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Reliability and Predictors of the Detection of Inspiratory Resistive Loads in Children with Persistent Asthma: A Multivariate Approach

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Abstract

Objective—Resistive load detection tasks enable analysis of individual differences in psychophysical outcomes. The purpose of this study was to determine both the reliability and predictors of resistive load detection in children with persistent asthma who completed multiple testing sessions.

Methods—Both UNC Charlotte and Ohio University institutional review boards approved the research protocol. The detection of inspiratory resistive loads was evaluated in 75 children with asthma between 8 and 15 years of age. Each child participated in four experimental sessions that occurred approximately once every two weeks. Multivariate analyses were used to delineate predictors of task performance.

Results—Reliability of resistive load detection was determined for each child, and predictors of load detection outcomes were investigated in two groups of children: those who performed reliably in all four sessions ($n = 31$) and those who performed reliably in three or fewer sessions ($n = 44$). Three factors (development, symptoms, and compliance) accounted for 66.3% of the variance among variables that predicted 38.7% of the variance in load detection outcomes (Multiple $R = 0.62$, $p = .004$) and correctly classified performance as reliable or less reliable in 80.6% of the children ($\chi^2(12) = 28.88$, $p = .004$).

Conclusions—Cognitive and physical development, appraisal of symptom experiences, and adherence-related behaviors 1) account for a significant proportion of the interrelationships among variables that affect perception of airflow obstruction in children with asthma and 2) differentiate between children who perform more or less reliably in a resistive load detection task.

A mix of factors related to the perception of asthma symptoms – including inaccurate judgments of airflow obstruction, disregard of symptoms, and delays in responding to

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worsening or severe symptoms – put patients with asthma at risk for more frequent, severe, or life-threatening asthma events (1–4). These conclusions follow long-standing demonstrations that asthma symptoms are not always closely correlated with underlying physiological changes in the airways (5–6) as well as frequent observations that patients with asthma demonstrate variability in the relationship between subjective and objective indicators of airflow obstruction (7–9). Accordingly, accurate perception of increases in the resistance to breathing is relevant to asthma control and to effective asthma self-management (10–16).

Since the pioneering work of Campbell and colleagues (17–19) a line of inquiry concerned with perception of increases in the resistance to breathing has involved application of psychophysical tasks either to determine the minimum, or threshold, level of added resistance necessary to evoke a “just noticeable” increase in the load to breathing; or to measure the sensory magnitude of gradations in resistive load intensity (20,21). It is not always clear that added loads are similar to intrinsic resistive loads associated with acute asthma, and evidence has been marshaled both for and against the relationship between perception and various physiological events (2,22–26). At a minimum, resistive load detection tasks enable analysis of individual differences in psychophysical outcomes.

Little consensus is apparent over the attributes of accurate asthma perceptions, however, and the individual differences that distinguish reliable from less reliable judgments of increased airflow obstruction are not well established (8,10–12). In children, a range of variables have been considered relevant in research involving single testing sessions including: age, asthma duration and symptoms, cognitive development, compliance with treatment, family attributes, and lung function (8,14,16,27–36). Multiple testing sessions improve the likelihood of observing clear results including underlying patterns of relationships among variables that affect perception of airflow obstruction. Such patterns are readily discerned through application of multivariate analytic methods.

In this project, we measured resistive load detection outcomes in children with moderate to severe asthma who completed four threshold resistance testing sessions. The purpose of the study was to determine 1) the reliability of performance of children with persistent asthma in a resistive load detection task and 2) the factors, or components, underlying consistency in resistive load detection. We hypothesized that multivariate analytic approaches could be used effectively to 1) uncover latent factors underlying consistency in task performance; and 2) predict children’s judgments of increases in the resistance to breathing as either more or less reliable.

Method

Research Setting

Participants in this report were enrolled in a pediatric asthma research program (Project On TRAC: Taking Responsibility for Asthma Control). The program consisted of asthma education, home monitoring of asthma symptoms, and resistive load testing. The threshold resistance to breathing was determined for each child at an initial session, and the effect of training on the perception of inspiratory resistive loads was determined in three subsequent

sessions. There were three resistive load testing conditions included in the design of Project On TRAC: resistive load training with immediate performance feedback, resistive load training with no performance feedback, or no resistive load training. Children were assigned at random to one condition at the completion of the initial session. The effects of training with or without feedback on the perception of resistive loads were the subject of a separate manuscript (37). This report is focused on the children ($n = 75$) who were assigned to the no resistive load training condition, and who completed four resistive load testing sessions designed to determine the reliability and predictors of resistive load detection.

