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# BMJ Open

## Unfavourable sedentary and physical activity behaviour before and after retirement. A population-based cohort study

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4 **based cohort study**  
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## Abstract

**Background:** During transition to retirement there is often a re-arrangement of daily life which might provide a key opportunity for interventions to promote a non-sedentary and active lifestyle. To be able to design effective interventions, it is essential to know which sedentary and physical behaviour domains (e.g. at home or during leisure time) have potential to facilitate healthy aging during the retirement transition.

**Objective:** To determine whether unfavourable sedentary and physical activity behaviour before retirement predict unfavourable sedentary and physical activity behaviour after retirement.

**Design:** Population-based cohort

**Setting and participants:** Adults (n=3272) employed in 2010 but retired in 2014.

**Methods:** Self-reported pre-retirement job activity, sedentary leisure time, physical activity at home, walking-cycling and exercise, were assessed as predictors for unfavourable sedentary and physical activity behaviours after retirement using logistic regression. Unfavourable behaviours were defined based on the respective median of the cohort distribution. Furthermore, the odds ratio (OR) for having multiple unfavourable behaviours post-retirement was determined, based on the amount of unfavourable behaviours pre-retirement. All models were adjusted for gender and education.

**Results:** Unfavourable sedentary and physical activity in a certain domain before retirement was the strongest predictor of the same behaviour after retirement. Unfavourable job activity did not predict physical activity but did predict unfavourable sedentary behaviour after retirement (OR=1.66, 95% Confidence interval (CI)=1.41-1.96). Unfavourable exercise behaviour pre-retirement predicted unfavourable sedentary and physical activity post-retirement in all domains. With all behaviours being unfavourable pre-retirement, the OR of having at least 3 unfavourable behaviours post-retirement was 36.7 (95% CI=16.8-80.5).

**Conclusions:** Adults with a higher number of unfavourable pre-retirement physical activity and sedentary behaviours are likely to carry these unfavourable behaviours into retirement age. Pre-retirement exercise interventions may have great potential to improve physical activity and sedentary behaviours and thereby facilitate healthy aging.

### Strengths and limitations of the study

- The study described a large longitudinal cohort investigating changes in sedentary behaviour and physical activity during retirement transition.
- Our methods are unique in studying a large variety of behaviours related to both sedentary behaviour and physical activity in different domains (e.g. at home, during leisure time) both before and after retirement.
- This study adds with valuable knowledge for public health researchers and policy makers that of all sedentary behaviour and physical activity domains, leisure time exercise seems to have the greatest potential in pre-retirement interventions that aim to facilitate healthy aging.
- Since there is no evidence for cut-off points for domain-specific physical activity and sedentary behaviour, we used the sample medians to distinguish between favourable and unfavourable behaviour.
- We did not have information on the exact time since retirement.

### Funding statement

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**Competing interests:** None declared.

### Author's contribution

All authors contributed to the design, methodology, and to manuscript review. CFJN was responsible for data analysis. NtH and CFJN were responsible for drafting the manuscript. All authors read and approved the final manuscript.

### Data sharing

Applications for access to data can be send to the Stockholm County Council  
<https://www.folkhalsoguiden.se/halsa-stockholm/halsa-stockholm---for-forskare/>

### Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research

## Introduction

An aging population and increasing life expectancy result in a growing number of adults spending a long time in retirement.<sup>1</sup> Sedentary behaviour and physical activity are two related and independent predictors of healthy aging.<sup>2</sup> More sedentary time and less physical activity are related to increased risk of diabetes, cardiovascular disease, and all-cause mortality.<sup>3-7</sup> Studies in older adults have additionally shown that unfavourable sedentary and physical activity patterns increase the risk of functional limitations in the performance of activities of daily life such as walking and performing house chores.<sup>8</sup>

Elderly spend 65-80% of their waking hours sedentary and only a minority meets physical activity recommendations.<sup>9-10</sup> During transition to retirement, daily life often undergoes a re-arrangement which might provide a key opportunity for interventions to stimulate a non-sedentary and active lifestyle. Lack of time is a frequently reported barrier to physical activity, which might not exist any longer after retirement.<sup>11</sup>

There is a lack of well-conducted studies investigating changes in sedentary and physical activity behaviour during and after transition from working life to retirement. Results are inconsistent, with varying patterns of change being identified during the retirement transition dependent on study methodology. Most studies used single item questions and did not focus on different domains simultaneously (e.g. at work, during leisure time).<sup>12-13</sup> With regard to sedentary behaviour, both decreases in total sitting time and an increase in sedentary leisure activities such as watching TV have been reported.<sup>12</sup> With regard to physical activity, decreases were mainly seen in occupational physical activity and transport physical activity.<sup>14</sup> The domain in which the sedentary and physical activity behaviour is performed is important since determinants and health effects may be different.<sup>15-16</sup> To be able to design effective interventions, it is essential to know which sedentary and physical behaviour domains have potential to facilitate healthy aging during the retirement transition.

A previous study showed that changing from an active to a more sedentary occupation was compensated by exercising more during leisure time, and the other way around.<sup>17</sup> It is therefore conceivable that persons who retire from a physically active occupation might compensate by being more active during leisure time activities after retirement. To get deeper insight into behaviours related to physical activity after retirement, research that simultaneously investigates sedentary and physical activity behaviour in different domains both before and after retirement is warranted.

Our aim was to determine which sedentary and physical activity behaviours are predictors of unfavourable sedentary and physical activity behaviour after retirement. We analysed whether sedentary and physical activity behaviour after retirement can be predicted by pre-retirement

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3 sedentary behaviour and physical activity in different domains (at work, at home or during leisure time)  
4 in a large population-based cohort including persons who recently retired. We hypothesized that  
5 having a more sedentary occupation, unfavourable leisure physical activity or unfavourable leisure  
6 sedentary behaviour before retirement predicts higher levels of sedentary behaviour and lower levels  
7 of physical activity behaviour after retirement. This study will add with valuable knowledge for public  
8 health and policy makers on who to target and which physical activity and sedentary behaviour to  
9 target to improve healthy aging during the retirement transition.  
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## 17 **Methods**

