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Physical activity modification over time according to socioeconomic position: results from the EPIC-Italy cohort study

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ABSTRACT

Objectives Our study aimed to investigate how physical activity (PA) changes over an 11-year follow-up among adults from different socioeconomic positions (SEP) near retirement age. Moreover, an analysis of different PA types is considered.

Methods We used data from the EPIC-Italy cohort. We evaluated PA using the Cambridge Physical Activity Index (CPAI) and the metabolic equivalent of tasks (MET) per hour of activity for recreational PA and household PA. Educational level was assessed using the Relative Index of Inequality (RII). Occupational classes were classified according to LIFEPATH Consortium knowledge. Logistic regression was used to analyse PA among SEP and changes during follow-up. Analyses were also conducted separately for sex.

Results The higher educated were more prevalent in the higher quartile of recreational PA than the lower educated both at baseline and follow-up (37% vs 28% and 37% vs 27%, respectively). At the baseline, the lower educated had a higher risk of being physically inactive than the higher educated based on recreational PA (overall OR: 1.50, 95% CI 1.40 to 1.60). Manual workers did not show a higher risk of less PA than professionals/managers (overall OR: 1.03, 95% CI 0.91 to 1.16).

At follow-up, the lower educated and manual workers showed a higher risk of being physically inactive (lower educated OR: 1.46, 95% CI 1.37 to 1.56; manual worker OR: 1.33, 95% CI 1.18 to 1.50). The analyses of changes in PA showed that those who were less educated or manual workers had a higher risk of worsening their PA during the follow-up period, particularly women in recreational PA and men in CPAI measurement.

Conclusion Individuals who had a disadvantaged SEP showed a higher risk of performing less PA over time.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Physical activity levels differ by socioeconomic position: those in higher socioeconomic positions tend to engage in more physical activity than those in lower socioeconomic positions.

WHAT THIS STUDY ADDS

⇒ This study tries to investigate changes in physical activity over time for different socioeconomic positions.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Understanding the fluctuations in physical activity levels across various socioeconomic positions can enable the development of preventive actions toward the most vulnerable population groups.

INTRODUCTION

It is widely acknowledged that physical activity (PA) has a significant impact on both health and quality of life. Many studies have observed the benefits of PA on cardiovascular disease and mortality,[1] healthy ageing,[2] cognitive declines,[3] diabetes,[4] cancer,[5] bone health[6] and mental health.[7] Additionally, regular PA was inversely associated with hospitalisations independently of sociodemographic and lifestyle factors.[8] PA can even contribute to modulating blood pressure[9] and ocular perfusion pressure.[10] Overall, PA habits are an optimal indicator of the population's well-being.

Regarding health and quality of life, differences in health according to social position have been reported consistently for several health outcomes, including self-reported health, chronic and long-term health conditions, and mortality[11–13]; a higher risk of cardiovascular disease[14] and of several cancer types[15] was found among less educated individuals.

In epidemiology, socioeconomic position (SEP) can be measured in a variety of methods. One common method is to use the level of education as a proxy when income and occupation are not available. Due to the strong influence of the family's background and cultural resources, education also reflects childhood and adolescent SEP. Although educational attainment may be affected by illness or challenges that happened at an early age, it remains a reliable indicator of SEP.[13]

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It has been observed SEP can have an impact on PA, as individuals with low SEP tend to be less active in adulthood.[16] Furthermore, a study conducted on the European Prospective Investigation into Cancer and Nutrition (EPIC)-Norfolk cohort revealed that an increasing trajectory of PA levels over time can have a positive influence on mortality, leading to a 24% lower risk of all-cause mortality.[17]

However, it is still not very clear how PA changes along the life course among different social positions.[18]

Understanding PA trajectories during adulthood is relevant in the context of healthy ageing, and studying the determinants of changes in PA can help identify strategies to improve well-being of the most deprived elderly population.

This study aims to understand how PA changes with advancing age among different social positions, especially, when individuals reach retirement age. Moreover, an analysis of different PA types is considered.

METHODS

Study population

We used data from individuals participating in the EPIC-Italy cohort. Project details are described elsewhere.[19] In the period 1993–98, EPIC-Italy recruited 47 749 volunteers (15 171 men, 32 578 women, aged 35–65 years) in five different regions of the country: Varese (12 083 volunteers) and Turin (10 604) in the north; Florence (13 597) in centre, and Naples (5062) and Ragusa (6403) in the south.[20] All participants in the EPIC-Italy cohort signed an informed consent form and agreed to provide information on lifestyle and nutrition and to donate a liquid nitrogen-stored blood sample. A follow-up of part of the cohort was conducted in Florence, Varese and Turin between 2004 and 2009, with an average follow-up period of 11 years.

Data collection

The lifestyle EPIC questionnaire was used to collect data[20 21] that assessed sociodemographic characteristics, PA, smoking and alcohol habits, household composition, diseases, and aspects of women's menstrual and reproductive life, following standard interviewing procedures. At baseline, the interviews were carried out in the departments of the centres involved, and questionnaires were self-administered. At follow-up, self-administered questionnaires were filled at home and returned to the centre. The diseases collected were as follows: heart attack, stroke, hypertension, diabetes, liver and kidney stones, intestinal polyps, and gastric or duodenal ulcers. During the interviews, anthropometric measurements were performed by trained interviewers using clinical equipment. At follow-up, anthropometric measurements were self-measured through a meterstick that was sent to each participant.

