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Physical Inactivity Is Associated with Lower Forced Expiratory Volume in 1 Second

European Prospective Investigation into Cancer-Norfolk Prospective Population Study

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Forced expiratory volume in 1 second (FEV_1) is a strong risk factor for cardiovascular disease, stroke, lung cancer, and all-cause mortality. One possible explanation for this association is that FEV_1 is a marker of other determinants of mortality risk, such as obesity and physical inactivity. In a population-based cohort study of 12,283 men and women aged 45–74 years from the European Prospective Investigation into Cancer-Norfolk Study recruited in 1993–1997, the cross-sectional association between physical activity and FEV_1 and that between physical activity and change in FEV_1 were analyzed. Indices of physical activity, including participation in vigorous recreational activity, stair climbing, and television viewing, were assessed with a validated questionnaire designed to assess activity in the previous year. Television viewing was negatively associated with FEV_1 in men and women ($p < 0.001$), whereas stair climbing and participation in vigorous leisure time activities were positively associated with FEV_1 in men and women ($p < 0.001$). The associations remained after adjustment for known confounders, including age, height, vitamin C, and smoking. Climbing more stairs and participating in vigorous leisure-time activity predicted a slower rate in annual percent decline in FEV_1 ($p < 0.004$ and $p < 0.002$, respectively). In conclusion, physical activity is associated with higher levels of FEV_1, whereas television viewing is associated with lower levels. *Am J Epidemiol* 2002;156:139–47.

exercise; lung; television

Abbreviations: EPAQ2, European Prospective Investigation into Cancer Physical Activity Questionnaire; EPIC, European Prospective Investigation into Cancer; FEV_1, forced expiratory volume in 1 second; MET, metabolic equivalent.

There is evidence that poor lung function is associated with mortality from chronic lung disease. More recent studies show that forced expiratory volume in 1 second (FEV_1) is a strong risk factor for cardiovascular disease, stroke, and lung cancer (1). The strong inverse relations demonstrated between FEV_1 and these diseases suggest that impaired lung function plays an important predictive and causal role in mortality. In a prospective, population-based study, an independent, inverse relation was demonstrated between FEV_1 and subsequent all-cause mortality in men and women (2). The relation between the rate of decline in lung function and mortality has been reported more recently, with particular reference to the effect of smoking on the decline of lung function (3).

Although epidemiologic studies have reported associations between lung function, physical activity, and disease (4, 5), studies of the association between physical activity and lung function are scarce (6, 7). One study found no association between physical activity and decline in lung function, although there was no comparison with a control group (8).

It is clear that FEV_1 is an important predictor of cardiovascular morbidity and mortality, and we postulate that physical

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activity might be one explanation for population variation in lung function through the effects on muscle strength, body composition, and fat distribution. Here, we report an analysis of both the cross-sectional associations between physical activity and FEV_1 and between physical activity and change in FEV_1 from the European Prospective Investigation into Cancer (EPIC)-Norfolk study, a large, population-based cohort of people recruited from general practice.

