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Original article

Patterns of physical activity and sedentary behavior in normal-weight, overweight and obese adults, as measured with a portable armband device and an electronic diary

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SUMMARY

Background & aims: Accurate data on domain-specific physical activity and sedentary behavior among normal-weight, overweight and obese adults are scarce. This study described a comprehensive physical (in)activity profile and examined variations in activity across the week.
Methods: Physical activity was measured in 442 Flemish adults (41.4 ± 9.8 years) for 7 days using the SenseWear Armband and an electronic diary. Differences in (in)activity between BMI subgroups were examined using one-way analyses of variance.
Results: Physical activity level decreased with increasing BMI in men (1.77−1.46 MET) and women (1.67 −1.31 MET). Sedentary time was higher in obese than normal-weight men (+1.09 h/day) and overweight and obese than normal-weight women (+1.04 and +1.88 h/day). Total hours of moderate-to-vigorous activity and bouts of moderate-to-vigorous activity were lower in overweight and obese than normal-weight subjects. The average duration of a sedentary bout and the number of breaks in sedentary time were only different between female BMI groups. The intensity of domain-specific activities decreased with increasing BMI. Activity patterns across the week differed between subgroups, with the difference most pronounced on Saturday for the male BMI groups.
Conclusions: This study described activity patterns among normal-weight, overweight and obese adults. The results should be used to design obesity prevention strategies.

1. Introduction

During the past three decades, the prevalence of overweight and obesity has increased to epidemic proportions in both developed and developing countries.[1] Worldwide, more than 1.4 billion adults are overweight and over 500 million are obese. In the European region, the prevalence of overweight is currently in the range of 50–60% and the prevalence of obesity around 20%.[2] This high prevalence forms one of the most serious public health challenges of the 21st century, because several other chronic diseases are associated with excess body weight. Obesity is a leading risk factor for type two diabetes, cardiovascular disease, hypertension, certain forms of cancer and osteoarthritis, and the fifth leading risk for global deaths, causing nearly three million deaths every year.[1,3] It also poses an economic burden on society. In developed countries, about 2–7% of total health care costs are directly attributable to overweight and obesity.[1] However, indirect costs associated with lost worked days, psychological problems and a reduced quality of life is even greater.[4]

Although reasons for the obesity epidemic are complex, the rapid weight gain over the past three decades is thought to be a result of environmental and behavioral changes.[5] The current environment is characterized by a situation whereby food is abundant and physical activity levels are low.[6] During the last century, technological advances have impacted the way we live at home, work and during leisure time. Fewer active occupations, greater availability of labor-saving devices and an increased use of cars have reduced the need for physical activity in daily life.[7] Simultaneously, there has been an increased preference for screened entertainment.[5,8]

Non-standard abbreviations: MVPA, Moderate-to-vigorous physical activity; SWA, SenseWear Armband.

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Regular physical activity has been proposed as a key component in the prevention of unhealthy weight gain and eventual reduction of obesity.[9] Increasing activity levels has therefore become a public health priority. It is essential to understand current activity patterns among normal-weight and especially among overweight and obese adults, for the development, implementation and evaluation of successful interventions. Yet, accurate data on physical activity and sedentary behavior in the overweight or obese are scarce, in part because of difficulties associated with the measurement of free-living activity.

So far, most studies have relied on questionnaires to quantify physical activity in daily life. However, the accuracy of self-reports is often limited due to recall errors, social desirability bias, misinterpretation of the questions and difficulties associated with capturing low-to-moderate activities.[10] Moreover, the validity of these instruments varies between body mass index (BMI) subgroups. It has been shown that obese participants overestimate their activity to a higher degree than normal-weight subjects.[11] Consequently, differences might be even more pronounced than previously reported.

Additionally, measurements of physical activity are largely restricted to leisure time, with work, domestic activities and transport rarely taken into account.[10] However, leisure time activity accounts for only a small proportion of time and energy expenditure.[12] To reverse a sedentary lifestyle, it may be more effective to increase the frequency or intensity of lifestyle activities, rather than to concentrate solely on recreational pursuits.[5,6,12] It has been shown that the maintenance of a healthy body weight is a function of total energy expenditure, including low-intensity activities such as household chores and occupational activities.[12,13] Thus, when considering obesity, it is necessary to take all domains of daily life into account.

Recently, more interest evolved in reducing sedentary time besides the promotion of physical activity.[14,15] However, which index of sedentary behavior is most informative remains unknown. Most of the evidence on the role of sedentary behavior in obesity is derived from self-reported TV viewing time. Though, watching TV is only one component of sedentary behavior and may not reflect overall sedentary time. The measurement of all sedentary behaviors, but also the manner in which sedentary time is accumulated may be important.[14,15]

Furthermore, surprisingly few studies have looked at variations in activity patterns across the week,[16,17] although campaigns to encourage activity should know at what time activity is low or when individuals are somewhat active, to promote additional physical activity.

Thus, at the moment, much about the precise, domain-specific patterns of physical activity and sedentary behavior among adults with various degrees of overweight remains unresolved. Recently, activity monitors such as accelerometers have been used more frequently to objectively characterize active and sedentary behavior.[16–18] However, these instruments provide no information on the type of activity. Clearly, if we are to identify specific activity parameters that differentiate between normal-weight, overweight and obese subjects, it is necessary to move beyond time spent in total physical activity and assess a full range of (in)activity parameters simultaneously. Only in this way, it is possible to appropriately design strategies to increase activity and prevent weight gain.[18]

Therefore, this study combined the objective monitoring through the SenseWear Pro3 Armband (SWA) with the assessment of the type of activity through an electronic diary. The combination of both techniques provides information that can help to understand the complex nature of human physical activity and sedentary behavior. The aim was to describe a comprehensive physical activity and inactivity profile among BMI-defined normal-weight, overweight and obese adults, using minute-by-minute SWA and diary data. Additionally, variations in physical (in)activity across the week were examined. It was hypothesized that overweight and obese subjects spend more time in sedentary behavior and less time in moderate and vigorous activity compared to their normal-weight peers.

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 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 $\pm$ 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 afterwards.

2.2. Anthropometric parameters

Anthropometric measurements were obtained in the morning prior to the consecutive seven-day period by trained staff with subjects barefoot and in underwear. 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). BMI was calculated as weight/height^2 (kg/m^2). Normal-weight was defined as BMI $<$25 kg/m^2, overweight as $\geq$25 but $<$30 kg/m^2 and obese as $\geq$30 kg/m^2.

2.3. Assessment of physical activity

Subjects were asked to wear an SWA (BodyMedia, Inc., Pittsburgh, PA, USA) 24 h a day except during water-based activities, for seven consecutive days. The SWA 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 physical activity 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.[19] have shown that diary-reported