EFFECTS OF CIGARETTE SMOKING ON LUNG FUNCTION IN ADOLESCENT BOYS AND GIRLS

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ABSTRACT

Background Little is known about the sex-specific effects of cigarette smoking on the level and growth of lung function in adolescence, when 71 percent of people in the United States who smoke tried their first cigarette.

Methods We studied the effects of cigarette smoking on the level and rate of growth of pulmonary function in a cohort of 5158 boys and 4902 girls 10 to 18 years of age, examined annually between 1974 and 1989 in six cities in the United States.

Results We found a dose–response relation between smoking and lower levels of both the ratio of forced expiratory volume in one second to forced vital capacity (FEV_1/FVC) and the forced expiratory flow between 25 and 75 percent of FVC ($FEF_{25–75}$). Each pack per day of smoking was associated with a 3.2 percent reduction in $FEF_{25–75}$ for girls ($P=0.01$) and a 3.5 percent reduction in $FEF_{25–75}$ for boys ($P=0.007$). Whereas the FVC level was elevated in smokers, the rate of growth of FVC and FEV_1 was reduced. Among adolescents of the same sex, smoking five or more cigarettes a day, as compared with never smoking, was associated with 1.09 percent slower growth of FEV_1 per year in girls (95 percent confidence interval, 0.70 to 1.47 percent) and 0.20 percent slower growth in boys (95 percent confidence interval, −0.16 to 0.56 percent), and with 1.25 percent slower growth of $FEF_{25–75}$ per year in girls (95 percent confidence interval, 0.38 to 2.13 percent) and 0.93 percent slower growth in boys (95 percent confidence interval, 0.21 to 1.65 percent). Whereas girls who did not smoke reached a plateau in lung function at 17 to 18 years of age, girls of the same age who smoked had a decline of FEV_1 and $FEF_{25–75}$.

Conclusions Cigarette smoking is associated with evidence of mild airway obstruction and slowed growth of lung function in adolescents. Adolescent girls may be more vulnerable than boys to the effects of smoking on the growth of lung function. (N Engl J Med 1996;335:931-7).

AMONG people in the United States who smoked in 1991, 71 percent reported that they tried their first cigarette before the age of 19 years.[1] In the 1950s many more boys than girls smoked, but adolescent girls now take up smoking at least as frequently as boys.[2] Girls and boys begin smoking at similar ages,[1,3] but they may not be at similar stages of physical maturation. Smoking may affect female and male lungs differently, and these sex differences may relate to the caliber of airways or to hormonal status at different stages of life. A higher prevalence of airway hyperresponsiveness in women who smoke than in men who smoke was partly explained by lower airway caliber in women, as measured by the absolute level of forced expiratory volume in one second (FEV_1).[4] Exposure to cigarette smoke led to a greater increase in the number of mucus-producing tracheal goblet cells in female rats than in male rats; differences between the sexes were related to the estrous cycle.[5-7] We examined the sex-specific effects of smoking on the level and growth of lung function in children 10 to 18 years of age. We previously reported the associations between smoking and chest illness, chronic cough, acute bronchitis, and wheezing in these children.[8]

METHODS

A total of 12,253 white children in the first through fourth grades were enrolled from schools in six areas of the United States (Watertown, Massachusetts; Kingston and Harriman, Tennessee; Steubenville and Mingo Junction, Ohio; St. Louis; Portage, Wisconsin; and Topeka, Kansas) between 1974 and 1979.[9,10] At each annual examination, up to grade nine, parents or guardians completed a questionnaire requesting information about the smoking habits of parents, demographic data, and a history of respiratory illnesses and symptoms for each child and his or her parents. Each child in grades four through eight was asked privately about personal smoking. Starting in grade nine, the questionnaire was completed by the participating children themselves and included questions about personal smoking.

Annually, each child's standing height in stocking feet was measured. Forced expiratory volumes were measured with a water-filled recording spirometer (Survey Spirometer, Warren E. Collins, Braintree, Mass.) while the subjects were sitting without noseclips. Each child performed at least five forced expirations but not more than eight. Forced vital capacity (FVC) and FEV_1 were measured for each expiration judged acceptable by the examiner. The mean of the best three efforts was calculated after corrections for body temperature, ambient pressure, and water saturation. The flow between 25 percent and 75 percent of FVC ($FEF_{25–75}$) was measured from the expiration with the highest value for the sum of the FVC and FEV_1.