Both UNC Charlotte (#09-09-03) and Ohio University (#03F024) institutional review boards approved the research protocol. At an initial enrollment meeting, children and their families were informed about all aspects of the research project. All children were diagnosed with asthma for at least two years; used controller medications daily; and reported at least occasional asthma symptoms and/or nighttime cough. The child's caregiver (parent or legal guardian) provided written informed consent and the child provided written informed assent.

Apparatus

Participants breathed on a circuit that consisted of a rubber mouthpiece attached to a pneumotachometer (Hans Rudolph, model R3813) and a two-way non-rebreathing Hans Rudolph J valve (model R2600). Airflow was measured using a Grass volumetric pressure transducer attached to the pneumotachometer and inspiratory pressure was measured with a second PT5 transducer attached to the mouthpiece. Airflow and pressure signals were monitored continuously, amplified with Grass DC preamplifiers (model 7P1G), and displayed on separate channels of a Grass polygraph (model 7D).

A two-way, computer-operated, solenoid valve located in a control room was attached to the inspiratory side of the circuit with rubber tubing (3 cm ID and 1.5 m in length). Resistive loads were constructed of nylon screens enclosed in polyvinyl chloride (PVC) pipe tubing, 2.5 cm in diameter and 17 cm in length, and were attached manually to one limb of the two-way solenoid valve. On trial breaths the relay closed the valve open to room air at the onset of inspiration (when rising inspiratory pressure was sustained for 100 msec) and opened the limb of the breathing circuit containing a resistive load. The valve switched back to room air when peak inspiratory pressure was detected.

Procedure

Children participated in four 60–90 minute laboratory sessions, one about every other week, and completed the sessions on average in 58 days. The child was seated in an armchair with a nose-clip in place, breathed continuously through a normally open circuit, and was instructed to pay attention to breaths that “may or may not feel different than normal.” Two warning cues were presented to each child during the breath immediately before a trial: a 1 KHz auditory tone, and the words “Next Breath” displayed on a computer monitor placed 1.5 m in front of the subject. On the breath after each trial, the child was asked to indicate whether or not there was a change in the resistance to breathing on the preceding inspiration by pressing keys on a response board. Prompts for the participants' keyboard responses were displayed on the computer monitor.

In each session ten resistive loads (linear for flow rates to 1 l/sec) including an imperceptible “catch load” consisting of a section of PVC pipe without nylon mesh were used. The loads ranged in intensity from 0.20 (the catch load) to 7.58 cmH₂O/l/s. Characteristic of procedures employing the method of constant stimuli (20), one of the ten loads was present in the circuit for a single inspiration on each trial and each load was presented ten times in random order (for a total of 100 load presentations), once every 3 to 6 breaths, with the restriction that each stimulus was presented only once in any ten-load sequence. Children removed the mouthpiece and nose-clip after the first 50 trials and rested for 3–5 minutes. At the end of Sessions 1 and 3 children selected a small prize from a toy box (book, puzzle, board game, etc.); at the end of Session 2 they obtained a \$10 gift card; and at the end of Session 4 they received a “Certificate of Completion.”

Peak expiratory flow rate was measured with a Wright meter at the beginning of each session, and lung function was recorded at the second laboratory session (Vacuumed, model 1618), as the best of three forced expiratory maneuvers performed while standing with a nose-clip in place. At the fourth laboratory session caregivers completed the Pediatric Asthma Symptom Scale (38) as well as the Paediatric Asthma Caregiver’s Quality of Life Questionnaire (39); and children judged their overall asthma difficulty from mild (“1”) to severe (“5”), from very well managed (“1”) to not managed at all (“5”), and from hardly noticeable (“1”) to very troublesome (“5”). Children also completed the Medication Taking Inventory (40), which is comprised of four items including “When you feel better do you sometimes stop taking your medicine?”

