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Change in physical activity and weight in relation to retirement: the French GAZEL Cohort Study

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ABSTRACT

Objectives: To examine the trajectories of physical activity from preretirement to postretirement and to further clarify whether the changes in physical activity are associated with changes in body weight.

Design: Prospective.

Setting: French national gas and electricity company (GAZEL cohort).

Participants: From the original sample of 20 625 employees, only those retiring between 2001 and 2008 on a statutory basis were selected for the analyses (analysis 1: n=2711, 63% men; analysis 2: n=3812, 75% men). Persons with data on at least one preretirement and postretirement measurement of the outcome were selected.

Primary and secondary outcome measures: All outcome data were gathered by questionnaires. In analysis 1, the annual prevalence of higher physical activity (walking ≥5 km/week) 4 years before and after retirement was analysed. In analysis 2, changes in leisure-time sport activities (engagement, frequency and manner) from preretirement to postretirement were analysed with simultaneous changes in body weight (kilogram).

Results: In analysis 1 (n=2711), prevalence estimates for 4 years before and 4 years after retirement showed that higher leisure-time physical activity (walking at least 5 km/week) increased by 36% in men and 61% in women during the transition to retirement. This increase was also observed among people at a higher risk of physical inactivity, such as smokers and those with elevated depressive symptoms. In a separate sample (analysis 2, n=3812), change in weight as a function of preretirement and postretirement physical activity was analysed. Weight gain preretirement to postretirement was 0.85 (95% CI 0.48 to 1.21) to 1.35 (0.79 to 1.90) kg greater among physically inactive persons (decrease in activity or inactive) compared with those physically active ($p<0.001$).

Conclusions: Retirement transition may be associated with beneficial changes in lifestyle and may thus be a good starting point to preventive interventions in various groups of individuals in order to maintain long-term changes.

ARTICLE SUMMARY

Article focus

- The main focus of this article was to examine whether statutory retirement is associated with changes in physical activity.
- Especially, we wanted to clarify what happens during the actual retirement transition (ie, the year of retirement ±1 year).
- Furthermore, we examined whether there were changes in body weight as a function of preretirement and postretirement physical activity level.

Key messages

- We were able to show that during a 9-year follow-up physical activity increased most during the retirement transition, both in men and women.
- Beneficial changes were noticed also among those usually considered as low physical activity groups, such as smokers.
- Physically inactive persons were most prone to gain weight during the follow-up.

Strengths and limitations of this study

- The main strength of this study was yearly measurements of the outcome, which enabled us to get accurate estimates of physical activity during the actual retirement transition.
- Large and stable occupational cohort, prospective study design, accurate register-based data on retirement and long follow-up both preretirement and postretirement were other strengths of this study.
- The main limitation was the use of self-report data of the outcome.

INTRODUCTION

Physical activity is one of the major components of a healthy lifestyle.[1] Despite a clear dose–response relationship between physical activity and disease risk, even moderate-intensity physical activity is associated with reduced risk of several chronic diseases (including cardiovascular disease, stroke, type 2 diabetes, breast and colon cancer, osteoporosis and depression) and increased longevity.[2 3] Physical inactivity, in turn, contributes to the (global) obesity epidemic[4] and has been estimated to cause 6% of all deaths.[1] Despite this evidence, only one-third of Europeans meet the recommended levels of physical activity.[5]

Level of physical activity varies across the life span depending on individual, socio-cultural and environmental factors.[6] A growing body of evidence suggests that different life transitions (eg, retirement, parenthood) may also significantly change peoples' engagement in physical activity in either direction.[7–11] Retirement is an important life transition,[12] which has been shown to associate with peoples' health behaviours. Some studies have reported beneficial changes in health behaviours, such as smoking cessation,[13] decreased alcohol consumption[14] and increased leisure-time physical activity[8–10 15 16] following retirement. However, prevalence of obesity has been shown to peak around retirement age,[17] and retirement itself has been associated with modest weight gain.[18–20] Contradictory results with regard to leisure-time physical activity have also been reported; some studies report only minor or no increase in leisure-time physical activities after retirement.[20–22] To the best of our knowledge, only one previous study has linked changes in physical activity after retirement with simultaneous changes in weight.[20] In that study, retirement was associated with an increase in weight and decreases in several leisure-time physical activities, but the findings were not consistent across occupational groups.

A major drawback of previous studies has been the use of self-reported data on retirement status (eg, 8–10, 20). Typically, the exact date of the retirement is not known and only a few preretirement and postretirement measurements have been available. This implies that estimations of the changes in physical activity during the retirement transition may have been imprecise. The aim of this study was to examine long-term trajectories of physical activity over a 9-year follow-up covering preretirement, periretirement and postretirement phases. We also studied the extent to which these changes were associated with change in weight.

METHODS

Study population

The GAZEL Cohort Study, established in 1989, is comprised of employees from the French national gas and electricity company: Electricité de France-Gaz de France (EDF-GDF).[23] EDF-GDF employees have a civil servant-like status that guarantees job security and opportunities for occupational mobility. Typically, employees are hired in their 20s and stay with the company until retirement, so losses to follow-up are small. At baseline (1989), 20 625 employees (73% men), aged 35–50 years, agreed to participate and have been followed since that annually by postal questionnaires requesting data on health, lifestyle, individual, familial, social and occupational factors. These data are linked to valid occupational and health data collected by the company, including retirement, long-standing work disability and sickness absence. The management, unions and medical department of EDF-GDF gave consent to the usage of all personal and health data files.[24]

Since our two research questions require different samples, we describe the analytic samples and procedures in two parts.

Analysis 1 prospectively examined self-reported physical activity (walking distance per week) trajectories over a time window from 4 years before to 4 years after retirement. Of GAZEL participants retiring between 2003 and 2008 on a statutory basis (n=3601), we included only those who had completed the annual questionnaire at least once before and once after their year of retirement, a final sample of 2711 employees (63% men).