Definitions

The children's smoking behavior was divided into five categories: never having smoked, having smoked formerly, or currently

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smoking ½ to 4, 5 to 14, or 15 or more cigarettes per day. Maternal smoking status, found previously to predict the level of lung function in this cohort,[11] was modeled with the use of an indicator for former smoking and current smoking measured as the number of cigarettes per day. When relations between smoking and lung function were linear, regression models were considered that included the number of cigarettes smoked per day as a continuous variable and former smoking as a categorical variable. The mean education of the parents was categorized as less than, equal to, or greater than 12 years.

Statistical Analysis

The analyses were restricted to the 10,060 children (5158 boys and 4902 girls) 10 to 18 years of age with at least one measurement of FVC (Table 1). The logarithm of the level of lung function was modeled as a function of log height and age in sex-specific regressions. Because the relation between pulmonary function and height varies according to age during adolescence, regression models for lung-function level and rate of growth for each one-year interval were estimated. Age-specific intercepts and slopes were linked to produce continuous expected values as a function of age and height.[12-14] Regression coefficients were estimated with independence-estimating equations, with estimated variances adjusted for the correlation among repeated measurements.[15]

Descriptive analyses showed that the effects of smoking on pulmonary function were additive on the logarithmic scale — that is, that smoking produced a proportional deficit in pulmonary function. Estimates and confidence intervals for smoking effects were calculated on the logarithmic scale and then expressed as percentage effects by taking the exponential of the estimates (or confidence intervals), subtracting 1, and multiplying the result by 100. All final regression analyses were sex-specific and adjusted for age, log height at each age, residence, parental education, and the smoking status of the mother. To test for the modification of effects between age group (10 to 14 years or 15 to 18 years) or wheezing status and smoking, we incorporated interaction terms in these models, separately according to sex. We assessed P values for differences between the sexes in the effects of smoking by comparing the difference between the estimated smoking effects in boys and girls, divided by the sum of the standard errors of these estimates, with the standard normal distribution. This is equivalent to assessing sex and smoking interactions in a joint analysis of boys and girls, provided that all other covariates also have sex interactions. All P values are two-tailed.

Examining growth requires pairs of pulmonary-function values to express the changes in the level of function between consecutive years. Hence, there were approximately 10 percent fewer observations for analyses of the growth of lung function than for analyses of lung-function level. The categories of medium smoking and heavy smoking were combined because the number of observations of heavy smoking was small, the observed effects of medium and heavy smoking were similar, and no statistically significant differences were found in the magnitude of the associations with the growth of lung function. The effects of smoking on the growth of lung function were examined on both a relative scale (comparing percentage differences) and an absolute scale (measuring in milliliters).

To assess whether differences in stage of maturity contributed to differences between the sexes in smoking effects, we repeated the analyses after each child's age was centered relative to his or her age at peak growth in height (a measure of the timing of the adolescent growth spurt) — that is, it was expressed as the number of years since the year of peak height growth.[16] Peak growth in height was determined only for boys who had three measures of one-year changes in height between the ages of 11.75 and 15.25 years, or four measures between the ages of 10.75 and 16.25 years. Girls were required to have three measures of one-year changes between the ages of 9.75 and 13.25 or four between the ages of 8.75 and 14.25.

Peak height-growth velocity was determined for 70 percent of the girls and 62 percent of the boys. Since the peak height-growth velocity occurred earlier for girls (average, 11.4 years) than for boys (average, 13.5 years), smoking data were sparse for the period before peak growth. Sufficient data were available on both boys and girls to permit comparison of smoking effects between the age of peak height growth and six years later.

TABLE 1. CHARACTERISTICS OF 10,060 CHILDREN 10 TO 18 YEARS OF AGE WITH AT LEAST ONE MEASUREMENT OF FORCED VITAL CAPACITY, ACCORDING TO SEX AND SMOKING STATUS.