Data Reduction

Psychometric functions were plotted for each child within each session by computing the percentage of positive responses to each level of resistance; the threshold resistance to breathing was subsequently calculated using regression analyses to predict the level of added resistance detected on 50% of the trials (Figure 1). Threshold values derived from psychophysical procedures do not take into account false alarms (i.e., when a subject indicates a positive response to a stimulus when none was presented). Accordingly, we employed a conservative approach in estimating threshold resistance values: threshold was defined as the stimulus intensity detected on 50% of the trials after adjusting positive responses to each level of resistance for false alarm rates (i.e., for the proportion of “yes” responses to the 10 catch trials, when no load was present) using the following formula:

$$\frac{\text{Proportion of “Yes” Responses} - \text{Proportion of False Alarms}}{1 - \text{Proportion of False Alarms}}.$$

Reliability of resistive load detection for each child was determined by correlating the percentage of positive responses corrected for false alarms (range, 0–100 percent) with resistive load stimulus intensities (range, 0.20–7.58 cmH₂O/l/s) for each session; significant ($p < .05$) Pearson’s correlation coefficients (r) provided evidence of reliable performance.

In subsequent multivariate analyses we delineated the predictors of reliable task performance. We incorporated variables previously identified in research involving children

with asthma including: age, asthma duration and symptoms, cognitive development, compliance with treatment, family attributes, and lung function (8,14,16,27–36). First, we employed exploratory factor analysis to uncover the latent factors among correlated variables underlying consistency in resistive load detection. To simplify the data structure and minimize cross-loading among factors we applied principal components analysis and oblique rotation; factors above the eigenvalue of 1 were retained (41–43). Second, we used multiple linear regression analysis to predict variability in task performance, and discriminant analysis to determine the extent children's performance could be classified correctly.

Results

Participants

The sample included 58 boys and 17 girls; 60% of the participants were non-Hispanic white and 37% of the participants were non-Hispanic black. Demographic, anthropometric characteristics, and lung function values of the children are summarized in Table 1; correlation coefficients among caregiver and child symptom measures are presented in Table 2.

Reliability of Load Detection

Psychometric functions derived from averages for all positive responses, and for all positive responses adjusted for false alarm rates, are shown in Figure 2. The number of children who demonstrated reliable task performance in each session ranged between 40 (in Session 1) and 45 (in Session Four). In terms of individual variability, 57 children (76%) exhibited reliable task performance in one or more sessions and 18 children (24%) did not demonstrate reliable performance in any session. The number of sessions judged reliable for each child based on the presence of a significant correlation between detection responses and resistive load stimulus intensities is summarized in Table 3. We subsequently formed two groups of children to compare those who performed reliably in all four sessions ($n = 31$) with those who performed reliably in three or fewer sessions ($n = 44$). Separate psychometric functions derived from averages for all positive responses, and for all positive responses adjusted for false alarm rates, for these two groups are shown in Figure 3. Average correlation coefficients obtained for each session in children who performed well consistently (range, 0.82–0.86) were significantly greater [$F(1,73) = 175.96, p < .001$] than those in children who performed reliably in three or fewer sessions (range, 0.21–0.29). The average threshold resistance to breathing for the group of children who demonstrated reliable performance in all four sessions increased from 4.39 cmH₂O/l/s in the first session to 6.35 cmH₂O/l/s in the fourth session [$F(3,30) = 10.84, p < .001$] (Figure 4). We were not able to calculate meaningful average threshold resistance values for the other group of children because they would have been based largely on non-significant relationships between subjective responses and physical stimulus intensities.

The two groups were more similar than dissimilar on a range of characteristics. For example, they did not differ by sex ($\chi^2(1) = 0.33, p = 0.57$) or by race ($\chi^2(3) = 2.18, p = 0.54$), or by the proportion of participants who depended more or less on symptoms for

managing asthma episodes ($\chi^2(9) = 7.15$, $p = 0.62$) or who were more or less confident in their ability to predict an asthma episode ($\chi^2(1) = 0.41$, $p = 0.52$). Peak flow values recorded at each laboratory session were stable and did not differ between groups ($F(3,165) = 0.29$, $p = 0.80$).

Predictors of Load Detection

Exploratory factor analysis yielded three factors accounting for 66.3% of the variance among individual differences in resistive load detection: development (age, grade in school, height, and lung function; factor loadings range, 0.78–0.93), symptoms (chest pain, nighttime awakenings, perceived severity, and quality of life; factor loadings range, 0.72–0.87), and compliance (medication compliance, parents in the home, and asthma duration; factor loadings, 0.42–0.78). The factor solution was robust: Kaiser-Meyer-Olkin Measure of Sampling Adequacy was 0.71; Bartlett's Test of Sphericity was significant ($\chi^2(66) = 453.41$, $p < .001$); and commonalities were uniformly high (average of 0.66). Results of statistical comparisons between groups of children who performed reliably in all four sessions and those who performed reliably in three or fewer sessions for the variables that comprised the three components are presented in Table 4; we include conservative, adjusted alpha levels for multiple comparisons based on the Holm-Bonferroni method (44).