Socioeconomic measurement

The Relative Index of Inequality (RII) was used to measure educational level, which takes into account differences between regions, genders and birth cohorts.[14] High RII values indicated a lower level of education. RII estimation can be found in Sergeant *et al*.[22] Occupational status was harmonised into three macro-categories (according to what was done within the LIFEPATH Consortium[23]) by grouping classes of the European Socio-economic Classification (E-SeC).[13] E-SeC is a European measure that classifies occupations into nine ordinal categories (see online supplemental material S1) based on the similarity of resources, in terms of opportunities and 'life chances', according to the Erikson & Goldthorpe classification.[24] The three macro-categories were professionals, retailer/farmer/clerical workers, and skilled/unskilled manual workers. In addition, the category of not-employed was added to the study sample, which included subjects who answered 'no' to the question 'Are you currently employed?' on the lifestyle EPIC questionnaire at baseline.

Physical activity measurement

The lifestyle EPIC questionnaire also investigated PA habits at work (occupational PA), at home (household PA) and in leisure time (recreational PA).[21 25] The occupational PA was assessed using a four-category question: sedentary, standing, moderate manual work and heavy manual work, providing examples such as office worker, shop assistant, plumber and construction worker respectively.[8] Recreational and household PA were assessed by questioning how many hours per week were spent in specific activities (separately in summer and winter periods) and assigning a metabolic equivalent of tasks (MET) value at each activity, using the compendium of physical activity.[26]

Household activities included housework, climbing stairs, do-it-yourself and gardening. Recreational activities included walking, cycling, swimming and other sports activities. Both household PA and recreational PA variables were continuous (sum of METS). Furthermore, the validated Cambridge Physical Activity Index (CPAI)[25] was used to assess the overall PA level. CPAI is a four-category index (active, moderately active, moderately inactive, and inactive) calculated by combining the four categories of occupational PA (sedentary work, standing work, manual work, heavy manual work) with time spent on recreational PA (see online supplemental material S2).

Statistical analyses

The descriptive table on study population characteristics and PA were reported using frequency (and percentages) for categorical variables and mean±SD for continuous variables. Recreational and household PA variables were categorised as sex-specific quartiles. The RII was categorised as tertiles. Multivariate logistic regression was employed to analyse the relationship between PA variables (CPAI, recreational PA quartiles and household PA quartiles) and socioeconomic variables (RII and occupational status, separately) at baseline and follow-up. For logistic regression, PA variables were set as low vs high.

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Table 1 Baseline characteristics of study population

Factors		Frequency (%)	By sex (%)	
		Total n=23 734 (100)	Male n=7617 (32)	Female n=16 117 (68)
Sociodemographic				
	Age group			
	mean±SD	50.52±7.64	50.22±7.43	50.66±7.73
	30–39	2028 (9)	575 (8)	1453 (9)
	40–49	8372 (35)	3040 (40)	5332 (33)
	50–59	10295 (43)	3085 (40)	7210 (45)
	60+	3039 (13)	917 (12)	2122 (13)
	EPIC centre			
	Florence	10365 (44)	2701 (35)	7664 (47)
	Varese	7126 (30)	1362 (18)	5764 (36)
	Turin	6243 (26)	3554 (47)	2689 (17)
	RII* (tertiles)			
	1° tertile	7798 (33)	2328 (31)	5470 (34)
	2° tertile	8081 (34)	2995 (39)	5086 (32)
	3° tertile	7855 (33)	2294 (30)	5561 (34)
	Occupation			
	Professionals/ managers (E-SeC: 1 and 2)	1407 (6)	746 (10)	670 (4)
	Retailer (E-SeC: 4)	1120 (5)	328 (4)	792 (5)
	Farmer (E-SeC: 5)	44 (<1)	11 (<1)	33 (<1)
	Clerical workers (E-SeC: 7)	9415 (39)	3593 (47)	5822 (36)
	Skilled workers (E-SeC: 8)	3947 (17)	1831 (24)	2116 (13)
	Unskilled workers (E-SeC: 9)	2896 (12)	1087 (14)	1809 (11)
	Not-employed	4905 (21)	21 (0)	4884 (30)
Clinical				
	Diseases†			
	0	14252 (60)	4265 (56)	9988 (62)
	1+	9481 (40)	3352 (44)	6129 (38)
Lifestyle/ anthropometry				
	BMI			
	up to 24.9	11923 (50)	2918 (38)	9 005 (56)
	25–29.9	9157 (39)	3873 (51)	5284 (33)
	30+	2654 (11)	826 (11)	1828 (11)
	Smoking			
	Current	5451 (23)	1827 (24)	3624 (22)
	Former	6854 (29)	3387 (44)	3467 (22)
	Non-smoker	11429 (48)	2403 (32)	9026 (56)
	Alcohol use			
	Current	18604 (78)	6911 (91)	11693 (72)

Continued

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Table 1 Continued

Factors		Frequency (%) Total n=23 734 (100)	By sex (%) Male n=7617 (32)	Female n=16 117 (68)
	Former	2110 (9)	442 (6)	1668 (10)
	Non-drinker	2941 (12)	205 (2)	2736 (17)
	Missing	79 (0)	59 (1)	20 (0)

*Relative Index of Inequality.
†Diseases explored: heart attack, stroke, hypertension, diabetes, liver and kidney stones, intestinal polyps, cancer, gastric or duodenal ulcer.

