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Official publication of the American College of Chest Physicians



Does Age Impact the Obese Asthma Phenotype?: Longitudinal Asthma Control, Airway Function and Airflow Perception among Mild Persistent Asthmatics

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Chest; Prepublished online July 28, 2011;
DOI 10.1378/chest.11-0675

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<http://chestjournal.chestpubs.org/content/early/2011/07/27/chest.11-0675>

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(<http://chestjournal.chestpubs.org/site/misc/reprints.xhtml>) ISSN:0012-3692

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Text word count: 3475
Abstract word count: 250

Does Age Impact the Obese Asthma Phenotype?: Longitudinal Asthma Control, Airway Function and Airflow Perception among Mild Persistent Asthmatics.

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Institutions at which work was performed: listed in detail under acknowledgements.

Support: Supported by an unrestricted grant from GlaxoSmithKline, which also supplied drugs and placebos for the trial, and a grant from the American Lung Association.

Disclosures:

Dr. Lang has no conflicts of interest in the subject matter of this manuscript

Dr. Hossain has no conflicts of interest in the subject matter of this manuscript

Dr. Dixon has no conflicts of interest in the subject matter of this manuscript

Dr. Shade as no conflicts of interest in the subject matter of this manuscript

Dr. Wise has no conflicts of interest in the subject matter of this manuscript

Dr. Peters has no conflicts of interest in the subject matter of this manuscript

Dr. Lima has no conflicts of interest in the subject matter of this manuscript

ABSTRACT:

Background The relationship between obesity and asthma remains inadequately defined. Studies conflict about how obesity affects asthma control and lung function. Additional focus on the effect of age as a modifier may make clearer the interaction between obesity and asthma phenotype. We sought to utilize a diverse and well-phenotyped cohort of asthmatic patients to determine how age impacts the relationship between obesity and spirometry, peak flow variability, airflow perception and asthma control.

Methods: Characteristics of 490 patients with mild persistent asthma taken from 2794 study visits from a prospective trial studying strategies of step-down therapy were included in this post-hoc

1 analysis. A longitudinal mixed-effect model was used to determine if age affects the relationship
2 between obesity and asthma characteristics including spirometry, asthma control, airway pH and
3 perception of airflow changes.

4 Results: The effect of obesity on asthma outcomes changes with age and gender. Obese 6-11
5 year olds had the largest reduction in lung function, but reported relatively fewer asthma
6 symptoms compared to similar non-obese asthmatics. Obese 12-17 year olds showed a trend
7 toward greater airflow obstruction and asthma symptoms compared to non-obese asthmatics.
8 Adults in general displayed few obesity-related alterations in asthma phenotype. Female gender
9 among 12-17 and 18-44 year olds was associated with greater obesity-related asthma impairment.

10 Conclusions: Age is a significant effect modifier on the relationship between obesity and asthma
11 phenotype. With increasing age, the influence of obesity on the asthma phenotype is generally
12 reduced. The asthma phenotype may be most impacted by obesity among children and females.