We subsequently used multiple regression analysis to determine the proportion of task performance accounted for by the variables related to consistency in resistive load detection uncovered through exploratory factor analysis; and we used discriminant analysis to determine the extent to which these variables could be used to correctly classify children's performance as either more or less reliable. The variables derived from exploratory factor analysis accounted for 38.7% of the variance in reliable task performance (Multiple $R = 0.62$, $p = .004$), of which a subset of these variables – FVC recorded at the second session, frequency of chest pain the past four weeks, and self-reported compliance with medications obtained at the fourth laboratory session – accounted for 30.6% of the variance in resistive load detection consistency (Multiple $R = 0.55$, $p < .001$). Better performance was associated with cognitive and physical growth ($\beta = 0.22$); with more frequent recent symptoms ($\beta = 0.37$); and with lower levels of self-reported compliance ($\beta = -0.33$). The variables correctly classified 80.6% of the cases ($\chi^2(12) = 28.88$, $p = .004$); children who performed less consistently were more likely to be classified correctly (87.2%) than those who performed reliably in all four sessions (71.4%). Three variables as before – FVC, frequency of chest pain, and medication compliance – predicted correct classification of 75% of the sample ($\chi^2(3) = 27.59$, $p < .001$).

Discussion

Our findings were based on observations of children with persistent asthma who completed four biweekly resistive load testing sessions. The number of observations we employed precluded direct comparison with most related research, which has involved one testing session; but some similarities may be identified. Our findings were similar to large inter-individual differences evident among children with or without asthma in repeated resistive load tasks (45) and to the low correlation between inspiratory threshold values obtained on

two days in adults with asthma (46). Additionally, the proportion of children who did not exhibit an interpretable level of performance in any session (~25%) was similar to previous findings (22, 31,34,37,45). It was also the case that in our group of children who demonstrated reliable performance threshold values were comparable to those reported previously (31,34). We note these values increased from the first session to the fourth session, fluctuations we attributed to the cumulative demands of completing a highly repetitive task.

The results of our exploratory factor analysis yielded three factors that accounted for a significant proportion of the variance (about 66%) among variables shown previously to affect perception of airflow obstruction in children with asthma. We labeled the factors in terms of the pattern of correlations (factor loadings) evident in the final, rotated solution: development; symptoms; and compliance. The factors accounted for nearly 40% of the difference between the two groups in reliability, and could be used to correctly classify about 80% of children whose judgments of increased airflow obstruction were consistently more or less accurate. Results of comparisons for each of the variables that comprised the three components between groups of children who were more or less accurate were not always statistically significant, underscoring the ability of multivariate approaches in uncovering latent patterns of complex interrelationships among correlated variables.

The first factor underlying consistency in resistive load detection – development, which accounted for most of the variance in the final, rotated solution (35%) – was comprised of the variables age, grade in school, height, and lung function. Each of these unambiguously reflected aspects of either cognitive or physical growth (16,34,47). In some cases, related research shed more light on how individual differences contributed to load detection. For example, it has been long recognized that height - an element of physical growth - affects intrinsic airway resistance levels, a contributor of load detection (31,34). The age range of our participants (8–15 years) made comparisons with other similar studies relevant (22,23,31,34,45) but children's health concepts and understanding of illness become more sophisticated and accurate at around 11–12 years (47), which may influence perception of increases in the resistance to breathing in unknown ways. This effect, though unique, appears to have some elements in common with another development variable, grade in school. Comprehension of task related details delivered as part of a controlled laboratory exercise may be important in this context although Fritz and colleagues (31) found no relationship between intelligence estimated from scaled scores obtained on subtests of the Wechsler Intelligence Scale for Children and either asthma morbidity or resistive load detection in a large sample of children with asthma. Considered as a group, these interconnections paint a complex picture of the role development plays in load detection; a picture with many possible elements, none of which have been determined yet to be more essential than others.