The low CPAI category grouped 'inactive' and 'moderately inactive' of CPAI. Low recreational PA category and low household PA category grouped the first and second quartiles for recreational PA and household PA, respectively. Analyses were conducted on the overall cohort and separately for men and women. The logistic model was adjusted for age at recruitment, sex (except for sex-stratified estimates), EPIC centre, presence of disease (yes/no), Body Mass Index (BMI), and alcohol and smoking habits. The adjustment set was chosen consistently with other studies on the EPIC cohort.[8 9] Subjects with missing values on PA variables and socioeconomic variables at baseline or follow-up were removed. ORs and their 95% CI were reported.

To assess whether individuals improved or worsened their PA during follow-up, a variable was created by making the difference between PA at follow-up and PA at baseline (CPAI and recreational PA, respectively). Values ranging from −3 (maximum worsening) to +3 (maximum improvement) were obtained for each observation. A value of 0 (zero) indicated that the individual maintained their PA level over time. However, only those with the lowest measurements at baseline could obtain the maximum improvement values (+3). Conversely, only those with the highest levels of (PA) at baseline could obtain the maximum worsening values (−3). Consequently, a value of −3 (maximum worsening) is no worse than a value of −1 (minimum worsening). For this reason, we dichotomised the difference variable into worsening (values = −1, −2, −3) vs maintenance or improvement (values=0, 1, 2, 3) to apply the logistic model.

Possible interactions between variables in the models were explored: variables that showed high interaction were treated separately. The chi-square test was performed. The test was two-sided and was considered a p value <0.05 to be significant.

BMI was categorised into three categories: up to 24.9 (normal weight), 25–29.9 (overweight) and 30 or more (obese).[27 28]

Additional sex-stratified analysis on workers aged 50 or over was conducted to assess the relationship between PA and SEP in individuals entering retirement age during the follow-up. In the 2000s, the retirement age in Italy was 65 for men and 60 for women.

Sankey diagrams were built using sankeymatic.com to show how subjects moved between different categories of CPAI from baseline to follow-up. Analyses were performed with STATA18.0.

Equity, diversity, and inclusion statement

The group of authors comprises 12 members, including seven women and five men. They consist of research fellows, junior, mid-career and senior researchers from various disciplines such as physiotherapy, epidemiology, hygiene, and biostatistics. However, all members of the author group belong to the same country.

Our research study involved males and females from different socioeconomic backgrounds, ages, and clinical and demographic characteristics. The (PA) outcomes were determined by considering various settings. We have discussed the influence of gender in our study. However, we acknowledge the lack of generalisability of our results due to some cohort characteristics, which we have explained in the discussion.

RESULTS

After removing missing values (n=4004, 14.4%), this study included 23 734 participants with data both at baseline and follow-up. Baseline characteristics are presented in table 1. With an overall mean age of about 50.5 at baseline, women made up 68% of the sample. Specific PA characteristics at baseline and at follow-up are reported in table 2 and in table 3. At CPAI, the lower educated showed a higher percentage of being active than the higher educated. Consequently, skilled/unskilled manual workers were the more prevalent occupational group in the active category. Regarding recreational PA, the higher educated were more prevalent in percentage in the higher quartile than the lower educated, both at baseline and follow-up (37% vs 28%, 34% vs 25%, respectively). Sex-specific PA characteristics at both baseline and follow-up were reported in online supplemental material S3 and S4. There was a slight deterioration in the CPAI from baseline to follow-up, as shown by using the Sankey diagram (figure 1). Study population movements on

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Table 2 Baseline physical activity frequencies of study population by groups

Sociodemographic factor	Cambridge Physical Activity Index Frequency (row percentages, %)			
	Inactive	Moderately inactive	Moderately active	Active
RII* (tertiles)				
1° tertile	1497 (19)	3764 (48)	1523 (20)	1014 (13)
2° tertile	1506 (19)	3502 (43)	1671 (21)	1402 (17)
3° tertile	1851 (23)	2957 (38)	1466 (19)	1581 (20)
Occupation				
Professionals/ managers (E-SeC: 1 and 2)	209 (15)	629 (45)	340 (24)	229 (16)
Clerical/farmer/ retailer workers (E-SeC: 4, 5, 7)	2026 (19)	4990 (47)	2186 (21)	1377 (13)
Skilled/unskilled workers (E-SeC: 8 and 9)	1063 (15)	2188 (32)	1560 (23)	2032 (30)
Not-employed	1556 (32)	2416 (49)	574 (12)	359 (7)
Total	4854 (20)	10223 (43)	4660 (20)	3997 (17)
	Recreational physical activity (quartiles) Frequency (row percentages, %)			
	1° Quartile	**2° Quartile**	**3° Quartile**	**4° Quartile**
RII* (tertiles)				
1° tertile	904 (12)	1905 (24)	2340 (30)	2649 (34)
2° tertile	1165 (14)	2094 (26)	2370 (29)	2452 (30)
3° tertile	1541 (20)	2178 (28)	2142 (27)	1994 (25)
Occupation				
Professionals/ managers (E-SeC: 1 and 2)	207 (15)	395 (28)	369 (26)	436 (31)
Clerical/farmer/ retailer workers (E-SeC: 4, 5, 7)	1478 (14)	2743 (26)	3145 (30)	3213 (30)
Skilled/unskilled workers (E-SeC: 8 and 9)	1303 (19)	1819 (27)	1843 (27)	1878 (27)
Not-employed	622 (13)	1220 (25)	1495 (30)	1568 (32)
Total	3610 (15)	6177 (26)	6852 (29)	7095 (30)

*Relative Inequality Index.

