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Physical activity patterns and metabolic syndrome in Costa Rica

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ABSTRACT

Objective. To examine whether total physical activity or activity patterns are associated with metabolic syndrome and its components.

Methods. Participants include 1994 controls from a case–control study of non-fatal myocardial infarction in Costa Rica (1994–2004). Physical activity was assessed via self-administered questionnaire and patterns were identified using principal components analysis. Metabolic syndrome was assessed via blood samples and anthropometry measurements from in-home study visits. Prevalence ratios (PRs) and 95% confidence intervals (CIs) were calculated using log binomial regression. Adjusted least squares means of metabolic syndrome components were calculated by quintile of total activity and pattern scores.

Results. Four activity patterns were identified: rest/sleep, agricultural, light indoor activity, and manual labor. Total activity was not associated with metabolic syndrome. Metabolic syndrome prevalence was 20% lower in participants with the highest scores on the agricultural job pattern compared to those with the lowest (PR: 0.80, 95% CI: 0.68–0.94). Higher total activity was associated with lower triglycerides and lower HDL cholesterol. Higher scores on each pattern were inversely associated with metabolic syndrome components, particularly waist circumference and fasting blood glucose.

Conclusions. Patterns or types of physical activity may be more strongly associated with metabolic syndrome and its components than total activity levels.

Introduction

Metabolic syndrome is characterized by several related cardiometabolic risk factors including abdominal obesity, hypertriglyceridemia, hypertension, low high-density lipoprotein (HDL) cholesterol, and elevated fasting glucose, and is significant because of its association with increased risk of diabetes and cardiovascular disease (Eckel et al., 2005; Expert Panel on Detection and Treatment of High Blood Cholesterol in Adults, 2001; Lakka et al., 2002). Prevalence of metabolic syndrome has increased in recent decades, in parallel with increases in obesity and diabetes, and is well over 20% in some countries (Ford et al., 2004; Halldin et al., 2007).

Preventing and reversing metabolic syndrome is a promising strategy for reducing its obesity-related comorbidities, and evidence suggests that physical activity is effective in preventing and treating metabolic syndrome (Ford and Li, 2006). Studies in several international populations suggest that higher total levels of physical activity are associated with lower incidence and prevalence of metabolic syndrome (Bertrais et al., 2005; Cho et al., 2009; Dunstan et al., 2005; He et al., 2013; Irwin et al., 2002; Lakka and Laaksonen, 2007; Panagiotakos et al., 2004; Santos et al., 2007; Zhu et al., 2004) and that low levels of physical activity are associated with progression to metabolic syndrome over time (Ekelund et al., 2005); however, these relationships may not be consistent by type or intensity of physical activity (Ford et al., 2005; He et al., 2013; Lakka and Laaksonen, 2007; Lakka et al., 2003). Cardiorespiratory fitness is also related to lower incidence (Ninomiya et al., 2004) and prevalence of metabolic syndrome (Irwin et al., 2002; Lakka and Laaksonen, 2007; Lee et al., 2005). Differences have been reported by type of physical activity, with some previous research suggesting that higher levels of leisure-time, but not occupational, physical activity are associated with lower metabolic syndrome prevalence (Halldin et al., 2007; Sisson et al., 2009). Relationships have also been reported between higher levels of leisure-time sedentary behavior and higher metabolic syndrome prevalence (Cho et al., 2009; Ford et al., 2005; Hamilton et al., 2007; Sisson et al., 2009).

The purpose of this study is to determine whether patterns of physical activity, identified through principal components analysis, are associated with metabolic syndrome or its components in a population-representative sample of Costa Rican adults with no history of myocardial

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infarction (MI). Given previous findings that associations between physical activity and metabolic syndrome may differ by type and intensity, examining activity patterns rather than total amounts may help capture associations not evident when looking at total activity. It is particularly important to address these questions in a population in the developing world, where prevalence of obesity and its comorbidities, including diabetes, has increased rapidly in recent decades (Malik et al., 2013).

Materials and methods

Study population

Participants were taken from the controls in a case–control study of non-fatal myocardial infarction (MI) conducted in the Central Valley of Costa Rica from 1994 to 2004. This study has been described previously (Baylin et al., 2003; Campos and Siles, 2000). Eligible cases were diagnosed with a first MI at one of the three hospitals in the study catchment area. Controls were matched to cases by age (within 5 years), sex, and county of residence using data from the National Census and Statistics Bureau of Costa Rica, and are representative of the general population within matching strata. The response rate for controls was 88%. Individuals were ineligible if they previously suffered an MI or were physically or mentally unable to answer the questionnaire.

The study enrolled a total of 2273 cases and 2274 controls. The analyses presented here are limited to controls. Additionally, participants were excluded if they were missing data on time spent sleeping ($n = 4$), reported sleeping less than 2 h per night ($n = 2$), were missing >2 physical activity questions ($n = 9$) or had insufficient physical activity data to conduct principal components analysis ($n = 32$), reported 6 + average METs/h of activity while awake ($n = 19$), >20 h/day of physical activity ($n = 185$), or total METs 2 + standard deviations from the mean (below 3.19 or above 67.86 METs/day) ($n = 97$); or whose metabolic syndrome status was unknown ($n = 29$). Exclusions were not mutually exclusive and yielded a final study population of 1994, including 916 participants with metabolic syndrome and 1078 without.

All participants gave informed consent. This study was approved by the Ethics Committee of the Harvard School of Public Health and the National Institute of Health Research (INISA) at the University of Costa Rica.

