

ORIGINAL ARTICLE

Active commuting in Swedish workers between 1998 and 2015—Trends, characteristics, and cardiovascular disease risk

Jane Salier Eriksson¹  | Björn Ekblom¹ | Lena V. Kallings¹ | Erik Hemmingsson¹ | Gunnar Andersson² | Peter Wallin² | Örjan Ekblom¹ | Elin Ekblom-Bak¹ 

¹Åstrand Laboratory of Work Physiology, The Swedish School of Sport and Health Sciences, Stockholm, Sweden

²Research Department, HPI Health Profile Institute, Danderyd, Sweden

Correspondence

Jane Salier Eriksson, The Swedish School of Sport and Health Sciences, The Åstrand Laboratory of Work Physiology, Stockholm, Sweden. Box 5626, S-114 56 Stockholm, Sweden.

Email: janes@gih.se

Funding information

Forskningsrådet om Hälsa, Arbetsliv och Välfärd, Grant/Award Number: Dnr 2018-00384; Hjärt-Lungfonden, Grant/Award Number: Dnr, 20180636

Background: Trend analyses of active commuting and potential variations in trends and association with cardiovascular disease (CVD) risk within subgroups are unknown.

Objectives: To (a) describe trends in active commuting between 1998 and 2015 and (b) to study the association between different amounts of active commuting and the incidence risk of CVD in a large sample of Swedish workers, and analyses of potential variations across subgroups of socio-demographics, physical activity, and BMI.

Methods: A total of 318 309 participants (47% women, 18-74 years) who participated in a nationwide occupational health service screening between 1998 and 2015 were included. Commuting habits were self-reported, and data on first-time CVD events were derived from national registers.

Results: Self-reported passive commuters decreased between 1998 and 2015 (64% to 56%), transferring to an increase in mainly moderate/high-dose active commuters (12% to 19%). Changes were seen in all subgroups. The characteristics and lifestyle habits of the typical passive and active commuter changed little over the study period. Low- and moderate/high-dose active commuters had significantly decreased risks for a first time CVD during follow-up. This was accentuated in men, middle-aged, and in participants with light physical work situations, irregular exercise habits, being overweight/obese, and with low fitness.

Conclusion: Increases in active commuting were observed between 1998 and 2015, however still leaving a majority who do not actively commute. As active commuting, regardless dose, is associated with a lower CVD risk, encouraging more people to actively commute may provide an easily accessible and time-efficient possibility to increase physical activity and health in the general population.

KEYWORDS

active commuting, cardiovascular disease, cycling, physical activity, trends, walking, working population

1 | INTRODUCTION

Regular physical activity (PA) is important for cardiovascular health and longevity.¹⁻³ In spite of this, a large part of the Swedish population does not meet the required national guidelines for PA,^{4,5} with lack of time often given as a reason for this.⁶ With the shift toward a more inactive lifestyle in society during the last decades and a decrease in aerobic capacity in Sweden,⁷ increasing levels of daily PA by active commuting to work may be a time-efficient possibility to reach important public health goals. Active commuting has previously been demonstrated to be independently associated with higher cardiorespiratory fitness,⁸ and lower risk of cardiovascular disease (CVD)⁸⁻¹³ and all-cause mortality.¹⁴ The prevalence of passive commuting today is reported to be high,^{9,15-17} with little population-based data of trends in commuting habits during the last decades.¹⁸ Moreover, more high-resolution analyses of potential variations between subgroups of socio-demographics, physical activity, and BMI in both trends and association with CVD risk are lacking, which would provide valuable knowledge for future intervention strategies. Previous studies have been conducted in different countries and may lack generalizability, while there is a scarcity of studies investigating the possible association of CVD and active commuting in Sweden.

The aims of this study were, in a large sample of men and women from the Swedish working population (a) to describe trends in active commuting between 1998 and 2015 and (b) to study the association between different amounts of active commuting and the incidence risk of CVD. Potential variations across subgroups of sex, age, geographical region, educational level, physical working situation, BMI, and cardiorespiratory fitness were investigated.

2 | MATERIAL AND METHODS

This study used data from the Health Profile Assessment (HPA) database, managed by the HPI Health Profile Institute (Stockholm, Sweden), which was responsible for standardization of methods and education of data collection staff since the late 1970s.^{19,20} Participation was optional and free of charge for the individual and was offered to all employees working for a company or organization connected to occupational or other health services. The HPA comprises an extensive questionnaire, anthropometric and blood pressure measurements, a submaximal cycle test, followed by a person-centered dialog.

Between January 1998 and December 2015, data from a total of 318,309 participants (47% women) with a first-time HPA aged 18-74 years, without previous CVD, with valid data on a question concerning active commuting and the other sub-group variables, were registered and stored in a

central database. During follow-up, data on first-time CVD events were derived from national registers and included in the present analyses on an individual level using the unique Swedish personal identity number. All participants provided informed consent prior to data collection. The study was approved by the ethics board at Karolinska University (Dnr 2015/1864-31/2) and adhered to the Declaration of Helsinki.

2.1 | Assessment of active commuting

The statement concerning active commuting read Transport mode to and from work (total time). Participants chose between five alternatives these being—by car, bus, or train; by walking or cycling <10 minutes; walking or cycling between 10 and 19 minutes; walking or cycling between 20 and 29 minutes; walking or cycling 30 minutes or more. In 2012, the statement was slightly revised to, I walk or cycle to and/or from work with the alternatives of—<5 minutes per day; 5-9 min/d; 10-19 min/d; 20-29 min/d; at least 30 min/d. In the description of the trends in active commuting (Table 2) as well as the association with CVD risk (Figures 1 and 2), participants reporting transport mode as by car, bus, or train or <5 minutes per day were defined as “passive commuters.” The alternatives 5-9 min/d and 10-19 min/d were merged into 5-19 min/d and defined as “low-dose active commuters,” and 20-29 min/d and at least 30 min/d were merged into ≥ 20 min/d and defined as “moderate/high-dose active commuters.”