CPAI between baseline and follow-up for each tertile of RII were reported in the online supplemental materials S5–S7.

Table 4 presents the findings of the logistic regression on the CPAI. At baseline, overall OR_{adj} showed that lower-educated were less likely to be physically inactive than higher-educated (OR 0.71, 95% CI 0.66 to 0.76). Regarding the occupational classes, the skilled/unskilled manual workers class showed a 51% reduced probability of being physically inactive compared with the professionals/managers class (OR 0.49, 95% CI 0.43 to 0.55), while the clerical/retailer/farmer class had a higher risk of being physically inactive compared with the professionals/managers class (1.23, 95% CI 1.10 to 1.38). Sex-stratified estimates followed the pattern of the overall estimate: the skilled/unskilled manual workers class showed a lower risk of performing less PA than the professionals/managers both for men (OR 0.40, 95% CI 0.33 to 0.47) and women (OR 0.62, 95% CI 0.52 to 0.74).

At follow-up, results on RII were in the opposite direction than at baseline: the lower-educated were more likely to be physically inactive than the higher educated (OR 1.20; 95% CI 1.11 to 1.30). The sex-stratified model showed similar results to the overall ORs_{adj} for women but not for men. Regarding occupation, the class of clerical/farmer/retailer workers and the not-employed

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Table 3 Follow-up physical activity frequencies of study population by groups

Sociodemographic factor	Cambridge Physical Activity Index Frequency (row percentages, %)			
	Inactive	Moderately inactive	Moderately active	Active
RII* (tertiles)				
1° tertile	1866 (24)	3840 (49)	1259 (16)	833 (11)
2° tertile	1999 (25)	3808 (47)	1293 (16)	981 (12)
3° tertile	2710 (34)	3353 (43)	959 (12)	833 (11)
Occupation				
Professionals/ managers (E-SeC: 1 and 2)	290 (21)	633 (45)	259 (18)	225 (16)
Clerical/farmer/ retailer workers (E-SeC: 4, 5, 7)	2595 (25)	5028 (47)	1732 (16)	1224 (12)
Skilled/unskilled workers (E-SeC: 8 and 9)	1926 (28)	3009 (44)	1011 (15)	897 (13)
Not-employed	1764 (36)	2331 (48)	509 (10)	301 (6)
Total	6575 (28)	11 001 (46)	3511 (15)	2647 (11)
	Recreational physical activity (quartiles) Frequency (row percentages, %)			
	1° quartile	**2° quartile**	**3° quartile**	**4° quartile**
RII* (tertiles)				
1° tertile	977 (12)	2035 (26)	2302 (30)	2484 (32)
2° tertile	1099 (14)	2225 (28)	2348 (29)	2409 (30)
3° tertile	1522 (19)	2389 (30)	2137 (27)	1807 (23)
Occupation				
Professionals/ managers (E-SeC: 1 and 2)	202 (14)	353 (25)	409 (29)	443 (32)
Clerical/farmer/ retailer workers (E-SeC: 4, 5, 7)	1404 (13)	2764 (26)	3132 (30)	3279 (31)
Skilled/unskilled workers (E-SeC: 8 and 9)	1201 (18)	2100 (31)	1822 (27)	1720 (25)
Not-employed	791 (16)	1432 (29)	1424 (29)	1258 (26)
Total	3598 (15)	6649 (28)	6787 (29)	6700 (28)

*Relative Inequality Index.

had a higher risk of being inactive than professionals/managers. Sex-stratified results for women showed clerical/farmer/retailer, skilled/unskilled, and not-employed had a higher risk of being physically inactive than professionals/managers (OR 1.48, 95% CI 1.24 to 1.77; OR 1.31, 95% CI 1.08 to 1.58; OR 1.83, 95% CI 1.52 to 2.21; respectively).

Table 5 shows the results of PA changes according to CPAI. There, the lower-educated had a higher risk of worsening over time than the higher-educated (OR 1.49, 95% CI 1.39 to 1.60). In sex-stratified estimates, lower-educated men had a 92% higher risk (1.92, 95% CI 1.70 to 2.17) of worsening in CPAI than higher-educated. Women showed a milder risk increase (OR 1.32, 95% CI 1.22 to 1.44). Regarding occupational classes, the skilled/unskilled manual workers class showed a higher risk of worsening PA than the professionals/managers class (OR 1.92, 95% CI 1.69 to 2.18), especially for men (OR 2.20, 95% CI 1.85 to 2.61).

