Efficacy of a Parent–Youth Teamwork Intervention to Promote Adherence in Pediatric Asthma

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Objective To determine whether a parent–youth teamwork intervention improved medication adherence and related outcomes among youth with asthma. Methods We used a randomized clinical trial with 48 youth (aged 9–15 years) assigned to 1 of 3 groups: Teamwork Intervention (TI), Asthma Education (AE), or Standard Care (SC). Treatment occurred across 2 months, with a 3-month follow-up assessment. Adherence to inhaled corticosteroids was assessed via the MDILog-II. Parent–adolescent conflict, asthma functional severity, and spirometry assessments were obtained pre-treatment, post-treatment, and on follow-up. Mixed linear model analysis was used to evaluate group and time effects for outcome measures. Results TI group had significantly higher adherence and lower functional severity scores than AE or SC conditions, and lower parent-reported conflict and a trend for higher spirometry values compared with the SC group. Conclusions Results suggest support for the efficacy of TI for improving medication adherence as youth acquire more responsibility for their asthma management.

Key words adherence; asthma education; electronic monitoring; parent–youth teamwork; pediatric asthma.

Asthma, a respiratory illness defined as recurrent episodes of wheezing or coughing, is the most common pediatric chronic illness, affecting >9% of children in the United States (CDC, 2012). Persistent asthma is treated with daily inhaled corticosteroids (ICS) to reduce airway inflammation and inhaled bronchodilators taken to relieve symptom exacerbations (Hogan & Wilson, 2003). Poorly managed asthma can negatively impact a child’s functioning (e.g., increased school absences, decreased participation in extracurricular activities) (Fiese & Wamboldt, 2000). Regimen non-adherence has been identified as one factor underlying ineffective asthma management. Objective measurement of adherence (e.g., electronic monitoring) is less prone to bias owing to the tendency of parents and children to overestimate adherence on self-report (e.g., Bender et al., 2007). Studies using electronic monitoring have found that on average, children with asthma take 46–57% of prescribed ICS doses (e.g., McQuaid, Kopel, Klein, & Fritz, 2003). Adolescents are identified as particularly at risk for low adherence (Fiese & Everhart, 2006; McQuaid et al., 2003). Psychosocial changes that occur in adolescence, such as drive for autonomy and social pressure from peers, have been linked to non-adherence to prescribed medical regimens (Bender, Milgrom, Rand, & Ackerson, 1998).

Despite these adherence difficulties, adolescents are more likely to be given primary responsibility for asthma management (Munzenberger, Secord, & Thomas, 2010). Yet, significant discrepancies exist between parent and child reports on who is responsible for specific asthma...
Parent–child collaborative management of regimens has been suggested for and related to better adherence and improved health outcome (e.g., Ellis et al., 2007; Fiese & Everhart, 2006). Families described as using a “family partnership” approach to managing pediatric asthma had the highest electronically monitored adherence rates (Fiese & Wamboldt, 2003). Yet, parents’ attempts at increasing their involvement in asthma care may be perceived as intrusive by youth (Drotar & Bonner, 2009; Penza-Clyve, Mansell, & McQuaid, 2004). Indeed, Bender and Bender (2005) reviewed qualitative studies examining patient-identified barriers to asthma treatment adherence and found that children and their parents cited challenges in effectively dividing and communicating shared responsibility for asthma management in the family.

Behavioral interventions have significantly improved adherence in families with pediatric asthma. Specifically, studies have involved parents in managing children’s asthma via behavioral strategies such as shaping and/or problem solving for barriers (Bartlett, Lukk, Butz, Lampros-Klein, & Rand, 2002; Burgess, Sly, & Devadason, 2010), applying contingency management (da Costa, Rapoff, Lemanek, & Goldstein, 1997; Kamps et al., 2008), and using interactive health care devices (Guendelman, Meade, Benson, Chen, & Samuels, 2002) or audiovisual reminders (Charles et al., 2007). With a particular focus on parent–child collaboration, Otsuki and colleagues (2009) had parents provide adherence feedback to their child (aged 2–12 years) and provide rewards for meeting asthma management and adherence goals. Families used electronic monitors to track goal attainment, whereas researchers obtained pharmacy refill data to index adherence. They found a significant increase in adherence during this 2-month, home-based intervention; however, this trend was not maintained over time.