### 18 Study population

19 We used data from the Stockholm Public Health Cohort (SPHC), a large population-based cohort in  
20 Stockholm County.<sup>18</sup> Population samples were randomly selected from Statistics Sweden's Register of  
21 the total population, after stratification according to residential municipality. Every four years,  
22 participants from all three samples completed similar questionnaire-based surveys on a range of  
23 demographic- and health variables. Register data from Statistics Sweden have been linked to the self-  
24 reported information. The present study was approved by the Stockholm Regional Ethical Review  
25 Board (case number: 2016/749-32).  
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34 Of the participants who completed the survey in 2010, 67% completed the follow up survey in 2014.<sup>18</sup>  
35 Participants who reported information on physical activity and sedentary behaviour in both 2010  
36 (baseline) and 2014 (follow-up) were assessed for eligibility (N=49133). Mean age of the sample  
37 assessed for eligibility was 54 years (SD=16), 57% were women and 48% highly educated. Participants  
38 were excluded if they were confined to bed on both occasions (n=26). In the current study, those who  
39 were employed or self-employed in 2010 but retired in 2014 were included, resulting in an analytical  
40 sample of 3272 participants.  
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### 48 Physical activity and sedentary behaviour assessment

49 Physical activity and sedentary behaviour were assessed with the physical activity questionnaire (PAQ),  
50 which has shown to be valid for classification into physically active or sedentary.<sup>19 20</sup> For all questions,  
51 participants were requested to answer on their average behaviour during the past 12 months,  
52 considering the week variability and seasonality.  
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57 Physical activity and sedentary in the following domains were assessed with this questionnaire:

58 - *Job activity*  
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3 With 6 answer categories: “mainly sedentary”, “sitting approximately half of the time”, “mainly  
4 standing”, “walking mostly, lifting, carrying a little”, “walking mainly, lifting, carrying a lot” or “heavy  
5 physical work”.

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8 - *Sedentary leisure time*

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10 This includes leisure sitting time e.g. watching TV or reading. There were 7 response categories ranging  
11 from less than one hour per day to more than 6 hours per day.

12  
13 - *Physical activity at home*

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15 This included physical activity during home, household and gardening tasks. There were 6 response  
16 categories ranging from less than 1 hr per day to more than 5 hrs per day.

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18 - *Walking- and cycling activity*

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20 With 6 response categories for answering combined walking and cycling activity, ranging from hardly  
21 ever to more than 2 hrs per day.

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23 - *Exercise*

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25 A question was asked about hours of exercise per week, excluding daily walking and cycling.  
26 Participants chose one of seven options ranging from hardly ever to more than 5 hours per week.

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30 Data analyses

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32 The cohort median for all physical activity and sedentary behaviour variables was determined and used  
33 to dichotomize behaviours into more favourable vs unfavourable. The medians were determined  
34 separately at baseline and at follow-up surveys, since occupational activity only applied to baseline  
35 and therefore the distribution of physical activity and sedentary behaviour domains was naturally  
36 different at follow-up after retirement.<sup>21</sup> Unfavourable sedentary behaviour at work (only baseline)  
37 was defined as mainly sedentary or sitting approximately half of the time. Unfavourable sedentary  
38 behaviour during leisure time at baseline was defined as 2-3 hours per day or more, and at follow-up  
39 as 3-4 hours per day or more. Physical activity at home was defined as unfavourable when less than 1  
40 hr per day at baseline and less than 1-2 hours per day at follow-up. For both baseline and follow-up  
41 walking-and cycling activity were defined as unfavourable when performed for less than 20 minutes  
42 per day, and exercise when accumulating less than 1 hour per week.

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51 Binary logistic regression analyses were conducted using general linear models in order to derive odds  
52 ratios (OR) of unfavourable behaviour after retirement for: 1) sedentary time, 2) physical activity at  
53 home, 3) walking/cycling and 4) exercise. Predictors were unfavourable behaviours before retirement  
54 related to: a) job activity, b) sedentary leisure time, c) physical activity at home, d) walking/cycling, and  
55 e) exercise.  
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3 A similar additional logistic regression analysis was conducted for all behaviours considered together,  
4 i.e. estimating the amount of unfavourable behaviours after retirement based on the amount of  
5 unfavourable behaviours before retirement. To obtain a dichotomous variable, the median number of  
6 unfavourable behaviours before retirement. To obtain a dichotomous variable, the median number of  
7 unfavourable behaviours after retirement was used, i.e. 3 or more unfavourable behaviours.  
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10 Education was used as an indicator of socioeconomic position, and all models were adjusted for  
11 education and gender  
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14 We checked for multicollinearity by assessing both correlations between the predictors and with VIF  
15 statistics and concluded that there were no indications of collinearity. All statistical analyses were  
16 performed in IBM SPSS Statistics version 24 (Armonk, NY: IBM Corp).  
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## 22 **Results**

23 Mean age of the analytical sample at baseline was 63 years (SD=2), 55% were women and 43% highly  
24 educated. The associations between pre-retirement and after-retirement behaviours are shown in  
25 table 1.  
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29 The results can be summarized as:

- 30 - Unfavourable sedentary and physical activity behaviour in a certain domain before retirement was  
31 the strongest predictor of the same behaviour in the same domain after retirement.  
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- 33 - Unfavourable job physical activity predicted unfavourable sedentary time after retirement, but not  
34 any other unfavourable physical activity behaviour.  
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- 36 - Unfavourable exercise behaviour before retirement predicted all unfavourable sedentary and  
37 physical activity behaviours after retirement.  
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42 The relation between multiple unfavourable behaviours before and after retirement is shown  
43 descriptively in Table 2. Among participants who presented with all unfavourable behaviours at  
44 baseline the adjusted OR of having three or more unfavourable behaviour after retirement (vs. 2 or  
45 less) was 36.7 (95% CI=16.8-80.5). The corresponding ORs for 4 unfavourable behaviours before  
46 retirement was 14.3 (95% CI=7.1-29.0); 6.6 (95% CI=3.3-13.2) for 3 unfavourable behaviours; 3.2 (95%  
47 CI=1.6-6.5) for 2 unfavourable behaviours and 1.7 (95% CI=0.8-3.6) for 1 unfavourable behaviour.  
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## 55 **Discussion**

