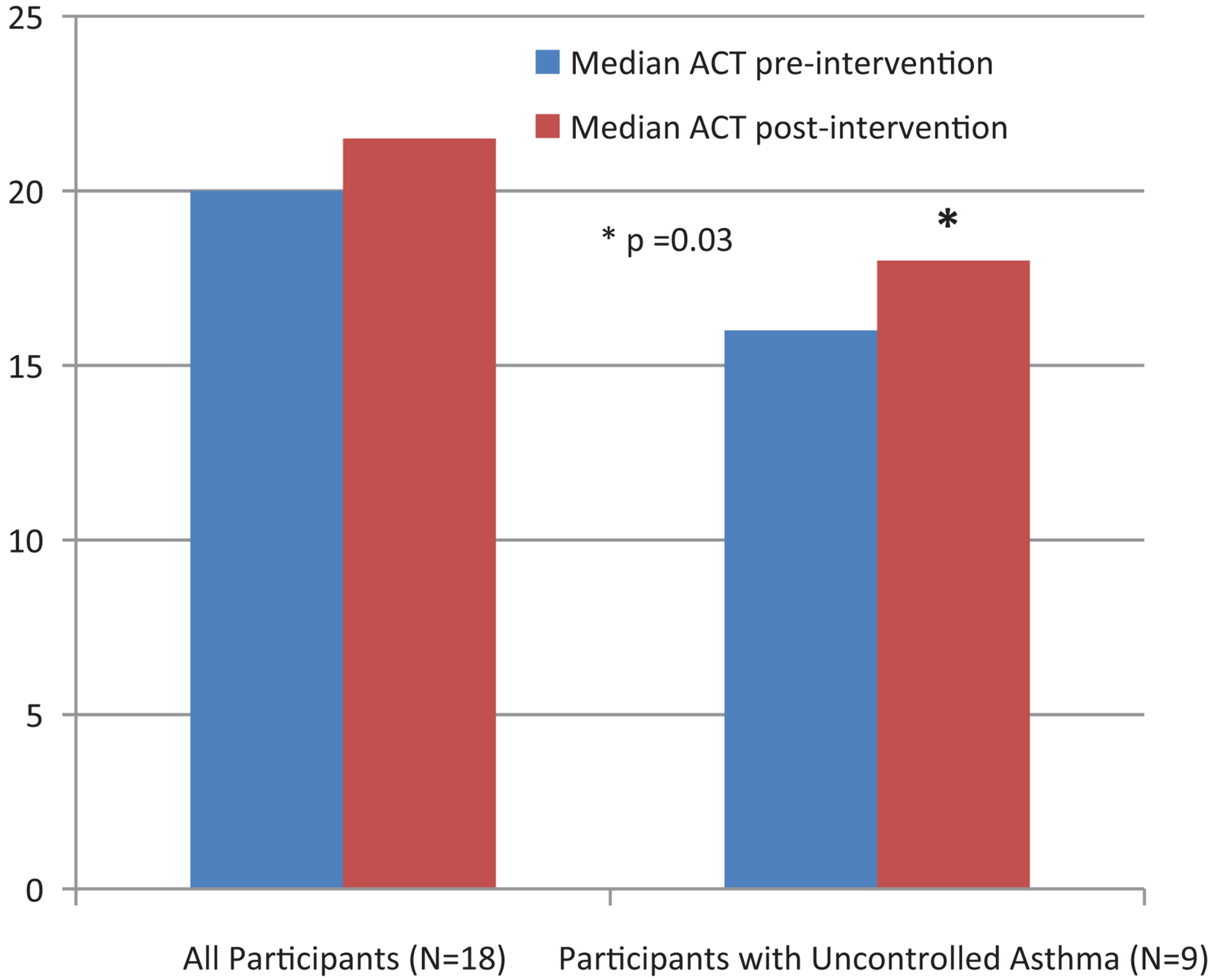

Figure 1.

Median ACT® scores pre- and post-intervention were measured for the total study group and for participants with uncontrolled asthma at baseline (baseline ACT® score ≤19). Participants with uncontrolled asthma at baseline had a statistically significant increase in median ACT® scores.

Table 1

Summary statistics for asthma self-efficacy scores at baseline and post-intervention.

		Median (Q1, Q3)		WSR
Self-efficacy	***n***	**Baseline**	**Post-intervention**	***p***
Total – overall	18	60.5 (54–64)	62 (56–64)	0.13
Uncontrolled asthma	9	54 (54–63)	60 (55–62)	0.69
Controlled asthma	9	62 (60–64)	63 (62–65)	0.15
Attack prevention – overall	18	34 (33–36)	36 (33–38)	**0.04**
Uncontrolled asthma	9	33 (32–36)	35 (33–36)	0.36
Controlled asthma	9	35 (34–36)	37 (34–38)	0.13
Attack management – overall	18	26 (20–28)	26 (23–28)	0.44
Uncontrolled asthma	9	22 (20–26)	24 (21–26)	0.71
Controlled asthma	9	28 (26–28)	27 (26–28)	0.63

WSR, Wilcoxon signed-rank; Q1, first quartile; and Q3, third quartile. *p* Values shown are from Wilcoxon signed-rank (WSR) test. Bold values indicate statistically significant results.