ORIGINAL ARTICLES

Parental Smoking and Lung Function in Healthy Children and Adolescents

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OBJECTIVE: The debate continues on the effect of passive smoking on nonsmokers. The effect of parental smoking on the lung function of children varies considerably according to geographic area, source of passive smoking, and sex. The objective of this study was to evaluate the effect of parental smoking on the lung function of children.

POPULATION AND METHODS: A cross-sectional study was performed on a sample of the population of healthy children and adolescents between 6 and 18 years of age in Galicia. Subjects were selected by means of 2-stage cluster sampling grouped by sex and age.

RESULTS: Approximately 56% of the children were exposed to the tobacco smoke of one of their parents. Children whose fathers were smokers presented a 40% higher risk of reduced forced expiratory flow at 75% of forced vital capacity ($FEF_{75\%}$) and a 30% higher risk of reduced $FEF_{25\%-75\%}$. Children whose mothers were smokers presented a 30% higher risk of reduced forced expiratory volume in the first second and a 40% higher risk of reduced $FEF_{50\%}$. There was a 60% increase in risk of reduced $FEF_{75\%}$. The fact that both parents smoked did not appear to increase the risk of reduced lung function.

CONCLUSIONS: Parental smoking has a considerable effect on the lung function of children and adolescents. Smoking by either the mother or the father has a decisive influence. The fact that this effect is independent of the growth of the child and that the obstructive effect is located principally in the distal airways appears to confirm the hypothesis that this effect is produced after birth.

Key words: *Lung function. Passive smoking. Spirometry.*

Tabaquismo parental y función pulmonar en niños y adolescentes sanos

OBJETIVO: Continúa la controversia sobre el efecto del tabaquismo pasivo en los no fumadores. El efecto del tabaquismo de los padres sobre la función pulmonar de los hijos presenta gran variabilidad entre diferentes zonas geográficas, fuente del tabaquismo pasivo y sexos. El objetivo del presente estudio ha sido valorar el efecto del tabaquismo de los padres sobre la función pulmonar de sus hijos.

POBLACIÓN Y MÉTODOS: Hemos llevado a cabo un estudio transversal en una muestra de la población de niños y adolescentes sanos de 6 a 18 años de Galicia, seleccionada mediante un muestreo bietápico en racimos y estratificada por sexo y edad.

RESULTADOS: Alrededor del 56% de los niños estaban expuestos al humo del tabaco de alguno de sus padres. Los niños de padres fumadores presentaban un 40% más de riesgo de reducción del flujo espiratorio forzado al 75% de la capacidad vital forzada ($FEF_{75\%}$), y un 30% de reducción del $FEF_{25-75\%}$. Los niños cuyas madres eran fumadoras tenían un 30% más de riesgo de reducción del volumen espiratorio forzado en el primer segundo, y un 40% de reducción del $FEF_{50\%}$. El incremento de riesgo de reducción del $FEF_{75\%}$ fue del 60%. El hecho de que fumaran ambos progenitores no pareció incrementar el riesgo de función pulmonar reducida.

CONCLUSIONES: El tabaquismo parental tiene un importante efecto sobre la función pulmonar de niños y adolescentes. Tanto el tabaquismo materno como el paterno influyen decisivamente. El hecho de que este efecto sea independiente del crecimiento del niño y que el efecto obstructivo se localice fundamentalmente en la vía aérea distal parece confirmar la hipótesis de que este efecto se produce después del nacimiento.

Palabras clave: *Función pulmonar. Tabaquismo pasivo. Espirometría.*

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Introduction

Debate continues on the effect of passive smoking on the lung function of nonsmokers.[1] Secondhand smoke contains toxic substances that can easily reach the

respiratory system of passive smokers.[2] Passive smoking in childhood is a serious health problem, mainly arising from parental smoking.[2,3]

Animal studies have established that secondhand smoke reduces endothelium-dependent relaxation of the pulmonary artery by reducing the activity of nitric oxide synthase and the arginine content of the endothelium.[4] The weight and volume of the lungs have also been shown to diminish significantly following prenatal exposure to nicotine.[5]

In the United States of America, approximately 15 million children are regularly exposed to passive smoking in the home.[6] Smoking by pregnant women fell in the 1990s, mainly due to the drop in smoking among women in general rather than women ceasing to smoke during pregnancy.[7] The prevalence of smoking among women is rising in Spain and is now higher among adolescent girls than boys. According to the 2003 Spanish National Health Survey,[8] 31% of females and 35% of males smoke in the age group between 16 and 24 years old. Another study on a sample of 16-year-olds in Barcelona, however, found that 22% of boys and 38% of girls smoke.[9]

The effect of parental smoking on the health of children is well documented[3] although it has been shown to vary significantly according to geographic area, source of passive smoking (father or mother), and sex.[10-12]

Our research is part of the Galinut study, an observational study performed between 1991 and 1997 on healthy children and adolescents in Galicia, Spain, in order to assess diet, lifestyle, and cardiovascular disease.[13] This part of the study aimed to evaluate the effect of exposure to passive smoking on the lung function of healthy children and adolescents.