MATERIALS AND METHODS

The EPIC Study is a prospective cohort study designed to investigate the etiology of major chronic diseases. Between 1993 and 1997, EPIC-Norfolk (United Kingdom) recruited a population-based cohort of 25,000 men and women aged 45–74 years identified from participating general practice lists. The recruitment and study methods for the EPIC-Norfolk study have been described in detail elsewhere (9). From January 1998 to October 2000, the cohort was invited for a second health check, and 15,515 people attended. The mean time between visits was 3.7 years. The study group for this analysis was all persons who had completed the physical activity questionnaire that was administered at the second health check. This European Prospective Investigation into Cancer Physical Activity Questionnaire (EPAQ2) is a self-completed questionnaire assessing previous-year activity that collects self-reported physical activity behaviors in a disaggregated way such that the information may be reaggregated according to the dimension of physical activity that is of interest (10). The questionnaire consists of three sections: activity at home, work, and recreation. The occupational activity is derived from the Modified Tecumseh Occupational Activity Questionnaire that has been validated elsewhere (11). The recreational section is derived from the Minnesota Leisure Time Activity Questionnaire (12), with activities ordered according to the frequency in a United Kingdom population (13). We calculated the amount of television viewing by summing responses to questions about viewing before and after 6 p.m. separately for weekdays and weekends. Stair climbing was calculated from responses to the usual number of flights climbed per day, again summed from answers given separately for weekdays and weekend days (a flight was defined as 10 steps). Time spent participating in recreational activities was derived from responses to frequency and usual time per episode separately for each activity. Intensity of recreational activity was calculated by applying published metabolic equivalent (MET) values to usual time spent participating and is expressed as MET-hours per week (14). The questionnaire was validated against an objective measure of energy expenditure, and the repeatability of the questionnaire has also been assessed (10). FEV_1 was measured both at initial recruitment and at the second health check by using an electronic turbine spirometer (Micro Medical, Ltd., Rochester, United Kingdom) with the higher of two consecutive expirations recorded after a practice blow. The study received ethical approval from the Norfolk Local Research Ethics Committee.

Three separate analyses were performed. First, cross-sectional associations between derived physical activity indices and FEV_1, both measured at the second health check, were determined by using linear regression analyses after adjustment for known confounding variables. These confounders included age, sex, height, plasma vitamin C, and self-reported smoking status. Television viewing was analyzed as categories of hours per day watched. The categories were determined by those used to collect the data in EPAQ2. The number of flights of stairs climbed per day was grouped in the analysis in the categories in which it was collected in the questionnaire. Participation in vigorous activities was defined as hours per week of reported participation in recreational activities with a MET score of more than five. A MET is a measure of the energy cost of an activity relative to energy expenditure at rest. The MET scores of activities reported in EPAQ2 were taken from published compendia (14). The categories of vigorous activity were determined a priori so that they might have public health meaning (i.e., <15 minutes, 15–60 minutes, and >1 hour per week). We also computed an index of total energy expenditure in MET-hours per week as the sum of reported activity at work and in recreation (10).

Second, identical analyses were performed by using the mean of the two measures of FEV_1 recorded at the baseline and second health check. This analysis was undertaken because the mean of two repeated measures of an outcome measured with random error is a better estimation of the usual level of outcome than is a single measure (15). Third, to examine predictors of change in respiratory function, linear regression analyses were performed by using percent change in FEV_1 between baseline and second health check as the outcome variable. Predictors of change in respiratory function included change in weight between visits and physical activity measured at the second health check. Results are presented as adjusted mean values based on the linear regression equations. All analyses, stratified by sex and combining men and women, were performed using Stata Statistical Software (16).

RESULTS

A total of 6,794 men and 8,721 women completed the physical activity questionnaire. Mean (standard deviation) time between lung function assessment was 3.7 (0.7) years for both men and women. Participants who answered yes to questions about a history of asthma or bronchitis and emphysema or who listed current use of bronchodilators (1,563 asthma, 1,568 bronchitis or emphysema, and 101 current medication) at either baseline or at second health check were excluded from subsequent analysis due to potential bias in reporting physical activity. Characteristics of the 5 ,467 men and 6,816 women who remained are shown in table 1.

Table 2 presents adjusted mean FEV_1 for each additional year of age, each additional centimeter of height, smoking category, and physical activity categories with FEV_1 as the dependent variable. Age, height, plasma vitamin C, and smoking were significantly related to FEV_1 in both men and women. After adjustment for these covariates, significant positive linear associations were observed between FEV_1 and stair climbing and with the amount of vigorous recreational activity in men and women. A significant negative

TABLE 1. Baseline characteristics of 5,467 men and 6,816 women who completed the European Prospective Investigation into Cancer-Norfolk physical activity questionnaire*, 1993–2000