Analysis 2 examined changes in physical activity pre- to postretirement in greater detail. These analyses included associations with weight change but were based on data from two surveys only (administered in 2000 and 2007). To allow at least one pre- and one postretirement assessment, only participants who retired on a statutory basis between 2001 and 2006 and provided responses to more detailed physical activity questions administered both in 2000 and 2007 were taken into account (n=3812 employees; 75% men).

Ascertainment of retirement

All pensions are paid by the employer, EDF-GDF, ensuring high-quality comprehensive retirement data. Statutory age of retirement is between 55 and 60 years, depending on the type of job. We only included persons retiring on a statutory basis (96% of the whole cohort) and excluded those retiring on health grounds. Year of statutory retirement was determined by receipt of an official retirement pension.

Measurement of physical activity and weight

Data on physical activity were drawn from questionnaires. Walking distance (analysis 1) per week was measured annually (2002–2009) using one question: "At the moment, how long a distance do you walk in the town or on the road?" Answers were categorised as follows: (1) <500 m/week, (2) between 500 m and 5 km/week, (3) between 5 and 10 km/week, (4) between 10 and 20 km/week and (5) >20 km/week. This measure was dichotomised into (1) higher activity (≥5 km/week) and (2) lower activity (<5 km/week).

For analysis 2, physical activity measurement was based on responses to three questions on leisure-time sport administered in 2000 (time 1, T1) and 2007 (Time 2, T2). The questions covered three different aspects of habitual physical activity: (1) engaging in leisure-time sport (yes/no), (2) frequency of leisure-time sport (moderate frequency: once a week/low frequency: once a month or sometimes) and (3) manner of the leisure-time sport (group/alone). Using responses to the first question at T1 and T2, participants were categorised as

(1) inactive (no sport at T1 or T2), (2) increasingly active (no sport at T1, but sport at T2), (3) decreasingly active (sport at T1, but not at T2) and (4) active (sport at T1 and T2). Self-reported weight was also drawn from the 2000 and 2007 questionnaires and used to calculate weight change between these years ($weight_{2007} - weight_{2000}$).

Covariates

Socio-demographic characteristics included sex, age at retirement, marital status and occupational position (a measure of socioeconomic status, SES). Marital status (married or cohabiting vs single, divorced or widowed) and SES were defined using the last measurement before retirement. SES was derived from the employer's records and classified into three groups: high SES (managers), intermediate SES (technical) and low SES (clerical and manual), based on categorisations of the French National Statistics Institute.

Work-related factors included night work (never vs occasionally or regularly) and work demands, assessed annually on an 8-point scale. For each participant, we calculated mean scores of physical and psychological work demands over the preretirement period (years −4 to −1) (analysis 1) or used the baseline (T1) value (analysis 2). Answers were dichotomised using the upper quartile as the cut-off point.

Health and health behaviour were assessed annually over the preretirement period (years −4 to −1) (analysis 1), and one affirmative response during this period was considered to indicate the presence of the particular health problem, medical condition or health behaviour. In analysis 2, we used the baseline value (T1) of the variables. Presence of chronic diseases (cancer, diabetes, chronic bronchitis, asthma, angina, myocardial infarction, stroke, osteoarthritis and rheumatoid arthritis) (no chronic disease vs at least one chronic disease) and depression (no depression vs depression) were derived from a checklist of over 50 medical conditions experienced during the past 12 months.[25] Questionnaire data on the amount of beer, wine and spirits consumed were transformed into units of alcohol per day. The average number of units per day over the preretirement period was classified as 0−3 units or >3 units.[26] Reports of height and weight were used to calculate average body mass index over the preretirement period (analysis 1) or at baseline (T1, analysis 2) to identify obese (≥30.0) individuals. Current smoking was ascertained using one question "Are you a current smoker?", dichotomised as smoker versus non-smoker or occasional smoker. Mental and physical fatigue were assessed on an 8-point scale (1=not at all… 8=very/extremely fatigued). The mean for the preretirement responses (analysis 1) or the baseline value (T1, analysis 2) for both items were dichotomised as (1) low fatigue and (2) high fatigue, using the upper quartile as the cut-off point.

Statistical analyses

Associations between the preretirement covariates and physical activity prior to retirement, expressed as prevalence ratios (PRs), were examined using logistic regression adjusted for sex and age at retirement.

Analysis 1

Prevalence of higher physical activity (ie, walking ≥5 km/week) around retirement was estimated using a repeated measures logistic regression analysis with the generalised estimating equations method.[27] This method was chosen since it takes into account the within-subject correlation between physical activity measurements and is not sensitive to missing measurements. All analyses were conducted separately for men and women.

First, we calculated the annual prevalence estimates of higher physical activity and their 95% CIs adjusting for age at retirement to illustrate the overall physical activity trajectory in relation to statutory retirement for the 9-year study period. Next, the whole study period was divided into three different phases: period 1 refers to the preretirement (years −4 through −2), period 2 to the retirement transition (years −1 through +1) and period 3 to the postretirement (years +2 through +4). We calculated the PRs and their 95% CIs for the physical activity trend within each period, treating time as a continuous variable. The risk ratios were expressed as PRs per 3 years within all periods. In order to find factors shaping the trajectory, we also examined multiplicative interactions (ie, the differences in physical activity trends within the periods by the level of each potential effect modifier) by testing the significance of an interaction term 'covariate × time × period' in a model including the main effect and all first-level interactions. Only demographic factors (age and SES) and variables significantly ($p<0.10$) associated with high physical activity at baseline were tested as potential effect modifiers. We calculated the PRs (95% CI) for higher physical activity by contrasting the trend of physical activity within each period for each level of the potential effect modifier. Finally, in order to examine differences in the maintenance of physical activity from preretirement to postretirement in each subgroup, we calculated the overall PRs (95% CI) for postretirement physical activity by contrasting the prevalence of physical activity in period 3 with the prevalence of physical activity in period 1 for each level of the potential effect modifier.

We conducted two sensitivity analyses to further test our results. First, in order to take into account the full variety of the physical activity measure (ie, all five classes of walking), we applied cumulative logistic regression and calculated cumulative OR (CORs) for each period. As another sensitivity analysis, we replicated the main analyses in a subgroup of participants who provided data on physical activity in year +4, in addition to 1 year both preretirement and postretirement, to assess the role of healthy survival effect.