2.2 | Other measurements

Body weight was assessed to the nearest 0.5 kg, height was measured to the nearest 0.5 cm, and body mass index (BMI) was subsequently calculated. VO_2max was estimated using the standardized submaximal Åstrand cycle ergometer test.²¹ Previous validation studies on adult populations show small and non-significant mean differences on a group level between estimated VO_2max by the Åstrand protocol and directly measured VO_2max during maximal performance on a treadmill (mean difference $0.01 \text{ L}\cdot\text{O}_2\cdot\text{min}^{-1}$ (95% CI -0.10 to 0.11)),^{22,23} making the submaximal test suitable for use in large unselected cohorts. A total of 57 422 participants did not have valid data on estimated VO_2max due to medication affecting the heart rate (such as betablockers) or heart rate outside the valid range. Some participants could not perform the test because of pain complaints, illness, or perceived inability. However, in a previous publication, dropout analysis revealed small differences in age, BMI, and educational level between those with and without a valid estimated VO_2max .⁷

Current exercise, diet, smoking, and perceived overall health were each self-reported through the following statements—I exercise for the purpose of maintaining/

improving my physical fitness, health and well-being... with the alternatives Never, Sometimes, 1-2 times/wk, 3-5 times/wk, or At least 6 times/wk; I consider my diet, regarding both meal frequency and nutritional content to be... with the alternatives Very poor, Poor, Neither good nor bad, Good, or Very good; I smoke... with the alternatives At least 20 cig/d, 11-19 cig/d, 1-10 cig/d, Occasionally, or Never; I perceive my physical and mental health as... with the alternatives Very poor, Poor, Neither good nor bad, Good, or Very good. The highest educational attainment at the time for the HPA was obtained from Statistics Sweden, by linking the participant's personal identity number, and defined as length of education (<9 years, 9-12 years, or > 12 years). Counties including the three largest cities of Sweden were categorized as "Urban"; counties including a majority of rural municipalities as defined by the Swedish Association of Local Authorities and Regions were categorized as "Rural"; all other counties were categorized as "All other". Physical work situation was self-reported and described as either Sitting with some movement, Physically active, Occasionally physically demanding, or Occasionally very physically demanding. A total of 27 017 people had not answered the relevant question for the physical working situation. Consequently,

291 292 participants were included in the physical work situation subgroup.

2.3 | CVD event surveillance

All participants were followed from the date of HPA completion, until their first CVD or until 31 December 2015. Incident cases of CVD event after the HPA (fatal or non-fatal myocardial infarction, angina pectoris, or ischemic stroke: ICD-8, 410-414 and 430-438; ICD-9, 410-414, 427, 429-437; ICD-10, I20-I25, I46, I60-I66) were ascertained through the national in-hospital registry.

2.4 | Statistical analyses

Differences between the different commuting groups were tested using a one-way ANOVA and Kruskal-Wallis ANOVA with post-hoc analyses adjusting for multiple comparisons.

Percentages of commuting habits were standardized, using the direct method, to the population 18-74 years old in Sweden in 2015 ($n = 6\ 842\ 976$) by sex, age (18-24 years, 25-34 years, 35-44 years, 45-49 years, 50-54 years, 55-64 years, 65-74 years), and length of education (<9 years; 10-12 years; ≥ 12 years). Relative changes

TABLE 1 Characteristics of the study population in relation to commuting habits ($n = 318\ 309$)

	Passive commuters $n = 198\ 282$	Low-dose commuters $n = 72\ 220$	Moderate/high-dose commuters $n = 47\ 807$
Sex (women)	43% (84 606) ^{a,b}	53% (38 387) ^b	55% (26 093)
Age (y)	43 \pm 11 ^{a,b}	43 \pm 12 ^b	44 \pm 12
Education (≥ 12 y)	22% (43 041) ^{a,b}	30% (21 779) ^b	35% (16 750)
Region (urban)	46% (91 952) ^{a,b}	50% (36 358) ^b	52% (24 657)
Weight (kg)	79.5 \pm 15.8 ^{a,b}	76.3 \pm 15.2 ^b	75.1 \pm 14.6
Height (cm)	174 \pm 9 ^{a,b}	173 \pm 9 ^b	173 \pm 9
BMI (kg/m ²)	26.1 \pm 4.3 ^{a,b}	25.4 \pm 4.2 ^b	25.1 \pm 3.9
Exercise (≥ 1 time/wk)	63% (123 848) ^{a,b}	69% (49 479) ^b	72% (34 341)
Diet (very good/good)	59% (117 590) ^{a,b}	64% (46 180) ^b	70% (33 544)
Smoking habits (non-smoker)	80% (158 921) ^{a,b}	82% (59 128) ^b	85% (40 631)
Perceived health (very good/good)	67% (132 932) ^{a,b}	70% (50 374) ^b	75% (35 726)
Physical work situation (strenuous)	N = 182 741	N = 65 581	N = 42 970
	16% (29 401) ^{a,b}	14% (9050) ^b	12% (5310)
Estimated VO ₂ max (mL/min/kg)	N = 161 418	N = 59 673	N = 39 796
	35.6 \pm 9.7 ^{a,b}	37.5 \pm 10.2 ^b	38.3 \pm 10.3
CVD events	2.0% (3944) ^{a,b}	1.5% (1096)	1.4% (674)
Mean follow-up time (y)	7.4 \pm 4.2 ^{a,b}	7.2 \pm 4.3 ^b	6.6 \pm 4.3
Incident rate (event/10 000 person years)	26.8 ^{a,b}	21.2	21.3

Note: Data are presented as mean (SD) or % (n).