CHARACTERISTIC	BOYS		GIRLS	
	WHO HAD NEVER SMOKED (N = 3374)	WHO HAD EVER SMOKED (N = 1784)	WHO HAD NEVER SMOKED (N = 3082)	WHO HAD EVER SMOKED (N = 1820)
	number (percent)			
Maternal smoking status				
Never smoked	1252 (37)	568 (32)	1247 (40)	536 (29)
Ever smoked	2053 (61)	1194 (67)	1779 (58)	1263 (69)
Unknown	69 (2)	22 (1)	56 (2)	21 (1)
Asthma and wheezing status				
Never had asthma or wheezing	1226 (36)	406 (23)	1227 (40)	365 (20)
Had had wheezing, but never asthma*	1689 (50)	1113 (62)	1507 (49)	1217 (67)
Had had asthma*	383 (11)	260 (15)	276 (9)	235 (13)
Unknown	76 (2)	5 (<1)	72 (2)	3 (<1)

*"Had had wheezing" was defined as ever having reported wheezing during participation in the study. "Had had asthma" was defined as ever having reported a diagnosis of asthma, including a diagnosis made before entry into the study.

RESULTS

Children who took up smoking had higher rates of having had asthma (14 percent vs. 10 percent) and of having had wheezing but not asthma (65 percent vs. 50 percent), and they were more likely to have mothers who smoked than were children who never smoked (Table 1). For both boys and girls, the proportion who smoked increased with increasing age (Table 2).[8] In observations made when the children were 15 to 18 years of age, the prevalence of current smoking was 17 percent in the boys and 19 percent in the girls. The overall mean number of cigarettes smoked was 8.9 (median, 5.7) for the boys and 7.5 (median, 4.3) for the girls. Girls whose level of smoking was medium (5 to 14 cigarettes per day) or heavy (≥15 cigarettes per day) smoked fewer cigarettes on average than boys (0.5 and 1.3 fewer cigarettes per day in the medium and heavy categories, respectively). Rates of wheezing increased according to the amount smoked and were higher for girls than for boys at each level of smoking. In an equal proportion of observations of nonsmoking boys and girls, there was current wheezing (25 percent). The proportion of observations of girls as compared with boys that involved wheezing was 45 versus 39 percent for light smoking, 56 versus 47 percent for medium smoking, and 69

TABLE 2. PREVALENCE OF SMOKING IN 58,460 OBSERVATIONS OF 10,060 CHILDREN 10 TO 18 YEARS OF AGE, ACCORDING TO SEX AND AGE GROUP.*

SMOKING STATUS AND AGE GROUP	BOYS	GIRLS
	no. of observations (%)	
Age, 10 to 14 years		
Never smoked	17,780 (96.0)	17,126 (95.8)
Formerly smoked	122 (0.7)	105 (0.6)
½–4 cigarettes/day	388 (2.1)	440 (2.5)
5–14 cigarettes/day	181 (1.0)	159 (0.9)
≥15 cigarettes/day	53 (0.3)	47 (0.3)
Total	18,524 (100.0)	17,877 (100.0)
Age, 15 to 18 years		
Never smoked	9,350 (79.5)	8,025 (78.0)
Formerly smoked	409 (3.5)	304 (3.0)
½–4 cigarettes/day	753 (6.4)	941 (9.1)
5–14 cigarettes/day	804 (6.8)	632 (6.1)
≥15 cigarettes/day	451 (3.8)	390 (3.8)
Total	11,767 (100.0)	10,292 (100.0)

*Children were observed more than once (see the Methods section). The median number of observations per child was 6 (range, 1 to 10).

versus 57 percent for heavy smoking ($P<0.001$ for the differences between the sexes).

Smoking and Level of Pulmonary Function

A dose–response relation was found between smoking and lower levels of FEV_1/FVC and $FEF_{25–75}$ (Fig. 1). Smoking 15 cigarettes or more per day, as compared with never smoking, was associated with a reduction in $FEF_{25–75}$ of 4.0 percent among the boys (95 percent confidence interval, 0.7 to 7.1 percent) and of 3.2 percent among the girls (95 percent confidence interval, 0.4 to 5.8 percent). No differences between the sexes or consistent age interactions were observed in the relation between smoking and the level of pulmonary function. Each pack per day of smoking was associated with a reduction in $FEF_{25–75}$ of 3.5 percent among the boys (95 percent confidence interval, 1.0 to 5.9 percent) and of 3.2 percent among the girls (95 percent confidence interval, 0.8 to 5.5 percent). Although there was no dose–response relation between the number of cigarettes smoked and the FVC, the FVC was larger in smokers than nonsmokers, suggesting larger lungs in those who took up smoking.