1 **Abbreviation List:**

2 ACQ = Asthma Control Questionnaire Score (Juniper)

3 ACQm = Asthma Control Questionnaire Score (Juniper) – modified

4 ALA-ACRCs = American Lung Association Asthma Clinical Research Centers

5 ANOVA = analysis of variance

6 ASUI = Asthma Symptom Utility Index

7 BMI = body mass index

8 EBC = exhaled breath condensate

9 FEV₁ = forced expiratory volume over 1 second

10 FVC = forced vital capacity

11 PF_{max} = peak expiratory flow maximum

12 PF_{mean} = peak expiratory flow mean

13 PF_{min} = peak expiratory flow minimum

14 PF_{var} = peak expiratory flow variability

15

Introduction

Obesity increases the risk for new asthma¹⁻⁹, and may complicate the asthma phenotype. Greater asthma impairment is reported among obese adults and children¹⁰⁻¹⁷, however some well-phenotyped asthma cohorts have failed to demonstrate significant obesity-related differences¹⁸⁻²⁰. Whether obesity alters innate disease severity, airflow obstruction, and temporal airflow stability remains poorly defined^{17,21,22}. In addition, exhaled breath condensate (EBC) pH, asthma symptom scores, peak flow variability (PF_{var}), and the relationship between peak flow variability and symptom scores (*airflow perception*) have not been studied extensively among lean and obese asthmatics across a broad age range. Since age is pertinent to both the natural progression of asthma and current management guidelines, age may also be an important covariate in the interaction between obesity and asthma phenotype that may have confounded past studies.

We hypothesize that age is an important modifier of obesity's impact on asthma. Few reports have evaluated how age and obesity interact and influence the perception of airway function. One report showed similar dyspnea reporting among lean and obese *adult* asthmatics following comparable bronchoconstriction²³. Others have shown increased asthma impairment among the obese *adults* despite similar objective lung function^{24,25}. However, little is known about how obesity affects airway perception among children in the reporting of asthma symptoms. We present the analysis of an asthma trial involving a large, diverse cohort ranging from age 6 to 76 from 19 US asthma centers assessing whether age impacts the association between obesity and asthma phenotype.

Methods

Details of the main study design have been published elsewhere²⁶. All participants signed written informed consents. The study was approved by the Nemours Florida IRB (03-016) and by all other ALA-ACRC network IRBs, and registered at ClinicalTrials.gov (NCT00156819). We included data from 2794 study visit encounters involving 490 participants age 6-76 with mild

1 persistent asthma randomized into a 16-week multicenter asthma trial assessing 3 step-down
2 therapies²⁶.

3 **Data Collected**

4 We analyzed demographics, daily peak flows, exhaled breath pH, spirometry, Asthma
5 Control Questionnaire (ACQ), and Asthma Symptoms Utility Index (ASUI) on 494 participants²⁶.

6 Spirometry was analyzed at randomization, and again 2, 4, 8, 12 and 16 weeks following
7 randomization. PF_{var} was calculated for each 10 day block immediately preceding visits 3-8. We
8 compared symptom questionnaire scores with PF_{var} taken during the corresponding time period.

9 $PF_{var} = (PF_{max} - PF_{min}) / (PF_{mean})$.

10 Asthma symptoms were assessed using patient reporting from the ACQ and ASUI. The
11 ACQ includes six questions assessing symptom control over the previous week, plus considers
12 FEV_1 . We calculated a modified ACQ score (ACQm) excluding FEV_1 to create a score based
13 solely upon patient subjective reporting. Participants were classified as underweight, normal
14 weight, overweight or obese based on their BMI (age 18-76) or BMI-percentile (age 6-17) taken
15 at enrollment and according to standard CDC classification (see BMI table). For all statistical
16 analyses, participants were grouped as either obese or non-obese. Weight and BMI were re-
17 assessed at the completion of the trial to

18 adjust for any significant weight changes.

19 The underweights (n=4) were dropped
20 from analyses.

BMI table	Age 6-17 (BMI-percentile)	Age 18-35 (raw BMI)
Underweight	< 5 th	< 18.5
Normal weight	5 - 84.9 th	18.5 - 24.9
Overweight	85 - 94.9 th	25 - 29.9
Obese	95 - 100 th	≥30

21 Scores on the Asthma Control Questionnaire (ACQ) range from 0 to 6, with a higher
22 score indicating worse asthma control; the minimal clinically important difference (MID) is 0.5;
23 Scores on the Asthma Control Questionnaire – modified (ACQm) range from 0 to 6, with a
24 higher score indicating worse asthma control; the MID is unknown. Scores on the Asthma
25 Symptom Utility Index (ASUI) range from 0 to 1, with a higher score indicating better asthma
26 control; the MID is unknown, but a difference of 0.3 is suggested to distinguish between mild-to-
27 moderate and moderate-to-severe asthma.