The results of recreational PA at baseline and follow-up are reported in table 6. Subjects who were lower-educated had a higher risk of being physically inactive (based on recreational PA) than the higher educated, both at baseline (1.50, 95% CI 1.40 to 1.60) and at follow-up (1.46, 95% CI 1.37 to 1.56). Lower-educated women showed a greater increase in risk than men compared with

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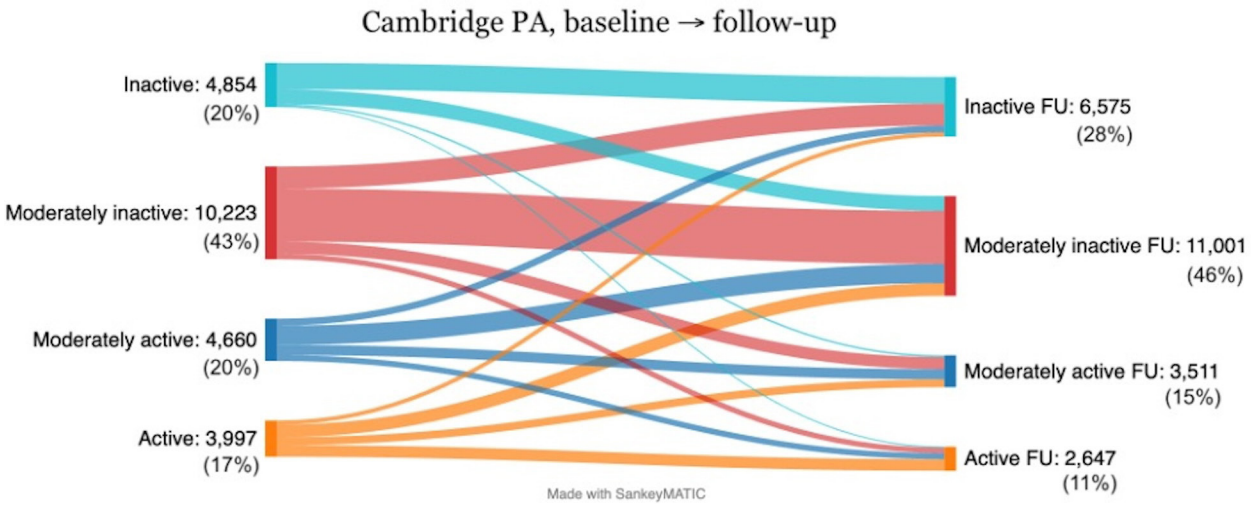

Figure 1 Sankey diagram, Cambridge Physical Activity Index flows from baseline to follow-up (FU).

higher-educated educated. For occupational status, it was important to note how skilled/unskilled workers and not-employed subjects had a higher risk of being physically inactive than the professionals/managers of follow-up (1.33, 95% CI 1.18 to 1.50; 1.36, 95% CI 1.19 to 1.54, respectively). In the sex-stratified analysis, every other woman's occupational category showed a higher risk of being physically inactive in recreational PA than the professionals/managers class.

In table 7, the OR_{adj} of changes in recreational PA over time showed an increased risk of worsening recreational PA for the lower-educated compared with the higher-educated (OR 1.09, 95% CI 1.01 to 1.16). In sex-stratified analyses for RII, less-educated men showed a higher risk of worsening recreational PA than more-educated men. Regarding estimates for occupational status in the overall cohort, skilled/unskilled manual workers and not-employed showed a higher risk of worsening their recreational PA than professionals/managers (OR 1.29, 95% CI 1.13 to 1.47; OR 1.47, 95% CI 1.28 to 1.69; respectively). In sex-stratified analyses, manual workers and not-employed women had a higher risk of worsening their recreational PA than professionals/managers (OR 1.41, 95% CI 1.16 to 1.70; OR 1.57, 95% CI 1.30 to 1.90; respectively).

Results on household PA are reported in online supplemental material S8. Overall, baseline and follow-up estimates showed that lower-educated were less likely to be physically inactive at home than higher-educated, for both men and women (baseline: OR men 0.61, 95% CI 0.54 to 0.69; OR women 0.45, 95% CI 0.42 to 0.49. Follow-up: OR men 0.64, 95% CI 0.56 to 0.72; OR women 0.64, 95% CI 0.59 to 0.69). Regarding occupational status, professionals/managers seemed to be the least active category in household PA. The further analysis conducted on workers aged 50 or more (online supplemental materials S9–S12) showed similar results to the analyses presented above: the lower-educated and manual workers had a higher risk of being physically inactive than the higher-educated and the professionals/managers (respectively), both at baseline and at follow-up. In addition, manual workers show a higher risk of worsening overall PA (based on CPAI) and recreational PA than the professionals/managers.

DISCUSSION

In this large prospective study conducted on the EPIC-Italy Cohort, we found that individuals with higher levels of education or those from less disadvantaged social classes had higher levels of PA than others and better maintained the level over time, which is especially visible when work activity ceases, particularly, in women. Our findings are consistent with prior studies regarding the relationship between PA and SEP and between PA and occupational status.[29–38]

Although at baseline the less educated or those belonging to lower social classes engage in more overall PA than the more educated individuals, the less educated tend to perform low PA over time, especially, when reaching retirement age. This was further supported by the analysis conducted on the difference between follow-up and baseline, where it was observed that people with a higher inequality index had a higher risk of worsening their PA levels in the follow-up period. Regarding occupational classes for both men and women, those in the manual worker class were shown to have a significant risk of worsening PA levels over time compared with the professionals/managers class.