Population and Methods

Population

We performed a cross-sectional population-based study in Galicia. The target population was chosen randomly by means of 2-stage cluster sampling grouped by sex and age, from healthy children and adolescents between 6 and 18 years of age. The first stage consisted of selecting 14 municipalities by means of simple random sampling. The second stage consisted of sampling subjects in clusters from a school where all subjects were members of the target population.

We performed spirometry on all children and adolescents who had informed consent signed by the parents or guardians, were present at the school on the previously arranged day for the examinations, and had correctly completed the previously distributed questionnaire. Subjects who did not perform the spirometry maneuvers correctly, those who did not show normal growth for their age, those who had allergic diseases or who had been hospitalized due to respiratory or cardiovascular diseases, and those who did not meet the "healthy child" criteria of the Cystic Fibrosis Foundation General Assembly Plenary Conference Committee[14] were excluded (Table 1).

TABLE 1
Exclusion Criteria

Refused to take part in the study
Did not perform spirometry test correctly
Failed to complete or incorrectly completed epidemiological questionnaire
History of allergic disease
History of chronic respiratory disease
History of acute respiratory disease in the 3 weeks prior to examination
History of systemic disease with known repercussion on respiratory function (neuromuscular disease, congenital cardiopathy)
History of disease of the rib cage
Active smoking unless limited to an isolated incident

Methods

A doctor from the working group informed the subjects and their parents about the study first verbally and then again in writing a week before the examinations took place. Subjects were provided with a questionnaire that included questions regarding any diseases they had had, their lifestyle, and their smoking habits and those of their parents. They were asked about chronic illnesses in general and about respiratory diseases, specifically, asthma, rhinitis, and allergies. The father or mother was considered to be a smoker if they answered affirmatively to the questions, "Does your father smoke every day?" or "Does your mother smoke every day?" For exclusion purposes, subjects who said they had never smoked or only smoked on a few isolated occasions were considered to be nonsmokers and those over the age of 10 years were also asked in private about their own smoking habits. The questionnaire was completed by the parents at home. When it was returned, the members of the team answered parents' questions about filling out the questionnaire, in order to complete the required information.

All spirometry was performed in accordance with the 1985 protocols of the Spanish Society of Pulmonology and Thoracic Surgery (SEPAR),[15] in a classroom at the school between 9:00 and 13:00. A Datospir 92 spirometer (Síbel, SA, Barcelona, Spain) was used.

The following 4 mutually exclusive categories of exposure to passive smoking were established: neither parent smokes, only the father smokes, only the mother smokes, and both parents smoke.

The study was approved by the ethics committee of Galicia and signed, informed consent was obtained from the parents or guardians.

Statistical Analysis

We used logistic regression to obtain the adjusted odds ratios and 95% confidence intervals for the prevalence of reduced lung function in relation to parental smoking. We defined children or adolescents with spirometric parameters below 25% of the distribution as cases and the rest as controls.

Results

The study population was comprised of 2408 children and adolescents—1270 boys (53%) and 1138 girls (47%). Half of the fathers and one fifth of the mothers were smokers. The general characteristics of this population, by sex, are shown in Table 2. Table 3 shows spirometric results according to parental smoking habits. Overall, the

mean was significantly lower among subjects with at least one parent who smoked.

In general, the negative effect of passive smoking was greater on the parameters relating to the distal airways. We found a 40% increase in the risk of reduced lung function for a forced expiratory flow (FEF) at 75% of forced vital capacity (FVC) and a 30% increase for $FEF_{25\%-75\%}$ in subjects whose fathers were regular smokers, compared to those with nonsmoking fathers (Table 4). Children of mothers who smoked showed a 30% increase in the risk of reduced forced expiratory volume in 1 second (FEV_1). The increased risk was 40% for a reduced $FEF_{50\%}$, 60% for a reduced $FEF_{75\%}$, and 30% for a reduced $FEF_{25\%-75\%}$. The fact that both parents smoked did not seem to increase the risk of reduced lung function.

