American Journal of Epidemiology
Vol. 98, No. 5

Printed in U.S.A.

RESIDENCE AND PEAK EXPIRATORY FLOW RATES AMONG NAVY RECRUITS[1]

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(Received for publication May 11, 1973)

Comstock, G. W. (Training Center for Public Health Research, Box 2067, Hagerstown, Md. 21740) and P. F. Rust. Residence and peak expiratory flow rates among Navy recruits. *Am J Epidemiol* 98: 348–354, 1973.— Between April 1970, and February 1971, peak expiratory flow rates were determined on 3409 white male Navy recruits at the Naval Training Center, San Diego, California. The peak expiratory flow rates were slightly higher among nonsmokers than among smokers. No significant differences were found among recruits from metropolitan and nonmetropolitan areas. Regional differences did not correlate well with death rates from chronic obstructive pulmonary disease.

pulmonary disease, geographic distribution; recruits; respiratory disease, chronic; ventilatory function

Chronic respiratory diseases caused nearly 2 per cent of all deaths in the United States in 1968 (1). Furthermore, deaths attributed to these causes have been increasing rapidly in recent years, especially among white men (2). Like deaths from many other causes, those attributed to chronic respiratory disease among white males 35 to 74 years of age show marked regional variations. Most of the highest rates are found in mountainous areas, particularly in the West, while the areas with the lowest rates are concentrated in the northern portions of the Great Plains (3). A striking feature of the regional distribution of chronic respiratory disease deaths is that few large metropolitan areas have high rates. This finding stands in sharp contrast to the higher bronchitis and pneumonia death rates found in Great Britain in urban areas, especially those with demonstrably high air pollution levels (4).

Surveys of respiratory symptoms and ventilatory function among adults have also shown discordant results. Based on carefully standardized examinations among men doing similar work in London and in three country towns in England, Holland and Reid (5) found that the London workers had more frequent and more severe respiratory symptoms, produced more sputum, and had significantly lower forced expiratory volumes even when age, physique and smoking were taken into account. Lambert and Reid (6), in a postal survey of a sample of nearly 10,000 persons in Britain, found respiratory symptoms to be most common in polluted urban areas. A careful study of two communities in the Netherlands, one urban and the other rural, dem-

Abbreviation: PEFR, peak expiratory flow rate.

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This study was supported in part by Career Research Award HL 21,670 from the National Heart and Lung Institute.

Information on air pollution levels in the San Diego area was provided by Dr. J. B. Askew, Health Officer and Air Pollution Control Officer of San Diego County, California.

onstrated increased prevalence of cough and phlegm in the urban area, but found no differences in forced expiratory volumes (7).

In contrast, a study of one rural and two urban districts in West Germany did not show significant differences in the frequency of persistent cough and phlegm nor in ventilatory function between the three districts (8). Among nonsmokers in Hagerstown, Maryland, peak expiratory flow rates (PEFR) were positively associated with the number of years of childhood spent in an urban area. There was also a significant nonlinear relationship with adult urban residence, positive at first but negative after seven years. Similar but nonsignificant relationships were found with urban residence and the symptoms of cough and phlegm. No association was found between urban living and forced expiratory volume (9). In two surveys of telephone workers in the Middle Atlantic area of the United States and in a similar survey in Tokyo, no differences in respiratory findings could be demonstrated between urban and rural environment of current work place, present or past residence, or place of birth (10). And in Norway, only minor differences in respiratory symptoms could be found between residents of urban and rural areas (11).

Because of indications that respiratory disease in adult life was closely related to urban residence in childhood (12, 13), a number of investigators have studied respiratory findings in children as related to air pollution levels at their places of residence (14–20). All but two (16, 18) showed increased symptoms or decreased ventilatory function to be associated with increased air pollution or with urban residence.

An opportunity to study the association of ventilatory function with place of residence in childhood in the United States arose in connection with the tuberculin testing of Navy recruits. These men are almost all between the ages of 17 and 23, and represent reasonably similar segments of the various communities from which they come. Unfortunately, the ventilatory function testing program could be conducted in only one of the three Naval Training Stations and only for a limited time. Even so, the examined population came from a wide geographic area and is large enough to permit examination of several variables of interest.

