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Associations between domains of physical activity, sitting time, and different measures of overweight and obesity

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ABSTRACT

Objective. To describe 1) cross-sectional associations between domain-specific physical activity, sitting time and different measures of overweight/obesity and 2) longitudinal associations between patterns of change in physical activity and overweight/obesity ten years later.

Methods. Cross-sectional and longitudinal analyses based on the first and second follow-up of the Swiss cohort study SAPALDIA (SAP) were conducted (SAP2 in 2002/03, SAP3 in 2010/11). Physical activity was assessed by self-report using the long International Physical Activity Questionnaire (IPAQ) and four short questions regarding moderate and vigorous activities. Overweight/obesity were defined based on body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR) and percent body fat based on bioelectric impedance analysis (BIA), all measured objectively. Multivariable logistic regression was used for analyses.

Results. Cross-sectionally, leisure-time and vigorous physical activity were inversely associated with all obesity parameters. Most consistent associations were found with BIA percent body fat. There were no associations between work-related and domestic activities and overweight/obesity. Sitting time was positively associated with BIA percent body fat, but not with BMI, WHR and WHtR. Longitudinally, remaining inactive from SAP2 to SAP3 was associated with obesity and BIA percent body fat at SAP3 and with weight increase, becoming inactive with BIA percent body fat and weight increase.

Conclusions. The results support associations between physical activity and overweight/obesity cross-sectionally and longitudinally. Most consistent associations were found for BIA percent body fat. For prevention purposes, the results indicate that physical activity can have an important contribution to weight management.

Introduction

Physical activity and sports contribute to between 25% and 50% of total daily energy expenditure (Bouchard et al., 2007) and can thus be important factors for weight control. There is evidence that active individuals have a healthier body mass and composition than inactive individuals (Physical Activity Guidelines Advisory Committee, 2008; Fogelholm and Kukkonen-Harjula, 2000). Total physical activity is usually composed of different aspects such as transport-related, job-related, domestic, and leisure-time physical activity, and there may be different associations between domain of physical activity and overweight/obesity. For example, an inverse relationship has been found for active transport (walking and cycling) and overweight/obesity (Wanner et al., 2012). In addition, there are indications that sedentary behavior represents a risk that is distinct from physical inactivity (Thorp et al., 2011). However, there is not much known about the impact of either different domains of physical activity or of different patterns of physical activity on weight status.

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Furthermore, overweight and obesity is mostly defined according to body mass index (BMI), often based on self-reported weight and height, which can be associated with limitations such as (selective) misclassification due to social desirability (Larson, 2000). Moreover, BMI has been criticized as not being an optimal measure of overweight and obesity, especially in terms of disease risks (Lee et al., 2008). Measures of central obesity like waist circumference (WC) (Czernichow et al., 2011), waist-to-hip ratio (WHR) (Czernichow et al., 2011; Petursson et al., 2011) and waist-to-height ratio (WHtR) (Lee et al., 2008) have been shown to be better discriminators for mortality and cardiovascular and metabolic disease phenotypes. However, it is not clear yet whether central fat is more strongly associated with health outcomes than fat located in other regions of the body, or whether central obesity measures are better measures of overall body fat. Furthermore, these measures can also be biased, e.g. depending on the body fat distribution.

Several factors may confound associations between physical activity and body weight. Some of the more obvious ones, such as age, education, smoking, and ethnicity, are often taken into account in analyses. However, not all studies have assessed other potential confounders such as information on dietary intake or self-reported general health status. Finally the role of reverse causality (individuals with higher weight being less likely to be active due to their body weight) is not clear yet. Longitudinal studies are needed to shed light on such associations.

The aims of the present study in a general adult population of Switzerland are: 1) To describe cross-sectional associations of domain-specific and total physical activity as well as sitting time with different objective measures of overweight and obesity: BMI, percent body fat based on bioelectric impedance analysis (BIA), WC, WHR, and WHtR, taking into account several potential confounders including health-related variables such as self-reported general health status, sleep duration, smoking, alcohol consumption and energy intake; 2) To describe longitudinal associations between patterns of change in general physical activity and different measures of overweight and obesity ten years later. The specific contribution of this study are the detailed information on domain-specific physical activity, information on weight status beyond BMI, the adjustment for a number of important potential confounders, and the longitudinal dimension in addition to the cross-sectional analyses.