Analysis 2

First, we calculated the likelihood of engaging in leisure-time sport (vs not engaging), of doing sport at a moderate frequency (vs low frequency) and of participating in group sports (vs alone) during the postretirement period compared with the preretirement and expressed results as PRs and their 95% CIs. Then we analysed the association between the changes in physical activity from preretirement to postretirement (inactive, increasingly active, decreasingly active and active) and simultaneous weight change (absolute and relative) by using the repeated measures analysis of variance, adjusting for age and sex. We calculated the contrast estimates by using active at T1 and T2 as reference category.

RESULTS

Table 1 shows baseline characteristics of the two samples and the association between covariates and higher physical activity. Before retirement, higher physical activity was more common among men than women in both samples. Low levels of mental and physical fatigue as well as being non-obese were also associated with higher physical activity at preretirement.

Analysis 1

The mean age of retirement in this sample (N=2711) was 58 years (SD 2.4, range 50−66), and most of the employees (94%) had retired by the age of 60. The analyses were based on 19 673 observation years (on average 7.3 observations per person). Before retirement, 58% of the participants reported walking at least 5 km/week, 25% between 5 km and 10 km and 17% >10 km.

Figure 1 shows the age-adjusted prevalence estimates (95% CIs) for higher physical activity (ie, walking ≥5 km/week) within the 9-year time window. Before retirement, the annual prevalence of men and women walking at least 5 km/week was around 40%. There was a significant difference in the prevalence of physical activity between the preretirement, periretirement and postretirement periods in both men and women (p value for interaction time × period <0.001 in both sexes) (tables 2 and 3). The proportion of men walking at least 5 km increased by 36% during period 2. A lesser, 18%, increase was noticed during period 1 and a non-significant, 8%, decrease in period 3. In women, the sharpest increase (61%) in physical activity also occurred during the retirement transition, in contrast to 14%−19% decreases in physical activity during the preretirement and postretirement phases. Importantly, a similar pattern of significant increases in physical activity, especially during period 2, was noticed across all subgroups. Of the covariates, only depression significantly shaped the physical activity trajectory pattern among male respondents. Interestingly, during period 2, the likelihood of higher physical activity increased more in men with elevated depressive symptoms compared with men with lower levels of depressive symptoms (PR 2.17, 95% CI 1.45 to 3.24 vs PR 1.32, 95% CI 1.21 to 1.44, p value (two sided) for interaction covariate × time × period <0.05).

Table 4 shows the comparisons between the overall prevalences of higher physical activity in period 3 compared with period 1. Both men and women maintained higher prevalence of physical activity over the whole postretirement period compared with the preretirement period (PR 1.13, 95% CI 1.06 to 1.19; PR 1.14 95% CI 1.05 to 1.24, respectively). However, in some subgroups, beneficial changes were no more maintained in period 3. For example, men and women belonging to the lowest SES category or with elevated depressive symptoms, as well as female smokers and women with high levels of mental or physical fatigue, were not able to maintain the increased level of physical activity postretirement.

Sensitivity analyses

Sensitivity analysis with cumulative logistic regression replicated the main results by showing a significant difference in physical activity between the periods (interaction year × period p<0.001 in both sexes). In both men and women, the sharpest increase in physical activity occurred during retirement transition (COR 1.99, 95% CI 1.71 to 2.31 in men; COR 2.23, 95% CI 1.81 to 2.74 in women), while slighter changes were noticed in preretirement and postretirement periods. In men, the proportion of those in higher physical activity groups increased significantly already in period 1, that is, during preretirement years (COR 1.32, 95% CI 1.04 to 1.67), while in women, no trend was observed (COR 0.97, 95% CI 0.75 to 1.25). In period 3, a decreasing trend was noticed in both sexes, even though statistically significant only in women (COR 0.86, 95% CI 0.74 to 1.01 in men; COR 0.74, 95% CI 0.57 to 0.95 in women). Despite the decreasing trend in period 3, both men and women maintained a significantly higher level of physical activity over the whole postretirement period compared with preretirement period (COR for the difference between period 3 and period 1 1.58, 95% CI 1.40 to 1.78 in men; COR 1.54, 95% CI 1.32 to 1.79 in women).

In another sensitivity analysis, conducted among 1492 participants who, in addition to one preretirement and one postretirement measurement, also provided data at the end of follow-up (year +4), the main result was replicated. In both men and women, the biggest increase (48% and 85%, respectively) in physical activity occurred during retirement transition (period 2). The beneficial changes were also maintained postretirement in both sexes (PR for the difference between period 3 and period 1 1.22, 95% CI 1.11 to 1.33 in men; PR 1.30, 95% CI 1.09 to 1.54 in women).

Analysis 2

The mean age of retirement was 56 (SD 2.4, range 48−63), and 99% of individuals had retired by the age of 60. As shown in table 5, the likelihood of engaging in sport activities increased preretirement to postretirement both in men and women (PR 1.15, 95% CI 1.11 to 1.20; PR 1.31, 95% CI 1.23 to 1.40, respectively).

Table 1 Baseline characteristics of the two samples and likelihood of high physical activity* by different covariates expressed as PRs and their 95% CIs in EDF-GDF employees, France