These studies suggest that behavioral strategies, particularly with an adherence feedback component, show promise in improving medication adherence in pediatric asthma. These studies, however, are limited by lack of control groups (Bartlett et al., 2002), reliance on self-reported adherence (Guendelman et al., 2002), home visits that require substantial resources (Bartlett et al., 2002; Guendelman et al., 2002; Kamps et al., 2008; Otsuki et al., 2009), lack of treatment integrity measures (Bartlett et al., 2002), and no follow-up phases (Bartlett et al., 2002; Burgess et al., 2010; Guendelman et al., 2002; Kamps et al., 2008). Moreover, the literature still lacks a concerted effort to address shared parent–adolescent collaboration for asthma management tasks (i.e., division of responsibility). The pediatric diabetes literature provides some helpful directions. One study implemented a teamwork intervention focused on teaching parents and adolescents how to share responsibility for diabetes tasks and address diabetes management conflicts. The adolescents involved in the intervention had significantly improved glycemic control when compared with a standard care group (Anderson, Brackett, Ho, & Laffel, 1999).

Using the Anderson et al. (1999) study as a guide, the current project used a randomized controlled trial (RCT) design to examine the efficacy of an asthma adherence intervention designed to increase youth responsibility through parent–youth collaboration and systematic fading of parental supervision of medication use. The primary goal of this study was to determine whether this parent–youth teamwork intervention improved medication adherence and related outcomes among youth with asthma. Participants were randomly assigned to one of three groups: Teamwork Intervention (TI) (i.e., establishing shared responsibility for asthma management), Asthma Education (AE) (i.e., traditional AE), and Standard Care (SC) (i.e., assessment only). Two primary hypotheses were made. Compared with youth in the comparison groups, TI participants will have significantly better medication adherence and health outcomes. Two secondary hypotheses were made: (1) Families in the TI will not have significant levels of parent–adolescent conflict throughout the study, and these levels will be significantly lower than those in the comparison groups; (2) Families in the TI will report high satisfaction with treatment procedures and outcomes.

**Method Participants**

Participants were 48 youth, aged 9–15 years ($M = 11.1$; $SD = 1.9$), and their primary caregiver (89.6% mothers; 4.2% fathers; 6.2% other). Using data from asthma treatment literature and the Anderson et al. (1999) study, an initial effect size of .30 was identified when considering a factorial design (Cohen, 1988). In referring to Kraemer and Thiemann’s (1987) text, it was determined that the effect size of .30 would increase to ~.50 with the repeated measures design. Consequently, a power of .80 would be achieved with at least 14 participants per group. Participation dates were April 2002–September 2005;
their prescribed ICS doses across all groups. /C24 suggests that participants generally would take gathered, as previous literature (e.g., Walders et al., 2000) 4-weeks; 6-weeks; 8-weeks/post-treatment; follow-up) was six sessions (pre-treatment/recruitment; 2-weeks; days; SD ¼ 17.4). Consequently, total participation time spanned approximately a 2-month period, with a follow-up assessment 3 months post-assessment (M ¼ 99.8 days; SD ¼ 17.4). Consequently, total participation time was six sessions (pre-treatment/recruitment; 2-weeks; 4-weeks; 6-weeks; 8-weeks/post-treatment; follow-up) across ~5 months. No baseline data for adherence were gathered, as previous literature (e.g., Walders et al., 2000) suggests that participants generally would take ~50% of their prescribed ICS doses across all groups.

Research Design
This RCT used a longitudinal design such that four sessions (scheduled 2–3 weeks apart) of treatment spanned approximately a 2-month period, with a follow-up assessment 3 months post-assessment (M ¼ 99.8 days; SD ¼ 17.4). Consequently, total participation time was six sessions (pre-treatment/recruitment; 2-weeks; 4-weeks; 6-weeks; 8-weeks/post-treatment; follow-up) across ~5 months. No baseline data for adherence were gathered, as previous literature (e.g., Walders et al., 2000) suggests that participants generally would take ~50% of their prescribed ICS doses across all groups. The MDILog-II was attached to a new canister of ICS at the end of the first session. The MDILog-II (Westmed Technologies, Englewood, CO) is an electronic recording device that objectively captures and stores data regarding inhaler use, indicating the date and time of each inhaler dispense and whether the participant inhaled the medication via a temperature sensitive thermistor. Each night, the MDILog-II device performs a self-check and battery test to safeguard data integrity.

To enhance the validity of adherence data, families were instructed to use only study inhalers with the MDILog-II attached and were asked about medication sharing or unmonitored medication use at each session. Data were downloaded to a laptop computer at each subsequent session, and families provided refill canisters for the researcher to attach to a new MDILog-II based on the schedule of prescribed dosing. Test puffs were checked before releasing the new MDILog-II to each family. Only families in the TI condition were aware of the exact function of this device. Families in the AE and SC groups were provided with honest, but non-detailed explanations when they queried research staff about the MDILog-II device. All families were paid a total of $30–$50 per session, depending on the time demands.