56 This longitudinal study increases the understanding of sedentary and physical activity behaviour during  
57 the retirement transition. We found that unfavourable pre-retirement physical activity and sedentary  
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3 behaviour at home or during leisure time were the strongest predictors of the same behaviour after  
4 retirement. Pre-retirement job activity did not predict low levels of physical activity but did predict  
5 sedentary behaviour after retirement. Furthermore, less than 1 hour exercise per week before  
6 retirement predicted all of the unfavourable behaviours after retirement. Moreover, the higher the  
7 number of unfavourable behaviours before retirement, the more likely it was that a person had  
8 multiple (at least three) unfavourable behaviours after retirement.  
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14 Contrary to our hypothesis, pre-retirement job activity did not seem to be related to post-retirement  
15 physical activity in this study, i.e. there was no hint that persons retiring from physically active jobs  
16 compensated the loss of this activity by increasing leisure time physical activity. A previous study  
17 showed that people changing job do compensate loss of job activity in their leisure time.<sup>17</sup> Retirement  
18 means a change to no job activity at all, potentially explaining why this compensation does not apply.  
19 Nevertheless, job activity did seem to predict sedentary behaviour after retirement in the anticipated  
20 direction. These results are in line with a previous study where decreases in occupational sedentary  
21 behaviour were compensated by increasing sitting time outside working hours.<sup>22</sup>  
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28 A systematic review<sup>12</sup> suggested that pre-retirement physical activity and sedentary behaviour outside  
29 work may be stronger predictors of behaviour after retirement compared to job activity. This  
30 hypothesis is supported by our findings that unfavourable pre-retirement physical activity and  
31 sedentary behaviour at home or during leisure time were the strongest predictors of the same  
32 unfavourable behaviours after retirement. These results confirm that behaviours tend to be rather  
33 stable over the life course<sup>23</sup>, and this is probably true even after a major life change such as retirement.  
34 Furthermore, we found that unfavourable exercise behaviour before retirement seems to influence  
35 practically all unfavourable physical activity and sedentary behaviour after retirement. It is possible  
36 that regular exercise results in a higher physical fitness level, subsequently in a lower strain when  
37 performing physical activities, making it easier to maintain a favourable level even at older age.  
38 Therefore, interventions promoting exercise behaviour before retirement may potentially prevent  
39 unfavourable physical activity and sedentary behaviour after retirement.  
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49 Older adults often have unfavourable physical activity and sedentary behaviour<sup>9 10</sup> which negatively  
50 impacts healthy aging.<sup>3-8</sup> Our results imply that adults with multiple unfavourable pre-retirement  
51 behaviours are at higher risk to hold this profile after retirement. This group should be thought of as a  
52 priority for preventive interventions targeting physical activity. Despite the paucity of studies of  
53 interventions during the retirement transition, a review concluded that different types of counselling  
54 programs, such as group sessions; individual training sessions; in-home exercise programmes or e-  
55 health programs can lead to positive effects in aging adults.<sup>24</sup> Our results carry a decisive suggestion  
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3 that future studies should evaluate the effectiveness of pre-retirement exercise interventions on  
4 overall post-retirement physical activity and sedentary behaviour.  
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7 When interpreting the results of the study it should be realized that we used the sample medians to  
8 distinguish between favourable and unfavourable behaviour. Since there is no evidence for cut-off  
9 points for domain-specific physical activity and sedentary behaviour, it is unclear whether the medians  
10 reflect a true border between favourable and unfavourable. For job activity, we defined favourable as  
11 being more active at work. However, a recent review indicates that high levels of job activity might  
12 have detrimental health consequences and therefore not necessarily be favourable.<sup>25</sup> Furthermore,  
13 we did not separate different leisure time sedentary activities (such as computer use, TV, reading etc.)  
14 whilst certain leisure sitting time might be more likely to be combined with other unfavourable health  
15 behaviour such as drinking alcohol and eating snacks.<sup>26</sup>  
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### 23 *Strengths and Limitations*

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25 To our knowledge, this is the largest cohort study that studied a variety of behaviours related to both  
26 physical activity and sedentary time in different domains both before and after retirement. However,  
27 there were also some limitations. First, all participants who retired in a time frame of 4 years were  
28 included in this study disregarding time since retirement, while this could have influenced behavioural  
29 adjustments. Second, we had no information on possible confounders of outcomes, such as  
30 comorbidities. Third, we included persons that completed two surveys, which might have led to a  
31 selection bias. A relatively large proportion of the included sample was highly educated, which is  
32 known to be related to more favourable exercise patterns and sedentary behaviour.<sup>27-29</sup> Furthermore,  
33 a decrease in income after retirement might have potentially influenced retirement behaviours  
34 including physical activity and sedentary behaviour. Last, we cannot rule out misclassification of  
35 sedentary behaviour and physical activity since it is known that self-report measures often  
36 demonstrate restricted validity and reliability.<sup>30</sup>  
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### 46 **Conclusions**

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48 This study contributes to a deeper understanding of unhealthy aging with novel insights on  
49 unfavourable sedentary and physical activity behaviour after retirement. Despite the major life event  
50 of retirement, pre-retirement unfavourable behaviours seem likely to be carried into retirement age.  
51 Likewise, those with multiple unfavourable pre-retirement behaviours seem at a higher risk to hold  
52 the same unfavourable profile after retirement and should therefore be a priority target for preventive  
53 interventions. There was however no indication that persons retiring from physically active jobs  
54 compensated the loss of this activity by increasing leisure time physical activity. As unfavourable  
55 exercise behaviour before retirement predicted unfavourable sedentary and physical activity after  
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retirement in all domains, pre-retirement exercise interventions may have great potential to facilitate healthy aging.

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**Table 1. Baseline characteristics and predictors of more unfavourable sedentary and physical activity behaviour after retirement**

	Sedentary leisure time		OR	95% CI
	Unfavourable after retirement	Favourable after retirement		
	n=1441	n=1805		
<i>Predictors of unfavourable leisure time sedentary behaviour after retirement*</i>	% (n)	% (n)		
Unfavourable job activity before retirement	70 (988)	59 (1042)	<b>1.66</b>	<b>1.41-1.96</b>
Unfavourable sedentary leisure time before retirement	66 (933)	33 (588)	<b>4.19</b>	<b>3.59-4.89</b>
Unfavourable activity at home before retirement	36 (512)	29 (522)	<b>1.32</b>	<b>1.12-1.56</b>
Unfavourable walking/cycling before retirement	72 (1029)	67 (1194)	1.17	0.99-1.38
Unfavourable exercise before retirement	48 (678)	40 (709)	<b>1.29</b>	<b>1.10-1.50</b>

\*adjusted for gender and education

	Physical activity at home		OR	95% CI
	Unfavourable after retirement	Favourable after retirement		
	n=1928	n=1302		
<i>Predictors of unfavourable home physical activity after retirement*</i>	% (n)	% (n)		
Unfavourable job activity before retirement	66 (1252)	60 (769)	1.16	0.99-1.37
Unfavourable sedentary leisure time before retirement	50 (957)	44 (562)	<b>1.35</b>	<b>1.16-1.58</b>
Unfavourable activity at home before retirement	44 (837)	15 (188)	<b>3.92</b>	<b>3.26-4.72</b>
Unfavourable walking/cycling before retirement	71 (1359)	66 (850)	1.06	0.90-1.25
Unfavourable exercise before retirement	46 (878)	39 (503)	<b>1.23</b>	<b>1.05-1.44</b>