The girls reached the maximal level of lung function between the ages of 16 and 18 years, a period when the level of lung function was still increasing in the boys. For the girls who never smoked, the mean $FEF_{25–75}$ was 3.82 liters per second, 3.80 liters per second, and 3.80 liters per second at the ages of 16, 17, and 18 years, respectively. Lower mean levels of $FEF_{25–75}$ were observed in the girls who smoked five or more cigarettes per day: 3.62, 3.69, and 3.65 liters per second at the ages of 16, 17, and 18 years, respectively.

Smoking and Growth of Pulmonary Function

Over the age range of 10 to 18 years, girls who smoked five or more cigarettes per day had a rate of growth of FVC that was 0.76 percent slower per year and a rate of growth of FEV_1 that was 1.09 percent slower per year than those of girls who never smoked (Table 3). For boys, smoking five or more cigarettes per day was not significantly associated with the growth of FVC (estimated effect, 0.03 percent slower growth per year; 95 percent confidence interval, −0.24 to 0.30 percent; $P<0.001$ for the difference between the sexes) or FEV_1 (estimated effect, 0.20 percent slower growth per year; 95 percent confidence interval, −0.16 to 0.56 percent; $P=0.001$ for the difference between the sexes). Smoking five or more cigarettes per day was associated with a significantly slower percentage growth in $FEF_{25–75}$ for both boys and girls. No significant interactions were found between age and smoking in their relations to lung-function growth.

Girls, but not boys, were observed at ages when growth in height and pulmonary function was completed. After the ages of 16 to 17, girls smoking five or more cigarettes per day appeared to have a decline in $FEF_{25–75}$ and FEV_1; in girls who did not smoke, pulmonary function stopped growing (i.e., reached a plateau) but did not decline (Fig. 2).

Expressing each child's age relative to the age at peak growth in height had little effect on the estimated differences between girls and boys in the effect of smoking on the rate of growth. The estimates of the effects of smoking five or more cigarettes per day on FVC and FEV_1 growth were still significantly larger for girls than for boys ($P=0.02$ and $P=0.04$ for differences between the sexes, respectively). Boys at or beyond their peak height growth who smoked five or more cigarettes per day had 0.23 percent slower growth per year in FVC (95 percent confidence interval, −0.07 to 0.52 percent) and 0.42 percent slower growth per year in FEV_1 (95 percent confidence interval, 0.03 to 0.81 percent) than boys who never smoked. Girls at or beyond their peak height growth who smoked five or more cigarettes per day had 0.85 percent slower growth per year in FVC (95 percent confidence interval, 0.42 to 1.26 percent) and 1.12 percent slower growth per year in FEV_1 (95 percent confidence interval, 0.60 to 1.63 percent) than girls who never smoked.

In analyses expressing each child's age relative to the age at peak growth in height, smoking was also associated with a greater absolute deficit in the growth of FVC and FEV_1 for girls than for boys, despite the fact that boys in adolescence had significantly higher values for FVC (suggesting larger lung volumes) and FEV_1 (suggesting larger airways) than girls.[17] For