Teamwork Intervention
The TI emphasized the importance of parents and youth sharing responsibility for the patient’s asthma management and learning methods for addressing conflicts associated with increased responsibility of youth. Thus, one portion of the TI involved reviewing with families a set of written handouts on topics (see Table II) related to adolescent development and shared responsibility of asthma care. For example, families were taught the steps to family problem-solving (Robin & Foster, 1989) around asthma management conflict.

The overriding plan for each family was not only to ensure consistent parental involvement but also to fade this involvement to a level appropriate for maintaining the patient’s adherence level while also promoting youth independence. Consequently, the other portion of TI involved training families in a standardized level system for parental supervision of medication use. All youth began the system at the lowest level with maximal parental involvement (i.e., observing each dose), and the MDILog-II served as the primary source of adherence information. Families were given guidelines for using this level system, including how to change levels based on fulfilling or failing to fulfill each level’s adherence goal (see Table III as a sample) and how to track fidelity to intervention on structured monitoring forms. The highest level in the system required that a
parent check the child’s MDIlog-II once a week; this was the least amount of parental supervision permitted. Specific adherence goals assigned to each level were pre-set in collaboration with the physicians involved in the study; in doing so, we considered the fact that shorter time frames (i.e., earlier in the intervention) would be easier to obtain higher adherence and offered an opportunity to “teach” the target behavior (i.e., adherence) early in the intervention, whereas longer intervals without parental checking afforded greater opportunities for non-adherence such that adherence goals needed to be loosened somewhat. Though our lowest adherence goal was 70% and less than ideal, it was consistent with literature showing that children with a median adherence level of 68% experienced no exacerbations over a 13-week period (Milgrom et al., 1996). A minimum level of consecutive performance (number of doses or days) also was required at each supervision level before proceeding to the next level to minimize any unnecessary variation or “bouncing back and forth” between levels. Although this level system was

standardized to be consistent between participants, it was structured such that each child would move up and down the levels based on his or her idiographic adherence behavior. Motivation to move higher in the level system rested on youth desiring less parental supervision. Thus, higher levels were associated with greater youth independence and, in turn, fewer monitoring tasks (including recording usage data on monitoring forms) for parents and less parental interaction with youth during asthma care tasks.

Each treatment session was spent briefly reviewing progress with the supervision level system, addressing family questions or concerns regarding its use, answering family questions with respect to any content from the previous session’s didactic/written materials, reviewing the current session’s didactic materials, and planning for upcoming supervision level system use. Families were encouraged to use personal examples of relevant struggles (e.g., child forgetting medication in the morning owing to always running late for school) whenever possible in session.

Figure 1. Diagram of flow of participants through the study. Note. Information regarding rate and reasons for refusal is not available.
Asthma Education
Similar to the TI group, families in the AE group received and reviewed written materials with the researcher during sessions. These materials covered topics often found in AE programs (see Table II). Time spent with families generally was equivalent to that of its parallel TI session, thereby creating an attention control condition.

Standard Care
Youth in the SC group completed all assessments at the same time interval as TI and AE participants, but did not receive any guidance beyond usual care. On completion of follow-up, these families were provided feedback on their child’s medication adherence and offered an opportunity to receive either of the two interventions (their choice).

Therapist Training and Treatment Integrity
Therapists included seven graduate students in a doctoral program for clinical psychology. Training involved shadowing of clinic staff, discussion of relevant reading material, review of audio-taped sessions, and in vivo observation of research sessions. Therapists used detailed treatment fidelity manuals to optimize congruity in session content between therapists and between participants. These therapist guidelines served as a checklist to confirm that key session elements were covered. Finally, therapists met weekly as a group with the principal author for supervision of ongoing cases.

All sessions were audio taped. AE (32.8%) and TI (31.3%) sessions were chosen randomly and reviewed by an independent rater to assess therapist fidelity to treatment. Total integrity for a session was computed as the percentage of session elements covered. Therapists were given feedback on their session integrity throughout the course of the study to prevent drift.

Device Accuracy
Approximately three separate reliability checks were performed on each participant’s MDILOG-II device during the study. These reliability checks required research staff