1 **Data Analysis**

2 Baseline data were summarized by age groups. Chi-square test was used for comparing
3 categorical variables between groups, while ANOVA or Kruskal Wallis tests were used to
4 compare quantitative variables between groups. A longitudinal linear mixed effect model with
5 random intercept and an unstructured within subject correlation structure for repeated
6 measurements were used to determine obesity and its joint effects with age, gender and atopy on
7 asthma symptom reporting after controlling for effects of race and treatment response. BMI
8 group, age, gender, race, atopy, and interactions of BMI with age, gender, and atopy were used in
9 the model. A longitudinal mixed effect model with random intercept and unstructured within
10 subject correlation structure for repeated measurements over study visits was used to determine
11 the relationship between quantitative subjective versus objective asthma measures after stratifying
12 to obese and non-obese groups and controlling for age, gender, and race. The study visit was
13 used as a repeated variable to account for within subject correlation for repeated measurements
14 over visits during the study period in all of these longitudinal mixed effect models. We assessed
15 the relationship between ACQm (score of patient's symptoms reported from a 7-day period) and
16 the PFvar from the same period, represented by the standardized coefficients in Table 3.
17 Analyses were stratified by age groups. We collected data from over 95% of the potential visits.
18 We had near complete data on participant demographics. Missing data existed for EBC pH (19%
19 of participants) and daily peak flows (~13% of total participant-days). We used mixed model
20 analyses that handled "missingness" using both Missing Completely at Random (MCAR) and
21 Missing At Random (MAR) mechanisms. The mixed model analysis procedure we used can
22 accommodate this type of missingness with a correct specification of a model for means and
23 covariances. We used caution in picking an appropriate model for means and covariances. More
24 information on the handling of missing data is available in the on-line supplement. SAS 9.1.2
25 (SAS Institute Inc, Cary, NC, USA) and SPSS 17.0 (SPSS Inc, Chicago, IL, USA) were used.
26 All tests were two-tailed at a level of significance of 0.05.

27

Results

Baseline Characteristics

The baseline characteristics at randomization of 490 children, adolescents, and adults are shown by age group (table 1). Approximately 60% of participants were between 18-44 years of age. Adults (18-76) tended to be female while younger participants were more likely to be male (table 1). There was a significantly higher prevalence of African-Americans (50%) among children than among adolescents (34%) and adults (24%). Overweight/obese prevalence increased with advancing age among the four age groups (fig 1). Increasing age saw a significant decline in FEV₁ % predicted, FEV₁-post bronchodilator improvement, FEV₁/FVC and PF_{var} in unadjusted analysis. Adults (age 18-76) had significantly worse asthma symptom scores versus 6-17 year olds (table 1, p<.03 for ACQ, ACQm and ASUI). No correlations existed between age group and atopy or exhaled breath pH.

Unadjusted analysis was also performed comparing baseline characteristics between BMI groups. Normal BMI participants had slightly greater FEV₁ % predicted and FEV₁/FVC compared to overweight and obese participants, while there were no BMI-related associations with asthma control, bronchodilator responsiveness, PF_{var}, EBC pH or atopy (data not shown).

Impact of Age on the Relationship between Obesity and Asthma Outcomes

Using a longitudinal multivariate mixed effect model without age stratification, we saw no clinically significant differences in lung function, bronchodilator responsiveness, PF_{var}, EBC pH or asthma control between BMI groups (data not shown). We noted a statistical interaction between age in years and body mass index (age*bmi) for FEV₁/FVC (p<.001) and PF_{var} (p=.007). Statistical interaction effects (age*bmi) were weaker for FEV₁ (p=.159) and ACQm (p=.279). Other interaction models using age in years with obesity group (age*obesity group) yielded similar results.