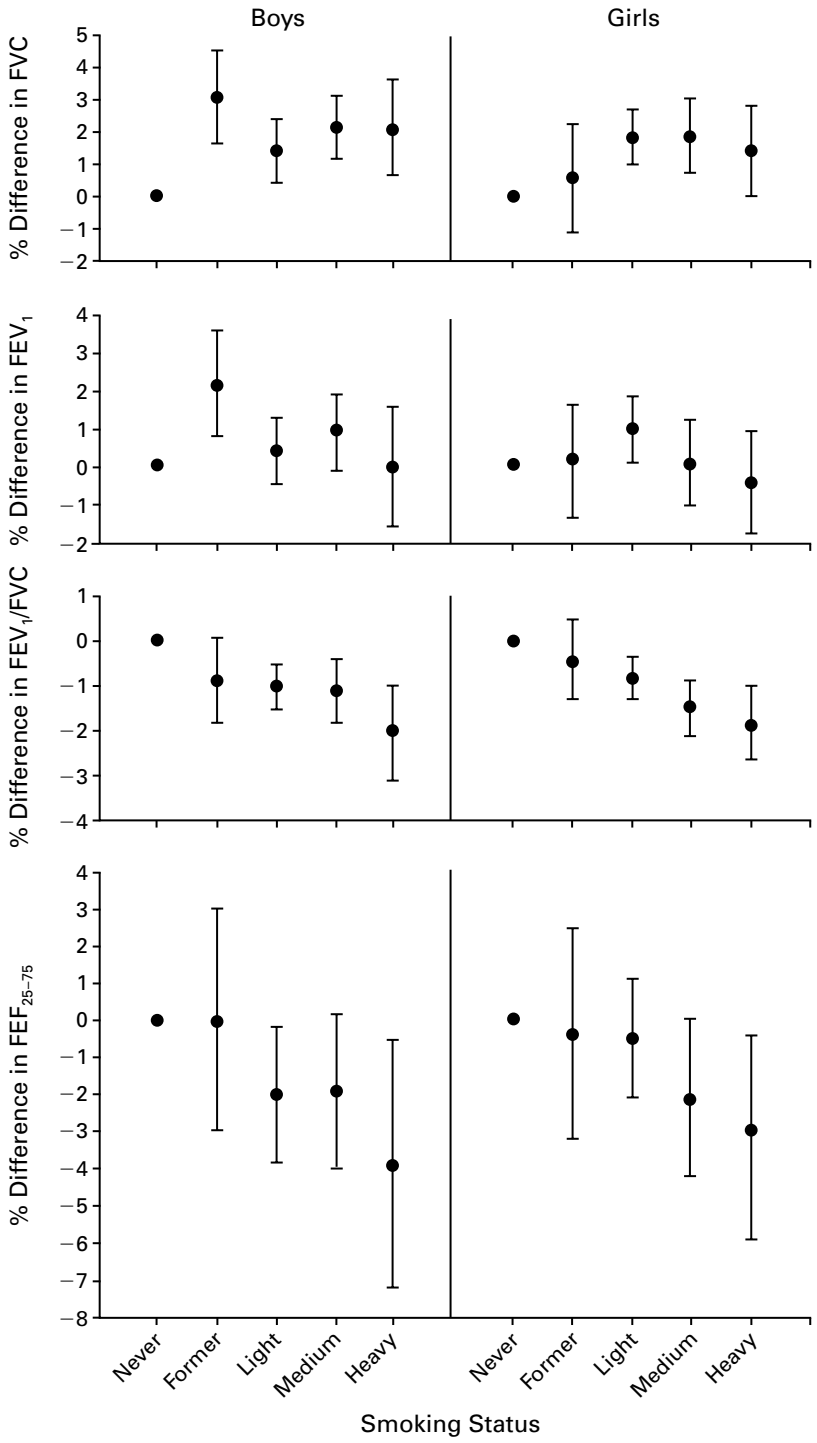

Figure 1. Sex-Specific Effects of Direct Exposure to Smoke on the Level of Pulmonary Function in Children 10 to 18 Years of Age, Estimated by Regression Analysis.

Percent differences and 95 percent confidence intervals are plotted for groups of children with differing levels of smoking as compared with children of identical age and log height who had never smoked, with adjustment for age, log height at each age, residence, parental education, and maternal smoking status. Never denotes never having smoked; Former, formerly having smoked; Light, ½ to 4 cigarettes per day; Medium, 5 to 14 cigarettes per day; and Heavy, 15 or more cigarettes per day. FVC denotes the forced vital capacity, FEV_1 the forced expiratory volume in one second, and FEF_{25-75} the forced expiratory flow between 25 and 75 percent of FVC.