	Men (mean (SD†))	Women (mean (SD))
Age (years)	59.6 (8.9)	58.4 (8.9)
Weight (kg)	80.1 (10.8)	67.0 (11.0)
Height (cm)	174.2 (6.6)	161.2 (6.1)
Vitamin C (mmol/liter)	49.3 (18.4)	60.7 (19.1)
FEV1† (liter) (baseline)	3.01 (0.7)	2.21 (0.5)
FEV_1 (liter) (second health check)	2.93 (0.7)	2.17 (0.5)
% change in FEV_1 (per year)‡	–0.74 (4.2)	–0.60 (4.1)
	%	%
Smoking		
Never	37	61
Former	53	30
Current	10	9

*Excludes those with self-reported asthma, bronchitis, and emphysema and those currently taking bronchodilators.

†SD, standard deviation; FEV_1, forced expiratory volume in 1 second.

‡ Median (interquartile range).

association was demonstrated between increasing category of television viewing and FEV_1 in women, although this was not statistically significant in men. Because obesity might be an intermediate variable in the biologic pathway between physical activity and respiratory function, adjustment for body mass index and waist-to-hip ratio was performed in a separate analysis (data not shown). The results remained, with slight attenuation in the effect size but were essentially the same as those without the adjustment for obesity.

In the second analysis, using the mean of baseline and second health check FEV_1 as the dependent variable in the linear regression analyses, the results were in the same direction and were of a magnitude similar to those of the analysis presented in table 2. However, the strength of the association was stronger. This is probably due to the reduction in the size of the measurement error as a result of using the mean of two FEV_1 recordings. The results are again presented as the mean FEV_1 in each category of the physical activity index in figures 1, 2, 3, and 4, adjusted for age, height, plasma vitamin C, gender, and smoking. The association between hours per week of participation in vigorous activity and FEV_1 (figure 3) appears to indicate the presence of a threshold, with most of the effect being accounted for by a difference between those who participated in no activity compared with those who reported at least some. This threshold was confirmed, since there was a significant difference between the bottom compared with the top three categories combined ($p < 0.001$), and within the top three categories, there was no evidence of linear trend ($p = 0.8$). Total energy expenditure was calculated by assigning a MET score to individual activities and summing all MET scores (17). Mean FEV_1 for each quintile of total energy expenditure is given in figure 4.

Percent change in FEV_1 between baseline and the second health check was also studied in a third analysis. Table 3 gives adjusted mean percentage change in FEV_1 for each covariate. The unadjusted median percent decline in FEV_1 per year was 0.37 (interquartile range, 4.1) for men and 0.14 (interquartile range, 4.0) for women. After exclusion of those in the top and bottom 1 percent of change in FEV_1, age was significantly associated with a higher rate of decline in both men and women. The rate of decline of FEV_1 in smokers who reported having quit was not significantly different from that of never smokers (men and women). There was no effect of height on the rate of decline of FEV_1. There was a linear negative association between quintiles of percentage weight change and percentage change in FEV_1 that was significant ($p < 0.001$) in men and women; that is, those who gained weight the fastest demonstrated the fastest rate of decline in FEV_1. Baseline physical activity was measured with a global questionnaire that lacked details that would enable the establishment of intensity of activity participation. However, with physical activity data collected at the second health check as a marker of long-term behavior, participation in activities with a MET score of five or more was associated with a lower percent change in FEV_1 in both men and women. More stair climbing was associated with a lower percentage change in FEV_1.

DISCUSSION

This study demonstrates cross-sectional associations between indices of self-reported physical activity and FEV_1 independent of age, height, body mass index, waist-hip ratio, and smoking in a large, population-based study. It also shows the existence of a longitudinal relation between physical activity and the rate of change in FEV_1. Those who participate in vigorous activity show a slower rate of decline in FEV_1 than those who do not, and participants who climb more stairs demonstrate a slower rate of decline in FEV_1. Since FEV_1 is an important predictor of cardiovascular and all-cause mortality, these are important observations.

