Change in physical activity and accumulation of cardiometabolic risk factors

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Abstract

This study aims to examine the association between change in physical activity levels over time and accumulation of cardiometabolic risk factors. Four consecutive surveys (Time 1 to 4) were conducted with 4-year intervals in 1997–2013 (the Finnish Public Sector study). Physical activity of 15,634 cardio-metabolically healthy participants (mean age 43.3 (SD 8.7) years, 85% women) was assessed using four-item survey measure and was expressed as weekly metabolic equivalent (MET) hours in Time 1, 2, and 3. At each time point, participants were categorised into low (<14 MET-h/week), moderate (≥14 to <30 MET-h/week), or high (≥30 MET-h/week) activity level and change in physical activity levels between Time 1 and 3 (over 8-years) was determined. The outcome was the number of incident cardiometabolic risk factors (hypertension, dyslipidemia, diabetes, and obesity) at Time 4. Cumulative logistic regression was used for data analysis. Compared to maintenance of low physical activity, increase in physical activity from low baseline activity level was associated with decreased accumulation of cardiometabolic risk factors in a dose-response manner (cumulative odds ratio [cOR]=0.73, 95% CI 0.59-0.90 for low-to-moderate and cOR=0.67, 95% CI 0.49-0.89 for low-to-high, P for trend 0.0007). Decrease in physical activity level from high to low was associated with increased accumulation of cardiometabolic risk factors (cOR=1.60, 95% CI 1.27-2.01) compared to those who remained at high activity level. Thus even a modest long-term increase in physical activity was associated with reduction in cardiometabolic risk whereas decrease in physical activity was related to increased risk.

Introduction

Physical inactivity has been ranked among the top risk factors for global burden of disease and mortality (GBD 2015 Mortality and Causes of Death Collaborators, 2016; GBD 2015 Risk Factors Collaborators et al., 2016). Physically inactive individuals have a higher risk for cardiovascular morbidity and mortality compared to those who are physically active (Physical Activity Guidelines Advisory Committee, 2008; Shiroma and Lee, 2010; Warburton et al., 2010). Meta-analyses have additionally shown that there is a dose-response relationship between higher levels of self-reported leisure time physical activity and reduced incidence of coronary heart disease (CHD) and stroke (Li et al., 2013; Li and Siegrist, 2012). However, most studies have measured physical activity at one time point only. The extent to which long-term changes, both increases and decreases, in physical activity may affect health outcomes remains unclear (Andersen, 2004; Shortreed et al., 2013).

Studies suggest that changes in physical activity during mid-life or later life are common and that the changes in physical activity are associated with the changes in body weight, waist circumference, blood pressure, and lipids (Aadahl et al., 2009; Balkau et al., 2006; Byberg et al., 2001). In addition, increase in physical activity has been found to be associated with a lower, and a decrease in physical activity with a higher mortality and cardiac event risk, when compared to unchanged activity (Byberg et al., 2009; Manson et al., 1999; Paffenbarger et al., 1993; Petersen et al., 2012; Wannamethee et al., 1998). However, associations between changes in physical activity over extended periods of time and accumulation of incident cardiovascular risk factors remain poorly characterized.

In this study, we examined whether change in physical activity level is associated with subsequent accumulation of incident hypertension, dyslipidemia, diabetes, and obesity in healthy adults. To capture long-term changes in physical activity, we used repeated data on physical activity over eight years.

Methods

Study population. The study population consisted of participants of the Finnish Public Sector (FPS) study which is an ongoing cohort study on employees of ten towns and six hospital districts (Kivimäki et al., 2007). Survey questionnaires were sent to all current employees of the target organizations as well as those who had earlier participated in the surveys. The participants were from a wide range of occupations from semi-skilled cleaners to physicians and mayors. The FPS has been approved by the ethics committee of the Hospital District of Helsinki and Uusimaa.

In this study we used data from four consecutive surveys conducted in 4-year intervals in 1997/98 (Time 1), 2000/02 (Time 2), 2004/05 (Time 3), and 2008/09 (Time 4), or, in 2000/02 (Time 1), 2004/05 (Time 2), 2008/09 (Time 3), and 2012/13 (Time 4). Overall 26,245 participants responded to all four consecutive surveys from Time 1 to 4. We included only those participants who had no missing data on physical activity from Time 1 to 3, no missing data on cardiometabolic risk factors at Time 3 and 4, and who were free from major cardiovascular events and cardiometabolic risk factors at Time 3. This resulted in an analytical sample of 15,634 cardio-metabolically healthy participants (mean age 43.3 (SD 8.7) years, 85% women) (Figure 1). The study design is illustrated in Figure 2.