Methods

Study design, procedures and participants

The present analysis is part of the SAPALDIA cohort study (Swiss Cohort Study on Air Pollution and Lung and Heart Disease in Adults), which started in 1991 with 9651 randomly selected adults aged 18–60 years from eight regions in Switzerland (Martin et al., 1997). No physical activity data was obtained at baseline (SAP 1). The first follow-up assessment (SAP 2) took place in 2002/03 and included four short questions regarding physical activity. 8047 individuals provided questionnaire data and 6500 additional data from physiological measurements (Ackermann-Liebrich et al., 2005). The second follow-up (SAP 3) was carried out in 2010/11 with questionnaire data available for 5921 and physiological data for 4808 surviving individuals who had participated in SAP2.

Measures

Weight-related measures

All overweight/obesity variables based on different objective measurement methods are summarized in Supplementary Material Table 1. Height and weight were measured according to standard operating procedures in SAP2 and SAP3. BMI was calculated as weight in kilograms divided by height in meters squared and categorized as overweight (25–29.99) and with obesity (≥30) according to WHO definitions (World Health Organization, 2000). Table 1 shows the different cut points used to classify overweight and obesity for the different weight variables.

Waist and hip circumference were measured in SAP 3 only with participants in relaxed standing position using a SECA 201 measuring tape (SECA GmbH&Co, Hamburg, Germany). WC categories defined by Lean et al. (1995), supported by World Health Organization (2000, 2008) and commonly used in research (de Hollander et al., 2012) were used to define overweight and obesity and increased risk of metabolic complications.

Waist-to-hip ratio was calculated and categorized as overweight (>0.8 for women, >0.9 for men) (National Institute of Health and National Heart Lung and Blood Institute, 1998) and with obesity (>0.85 for women, >1.0 for men) (World Health Organization, 2000).

Waist-to-height ratio has been shown to be a good discriminator for cardiovascular disease risk (Lee et al., 2008; Ashwell et al., 2012) and was therefore additionally included. Cut-offs of ≥0.5 for overweight (Browning et al., 2010) and of ≥0.6 for obesity (Ashwell, 2012) were used for both gender groups.

Percent body fat was measured with BIA using the device Helios (Helios, Forana, Frankfurt, Germany). Cut-offs of >25% for men (Peterson et al., 2014) and >32% for women (which is between the commonly used values of 30% (Snitker, 2010) and 35% (Peterson et al., 2014)) were used.

Physical activity measures

Physical activity measures are summarized in Supplementary Material Table 1. For cross-sectional analyses, data on different domains of physical activity and on sitting time were available from the long version of the International Physical Activity Questionnaire (IPAQ) in a random sub sample of SAP 3 participants (3042 individuals). The IPAQ has been validated in several countries (Craig et al., 2003) and a validation study has also been carried out in the SAPALDIA population (Wanner et al., under review). The IPAQ data have been processed according to the IPAQ Scoring protocol (International Physical Activity Questionnaire team, 2005). For each domain and intensity of physical activity the MET-minutes per week were computed. MET (metabolic equivalent) is a physiological measure that expresses the energy cost of physical activities. One MET is the energy expended at rest. For sedentary time, hours per day spent sitting were analyzed.

Table 1
Different measures of overweight and obesity and the cut-off points used.

	Men			Women		
	Normal weight	Overweight	With obesity	Normal weight	Overweight	With obesity
Body Mass Index (BMI) (World Health Organization, 2000)	<25	25–29.99	≥30	<25	25–29.99	≥30
Waist circumference (WC) (World Health Organization, 2000; Lean et al., 1995; World Health Organization, 2008)	<94	94–101.9	≥102	<80	80–87.9	≥88
Waist-to-hip ratio (WHR) (World Health Organization, 2000; National Institute of Health and National Heart Lung and Blood Institute, 1998)	<0.9	0.9–0.99	≥1.0	<0.8	0.8–0.84	≥0.85
Waist-to-height ratio (WHtR) (Browning et al., 2010; Ashwell, 2012)	<0.5	≥0.5	≥0.6	<0.5	≥0.5	≥0.6
BIA percent body fat (Peterson et al., 2014; Snitker, 2010)	≤25%	>25%		≤32%	>32%	