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Original research

A 6 year longitudinal study of accelerometer-measured physical activity and sedentary time in Swedish adults

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ABSTRACT

Objectives: The aim of this study was to investigate changes over six years in physical activity and sedentary behavior assessed with accelerometry in a representative sample of Swedish adults.
Design: A longitudinal study over six years.
Methods: The cohort consisted of 1172 participants (46% males) in 2002 and 511 participants (46% males) in 2008, of which 478 (45% males) had valid data on both occasions. Mean (SD) age at baseline was 45 (15) years. To analyze changes over time, a mixed linear model for average intensity physical activity (counts/min) and time in sedentary behavior and light- and moderate- or higher-intensity physical activity was conducted, stratified for sex and age, and adjusted for BMI, education, self-rated health and Δ wear time.
Results: Over a six year period no significant changes were seen in the total cohort for average intensity and time in moderate- or higher intensity physical activity. A significant decrease in average intensity physical activity was found for men ($p = 0.006$) and those aged 60+ years at baseline ($p < 0.001$). A significant increase (26 min/day) for sedentary time in the total cohort ($p < 0.001$) and for time in moderate or higher intensity physical activity among women ($p < 0.001$) and those aged 40–59 years at baseline ($p = 0.014$) was found over the follow-up period.
Conclusions: The overall increase in sedentary time and decrease in average physical activity among men and the elderly are of concern, since they might result in an elevated risk of developing chronic diseases.

1. Introduction

Participation in regular physical activity reduces the risk of coronary heart disease, stroke, diabetes, hypertension, colon cancer, breast cancer, depression, and premature death.[1,2] Data on adults indicate that the minimal amount of physical activity to achieve substantial health benefits occurs at levels of 150 min of at least moderate-intensity physical activity per week.[2,3] This activity should be in addition to routine light-intensity physical activities of daily living. Irrespective of the amount of time in moderate- or higher-intensity physical activity, time spent sedentarily has been suggested as an independent risk factor for metabolic diseases and premature death.[4,5]

The World Health Organization (WHO) has called for urgent actions to monitor population physical activity data and key factors affecting physical activity.[6,7] To be able to promote physical activity, a better understanding is needed of group-level changes in physical activity and sedentary behavior over time. One reason for the lack of knowledge in this area to date is the complexity of measuring physical activity. Data on physical activity is most often self-reported, which has limitations regarding criterion validity.[8] Objective measures of physical activity by motion sensors, such as accelerometers and pedometers, have therefore become common in research, as they are more valid, unbiased, and unobtrusive and can store information, and they can measure a whole day or week without much inconvenience for the participants.[9] Furthermore, they can provide accurate information on total physical activity and sedentary behavior, as well as patterns of physical activity in different intensities.

Recent population-based cross-sectional studies using objective measures have reported a much lower prevalence of achieving the current recommendations on physical activity compared to

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self-reported data.[10–12] This further underscores the importance of using objective measures to accurately assess changes in physical activity and sedentary time over the lifespan. Despite the advantages of objective measures there are, to our knowledge, no studies to date that have used objective measures of physical activity to assess changes over time in physical activity among representative population samples of adults.

The 2002 Swedish ABC (attitude, behavior, and change) study was one of the first to use accelerometry at a population level to objectively measure physical activity and sedentary time in adults.[10] For the present study the participants of the ABC study were measured again after a six-year follow-up period.

The aim of this study was to investigate changes in objectively measured total physical activity, time in different intensity of physical activity, and sedentary behavior in Swedish adults over a six-year period.

2. Methods

In 2002, physical activity levels and patterns were assessed in a nationally representative sample of Swedish adults (aged 18–75) using accelerometry.[10] The same cohort was contacted again six years later (in 2008). Each individual was reassessed in the same month of the year as in the first measurement. The study was approved by the Huddinge University Hospital ethical board (378/02). A detailed description of the study is provided elsewhere[10,13].

Physical activity was assessed with a uniaxial Actigraph Model 7164 accelerometer (Actigraph, LLC, Fort Walton Beach, Florida, USA) set at 1-min epochs. The Actigraph measures vertical acceleration, and when processed in a digital filter the output is *counts*. Using an elasticized belt, participants were instructed to wear the accelerometer for seven consecutive days on the lower back and to remove the device while sleeping, swimming, and bathing.