Grouping the study population by age (younger subjects compared to older subjects) did not significantly alter the results. Furthermore, no significant effects were observed for FVC or peak expiratory flow.

Discussion

The Galinut study evaluated a representative sample of the population of Galicia with high exposure to passive smoking (57% for boys and 55% for girls). This level of exposure is higher than that detected in other recent studies.[16-18]

Published studies on the effect of passive smoking on the lung function of children show differing results. The greatest disagreement is found for the FVC of passive smokers, which shows no change in some studies[18-20] but appears to fall in others.[21,22] Our study showed no effect for parental smoking on FVC or peak expiratory flow. We did, however, find a reduction in the other study parameters in subjects whose parents smoked. As has been described in previous studies, this effect is greater in the smaller-diameter airways[16-20] and this is similar to observations in active smokers.[23]

In our study, the effect of passive smoking remained unchanged after adjusting for age, weight, and height. This appears to exclude the possibility that the negative effect of passive smoking would be an artefact of different growth rates of the subjects.[24] This finding, together with the fact that the effect of passive smoking is more marked on flows than on volumes, indicates the existence of an obstructive defect rather than a reduction in lung growth. It is also worth pointing out that we observed no noticeable effect on FVC—a parameter that indirectly reflects lung size.

Each smoking parent's contribution to the negative effect on the lung function of the subject is the subject of debate.[12,25-27] Our study shows that smoking by each parent is related to a child's reduced lung function, even in a study population such as ours with relatively strict selection criteria that included only healthy children and adolescents with normal lung function.

Our study and those of other authors[20,25] have shown that the greatest effect occurs where the mother smokes. Nevertheless, in our study population, a father's smoking also had a significant effect on the deterioration of the child's lung function. Similar findings were obtained in

TABLE 2
Principal Characteristics of the Study Population by Sex*

	Boys	Girls
Number	1270	1138
Age, y	13	13
Weight, kg	49.1	45.3
Height, cm	156.1	150.3
Father smokes, %	49.55	47.10
Mother smokes, %	20.47	17.43
Both parents smoke, %	13.72	10.34
$FEF_{75\%}$, L/s	2.31	2.22
$FEF_{50\%}$, L/s	4.24	3.78
$FEF_{25\%-75\%}$, L/s	3.75	3.40
FEV_1, L	3.08	2.61
FVC, L	3.42	2.83
FEV_1/FVC, %	90.93	92.65
PEF, L/s	6.195	4.957

*Data are means unless otherwise indicated as percentages. $FEF_{75\%}$, $FEF_{50\%}$, and $FEF_{25\%-75\%}$ indicate forced expiratory flow at 75%, 50%, and 25%-75%, respectively, of forced vital capacity (FVC); FEV_1, forced expiratory volume in 1 second; and PEF, peak expiratory flow.

TABLE 3
Comparison of Mean Values for Lung Function Parameters in 2408 Children and Adolescents in Galicia, According to Parental Smoking Habits*

	Smoker				*P*
	Neither	Father	Mother	Both	
FEV_1	2.71	2.56	2.34	2.40	.00001
$FEF_{50\%}$	3.85	3.71	3.28	3.41	.00001
$FEF_{75\%}$	2.21	2.07	1.75	1.85	.00001
$FEF_{25\%-75\%}$	3.44	3.29	2.88	3.02	.00001

*$FEF_{75\%}$, $FEF_{50\%}$, and $FEF_{25-75\%}$ indicate forced expiratory flow at 75%, 50%, and 25%-75%, respectively, of forced vital capacity; FEV_1, forced expiratory volume in 1 second.

TABLE 4
Odds Ratio for Prevalence of Reduced Lung Function Related to Parental Smoking in 2408 Children and Adolescents in Galicia*

	OR†	95% CI
Mother smokes		
FEV_1	1.3	0.9-1,8
$FEF_{50\%}$	1.4	1.0-1.9
$FEF_{75\%}$	1.6	1.1-2.1
$FEF_{25\%-75\%}$	1.3	1.0-1.8
Father smokes		
FEV_1	1.3	0.9-1.8
$FEF_{50\%}$	1.4	1.0-1.9
$FEF_{75\%}$	1.4	1.1-1.8
$FEF_{25\%-75\%}$	1.3	1.0-1.6
Both parents smoke		
FEV_1	1.3	0.8-1.9
$FEF_{50\%}$	1.5	1.0-2.2
$FEF_{75\%}$	1.7	1.2-2.6
$FEF_{25\%-75\%}$	1.5	1.0-2.2