In contrast to indexes of development the second factor, symptoms, is to a greater degree based on less objective parameters. We link the relevance of the second factor to resistive load detection to symptom appraisal processes and to the premise of “implicit psychophysiology” originally described by Pennebaker and colleagues (48,49). In that formulation, the perception of symptoms is dependent on beliefs about physiological activity

in addition to physiological activity itself. Judgments over difficult physiological discriminations as occur in laboratory settings are likely dependent, therefore, not only on perception of changes in internal state but also on the perceived relatedness among the frequency and relevance of previous physiological signals; response bias; and, environmental cues (48–52). If previous symptom experiences positively predict future perceptions than feedback training to improve discrimination of increases in the resistance to breathing in a controlled setting may be pertinent to asthma self-management (37). The second factor was comprised of symptom measures reported by both the child and caregiver, which were correlated significantly albeit modestly. Agreement between children and their parents is often modest, although agreement over symptoms of distress increases in older children (8,33,53,54). Such agreement, however, does not necessarily guarantee appropriate action in response to accurate asthma perceptions (e.g., 54).

The third factor that emerged from our analysis, compliance, included three variables: medication compliance, parents in the home, and asthma duration. Poor adherence to daily maintenance therapy is common in asthma and adherence rates typically decline during adolescence (15,30,55). In a recent review treatment adherence was more closely associated, however, with parental variables such as family functioning and the quality of management routines than it was to age, psychological factors, and quality of life (30). Families vary in their willingness to embrace medical therapies based on beliefs and in their capacity to follow through with therapeutic recommendations; to cope with persistent symptoms and severe exacerbations; and to enable self-management practices as children develop (56,57). We largely interpret, therefore, the third factor as associated with a history of child-caregiver interactions managing care, monitoring health, and supervising medications that affect child health-related beliefs and expectancies and ultimately adherence behavior (30,58,59); medication adherence is a behavior (60) so factors that predict such behavior would seem relevant to understanding responses in a resistive load detection judgment task. Surprisingly, consistency in resistive load detection was associated with lower levels of self-reported compliance; children who performed reliably in the resistive load detection task were especially more likely to endorse positively one of the four items that comprise the Medication Taking Inventory, “When you feel better do you sometimes stop taking your medicine?” Possibly, these children were more likely to exercise risky health-related decisions based on symptoms although not always appropriately; they also evidenced more frequent recent symptoms.

Application of the variables that comprised the three components in multiple regression and discriminant analyses yielded complementary findings. In terms of multiple regression, the collection of variables together accounted for nearly 40% of the individual differences in resistive load detection consistency; moreover, one variable that loaded on each factor emerged to account for about a third of the variability in load detection outcomes in separate analyses verifying the conclusion that the constructs development, symptoms, and compliance serve as independent contributors in explaining more or less accurate discriminations of increases in the resistance to breathing. Similar patterns of findings were evident in the results of the discriminant analysis. On the other hand, we would be remiss to further conclude that FVC, frequency of chest pain reported by the parent, and child reported compliance represent the key features of more or less accurate load detection

outcomes. For example, a limit of regression techniques is that such analyses unmask statistical relationships, not causal mechanisms.

Several additional limitations were evident in our study. First, principal components analysis is an exploratory technique intended to uncover clusters of related variables. Verification of our findings will require application of confirmatory factor analysis. Second, our findings were based on a sample of children who reported occasional symptoms but also demonstrated normal levels of lung function. Among the factors that influence reduced symptom perception, one often considered is sensory adaptation (61). Intermittent or chronic low lung function might render a patient less sensitive to added loads, and less well-controlled asthma may serve to interfere with accurate self-monitoring of asthma control (37). Finally, the variables derived from exploratory factor analysis accounted for about 40% of the difference between groups of children. Additional variables are essential to consider in future work to characterize more fully judgments of airflow obstruction such as comorbidities, level of medical care, self-management education, triggers (62), and psychological measures (i.e., anxiety, depression, or negative affect). The latter are known to influence judgments of increased airflow obstruction (8,16,50). Despite these deficiencies, the factors we uncovered were consistent with ones for accuracy in the detection of blood glucose levels in adolescents with type 1 diabetes (63,64) raising the possibility that a limited number of variables predict perception of physiological changes in children.

Conclusions

Accurate perception of airflow obstruction in children is affected by cognitive and physical development; by appraisal of symptom experiences; and by adherence-related behaviors. Probing the relationship between perception and various physiological events is worthwhile within the context of asthma management, and prospective studies employing multivariate techniques that explore accurate asthma perceptions may bring clarity to the individual differences that lead to effective asthma control.

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Figure 1.
An idealized psychometric function.

Figure 2.

Psychometric functions derived from averages for all positive responses (filled circles) and for all positive responses corrected for false alarm rates (open circles) for each session (n = 75).

Figure 3.