At Time 1, mean age did not differ between the study population (respondents to 4 consecutive study waves; N=15,634) and the baseline eligible population of 75,572 cohort participants (43.3 (SD 8.7) vs. 43.7 (SD 9.6) years, respectively). There were more women (85% vs. 76%) and less low educated participants (8% vs. 16%) in the study population vs. eligible population.

Physical activity assessment. Physical activity was assessed identically with four-item survey measure at Time 1, 2, and 3. The respondents were asked to estimate their average weekly hours of both leisure-time and commuting physical activity/exercise within the preceding year in four different intensity level: walking, brisk walking, jogging, and running, or activities with equivalent intensities (Lahti et al., 2010). Each intensity level had five response alternatives of which the class mid-points were used to calculate the time spent in each intensity level: no activity, less than 0.5 hours (15 min used for calculation), ~1 hour (45 min), 2-3 hours (2.5 h), and ≥ 4 hours/week (5 h). Time spent on activity at each intensity level in hours per week was multiplied by the average energy expenditure of each activity and expressed as Metabolic Equivalent (MET). We used the latest available MET-values for each intensity level: walking, brisk walking, jogging, and running corresponded to 3.5, 5, 8, and 11 METs, respectively

(Ainsworth et al., 2011). The amount of physical activity, including both leisure-time and commuting activity, was quantified as weekly MET-hours (Kujala et al., 1998) by summing up the amount of activity at each intensity level together.

The mean of amount of physical activity at Time 1 and Time 2 was used to define the baseline activity level in order to take into account the phenomenon of regression to the mean (Chiolero et al., 2013). The amount of physical activity at Time 3 was used to define the follow-up physical activity level. The participants were categorized into low (<14 MET-h/week), moderate (≥14 to <30 MET-h/week), and high (≥30 MET-h/week) activity levels at baseline and at Time 3. This allowed us to identify individuals who either remained at their baseline activity level or increased or decreased their activity by Time 3 (Figure 2).

We choose the cut-point of 14 MET-h/week because physical activity higher than 14 MET-h/week has been shown to be associated with CHD (Tanasescu et al., 2000) and mortality (Arem et al., 2015; Moore et al., 2012). The activity of 30 MET-h/week is showed to be needed for weight management (Fogelholm et al., 2005).

Assessment of cardiometabolic risk factors. Incident hypertension, dyslipidemia, and diabetes were derived from national registers, and incident obesity was defined as body mass index (BMI) ≥30 kg/m^2 from the self-reported body weight and height. We used data on prescription purchases of antihypertensive, lipid-lowering (statins), and antidiabetic medication to identify cases of hypertension, dyslipidemia, and diabetes, respectively (Halonen et al., 2015). In Finland, drugs for the treatment of these conditions are available by prescription only. All residents are covered by national health insurance, which provides reimbursement for the drugs included in this study and all the reimbursed prescriptions are registered in the Finnish Prescription Register managed by the Social Insurance Institution. For each drug prescription, the dispensing date, the World Health Organization Anatomic Therapeutic Chemical (ATC) code, and the Defined Daily Dosages (DDD) (World Health Organisation, n.d.) were recorded. For antihypertensive medication we used ATC codes C02, C03, C07, C08, and C09; for statins code C10AA, and for antidiabetic drugs code A10. Participants having hypertension or type 2 diabetes were additionally identified based on eligibility for special medication reimbursement for these conditions (Halonen et al., 2015).

The incident cases of hypertension were participants who, for the first time after Time 3, had purchased antihypertensive medication for a minimum of 100 DDD's (three months' medication) or were eligible for special reimbursement for an antihypertensive drug.

Correspondingly, the definition of incident case of diabetes was any participant who had purchased diabetes medication for a minimum of 100 DDD's for the first time after Time 3 or was eligible for special reimbursement for diabetes treatment, and an incident case of dyslipidemia was any participant who had purchased statins for a minimum of 100 DDD's for the first time after Time 3. Subjects with hypertension, dyslipidemia, and diabetes identified by these criteria have previously shown to be 1.7 to 2.4 (95% CIs ranging between 1.3 and 3.7) times more likely to have a definite cardiovascular event (Halonen et al., 2015). The number of incident cases of hypertension, dyslipidemia, diabetes, and obesity at Time 4 were used as the outcome (Figure 2).