Materials and methods

From 1958 to 1971, a cooperative tuberculin testing program of all naval recruits was conducted by the U.S. Navy and the Tuberculosis Program of the U.S. Public Health Service. A full description of this program has been published previously (21). During the period of the present study, the information on each recruit included race, birthdate, height, weight, smoking history and place of residence from birth to entrance into the Navy. Recruits were classified both by their life-time residence and by residence at time of induction. Metropolitan areas in this paper refer to the Standard Metropolitan Statistical Areas defined by the Bureau of the Census. Each metropolitan area includes more than one county and has a population of more than a million persons. Virtually all men classified as smokers stated that they had smoked cigarettes; over 60 per cent had smoked more than 10 cigarettes a day for at least two years.

In April, 1970, a determination of PEFR was added to the examination routine at the Naval Training Center in San Diego, California. Most of the tests were done by Public Health Service nurses at the time of tuberculin testing, with occasional assistance from Navy hospital corpsmen trained by the nurses. A single Wright Peak Flow Meter was used. Three successive tests were given and each result was recorded, although for the purposes of this study only the maximum value was used. Peak expiratory flow rates were adjusted for differences in age and standing height by multiple linear regression. Each man's PEFR was expressed as a score, which is his observed

PEFR expressed as the percentage of his predicted PEFR as determined from the regression equation.

$$\text{PEFR score} = \frac{\text{observed PEFR value}}{\text{predicted value based on age and height}} \times 100$$

Although every effort was made to examine all recruits who were tuberculin tested, so many men passed through the testing station on some days that not all of them could be examined before they had to leave for their next assignment. There were also several periods when only one nurse was available, and because tuberculin testing was given first priority, PEFR testing had to be temporarily discontinued. However, there is no reason to believe that there were differences between the men who were tested and those who were not. Because of financial difficulties, the tuberculin testing program, and with it the PEFR testing, had to be discontinued in February, 1971.

The analysis is limited to examinations on white males. Too few recruits in other categories were examined to yield meaningful results.

TABLE 1

Distribution of study population by age, standing height, and peak expiratory flow rate

	No.	%
Age (years)		
17	429	12.6
18	1340	39.3
19	888	26.0
20	422	12.4
21–29	330	9.7
Height (cm)		
<167.6	150	4.4
167.6–	425	12.5
172.7–	772	22.6
177.8–	1001	29.4
182.9–	701	20.6
188+	360	10.6
Peak expiratory flow, liters/min		
<400	31	0.9
400–	520	15.3
500–	1686	49.5
600–	1043	30.6
700+	129	3.8
Total study population	3409	100.0

RESULTS

The age composition of the study population is given in table 1, along with the distribution of standing heights and observed peak flow expiratory rates. More than 60 per cent of the group were 18 or 19 years of age. Less than 10 per cent were over 20, and most of these men were in their early twenties. The median age was 19.0 years, the median height was 179.6 cm and the median PEFR was 568 liters per minute.

The relationship of PEFR to age and standing height can be summarized by the following regression equation, in which age is expressed in years at last birthday, standing height in centimeters, and PEFR in liters per minute.

$$\text{PEFR} = 101.4 + 3.90 \text{ Age} + 2.19 \text{ Height}$$

The usual direct association with height was noted. However, in this period of late adolescence and early adult life, PEFR did not decrease with age.

The mean PEFR scores showed a peculiar seasonal pattern which is shown in table 2. Only a few examinations were done before July 1970. The mean scores were highest in July, November and December, and

TABLE 2

Number of men examined and mean peak expiratory flow rate scores by month of examination

Month and year of examination	No. of men examined	Mean PEFR scores
1970		
April	79	97.1
May	0	
June	0	
July	568	104.4
Aug.	382	99.4
Sept.	877	94.2
Oct.	603	100.3
Nov.	332	105.2
Dec.	267	104.9
1971		
Jan.	240	99.4
Feb.	61	98.2

lowest in September. There were no known changes in testing procedures during this period. The pattern was not associated with air pollution levels in the San Diego area (22), nor with hospital admissions for respiratory disease at the Navy base. The proportion of smokers and nonsmokers was essentially the same each month. However, the proportion of recruits from different geographic areas did vary by month, and for this reason the mean PEFR scores were adjusted for month of examination. The proportion of smokers and nonsmokers was similar for the various geographic areas.