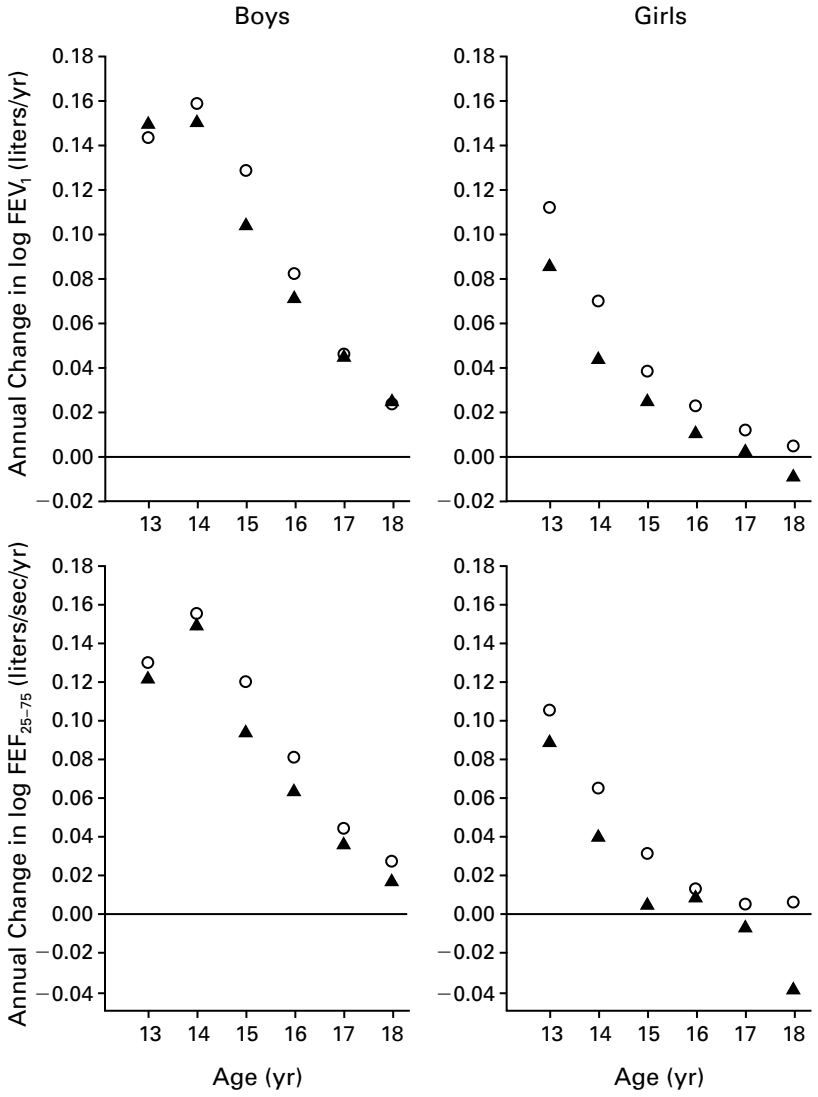

Figure 2. Mean Rates of Pulmonary-Function Growth According to Age, Sex, and Category of Smoking.

The circles represent the children who had never smoked, and the triangles those who smoked five or more cigarettes per day. There were fewer than 15 observations for smokers before the age of 13. The numbers of observations of FEV_1 in boys who smoked five or more cigarettes per day were 41 at age 13, 120 at age 14, 213 at age 15, 311 at age 16, 361 at age 17, and 151 at age 18. In girls who smoked five or more cigarettes per day, the numbers of observations of FEV_1 were 39 at age 13, 109 at age 14, 197 at age 15, 254 at age 16, 290 at age 17, and 90 at age 18. FEV_1 denotes the forced expiratory volume in one second, and $FEF_{25–75}$ the forced expiratory flow between 25 and 75 percent of the forced vital capacity.