The results shown here are unlikely to be due to chance, and the effect of confounding has been diminished, since we adjusted for known determinants of FEV_1, including age, height, smoking, and vitamin C. Throughout our analyses, we have initially stratified by sex because of the marked difference in FEV_1 between men and women, a difference that is not explained by age or height. It is possible that the sex difference in FEV_1 results from differences in body size that are only imperfectly accounted for by height. However, on the whole, the magnitude and direction of the observed associations were consistent between men and women, but the significance of the linear trend of FEV_1 and television viewing was less for men. It may be that this difference is a function of gender variation in the response to the television viewing question or gender-specific unmeasured confounding. Biases in the reporting of physical activity have been reduced by excluding persons with prevalent asthma, bronchitis, and emphysema and those who were using medication prescribed for respiratory

TABLE 2. Adjusted mean* forced expiratory volume in 1 second (liters), from linear regression models of 5,467 men and 6,816 women who completed the European Prospective Investigation into Cancer-Norfolk physical activity questionnaire at the second health check, 1998–2000†

	Men				Women				All‡			
	%	FEV_1§	(SE)§	p_{trend}	%	FEV_1	(SE)	p trend	%	FEV_1	(SE)	p_{trend}
Age (each year)		–0.04	(0.001)	<0.001		–0.03	(0.001)	<0.001		–0.03	(0.001)	<0.001
Height (each cm)		0.03	(0.001)	<0.001		0.02	(0.001)	<0.001		0.03	(0.001)	<0.001
Vitamin C (each mmol/liter)		0.001	(0.0004)	<0.001		0.001	(0.0002)	<0.001		0.001	(0.0001)	<0.001
Sex												
Men									45	2.78	(0.01)	
Women									55	2.31	(0.01)	<0.001
Smoking status												
Never	37	3.03	(0.01)		61	2.19	(0.01)		50	2.56	(0.01)	
Former	53	2.92	(0.01)	<0.001¶	30	2.19	(0.01)	0.9¶	41	2.51	(0.01)	<0.001¶
Current	10	2.69	(0.02)	<0.001¶	9	2.07	(0.02)	<0.001¶	9	2.35	(0.01)	<0.001¶
Television viewing† (hours per day)												
<2	23	2.98	(0.02)	0.06	22	2.21	(0.01)	<0.001	22	2.56	(0.01)	< 0.001
2–2.9	26	2.92	(0.01)		24	2.19	(0.01)		25	2.52	(0.01)	
3–3.9	24	2.93	(0.02)		25	2.17	(0.01)		25	2.52	(0.01)	
4–4.9	16	2.94	(0.02)		17	2.17	(0.01)		17	2.52	(0.01)	
≥5	11	2.90	(0.02)		12	2.13	(0.01)		11	2.48	(0.01)	
Stair climbing† (flights per day)												
None	35	2.91	(0.01)	<0.001	34	2.16	(0.01)	0.004	34	2.50	(0.01)	< 0.001
1–5	27	2.92	(0.01)		22	2.17	(0.01)		24	2.51	(0.01)	
6–10	26	2.95	(0.01)		27	2.19	(0.01)		27	2.53	(0.01)	
≥11	12	3.03	(0.02)		17	2.20	(0.01)		15	2.57	(0.01)	
Vigorous activity† (hours per week)												
None	61	2.90	(0.01)	<0.001	59	2.15	(0.01)	<0.001	59	2.49	(0.01)	<0.001
<0.25	13	2.98	(0.02)		12	2.21	(0.01)		13	2.55	(0.01)	
0.25–1.00	11	2.98	(0.02)		13	2.20	(0.01)		12	2.56	(0.01)	
>1	15	3.00	(0.02)		16	2.24	(0.01)		16	2.59	(0.01)	

* Adjusted for age (continuous), height (continuous), plasma vitamin C (continuous), and smoking status (never, former, and current).
† Excludes those with self-reported asthma, bronchitis/emphysema, and current use of bronchodilators)
‡Adjusted for sex.
§ FEV_1, forced expiratory volume in 1 second; SE, standard error.
¶Calculated in comparison with never smokers.

