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# Physical activity pattern, cardiorespiratory fitness, and socioeconomic status in the SCAPIS pilot trial — A cross-sectional study

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ABSTRACT

Living in a low socioeconomic status (SES) area is associated with an increased risk of cardiovascular events and all-cause mortality. Previous studies have suggested a socioeconomic gradient in daily physical activity (PA), but have mainly relied on self-reported data, and individual rather than residential area SES. This study aimed to investigate the relationships between residential area SES, PA pattern, compliance with PA-recommendations and fitness in a Swedish middle-aged population, using objective measurements. We included 948 individuals from the SCAPIS pilot study (Gothenburg, Sweden, 2012, stratified for SES, 49% women, median age: 58 years), in three low and three high SES districts. Accelerometer data were summarized into intensity-specific categories: sedentary (SED), low (LIPA), and medium-to-vigorous PA (MVPA). Fitness was estimated by submaximal ergometer testing. Participants of low SES areas had a more adverse cardiovascular disease risk factor profile (smoking: 20% vs. 6%; diabetes: 9% vs. 3%; hypertension: 38% vs. 25%; obesity: 31% vs. 13%), and less frequently reached 150 min of MVPA per week (67% vs. 77%, odds ratio [OR] = 0.61; 95% confidence interval [95% CI] = 0.46–0.82), from 10-minute bouts (19% vs. 31%, OR = 0.53, 95% CI = 0.39–0.72). Individuals in low SES areas showed lower PA levels (mean cpm: 320 vs. 348) and daily average MVPA (29.9 vs. 35.5 min), and 12% lower fitness (25.1 vs. 28.5 $mL \times min^{-1} \times kg^{-1}$) than did those in high SES areas. Reduced PA and fitness levels may contribute to social inequalities in health, and should be a target for improved public health in low SES areas.



## 1. Introduction

Socioeconomic status (SES) refers to classification of an individual's position in society, usually assessed as education, income and/or occupation (Galobardes et al., 2006). Low SES is associated with a higher burden of cardiovascular disease (CVD) and all-cause mortality for the individual, as well as on a residential area level (Mackenbach et al., 2000; Meijer et al., 2012; Rosengren et al., 2009; Schaufelberger and Rosengren, 2007; Bergstrom et al., 2015a; Rawshani et al., 2015). Low SES is also associated with worse prognosis after manifestation of CVD (Bergstrom et al., 2015a). Although low SES is known to be associated with adverse CVD risk factors, such as smoking, hypertension, and hyperlipidemia, as well as health-associated behaviors (Manhem et al., 2000; Kanjilal et al., 2006), these factors only provide a partial explanation for discrepancies in SES with respect to CVD (Marmot et al., 1997; Laaksonen et al., 2008). Psychosocial factors have also been suggested as potential mediators (Marmot et al., 1997). The unexplained difference in morbidity and mortality in relation to SES needs to be further investigated.

The city of Gothenburg is socially segregated, with a clear geographical distinction between socioeconomic groups. There are also differences in prevalence and all-cause mortality of CVD between areas of high and low SES (Inequalities in Health and Living Conditions in Gothenburg: Interim Report, 2014). Area-level SES provides information of the habitants, as well as its history, class, accumulation of capital and other aspects shaping health. Therefore, relevant information regarding the social and health status of the investigated population may be lost when only investigating individual characteristics (Galobardes et al., 2007). Additionally, studying health effects at an area level is relevant for policy making having a potential effect on neighborhood health (Sugiyama et al., 2015).

Daily physical activity (PA) and cardiorespiratory fitness (CRF) have widely documented cardioprotective effects (Lee et al., n.d.; Blair et al., 1989). There is rising concern that sedentary behavior in itself may contribute to CVD independently of PA levels (Dunstan et al., 2012) or fitness. Direct measurement of absolute intensity of PA allows for detailed assessment of individual PA patterns. This can be defined as

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time spent in different activity levels, varying from sedentary behavior (SED) to light intensity PA (LIPA) and PA of moderate-to-vigorous intensity (MVPA).

Current national/international PA guidelines typically recommend at least 150 min/week of MVPA, spent in prolonged bouts of 10 min or longer, preferably on most days of the week (Haskell et al., 2007; The Swedish National Board of Health and Welfare, 2011). Previous studies that used objective measurements of PA have shown generally low rates of adherence to the current PA guidelines (Hagstromer et al., 2007). The daily movement pattern and fulfillment of national PA recommendations in Swedish men and women aged 50–65 years have previously been described (Ekblom-Bak et al., 2015). There are higher levels of MVPA and sedentary time in individuals with a higher education. However, the relationships between area-level SES, daily PA, fitness, and fulfillment of national PA recommendations have not been examined. Area-level SES is associated with objective and perceived environmental attributes known to correlate with physical activity, such as neighborhood density, esthetics, and fear of crime (Sugiyama et al., 2015). Therefore, area-level SES may influence physical activity independently of individual SES. This study aimed to investigate the relationships of area-level SES with PA patterns, CRF, and adherence to national physical activity guidelines in a middle-aged Gothenburg population.