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Table I. Demographic and Medical Characteristics for Sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levels</th>
<th>Total %</th>
<th>TI* %</th>
<th>AEb %</th>
<th>SCc %</th>
<th>Group differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>64.6</td>
<td>50.0</td>
<td>68.8</td>
<td>75.0</td>
<td>(\chi^2(2) = 2.37)</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>35.4</td>
<td>50.0</td>
<td>31.2</td>
<td>25.0</td>
<td>(\chi^2(2) = 3.31)</td>
</tr>
<tr>
<td>Race</td>
<td>Caucasian</td>
<td>79.2</td>
<td>93.8</td>
<td>75.0</td>
<td>68.8</td>
<td>(\chi^2(6) = 12.13)</td>
</tr>
<tr>
<td></td>
<td>African-American</td>
<td>8.3</td>
<td>0.0</td>
<td>18.8</td>
<td>6.3</td>
<td>(p = .06)</td>
</tr>
<tr>
<td></td>
<td>Hispanic-American</td>
<td>2.1</td>
<td>0.0</td>
<td>6.3</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biracial/Other</td>
<td>6.3</td>
<td>0.0</td>
<td>0.0</td>
<td>18.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Missing</td>
<td>4.2</td>
<td>6.3</td>
<td>0.0</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td>Family structure</td>
<td>Intact</td>
<td>58.3</td>
<td>62.5</td>
<td>56.3</td>
<td>56.3</td>
<td>(\chi^2(6) = 4.01)</td>
</tr>
<tr>
<td></td>
<td>Blended</td>
<td>20.8</td>
<td>25.0</td>
<td>25.0</td>
<td>12.5</td>
<td>(p = .08)</td>
</tr>
<tr>
<td></td>
<td>Single parent</td>
<td>14.6</td>
<td>6.3</td>
<td>18.8</td>
<td>18.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>6.3</td>
<td>6.3</td>
<td>0.0</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>Residence(d)</td>
<td>Urban</td>
<td>6.2</td>
<td>6.3</td>
<td>12.5</td>
<td>0</td>
<td>(\chi^2(4) = 2.18)</td>
</tr>
<tr>
<td></td>
<td>Suburban</td>
<td>54.2</td>
<td>56.2</td>
<td>50.0</td>
<td>56.3</td>
<td>(p = .70)</td>
</tr>
<tr>
<td></td>
<td>Rural</td>
<td>39.6</td>
<td>37.5</td>
<td>37.5</td>
<td>43.7</td>
<td></td>
</tr>
<tr>
<td>Annual family income</td>
<td>&lt;$25,000</td>
<td>33.4</td>
<td>12.5</td>
<td>37.5</td>
<td>50.0</td>
<td>(\chi^2(4) = 5.54)</td>
</tr>
<tr>
<td></td>
<td>$25,000–$50,000</td>
<td>20.8</td>
<td>31.3</td>
<td>18.8</td>
<td>12.3</td>
<td>(p = .24)</td>
</tr>
<tr>
<td></td>
<td>&gt;$50,000</td>
<td>45.8</td>
<td>56.2</td>
<td>43.7</td>
<td>37.5</td>
<td></td>
</tr>
<tr>
<td>Primary caregiver’s level</td>
<td>Less than high school graduate</td>
<td>10.4</td>
<td>0.0</td>
<td>12.5</td>
<td>18.8</td>
<td>(\chi^2(6) = 9.93)</td>
</tr>
<tr>
<td></td>
<td>High school graduate</td>
<td>27.1</td>
<td>43.7</td>
<td>6.3</td>
<td>31.2</td>
<td>(p = .13)</td>
</tr>
<tr>
<td></td>
<td>Some college or vocational training</td>
<td>27.1</td>
<td>31.3</td>
<td>37.5</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>College graduate</td>
<td>35.4</td>
<td>25.0</td>
<td>43.7</td>
<td>37.5</td>
<td></td>
</tr>
<tr>
<td>Asthma severity(e)</td>
<td>Mild persistent</td>
<td>27.1</td>
<td>37.5</td>
<td>25.0</td>
<td>18.8</td>
<td>(\chi^2(4) = 1.55)</td>
</tr>
<tr>
<td></td>
<td>Moderate persistent</td>
<td>56.3</td>
<td>50.0</td>
<td>56.2</td>
<td>62.5</td>
<td>(p = .82)</td>
</tr>
<tr>
<td></td>
<td>Severe persistent</td>
<td>16.6</td>
<td>12.5</td>
<td>18.8</td>
<td>18.8</td>
<td></td>
</tr>
<tr>
<td>Prescription dosing schedule</td>
<td>qD (once daily)</td>
<td>50.0</td>
<td>56.2</td>
<td>43.8</td>
<td>50.0</td>
<td>(\chi^2(2) = 0.50)</td>
</tr>
<tr>
<td></td>
<td>BID (twice daily)</td>
<td>50.0</td>
<td>43.8</td>
<td>36.2</td>
<td>50.0</td>
<td>(p = .78)</td>
</tr>
</tbody>
</table>

Note. All results are reported for the full sample (n = 48), except where noted.

*Teamwork Intervention group; "Asthma Education group; "Standard Care group; "Based on U.S. Census Bureau (2011); "Asthma severity assigned by attending physician according to NHLBI (2007) guidelines.
to run the device through a series of 10 pre-specified combinations of actions (e.g., multiple dispense without inhalation) with a placebo canister (Apter, Tor, & Feldman, 2001). To calculate an overall device accuracy rate, data downloaded from the MDILog-II were contrasted with those expected from the pre-specified actions for percent agreement (across the 10 checks).