\*adjusted for gender and education

<b>Walking/cycling</b>				
	Unfavourable after retirement	Favourable after retirement	OR	95% CI
	n=1923	n=1313		
<i>Predictors of unfavourable walking/cycling after retirement*</i>	% (n)	% (n)		
Unfavourable job activity before retirement	66 (1240)	61 (787)	1.07	0.91-1.26
Unfavourable sedentary leisure time before retirement	47 (902)	48 (620)	0.99	0.84-1.15
Unfavourable activity at home before retirement	34 (651)	29 (374)	1.04	0.88-1.23
Unfavourable walking/cycling before retirement	81 (1537)	53 (681)	<b>3.74</b>	<b>3.18-4.41</b>
Unfavourable exercise before retirement	48 (911)	37 (474)	<b>1.43</b>	<b>1.22-1.66</b>

\*adjusted for gender and education

<b>Exercise</b>				
	Unfavourable after retirement	Favourable after retirement	OR	95% CI
	n=1414	n=1833		
<i>Predictors of unfavourable exercise after retirement*</i>	% (n)	% (n)		
Unfavourable job activity before retirement	65 (896)	63 (1134)	1.07	0.91-1.26
Unfavourable sedentary leisure time before retirement	52 (731)	44 (791)	<b>1.36</b>	<b>1.17-1.59</b>
Unfavourable activity at home before retirement	35 (483)	30 (547)	1.05	0.89-1.24
Unfavourable walking/cycling before retirement	73 (1021)	67 (1205)	1.15	0.97-1.36
Unfavourable exercise before retirement	64 (900)	26 (478)	<b>4.92</b>	<b>4.21-5.75</b>

\*adjusted for gender and education

**Table 2.** Multiple unfavourable behaviours before and after retirement

		Number of unfavourable behaviours after retirement (n=3092)				
% (n)		All	3	2	1	None
		10 (309)	24 (755)	35 (1087)	24 (732)	7 (209)
Number of unfavourable behaviours before retirement	All	43 (68)	35 (55)	18 (28)	4 (6)	0 (0)
	4	22 (109)	36 (182)	32 (160)	10 (50)	1 (4)
	3	9 (83)	30 (282)	39 (369)	19 (183)	3 (32)
	2	4 (40)	19 (170)	37 (340)	31 (286)	8 (74)
	1	2 (9)	12 (56)	35 (163)	35 (163)	16 (74)
	None	0 (0)	9 (10)	26 (27)	42 (44)	24 (25)



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## Unfavourable sedentary and physical activity behaviour before and after retirement. A population-based cohort study

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3 **Unfavourable sedentary and physical activity behaviour before and after retirement. A population-**  
4 **based cohort study**  
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## 1 **Abstract**

2 Background: During transition to retirement there is often a re-arrangement of daily life which might  
3 provide a key opportunity for interventions to promote a non-sedentary and active lifestyle. To be able  
4 to design effective interventions, it is essential to know which sedentary and physical behaviour  
5 domains (e.g. at home or during leisure time) have potential to facilitate healthy aging during the  
6 retirement transition.

7 Objective: To determine whether unfavourable sedentary and physical activity behaviour before  
8 retirement predict unfavourable sedentary and physical activity behaviour after retirement.

9 Design: Population-based cohort

10 Setting and participants: Adults (n=3272) employed in 2010 but retired in 2014.

11 Methods: Self-reported pre-retirement job activity, sedentary leisure time, physical activity at home,  
12 walking-cycling and exercise, were assessed as predictors for unfavourable sedentary and physical  
13 activity behaviours after retirement using logistic regression. Unfavourable behaviours were defined  
14 based on the respective median of the cohort distribution. Furthermore, the odds ratio (OR) for having  
15 multiple unfavourable behaviours post-retirement was determined, based on the amount of  
16 unfavourable behaviours pre-retirement. All models were adjusted for gender and education.

17 Results: Unfavourable pre-retirement physical activity and sedentary behaviour at home or during  
18 leisure time were the strongest predictors of the same behaviours after retirement. Unfavourable job  
19 activity did not predict physical activity but did predict unfavourable sedentary behaviour after  
20 retirement (OR=1.66, 95% Confidence interval (CI)=1.41-1.96). Unfavourable exercise behaviour pre-  
21 retirement predicted unfavourable sedentary and physical activity post-retirement in all domains.  
22 With all behaviours being unfavourable pre-retirement, the OR of having at least 3 unfavourable  
23 behaviours post-retirement was 36.7 (95% CI=16.8-80.5).

24 Conclusions: Adults with a higher number of unfavourable pre-retirement physical activity and  
25 sedentary behaviours are likely to carry these unfavourable behaviours into retirement age.  
26 Interventions should target those with more unfavourable pre-retirement physical activity and  
27 sedentary behaviours pre-retirement, and those interventions focusing on exercise might have  
28 greatest potential

29

### 30 **Strengths and limitations of the study**

- 31 • The study described a large longitudinal cohort investigating changes in sedentary behaviour and  
32 physical activity during retirement transition.
- 33 • The used instrument (PAQ questionnaire) takes into account both physical activity and sedentary  
34 behaviour in different domains (e.g. at work, during leisure time).
- 35 • This study provides valuable knowledge for public health researchers and policy makers,  
36 indicating that interventions preferably focussing on exercise should target individuals with  
37 unfavourable physical activity and sedentary behaviours pre-retirement
- 38 • We did not have information on the exact time since retirement.

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44 **Competing interests:** None declared.

### 46 **Author's contribution**

47 NtH and CN planned the study. NtH, ME, RG, YF, CN contributed to design and methodology of the  
48 manuscript. CN was responsible for data analysis and data interpretation. NtH, ME, RG, YF  
49 contributed to interpreting the data. NtH was responsible for drafting the manuscript and revision of  
50 the manuscript after review. All authors read and approved the final manuscript.