^aSignificant difference versus low-dose commuters.

^bSignificant difference versus moderate/high-dose commuters.

in standardized percentages were calculated by dividing the absolute change with the percentage in 1998-2002. Multivariable logistic regression modeling adjusting for sex, age, and educational level was used to test for significant differences of the standardized percentages (a) over time (1998-2002 vs 2011-2015) and (b) between subgroups within each alternative of reply (<5 min/d, 5-19 min/d and ≥ 20 min/d, respectively). Cox proportional hazard regression modeling was used to assess hazard ratios (HR) with 95% confidence interval (CI) for first time CVD incidence in relation to commuting habits at baseline in the total population and in subgroups. A sensitivity analysis of all CVD incidence rates (n = 5714) and incidence rates excluding any events occurring within the first two years after doing the HPA (n = 4640) did not change the results. The proportionality assumption for Cox regression was examined using scaled Schönfelds residuals, and we found no

violation of the proportionality assumption. Data were analyzed using IBM SPSS (Statistical Package for the Social Sciences for Windows), version 24.0.0, 2016, SPSS Inc.

3 | RESULTS

A total of 318 309 participants (47% women) were included in the analyses. The majority (62%) reported being passive commuters (Table 1). Participants engaging in more, compared to those engaging in less, daily active commuting were significantly more often women, had a higher educational level, lower BMI, exercised more often, perceived their diet habits to be better, were more often non-smokers, perceived their overall health to be better, had higher estimated VO₂max and had a less strenuous work situation.

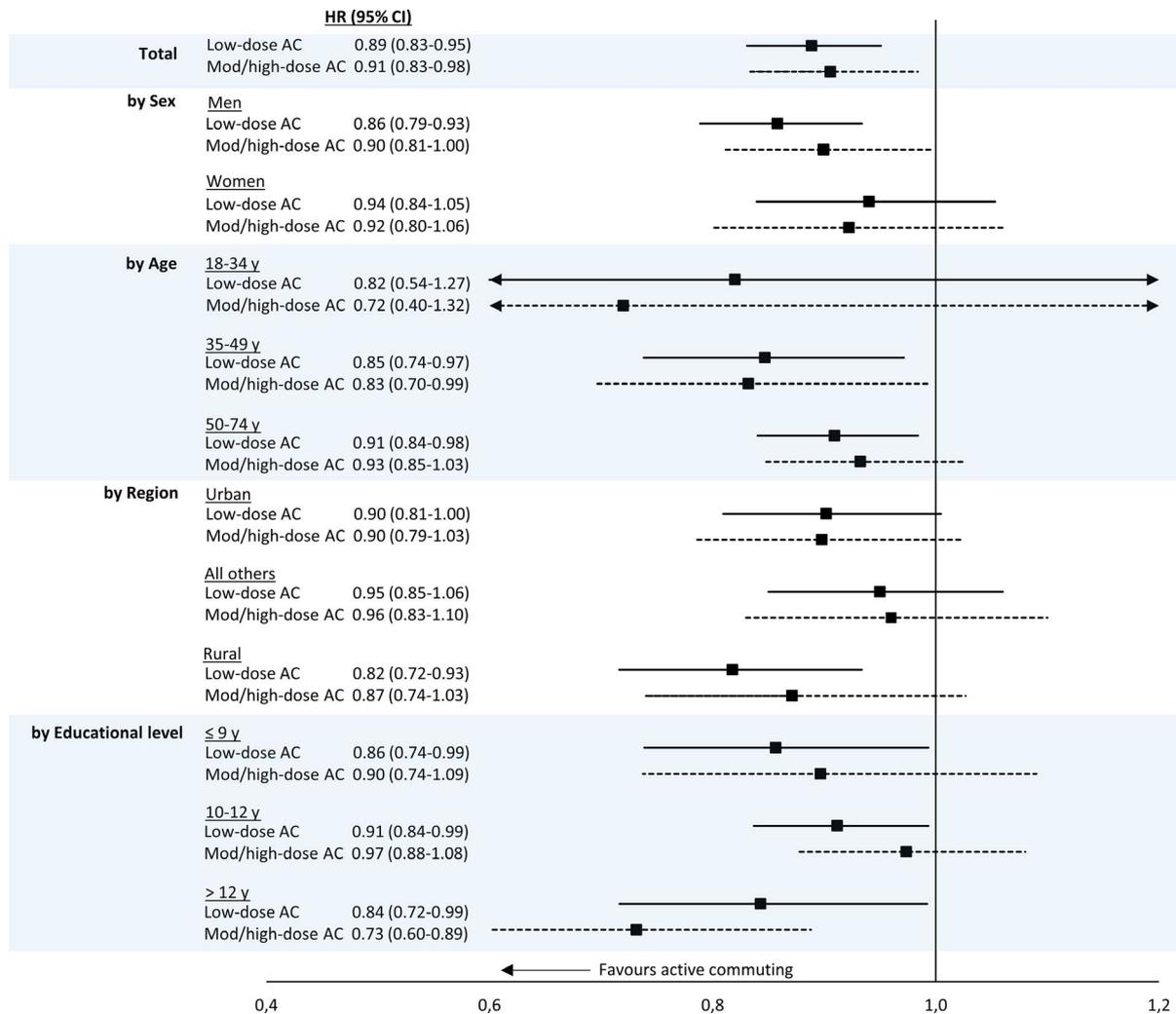


FIGURE 1 Forest plot of hazard ratio (95% CI) for first-time CVD event in relation to active commuting habits in the total sample and in socio-demographic subgroups. All analyses are adjusted for sex, age, performed year, diet, smoking, BMI, exercise, educational level (when not evaluated as subgroup). AC, active commuting