Adjustment for the effect of month of examination was based on the assumption that the variations observed by month were not related to place of residence. This assumption was borne out by the fact that recruits from all regions showed a similar monthly pattern. Every man's PEFR score in a given month was increased or decreased by the ratio necessary to bring the mean score for that month to 100.0. Thus within a given month, the relative rank of each man was unchanged.

The observed and month-adjusted mean PEFR scores are shown in table 3 for smokers and nonsmokers, and for recruits from different geographic regions. Smokers had slightly lower mean scores than nonsmokers and a slightly higher proportion of men with scores below 85 per cent of the predicted value based on their height and age.

Recruits who came from metropolitan areas had slightly higher mean PEFR scores than recruits from nonmetropolitan areas, a difference that is not statistically significant. When the effect of month of examination was taken into account, there

TABLE 3

Mean peak expiratory flow rate scores and per cent with scores less than 85 per cent of the predicted value, by smoking history and geographic area of residence

Smoking and geographic classification	No. examined	PEFR scores				% with PEFR scores below 85% of predicted values	
		Observed		Adjusted*			
		Mean	S.D.	Mean	S.D.	Observed	Adjusted*
Nonsmokers	1410	100.5	0.3	100.7	0.3	10.6	8.5
Smokers	1999	99.6	0.3	99.5	0.3	11.5	10.8
Nonmetropolitan	1422	99.5	0.3	99.6	0.3	12.1	9.7
Metropolitan	1935	100.2	0.3	100.3	0.3	10.6	10.0
Unclassified	52	102.6	1.8	101.4	1.6	6.8	7.7
Washington	242	100.1	0.7	100.2	0.7	9.1	7.0
Oregon	171	101.6	1.0	101.5	0.9	7.6	6.4
California	810	101.8	0.5	101.5	0.4	9.4	8.2
Northern Mountain	448	98.3	0.6	98.4	0.5	14.3	12.3
Southern Mountain	156	98.6	1.0	98.4	1.0	10.3	9.6
West North Central	813	99.0	0.4	99.1	0.4	12.6	12.7
East North Central	316	99.5	0.7	100.1	0.6	12.7	9.2
West South Central	140	100.6	1.1	100.2	1.1	12.1	10.0
East South Central and South Atlantic	120	98.9	1.2	99.3	1.2	15.0	12.5
Other and unclassified	193	100.5	0.8	101.1	0.8	6.2	5.7
Totals	3409	100.0	0.2	100.0	0.2	11.2	9.9

* See text for method of adjustment.

was essentially no difference between the proportion of men with abnormally low scores from metropolitan and nonmetropolitan areas.

Men from the Northern Mountain states of Montana, Idaho, Wyoming, Colorado, Utah and Nevada and the Southern Mountain states of Arizona and New Mexico had the lowest mean PEFR scores, while those from California and Oregon had the highest mean scores. The difference between these two extremes, while not great, is unlikely to have occurred by chance. A somewhat similar pattern emerged when geographic regions were ranked according to the proportion of men with scores below 85 per cent of predicted. The rank order correlation between these two indices, mean scores and per cent below 85, was 0.74. The highest proportions of abnormally low PEFR scores were found among men from the West Central states of North and South Dakota, Minnesota, Nebraska, Kansas, Iowa and Missouri, and among men from the North Mountain states.

Among the total study population, there were 1329 men who were classified as lifetime residents of a single county, not having resided outside of that county for more than six months. As a group, they were slightly younger than the total study population, nearly 70 per cent being 18 or 19 years old.