**Measures**

**Demographic and Medical Information**
Families completed a *Patient Information Form* with regard to relevant demographic variables (e.g., child age, race) and medical information (e.g., age of diagnosis). This questionnaire was devised for the purpose of this study.

**Medication Adherence**
To address the principal aim of the study, medication adherence was measured via the MDILog-II. Test puffs were removed from the database. Mean daily adherence was defined as follows: total number of puffs inhaled divided by total number of puffs prescribed, multiplied by 100. Data for the middle 10 days between each session were extracted to avoid any potential bias in terms of demand characteristics associated with session appointments. Daily adherence was capped at 100% to prevent skewing data. MDILog-II data outputs were reviewed carefully for patterns of use and systematic errors suggestive of device problems, such as erroneous actuations, faulty calibrations, and battery failure. Consistent with previous research (e.g., McQuaid et al., 2003), episodes of ≥10 actuations in less than a minute were identified as “dumps” (i.e., participant’s intentional attempt to appear more adherent) or device error and excluded from the data set before calculating adherence. Medication adherence was monitored throughout treatment and ~1 month before follow-up; data were downloaded five different times for each participant (sessions 2–6).

**Parent–Adolescent Conflict**
As a measure of potential changes in parent–adolescent communication and conflict behaviors, youth completed...
a Conflict Behavior Questionnaire-20 (CBQ-20; Robin & Foster, 1989) on their primary caregiver, whereas the caregiver completed a parent version of the CBQ-20 for their adolescent at sessions 1, 5, and 6. The CBQ-20 consists of 20 true–false items tapping parent–adolescent communication, conflict, and relations. Robin and Foster (1989) provide support for its psychometric properties and endorse its use as a treatment-outcome measure for parent–adolescent conflict. A total score was calculated by summing all items in the problematic direction; this total score was used in data analyses.

Health Outcomes
Parents and youth completed a Functional Severity Index (FSI; Rosier et al., 1994) together at sessions 1, 5, and 6. The FSI is a 6-item measure of asthma symptom severity and functional impairment during the previous month; higher scores represent greater symptoms and impairment. Although it is not standard procedure to have parents and youth complete the measure together, our research program has found that doing so leads to more complete information and valid scores. The total raw score was used in data analyses.

As a measure of lung functioning, each participant also received a spirometry assessment in accordance with the guidelines established by NHLBI (2007). Spirometry was measured during the same sessions (1, 5, and 6) that the FSI was completed. Of all the measures in this study, only spirometry results were shared with health care professionals so that all participants’ lung functioning could be monitored carefully throughout their participation. Results for FEF25-75 (small airways) were examined because this index is the most sensitive measure in patients with asthma (Gibb, Thyne, Kaplan, & Ly, 2012; Simon et al., 2010).

Consumer Satisfaction
Parents and youth individually completed a study-specific survey (Consumer Satisfaction Survey; CSQ) to elicit responses regarding satisfaction with treatment and research participation. When relevant, items crossed groups (e.g., scheduling of sessions), whereas others were specific to treatment condition (e.g., difficulty in using TI supervision charts). Therapy content items were extracted from the CSQ for AE and TI to measure the following for parents only (P) or both parents and child (B): difficulty level of written materials (P), usefulness of written materials (B), quality of therapist teaching (B), preparedness of therapist (P), likelihood that family would recommend program to others (B), and overall feeling about program (B). For TI participants, four additional items were included: difficulty in using MDILog-II (P), usefulness of MDILog-II (B), difficulty in using supervision charts (P), and usefulness of supervision charts (P). Items were rated on a 7-point Likert-type scale with anchors ranging from very negative (1) to neutral (4) to very positive (7). A mean item score across the questionnaire was calculated.

Analytic Approach
To ensure group equivalence with regard to key demographic and medical variables, groups were compared via ANOVA and post-hoc Tukey honestly significant difference comparisons for continuous data and chi-square analysis for categorical data. Descriptive statistics were calculated for therapist integrity to treatment and for MDILog-II device reliability.

The aims of this study were evaluated via mixed linear model analysis, with group (TI, AE, SC) as a between-subjects factor and time as the within-subjects factor. For each outcome measure, a random slopes model (group × time) was examined first. There was not significant variability in time slopes across outcomes. Consequently, a random intercepts model with the two-way interaction term (group × time) was conducted next, but there were no significant interaction effects across dependent variables. Thus, random intercepts models, with group and time as main effects, were run with no interaction term. When interpreting significant main effects for group, the TI group served as the reference point.

Results
Randomization Checks
Statistical analyses revealed that the three groups did not differ significantly from one another with regard to key demographic and medical variables (see Table I) or pre-treatment (Session 1) levels of all outcome variables (see Table IV).