3.1 | Trends in active commuting habits

The proportion of passive commuters decreased significantly over the study period, from 64% in 1998-2002 to 56% in 2011-2015 ($P < .001$) (Table 2). This transferred into a small increase in low-dose active commuters (24% to 25%, $P < .001$), and a greater increase in moderate/high-dose active commuters (12% to 19%, $P < .001$). The decrease in passive commuters and increase in moderate/high-dose active commuters were seen in all subgroups of sex, age, geographical region, level of education, physical working situation, exercise habits, BMI, and estimated VO_{2max} . More specifically, the relative decrease in passive commuting within the different subgroups was more pronounced in women, young age-group, urban region, the lowest and highest educational levels, light physical work situation, none/irregular exercisers, normal weight and obese, and low estimated VO_{2max} . The relative increase in moderate/high-dose active commuters was more pronounced in women, youngest and oldest

age-group, urban region, low- and middle-educational levels, none/irregular exercisers, normal weight, and moderate/high estimated VO_{2max} .

3.2 | The passive and active commuter

A passive commuter in 2011-2015 was more likely to be a man, middle-aged, live in a rural area, have a low educational level, have a strenuous work situation, be a none/irregular exerciser, be overweight or obese, and have low estimated VO_{2max} (see supplement Table 1). This is similar to the typical passive commuter in 1998-2002, except for physical work situation, where a passive commuter in 1998-2002 was more likely to have a light work situation.

Both a low- and moderate/high-dose active commuter in 2011-2015 was more likely to be a woman, live in an urban region, have a high educational level, have a light physical work situation, be weekly regular exercisers, be a normal weight, and have a moderate/high estimated