FVC, smoking five or more cigarettes per day, as compared with never smoking, was associated with growth that was 25 ml per year slower in girls (95 percent confidence interval, 10 to 39); the estimated effect in boys was not significant (growth was 1 ml per year slower; 95 percent confidence interval, −13 to 15; $P=0.03$ for the difference between the sexes). For FEV_1, smoking five or more cigarettes per day was associated with growth of lung function that was 31 ml per year slower in girls (95 percent confidence interval, 16 to 46) and 9 ml per year slower in boys (95 percent confidence interval, −6 to 24) ($P=0.05$ for the difference between the sexes). As with percentage growth, the effect of smoking in slowing the absolute growth of $FEF_{25–75}$ in boys and girls was similar (for boys, 48 ml per second per year; 95 percent confidence interval, 14 to 81; for girls, 38 ml per second per year; 95 percent confidence interval, 3 to 80). For all the measures of lung function considered, estimates of the effects of cigarette smoking on absolute growth in lung function were similar in analyses with and without adjustment for peak growth in height.

Excluding children with a history of asthma from

TABLE 3. SEX-SPECIFIC EFFECTS OF DIRECT EXPOSURE TO SMOKE ON THE ANNUAL GROWTH RATE OF PULMONARY FUNCTION IN CHILDREN 10 TO 18 YEARS OF AGE, ESTIMATED BY REGRESSION ANALYSIS.*

MEASURE OF PULMONARY FUNCTION AND SMOKING STATUS	BOYS	GIRLS
	percentage difference (95% confidence interval)	
FVC		
Formerly smoked	−0.04 (−0.41 to 0.33)	−0.13 (−0.62 to 0.37)
½–4 cigarettes/day	0.10 (−0.25 to 0.45)	0.06 (−0.26 to 0.38)
≥5 cigarettes/day	−0.03 (−0.30 to 0.24)	−0.76 (−1.06 to −0.45)
FEV_1		
Formerly smoked	−0.06 (−0.50 to 0.38)	−0.17 (−0.77 to 0.44)
½–4 cigarettes/day	−0.09 (−0.53 to 0.34)	−0.05 (−0.44 to 0.34)
≥5 cigarettes/day	−0.20 (−0.56 to 0.16)	−1.09 (−1.47 to −0.70)
$FEF_{25–75}$		
Formerly smoked	−0.35 (−1.40 to 0.72)	0.12 (−1.20 to 1.45)
½–4 cigarettes/day	−0.39 (−1.30 to 0.53)	−0.25 (−1.10 to 0.60)
≥5 cigarettes/day	−0.93 (−1.65 to −0.21)	−1.25 (−2.13 to −0.38)

*Values are percent differences in annual growth of children in a particular category of smoking as compared with children of identical age and change in log height who had never smoked, with adjustments for age, change in log height at each age, residence, parental education, and maternal smoking status. A negative value reflects slower growth (e.g., a percent difference in FEV_1 of −1.09 between girls smoking five or more cigarettes per day and girls who had never smoked is expressed as 1.09 percent slower growth). FVC denotes the forced vital capacity, FEV_1 the forced expiratory volume in one second, and $FEF_{25–75}$ the forced expiratory flow between 25 and 75 percent of FVC.

the analysis did not significantly alter the sex-specific relations between cigarette smoking and the level or growth of pulmonary function. For girls, but not for boys, there was an interaction between current wheezing and cigarette smoking. Girls who wheezed when they smoked five or more cigarettes per day had a 2.84 percent lower FEV_1/FVC ratio (95 percent confidence interval, 2.12 to 3.55) and a 6.69 percent lower $FEF_{25–75}$ level (95 percent confidence interval, 4.15 to 9.16) than nonsmoking girls without wheezing symptoms, after adjustment for age and height.

DISCUSSION

For adolescent girls and boys, we found that relatively small amounts of cigarette smoke cause similar deficits in levels of both FEV_1/FVC and $FEF_{25–75}$, measures described in many studies as the earliest spirometric indicators of airway obstruction and small-airway disease in adult smokers.[18-20] Our findings also suggest that although smoking may slow the growth of lung function in both girls and boys, the deficits may be greater in girls. The effects of smoking on the growth of lung function were greater in girls in absolute as well as percentage terms, despite the fact that boys had larger forced expiratory volumes and reported that they smoked more cigarettes. Tager and colleagues[21] demonstrated associations between smoking and both a lower level and slower growth of lung function in both female and male adolescents from East Boston, Massachusetts; the size of the sample limited the study's capacity to examine sex-specific differences. Previous studies of adults from the same six areas of the United States as the children in our study suggested that cigarette smoke had a larger effect on lung function in men; the effect on lung function of smoking one pack of cigarettes per day for a year (one pack-year) was a 0.36 percent annual loss of FEV_1 for men and a 0.29 percent annual loss for women.[22,23] This sex-specific difference may relate not to heightened sensitivity of men's lungs to cigarette smoke but to a cohort effect, since women had fewer cumulative pack-years of smoke exposure and began smoking at later ages. In a cross-sectional study from Canada, women had greater deficits in lung function per pack-year of cigarettes smoked.[24]