Treatment Integrity and Device Accuracy
Assessment data suggested that treatment content was consistent within and between therapists across the various TI (M = 93%; Range = 83–100%) and AE (M = 95%; Range = 83–100%) sessions. Across participants and devices, MDILog-II reliability checks yielded 99.8% accuracy in detecting inhalation. MDILog-II data were not available for a total of 10 sessions (4.2%) across 10 different participants owing to device error/damage (n = 2), experimenter error (n = 2), use of unmonitored medication (n = 1), lost inhaler/device (n = 1), or lost to follow-up (n = 4). Two participants (one in AE and one in SC groups) each had 3 and 6 days, respectively, with a pattern of medication dumping. Participants with missing adherence data did not
differ significantly \((p > .05)\) from participants with complete data with regard to age, gender, race, and asthma severity. Our rate of missing data owing to device error also was lower than that reported in other pediatric asthma studies (e.g., 9% for McQuaid et al. [2003] for 1-month duration).

**Outcome Measures**

Table IV presents descriptive statistics for all dependent variables across each time point. Table V displays results from the mixed linear model analysis for each outcome variable. With regard to our primary outcome measure, medication adherence, the TI group had significantly higher adherence rates than did the AE and SC groups. Because there was no significant interaction effect, all three groups declined similarly in their adherence rates across the course of the study at \(\sim 1.07\%\) per week.

For parental rating of conflict with adolescents (PCBQ), pairwise comparisons for a significant group effect indicated that parents in the SC group reported significantly higher conflict than parents in the TI group. With regard to adolescent report of conflict with their primary caregiver (ACBQ), pairwise comparisons for a significant group effect revealed that TI group scores were not significantly different from the AE and SC groups. Rather, when a mixed linear model analysis was run with the AE group serving as the reference point, a significant group difference was obtained between the AE and SC groups \((t[124.60] = 2.73; B = 2.20; CI = 0.61–3.80; SE = 0.81; p = .007)\).

With regard to health outcomes, pairwise comparisons for a significant group effect for FSI scores demonstrated that the TI group reported less asthma symptoms than did the AE and SC groups. With a significant time effect, all three groups had FSI scores decreasing at a rate of \(-0.02\) points per week. In contrast, our findings for spirometry (FEF25–75) values showed that the TI group had a statistical trend toward better small airway functioning compared with the SC group, but no significant difference from the AE group.

**Consumer Satisfaction**

Mean item scores for general therapy content items on the CSQ suggested that parents in the AE \((M = 6.01; SD = 0.57)\) and TI \((M = 6.00; SD = 0.48)\) rated their treatment experience as positive to very positive, overall. CSQ descriptive data also were positive when examining youth report for AE \((M = 6.05; SD = 0.78)\) and TI \((M = 5.68; SD = 0.63)\)
**Table V. Results From Mixed Linear Model Analyses by Dependent Variable**