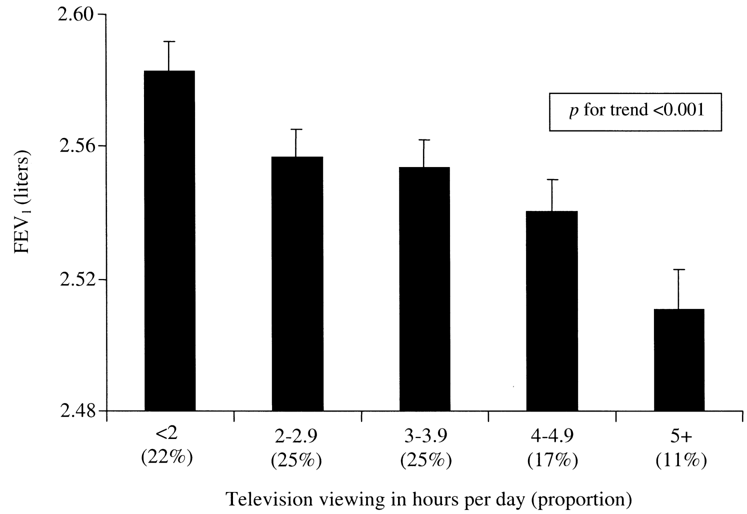

FIGURE 1. Adjusted mean forced expiratory volume in 1 second (FEV_1) (liters) by categories of television viewing (hours per day) in 12,283 men and women in the European Prospective Investigation into Cancer-Norfolk Prospective Population Study, 1993–2000. Adjusted for age (continuous), height (continuous), plasma vitamin C (continuous), sex, and smoking status (never, former, and current).

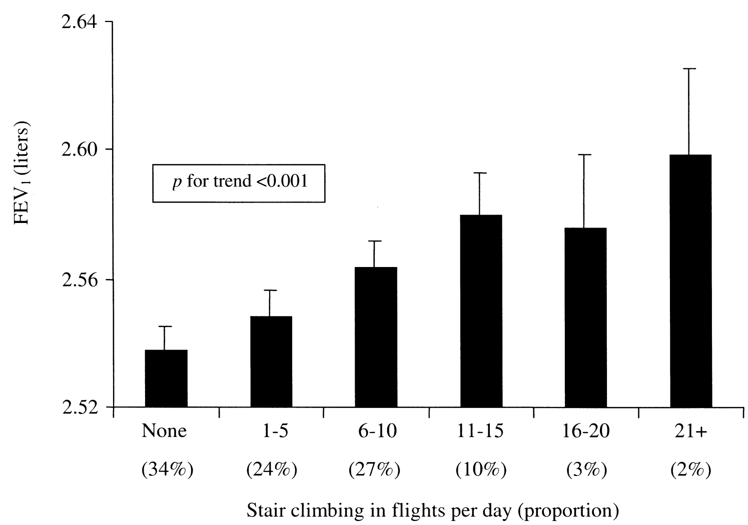

FIGURE 2. Adjusted mean forced expiratory volume in 1 second (FEV_1) (liters) by categories of stair climbing (flights per day) in 12,283 men and women in the European Prospective Investigation into Cancer-Norfolk Prospective Population Study, 1993–2000. Adjusted for age (continuous), height (continuous), plasma vitamin C (continuous), sex, and smoking status (never, former, and current).

disease at the time when physical activity was recorded. However, analyses of this type are unable to determine the causal direction of the association between physical activity and FEV_1. The analyses using percentage change in FEV_1 go partway toward strengthening the causal inference that physical activity affects FEV_1 rather than vice versa. After adjustment for age, smoking, and rate of change in weight, there was a significantly reduced rate of decline in FEV_1 in those who participated in vigorous activity. A similar pattern was observed in those who climbed more stairs per day (table 3).