Data collection

Data collection was completed in participants' homes and included the administration of a detailed questionnaire; anthropomorphic measurements; and a blood sample. The questionnaire included information on sociodemographic characteristics; detailed medical history, including individual and family history of diabetes and hypertension; medication use; and health behaviors including smoking, diet, and physical activity.

Physical activity

Physical activity and energy expenditure were assessed using questions about sleep duration on weekends and weekdays and frequency and duration of several occupational, household, and leisure time activities during the previous year. This questionnaire was validated against its ability to predict performance on the Harvard Step test in previous studies in Puriscal, Costa Rica (Campos et al., 1991, 1992). Activities were assigned metabolic equivalent (MET) values based on their intensity. METs provide a standardized measure of estimated energy expenditure of several activities relative to a resting metabolic rate of 1.0 ((4.184 kJ)$\cdot$kg$^{-1}\cdot$h^{-1}), equivalent to sitting quietly, and were assigned to activities as follows: sleeping; napping; lying in bed during the day to read; watch television or listen to music (0.9 METs); sitting at work or in activities such as driving or watching TV (1.0 METs); standing in light activities at work (e.g. copying, filing) or at home (e.g. laundry, cooking, cleaning) (2.3 METs); standing doing general cleaning (e.g. mopping, sweeping, washing the car) or walking on flat terrain (2.5 METs); standing and kneeling doing yard work (3.0 METs); non-vigorous agriculture work or work in construction (4.5 METs); practicing sports (general) (6.0 METs); walking on mountainous terrain (6.3 METs); moving or carrying heavy items (e.g. furniture, luggage) (7.0 METs); practicing team sports (e.g. soccer, basketball) aerobics, racquet sports (7.2 METs); climbing stairs; practicing individual sports (e.g. swimming, running, cycling) (8.0 METs); and performing heavy or vigorous jobs (e.g. shoveling digging ditches, cutting trees) (8.5 METs) (Ainsworth et al., 1993, 2000).

Metabolic syndrome

Metabolic syndrome was defined based on the guidelines of the National Cholesterol Education Program's Adult Treatment Panel III (Expert Panel on Detection and Treatment of High Blood Cholesterol in Adults, 2001), and updated by the American Heart Association and National Heart, Lung, and Blood Institute (Grundy et al., 2005). Participants were classified as having metabolic syndrome if they had at least three of the following risk factors: waist circumference >102 cm in men or >88 cm in women; triglycerides ≥150 mg/dL or taking medication to lower triglycerides; high-density lipoprotein (HDL) cholesterol <40 mg/dL in men or <50 mg/dL in women, or taking medication to improve HDL cholesterol; systolic blood pressure ≥130 mm Hg or diastolic blood pressure ≥85 mm Hg or taking antihypertensive medication; or fasting glucose ≥100 mg/dL or taking medication to lower blood glucose. Waist circumference and blood pressure were each measured twice by study staff, and the average of the two measures was used in analysis. Triglycerides, HDL cholesterol, and fasting blood glucose were assessed using a fasting blood sample, and both the blood sample and blood pressure measurements were taken in the morning, after participants voided urine and rested for 10 min.

Data analysis

Physical activity patterns were identified using principal components analysis (PCA) on 18 physical activity variables using orthogonal varimax rotation to yield four components (physical activity patterns) that were independent and interpretable. The number of retained patterns was determined by examination of the scree plots, eigenvalues, the interpretability of the resulting patterns, and parsimony (Mertler and Vannatta, 2010). Participants' scores on each of the four components were calculated by summing the time spent in each activity, weighted by their component loadings. Higher component loadings indicate higher adherence to that pattern. The factor score for the light indoor activity pattern was reversed so that higher scores indicate higher levels of standing in light activities and doing general cleaning, and lower levels of sitting at work or in activities such as driving or watching television. Similar physical activity patterns emerged in a sensitivity analysis where PCA was conducted separately in men and women, so they are combined in the analyses presented here.

We used t-tests and chi-square tests to compare means and proportions between participants with and without metabolic syndrome. We used binomial models to estimate prevalence ratios and 95% confidence intervals of metabolic syndrome by quintiles of total physical activity and each physical activity pattern score. *P*-values for trend were obtained from the Wald test of quintiles of physical activity modeled as a continuous variable. Least squares means and 95% confidence intervals were estimated for each component of metabolic syndrome by quintile of total physical activity and quintile of each physical activity pattern score using generalized linear models. Linear mixed models with empirical variances were used in models of triglycerides and blood glucose, which were not normally distributed (Kim et al., 2010; White, 1980). Adjusted models included continuous age, sex, urbanicity (urban/periurban/rural), monthly household income (continuous), whether participants were current smokers (yes/no), and maternal or paternal history of hypertension (yes/no) and diabetes (yes/no). Inclusion of several additional dietary and other factors, including waist-to-hip ratio; total energy intake; percent of calories from protein, carbohydrate and total, monounsaturated, polyunsaturated, saturated and trans fat; total fiber intake; and total METs of physical activity did not affect the results and these variables are not included in the final models, unless otherwise noted.

All analyses were conducted using SAS 9.2 (SAS Institute, Cary, NC).

Results

Nearly half of the participants (45.9%) had metabolic syndrome. Participants with metabolic syndrome were older on average, a higher proportion was female, and a lower proportion lived in urban areas or was current smokers compared to those without metabolic syndrome (Table 1). Monthly household income was somewhat lower in participants with metabolic syndrome than in other respondents.

High blood pressure, hypertriglyceridemia, and low HDL cholesterol were the most prevalent components of metabolic syndrome among both participants with metabolic syndrome (91.7%, 90.5%, and 85.4%, respectively), and those without (47.6%, 52.2%, and 45.6%, respectively).