<table>
<thead>
<tr>
<th>Outcome/parameter</th>
<th>B</th>
<th>Standard error</th>
<th>Main effect</th>
<th>Pairwise comparison*</th>
<th>95% CI</th>
<th>Effect size (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medication adherence</td>
<td>F(2, 230) = 42.14, p &lt; .001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>AE</td>
<td>−35.72</td>
<td>4.40</td>
<td>t(230) = −8.13, p &lt; .001</td>
<td>−44.38 to −27.06</td>
<td>.47</td>
</tr>
<tr>
<td></td>
<td>SC</td>
<td>−33.99</td>
<td>4.37</td>
<td>t(230) = −7.78, p &lt; .001</td>
<td>−42.59 to −25.38</td>
<td>.46</td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td>−1.07</td>
<td>0.29</td>
<td>F(1, 230) = 13.75, p &lt; .001</td>
<td>−1.64 to −0.50</td>
<td>.24</td>
</tr>
<tr>
<td>PCBQ&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Group</td>
<td>F(2, 124.79) = 4.45, p = .01</td>
<td></td>
<td></td>
<td></td>
<td>.19</td>
</tr>
<tr>
<td></td>
<td>AE</td>
<td>−0.50</td>
<td>0.66</td>
<td>t(123.72) = −.76, p = .45</td>
<td>−1.80 to 0.81</td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td>SC</td>
<td>1.41</td>
<td>0.66</td>
<td>t(123.82) = 2.14, p = .04</td>
<td>0.10 to 2.73</td>
<td>.19</td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td>−0.05</td>
<td>0.03</td>
<td>F(1, 116.28) = 2.80, p = .10</td>
<td>−0.12 to 0.01</td>
<td>.15</td>
</tr>
<tr>
<td>ACBQ&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Group</td>
<td>F(2, 122.85) = 3.77, p = .03</td>
<td></td>
<td></td>
<td></td>
<td>.17</td>
</tr>
<tr>
<td></td>
<td>AE</td>
<td>−1.29</td>
<td>0.80</td>
<td>t(122.07) = −1.62, p = .11</td>
<td>−2.87 to 0.29</td>
<td>.15</td>
</tr>
<tr>
<td></td>
<td>SC</td>
<td>0.91</td>
<td>0.80</td>
<td>t(122.03) = 1.13, p = .26</td>
<td>−0.68 to 2.50</td>
<td>.10</td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td>0.02</td>
<td>0.04</td>
<td>F(1, 114.73) = 0.20, p = .66</td>
<td>−0.06 to 0.09</td>
<td>.04</td>
</tr>
<tr>
<td>FSI</td>
<td>Group</td>
<td>F(2, 127.84) = 4.83, p = .01</td>
<td></td>
<td></td>
<td></td>
<td>.19</td>
</tr>
<tr>
<td></td>
<td>AE</td>
<td>0.43</td>
<td>0.17</td>
<td>t(127.42) = 2.51, p = .01</td>
<td>0.09 to 0.78</td>
<td>.22</td>
</tr>
<tr>
<td></td>
<td>SC</td>
<td>0.50</td>
<td>0.18</td>
<td>t(127.56) = 2.85, p = .005</td>
<td>0.15 to 0.85</td>
<td>.24</td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td>−0.02</td>
<td>0.01</td>
<td>F(1, 115.60) = 4.81, p = .03</td>
<td>−0.04 to 0.00</td>
<td>.20</td>
</tr>
<tr>
<td>FEF2&lt;sub&gt;1–75&lt;/sub&gt;</td>
<td>Group</td>
<td>F(2, 115.07) = 6.80, p = .002</td>
<td></td>
<td></td>
<td></td>
<td>.24</td>
</tr>
<tr>
<td></td>
<td>AE</td>
<td>8.92</td>
<td>5.26</td>
<td>t(112.54) = 1.70, p = .09</td>
<td>−1.50 to 19.33</td>
<td>.16</td>
</tr>
<tr>
<td></td>
<td>SC</td>
<td>−10.64</td>
<td>5.44</td>
<td>t(116.40) = −1.96, p = .05</td>
<td>−21.42 to 0.14</td>
<td>.18</td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td>0.00</td>
<td>0.26</td>
<td>F(1, 104.01) = 0.00, p = .996</td>
<td>−0.51 to 0.51</td>
<td>.00</td>
</tr>
</tbody>
</table>

*When interpreting significant main effects for group, the Teamwork Intervention group served as the reference point; AE = asthma education; SC = standard care.

<sup>2</sup>Effect sizes were calculated using Rosnow, Rosenthal, and Rubin (2000) formula: r = square root of (t<sup>2</sup>/t<sup>2</sup> + df).

<sup>3</sup>PCBQ = parent CBQ on adolescent.

<sup>4</sup>ACBQ = adolescent CBQ on parent.

SD = 0.77) groups. Independent samples t-tests comparing the TI (n = 14) and AE (n = 15) groups yielded non-significant results for the parent CSQ (t(27) = 0.01, p = .99) and youth CSQ (t(27) = 1.27; p = .22).

With respect to TI-specific items, parents rated aspects of using the MDILog-II (Difficulty: M = 5.79, SD = 0.97; Usefulness: M = 5.93, SD = 0.73) and supervision chart (Difficulty: M = 5.64, SD = 0.84; Usefulness: M = 5.71, SD = 1.07). Using the same scale, youth reported a mean item score of 5.50 (1.91) for usefulness of the MDILog-II.

**Family Fidelity to Level System in the TI**

In all, 12 of the 16 families in the TI group provided level system monitoring forms to measure fidelity to TI procedures. Across families, an average of 6.58 (range = 1–11) level changes were made during active treatment. The highest level reached by families was E (n = 5), C/D/F (n = 2 each) and B (1). A mean of 18.5 days (range = 0–52) across the 2 months of active treatment were missing from completed charts. On average, families made an error on 47% of the level changes made or expected to be made.

**Discussion**

Our results indicated that the TI produced a significantly higher rate of medication adherence (i.e., >80%) across the 3-month course of the study, when compared with an attention control (AE) and standard care (SC) condition, each of which averaged ~50% of prescribed doses. Overall adherence rates for the comparison groups were consistent with those found in pediatric asthma studies (e.g., Walders et al., 2000). The significant TI effects were apparent during the first couple of weeks of treatment, and though they declined slightly with time, adherence still exceeded 80% on average, yielding a clinically meaningful improvement. Although a significant group by time interaction was not obtained, our overall effect on adherence is similar to that found in other behaviorally based studies to improve adherence in pediatric asthma (e.g., Bartlett et al., 2002; Burgess et al., 2010; da Costa et al., 1997), including those focused largely on adherence feedback (e.g., Spaulding et al., 2012). Results of this study also produced a significant main effect for time with regard to medication.
adherence. Review of data suggests that this finding likely stemmed from the fact that the AE and SC groups decreased adherence rates substantially across time, perhaps owing to families becoming more accustomed to their MDILOG-II devices and the demand characteristics inherent with participating in the study.