The results of the analysis of the experience of the lifetime one-county residents are shown in table 4. The findings are generally similar to those obtained for the total study population. The two indices, adjusted mean PEFR score and per cent with scores below 85 per cent of the predicted value, were highly correlated, the rank order correlation coefficient being 0.86. Differences

TABLE 4

Mean peak expiratory flow rate scores and per cent with scores less than 85 per cent of the predicted value, among life-time one-county residents, by smoking history and geographic area of residence

Smoking and geographic classification	No. examined	PEFR Scores				% with PEFR scores below 85% of predicted values	
		Observed		Adjusted*			
		Mean	S D.	Mean	S D.	Observed	Adjusted*
Nonsmokers	539	100.7	0.5	100.7	0.5	9.3	7.1
Smokers	790	99.5	0.5	99.5	0.4	12.9	12.2
Nonmetropolitan	540	99.2	0.5	99.4	0.5	10.7	9.3
Metropolitan	789	100.5	0.5	100.4	0.4	11.9	10.6
Washington	102	100.4	1.1	100 2	1.1	10.8	6.9
Oregon	71	101.7	1.4	101.4	1.3	5.6	5.6
California	256	102.3	0.8	101.8	0.8	9.8	8.6
Northern Mountain	159	98.5	1.0	98.3	0.9	14.5	13.8
Southern Mountain	39	98.9	2.1	98.4	2.0	12.8	15.4
West North Central	393	99.2	0.6	99.3	0.6	11.5	12.2
East North Central	159	98.0	1.0	98.6	0.9	16.4	9.4
West South Central	34	103.0	2.5	102.3	2.6	5.9	5.9
East South Central and South Atlantic	39	99.6	2.1	100.1	2.0	17.9	12.8
Other and unclassified	77	100.9	1.3	102.2	1.2	5.2	3.9
Total	1329	100.0	0.3	100.0	0.3	11.4	10.1

* See text for method of adjustment.

between smokers and nonsmokers, and between residents of different geographic areas were slightly greater than among the total study population. Lifetime residents from the Mountain states again had the lowest PEFR scores, while the men from the Pacific Coastal states tended to rank rather high.

Discussion

Navy recruits are obviously a selected population. In addition to being limited to males in late adolescent and early adult life, men with obvious disabilities or abnormal chest roentgenograms are excluded by examinations prior to arrival at the Training Stations. As a consequence of such exclusions, it is not possible to study the relationship of geography to obvious respiratory disease. To the extent that geographic factors might affect the PEFR scores of only a few susceptible persons, Navy recruits are a poor sample.

On the other hand, the application of selective factors appears to be uniform in all areas, and it seems reasonable to believe that recruits represent pretty much the same kind of people in all geographic regions. The effects of factors that impinge on all or most members of a population should be mirrored rather well among Navy recruits, if such effects become manifest by the age of 17; in this respect, they seem to be a good sample.

The fact that mean PEFR scores varied by month is troublesome, particularly since the cause of this variation is unclear. It is believed that adjusting the scores for effects associated with month of testing yields the most appropriate values for comparing different population subgroups. Fortunately, similar trends are observed whether one uses crude or adjusted scores. Both show slight differences in favor of nonsmokers over smokers, and neither shows a clearcut advantage of nonmetropolitan over metropolitan residents.

Age-adjusted death rates from chronic respiratory disease among white males in 1959–1961 have been reported to be highest in both the North and South Mountain regions, and lowest in the East and West North Central areas (3). The present study confirms the poor ranking of the North Mountain states, but not the good ranking of the North Central areas. Whatever it may be in these regions that leads to variations in death rates from chronic respiratory disease is not clearly reflected in the peak expiratory flow rates among the general run of young male residents.

The results of this analysis cannot be taken to refute the possibility that air pollution has a deleterious effect on the ventilatory function of young adult males. The study had to be discontinued before sufficient numbers of recruits could be examined to allow analyses of individual metropolitan areas known to be highly polluted. All that can be said is that, taken all together, residents of metropolitan areas in the western part of the United States show no evidence that their place of residence has resulted in significant impairment of their ventilatory function.

Finally, it should be noted that most studies indicating an association of air pollution with symptoms of chronic respiratory disease have been done in areas where sulfur dioxide was a major pollutant. To the extent that this pollutant might be an important determinant of PEFR, recruits from metropolitan areas might compare more favorably with those from nonmetropolitan areas in 1971 than would have been the case before the recent change-over to low sulfur fuels had occurred.

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