The magnitude of the association observed in this study between physical activity and FEV_1 is modest. However, imprecision in the measurement of activity is likely to lead to an underestimate of the effect size. It is not possible to clearly separate etiologic effects of fitness-inducing aspects of physical activity as opposed to the totality of energy expenditure by using the questionnaire as the measure of

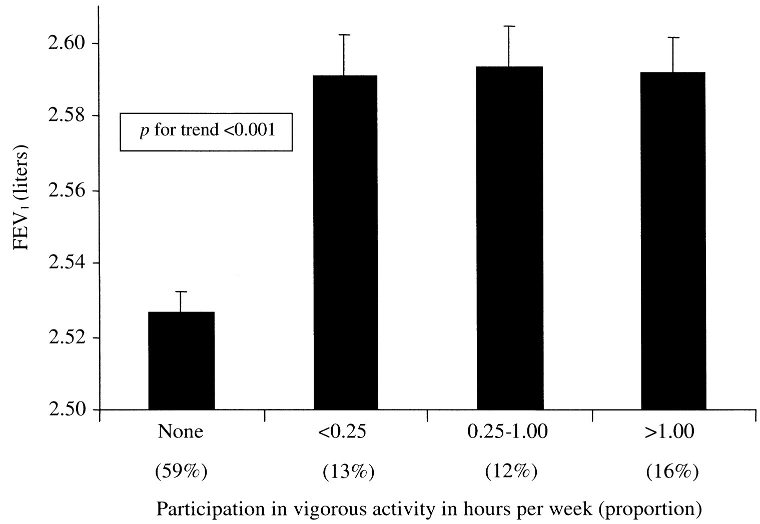

FIGURE 3. Adjusted mean forced expiratory volume in 1 second (FEV_1) (liters) by participation in vigorous activity (hours per week) in 12,283 men and women in the European Prospective Investigation into Cancer-Norfolk Prospective Population Study, 1993–2000. Adjusted for age (continuous), height (continuous), plasma vitamin C (continuous), sex, and smoking status (never, former, and current).

exposure. However, in a substudy of participants in EPIC who underwent more detailed physiologic measurement, we observed a correlation of 0.36 ($p < 0.0001$) between FEV_1 and VO_{2max} after adjustment for age, sex, and height. There was no association (data not shown) with overall energy expenditure measured by the objective quantitative method of heart-rate monitoring with individual calibration (18). These data suggest that it is the fitness-inducing aspects of physical activity that are associated with respiratory function. Self-reported participation in vigorous activity as assessed by EPAQ2 is only a poor proxy measure of VO_{2max}, since our validation study demonstrated a correlation, after adjustment for age, of 0.22 ($p < 0.01$) (10). This level of imprecision in the measurement of fitness by questionnaire would be expected to give rise to a considerable degree of attenuation of the association between activity and FEV_1.

The mechanisms by which physical activity or inactivity might influence FEV_1 are unclear. Physical characteristics of

