Clinical Nutrition 32 (2013) 999–1006

Contents lists available at SciVerse ScienceDirect

Clinical Nutrition

journal homepage: http://www.elsevier.com/locate/clnu

Original article

Objectively-determined intensity- and domain-specific physical activity and sedentary behavior in relation to percent body fat

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ARTICLE INFO

Article history:
Received 23 August 2012
Accepted 17 March 2013

Keywords:
Objective monitoring
Activities of daily living
Epidemiology
Body composition
Bioelectrical impedance analysis

SUMMARY

Background & aims: This study examined the independent and joint associations of overall, intensity-specific and domain-specific physical activity and sedentary behavior with bioelectrical impedance-determined percent body fat.

Methods: Physical activity was measured in 442 Flemish adults (41.4 ± 9.8 years) using the SenseWear Armband and an electronic diary. Two-way analyses of covariance investigated the interaction of physical activity and sedentary behavior with percent body fat. Multiple linear regression analyses, adjusted for potential confounders, examined the associations of intensity-specific and domain-specific physical activity and sedentary behavior with percent body fat.

Results: Results showed a significant main effect for physical activity in both genders and for sedentary behavior in women, but no interaction effects. Light activity was positively ($\beta = 0.41$ for men and 0.43 for women) and moderate ($\beta = -0.64$ and -0.41), vigorous ($\beta = -0.21$ and -0.24) and moderate-to-vigorous physical activity (MVPA) inversely associated with percent body fat, independent of sedentary time. Regarding domain-specific physical activity, significant associations were present for occupation, leisure time and household chores, irrespective of sedentary time. The positive associations between body fat and total and domain-specific sedentary behavior diminished after MVPA was controlled for.

Conclusions: MVPA during leisure time, occupation and household chores may be essential to prevent fat gain.

1. Introduction

The increased prevalence of overweight and obesity in both developed and developing countries poses one of the most serious public health challenges of the 21st century, with individuals having an elevated risk of developing chronic diseases such as type 2 diabetes, cardiovascular disease, hypertension, certain forms of cancer and osteoarthritis.[1]

A sedentary lifestyle is considered to be an important risk factor for the development and maintenance of obesity,[2,3] while regular physical activity (PA) has been proposed as a key component in the prevention of weight gain and treatment of obesity.[4] However, there are several limitations in the current evidence.

First, although obesity is generally defined as an excess in body fat,[1] most epidemiological studies rely on body mass index (BMI) as the sole indicator to diagnose adiposity.[2,5] BMI has many advantages as a proxy of body fatness, yet it fails to discriminate between lean mass and fat mass, especially in non-obese individuals.[6] People with intermediate BMI values (20–25 kg/m^2) may have limited lean mass and high body fat content or so called normal-weight obesity.[7,8] Because excess body fat has been associated with cardiometabolic dysregulation, direct measurements of percent body fat (%BF) would be more appropriate for diagnosing obesity and associated health risks.[7] Recently, skinfold measures and bioelectrical impedance analysis (BIA) are being used more frequently to evaluate body composition. BIA is a technically simple, inexpensive and non-invasive procedure with minimal intra- and inter-observer variability and thus a feasible alternative to assess %BF in large-scale studies.[9]

Non-standard abbreviations: %BF, percent body fat; BIA, bioelectrical impedance analysis; PA, physical activity; MVPA, moderate-to-vigorous physical activity.

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http://dx.doi.org/10.1016/j.clnu.2013.03.014

Secondly, associations of PA with %BF are not firmly established, in part because of the measurement error of PA due to inaccurate recall.[10] In addition, research has focused primarily on total PA or vigorous leisure time pursuits, while analyses on occupational, household and commuting activity are scarce.[5,11,12] It is highly important to use objective measures of PA and elucidate the separate effects of different intensities and different domains of activity, in order to promote those activities that contribute the most to a healthy body composition.

In addition, the reduction of time spent being sedentary may be as important as the promotion of PA to prevent fat gain and eventually reduce obesity. However, current guidelines concentrate solely on moderate-to-vigorous physical activity (MVPA) and do not include reducing sedentary behavior.[13] This may be the result of restrictions in the current knowledge due to the practical difficulties of quantifying sedentary behavior in free-living conditions. Researchers have rarely measured sedentary behavior in direct ways. More typically, participants who did not report enough MVPA to be categorized as active, were labeled sedentary.[14] However, sedentary behavior and MVPA are two different classes of behavior that may coexist. An individual can meet the guidelines for MVPA, yet spend most of the waking hours involved in sedentary behavior. Conversely, those who do not meet the guidelines could have low amounts of sedentary behavior by engaging in high volumes of light-intensity activities.[5] Furthermore, it has been suggested that sedentary behavior has underlying biological mechanisms and health consequences that are distinct from those of too little exercise.[15] In recent years, more interest evolved in the direct measurement of sitting time. Though, until now, most studies have concentrated on TV viewing time.[3,12] However, watching TV is only one component of sedentary behavior and may not reflect overall sedentary time. Given the enormous amounts of occupational, commuting and recreational time spent being sedentary, it becomes imperative to consider all domains of daily life to fully understand the associations of sedentary behavior with %BF.