Accelerometer data were analyzed in the Actigraph complementary software, Actilife 6. Data for respondents with at least four days and >10 h per day of valid wear time were included in the analysis. A minimum of 4 recording days has been recommended by Trost et al. to reflect 1 week of physical activity.[14] Wear time was defined by subtracting non-wear time from 24 h. "Non-wear time" was defined as an interval of at least 60 consecutive minutes of 0 counts, with allowance for up to 2 min of up to 100 counts.

Total physical activity is presented as average intensity—i.e. total counts divided by wear time (counts/min). Cutoffs for time in sedentary behavior and moderate or higher intensity were defined in accordance with previous studies of this population.[13] Time spent in sedentary behavior was estimated as the amount of wear time accumulated below 100 counts/min.[15] For the classification of moderate- or higher-intensity activities we used a threshold of ≥2020 counts/min.[12] Light intensity was consequently classified as counts between 100 and 2019 counts/min. To control for different wear times at the two time points we also calculated percent (%) of wear time for each physical activity category.

Demographic and anthropometric data were self-reported at the first test occasion and included age, sex, height, weight, educational attainment, self-rated health, and leisure-time exercise habits. Body mass index was computed as weight (kg)/height (m)^2. Age and body mass index were each categorized into three levels (18–39, 40–59, 60–75 years; <25, 25–29.9, >30 kg/m^2). Educational attainment was categorized into primary school, upper secondary, and university degree or more. Self-rated health was reported on a five–point scale, ranging from excellent to poor and grouped into three levels (excellent/very good, good, fair/poor). Exercise habits were assessed with the same question used by Statistics Sweden in their biennial surveys on living conditions.[16] The scale ranged from (1) never, (2) seldom, (3) once a week, (4) regularly, around twice a week, to (5) regularly, at least three to four times per week at a strenuous level. For the analyses, responses were categorized into two groups using levels four and five as indicators of regular exercisers (twice per week or more).

Descriptive data on physical activity variables are presented as means and standard deviations (SD). Descriptive data on sex, age groups, BMI groups, education, self-rated health, and exercise habits are presented as frequency and/or percentage (%). Chi-square tests were performed to determine potential differences between baseline and follow-up demographic variables such as sex, age groups, BMI categories, educational level, and exercise habits.

To calculate changes in physical activity and sedentary time on a group level between 2002 and 2008, a mixed linear model design was used, with unstructured covariance for total physical activity as counts per minute, as well as for time and percent of wear time in sedentary behavior, light-intensity activity, and moderate- or higher-intensity activity. An advantage of mixed modeling is that it allows for inclusion of subjects with different numbers of observations, maximizing the power in the analyses.[17] Models were built considering both random intercepts and slopes in order to model individual change over time. The results are presented as estimated marginal mean differences with 95% confidence intervals (CI). All variables were adjusted for sex, age group, BMI category, educational level, and accelerometer Δ wear time (difference in wear time between the two time points). Time in sedentary behavior and time in physical activity at light and moderate or higher intensity were also adjusted for wear time. Interactions between time and sex, age, and BMI, respectively, were tested. If significant interactions occurred, data were stratified.

The data were analyzed using Statistical Package for the Social Sciences (SPSS) version 20.0 SPSS Inc., Chicago IL, USA. The significance level was set to $p < 0.05$.

3. Results

Characteristics of the cohort by measurement year are shown in Table 1. In total, 1172 participants (46% males) in 2002 and 511 participants (46% males) in 2008 had valid data, of which 478 (45%males) had valid data on both test occasions. Mean (SD) age at baseline for the total sample was 45 (15) years and for the included sample 45 (14) years. The significant difference between the age group proportions at baseline and among those lost to follow-up indicates that more young people were lost to follow-up. No differences in baseline data were found for those who dropped out compared to those who followed the study with regard to sex, BMI, education level, self-reported health, or exercise habits.

Levels and patterns of physical activity and sedentary time at both time points are shown in Table 2. A significant interaction effect for time and sex, as well as for time and age, was found for average intensity (counts/min) and time in light and moderate or higher intensity ($p < 0.001$). Therefore, data was stratified by sex and age. No interaction effect was found for time and BMI.

Table 3 shows the estimated marginal mean differences, 95% CIs, and p-values between baseline and follow-up for the total sample and for the sex and age groups. For total physical activity (average intensity), no significant change was found for the total group ($p = 0.097$). However, a significant decrease over the follow-up period was found for men (mean 33 counts/min, $p = 0.006$) and those aged 60+ years at baseline (mean 53 counts/min $p < 0.001$).

For sedentary time, a significant increase over the follow-up period was found in the total sample, with a mean of 26 min per day ($p < 0.001$). The significant increase in sedentary time held up