### 52 **Data sharing**

53 Applications for access to data can be send to the Stockholm County Council  
54 <https://www.folkhalsoguiden.se/halsa-stockholm/halsa-stockholm---for-forskare/>

### 56 **Patient and public involvement**

57 Patients or the public were not involved in the design, or conduct, or reporting, or dissemination  
58 plans of our research



## 59 Introduction

60 An aging population and increasing life expectancy result in a growing number of adults spending a  
61 long time in retirement.<sup>1</sup> Sedentary behaviour and physical activity are two related and independent  
62 predictors of healthy aging.<sup>2</sup> More sedentary time and less physical activity are related to increased  
63 risk of diabetes, cardiovascular disease, and all-cause mortality.<sup>3-7</sup> Studies in older adults have  
64 additionally shown that unfavourable sedentary and physical activity patterns increase the risk of  
65 functional limitations in the performance of activities of daily life such as walking and performing house  
66 chores.<sup>8</sup>

67 Elderly spend 65-80% of their waking hours sedentary and only a minority meets physical activity  
68 recommendations.<sup>9 10</sup> During transition to retirement, daily life often undergoes a re-arrangement  
69 which might provide a key opportunity for interventions to stimulate a non-sedentary and active  
70 lifestyle. Lack of time is a frequently reported barrier to physical activity, which might not exist any  
71 longer after retirement.<sup>11</sup>

72 Results of previous studies investigating changes in sedentary and physical activity behaviour during  
73 transition from working life to retirement identified varying patterns of change dependent on study  
74 methodology. Most studies used single item questions and did not focus on different domains  
75 simultaneously (e.g. at work, during leisure time).<sup>12 13</sup> With regard to sedentary behaviour, both  
76 decreases in total sitting time and an increase in sedentary leisure activities such as watching TV have  
77 been reported.<sup>12 14 15</sup> With regard to physical activity, decreases were mainly seen in occupational  
78 physical activity and transport physical activity<sup>14 16</sup>, while increases were reported in time spent in  
79 leisure time physical activity and walking<sup>15 17-19</sup> The domain in which the sedentary and physical activity  
80 behaviour is performed is important since determinants and health effects may be different.<sup>20 21</sup> To be  
81 able to design effective interventions, it is essential to know which sedentary and physical behaviour  
82 domains have potential to facilitate healthy aging during the retirement transition.

83 A previous study showed that changing from an active to a less active occupation was compensated  
84 by exercising more during leisure time, and the other way around.<sup>22</sup> It is therefore conceivable that  
85 persons who retire from a physically active occupation might compensate by being more active during  
86 leisure time activities after retirement. In line with this hypothesis, it has been suggested that persons  
87 with a high occupational sitting time and low levels of physical activity before retirement are at risk for  
88 adverse sedentary behaviour outcomes after retirement.<sup>14</sup> Furthermore, a large cohort study found a  
89 relation between increased walking time and decreasing sedentary leisure time after retirement.<sup>19</sup> On  
90 the contrary, in another cohort study, no relations were found between changes in time spent in  
91 different physical activity and sedentary behaviours during retirement.<sup>15</sup> To get deeper insight into



1  
2  
3 92 behaviours related to sedentary behaviour and physical activity after retirement, more large-scale  
4  
5 93 research that simultaneously investigates the relation between sedentary and physical activity  
6  
7 94 behaviour in different domains both before and after retirement is warranted.

8  
9 95 Our aim was to determine which sedentary and physical activity behaviours are predictors of  
10  
11 96 unfavourable sedentary and physical activity behaviour after retirement. We analysed whether  
12  
13 97 sedentary and physical activity behaviour after retirement can be predicted by pre-retirement  
14  
15 98 sedentary behaviour and physical activity in different domains (at work, at home or during leisure time)  
16  
17 99 in a large population-based cohort including persons who recently retired. We hypothesized that  
18  
19 100 having a more sedentary occupation, unfavourable leisure physical activity or unfavourable leisure  
20  
21 101 sedentary behaviour before retirement predicts higher levels of sedentary behaviour and lower levels  
22  
23 102 of physical activity behaviour after retirement. This study will add with valuable knowledge for public  
24  
25 103 health and policy makers on who to target and which physical activity and sedentary behaviour to  
26  
27 104 target to improve healthy aging during the retirement transition.

28

## 106 **Methods**

### 107 Study population

31  
32 108 We used data from the Stockholm Public Health Cohort (SPHC), a large population-based cohort in  
33  
34 109 Stockholm County.<sup>23</sup> Population samples were randomly selected from Statistics Sweden's Register of  
35  
36 110 the total population, after stratification according to residential municipality. Every four years,  
37  
38 111 participants from all three samples completed similar questionnaire-based surveys on a range of  
39  
40 112 demographic- and health variables. Register data from Statistics Sweden have been linked to the self-  
41  
42 113 reported information. The present study was approved by the Stockholm Regional Ethical Review  
43  
44 114 Board (case number: 2016/749-32).

45

46  
47 116 Of the participants who completed the survey in 2010, 67% completed the follow up survey in 2014.<sup>23</sup>  
48  
49 117 Participants who reported information on physical activity and sedentary behaviour in both 2010  
50  
51 118 (baseline) and 2014 (follow-up) were assessed for eligibility (N=49133). Mean age of the sample  
52  
53 119 assessed for eligibility was 54 years (SD=16), 57% were women and 48% highly educated. Participants  
54  
55 120 were excluded if they were confined to bed on both occasions (n=26). In the current study, those who  
56  
57 121 were employed or self-employed in 2010 but full-time retired in 2014 were included, resulting in an  
58  
59 122 analytical sample of 3272 participants. See Figure 1.

60

### 124 Physical activity and sedentary behaviour assessment

1  
2  
3 125 Physical activity and sedentary behaviour were assessed with the physical activity questionnaire (PAQ),  
4  
5 126 which has shown to be valid for classification into physically active or sedentary.<sup>24 25</sup> For all questions,  
6  
7 127 participants were requested to answer on their average behaviour during the past 12 months,  
8  
9 128 considering the week variability and seasonality.

10 129  
11 130 Physical activity and sedentary in the following domains were assessed with this questionnaire:

12  
13 131 *- Job activity*

14  
15 132 With 6 answer categories: “mainly sedentary”, “sitting approximately half of the time”, “mainly  
16  
17 133 standing”, “walking mostly, lifting, carrying a little”, “walking mainly, lifting, carrying a lot” or “heavy  
18  
19 134 physical work”.

20 135 *- Sedentary leisure time*

21 136 This includes leisure sitting time e.g. watching TV or reading. There were 7 response categories ranging  
22  
23 137 from less than one hour per day to more than 6 hours per day.

24  
25 138 *- Physical activity at home*

26 139 This included physical activity during home, household and gardening tasks. There were 6 response  
27  
28 140 categories ranging from less than 1 hr per day to more than 5 hrs per day.

29  
30 141 *- Walking- and cycling activity*

31 142 With 6 response categories for answering combined walking and cycling activity, ranging from hardly  
32  
33 143 ever to more than 2 hrs per day.

34  
35 144 *- Exercise*

36 145 A question was asked about hours of exercise per week, excluding daily walking and cycling.  
37  
38 146 Participants chose one of seven options ranging from hardly ever to more than 5 hours per week.