*$FEF_{75\%}$, $FEF_{50\%}$, $FFF_{25\%-75\%}$ indicate forced expiratory flow at 75%, 50%, and 25%-75%, respectively, of forced vital capacity; FEV_1, forced expiratory volume in 1 second; OR, odds ratio; and CI, confidence interval.
†Adjusted for sex, age, height, weight, and residence (urban/rural and coastal/inland). Reference category: Neither parent smokes

studies performed in China and Turkey—countries with a low incidence of smoking among women.[11,21,26] The results of studies carried out in Western populations, where smoking among women is common, have not shown an independent effect of smoking by fathers on the lung function of their children.[3,25,28] In developed countries, only the study by Gilliland et al,[16] in a population from California, shows a reduction in peak expiratory flow and FVC in the children of fathers who smoke, with no effect on $FEF_{25\%-75\%}$ and $FEF_{75\%}$. That study, however, did not exclude children with respiratory diseases and the results can therefore not be extrapolated to the healthy population as the greater intensity of the harmful effect of smoking on people with respiratory diseases than on healthy people is well-known.

The greater effect of a mother's smoking may be partially related to the exposure of the fetus to maternal smoking during pregnancy, since pregnant women smokers do not tend to quit.[7,29,30]

For some authors, the effect is more marked in males[31] whereas for others it is less marked.[11] Neither the largest prospective study performed[20] nor a meta-analysis[12] have shown any evidence of differences between sexes. Our results are consistent with these findings.

In summary, our study, performed on a representative sample of healthy children and adolescents with high exposure to passive smoking, seems to show a negative effect of parental smoking on the lung function of offspring. The validity of the evaluation of smoking habits using questionnaires has been shown by the strong correlation with cotinine values.[24] The lack of information on maternal smoking during pregnancy makes it difficult to evaluate the effect of intrauterine exposure to tobacco. However, the demonstration of a negative effect of parental smoking plus a finding that this effect is independent of the child's growth and that the obstructive effect is located mainly in the distal airways, as is the case with active smokers, would seem to confirm the hypothesis of a negative effect of parental smoking after birth.