Covariates. We included demographic factors (age, sex, and education), alcohol consumption, smoking status and medical conditions (depression, cancer, asthma and rheumatic disorder) as covariates because they are potential confounders for the association between physical activity and the outcomes (Bauman et al., 2012). The covariates were taken from Time 3, which is the start of the follow-up for the outcomes. Age and sex of the participants were obtained from the employers' registers. Information about the participants' highest educational degree was obtained from Statistics Finland and it was used as a three-class variable for individual socioeconomic status: low (≤9 years of education), intermediate (>9 to ≤12 years) and high (>12 years). High alcohol intake was indicated by self-reported average consumption of more than 288 g/week of pure alcohol for men and 192 g/week for women or having passed out due to high alcohol consumption at least once during the past 12 months. Self-reported smoking status was derived from the survey and dichotomized into current smoker and current non-smoker. Information on depression was based on the Finnish Prescription Register kept by the Social Insurance Institution of Finland (SII) (ATC code N06A). Other chronic medical conditions were obtained from nationwide registers: asthma and rheumatic disorder based on Drug Reimbursement Register by SII and cancer based on the Finnish Cancer Registry. For the analyses, participants were categorized as having no medical conditions or having ≥1 medical conditions (depression, cancer, asthma, and/or rheumatic disorder).

Statistical analysis. We used cumulative logistic regression analysis to estimate the association between change in physical activity levels from baseline (mean of Time 1 and 2) to Time 3 and the number of incident cardiometabolic risk factors at Time 4. The results were expressed as cumulative odds ratios (cORs) and their 95% confidential intervals (CIs). We stratified all analyses by the baseline activity levels (low, moderate or high), using those who did not change their activity level between baseline and Time 3 as reference groups. We also examined the association between change in physical activity levels and the 4-year incidence of specific risk factors (hypertension, dyslipidemia, obesity, and diabetes) separately in the three baseline activity levels by using logistic regression analysis for each of the outcomes. We examined the interactions between sex and all cardiometabolic risk factors and their sum on changes in physical activity. The sex interaction was suggestive only for hypertension (P=0.09), but not with other risk factors (sum of cardiometabolic risk factors, P=0.37; dyslipidemia, P=0.80; obesity, P=0.65; diabetes, P=0.48). Thus, we decided to conduct all analyses combined for men and women. P for trend was analyzed with logistic regression for each baseline activity level by using the physical activity level at Time 3 as a continuous variable. All analyses were adjusted for age, sex, education, smoking status, alcohol consumption, and medical conditions at Time 3. The SAS 9.4 Statistical Package was used for all of the analyses (SAS Institute Inc., Cary, NC).

Results

Characteristics of the study population at the beginning of the follow-up (Time 3) by baseline physical activity levels are presented in Table 1. Mean age of the study population was 50.5 (SD 8.7) years, 85% of them being women, 8% having low education and 21% medical conditions. Of the participants, 24% had low (mean activity 8.8 (SD 3.6) MET-hours/week), 37% moderate (mean activity 21.6 (SD 4.4) MET-hours/week), and 39% high (mean activity 49.9 (SD 20.9) MET-hours/week) baseline physical activity level. By Time 3, 22% had increased and 27% had decreased their physical activity. At Time 4, 87% of the participants had no risk factors (n=13,648), 11% had one (n=1,757) and 1.5% (n=229) had more than one of the risk factors.

The associations between change in physical activity from baseline to Time 3 and the accumulation of incident cardiometabolic risk factors at Time 4 are shown in Table 2. Compared to those who remained at low activity level, participants who increased their activity were less likely to have cardiometabolic risk factors at Time 4 (cOR=0.73, 95% CI 0.59-0.90 for low-to-moderate and cOR=0.67, 95% CI 0.49-0.89 for low-to-high, P for trend 0.0007). The mean increase in physical activity from low to moderate level was 10.6 (SD 5.1) MET-hours/week and from low to high level 31.7 (SD 16.2) MET-hours/week. Those participants who had a high baseline physical activity level but decreased their physical activity to low level by Time 3 were more likely to accumulate cardiometabolic risk factors by Time 4 compared to those who remained at high activity level (cOR=1.60 (95% CI 1.27-2.01). The mean decrease in physical activity from high to low activity level was 35.0 (SD 17.2) MET-hours/week.

Table 3 shows the associations between change in physical activity and 4-year incidence of hypertension, dyslipidemia, obesity, and diabetes separately. Compared to those who remained at low activity level, participants who increased their activity level from low to moderate lowered the risk for incident obesity (OR=0.69, 95% CI 0.50-0.95). In addition, there was a trend towards lower risk of hypertension and diabetes with increasing physical activity from low baseline activity level (P for trend <0.05) and a trend towards higher risk of dyslipidemia, obesity and diabetes with decreasing physical activity from high baseline activity level (P for trend <0.05). Participants who decreased their activity level from high to low were 1.4 to 1.7 times more likely to develop hypertension (OR=1.41, 95% CI 1.03-1.92), dyslipidemia (OR=1.71, 95% CI 1.00-2.90), and obesity (OR=1.67, 95% CI 1.19-2.34), and four times more likely to develop diabetes (OR=4.27, 95% CI 1.06-17.16) over the next four years when compared to those who remained at high activity level.