Based on the CPAI, individuals with lower levels of education presumably had higher baseline levels of PA since they were more likely to do PA during work hours but less likely to do so during leisure time.[33] However, the reasons for this occurrence may also be attributed to other social factors. According to Jaana T. Kari and colleagues,[31] education is related to decision-making abilities, which can lead individuals to make healthier long-term decisions in their behaviour. Additionally, there may be a mediating effect of income on the relationship

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Table 4 Association between socioeconomic characteristics at baseline and low (vs high) PA level as assessed by Cambridge Physical Activity Index (CPAI) at baseline and follow-up (low CPAI level = inactive, moderately inactive; high CPAI level (ref.) = active, moderately active).

Covariates		OR adjusted (CI*)		
		Overall (n=23, 734)	Male (n=7617)	Female (n=16 117)
		***Baseline CPAI*†**		
RII‡				
	1° tertile	1.00 (ref)	1.00 (ref)	1.00 (ref)
	2° tertile	0.91 (0.85, 0.98)	0.72 (0.64, 0.81)	1.03 (0.95, 1.13)
	3° tertile	0.71 (0.66, 0.76)	0.46 (0.41, 0.52)	0.88 (0.81, 0.96)
Occupation				
	Professionals/ managers (E-SeC: 1 and 2)	1.00 (ref)	1.00 (ref)	1.00 (ref)
	Clerical/farmer/ retailer workers (E-SeC: 4, 5, 7)	1.23 (1.10, 1.38)	1.07 (0.91, 1.27)	1.47 (1.24, 1.74)
	Skilled/unskilled workers (E-SeC: 8 and 9)	0.49 (0.43, 0.55)	0.40 (0.33, 0.47)	0.62 (0.52, 0.74)
	Not-employed	1.74 (1.51, 1.99)	1.24 (0.50, 3.07)	2.11 (1.76, 2.52)
		***Follow-up CPAI*†**		
RII‡				
	1° tertile	1.00 (ref)	1.00 (ref)	1.00 (ref)
	2° tertile	1.13 (1.05, 1.22)	1.06 (0.94, 1.19)	1.17 (1.07, 1.29)
	3° tertile	1.20 (1.11, 1.30)	1.01 (0.89, 1.15)	1.32 (1.19, 1.45)
Occupation				
	Professionals/ managers (E-SeC: 1 and 2)	1.00 (ref)	1.00 (ref)	1.00 (ref)
	Clerical/farmer/ retailer workers (E-SeC: 4, 5, 7)	1.25 (1.10, 1.41)	1.08 (0.91, 1.28)	1.48 (1.24, 1.77)
	Skilled/unskilled workers (E-SeC: 8 and 9)	1.11 (0.98, 1.26)	0.96 (0.81, 1.15)	1.31 (1.08, 1.58)
	Not-employed	1.57 (1.36, 1.81)	0.70 (0.28, 1.72)	1.83 (1.52, 2.21)

Note: The reported ORs estimate the association between physical activity (PA) and socioeconomic position (SEP). Overall cohort logistic model was adjusted for age, sex, EPIC centre, BMI, disease (yes/no), and smoking and alcohol habits. Sex-stratified logistic models were adjusted for age, EPIC centre, BMI, disease (yes/no), and smoking and alcohol habits.
* 95% CI.
†Physical Activity Index.
‡Relative Index of Inequality, tertiles: the first tertile includes the higher educational level.

between education and PA: a higher education increases income levels, which, in turn, provides greater opportunities to invest in PA. In accordance, findings of our cohort showed the less educated were less likely to do recreational PA at both baseline and follow-up, and a higher risk of worsening recreational PA levels over time than the more educated.

The WHO defines PA as 'any bodily movement produced by skeletal muscles that requires energy expenditure, […] all movement including during leisure time, for transport to get to and from places, or as part of a person's work'.[39] However, the quality of PA can play a significant role in health outcomes. Recent studies observed that workers who perform more PA at work have worse health outcomes than those who perform less physically demanding jobs[40] and that higher levels of PA at work can lead to an increased risk of cardiovascular disease, in contrast to leisure-time PA.[41] This occurrence has been described in the literature by Holtermann[42] as 'the physical activity paradox'. According to the author, a possible explanation for the discordance of different PA settings on health outcomes could lie in the substantial

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Table 5 Association between baseline socioeconomic characteristics and changes in Cambridge Physical Activity Index (CPAI) over time (follow-up minus baseline) (worsening in CPAI level (–3 to –1) vs maintenance/improvement in CPAI level (0 to +3))