39  
40 147

41  
42 148 Data analyses

43 149 The cohort median for all physical activity and sedentary behaviour variables was determined and used  
44  
45 150 to dichotomize behaviours into more favourable vs unfavourable. The medians were determined  
46  
47 151 separately at baseline and at follow-up surveys, since occupational activity only applied to baseline  
48  
49 152 and therefore the distribution of physical activity and sedentary behaviour domains was naturally  
50  
51 153 different at follow-up after retirement.<sup>26</sup> Unfavourable job activity at work (only baseline) was defined  
52  
53 154 as mainly sedentary or sitting approximately half of the time. Unfavourable sedentary behaviour  
54  
55 155 during leisure time at baseline was defined as 2-3 hours per day or more, and at follow-up as 3-4 hours  
56  
57 156 per day or more. Physical activity at home was defined as unfavourable when less than 1 hr per day at  
58  
59 157 baseline and less than 1-2 hours per day at follow-up. For both baseline and follow-up walking-and  
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158 cycling activity were defined as unfavourable when performed for less than 20 minutes per day, and  
159  
159 exercise when accumulating less than 1 hour per week.

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5 161 Binary logistic regression analyses were conducted using general linear models in order to derive odds  
6 162 ratios (OR) of unfavourable behaviour after retirement for: 1) sedentary time, 2) physical activity at  
7 163 home, 3) walking/cycling and 4) exercise. Predictors were unfavourable behaviours before retirement  
8 164 related to: a) job activity, b) sedentary leisure time, c) physical activity at home, d) walking/cycling, and  
9 165 e) exercise.

13  
14 166 A similar additional logistic regression analysis was conducted for all behaviours considered together,  
15 167 i.e. estimating the amount of unfavourable behaviours after retirement based on the amount of  
16 168 unfavourable behaviours before retirement. To obtain a dichotomous variable, the median number of  
17 169 unfavourable behaviours after retirement was used, i.e. 3 or more unfavourable behaviours.

20  
21 170 Education was used as an indicator of socioeconomic position, and all models were adjusted for  
22 171 education and gender

23  
24  
25 172 We checked for multicollinearity by assessing both correlations between the predictors and with VIF  
26 173 statistics and concluded that there were no indications of collinearity. All statistical analyses were  
27 174 performed in IBM SPSS Statistics version 24 (Armonk, NY: IBM Corp).

30  
31 175

## 32 33 176 **Results**

34  
35 177 Mean age of the analytical sample at baseline was 63 years (SD=2), 55% were women and 43% highly  
36 178 educated. The associations between pre-retirement and after-retirement behaviours are shown in  
37 179 Table 1.

40  
41 180 The results can be summarized as:

- 42 181 - Unfavourable pre-retirement physical activity and sedentary behaviour at home or during leisure  
43 182 time were the strongest predictors of the same behaviour after retirement.
- 44 183 - Unfavourable job physical activity predicted unfavourable sedentary time after retirement, but not  
45 184 any other unfavourable physical activity behaviour.
- 46 185 - Unfavourable exercise behaviour before retirement predicted all unfavourable sedentary and  
47 186 physical activity behaviours after retirement.
- 48  
49 187 -Unfavourable sedentary leisure time predicted all unfavourable behaviours, except for  
50  
51 188 walking/cycling

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57 189 The relation between multiple unfavourable behaviours before and after retirement is shown  
58 190 descriptively in Table 2. Among participants who presented with all unfavourable behaviours at

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3 191 baseline the adjusted OR of having three or more unfavourable behaviour after retirement (vs. 2 or  
4 192 less) was 36.7 (95% CI=16.8-80.5). The corresponding ORs for 4 unfavourable behaviours before  
5 193 retirement was 14.3 (95% CI=7.1-29.0); 6.6 (95% CI=3.3-13.2) for 3 unfavourable behaviours; 3.2 (95%  
6 194 CI=1.6-6.5) for 2 unfavourable behaviours and 1.7 (95% CI=0.8-3.6) for 1 unfavourable behaviour.

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## 11 196 **Discussion**

12  
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14  
15 197 This longitudinal study increases the understanding of sedentary and physical activity behaviour during  
16 198 the retirement transition. We found that unfavourable pre-retirement physical activity and sedentary  
17 199 behaviour at home or during leisure time were the strongest predictors of the same behaviour after  
18 200 retirement. Pre-retirement job activity did not predict low levels of physical activity but did predict  
19 201 sedentary behaviour after retirement. Furthermore, less than 1 hour exercise per week before  
20 202 retirement predicted all of the unfavourable behaviours after retirement. Unfavourable sedentary  
21 203 leisure time before retirement predicted both sedentary time and most physical activity behaviours  
22 204 after retirement. Moreover, the higher the number of unfavourable behaviours before retirement,  
23 205 the more likely it was that a person had multiple (at least three) unfavourable behaviours after  
24 206 retirement.

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33 207 Contrary to our hypothesis, pre-retirement job activity did not seem to be related to post-retirement  
34 208 physical activity in this study, i.e. there was no hint that persons retiring from physically active jobs  
35 209 compensated the loss of this activity by increasing leisure time physical activity. A previous study  
36 210 showed that people changing job do compensate loss of job activity in their leisure time.<sup>22</sup> Retirement  
37 211 means a change to no job activity at all, potentially explaining why this compensation does not apply.  
38 212 Nevertheless, job activity did seem to predict sedentary behaviour after retirement in the anticipated  
39 213 direction. These results are in line with a previous study where decreases in occupational sedentary  
40 214 behaviour were compensated by increasing sitting time outside working hours.<sup>27</sup>

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47 215 A systematic review<sup>12</sup> suggested that pre-retirement physical activity and sedentary behaviour outside  
48 216 work may be stronger predictors of behaviour after retirement compared to job activity. This  
49 217 hypothesis is supported by our findings that unfavourable pre-retirement physical activity and  
50 218 sedentary behaviour at home or during leisure time were the strongest predictors of the same  
51 219 unfavourable behaviours after retirement. These results confirm that behaviours tend to be rather  
52 220 stable over the life course<sup>28</sup>, and this is probably true even after a major life change such as retirement.