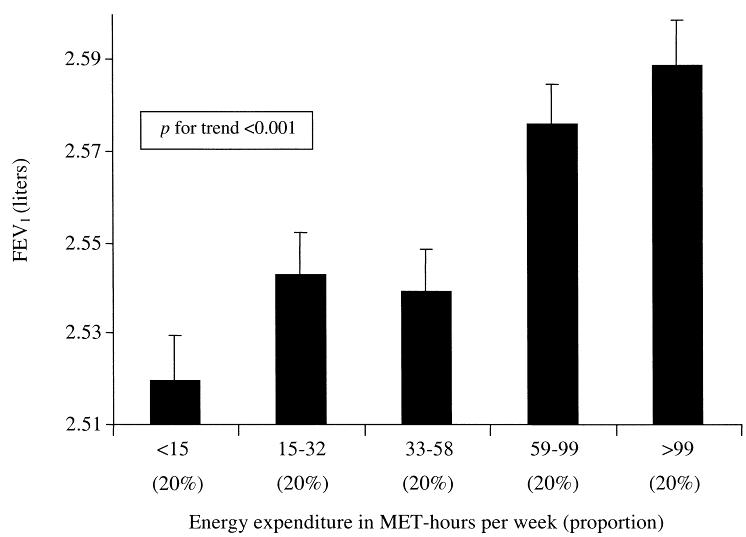

FIGURE 4. Adjusted mean forced expiratory volume in 1 second (FEV_1) (liters) by quintile of total energy expenditure (metabolic equivalent (MET)-hours per week) in 12,283 men and women in the European Prospective Investigation into Cancer-Norfolk Prospective Population Study, 1993–2000. Adjusted for age (continuous), height (continuous), plasma vitamin C (continuous), sex, and smoking status (never, former, and current).

TABLE 3. Adjusted mean* change per year in forced expiratory volume in 1 second (%), from linear regression models, of 12,030 men and women in the European Prospective Investigation into Cancer-Norfolk Prospective Population Study, 1993–2000†

	Men				Women				All‡			
	%	FEV_1§ (% change per year)	(SE)§	p_{trend}	%	FEV_1 (% change per year)	(SE)	p_{trend}	%	FEV_1 (% change per year)	(SE)	p_{trend}
Age (each year)		–0.06	(0.01)	<0.001		–0.06	(0.01)	<0.001		–0.06	(0.01)	<0.001
Sex												
Men									45	–0.31	(0.06)	
Women									55	–0.17	(0.06)	0.07
Smoking status												
Never	37	–0.22	(0.09)		60	–0.10	(0.07)		50	–0.17	(0.05)	
Former	53	–0.38	(0.08)	0.2¶	31	–0.09	(0.09)	0.9¶	41	–0.23	(0.06)	0.5¶
Current	10	–0.74	(0.19)	0.01¶	9	–0.49	(0.17)	0.04¶	9	–0.60	(0.13)	0.002¶
% change in weight (quintile)#												
1	20	0.29	(0.13)	<0.001	20	0.46	(0.11)	<0.001	20	0.38	(0.09)	<0.001
2	20	–0.29	(0.13)		20	–0.07	(0.11)		20	–0.16	(0.09)	
3	20	–0.41	(0.13)		20	–0.41	(0.11)		20	–0.40	(0.09)	
4	20	–0.71	(0.13)		20	–0.33	(0.11)		20	–0.53	(0.09)	
5	20	–0.63	(0.13)		20	–0.30	(0.11)		20	–0.45	(0.09)	
Television viewing (hours per day)												
<2	23	–0.39	(0.12)	0.1	22	0.02	(0.11)	0.2	22	–0.18	(0.09)	0.9
2–2.9	26	–0.42	(0.11)		24	–0.14	(0.11)		25	–0.27	(0.08)	
3–3.9	24	–0.43	(0.12)		25	–0.08	(0.10)		25	–0.23	(0.08)	
4–4.9	16	–0.10	(0.14)		17	–0.23	(0.13)		17	–0.16	(0.09)	
≥5	11	–0.23	(0.18)		12	–0.26	(0.15)		11	–0.24	(0.12)	
Stair climbing (flights per day)												
None	35	–0.48	(0.10)	0.1	34	–0.31	(0.09)	0.01	34	–0.38	(0.07)	0.004
1–5	27	–0.34	(0.11)		22	–0.11	(0.11)		24	–0.22	(0.08)	
6–10	26	–0.22	(0.11)		27	–0.03	(0.10)		27	–0.12	(0.07)	
≥11	12	–0.31	(0.16)		17	0.04	(0.12)		15	–0.10	(0.10)	
Vigorous activity (hours per week)												
None	61	–0.42	(0.08)	0.09	59	–0.22	(0.07)	0.01	59	–0.31	(0.05)	0.002
<0.25	13	–0.46	(0.16)		12	–0.34	(0.15)		13	–0.39	(0.11)	
0.25–1.00	11	0.02	(0.17)		13	0.27	(0.14)		12	0.16	(0.11)	
>1	15	–0.25	(0.15)		16	0.03	(0.13)		16	–0.09	(0.10)	

* Adjusted for age (continuous), smoking status (never, former and current), percent change in weight (continuous).