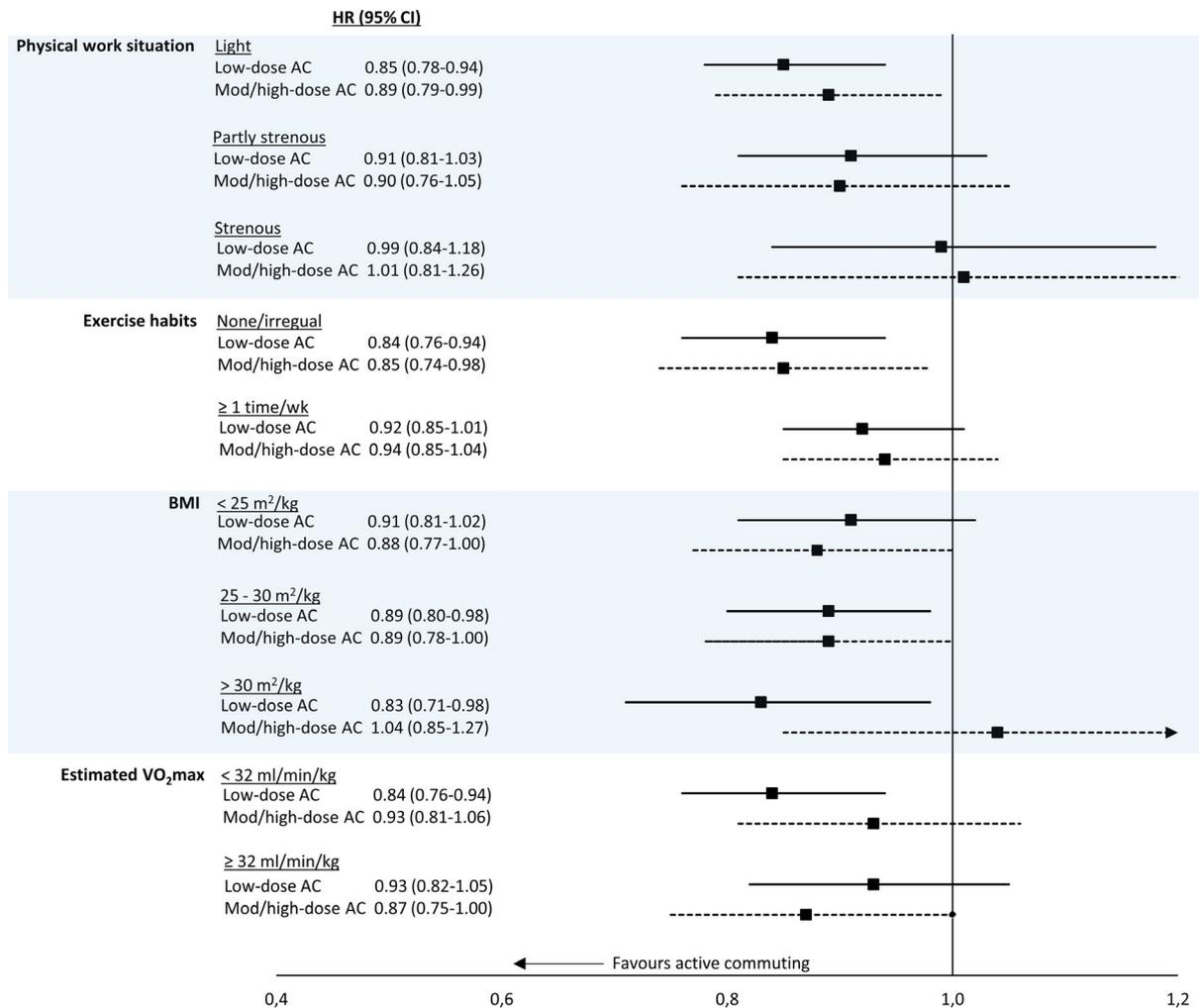


FIGURE 2 Forest plot of hazard ratio (95% CI) for first-time CVD event in relation to active commuting habits in the total sample and in lifestyle related subgroups. All analyses are adjusted for sex, age, performed year, diet, smoking, BMI, exercise, educational level (when not evaluated as sub-group). AC, active commuting

TABLE 2 Standardized percentages and relative changes of commuting habits in 1998-2002 and 2011-2015, respectively, in the total sample and in socio-demographic and lifestyle related subgroups

	Passive commuters (%)			Low-dose commuters (%)			Moderate/high-dose commuters (%)		
	1998-2002	2011-2015	Relative change	1998-2002	2011-2015	Relative change	1998-2002	2011-2015	Relative change
Total	64	56	-13	24	25	4	12	19	58
Sex									
Women	60	50	-17	28	27	-4	12	23	92
Men	69	63	-9	20	22	10	11	16	45
Age									
18-34 y	66	57	-14	23	26	13	11	17	55
35-49 y	65	60	-8	22	23	5	13	17	31
50-74 y	62	55	-11	24	23	-4	14	22	57
Region									
Urban	65	53	-18	24	27	13	12	20	67
All others	61	59	-3	27	23	-15	13	19	46
Rural	68	63	-7	21	21	0	11	17	55
Educational level									
≤9 y	73	62	-15	18	20	11	10	18	80
10-12 y	65	60	-8	25	24	-4	10	17	70
≥12 y	57	44	-23	26	30	15	17	26	53
Physical work situation									
Light	65	56	-14	23	25	9	12	19	58
Partly strenuous	60	57	-5	27	24	-11	13	20	54
Strenuous	65	61	-6	22	20	-9	13	19	46
Exercise habits									
None/irregular	69	59	-14	21	23	10	10	18	80
≥1 time/wk	59	55	-7	27	25	-7	14	20	43
BMI									
<25 m ² /kg	61	53	-13	27	25	-7	12	21	75
25-30 m ² /kg	63	59	-6	25	24	-4	12	18	50
>30 m ² /kg	70	61	-13	21	24	14	10	15	50
Estimated VO ₂ max									
<32 mL/min/kg	67	61	-9	22	23	5	11	16	45
≥32 mL/min/kg	55	52	-5	32	25	-22	14	23	64

Note: Bold text indicates non-significant ($P > .05$) differences from 1998-2002.

VO₂max. They only differed in age, where a low-dose active commuter was more likely to be young and a moderate/high-dose active commuter to be in the older age-group. These characteristics of a typical commuter were similar in 1998-2002, except for that both low- and moderate/high-dose active commuters were more likely to have strenuous jobs in the earlier years compared to the later years of the study period.

3.3 | Commuting habits and CVD risk

During a mean follow-up time of 7.2 years, a total of 5714 first-time CVD events occurred. Compared to passive commuters, those being low- and moderate/high-dose active commuters at baseline had a significantly lower risk of a first-time CVD event after multi-adjustment for sex, age, performed year, diet, smoking, BMI, exercise, and educational

level (HR 0.89, 95% CI 0.83-0.95 and 0.91, 0.83-0.98, respectively) (Figure 1). Men had a significantly decreased CVD risk if engaging in active commuting at baseline, regardless of commuting dose. Similar trends were seen for the middle-age group, and in the oldest age-group for low-dose active commuting. Participants living in urban and rural regions, and of all educational levels, had a beneficial effect of low-dose active commuting. Only participants with high educational levels had significantly decreased CVD risk with moderate/high-dose active commuting. In relation to lifestyle habits, participants with light work situations, being none/irregular exercisers, overweight, and having a low estimated VO_{2max} had a significantly decreased CVD risk if engaging in active commuting, irrespective of dose, compared to passive commuters (Figure 2). For obese participants, low-dose active commuting was associated with significantly reduced CVD risk.

4 | DISCUSSION

The main findings of the present study are an increase in mainly moderate/high-dose active commuters, (12% to 19%, between 1998 and 2015), and a decline in self-reported passive commuters (64% to 56%). These changes were seen in all subgroups of socio-demographics, physical activity, and BMI. However, the changes were more pronounced in some subgroups compared to others. A pattern of a typical passive and active commuter in 2011-2015 emerged, which had changed little since 1998-2002. Low- and moderate/high-dose active commuters, compared to passive commuters, had similar significantly decreased risks for a first time CVD during follow-up. This was accentuated in men, the middle-aged group, and participants with a light physical work situation, as well as those with none/irregular exercise habits, being overweight/obese, and with low estimated VO_{2max} .