REFERENCES

1. Enstrom JE, Kabat GC. Environmental tobacco smoke and tobacco related mortality in a prospective study of Californians, 196098. BMJ. 2003;326:1057.
2. Fielding JE, Phenow KJ. Health effects of involuntary smoking. N Engl J Med. 1988;319:1452-60.
3. Cook DG, Strachan DP. Health effects of passive smoking-10: summary of effects of parental smoking on the respiratory health of children and implications for research. Thorax. 1999;54: 357-66.
4. Hutchison SJ, Sievers RE, Zhu BQ, Sun YP, Stewart DJ, Parmley WW, et al. Secondhand tobacco smoke impairs rabbit pulmonary artery endothelium-dependent relaxation. Chest. 2001;120: 2004-12.
5. Sekhon HS, Keller JA, Benowitz NL, Spindel ER. Prenatal nicotine exposure alters pulmonary function in newborn rhesus monkeys. Am J Respir Crit Care Med. 2001;164:989-94.
6. Gilliland FD, Li YF, Peters JM. Effects of maternal smoking during pregnancy and environmental tobacco smoke on asthma and wheezing in children. Am J Respir Crit Care Med. 2001;163: 429-36.
7. Ebrahim SH, Floyd RL, Merritt RK II, Decoufle P, Holtzman D. Trends in pregnancy-related smoking rates in the United States, 1987-1996. JAMA. 2000;283:361-6.
8. Encuesta Nacional de Salud 2003. Madrid: Ministerio de Sanidad y Consumo; 2004.
9. Nebot M, Tomás Z, Ariza C, Valmayor S, López MJ, Juárez O. Factores asociados con el inicio del tabaquismo: seguimiento a los 3 años de una cohorte de escolares. Arch Bronconeumol. 2004; 40:495-501.
10. Henderson AJ, Sherriff A, Northstone K, Kukla L, Hruba D. Preand postnatal parental smoking and wheeze in infancy: cross cultural differences. Avon Study of Parents and Children (ALSPAC) Study Team, European Longitudinal Study of Pregnancy and Childhood (ELSPAC) Co-ordinating Centre. Eur Respir J. 2001; 18:323-9.
11. Chen Y, Li WX. The effect of passive smoking on children's pulmonary function in Shangai. Am J Public Health. 1986;76: 515-8.
12. Cook DG, Strachan DP, MCarey I. Parental smoking and spirometric indices in children. Thorax. 1998;53:884-93.
13. Leis R, Pavón P, Queiro T, Recarey D, Tojo R. Atherogenic diet and blood lipid profile in children and adolescents from Galicia, NW Spain. The Galinut Study. Acta Paediatr. 1999;88: 19-23.
14. Taussig LM, Chernick V, Wood R, Farrell P, Mellins RB. Standardization of lung function testing in children. Proceedings and recommendations of the GAP Conference Committee, Cystic Fibrosis Foundation. J Pediatr. 1980;97:668-76.
15. Sanchis Aldás J, Casan Clará P, Castillo Gómez J, González Mangado N, Palenciano Ballesteros N, Roca Torrent J. Normativa para la espirometría forzada. Grupo de trabajo de la SEPAR para la práctica de la espirometría clínica. Barcelona: Doyma; 1985.
16. Gilliland FD, Berhane K, McConnell R, Gauderman WJ, Vora H, Rappaport EB, et al. Maternal smoking during pregnancy, environmental tobacco smoke exposure and childhood lung function. Thorax. 2000;55:271-6.
17. Gergen PJ, Fowler JA, Maurer KR, Davis WW, Overpeck MD. The burden of environmental tobacco smoke exposure on the respiratory health of children 2 months through 5 years of age in the United States: Third National Health and Nutrition Examination Survey, 1988 to 1994. Pediatrics. 1998;101:e8.
18. O'Connor GT, Sparrow D, Demolles D, Dockery D, Raizenne M, Fay M, et al. Maximal and partial expiratory flow rates in a population sample of 10- to 11-year-old school children. Am J Respir Crit Care Med. 2000;162:436-9.
19. Li YF, Gilliland FD, Berhane K, McConnell R, Gauderman WJ, Rappaport EB, et al. Effects of in utero and environmental tobacco smoke exposure on lung function in boys and girls with and without asthma. Am J Respir Crit Care Med. 2000;162:2097-104.
20. Wang X, Wypij D, Gold DR, Speizer FE, Ware JH, Ferris BG Jr, et al. A longitudinal study of the effects of parental smoking on pulmonary function in children 6-18 years. Am J Respir Crit Care Med. 1994;149:1420-5.
21. Venners SA, Wang X, Chen C, Wang B, Ni J, Jin Y, et al. Exposure-response relationship between paternal smoking and children's pulmonary function. Am J Respir Crit Care Med. 2001; 164: 973-6.
22. Mannino DM, Homa D, Redd S. Involuntary smoking and asthma severity in children. Chest. 2002;122:409-15.
23. Morris JF, Koski A, Breese JD. Normal values and evaluation of forced end-expiratory flow. Am Rev Respir Dis. 1975;111:755-62.
24. Wang X, Tager IB, van Vunakis H, Speizer FE, Hanrahan JP. Maternal smoking during pregnancy, urine cotinine concentrations, and birth outcomes. A prospective cohort study. Int J Epidemiol. 1997;26:978-88.
25. Rona RJ, Chinn S. Lung function, respiratory illness, and passive smoking in British primary school children. Thorax. 1993;48:21-5.
26. Bek K, Tomaç N, Delibas A, Tuna F, Tezic HT, Sungur M. The effect of passive smoking on pulmonary function during childhood. Postgrad Med J. 1999;75:339-41.
27. Svanes C, Omenaas E, Jarvis D, Chinn S, Gulsvik A, Burney P. Parental smoking in childhood and adult obstructive lung disease: results from the European Community Respiratory Health Survey. Thorax. 2004;59:295-302.

28. Duffy DL, Mitchell CA. Lower respiratory tract symptoms in Queensland schoolchildren: risk factors for wheeze, cough and diminished ventilatory function. Thorax. 1993;48:1021-4.
29. Owen L, McNeill A, Callum C. Trends in smoking during pregnancy in England, 1992-7: quota sampling surveys. BMJ. 1998;317:728.
30. Stick SM, Burton PR, Gurrin L, Sly PD, leSouef PN. Effects of maternal smoking during pregnancy and a family history of asthma on respiratory function in newborn infants. Lancet. 1996;348: 1060-4.
31. Cunningham J, Dockery DW, Speizer FE. Maternal smoking during pregnancy as a predictor of lung function in children. Am J Epidemiol. 1994;139:1139-52.