	Analysis 1, N=2711				Analysis 2, N=3812			
	N	%	PR	95% CI	N	%	PR	95% CI
Demographics								
Sex†								
Male	1703	62.8	1.00	ref.	2872	75.3	1.00	ref.
Female	1008	37.2	0.79	0.71 to 0.88	940	24.7	0.84	0.74 to 0.96
Age at retirement								
≤53	98	3.6	1.00	ref.	516	13.5	1.00	ref.
54–56	933	34.4	1.08	0.76 to 1.54	1925	50.5	0.99	0.86 to 1.06
≥57	1680	62.0	1.19	0.84 to 1.68	1371	36.0	0.99	0.87 to 1.13
Employment grade								
Higher	1104	40.8	1.00	ref.	1574	41.3	1.00	ref.
Intermediate	1281	47.3	1.01	0.91 to 1.12	1855	48.7	0.90	0.82 to 1.00
Lower	324	12.0	0.89	0.74 to 1.07	380	10.0	0.90	0.75 to 1.07
Marital status								
Married	2276	84.0	1.00	ref.	3325	87.2	1.00	ref.
Single, divorced or widowed	435	16.1	0.96	0.76 to 1.22	487	12.8	1.04	0.90 to 1.21
Work characteristics								
Night work								
No	2029	75.0	1.00	ref.	2572	67.5	1.00	ref.
Yes	679	25.1	0.92	0.82 to 1.02	1236	32.5	1.07	0.97 to 1.19
Psychological work demands†								
Low	2090	77.7	1.00	ref.	2841	74.7	1.00	ref.
High	601	22.3	0.90	0.79 to 1.01	960	25.3	0.95	0.86 to 1.06
Physical work demands								
Low	2079	77.3	1.00	ref.	2817	74.1	1.00	ref.
High	612	22.7	1.04	0.93 to 1.16	984	25.9	0.90	0.81 to 1.01
Health								
Mental fatigue†								
Low	2041	75.4	1.00	ref.	2848	74.7	1.00	ref.
High	667	24.6	0.84	0.75 to 0.96	964	25.3	0.94	0.84 to 1.04
Physical fatigue†								
Low	1992	73.5	1.00	ref.	2833	74.3	1.00	ref.
High	718	26.5	0.85	0.75 to 0.96	979	25.7	0.83	0.73 to 0.93
Chronic diseases‡								
No	1390	52.3	1.00	ref.	1941	50.9	1.00	ref.
Yes	1321	48.7	0.93	0.84 to 1.02	1871	49.1	0.95	0.86 to 1.04
Depression†								
No	2381	87.8	1.00	ref.	3279	86.0	1.00	ref.
Yes	330	12.2	0.87	0.74 to 1.03	533	14.0	0.93	0.81 to 1.08
Smoking†								
No	2209	81.6	1.00	ref.	3061	87.6	1.00	ref.
Yes	498	18.4	0.89	0.78 to 1.02	433	12.4	0.84	0.74 to 0.96
Alcohol consumption								
≤3	1816	77.3	1.00	ref.	2857	79.2	1.00	ref.
>3	532	22.7	0.99	0.89 to 1.10	750	20.8	1.00	0.91 to 1.11
BMI†								
<30	2111	90.6	1.00	ref.	3215	89.4	1.00	ref.
≥30	218	9.4	0.63	0.50 to 0.80	381	10.6	0.59	0.45 to 0.77

Models were adjusted for age and sex.
*High physical activity ≥5 km walking distance/week (analysis 1); Likelihood of engaging in leisure-time sport (analysis 2).
†p Value <0.100 for the difference between covariate classes in analysis 1.
‡Chronic diseases = cancer, diabetes, chronic bronchitis, asthma, angina, myocardial infarction, stroke, osteoarthritis and rheumatoid arthritis.
PR, prevalence ratio; EDF-GDF, Eléctricité de France-Gaz de France.

The frequency of sport activities increased to almost threefold (PR 2.77, 95% CI 1.94 to 3.96) in women and to 1.6-fold in men. After retirement, male and female participants were also more likely to engage in sport activities in groups than alone, group activities being more frequent among men.

Repeated measures analysis of variance showed a significant difference in weight change preretirement

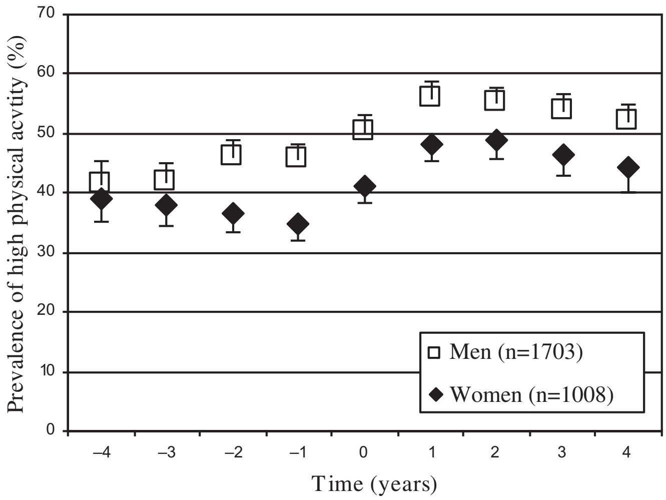

Figure 1 Proportion of men and women walking at least 5 km/week in relation to the year of retirement (year 0) among Eléctricité de France-Gaz de France (EDF-GDF) employees, France, 2002–2009. Adjusted for age.

to postretirement between different physical activity classes (p value for physical activity change main effect <0.001), when adjusted for age and sex. Participants who either stopped taking part in leisure-time sports after retirement or who maintained an inactive lifestyle during the entire follow-up gained on average 0.85–1.35 kg more weight (corresponding 1.2%–1.7% of participants' initial weight) compared with those engaging in leisure-time sports both before and after retirement (table 6).

DISCUSSION

In this large cohort of French national gas and electricity company employees, statutory retirement was associated with a substantial increase in leisure-time physical activity. During the retirement transition, the prevalence of those walking at least 5 km/week increased by 36% in men and 61% in women. Since the main results were further confirmed by cumulative logistic regression, they hardly arise from an arbitrarily chosen cut-off point. In addition, the likelihood of engaging in sport activities, as well as sport frequency, significantly increased in both sexes, the latter being especially pronounced in women. Importantly, the increase in physical activity over the retirement transition was observable even among those belonging to risk groups for low physical activity

Table 2 Age-adjusted PRs and 95% CIs of higher physical activity in preretirement, periretirement and postretirement among male EDF-GDF employees, France, 2002–2009