4.1 | Prevalence and trends in active commuting habits

The proportion of participants who reported being passive commuters in 2011-2015 (56%) is lower than in previous studies. In a nationally representative survey of UK residents in 2009-2011, 85% of participants aged between 16 and 65 years reported passive commuting by private or public transport.¹⁶ Further, in 2007-2010, 76% and 78% of participants in the NHANES and UK Biobank project, respectively, reported having no active transportation.^{9,24} In the Swedish national travel survey from 2011 to 2014, which investigates the travel habits in the Swedish population between the ages of 6-84, car or public transport was used as the main mode of travel for 71% of the total yearly business, work, and study-related journeys.¹⁷ Only 25% of the yearly commuting journeys

used walking or cycling as the main mode. The characteristics seen in the present study of a typical active commuter (regardless dose) more often being a woman, older, having a high education and a light physical work situation, being regular exercisers, having lower BMI and higher fitness, are similar to previous reports.^{9,11,12,17} Only in the NHANES study, those with the highest level of active transportation were young and most likely to be men. The characteristics of the typical passive and active commuter were stable over the study period except for the association with physical work situation, where an active commuter was more likely to have a sedentary work situation at the end compared to the beginning of the study period.

Previous population-based trend data on commuting habits are equivocal. Contrary to the present findings, commuting by car (comparable to our passive commuting) increased significantly from 21% to 68% in Glasgow during the period 1966-2001, while cycling and walking to work decreased from approx. 28% to 13% (from 4% to 1% and 24 to 12% for cycling and walking, respectively).¹⁸ Comparing data from the Swedish national travel survey in 1999 with the previously reported figures from 2011 to 2014,²⁵ small changes were seen in the main mode used for business, work, and study-related journeys between the two time periods (from 67% to 71% by car/public transport and 27% to 25% by cycling/walking). Looking specifically at cycling as a mean of transportation in Sweden, although both average kilometer and numbers of trips declined between 1995 and 2014 (-16% and -34%, respectively),²⁶ there was no change over the period when the main purpose of cycling was commuting. On the contrary, cycling has been reported to increase in the whole of Denmark during the same period.²⁷ Looking back in time, in Stockholm (Sweden) in 1949, a large company conducted a questionnaire including all their 5000 employees asking how they travelled to and from work. 60% of their employees cycled to work and 19% walked while only 1% used a totally passive transport mode.²⁸ It would seem that active commuting trends, although increasing in Sweden and Denmark since 1998, are possibly still at a lower level in comparison to 40 years ago, so creating strategies or policies to promote active commuting up to similar levels of 40 years ago might translate into increased physical activity in the general population.

4.2 | Active commuting habits and CVD risk

We found a decreased CVD risk with active commuting, compared to passive commuting, of 11% and 9%, respectively, for those reporting low- and moderate/high-dose of active commuting, without the possibility of making any further distinction in the analyses of mode used (walking or cycling), intensity during commuting or distance travelled. However, our results are similar to a meta-analytic

review including 173 146 participants¹⁰ and data from the UK Biobank including 358 799 middle-aged and older participants,¹² which both reported a 11% lower risk associated with self-reported active commuting using walking or cycling, with no further analyses on the intensity of commuting activity. In the meta-analytic review, a more robust association was seen among women, which is opposite to the results in the present study where only significantly reduced risk was seen in men. However, taking into consideration, the mode of active commuting may be important, as walking and cycling might differ in the intensity of the activity.^{9,13} The importance of walking and cycling separately on incident CVD risk was investigated in 263 450 middle-aged men and women, showing no significant association with short distance (below median) travelled, but significantly lower risk with long-distance (above median) travelled, however, with small differences between the two modes of commuting (walking HR = 0.59, 95% CI 0.38 to 0.92 and cycling 0.53, 0.29 to 0.97).⁹ Moreover, in a population-based sample from the Northern parts of Sweden, regular car commuting was associated with a 74% increased risk for a first-time myocardial infarction, compared to bus, walking, or cycling.¹¹ In sex-specific analyses, the associations remained significant only in men.

Importantly, we found a reduced CVD risk from active commuting, regardless of dose, in both middle-aged and older participants, urban and rural geographic sites, and in all levels of education after multi-adjustment including exercise. This is highly relevant in many perspectives. For example, in the light of a demographic shift to an older population, who often find it difficult to achieve recommended exercise levels,⁴ active commuting may provide an opportunity for middle-aged and older adults to maintain a health-preserving activity level. Also, as lower educational levels or socioeconomic status are reported to be associated with lower fulfillment of recommended levels of exercise,⁴ as well as a higher burden of disease and shorter life expectancy,²⁹ the decreased CVD risk with even low-dose active commuting in participants with a short education (≤ 9 years) is highly relevant both from an individual and a public health perspective.

Participants in the least beneficial subgroups of physical activity and obesity exhibited the strongest CVD risk reduction with active commuting. Low-dose active commuting was associated with 11% to 17% reduced CVD risk for those with light occupational, none/irregular exercise habits, with low estimated VO_2max or being overweight or obese. This is supported by previous reports, showing that the greatest health benefits and CVD risk reductions are seen when sedentary individuals go from no physical activity to some physical activity, or very low fit individuals improve their fitness levels somewhat—although not reaching recommended physical activity or fitness target levels.^{30,31} We were not able to define

the intensity of the active commuting. However, the low-dose active commuting in the present study does not reach the recommended levels of physical activity over the week (150 minutes), but does replace time that would otherwise be spent sedentary (for example by passive commuting by car). A substitution of small amounts of time spent sedentary with either light or moderate-to-vigorous physical activity has previously been shown to be associated with more beneficial cardiovascular risk profiles and lower all-cause mortality.³² Hence, active commuting may be a highly important source of daily activity, inducing health benefits in those individuals who need it the most.