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57 221 We found that unfavourable exercise behaviour before retirement seems to influence practically all  
58 222 unfavourable physical activity and sedentary behaviours after retirement. It is possible that regular  
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3 223 exercise results in a higher physical fitness level, subsequently in a lower strain when performing  
4 224 physical activities, making it easier to maintain a favourable level of both physical activity and  
5 225 sedentary behaviour even at older age. This outcome is in line with a previous study that found that  
6 226 persons with low levels of physical activity before retirement are at risk for unfavourable sedentary  
7 227 behaviour after retirement.<sup>14</sup> In addition to exercise behaviour, unfavourable sedentary leisure time  
8 228 before retirement predicted both sedentary time and most physical activity behaviours after  
9 229 retirement. These outcomes suggest that interventions promoting exercise behaviour and limiting  
10 230 sedentary time before retirement may potentially prevent unfavourable physical activity and  
11 231 sedentary behaviour also after retirement.

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13 232 Older adults often have unfavourable physical activity and sedentary behaviour<sup>9 10</sup> which negatively  
14 233 impacts healthy aging.<sup>3-8</sup> Our results imply that adults with multiple unfavourable pre-retirement  
15 234 behaviours are at higher risk to hold this profile after retirement. This group should be thought of as a  
16 235 priority for preventive interventions targeting physical activity and sedentary behaviour. Despite the  
17 236 paucity of studies of interventions during the retirement transition, a review concluded that different  
18 237 types of counselling programs, such as group sessions; individual training sessions; in-home exercise  
19 238 programmes or e-health programs can lead to positive effects in aging adults.<sup>29</sup> Our results carry a  
20 239 decisive suggestion that future studies should evaluate the effectiveness of pre-retirement exercise  
21 240 and sedentary behaviour interventions on overall post-retirement physical activity and sedentary  
22 241 behaviour.

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24 242 When interpreting the results of the study it should be realized that we used the sample medians to  
25 243 distinguish between favourable and unfavourable behaviour. Since there is no evidence for cut-off  
26 244 points for domain-specific physical activity and sedentary behaviour, it is unclear whether the medians  
27 245 reflect a true border between favourable and unfavourable. The question on job activity was a  
28 246 combination of sedentary behaviour and physical activity and our definition of favourable was being  
29 247 more active at work. However, a recent review indicates that high levels of job activity might have  
30 248 detrimental health consequences and therefore not necessarily be favourable.<sup>30</sup> Furthermore, we did  
31 249 not separate different leisure time sedentary activities (such as computer use, TV, reading etc.) whilst  
32 250 certain leisure sitting time might be more likely to be combined with other unfavourable health  
33 251 behaviours such as drinking alcohol and eating snacks.<sup>31</sup> In addition, we did also not separate between  
34 252 walking and cycling and between different exercise modalities even though we are aware that health  
35 253 effects might depend on the intensity and type of exercise performed.

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59 255 *Strengths and Limitations*  
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3 256 The used instrument (PAQ questionnaire) takes into account both physical activity and sedentary  
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5 257 behaviour in different domains and was used to measure these behaviours both before and after  
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7 258 retirement, which is a major strength of our study. Nevertheless, as discussed above, the instrument  
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9 259 does not differentiate between vocational physical activity and sedentary behaviour, between  
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11 260 different types of leisure sedentary activities and between types of exercise performed. There were  
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13 261 also some limitations. First, all participants who retired in a time frame of 4 years were included in this  
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15 262 study. There was no information available on the exact time of retirement, while this could have  
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17 263 influenced behavioural adjustments. Second, we had no information on possible confounders of  
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19 264 outcomes, such as comorbidities. Third, we included persons that completed two surveys, which might  
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21 265 have led to a selection bias. A relatively large proportion of the included sample was highly educated,  
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23 266 which is known to be related to more favourable exercise patterns and sedentary behaviour.<sup>32-34</sup>  
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25 267 Furthermore, a decrease in income after retirement might have potentially influenced retirement  
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27 268 behaviours including physical activity and sedentary behaviour. Last, we cannot rule out  
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29 269 misclassification of sedentary behaviour and physical activity since it is known that self-report  
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31 270 measures often demonstrate restricted validity and reliability.<sup>35</sup>

## 271 **Conclusions**

31 272 This study contributes to a deeper understanding of unhealthy aging with novel insights on  
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33 273 unfavourable sedentary and physical activity behaviour after retirement. Despite the major life event  
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35 274 of retirement, pre-retirement unfavourable behaviours seem likely to be carried into retirement age.  
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37 275 Likewise, those with multiple unfavourable pre-retirement behaviours seem at a higher risk to hold  
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39 276 the same unfavourable profile after retirement. There was no indication that persons retiring from  
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41 277 physically active jobs compensated the loss of this activity by increasing leisure time physical activity.  
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43 278 Interventions should target those with more unfavourable pre-retirement physical activity and  
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45 279 sedentary behaviours pre-retirement, and those interventions focusing on exercise might have  
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47 280 greatest potential.

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283 **Table 1. Baseline characteristics and predictors of more unfavourable sedentary and physical**  
 284 **activity behaviour after retirement**

	Sedentary leisure time after retirement		OR	95% CI
	Unfavourable after retirement	Favourable after retirement		
	n=1441	n=1805		
<i>Predictors of unfavourable leisure time sedentary behaviour after retirement*</i>	% (n)	% (n)		
Unfavourable job activity before retirement	70 (988)	59 (1042)	<b>1.66</b>	<b>1.41-1.96</b>
Unfavourable sedentary leisure time before retirement	66 (933)	33 (588)	<b>4.19</b>	<b>3.59-4.89</b>
Unfavourable activity at home before retirement	36 (512)	29 (522)	<b>1.32</b>	<b>1.12-1.56</b>
Unfavourable walking/cycling before retirement	72 (1029)	67 (1194)	1.17	0.99-1.38
Unfavourable exercise before retirement	48 (678)	40 (709)	<b>1.29</b>	<b>1.10-1.50</b>

285 \*adjusted for gender and education

	Physical activity at home after retirement		OR	95% CI
	Unfavourable after retirement	Favourable after retirement		
	n=1928	n=1302		
<i>Predictors of unfavourable home physical activity after retirement*</i>	% (n)	% (n)		
Unfavourable job activity before retirement	66 (1252)	60 (769)	1.16	0.99-1.37
Unfavourable sedentary leisure time before retirement	50 (957)	44 (562)	<b>1.35</b>	<b>1.16-1.58</b>
Unfavourable activity at home before retirement	44 (837)	15 (188)	<b>3.92</b>	<b>3.26-4.72</b>
Unfavourable walking/cycling before retirement	71 (1359)	66 (850)	1.06	0.90-1.25
Unfavourable exercise before retirement	46 (878)	39 (503)	<b>1.23</b>	<b>1.05-1.44</b>