When we stratified by the four age-groups (table 2), we saw distinct age-related obesity and gender effects on several asthma outcomes. We noted relatively few obesity-related

1 differences among 18-44 and 45-76 year olds. Obesity did not significantly impact lung function
2 decline with advancing age (fig2, FEV₁% predicted, p=.103; FEV₁/FVC, p=.307). Among obese
3 18-44 year olds, we saw a reduced FEV₁% predicted driven mainly by a statistical interaction
4 between obesity and female gender. In addition, obese 18-44 year old females (but not males)
5 reported worse asthma symptoms compared to similar non-obese females (ACQm p=.019, ACQ
6 p=.016, ASUI p=.057). Obese 12-17 year old females (but not males) also displayed worse
7 asthma symptoms (ACQ p=.008, ACQm p=.02) and a trend toward reduced FEV₁% predicted
8 (p=.078) compared to gender-matched non-obese adolescents. Obese asthmatics 6-11 year olds
9 (both genders) had significantly reduced FEV₁% predicted (p=.02) and FEV₁/FVC (p=.001)
10 compared to age-matched non-obese asthmatics. Obese 6-11 year olds also reported fewer
11 asthma symptoms compared to age-matched non-obese asthmatics. This obesity effect on
12 reduced asthma symptoms was driven primarily by a statistical interaction with gender; obese
13 males reported significantly fewer symptoms than non-obese males (p<.05) while there was no
14 obesity-related difference among 6-11 year old females.

15 PF_{var} between obese and non-obese participants was similar within both adult age groups.
16 We noted a trend toward reduced PF_{var} among the obese versus non-obese 6-11 year olds (p=.09).
17 The direction of this trend appeared to reverse among the adolescent age group (table 2). No
18 differences were seen in three symptom scores (ACQ, ACQm, ASUI) between obese and non-
19 obese participants in the two adult age groups. A reduction in asthma symptoms was noted
20 consistently in 6-11 year old obese asthmatics from all three validated scores (ACQ, ASUI,
21 ACQm). This was not seen among obese 12-17 year olds, where there was a trend for higher
22 mean ACQ score, suggesting greater symptom reporting (p=.09, 2-sided).

24 ***Impact of Obesity on the Relationship between Lung Function and Symptom Reporting***

25 We evaluated the relationship between PF_{var} and the corresponding symptom reporting (ACQm)
26 from the same time period. The degree of the asthma symptoms-to-PF_{var} relationship (termed
27 “airflow perception”) was compared between obese and non-obese participants in the four age

groups (Table 3). The extent and direction of the relationships are quantified in table 3 by standardized coefficient. We are evaluating how obesity-status affects the relationship between fluctuations in airflow and the resulting symptoms over the same period. Among 45-76 year olds, there was no significant relationship between PF_{var} and asthma symptom reporting (ACQm) in either obese (-1.014, $p=.313$) or non-obese (-.743, $p=.459$) participants. However, among the three younger age groups, both obese and non-obese participants displayed a significant positive relationship between PF_{var} and ACQm (an increase in PF_{var} corresponds to an increase in symptom reporting). For the three younger groups, there was also a statistically significant difference in the degree of the relationship between obese and non-obese, however the direction of association was age-dependent. Among 18-44 year olds, the standardized coefficient between PF_{var} and ACQm was significantly greater among non-obese compared to obese participants (5.45 vs. 3.38, $p<.001$). However, in the pediatric population, the direction of this relationship was reversed. Among 6-11 year olds and 12-17 year olds, the standardized coefficients between PF_{var} with ACQm were significantly greater among the obese population compared to the non-obese (table 3).

A similar analysis was conducted comparing subjective versus objective asthma measures utilizing FEV_1 % with ACQm. Changes in FEV_1 % did not correlate as well with symptom control as did PF_{var} , particularly among the obese (data not shown). Table 4 summarizes the major obesity-related asthma findings by age group.