4.3 | Possibilities and challenges of active commuting

Although we report an overall decline in passive commuters between 1998 and 2015, the majority of the participants at the end of the study period still passively commute. Interventions that encourage people to actively commute, if only for a few minutes per day, may be a more feasible and individually motivated option compared to leisure-time exercise interventions, especially as it is time-efficient with no need to be seen as structured and planned exercise (which may be repelling for many). Interestingly, it has been suggested that there is great potential for car commuters in Stockholm to change to active commuting by cycling.³³ A possible 111 000 car commuters have been estimated to have the physical capacity and a short enough distance to work (30 minutes) to change to cycle commuting. This could yield large health benefits both from the actual commuting and from lower emissions of air pollutants from cars.

Apart from internal motivation, several external factors are key determinants for getting individuals to choose active modes of transportation over passive modes. In Sweden (and other elongated Nordic countries such as Norway and Finland), seasonal weather variations, as well as climate differences between the southern and northern part of the country, induce specific local challenges for sustained active commuting throughout the year. For example, in a study in a Nordic metropolitan setting, the trip frequency in active commuters who only cycled varied largely over the year (with lower levels in the wintertime), while the trip frequency was more stable in actively commuting pedestrians or in those who alternately cycled and walked throughout the year.³⁴ Moreover, external physical and social characteristics such as infrastructure, distance, and safety of travel are identified as directly and indirectly influencing active travel habits.³⁵ Levels of cycling and walking rates may vary largely between countries as well as between urban and rural areas (as reported in the present study), which highlights the differences in prerequisites and challenges between different areas, and the importance to develop localized policies and implementation strategies for increasing active travel.

4.4 | Strengths and limitations

The main strength is the large sample of women and men, giving the potential to perform highly clinically relevant analyses of variations across subgroups. Another strength of this study is that the definition of active commuting has been consistent over the years of data collection. Standardization of commuting data in relation to the Swedish population with regard to sex, age, and length of education enabled comparisons over the study period. The main limitations are the self-reported nature and the lack of information of the mode, frequency, or intensity of the active commuting, which restricts more high-resolution analyses in trends and associations with CVD risk. Fully valid comparisons between the results from previous studies regarding prevalence and trends in commuting habits are hampered due to the different questions and alternatives of reply used, and these comparisons should be interpreted cautiously.

Another limitation of this study is that the information concerning CVD events was only ascertained from the in-hospital registry instead of also the cause-of-death register as small discrepancies can be found between the two, and some incidences of CVD which lead to sudden cardiac death outside the hospital may not have been recorded at the time we received the inpatient register.

5 | PERSPECTIVES

In a large sample of men and women of different ages from the Swedish working population, we report an increase in mainly moderate/high-dose active commuters, and a decline in self-reported passive commuters, between 1998 and 2015. However, this still leaves a majority who do not actively commute. As both low- and moderate/high-dose active commuters had a significantly lower CVD risk compared to passive commuters, encouraging more people to actively commute may provide an easily accessible and time-efficient possibility to increase physical activity and health in the general population. This is especially so in the light of recently reported declines in fitness in Sweden.⁷ Replication of the findings using objectively assessed active commuting habits is needed.

ACKNOWLEDGEMENT

We thank Jonas Söderling for excellent statistical assistance.

CONFLICT OF INTEREST

GA (responsible for research and method) and PW (CEO and responsible for research and method) are employed at the HPI Health Profile Institute.

ORCID

Jane Salier Eriksson  <https://orcid.org/0000-0001-5213-4439>

Elin Ekblom-Bak  <https://orcid.org/0000-0002-3901-7833>

REFERENCES

1. Lee IM, Shiroma EJ, Lobelo F, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet*. 2012;380(9838):219-229.
2. Morris JN, Heady JA, Raffle PAB, Roberts CG, Parks JW. Coronary Heart-disease and Physical Activity of Work. *Lancet*. 1953;262(6795):1053-1057.
3. Paffenbarger RS Jr, Hyde RT, Wing AL, Hsieh CC. Physical activity, all-cause mortality, and longevity of college alumni. *N Eng J Med*. 1986;314(10):605-613.
4. Ekblom-Bak E, Olsson G, Ekblom O, Ekblom B, Bergstrom G, Borjesson M. The Daily Movement Pattern and Fulfilment of Physical Activity Recommendations in Swedish Middle-Aged Adults: The SCAPIS Pilot Study. *PLoS ONE*. 2015;10(5):e0126336.
5. Hagstromer M, Oja P, Sjostrom M. Physical activity and inactivity in an adult population assessed by accelerometry. *Med Sci Sports Exerc*. 2007;39(9):1502-1508.
6. Dunn AL, Andersen RE, Jakicic JM. Lifestyle physical activity interventions. History, short- and long-term effects, and recommendations. *Am J Prev Med*. 1998;15(4):398-412.
7. Ekblom-Bak E, Ekblom O, Andersson G, et al. Decline in cardiorespiratory fitness in the Swedish working force between 1995 and 2017. *Scand J Med Sci Sports*. 2019;29(2):232-239.
8. Oja P, Titze S, Bauman A, et al. Health benefits of cycling: a systematic review. *Scand J Med Sci Sports*. 2011;21(4):496-509.
9. Celis-Morales CA, Lyall DM, Welsh P, et al. Association between active commuting and incident cardiovascular disease, cancer, and mortality: prospective cohort study. *BMJ*. 2017;357:j1456.
10. Hamer M, Chida Y. Active commuting and cardiovascular risk: a meta-analytic review. *Prev Med*. 2008;46(1):9-13.
11. Wennberg P, Lindahl B, Hallmans G, et al. The effects of commuting activity and occupational and leisure time physical activity on risk of myocardial infarction. *Eur J Cardiovasc Prev Rehabil*. 2006;13(6):924-930.
12. Panter J, Mytton O, Sharp S, et al. Using alternatives to the car and risk of all-cause, cardiovascular and cancer mortality. *Heart*. 2018;104(21):1749-1755.
13. Nordengen S, Andersen LB, Solbraa AK, Riiser A. Cycling is associated with a lower incidence of cardiovascular diseases and death: Part 1 - systematic review of cohort studies with meta-analysis. *Br J Sports Med*. 2019;53(14):870-878.
14. Dinu M, Pagliai G, Macchi C, Sofi F. Active Commuting and Multiple Health Outcomes: A Systematic Review and Meta-Analysis. *Sports medicine*. 2019;49(3):437-452.
15. Furie GL, Desai MM. Active transportation and cardiovascular disease risk factors in U.S. adults. *Am J Prev Med*. 2012;43(6):621-628.
16. Laverty AA, Mindell JS, Webb EA, Millett C. Active travel to work and cardiovascular risk factors in the United Kingdom. *Am J Prev Med*. 2013;45(3):282-288.
17. Transport Analysis. The Swedish National Travel Survey 2011–2014. Report. 2014. <https://www.trafa.se/en/travel-survey/travel-survey/>