† Excludes those with self-reported asthma, bronchitis/emphysema, and current use of bronchodilators.

‡ Adjusted for sex.

§ FEV_1, forced expiratory volume in 1 second; SE, standard error.

¶ Calculated in comparison with never-smokers.

Range in each quintile (% change in weight per year): men: Q1, <–0.43; Q2, –0.43 to 0.21; Q3, 0.22 to 0.72; Q4, 0.73 to 1.39; Q5, >1.39. Women: Q1,< –0.55; Q2, –0.55 to 0.27; Q3, 0.28 to 0.89; Q4, 0.90 to 1.73; Q5, >1.73. All: <–0.48; Q2, –0.48 to 0.24; Q3, 0.25 to 0.82; Q4, 0.83 to 1.57; Q5, >1.57.

the pulmonary system that influence FEV_1 are the size of the airway, its elasticity, which, in turn, is associated with age-related interstitial fibrosis, other respiratory disease, inflammation, airway obstruction, and smoking tobacco. It seems unlikely that there are physiologic mechanisms through which physical activity might influence either the size or the elasticity of airways. However, it is possible that associations between physical activity and respiratory function are mediated through an effect on obesity and fat distribution and, to a lesser extent, through effects on ventilatory muscle strength. Obesity impairs respiratory function and structure, leading to physiologic and pathophysiologic impairments, and the work of breathing is increased. This is mainly as a result of stiffness of the thoracic cage due to the accumulation of fat tissue around the ribs, abdomen, and diaphragm (19). Reports have shown that central obesity is negatively associated with lung function in healthy adults (20–23). Leith and Bradley (24) report that ventilatory muscle strength or endurance training can be specifically increased by appropriate ventilatory muscle training programs; however, effects on FEV_1 specifically were not reported. Further, it has been reported that respiratory muscle strength and lung function are closely associated with body weight and lean body mass in patients with chronic obstructive pulmonary disease (25).

The observed relation between weight gain and an increasing rate of decline in FEV_1 is interesting and needs further exploration. In particular, it is possible that the associations seen between weight gain and lung function are mediated through the effects of increased inactivity and decreased activity on weight gain. The differences in effect size on FEV_1 between objective measures and self-reported physical activity are further reinforced if one compares the effect size of change in weight and that of vigorous activity on change in FEV_1 (table 3). Participants categorized in the bottom quintile of weight change demonstrate an adjusted mean change in FEV_1 of 0.38 percent per year compared with –0.45 percent per year for those in the top quintile. For reported physical activity, those do not participate in vigorous activity had a mean change of –0.32 percent per year, whereas those who participated most had a mean change of –0.09 percent per year. The difference in FEV_1 between persons in extreme categories of weight change is almost four times as great as that between people in extreme categories of vigorous activity.

The associations observed in this study are important because they may shed light on why FEV_1 is so strongly predictive of mortality. We cannot infer the direction of causality of the association between activity and FEV_1 from these data. Indeed, observational studies may never be able to resolve this issue, and it may require evidence from experimental designs, such as trials of physical activity interventions, to provide definitive evidence of causal direction and reversibility. Information about change in FEV_1 from physical activity trials in the general population is not currently available. Although studies have been conducted in groups with specific disorders of airways obstruction (26), it may not be appropriate to generalize their results to the effect of physical activity on FEV_1 in the population as a whole.

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The physical activity questionnaire (EPAQ2) can be viewed at the following location: http://www.srl.cam.ac.uk/epic/questionnaires/epaq2/

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