Discussion

Obesity is a risk-factor for new asthma across a broad age range^{1-5,27}, and may complicate asthma control^{17,22,28}. After assessing lung function, breath pH, airflow lability, symptom-control and airflow perception among obese and non-obese participants, we conclude that age is an important effect modifier in the obesity-asthma relationship and, along with gender, is a primary co-variate determining the obese-asthma phenotype.

1 In summary, young children appeared to be most affected by obesity in terms of lung
2 function, and were the only group with evidence of obesity-related airflow obstruction.
3 Paradoxically, obese young children, primarily boys, reported reduced asthma symptoms.
4 Obesity, however, may be most problematic among adolescents. Despite a limited power, the
5 obese adolescent group consistently showed a tendency for worse lung function, PF_{var} , and
6 symptom reporting compared with non-obese adolescents. Maintaining a healthy weight may be
7 most important during the adolescent years. Obese adults between 18-44 years of age (of both
8 genders) had significantly reduced $FEV_1\%$ predicted versus comparable leans. Though obese
9 asthmatics may be at greater risk for asthma attacks^{11,29}, our data suggest that these attacks do not
10 appear to result from greater airway contractility or lability. There was also a significant
11 association between PF_{var} and symptom reporting in all age groups except the 44-76 year olds.
12 Obesity was an important effect-modifier that interacted with age in this PF_{var} -ACQm association.
13 Both pediatric obese groups were more sensitive to changes in peak flows compared with their
14 comparable pediatric non-obese groups (greater airflow perception), while the young adult obese
15 group had reduced airway perception.

16 When we assessed the effect of obesity among the entire cohort (without age
17 stratification), we found that obesity had little impact on asthma outcomes. However, with age-
18 group stratification, the longitudinal data revealed important BMI-related differences. Obese 6-
19 11 year olds of both genders had significantly reduced $FEV_1\%$ predicted and FEV_1/FVC
20 compared to non-obese children. Low-volume respiration ('latch-effect'³⁰) has been proposed in
21 obesity-related lung impairment, however this mechanism might be expected to lead to greater β -
22 agonist response, which we did not see. Obese 6-11 year olds had normal airway pH and fewer
23 symptoms. These findings do not support the mechanisms of esophageal reflux or greater airway
24 inflammation as a factor in obesity-related lung impairment. These finding need to be interpreted
25 with caution as measurement of airway acidification can be variably influenced by a host of
26 collection and handling factors³¹. Obesity may not act causally in early airflow obstruction, but
27 rather large body mass early in life may be associated with altered development patterns that

1 include more accelerated lung volume expansion with a relative delay in airway caliber. Obese
2 boys, despite reduced lung function compared to leans, reported fewer symptoms, suggesting
3 early growth alterations could also impact disease perception. Further longitudinal studies that
4 assess body mass, airway function and symptom perception during development are needed.

5 Others have reported a reduction in asthma-related quality of life in obese children²⁵.
6 Paradoxically, we found lower lung function with *fewer* symptoms in the 6-11 year old obese
7 children. This might be explained by reduced activity levels among obese children. A sedentary
8 nature among some young asthmatic children could be an underlying mechanism for both obesity
9 and reduced symptoms, which would lead to the paradoxical association that we saw in 6-11 year
10 olds. Alternatively, obese 6-11 year old males could have inherently more stable disease, which
11 is supported by the trend for reduced PF_{var} in 6-11 year olds overall, resulting from altered
12 response to early viral infection or triggers such as environmental tobacco smoke, compared with
13 their leaner age-matched counterparts. Obesity in this early age may impair adaptive responses to
14 respiratory viruses, resulting in reduced asthma triggering. Obese animal models have shown
15 impaired cytokine responses to influenza³² and delayed inflammatory cell recruitment to the
16 lung³³. It is not clear why obesity increases the risk for new asthma in this young age^{5,6}, while
17 being associated with reduced asthma symptoms. Obesity has been most strongly associated with
18 non-atopic asthma, while our cohort was primarily of the atopic phenotype. It is possible that
19 obesity among atopic asthmatics may ameliorate allergic airway inflammation and resulting
20 symptoms.

