Preventive Medicine 62 (2014) 89–95

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Impact of different domains of physical activity on cause-specific mortality: A longitudinal study

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ARTICLE INFO

Available online 8 February 2014

Keywords:
Physical activity
Mortality
Cancer
Cardiovascular disease
Adults
Switzerland

ABSTRACT

Objective. The aim of this paper is to examine the associations between different domains of physical activity and all-cause, cardiovascular disease (CVD) and cancer mortality.

Methods. Participants (n = 17,663, aged 16–92 years) of two general population health studies conducted between 1977 and 1993 in Switzerland were included. Physical activity was assessed at baseline in the domains of commuting to work, work-related physical activity, and leisure-time physical activity (including leisure-time activity level and sport activity). A median follow-up time of 20.2 years was obtained with anonymous record linkage providing 3878 deaths (CVD: 1357; cancer: 1351). Adjusted Cox proportional hazard models were calculated.

Results. There were no significant associations between commuting and work-related physical activities, respectively, and mortality. Leisure-time activity level was associated with all-cause mortality in men [adjusted hazard ratio (HR) 0.75, 95% confidence intervals (CI) 0.63–0.89] and women [HR 0.82 (0.74–0.91)], with CVD mortality in women only [HR 0.79 (0.67–0.94)] and with cancer mortality in men only [HR 0.63 (0.47–0.86)]. Sport activity was associated with all-cause, CVD and cancer mortality in men [HR ranged between 0.76 (0.63–0.92) and 0.85 (0.76–0.95)], but not in women.

Conclusions. These results underline the public health relevance of physical activity for the prevention of CVD and cancer, especially regarding leisure-time physical activity.

Introduction

Being physically active decreases the risk of several diseases, including cardiovascular disease (CVD), some types of cancer, diabetes, and osteoporosis (Physical Activity Guidelines Advisory Committee, 2008). In a recent review and meta-analysis, physical activity was inversely associated with all-cause and cause-specific mortality (Nocon et al., 2008); however the strength of evidence differed by cause of death and by sex. While there was a decrease in cancer mortality with higher physical activity levels in men (Kampert et al., 1996; Laukkanen et al., 2011; Orsini et al., 2008), evidence was less clear in women (Kampert et al., 1996). In contrast, evidence for all-cause and CVD mortality is more consistent (Lollgen et al., 2009; Nocon et al., 2008; Woodcock et al., 2011). A meta-analysis showed a risk reduction of 35% for CVD mortality and of 33% for all-cause mortality in the most active compared to the least active participants (Nocon et al., 2008). However, the range of benefits varied considerably between the studies which often assessed different aspects of physical activity such as total physical activity or leisure-time physical activity (from 2% to 81% reduction in CVD and all-cause mortality risk). In order to support domain-specific physical activity promotion, it is important to identify the impact of the different domains of physical activity on health (Slingerland and Borghouts, 2011).

Associations between fitness and all-cause mortality (Blair et al., 1996; Syvaoja et al., 2013) and between physical activity and all-cause mortality (Lee and Paffenbarger, 2000; Paffenbarger et al., 1994) have been described. However, only few studies have investigated the association between different domains of physical activity and all-cause as well as cause-specific mortality, and the evidence is inconsistent (Andersen et al., 2000; Arrieta and Russell, 2008; Autenrieth et al., 2011; Barengo et al., 2004; Besson et al., 2008). Only few of the large cohort studies with data on physical activity and mortality have

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http://dx.doi.org/10.1016/j.ypmed.2014.01.025

included women and relatively few deaths were observed, leaving uncertainty about the benefit of physical activity in women (Andersen et al., 2000). Therefore, it is appropriate to present the results of studies that also included women stratified by sex, as seen in other publications (Andersen et al., 2000; Barengo et al., 2004; Herzig et al., 2012).

In Switzerland, approximately 16,000 and 20,000 individuals died from cancer and CVD in 2010, respectively, accounting for more than 60% of all deaths (Federal Statistical Office (FSO), 2010). Identifying modifiable risk factors associated with these health risks will help to develop promotional activities and allocate resources.

The aim was to analyse the association between different domains of physical activity and all-cause, CVD and cancer mortality in a general population sample from Switzerland with a follow-up time of up to 32 years. Physical-activity domains under consideration were work-related physical activity, active commuting to work, and leisure-time physical activity (including leisure-time activity level and sport activity).

Methods

Study population

The sample ($n = 17{,}663$, aged 16–92 years at baseline) included participants of two studies aimed at assessing and preventing CVD: the National Research Program 1A (NRP 1A) (Gutzwiller et al., 1985), and the Swiss MONICA (MONItoring of trends and determinants in CArdiovascular disease) study (Mattocks et al., 2008). The NRP 1A was conducted from 1977 to 1979 in the three main language regions of Switzerland based on a random sample of 4378 and a convenience sample of 3873 participants (Bopp et al., 2012). The Swiss MONICA study was conducted in the French and Italian speaking parts of Switzerland in three waves between 1984 and 1993 (Wietlisbach, 1987; Wietlisbach et al., 1997). Participants attended a health examination and completed a self-administered questionnaire. The questionnaire was only administered at baseline.