Psychometric functions derived from averages for all positive responses corrected for false alarm rates for each session in children who performed reliably in all four sessions (filled circles; $n = 31$) and in children who performed reliably in three or fewer sessions (open circles; $n = 44$).

Figure 4. Average threshold resistance values ($\pm$ SEM) for each session in children who performed reliably in all four sessions ($n = 31$).

Table 1

Characteristics of participants (n = 75).

Variable	Mean (+ SD)
Age (yrs)	10.04 ± 1.4
Age at asthma diagnosis (yrs)	3.59 ± 2.6
School missed the previous 12 months (days)	5.33 ± 9.1
Asthma attacks the past 12 months (number)	14.08 ± 42.9
Self-reported asthma difficulty ¹	
Severity	2.67 ± 1.3
Managed	2.65 ± 1.0
Troublesome	2.96 ± 1.1
Anthropometrics	
Height (cm)	146.75 ± 10.3
Weight (kg)	47.43 ± 18.3
BMI ²	21.45 ± 5.8
Lung function	
FVC ³ (l)	2.30 ± 0.6
FVC percent predicted	99.24 ± 21.6
FEV ₁ ⁴ (l)	1.93 ± 0.6
FEV ₁ percent predicted	97.27 ± 23.1
FEV ₁ /FVC	84.24 ± 10.5

¹ Asthma difficulty was rated from mild ("1") to severe ("5"), from very well managed ("1") to not managed at all ("5"), and from hardly noticeable ("1") to very troublesome ("5");

² BMI = body mass index;

³ FVC = forced vital capacity;

⁴ FEV₁ = forced expiratory volume in one second.

Table 2

Correlation coefficients among caregiver and child symptom measures (n = 75).

	Caregiver Perceived Chest Pain ¹	Caregiver Nighttime Awakenings ²	Caregiver Overall Quality of Life ³
Child Perceived Asthma Severity ⁴	0.463 ^a	0.398 ^a	−0.435 ^a
Caregiver Perceived Chest Pain		0.633 ^a	−0.428 ^a
Caregiver Nighttime Awakening			−0.577 ^a

¹ Asthma severity (Mild to Severe);² Paediatric Asthma Caregiver's Quality of Life Questionnaire (Severe Impairment to No Impairment);³ Frequency of child chest pain during the past four weeks (Never to Everyday);⁴ Frequency of child nighttime awakenings because of asthma during the past four weeks (Never to Every Night);^a p < .001.

Table 3

Number of sessions judged reliable for each child (n = 75) based on the significance level of the correlation ($p < .05$) between detection responses and resistive load stimulus intensities.

Number of Sessions with Significant Correlations	Number of Participants	Percent of Participants	Cumulative Percent
0	18	24.0	24.0
1	13	17.3	41.3
2	4	5.3	46.7
3	9	12.0	58.7
4	31	41.3	100.0

Table 4

Results of individual statistical comparisons for variables related to consistency in resistive load detection.

Variable	Children who performed reliably in all sessions ¹ (n = 31)	Children who performed reliably in three or fewer sessions (n = 44)	t	p-value	Adjusted p-value
Age (yrs)	10.7 ± 1.1	10.1 ± 1.6	1.74	0.085	0.234
Grade in school (yrs)	5.1 ± 1.2	4.5 ± 1.6	1.89	0.063	0.234
Height (cm)	149.4 ± 11.2	144.9 ± 9.4	1.89	0.063	0.234
FVC ² (l)	2.5 ± 0.7	2.2 ± 0.6	2.39	0.019	0.133
FEV ² (l)	2.1 ± 0.7	1.8 ± 0.5	2.08	0.041	0.234
Child asthma severity ²	2.7 ± 1.3	2.1 ± 1.3	2.10	0.039	0.234
Chest pain ²	1.8 ± 0.9	1.2 ± 0.4	3.46	0.001	0.010
Nighttime awakenings ²	1.9 ± 0.9	1.5 ± 0.7	2.02	0.048	0.234
Quality of life ²	5.8 ± 0.9	6.3 ± 0.7	-2.66	0.010	0.090
Medication compliance ³	2.1 ± 1.2	2.8 ± 1.2	-2.47	0.016	0.128
Parents in the home	1.8 ± 0.4	1.8 ± 0.4	-0.67	0.507	0.510
Asthma duration (yrs)	6.6 ± 2.7	6.4 ± 2.9	0.29	0.776	0.780

¹ Values are mean ± SD;

² Abbreviations and explanations as in Table 1 and Table 2;

³ Medication Taking Inventory (Ref. 40).