287 \*adjusted for gender and education



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	<b>Walking/cycling after retirement</b>			
	Unfavourable after retirement	Favourable after retirement	OR	95% CI
	n=1923	n=1313		
<i>Predictors of unfavourable walking/cycling after retirement*</i>	% (n)	% (n)		
Unfavourable job activity before retirement	66 (1240)	61 (787)	1.07	0.91-1.26
Unfavourable sedentary leisure time before retirement	47 (902)	48 (620)	0.99	0.84-1.15
Unfavourable activity at home before retirement	34 (651)	29 (374)	1.04	0.88-1.23
Unfavourable walking/cycling before retirement	81 (1537)	53 (681)	<b>3.74</b>	<b>3.18-4.41</b>
Unfavourable exercise before retirement	48 (911)	37 (474)	<b>1.43</b>	<b>1.22-1.66</b>

293 \*adjusted for gender and education

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	<b>Exercise after retirement</b>			
	Unfavourable after retirement	Favourable after retirement	OR	95% CI
	n=1414	n=1833		
<i>Predictors of unfavourable exercise after retirement*</i>	% (n)	% (n)		
Unfavourable job activity before retirement	65 (896)	63 (1134)	1.07	0.91-1.26
Unfavourable sedentary leisure time before retirement	52 (731)	44 (791)	<b>1.36</b>	<b>1.17-1.59</b>
Unfavourable activity at home before retirement	35 (483)	30 (547)	1.05	0.89-1.24
Unfavourable walking/cycling before retirement	73 (1021)	67 (1205)	1.15	0.97-1.36
Unfavourable exercise before retirement	64 (900)	26 (478)	<b>4.92</b>	<b>4.21-5.75</b>

295 \*adjusted for gender and education

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301 **Table 2.** Multiple unfavourable behaviours before and after retirement

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		<b>Number of unfavourable behaviours after retirement (n=3092)</b>				
% (n)		All	3	2	1	None
		10 (309)	24 (755)	35 (1087)	24 (732)	7 (209)
<b>Number of unfavourable behaviours before retirement</b>	All	43 (68)	35 (55)	18 (28)	4 (6)	0 (0)
	4	22 (109)	36 (182)	32 (160)	10 (50)	1 (4)
	3	9 (83)	30 (282)	39 (369)	19 (183)	3 (32)
	2	4 (40)	19 (170)	37 (340)	31 (286)	8 (74)
	1	2 (9)	12 (56)	35 (163)	35 (163)	16 (74)
	None	0 (0)	9 (10)	26 (27)	42 (44)	24 (25)

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309 **Figure 1.** Flowchart of Participants

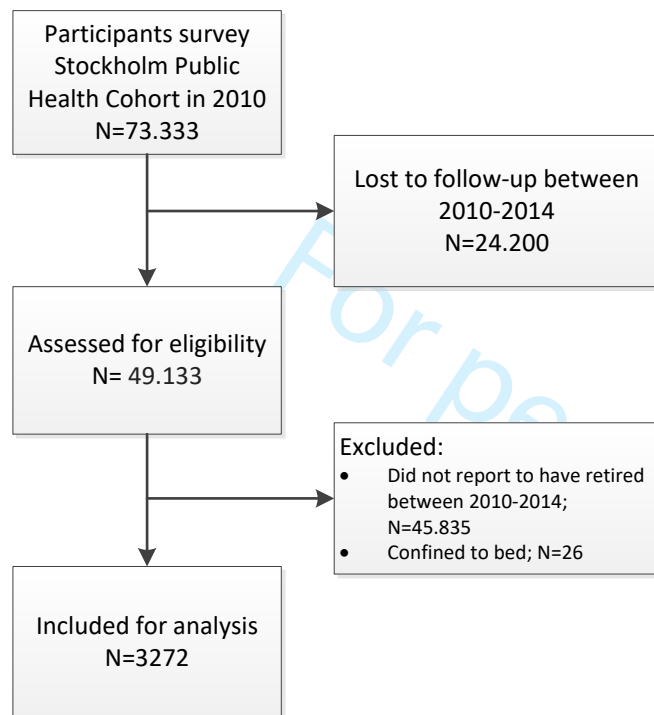
For peer review only

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STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract <b>p.2 (marked copy)</b> (b) Provide in the abstract an informative and balanced summary of what was done and what was found <b>p.2 (marked copy)</b>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b>p.4 (marked copy)</b>
Objectives	3	State specific objectives, including any prespecified hypotheses <b>p.5 (marked copy)</b>
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b>p.5 (marked copy)</b>
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b>p.5 (marked copy)</b>
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up. <b>p.5 (marked copy)</b> (b) For matched studies, give matching criteria and number of exposed and unexposed <b>N.A.</b>
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b>p.6-7 (marked copy)</b>
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group <b>p.6 (marked copy)</b>
Bias	9	Describe any efforts to address potential sources of bias <b>p.7 + p.10 (marked copy)</b>
Study size	10	Explain how the study size was arrived at <b>p.5 (marked copy) + Figure 1</b>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why <b>p.6-7 (marked copy)</b>
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding <b>p.6-7 (marked copy)</b> (b) Describe any methods used to examine subgroups and interactions <b>p.6-7 (marked copy)</b> (c) Explain how missing data were addressed <b>N.A. complete cases selected, see page 5</b> (d) If applicable, explain how loss to follow-up was addressed <b>p.5 (marked copy)</b> (e) Describe any sensitivity analyses <b>N.a.</b>
<b>Results</b>		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed <b>p.5 (marked copy) + Figure 1</b> (b) Give reasons for non-participation at each stage <b>N.a.</b> (c) Consider use of a flow diagram <b>Figure 1</b>
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <b>p.7 (marked copy)</b> (b) Indicate number of participants with missing data for each variable of interest <b>N.A. complete cases selected, see page 5</b> (c) Summarise follow-up time (eg, average and total amount) <b>N.A.</b>
Outcome data	15*	Report numbers of outcome events or summary measures over time <b>p.7+8 (marked copy)</b>

		<b>copy)</b>
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included <b>p.8 + Table 1+2 (marked copy)</b>
		(b) Report category boundaries when continuous variables were categorized <b>p.6+7 (marked copy)</b>
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period <b>N.a.</b>
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <b>N.a.</b>
<b>Discussion</b>		
Key results	18	Summarise key results with reference to study objectives <b>p.8 (marked copy)</b>
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias <b>p.10 (marked copy)</b>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <b>p.10+11 (marked copy)</b>
Generalisability	21	Discuss the generalisability (external validity) of the study results <b>p.8-11 (marked copy)</b>
<b>Other information</b>		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based <b>p.3 (marked copy)</b>

\*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at <http://www.strobe-statement.org>.