Furthermore, because of their behavioral independence, it is important to examine whether sedentary behavior and PA are independently associated with adiposity. A better understanding of the complex relationships of subcomponents of PA and sedentary behavior with %BF will aid the development of strategies to prevent fat gain.

Objective instruments such as accelerometers and the SenseWear Armband can monitor a wide range of intensities, including sedentary behavior and light PA. By combining accelerometry with physiological sensors, the SenseWear has the additional advantage of detecting small increases in energy expenditure associated with everyday activities such as carrying loads, upper body movement and walking on an incline.[16,17]

The present study combined the objective monitoring through the SenseWear with the assessment of the type of activity through an electronic diary. The combination of both techniques made it possible to calculate the amount of sedentary behavior and PA in all domains of daily life. The purpose was to examine the independent and joint associations of subcomponents of PA and sedentary behavior with BIA-determined %BF. First, we investigated overall PA and sedentary behavior. Secondly, physical (in)activity was examined in terms of time spent in different intensities and thirdly, domain-specific PA and sedentary behavior were considered.

2. Materials and methods

2.1. Subjects

Subjects were recruited from various companies and different work sectors (private companies, multinationals, education, research, social and welfare services, municipal services and industry) in Flanders, Belgium. Individuals volunteered to participate in the study and provided written informed consent prior to participation. The study was approved by the Medical Ethics Committee of the KU Leuven. A total of 442 subjects (212 men and 230 women) between 22 and 64 years (41.4 ± 9.8 years) were enrolled. Subjects did not receive any financial reimbursement for participating in the study. However, a detailed activity and health report was provided afterward.

2.2. Data collection

Anthropometric parameters. Anthropometric measurements were obtained in the morning prior to the PA monitoring period, after an overnight fast. Body weight was measured to the nearest 0.1 kg using a digital scale (Seca, Hamburg, Germany). Height was measured to the nearest 0.1 cm using a portable anthropometer (GPM anthropological instruments, Zurich, Switzerland). All measurements were taken by trained staff with subjects barefoot and in underwear.

Body composition. Whole-body resistance was determined by means of a single measurement at 50 kHz, using a Bodystat 1500 MDD bioelectrical impedance analyzer (Bodystat Ltd, Douglas, Isle of Man, UK). Two electrodes were placed on the right hand and two on the right foot, with the participants in a supine position. All subjects were requested to avoid exercise and eating or drinking anything except water during a minimum 10 h fasting period. In addition, they were asked to restrain from drinking one hour before the measurement. Fat free mass was calculated using algorithms developed by Sun et al.[18] %BF was subsequently calculated as: [(body weight − fat free mass)/body weight]*100.

Covariates. Age, education, smoking status and alcohol consumption were taken into account as known covariates in all analyses.[19] Age was included as a continuous variable. Education was dichotomized as high school or less vs. college or university. Smoking status was categorized as current smoker or quit less than six months ago vs. not current smoker. Alcohol consumption was expressed as the number of glasses per week.

Physical activity and sedentary behavior. Subjects were asked to wear a SenseWear Pro 3 Armband (BodyMedia, Inc., Pittsburgh, PA, USA) 24 h a day except during water-based activities, for seven consecutive days.[20] The SenseWear is a multisensor body monitor, worn over the triceps muscle of the right arm. It enables continuous collection of various physiological and movement parameters through multiple sensors, including a two-axis accelerometer and sensors measuring heat flux, galvanic skin response, skin temperature and near body ambient temperature. Data from these sensors are combined with gender, age, body weight and height, to estimate energy expenditure and PA intensity, using algorithms developed by the manufacturer (SenseWear Professional software, version 6.1).

In addition, subjects were asked to register their activities in an electronic diary, each time a new activity was started, for the entire seven-day period. The diary software program was developed at the Department of Kinesiology of the KU Leuven and stored in a Palm Z22 Personal Digital Assistant (Palm, Inc., Sunnyvale, CA, USA). The diary consisted of seven categories: sleeping/resting, personal care, eating/drinking, job, leisure time, transport and household chores. The last three categories were divided into a number of subcategories, to allow subjects to specify their activity in more detail. Leisure time was divided into active and inactive leisure time, both comprising several specific activities, including a list of 200 different sports. Transport consisted of motorized transport, walking and bicycling. Household chores were split into in-house activities, garden activities, running errands and renovating or moving. Dunton et al.[21] have shown that diary-reported