	Men			
	Period 1 PR (95% CI)	Period 2 PR (95% CI)	Period 3 PR (95% CI)	p Value*
All	1.18 (1.03 to 1.37)	1.36 (1.25 to 1.48)	0.92 (0.85 to 1.00)	<0.001
SES				0.35
Higher	1.16 (0.97 to 1.39)	1.46 (1.31 to 1.63)	0.93 (0.83 to 1.03)	
Intermediate	1.12 (0.87 to 1.44)	1.17 (1.01 to 1.35)	0.90 (0.79 to 1.02)	
Lower	1.92 (0.99 to 3.72)	1.78 (1.21 to 2.61)	0.99 (0.71 to 1.37)	
Age at retirement				0.27
<57	0.70 (0.35 to 1.41)	1.44 (1.25 to 1.65)	0.92 (0.83 to 1.02)	
≥57	1.21 (1.04 to 1.40)	1.31 (1.18 to 1.46)	0.90 (0.79 to 1.02)	
Psychological work demands				0.86
Low	1.20 (1.03 to 1.41)	1.34 (1.22 to 1.48)	0.91 (0.83 to 1.00)	
High	1.14 (0.81 to 1.61)	1.44 (1.18 to 1.75)	0.97 (0.82 to 1.14)	
Mental fatigue				
Low	1.16 (1.00 to 1.35)	1.30 (1.18 to 1.42)	0.92 (0.84 to 1.00)	0.33
High	1.36 (0.89 to 2.09)	1.68 (1.34 to 2.11)	0.94 (0.78 to 1.13)	
Physical fatigue				
Low	1.20 (1.03 to 1.40)	1.34 (1.22 to 1.47)	0.92 (0.84 to 1.00)	0.86
High	1.16 (0.79 to 1.72)	1.47 (1.19 to 1.81)	0.94 (0.78 to 1.14)	
BMI				0.61
<30	1.19 (1.03 to 1.38)	1.34 (1.23 to 1.46)	0.91 (0.84 to 0.99)	
≥30	1.02 (0.52 to 1.98)	1.73 (1.17 to 2.55)	1.02 (0.73 to 1.43)	
Smoking				0.23
No	1.22 (1.05 to 1.43)	1.34 (1.22 to 1.46)	0.94 (0.86 to 1.03)	
Yes	1.00 (0.70 to 1.44)	1.49 (1.20 to 1.85)	0.82 (0.69 to 0.99)	
Depression				0.05
No	1.21 (1.05 to 1.40)	1.32 (1.21 to 1.44)	0.92 (0.85 to 1.00)	
Yes	0.80 (0.38 to 1.70)	2.17 (1.45 to 3.24)	0.90 (0.64 to 1.26)	

Models were adjusted for age at retirement. Period 1=years −4 to −2 (preretirement); period 2=years 1− to +1 (periretirement); period 3=years +2 to +4 (postretirement).
*p Values (two sided) refer to interaction time × period × covariate (except for all, where p value refers to period main effect).
PR, prevalence ratio; EDF-GDF, Eléctricité de France-Gaz de France.

Table 3 Age-adjusted PRs and 95% CIs of higher physical activity in preretirement, periretirement and postretirement among female EDF-GDF employees, France, 2002–2009

	Women			
	Period 1 PR (95% CI)	Period 2 PR (95% CI)	Period 3 PR (95% CI)	p Value*
All	0.91 (0.75 to 1.09)	1.61 (1.40 to 1.86)	0.86 (0.74 to 0.99)	<0.001
SES				0.99
Higher	1.05 (0.69 to 1.58)	1.69 (1.22 to 2.35)	0.88 (0.61 to 1.28)	
Intermediate	0.88 (0.69 to 1.12)	1.63 (1.37 to 1.94)	0.87 (0.73 to 1.03)	
Lower	0.86 (0.55 to 1.34)	1.46 (1.03 to 2.06)	0.78 (0.51 to 1.19)	
Age at retirement				0.10
<57	0.86 (0.66 to 1.12)	1.86 (1.55 to 2.23)	0.86 (0.73 to 1.02)	
≥57	0.98 (0.75 to 1.29)	1.28 (1.03 to 1.58)	0.84 (0.63 to 1.12)	
Psychological work demands				0.69
Low	0.90 (0.73 to 1.11)	1.54 (1.32 to 1.80)	0.85 (0.71 to 1.00)	
High	0.92 (0.58 to 1.45)	2.04 (1.43 to 2.90)	0.93 (0.67 to 1.25)	
Mental fatigue				
Low	0.96 (0.78 to 1.18)	1.54 (1.31 to 1.82)	0.91 (0.77 to 1.08)	0.23
High	0.76 (0.50 to 1.17)	1.85 (1.40 to 2.44)	0.75 (0.56 to 1.00)	
Physical fatigue				
Low	0.94 (0.76 to 1.16)	1.58 (1.34 to 1.85)	0.85 (0.72 to 1.01)	0.77
High	0.84 (0.56 to 1.25)	1.71 (1.29 to 2.27)	0.90 (0.67 to 1.19)	
BMI				0.84
<30	0.91 (0.75 to 1.10)	1.63 (1.42 to 1.88)	0.85 (0.73 to 0.98)	
≥30	0.95 (0.41 to 2.20)	1.37 (0.53 to 3.52)	1.12 (0.41 to 3.11)	
Smoking				0.48
No	0.92 (0.76 to 1.12)	1.53 (1.32 to 1.78)	0.83 (0.71 to 0.97)	
Yes	0.83 (0.47 to 1.46)	2.20 (1.46 to 3.33)	1.05 (0.67 to 1.63)	
Depression				0.12
No	0.98 (0.80 to 1.20)	1.54 (1.31 to 1.81)	0.86 (0.73 to 1.03)	
Yes	0.60 (0.36 to 1.00)	1.88 (1.42 to 2.49)	0.83 (0.64 to 1.09)	

Models were adjusted for age at retirement. Period 1 = years −4 to −2 (preretirement); period 2 = years 1− to +1 (periretirement); period 3 = years +2 to +4 (postretirement).
*p Values (two sided) refer to interaction time × period × covariate (except for all, where p value refers to period main effect).
PR, prevalence ratio; EDF-GDF, Eléctricité de France-Gaz de France.