Mortality follow-up data were obtained up to 2008 by anonymous record linkage with data from the Swiss National Cohort (SNC) (Bopp et al., 2010, 2012, 2009). Approval (Nr. 13/06) was obtained from the Ethics Committee of the Canton of Zurich. Briefly, 8008 out of 8539 eligible (93.8%) participants of NRP 1A (Bopp et al., 2012) and 9853 out of 10,160 eligible MONICA participants (97.0%) could be linked with the SNC (Bopp et al., 2010). For the present analyses, 7890 NRP 1A participants (98.5%) were included accumulating 204,095 person-years of follow-up and 2370 deaths. 500 individuals were excluded due to missing data. From the MONICA study, 9773 participants (99.2%) were included accumulating 174,700 person-years and 1508 deaths. 165 individuals were excluded due to missing data. The final dataset included 17,663 individuals, 378,795 person-years of follow-up and 3878 deaths (1357 due to CVD and 1351 due to cancer).

Measurements

Self-reported current physical activity as exposure variable was available in the following domains: transportation (number of minutes per day of active commuting (cycling or walking) to work), work-related physical activity (intensity of professional activity), and leisure-time physical activity, including frequency of "sport activity" (more than once a week, once a week, and less or never) and "leisure-time activity level" (low, moderate, high). The questions and categorisations are available in the Appendix A. The categorisation of the work-related variable was driven by the slightly different assessment in the two surveys.

Apart from the physical activity variables, we used the following covariates: sex, age (in years), educational level (according to the International Standard Classification of Education ISCED: mandatory school, vocational education, higher vocational education, university), marital status (single, married, widowed, divorced/separated), survey (NRP 1A, MONICA), smoking (never smoker, former smoker, light smoker, heavy smoker), diet (having three regular meals per day: breakfast, lunch, dinner; based on evidence that skipping meals such as breakfast is associated with an increased risk of coronary heart disease (Cahill et al., 2013)), body mass index (BMI) based on measured height and weight (kg/m^2), systolic blood pressure (mm Hg), and cholesterol (mmol/l).

The outcome was defined as all-cause mortality and cause-specific mortality (CVD: ICD-8: 410–438; ICD-10: I00–I99; cancer: ICD-8: 140–239; ICD-10: C00–C99; D00–D48). In Switzerland, causes of death were coded based on ICD-8 until 1994 and based on ICD-10 from 1995 on.

Statistical analyses

Associations between physical activity and mortality were calculated using Cox proportional hazard models and displayed as hazard ratios (HR) and 95% confidence intervals (95% CI). Time to event was the difference between start time (date of baseline interview) and stop time (date of death, emigration or end of study on December 31, 2008). In a first step, all domains of physical activity were included in one model with the outcome all-cause mortality. In this model, only persons with occupation working ≥50% ("working population") were used for analysis since work-related physical activity and active commuting to work were only available for those participants. Because the associations between work-related or commuting activities, respectively, and all-cause mortality were statistically not significant (see result section), cause-specific mortality was analysed only for leisure-time activity level and sport activity. This also increased the sample size and the number of deaths, especially for women, as all individuals and not only the working population could be included in the analyses. Therefore, in a second step, leisure-time activity level and sport activity were entered into the models separately because of high correlation between these two variables (data not shown).

Akaike's information criterion (AIC) and the Bayesian information criterion (BIC) were used for model choice. The following adjustments were made: Model 1 for the socio-demographic variables sex, age, educational level, marital status, and survey; Model 2 additionally for the behavioural variables smoking and diet; Model 3 additionally for the clinical/biological variables BMI, blood pressure and cholesterol. Models 3 are presented in the Electronic Supplementary Material only, since these physiological parameters may also be intermediate variables on the causal pathway between physical activity and mortality, and controlling for them may therefore result in over-adjustment (Bundesamt für Statistik BFS, 2013). In view of the lack of data on the association between physical activity and mortality in women (Andersen et al., 2000; Barengo et al., 2004), the analyses were computed also stratified by gender, even though formal testing for interaction between gender and the physical activity variables did not reveal significant results. Age-standardised mortality rates (based on Switzerland's population on December 31, 1990) were calculated per 100,000 person-years for different combinations of sport and leisure-time activity levels for men and women separately.

Statistical significance was set at $p < 0.05$. Analyses were carried out using STATA version 12 (StataCorp LP, College Station, Texas, 2011).

Results

Characteristics of participants

The characteristics of the participants are shown in Table 1 separately for the entire population and for the working population. The proportion of women was 51.1%, the mean age 45.0 years. On average, men had higher educational levels than women, were more often former and heavy smokers, were more likely to be married and less likely to have three regular meals per day.

MONICA participants were older than NRP 1A participants (men 47.0 versus 42.0 years, women 47.3 versus 43.3 years); this is due to the inclusion of participants aged 25–74 years only in MONICA while in NRP 1A the lower age limit was 16 years. Probably due to the same reason, a higher proportion of MONICA participants was married (men 80.2% versus 73.9%, women 74.0% versus 65.8%) and had a higher educational level (men 10.5% versus 6.6%, women 4.5% versus 1.4% with a university degree).

The total person-years of follow-up are shown in Table 1, the median follow-up time was 20.0 years for men and 22.6 years for women.

All-cause mortality

As shown in Table 2 and in Electronic Supplementary Material Table 1 (working population only), there were no significant associations