Discussion

In this large prospective cohort study with repeated measures of physical activity over eight years, we found that adults with an increase in physical activity from low to moderate or high had a lower likelihood of accumulating cardiometabolic risk factors than those with unchanged low physical activity level. This association followed a dose-response pattern with greater increases being related to greater benefits. In contrast, participants who decreased their physical activity from high to low level had higher odds of developing new cardiometabolic risk factors when compared to those who remained at high physical activity level.

In our study, half of the participants changed their baseline physical activity level by Time 3. This is in line with the proportions found in the previous studies on change in physical activity, although they have been based on only two measurement points (Aadahl et al., 2009; Almeida et al., 2014; Balkau et al., 2006; Byberg et al., 2001). We found that increase in physical activity among the less active individuals lowered the likelihood for accumulating cardiometabolic risk factors in a dose-response manner when compared to those who remained physically inactive. This suggests that even a modest (~10 MET-hours/week) increase in leisure-time or commuting physical activity may be sufficient in reducing the risk of obesity and other cardiometabolic risk factors. Although the differences between activity change categories were not all significant, there was a tendency towards lower risk of hypertension, obesity and diabetes with increasing physical activity from low baseline activity level. Thus, our results complement previous findings suggesting that an increase in physical activity over time is associated with improved blood glucose, reduced weight and waist circumference (Aadahl et al., 2009; Balkau et al., 2006; Byberg et al., 2001; DiPietro et al., 2004).

The findings of this study add evidence on dose-response relationship between amount of physical activity and cardiometabolic health (Eljsvogels and Thompson, 2015; Physical Activity Guidelines Advisory Committee, 2008; Powell et al., 2011), and highlight that cardio-metabolically healthy individuals who are less physically active can reduce their future health risk by only modestly increasing their physical activity level. However, as chronic diseases develop slowly, physical activity should be regular and sufficient over time in order to offer these health benefits. For example, in the Uppsala cohort (Byberg et al., 2009), men who increased their physical activity to a high level over 10 years halved their mortality risk to a level on a par with those who had unchanged high activity level. The reduction in mortality risk by an increase in physical activity was similar to that of smoking cessation in the same cohort.

The participants who decreased their high baseline activity level to low level by Time 3 were more likely to accumulate incident cardiometabolic risk factors over the next four years compared to those who remained at high activity level. A decrease from high to low physical activity level increased the risk for incident diabetes markedly and almost doubled the risk for other risk factors. Although it is plausible that decrease in physical activity over time increases cardiometabolic risk (Booth et al., 2012; Byberg et al., 2001; Petersen et al., 2012; Wannamethee et al., 1998), chronic medical conditions, which are associated to both physical activity and cardiometabolic risk can be an alternative explanation for the link. Thus, we have adjusted our analysis for depression, cancer, asthma and rheumatic disorder. Because controlling for chronic medical conditions did not markedly impacted the results, reversed causality is an unlikely alternative explanation for the link.

Strengths and weaknesses of the study. Strengths of this study include information on repeatedly measured duration, frequency and intensity of leisure-time and commuting physical activity from a large sample of over 15,000 cardio-metabolically healthy individuals over an extended time period. Because baseline assessment used data on two measurements with a 4-

year interval, we were able to minimize biases due to regression to the mean (10). Moreover, all cardiometabolic risk factors, except obesity, were defined based on linkage to reliable national health registers.

Self-report of physical activity can be regarded as a weakness of the study although self-reported activity is frequently used to separate participants into different activity categories in large population studies (Bauman et al., 2009). The chosen cut-point of physical activity ≥14 MET-hours per week has previously been shown to associate with health outcomes in large epidemiological studies (Arem et al., 2015; Moore et al., 2012; Tanasescu et al., 2000). However, some of the participants in the “low activity” group met the current physical activity recommendations. Furthermore, measurement of physical activity did not include occupational physical activity, thus we could not assess total amount of physical activity. Although there were more women and a higher proportion of highly educated participants at the study population compared to the eligible population at Time 1, the test of interactions for the association between change in physical activity and the sum of incident cardiometabolic risk factors by sex ($P=0.37$) and by education ($P=0.71$) was non-significant, suggesting that any difference in the sex distribution or educational attainment between the analytic and eligible population is an unlikely source of important bias in this study. The study population is representative of the Finnish public sector employees, however, the results may not necessarily be generalizable to other sectors or non-working populations.

Conclusions

To conclude, the present study showed that even a modest increase from low activity level over time is enough to reduce risk of obesity and accumulation of incident cardiometabolic risk factors among healthy adults.

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Conflicts of interest:

None declared.

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Figure captions

Figure 1. Flow chart of the selection of the analytical sample. Finnish Public Sector study 1997–2013.

Figure 2. Study design. Finnish Public Sector study 1997–2013.