(eg, smokers). Weight changes preretirement to postretirement appeared to be limited to a gain in weight among participants with low or decreasing levels of leisure-time physical activity, with no significant changes observable among those with increasing leisure-time physical activity. The reasons behind the retirement-related increase in physical activity remain unknown, but multiple factors may be involved, such as social factors,[8 10] sense of purpose,[28] more time availability and flexibility[8 10] and increasing concerns about health and well-being postretirement.[8] Since the manner of exercise also changed (ie, participants engaged more in group activities compared with exercising alone after retirement), social factors may have played a significant role as a motivating factor in this particular cohort.

In contrast to previous studies mostly relying on self-reported retirement data, we were able to use records including the exact year of retirement, which were collected by a single employer. Other strengths include a large sample size and annually repeated measurements over an extended time window of 9 years. Even though observational evidence cannot be used to infer causality, alternative explanations of our results appear implausible. These data suggest that retirement is associated with benefits in terms of increasing physical activity.

The main limitation of this study was the reliance on self-reported physical activity and weight, as these data can be subject to recall and self-report bias.[29] Previous studies suggest that the level of both moderate intensity physical activity and weight tends to be underestimated by responders.[30 31] Also various characteristics of the respondents, such as age and education level, have been shown to affect self-reports of physical activity.[30] A further limitation is that we measured only leisure-time physical activity, rendering the estimations of the net changes in total physical activity impossible. It may be that people at work are actually more likely to achieve the recommended overall levels of physical activity compared with those already retired because for some people, work involves a substantial amount of physical activity which is lost upon retirement.[20] However, only a minority of the study participants retired from manual occupations (10%–12%) suggesting that net gains in physical activity after retirement are likely. Furthermore,

Table 4 Differences in physical activity between period 3 and period 1, expressed as PRs and their 95% CIs, among EDF-GDF employees, France, 2002−2009

	Men		Women	
	Period 3 versus period 1		Period 3 versus period 1	
	PR (95% CI)	p Value*	PR (95% CI)	p Value*
All	1.13 (1.06 to 1.19)	<0.001	1.14 (1.05 to 1.24)	0.006
Employment grade		0.03		0.37
Higher	1.31 (1.13 to 1.52)		1.20 (0.83 to 1.73)	
Intermediate	1.24 (1.02 to 1.50)		1.34 (1.11 to 1.61)	
Lower	0.83 (0.53 to 1.33)		1.07 (0.77 to 1.48)	
Age at retirement		0.55		0.63
>57	1.13 (0.99 to 1.29)		1.17 (1.05 to 1.31)	
≥57	1.10 (1.02 to 1.18)		1.10 (0.96 to 1.26)	
Psychological work demands		0.85		0.30
Low	1.12 (1.05 to 1.19)		1.15 (1.04 to 1.26)	
High	1.16 (1.02 to 1.33)		1.17 (0.96 to 1.43)	
Mental fatigue		0.77		0.05
Low	1.11 (1.04 to 1.18)		1.19 (1.08 to 1.31)	
High	1.16 (1.00 to 1.35)		1.05 (0.87 to 1.27)	
Physical fatigue		0.42		0.06
Low	1.12 (1.05 to 1.19)		1.19 (1.08 to 1.31)	
High	1.16 (1.00 to 1.36)		1.06 (0.89 to 1.27)	
BMI		0.19		0.03
<30	1.09 (1.00 to 1.20)		1.23 (1.11 to 1.36)	
≥30	1.14 (1.05 to 1.22)		0.95 (0.80 to 1.12)	
Smoking		0.77		0.05
No	1.12 (1.05 to 1.19)		1.18 (1.08 to 1.30)	
Yes	1.17 (1.01 to 1.36)		0.91 (0.72 to 1.15)	
Depression		0.18		0.13
No	1.14 (1.07 to 1.21)		1.16 (1.06 to 1.28)	
Yes	0.95 (0.73 to 1.22)		1.07 (0.88 to 1.31)	

Models were adjusted for age at retirement.
Period 1 = years −4 to −2 (preretirement); period 2 = years 1− to +1 (periretirement); period 3 = years +2 to +4 (postretirement).
*p Values (two sided) refer to interaction covariate × period (except for all, where p value refers to period main effect).
PR, prevalence ratio; EDF-GDF, Eléctricité de France-Gaz de France.

we were not able to define intensity of exercise or single session duration. These variables would be necessary when estimating energy consumption and net health effects of physical activity. With regard to weight changes, the main limitation was that we did not consider simultaneous changes in diet including alcohol consumption, which has been shown to increase in GAZEL cohort around retirement.[32] Both the decrease in physical activities as well as unhealthier eating or drinking habits may contribute to weight changes at retirement as shown, for example, in the study of Nooyens *et al*.[20]

In large cohort studies, where the participants are followed by surveys for a long time, persons with severe illnesses or functional impairments tend to drop out[33] creating a healthy survivor effect. Since physical inactivity is associated with many chronic diseases,[2 3] it is likely that persons with the most severe conditions were lost to follow-up. The fact that the results remained essentially the same when the analysis was restricted to

Table 5 Likelihood of sports activities during postretirement compared with preretirement years, expressed as PRs and their 95% CIs, among EDF-GDF employees, France, 2000−2007

	All PR (95% CI)	Men PR (95% CI)	Women PR (95% CI)	p Value*
Sport activity (active versus inactive)	1.19 (1.15 to 1.23)	1.15 (1.11 to 1.20)	1.31 (1.23 to 1.40)	<0.001
Sport frequency (moderate versus high)	1.77 (1.56 to 2.00)	1.62 (1.42 to 1.85)	2.77 (1.94 to 3.96)	0.02
Sport manner (group versus alone)	1.68 (1.48 to 1.91)	1.28 (1.19 to 1.38)	1.11 (1.04 to 1.19)	<0.001

Adjusted for age at retirement.
*p Values (two sided) refer to interaction sex × year.
PR, prevalence ratio; EDF-GDF, Eléctricité de France-Gaz de France.