21 Obese adolescent males and females, unlike the 6-11 year olds, did not have significantly
22 improved asthma control. We noted a gender and age interaction, where obese adolescent girls
23 had greater asthma symptoms compared with non-obese girls. The degree of obesity-related
24 airflow obstruction was even greater in obese adolescents (compared with 6-11), but did not reach
25 statistical significance. Among girls only, $FEV_1\%$ predicted was reduced in the obese. We and
26 others have reported airflow obstruction among obese asthmatics³⁴⁻³⁶. Weight loss as an asthma

1 therapy in children deserves study and these data suggest that adolescents especially should be
2 promoted for a multidisciplinary approach to asthma control when obesity is present.

3 Among adults, obesity-related differences in asthma control were absent. The ACRC
4 previously reported few differences between obese and lean asthmatic adults¹⁹. The current
5 analysis saw only a reduced FEV₁% predicted (primarily among females) and PF_{var}-asthma
6 symptom association (both genders) among 18-44 year olds. These findings were absent in 45-76
7 year olds. We theorized that obesity may accelerate age-related lung function decline but this
8 was not the case.

9 Past studies have shown an inconsistent statistical interaction between gender and obesity
10 on asthma risk^{3-5,9,37,38}. For adults, there may be a greater risk for incident asthma among obese
11 woman compared to obese men³⁹. In youths, the age of obesity onset appears to be important.
12 Cohort studies in younger children do not show a consistent gender risk pattern. However, after
13 puberty, adolescent girls appear to be more consistently at risk for new obesity-related asthma^{4,5,9}.
14 Fewer studies involving well-characterized asthmatics have addressed the obesity-gender
15 interaction on phenotype characteristics. In our cohort, despite substantially limited power, we
16 found that female gender, especially among the 12-17 and 18-44 age groups, was associated with
17 greater obesity-related asthma impairment. Tantisira found no gender-obesity interaction
18 affecting asthma symptoms in the CAMP cohort involving 5-12 year olds, but did see a reduction
19 in FEV₁/FVC mainly in boys and greater airway responsiveness mainly in girls⁴⁰. Ross and
20 colleagues studied 4-18 year old asthmatics and did not find a statistical interaction between
21 obesity and gender on either asthma control or lung function¹⁸.

22 This was the first study to our knowledge to assess obesity-gender effect modification on
23 asthma phenotype across a broad age range. Though our study involved highly phenotyped
24 asthmatics, the analysis was seriously hampered by power in its ability to assess multiple
25 interactions. Larger studies involving well-phenotyped asthma cohorts are needed to untangle the
26 age-specific effects of gender and obesity on asthma.

1 This is also the first study to our knowledge defining the impact of obesity and age on
2 PF_{var}. A positive standardized coefficient suggests a direct relationship between PF_{var} and asthma
3 symptom reporting. Children and adolescents with obesity had a significantly *greater* direct
4 relationship compared to the non-obese, suggesting the obese may have a more acute sensitivity
5 to airflow alterations, which may contribute to greater symptom reporting and poorer asthma
6 control reported previously among the obese^{11,13,15}. Age modifies the PF_{var}-symptom score
7 relationship. Obese 18-44 year olds displayed a significantly *reduced* standardized coefficient
8 compared to non-obese adults, suggesting obesity during early adulthood may be associated with
9 altered perception of airflow. Data on how obesity impacts symptom reporting, adjusted for
10 objective lung impairment, are scarce. Reports of greater asthma severity in the obese appear to
11 stem primarily from greater symptom reporting and healthcare utilization^{14,15,29}. Our data suggest
12 that at least among adolescents, poor asthma control reported among the obese may be in part the
13 result of heightened perception of airflow perturbations.