18. Glasgow Centre for Population Health. Are trends in adult active travel moving in the right direction? Report. 2011. https://www.gcph.co.uk/assets/0000/1125/GCPH_Briefing_Paper28_web_final.pdf
19. Andersson G. *The importance of exercise for sick leave and perceived health*. Linköping, Sweden: Department of Preventive and Social Medicine, Linköping University; 1987.
20. Lilliecreutz Huitema E, Andersson G, Samuelsson K. Lifestyle changes with help from Health Profile Assessment in combination with support in individual interventions for persons with acquired brain injury – A pilot study. *Eur J Physiother*. 2014;16:151-158.
21. Astrand I. Aerobic work capacity in men and women with special reference to age. *Acta Physiol Scand Suppl*. 1960;49(169):1-92.
22. Bjorkman F, Ekblom-Bak E, Ekblom O, Ekblom B. Validity of the revised Ekblom Bak cycle ergometer test in adults. *Eur J Appl Physiol*. 2016;116(9):1627-1638.
23. Ekblom B, Engstrom LM, Ekblom O. Secular trends of physical fitness in Swedish adults. *Scand J Med Sci Sports*. 2007;17(3):267-273.
24. Furie GL, Desai MM. Active Transportation and Cardiovascular Disease Risk Factors in U.S. Adults. *Am J Prev Med*. 2012;43(6):621-628.
25. Official Statistics of Sweden. Swedish Institute for Transport and Communications Analysis. National Travel Survey 1999. Report. 2000; https://www.trafa.se/globalassets/sika/sika-statistik/ss2000_5.pdf
26. Transport Analysis. Cyklandets utveckling i Sverige 1995–2014 – en analys av de nationella resvaneundersökningarna [Cycling in Sweden 1995-2014 - an analysis of the national travel surveys]. Report. 2015; https://www.trafa.se/globalassets/rapporter/2010-2015/2015/rappo-rt-2015_14-cyklandets-utveckling-i-sverige-1995-2014.pdf
27. Andersen LB, Riiser A, Rutter H, Goenka S, Nordengen S, Solbraa AK. Trends in cycling and cycle related injuries and a calculation of prevented morbidity and mortality (Article in press). *J Transport and health*. 2018;9:217-225.
28. Gyllenberg E. Telefonplan har ömsat skinn [Telefonplan has shed its skin] DagensNyheter [The Daily News]. 2006. <https://www.dn.se/arkiv/stockholm/telefonplan-har-omsat-skinn/>
29. Rosengren A, Subramanian SV, Islam S, et al. Education and risk for acute myocardial infarction in 52 high, middle and low-income countries: INTERHEART case-control study. *Heart*. 2009;95(24):2014-2022.
30. Despres JP. Physical Activity, Sedentary Behaviours, and Cardiovascular Health: When Will Cardiorespiratory Fitness Become a Vital Sign? *Can J Cardiol*. 2016;32(4):505-513.
31. O'Donovan G, Lee IM, Hamer M, Stamatakis E. Association of "Weekend Warrior" and Other Leisure Time Physical Activity Patterns With Risks for All-Cause, Cardiovascular Disease, and Cancer Mortality. *JAMA Intern Med*. 2017;177(3):335-342.
32. Del Pozo-Cruz J, Garcia-Hermoso A, Alfonso-Rosa RM, et al. Replacing Sedentary Time: Meta-analysis of Objective-Assessment Studies. *Am J Prev Med*. 2018;55(3):395-402.
33. Johansson C, Lovenheim B, Schantz P, et al. Impacts on air pollution and health by changing commuting from car to bicycle. *The Science of the total environment*. 2017;584–585:55-63.
34. Stigell E, Schantz P. Active Commuting Behaviors in a Nordic Metropolitan Setting in Relation to Modality, Gender, and Health Recommendations. *Int J Environ Res Public Health*. 2015;12(12):15626-15648.
35. Winters M, Buehler R, Gotschi T. Policies to Promote Active Travel: Evidence from Reviews of the Literature. *Curr Environ Health Rep*. 2017;4(3):278-285.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Eriksson JS, Ekblom B, Kallings LV, et al. Active commuting in Swedish workers between 1998 and 2015—Trends, characteristics, and cardiovascular disease risk. *Scand J Med Sci Sports*. 2019;00:1–10. <https://doi.org/10.1111/sms.13581>