Table 6 Differences in weight changes in different categories of physical activity compared with participants who were physically active during whole study period, expressed as least square means (LS-means) and their 95% CIs and as procentual changes from initial preretirement weight

Between-group differences in weight changes (kg/% of initial weight) from preretirement to postretirement

	All			Men			Women		
	LS-means kg (%)	95% CI	p Value*	LS-means kg (%)	95% CI	p Value*	LS-means kg (%)	95% CI	p Value*
Inactive versus active	0.85 (1.2)	0.48 to 1.21	<0.001	0.65 (0.8)	0.24 to 1.06	<0.01	1.52 (2.3)	0.75 to 2.28	<0.001
Increasing versus active	−0.15 (−0.1)	−0.53 to 0.24	0.45	−0.38 (−0.4)	−0.83 to 0.07	0.10	0.48 (0.7)	−0.23 to 1.19	0.19
Decreasing versus active	1.35 (1.7)	0.79 to 1.90	<0.001	1.36 (1.6)	0.74 to 1.99	<0.001	1.22 (1.8)	0.01 to 2.44	0.05

Number of responders during the follow-up

Year	−4	−3	−2	−1	0	+1	+2	+3	+4
Men	480	625	875	1474	1506	1546	1424	1223	1030
Women	423	508	593	847	856	876	712	584	457

Adjusted for age at retirement. Active both in 2000 and 2007 used as a reference.
*p Values (two sided) refer to differences between the two classes in repeated measures analysis of variance contrast estimates.
LS-means, least square means.

participants also providing data for year +4 following retirement suggests that any healthy survivor effect is likely to be small. It is also noteworthy that the particularities of this cohort (eg, stable job status, low statutory retirement age and high pensions) may limit the generalisability to other working cohorts.

The observed increase in physical activity after retirement is in agreement with previous studies with shorter follow-up times.[8–10] Supportive of our findings are also the results by Lahti *et al* [16] stating that time spent in moderate intensity exercise (walking or alike) increased among retirees. However, contradictory results have also been reported.[20–22] Berger *et al*[22] reported only marginal increases in physical activity after retirement, and Slingerland *et al*[21] reported no association between retirement and physical activity (i.e. no increase in sport participation or non-sport physical activity including walking, cycling and gardening was noticed). However, these longitudinal studies had only one measure of physical activity at follow-up, preventing precise detection of changes in physical activity in relation to retirement. Nooyens *et al*[20] also showed retirement to be associated with increases in weight and waist circumference, which in turn were found to be related to decreases in several physical activities. However, these results were based on a small sample of 288 men. The results of the present study are also in agreement with, and may partly explain, the earlier findings from the same cohort that retirement is associated with improved self-rated health[34] and decreased prevalence of sleep problems.[35]

One intriguing finding was that leisure-time physical activity increased significantly in men with higher levels of depression prior to retirement. However, retirement has been associated with a substantial reduction in mental and physical fatigue as well as depressive symptoms in this and other cohorts.[36–38] Among older workers who feel tired of their work, the decrease in fatigue during retirement transition could increase energy resulting in a higher probability to spend time in stimulating and restorative activities, such as physical exercise.[39] Unfortunately, men who were depressed before retirement were not able to maintain the increased levels of physical activity beyond retirement transition. A similar phenomenon was noticed among women; female smokers, women with high levels of depression, high mental or physical fatigue and those with high physical work demands increased their physical activity substantially during retirement transition but were unable to maintain the benefits postretirement. These findings show that also individuals belonging to 'risk groups' of low physical activity have potential to improve their habits, when encountering a major life event. This is promising with regard to health promotion even though interventions aimed at maintaining high physical activity levels are crucial to ensure long-term improvements.

In this occupational cohort of French employees, a clear increase in leisure-time physical activity, walking and sport activities, was found in both men and women. These results highlight the importance of retirement as a life transition during which considerable changes in health habits are likely. Our findings should be taken into account by policymakers and those involved in planning and developing health promotion strategies for older employees.

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Patient consent Participants in GAZEL did not fill in any formal informed consent. However, CNIL (the French legal authority for data privacy) considered that as participants themselves fill in and send written questionnaires, this is equivalent to a formal consent. All legal authorizations for the GAZEL study were obtained from the Commission Nationale de l'Informatique et des Libertés-CNIL (CNIL NÂ° 105 728, 26 April 1988).

Ethics approval Ethics approval was provided by CNIL, Commission Nationale de l'Informatique et des Libertés.

Contributors All authors participated in writing of the manuscript have seen the latest version of the manuscript and will take the full responsibility for the entire manuscript. In more detail: authors NMS and JV designed the original hypothesis. NMS analysed the data and drafted the first version of the manuscript, in close collaboration with JV, who is a supervisor of this study. JP provided statistical advice and helped planning and conducting the statistical analyses. MZ and MG are the founders of GAZEL cohort and manage all the data. They also made a significant contribution to the conception and design of this study. All other authors (MK, AS-M, JEF and HW) significantly contributed to subsequent drafts and helped in interpretation of the results and revision of the text. All authors approved the final draft of the report.