14 A limitation to this study is the inclusion of only mild persistent asthmatics. Though the
15 majority of persistent asthmatics have mild disease, patients with moderate to severe disease
16 consume a large portion of asthma-related health resources. This study describes how obesity
17 impacts patient of a broad age-range having mild-persistent disease during a relatively stable
18 step-down period. This study cannot directly comment on the impact of obesity and age on
19 moderate-severe disease, however. It is also important to note that our findings are the result of a
20 post-hoc analysis of data from a multicenter clinical trial not specifically designed to assess age
21 and obesity on asthma outcomes. Another limitation is the use of PF_{var}. Peak flow variability is
22 far from a perfect objective marker of airway function. Though peak flow monitoring is
23 recommended as a potential component of daily self-management⁴¹, its use has fallen out of favor
24 with many experts due to challenges with adherence and variability especially with young
25 children. However, it nonetheless gives us some objective measure of day-to-day airway
26 functioning during the exact period of time for which the patient was reporting their symptoms.
27 Lastly, this study was limited by power. In order to complete a thorough analysis of the

modifying effects of age and gender on the impact of obesity on asthma outcomes, a study must be both large and diverse. Though we were able to show some significant effects related to age and gender in this moderately sized asthma trial, some of the sub-groups (e.g. *obese, 12-17 year old females*) were small. Multiple comparisons involving small groups are susceptible to both type 1 (false positive) and type 2 (false negative) error, and limited in the ability to fully assess statistical interactions and confounding effects. Nevertheless, our data suggests that there is not a universal “obese asthma” phenotype, and that gender and age are important co-variables. These data strongly suggest that in order to define the impact of obesity on the asthma phenotype, large cohorts involving children, adolescents and older adults of diverse demographic backgrounds must undergo further study.

Overall, this study shows that the effects of obesity on lung function and asthma scores change with age. The greatest effects may occur in childhood and females and may be mediated by alterations in growth and airflow perception, rather than by airway inflammation or instability.

***Acknowledgements:**

This research was performed by the American Lung Association Asthma Clinical Research Centers (ALA-ACRC). The members of the ALA-ACRC research group for the trial were as follows: Baylor College of Medicine, Houston: N.A. Hanania (principal investigator), M. Sockrider (coprincipal investigator), L. Giraldo (principal clinic coordinator), R. Valdez (coordinator); Maria Fareri Children's Hospital at Westchester Medical Center and New York Medical College, Valhalla: A. Dozor (principal investigator), N. Amin, Y.C. Kim (coprincipal investigators), I. Gherson (principal clinic coordinator), M. Heydendael, M. Key (coordinators); Columbia University–New York University Consortium, New York: J. Reibman (principal investigator), E. DiMango (coprincipal investigator), W. Hoerning (clinic coordinator at New York University), J. Sormillon (clinic coordinator at Columbia University); Duke University Medical Center, Durham, NC: L. Williams (principal investigator), J. Sundy (coprincipal investigator), G. Dudek (principal clinic coordinator), R. Newton (coordinator); Emory