Covariates		OR adjusted (CI*)		
		Overall (n=23 734)	Male (n=7617)	Female (n=16 117)
		CPAI†		
RII‡				
	1° tertile	1.00 (ref)	1.00 (ref)	1.00 (ref)
	2° tertile	1.20 (1.12, 1.29)	1.38 (1.23, 1.55)	1.13 (1.03, 1.23)
	3° tertile	1.49 (1.39, 1.60)	1.92 (1.70, 2.17)	1.33 (1.22, 1.44)
Occupation				
	Professionals/ managers (E-SeC: 1 and 2)	1.00 (ref)	1.00 (ref)	1.00 (ref)
	Clerical/farmer/ retailer workers (E-SeC: 4, 5, 7)	0.99 (0.88, 1.13)	1.13 (0.94, 1.34)	0.88 (0.74, 1.05)
	Skilled/unskilled workers (E-SeC: 8 and 9)	1.92 (1.69, 2.18)	2.20 (1.85, 2.61)	1.67 (1.39, 2.00)
	Not-employed	0.89 (0.78, 1.03)	1.07 (0.43, 2.72)	0.79 (0.66, 0.95)

Note: The reported ORs estimate the association between physical activity difference (follow-up minus baseline) and socioeconomic position (SEP). Overall cohort logistic model was adjusted for age, sex, EPIC centre, BMI, disease (yes/no), and smoking and alcohol habits. Sex-stratified logistic models were adjusted for age, EPIC centre, BMI, disease (yes/no), and smoking and alcohol habits.
P value<0,05.
*95% CI.
†Cambridge Physical Activity Index.
‡Relative Inequality Index, tertiles: the first tertile includes the higher educational level.

difference between the two types of activity (recreational PA vs occupational PA). Occupational PA is usually characterised by a sustained low intensity over a long period with inadequate breaks and recovery times, whereas, recreational PA is usually carried out over a shorter period with a moderate to vigorous intensity and adequate resting time. Additionally, levels of occupational PA appear to be inversely correlated with recreational PA among individuals: those who showed higher levels of recreational PA had sedentary jobs, while those who had heavy manual jobs showed lower levels of recreational PA.[43 44]

Our results show that skilled/unskilled manual workers tend to do less recreational PA than managers/professionals at follow-up but not at baseline.

Contrary to our expectations, the results of the sex-stratified models for recreational PA on men were not statistically significant compared with women. However, several studies have observed that men tend to engage in more PA during life than women independently of education and equity.[32 33 45] In addition, we had a higher proportion of women than men in our sample. This could account for our results (see table 1). However, the lower-educated men tended to worsen the recreational PA level over time in our cohort.

Another aspect worth considering is the effect of diseases on PA habits. Diseases may hinder PA among subjects, in a pattern of reverse causality. Dong Hoon Lee and colleagues[27] in their study emphasise how recent disease events or undiagnosed illnesses may overestimate the effect of PA on health and mortality. However, this effect occurred when the follow-up of studies was shorter. In our study, the follow-up is over 10 years on average.

The difference that emerged between the clerical/farmer/retailer class and the skilled/unskilled manual worker class deserves further investigation. The class of clerical, farmer and retailer workers showed a lower PA level at baseline than the professionals/managers class (based on CPAI, which also considered PA at work). One possible explanation could come from the fact that, in comparison to the farmers and retail workers, the second occupational class consists of 89% of clerical workers who perform sedentary work (*see* table 1).

In this study, household PA was also analysed. In the literature, studies concerning the effect of household setting are not yet very consistent. However, similar to recreational PA, it has been observed that higher levels of household activity may be associated with a reduction in the risk of all-cause mortality and mortality from cardiovascular and respiratory causes, irrespective of leisure-time PA.[46 47] In addition, higher levels of household activity seem to be associated with better subjective

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Table 6 Association between socioeconomic characteristics at baseline and low (vs high) PA level as assessed by recreational PA at baseline and follow-up (low recreational PA=I and II quartiles; high recreational PA (ref.) = III and IV quartiles)

Covariates		OR adjusted (CI*)		
		Overall (n=23 734)	Male (n=7 617)	Female (n=16 117)
		Baseline recreational PA†		
RII‡				
	1° tertile	1.00 (ref)	1.00 (ref)	1.00 (ref)
	2° tertile	1.17 (1.10, 1.25)	1.04 (0.93, 1.17)	1.24 (1.14, 1.35)
	3° tertile	1.50 (1.40, 1.60)	1.15 (1.02, 1.29)	1.68 (1.55, 1.82)
Occupation				
	Professionals/ managers (E-SeC: 1 and 2)	1.00 (ref)	1.00 (ref)	1.00 (ref)
	Clerical/farmer/ retailer workers (E-SeC: 4, 5, 7)	0.94 (0.84, 1.05)	0.90 (0.77, 1.06)	1.00 (0.84, 1.18)
	Skilled/unskilled workers (E-SeC: 8 and 9)	1.03 (0.91, 1.16)	0.90 (0.76, 1.06)	1.16 (0.98, 1.39)
	Not-employed	0.85 (0.75, 0.97)	0.86 (0.35, 2.07)	0.93 (0.78, 1.10)
		Follow-up recreational PA†		
RII‡				
	1° tertile	1.00 (ref)	1.00 (ref)	1.00 (ref)
	2° tertile	1.14 (1.07, 1.22)	1.03 (0.92, 1.15)	1.21 (1.11, 1.31)
	3° tertile	1.46 (1.37, 1.56)	1.18 (1.04, 1.33)	1.60 (1.48, 1.73)
Occupation				
	Professionals/ managers (E-SeC: 1 and 2)	1.00 (ref)	1.00 (ref)	1.00 (ref)
	Clerical/farmer/ retailer workers (E-SeC: 4, 5, 7)	1.07 (0.96, 1.21)	0.94 (0.80, 1.11)	1.30 (1.09, 1.55)
	Skilled/unskilled workers (E-SeC: 8 and 9)	1.33 (1.18, 1.50)	1.07 (0.90, 1.26)	1.69 (1.41, 2.03)
	Not-employed	1.36 (1.19, 1.54)	0.65 (0.26, 1.61)	1.65 (1.38, 1.98)