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REFERENCES

1. World Health Organization. *Global Recommendations on Physical Activity for Health.* Geneva: WHO Press, 2010:10.
2. Warburton DE, Nicol CW, Bredin SSD. Health benefits of physical activity: the evidence. *CMAJ* 2006;174:801–9.
3. Warburton DE, Charlesworth S, Ivey A, *et al.* A systematic review of the evidence for Canada's Physical Activity Guidelines for Adults. *Int J Behav Nutr Phys Act* 2010;7:39.
4. Caballero B. The global epidemic of obesity: an overview. *Epidemiol Rev* 2007;29:1–5.
5. Sjöström M, Oja P, Hagströmer M, *et al.* Health-enhancing physical activity across European Union countries: the Eurobarometer study. *J Public Health* 2006;14:291–300.
6. Trost SG, Owen N, Bauman AE, *et al.* Correlates of adults' participation in activity: review and update. *Med Sci Sports Exerc* 2002;34:1996–2001.
7. Hull EE, Rofey DL, Robertson RJ, *et al.* Influence of marriage and parenthood on physical activity: a 2-year prospective analysis. *J Phys Act Health* 2010;7:577–83.
8. Evenson KR, Rosamond WD, Cai J, *et al*; Atherosclerosis Risk in Communities Study Investigators. Influence of retirement on leisure-time physical activity: the Atherosclerosis Risk in Communities Study. *Am J Epidemiol* 2002;155:692–9.
9. Henkens K, van Solinge H, Gallo WT. Effects of retirement voluntariness on changes in smoking, drinking and physical activity among Dutch older workers. *Eur J Public Health* 2008;18:644–9.
10. Touvier M, Bertrais S, Charreire H, *et al.* Changes in leisure-time physical activity and sedentary behaviour at retirement: a prospective study in middle-aged French subjects. *Int J Behav Nutr Phys Act* 2010;7:14.
11. Brown WJ, Heesch KC, Miller YD. Life events and changing physical activity patterns in women at different life stages. *Ann Behav Med* 2009;37:294–305.
12. Nuttman-Shwartz O. Like a high wave: adjustment to retirement. *Gerontologist* 2004;44:229–36.
13. Lang IA, Rice NE, Wallace RW, *et al.* Smoking cessation and transition into retirement: analyses from the English Longitudinal Study of Ageing. *Age Ageing* 2007;36:638–43.
14. Brennan PL, Schutte KK, Moos RH. Retired status and older adults' 10-year drinking trajectories. *J Stud Alcohol Drugs* 2010;71:165–8.
15. Mein GK, Shipley MJ, Hillsdon M, *et al.* Work, retirement and physical activity: cross-sectional analyses from the Whitehall II study. *Eur J Public Health* 2005;15:317–22.
16. Lahti J, Laaksonen M, Lahelma E, *et al.* Changes in leisure-time physical activity after transition to retirement: a follow-up study. *Int J Behav Nutr phys Act* 2011;8:36.
17. Houston DK, Nicklas BJ, Zizza CA. Weighty concerns: the growing prevalence of obesity among older adults. *J Am Diet Assoc* 2009;109:1886–95.
18. Forman-Hoffman VL, Richardson KK, Yankey JW, *et al.* Retirement and weight changes among men and women in the health and retirement study. *J Gerontol B Psychol Sci Soc Sci* 2008;63:S146–53.
19. Chung S, Domino ME, Stearns SC. The effect of retirement on weight. *J Gerontol B Psychol Sci Soc Sci* 2009;64B:656–65.
20. Nooyens AC, Visscher TL, Schuit AJ, *et al.* Effects of retirement on lifestyle in relation to changes in weight and waist circumference in Dutch men: a prospective study. *Public Health Nutr* 2005;8:1266–74.
21. Slingerland AS, van Lenthe FJ, Jukema JW, *et al.* Aging, retirement, and changes in physical activity: prospective cohort findings from the GLOBE study. *Am J Epidemiol* 2007;165:1356–63.
22. Berger U, Der G, Mutrie N, *et al.* The impact of retirement on physical activity. *Ageing Soc* 2005;25:181–95.
23. Zins M, Leclerc A, Goldberg M. The French GAZEL Cohort Study: 20 years of epidemiologic research. *Adv Life Course Res* 2009;14:135–46.
24. Goldberg M, Leclerc A, Bonenfant S, *et al.* Cohort profile: the GAZEL Cohort Study. *Int J Epidemiol* 2007;36:32–9.
25. Goldberg P, Gueguen A, Schmaus A, *et al.* Longitudinal study of associations between perceived health status and self reported diseases in the French Gazel cohort. *J Epidemiol Community Health* 2001;55:233–8.
26. Zins M, Carle F, Bugel I, *et al.* Predictors of change in alcohol consumption among Frenchmen of the GAZEL study cohort. *Addiction* 1999;94:385–95.
27. Lipsitz SR, Kim K, Zhao L. Analysis of repeated categorical data using generalized estimating equations. *Stat Med* 1994;13:1149–63.
28. Beck F, Gillison F, Standage M. A theoretical investigation of the development of physical activity habits in retirement. *Br J Health Psychol* 2010;15:663–79.
29. Donaldson SI, Grant-Vallone EJ. Understanding self-report bias in organizational behavior research. *J Bus Psychol* 2002;17:245–60.
30. Durante R, Ainsworth BE. The recall of physical activity: using a cognitive model of the question-answering process. *Med Sci Sports Exerc* 1996;28:1282–91.
31. Niedhammer I, Bugel I, Bonenfant S, *et al.* Validity of self-reported weight and height in the French GAZEL cohort. *Int J Obes Relat Metab Disord* 2000;24:1111–18.
32. Zins M, Guéguen A, Kivimäki M, *et al.* Effect of retirement on alcohol consumption: longitudinal evidence from the French Gazel Cohort Study. *PLoS One* 2011;6:e26531.
33. Goldberg M, Chastang JF, Zins M, *et al.* Health problems were the strongest predictors of attrition during follow up of the GAZEL cohort. *J Clin Epidemiol* 2006;59:1213–21.

34. Westerlund H, Kivimäki M, Singh-Manoux A, *et al*. Self-rated health before and after retirement in France (GAZEL): a cohort study. *Lancet* 2009;374:1889−96.
35. Vahtera J, Westerlund H, Hall M, *et al*. Effect of retirement on sleep disturbances: the GAZEL prospective cohort study. *Sleep* 2009;32:1459−66.
36. Jokela M, Ferrie JE, Gimeno D, *et al*. From midlife to early old age: health trajectories associated with retirement. *Epidemiology* 2010;21:284−90.
37. Westerlund H, Vahtera J, Ferrie JE, *et al*. Effect of retirement on major chronic conditions and fatigue: the French GAZEL occupational cohort study. *BMJ* 2010;341:1145.
38. Oksanen T, Vahtera J, Westerlund H, *et al*. Is retirement beneficial for mental health? Longitudinal analysis of antidepressant use before and after retirement. *Epidemiology* 2011;22:553−9.
39. Evenson KR, Rosamond WD, Cai J, *et al*. Influence of retirement on leisure-time physical activity: the atherosclerosis risk in communities study. *Am J Epidemiol* 2002;155:692−9.