1 University School of Medicine, Atlanta: W.G. Teague (principal investigator), S. Khatri
2 (coprincipal investigator), J. Costolnick, (principal clinic coordinator), J. Peabody, R. Patel
3 (coordinators); Illinois Consortium, Chicago: L. Smith (principal investigator), J. Moy, E.
4 Naurekas, C.S. Olopade (coprincipal investigators), J. Hixon (principal clinic coordinator), A.
5 Brees, G. Rivera, S. Sietsema, V. Zagaja (coordinators); Indiana University Asthma Clinical
6 Research Center, Indianapolis: M. Busk (principal investigator), F. Leickly, C. Williams
7 (coprincipal investigators), S. Lynch (principal clinic coordinator); P. Puntenney (coordinator);
8 Jefferson Medical College, Philadelphia: F. Leone (principal investigator), M. Hayes-Hampton
9 (principal clinic coordinator); Louisiana State University Health Sciences Center, Ernest N.
10 Morial Asthma, Allergy, and Respiratory Disease Center, New Orleans: W.R. Summer (principal
11 investigator), C. Glynn (principal clinic coordinator); National Jewish Medical and Research
12 Center, Denver: S. Wenzel (principal investigator), P. Silkoff (coprincipal investigator), R. Gibbs
13 (principal clinic coordinator), L. Lopez, C. Ruis, B. Schoen (coordinators); Nemours Children's
14 Clinic–University of Florida Consortium, Jacksonville: J. Lima (principal investigator), K. Blake,
15 D. Schaeffer (coprincipal investigators), A. Santos (principal clinic coordinator), L. Duckworth
16 (coordinator); North Shore–Long Island Jewish Health System, New Hyde Park, NY: J. Karpel
17 (principal investigator), R. Cohen (coprincipal investigator), R. Ramdeo (principal clinic
18 coordinator); Northern New England Consortium (formerly Vermont Lung Center at the
19 University of Vermont), Colchester: C.G. Irvin (principal investigator), A.E. Dixon, D.A.
20 Kaminsky, E. Kent, T. Lahiri, P. Shapiro (coprincipal investigators), S. Lang (principal clinic
21 coordinator), J. Allen, A. Coote, L.M. Doucette, K. Girard, J. Lynn, L. Moon, T. Viola
22 (coordinators); Ohio State University Medical Center–Columbus Children's Hospital, Columbus:
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2 submitted article. Dr. Lang also vouches for the integrity of the data and accuracy of the data
3 analysis.

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8 Dr. Dixon made substantial contributions to the design, and acquisition
9 of data for this study. She helped critically edit the manuscript for important intellectual content.

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18 Dr Peters designed the main clinical trial on which this analysis is based. He contributed to the
19 analysis and interpretation of data for this current study. He helped draft the submitted article and
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22 Dr Lima has made substantial contributions to the conception, design, and acquisition
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Figure Legends

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28 **Figure 1.** – Percent of participants who are overweight or obese by age group. BMI – body mass
29 index. Overweight or obese include participants with randomization visit BMI > 85th percentile

for children and adolescents (age groups 6-11 and 12-17, respectively), or BMI >25 for adults (age groups 18-44 and 45-76). Obese participants had a randomization visit BMI > 95th percentile for children and adolescents (age groups 6-11 and 12-17, respectively), or BMI >30 for adults (age groups 18-44 and 45-76).

Figure 2. – A) Raw data points for FEV₁ versus age among adults age 18-76 during visits 3-8, with fitted regression of mean predicted FEV₁% on age, adjusting for race, treatment, gender and atopy. Regression coefficients describing change in FEV₁% predicted for change in age for obese adults was -0.174 (p=.009) versus -0.109 (p=.013) for non-obese adults. There was no rate difference in age-related FEV₁ –decline among obese versus non-obese asthmatics (p-value for difference in regression coefficients, p=.374). B) Raw data points for FEV₁/FVC versus age among adults age 18-76 during visits 3-8, with fitted regression of mean predicted FEV₁/FVC on age, adjusting for race, treatment, gender and atopy. Regression coefficients describing change in FEV₁/FVC for change in age for obese adults was -0.007 (p=.103) versus -0.0011 (p<0.001) for non-obese adults. There was no statistical difference in age-related FEV₁/FVC decline among obese versus non-obese asthmatics (p-value for difference in regression coefficients, p=.307). / - denotes zero suppression.

Does Age Impact the Obese Asthma Phenotype?: Longitudinal Asthma Control, Airway Function and Airflow Perception among Mild Persistent Asthmatics

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Chest; Prepublished online July 28, 2011;
DOI 10.1378/chest.11-0675

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