## 2. Methods

### 2.1. Study population

The study population for this investigation originated from the Swedish CArdioPulmonary bioImage Study (SCAPIS) pilot trial, which was conducted at the Sahlgrenska University Hospital in Gothenburg, Sweden in 2012 (Bergstrom et al., 2015b). A total of 2243 middle-aged individuals (50–65 years) were selected from the Swedish population registries and stratified for socioeconomic area. Participation rates were significantly different (37.1% in low vs. 67.2% in high SES areas). A total of 1111 individuals agreed to participate. The extensive study procedures occurred during 2 or 3 days and included measurement of blood chemistry, anthropometry, electrocardiogram, blood pressure, and lung function testing, as well as imaging studies. To estimate daily PA and fitness, participants wore an accelerometer during 7 consecutive days and performed a submaximal bicycle test. All of the participants provided written informed consent. The study was approved by the Ethics Committee of the University of Umeå (Dnr 2010-228-31M).

### 2.2. Socioeconomic status

The known geographical disparities in the Gothenburg region, described above, enabled assessment of SES by residential area. Participants from the north-eastern residential areas were classified as having low SES, while residents of the western areas were classified as having high SES. Information regarding education level was also collected to control for individual-level SES. Education level was divided into four categories: (1) no basic education, (2) completed primary school, (3) completed secondary education, and (4) university degree or higher.

### 2.3. Physical activity

PA data were collected using the ActiGraph model GT3X/GT3X+ accelerometer (Actigraph LCC, Pensacola, FL, USA). This small device measures acceleration, thereby providing continuous data of PA intensity and frequency, which is summarized into units called counts. The accelerometer is carried in an elastic belt over the right hip. Study participants were instructed to wear this device during waking hours for 7 consecutive days from the first study visit, the only exception being water-based activities. After completion, the accelerometer was returned to the laboratory by prepaid mail. The accelerometer was initialized and downloaded using ActiLife v.6.10.1 software. Raw data sampling frequency was set to 30 Hz, and extracted as 60-s epochs with a low frequency extension filter for the present analyses. Uniaxial data were analyzed.

Of the 1111 participants, 1067 (96%) agreed to wear the accelerometer and 948 (85.3%) showed valid data of at least 600 min of recording for at least 4 days (Trost et al., 2005). The majority (67%) showed valid data for the entire 7-day period, 19% had data for 6 days, 9% for 5 days, and 5% for 4 days. Accelerometer data are shown as average time per day spent in intensity-specific categories (SED, LIPA, and MVPA), using mean counts per minute (cpm) as a mean value of activity over the entire studied period, and as the degree of fulfillment of current PA recommendations. Wear time was defined as the non-wear time subtracted from 24 h. Non-wear time was defined as 0 cpm for more than 60 min, while allowing a maximum of 2 min between 0 and 100 (Troiano et al., 2008). With regard to intensity, cpm < 100 was defined as being in SED (Matthews et al., 2008), between 100 and 2019 cpm as LIPA, and >2019 cpm as MVPA (Troiano et al., 2008). Mean cpm is a measure of total PA, which was calculated by dividing the total number of counts registered by total wear time.

To better understand to which extent Swedish national PA recommendations are actually met, analyses were performed with variation in strictness of interpretation as follows: (1) accumulating at least 150 min/week; (2) accumulating at least 150 min/week from prolonged bouts of 10 min or more; (3) accumulating at least 30 min/day on at least 5 days of the week; and (4) accumulating at least 30 min/day on at least 5 days of the week, all from bouts of 10 min or more.

### 2.4. Cardiorespiratory fitness

All of the participants were invited to undertake a submaximal ergometer test. CRF ($VO_2$max, expressed as $mL \cdot min^{-1} \cdot kg^{-1}$) was estimated by the Åstrand method (Astrand, 1953; Astrand and Ryhming, 1954), which is based on a linear relationship between heart rate and oxygen consumption with workload. Measurement of heart rate at a sub-maximal work rate, usually 60–70%, allowed for estimation of maximal oxygen uptake. A total of 592 participants had valid tests. Participants with a diagnosed heart condition or taking beta-adrenergic blockers constituted a majority of excluded participants, other reasons for non-participation included pain (hips, back, knees), obesity and perceived inability to perform the test.

### 2.5. Other measurements

Anthropometrics, including weight, height, waist, and hip circumference, were measured at the first study visit. Body mass index (BMI) was calculated (body weight / height squared) and stratified into groups: (1) underweight (BMI < 20); (2) normal weight (BMI ≥ 20 and <25); (3) overweight (BMI ≥ 25 and <30); and (4) obese (BMI ≥ 30). The waist-hip-ratio (WHR) was calculated and classified as high or low according to current WHO guidelines, with >0.90 for men and >0.85 for women classified as high (Nishida et al., 2010). A comprehensive questionnaire was administered to collect data regarding self-reported health, and environmental and psychosocial factors. Self-reported active smoking, diabetes, and chronic obstructive pulmonary disease/asthma diagnosis were dichotomized. Measurements of brachial blood pressure and samples for blood chemistry were also collected.

### 2.6. Statistical analysis

Data were tested for normality using the Shapiro–Wilk test. Because most variables were skewed, descriptive data are shown untransformed as median and interquartile range (Q1–Q3). We used multiple regression models to estimate the associations of our main outcomes and SES areas, independently of sex, age, and educational level, and their