In our cohort of teenagers, rates of wheezing were higher among girls than boys at each level of smoking. This may relate, in part, to the smaller absolute caliber of the girls' airways, as reflected in their lower absolute levels of FEV_1.[4,17] Wheezing in response to smoking may not result from the same physiologic mechanisms as wheezing in people with atopic asthma. In analyses adjusted for smoking, premenopausal women were at greater risk for asthma than postmenopausal women, and postmenopausal women receiving hormone therapy were at greater risk than women who were not receiving such therapy.[25] Further studies would be needed to assess whether the effect of cigarette smoke on either wheezing symptoms or lung function is modulated by hormonal factors reflected in the stage of the subject's menstrual cycle, the onset of menarche during adolescence, the onset of menopause, or the administration of hormone therapy at other times.

It was not possible to evaluate differences between the sexes in the maximal level of lung function attained or in the effects of smoking on the decline of lung function. Since boys attain their maximal pulmonary function in their early 20s, we were not able to observe the effects of smoking once the growth of pulmonary function ceased. Although our findings suggest that girls who smoke attain a lower maximal level of pulmonary function than nonsmokers and have an earlier decline in pulmonary function, this apparent trend could not be analyzed in girls beyond the age of 18 because of the lack of follow-up data.

There are limitations on the interpretation of analyses comparing the sex-specific effects of cigarette smoking on the growth of lung function in boys and girls in which each child's age is expressed relative to his or her age at peak growth in height. Although we believe that this approach brought us closer to a fair comparison between boys and girls, children at the same stage of peak growth in height are not necessarily at the same stage in other aspects of the onset of

puberty. No data were obtained on development of pubertal hair, breast development, or other markers of maturation. Peak growth in height is directly related to peak growth of lung function, and its use as an indicator of the stage of maturation enabled us to exclude fewer observations than if we had centered the children's ages on peak growth of lung function. Nevertheless, a significant proportion of the data could not be used in the comparisons between the sexes that used age at peak growth in height, because of the sparsity of data on smoking for girls before peak height growth and the sparsity of any data for boys more than six years after peak height growth. A decrease in the number of observations by as much as 55 percent in boys and 40 percent in girls may explain the decrease in the magnitude of the significance of sex-specific differences in the analyses centering on peak growth in height as compared with the analyses that included all available data.

The sex-specific differences we observed in the growth of lung function may relate to unmeasured confounders such as sex-specific reporting bias, differences between the sexes in the amount of inhaled smoke per cigarette, or differences in unmeasured exposure to environmental tobacco smoke outside the home. We did not measure cotinine levels to verify the reporting of cigarette smoking. Before taking up smoking, future smokers did not differ from those who had never smoked in their history of illness before the age of two, bronchitis, or chest illness. The age at peak growth in height was similar in these two groups.

Although the growth of FVC was slower among female smokers than nonsmokers, smoking was associated with a higher level of FVC. In the year before they started to smoke, many already had elevated FVC values (data not shown). Other investigators have found that whereas older symptomatic adult smokers with histories of large numbers of pack-years may have lower FVC levels than nonsmokers, young adult smokers have FVC levels equivalent to or higher than age-equivalent nonsmokers.[26-29] It is possible that at the time they started smoking, children who had recently developed somewhat larger lungs experienced less discomfort when they experimented with cigarettes and were therefore more inclined to smoke on a regular basis.

In conclusion, the effect of relatively small amounts of cigarette smoke on the level and growth of lung function of children and adolescents is yet another reason to prevent young people from starting to smoke.

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This paper is dedicated to Professor (Emeritus) Benjamin G. Ferris, Jr., the original principal investigator of the Harvard Six Cities Study, who died August 1, 1996.

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