Though many pediatric behavioral studies aimed at improving asthma medication adherence either have not found improved lung functioning (e.g., Kamps et al., 2008) or did not measure it (e.g., Bartlett et al., 2002), we obtained significantly better health outcomes (i.e., small airway functioning, fewer self-reported asthma symptoms and activity restriction) for the TI group when compared with the other groups, likely as a function of enhanced medication adherence. Our lung functioning results and functional severity scores suggested that participants overall had low-to-mild range of symptoms, and thus our findings may have been influenced by ceiling effects. Given that improvements in lung functioning subsequent to better ICS adherence often are delayed, it will be important for future research to examine the impact of the TI on health outcomes for a longer follow-up period. We also explored parent–adolescent conflict as additional outcome measure. Our findings indicated that parent report of conflict with youth was significantly lower for the TI group in contrast to that found in the SC condition, which is consistent with results from the Anderson et al. (1999) teamwork study in diabetes. Unlike Anderson et al. (1999), we also examined adolescent report of conflict, but we did not find a significant difference from the comparison groups or a significant decrease in conflict over time with our intervention. Rather, we obtained a slight but non-significant increase in scores for the TI group across time, perhaps resulting from the probable increase in parental involvement in asthma care with the intervention. However, all mean CBQ scores were within the normal range and thus likely reflect a lack of clinical significance.

Finally, families completed a consumer satisfaction questionnaire and reported positive to very positive ratings of their experience in general. However, some aspects of the TI (i.e., difficulty in using charts and devices in the level system) were rated less favorably by some families in contrast to other features of their study participation (e.g., therapist variables). Indeed, families reported that they found it tedious to perform math calculations to determine when level changes were necessary and then record these data on monitoring forms. It is not surprising then that our qualitative review of family fidelity to TI procedures yielded variable results, including incomplete level charts and a high average rate of errors in making level changes. With our small sample size, it is not clear whether their concerns suggest a general need to simplify the components of the TI. Given that we obtained dramatic improvement in medication adherence for the TI participants, despite less than satisfactory parental fidelity to medication monitoring procedures, it is possible that the TI could be reduced in structure and intensity and still obtain significant effects. For example, some parents may benefit solely from receiving general behavioral guidance in prompting and fading of medication supervision in conjunction with their and their child’s knowledge of a monitoring device for inhaler use. Certainly, a key clinical implication of our findings is that parents need to provide some level of continuing supervision as youth become more independent and responsible for their asthma care (Buford, 2004).

Our study was strengthened by several key features such as using an objective measure of medication adherence, applying strategies to ensure therapist integrity to treatment procedures, assessing family fidelity with treatment components, and measuring health outcome variables. On the other hand, this study was limited in terms of sample characteristics (e.g., diversity, sample size), lack of baseline data for adherence, and use of a brief follow-up period. Despite randomization, it is possible that groups differed with respect to medication adherence before the intervention. Also due to design, it is not possible to determine the extent to which particular aspects of the TI (i.e., didactic sessions, levels system) contributed to significant outcomes. Still, our results provide initial support for the efficacy of the TI in improving medication adherence as youth begin to transition to more responsibility for their asthma management. It will be important to evaluate whether these treatment effects can be maintained for a long-term follow-up period in a large-scale RCT that incorporates baseline adherence data. However, before moving in this direction, the next step in future research should examine whether a “reduced intensity” version of TI can yield similar results in terms of enhanced medication adherence and health outcomes, and if so, whether this revised version also promotes better family fidelity to treatment procedures. Indeed, improved adherence may have come under the control of more natural contingencies (e.g., other than parental directives) as a part of the fading component in the supervision level system. This less structured variant of the TI also may be more amenable to use in fast-paced clinics and by standard clinic staff. Moreover, it will be important for future research to investigate family processes (e.g., family conflict), as well as parental (e.g., general monitoring) and adolescent characteristics (e.g., health beliefs) that lead to heterogeneity of treatment effects so that the intervention can be tailored to such variation and thereby enhanced (Drotar & Bonner,
2009; Kaugars, Klinnert, & Bender, 2004). Altogether, this line of research should provide a solid basis for a feasible and practical office-based intervention to assist health care providers in addressing medication adherence difficulties in their pediatric patients with asthma via a parent–youth teamwork approach.

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References