Note: The reported ORs estimate the association between physical activity (PA) and socioeconomic position (SEP). Overall cohort logistic model was adjusted for age, sex, EPIC centre, BMI, disease (yes/no), and smoking and alcohol habits. Sex-stratified logistic models were adjusted for age, EPIC centre, BMI, disease (yes/no), and smoking and alcohol habits.
*95% CI.
†Physical Activity.
‡Relative Index of Inequality, tertiles: the first tertile includes the higher educational level.

well-being, and a higher volume of grey matter in the elderly.[48 49]

However, the habit of household PA among different levels of socioeconomic position is still unclear.[48] As mentioned, higher SEP was associated with higher overall levels of PA.[16 48] However, in our study, the relationship between household PA and SEP is the opposite of the one described in the previous sentence (Supplementals): less-educated individuals tend to perform more household PA than more educated individuals, particularly, in the female sex. The higher prevalence of women in PA habits at home has also been found in other studies.[50 51] Further investigation of the effects of household PA on health outcomes would be necessary. However, this study may offer new insights into the habit of household PA among SEP.

One of our study's strong points is its prospective design. Second, the analysis included a large number of subjects (n=23 734) with a long-duration follow-up which, given the mean age of the population, allowed us to study PA levels in people entering retirement age. However, there are a few limitations. First, although the lifestyle EPIC questionnaire has been validated for a different country,[25 52] PA was measured on self-reported

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Table 7 Association between baseline socioeconomic characteristics and changes in recreational PA (follow-up minus baseline) (worsening in recreational PA level (–3 to –1) vs maintenance/improvement in recreational PA level (0 to +3))

Covariates		OR adjusted (CI*)		
		Overall (n=23 734)	Male (n=7 617)	Female (n=16 117)
		Recreational PA†		
RII‡				
	1° tertile	1.00 (ref)	1.00 (ref)	1.00 (ref)
	2° tertile	1.04 (0.97, 1.11)	1.06 (0.94, 1.20)	1.02 (0.94, 1.11)
	3° tertile	1.09 (1.01, 1.16)	1.15 (1.01, 1.31)	1.05 (0.97, 1.14)
Occupation				
	Professionals/ managers (E-SeC: 1 and 2)	1.00 (ref)	1.00 (ref)	1.00 (ref)
	Clerical/farmer/ retailer workers (E-SeC: 4, 5, 7)	1.10 (0.97, 1.25)	1.04 (0.87, 1.25)	1.19 (0.99, 1.43)
	Skilled/unskilled workers (E-SeC: 8 and 9)	1.29 (1.13, 1.47)	1.18 (0.99, 1.42)	1.41 (1.16, 1.70)
	Not-employed	1.47 (1.28, 1.69)	1.14 (0.43, 2.99)	1.57 (1.30, 1.90)

Note: The reported ORs estimate the association between physical activity difference (follow-up minus baseline) and socioeconomic position (SEP). Overall cohort logistic model was adjusted for age, sex, EPIC centre, BMI, disease (yes/no), and smoking and alcohol habits. Sex-stratified logistic models were adjusted for age, EPIC centre, BMI, disease (yes/no), and smoking and alcohol habits.
P value <0.05.
*95% CI.
†Physical Activity Index.
‡Relative Inequality Index, tertiles: first tertile includes the higher educational level.

data. Second, the cohort examined, while very large and varied, is not representative of the general Italian population. This is because the subjects in the cohort are volunteers with good lifestyles and on average, more aware regarding eating habits than the general population at the time. However, it is not a very physically active cohort. The type of data available represented another limitation of the study: whereas, recreational PA and household PA were quantitative ordinal variables per observation (MET), occupational PA, measured with Cambridge Physical Activity Index, was a four-categorical variable. Moreover, CPAI did not represent a pure assessment of occupational PA but a combination of activity at work (categorical) and recreational PA. The use of other validated questionnaires to measure moderate-to-vigorous physical activity in adults would have allowed a more in-depth evaluation.[53 54] However, most of these evaluation surveys were validated after the start of the data collection process of the EPIC cohort. Finally, due to observational design, residual confounding cannot fully be discharged. Despite the abovementioned point, our study represents one of the largest studies that assessed changes in PA through various SEP measurements.

Further studies should explore the mediating role played by diseases on PA changes, and how PA changes may predict the onset of new diseases.

CONCLUSION

The study's findings indicate that individuals from lower social positions had an increased risk of being physically inactive over time than individuals from higher social positions, particularly, as they reach retirement age, mainly concerning recreational PA. Those with higher levels of education or social position were more likely to engage in recreational PA, which represents the only form of PA that is protective against all causes of mortality. These results can be considered a subject for public health discussion to develop preventive actions toward the most disadvantaged individuals in the community.

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Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

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