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Original Study

Objective Measures of Activity in the Elderly: Distribution and Associations With Demographic and Health Factors

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ABSTRACT

Background: Little is known about the distribution of activity over the full 24-hour spectrum in late old age and its association with demographic and health factors. Therefore, we aimed to evaluate the distribution of physical activity (PA), sedentary behavior, and sleep, and associated factors in the elderly population.
Methods: Our study included 1210 participants (51.9% women) aged 70–94 years [mean age 77.5 years, standard deviation (SD) 5.0] from the population-based Rotterdam Study. Participants wore a triaxial accelerometer (GENEActiv) around the wrist for 7 days between July 2014 and June 2016. We examined if PA, sedentary behavior, and sleep differed by age, sex, body mass index (BMI), smoking status, alcohol consumption, education, season, functional capacity, marital status, presence of chronic disease, and use of sleep medication.
Results: Mean total PA, expressed in milli-gravity (mg) units, was slightly higher for women (20.3, SD 5.6) than for men (19.3, SD 5.2, $P < .01$). Mean (SD) daily duration spent in sedentary behavior and light and moderate-to-vigorous PA was 13.3 (1.5) h/d, 147.5 (31.5) min/d, and 75.0 (25.5) min/d, respectively, among women; and 13.8 (1.6) h/d, 140.5 (31.1) min/d, and 71.5 (24.5) min/d, respectively, among men. Women spent on average 6.7 (SD 1.1) h/d sleeping and men 6.6 (1.4) h/d. Across increasing categories of age and BMI and in participants with chronic disease and disability, time spent in light and moderate-to-vigorous PA was decreased. Higher age and BMI were associated with more sedentary time. In addition, obese men spent slightly more time sleeping than their normal weight counterparts and women spent slightly less time sleeping in the summer than in spring.
Conclusions: PA and sedentary behavior in the elderly differed by sex, age, BMI, prevalence of chronic disease, and disability, whereas there were no clear patterns for sleep. On average, our participants spent up to 79.5% of their time awake being sedentary and 7%–8% in moderate-to-vigorous PA. Replacing sedentary behavior with light PA would be a good starting point for those with the lowest level of PA. Older adults, those with high BMI and worse health could benefit from targeted interventions to increase PA.

Physical activity (PA) plays a major role in healthy aging, by preventing disease, reducing disability, and improving well-being.[1–3] Given the importance of PA in older adulthood, understanding the levels of PA in elderly adults might provide information for public health institutions to create targeted recommendations. In epidemiologic studies, PA is usually assessed by questionnaires.[4] However,

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these data are known to be prone to reporting errors and recall bias, especially for low intensity behaviors.[5,6] These limitations may be exacerbated in older populations, in whom cognitive impairment is more likely.[7] Therefore, accelerometers are increasingly used to measure PA and sedentary behavior objectively.[8]

To date, several studies objectively assessed PA and sedentary behavior using accelerometers in adults aged 60 years and over[9–19] and examined the associations with demographic and health factors. It has been shown that PA levels decrease with increasing age[9–13,16,19] and across increasing levels of body mass index (BMI).[9–12,14] Whereas these studies provided useful information, the associations were often obtained from unadjusted analyses. Moreover, there is limited information on the 24-hour activity spectrum in the elderly, including PA, sedentary behavior, and sleep. It remains unknown how these factors are interrelated and how they are distributed across age-groups and other demographic and health factors. In previous studies, accelerometers have most often been worn on the hip and had to be removed for sleeping. Wrist-worn devices can be worn day and night, thereby allowing for collection of 24-hour of activity data, recently shown to be valid indicators of activity energy expenditure.[20,21] In addition, wrist-worn devices have been argued to promote better compliance of device wear.[22]

The Rotterdam Study is one of the first large population studies to objectively assess PA in an elderly population of adults aged 70-94 years using a triaxial accelerometer. The main aim of this study was to provide a description of objectively measured activity in elderly adults from the Rotterdam Study, over the complete 24-hour period. In addition, we examined the demographic and health factors associated with activity measures in this cohort.

Methods

Study Population

This study was embedded in the Rotterdam Study, a prospective population-based cohort in The Netherlands. The main aim of this study was to examine the incidence of risk factors for neurologic, cardiovascular, psychiatric, and other chronic diseases. Details of the study have been published previously.[23] For the current study, 1900 successive participants of the Rotterdam Study were invited to participate from July 2014 to May 2016, of which 506 did not consent. For 1210 participants valid data (>1200 min/d) on at least 4 days was available (Figure 1).

All participants gave written informed consent, and the study protocol was approved by the medical ethics committee of Erasmus University, Rotterdam. Detailed information on the design of the Rotterdam Study can be found elsewhere.[23]

Accelerometer-Assessed PA

All participants were asked to wear a triaxial accelerometer (GENEActiv Activinsights Ltd, Kimbolton, Cambridgeshire, United Kingdom; http://www.geneactiv.org/) on the nondominant wrist for 7 consecutive days and nights and to complete a 7-day sleep diary to report overnight sleep periods. The accelerometer sampled at 50 Hz and as in previous studies.[18,24,25] Acceleration was expressed relative to gravity (g units; 1 g = 9.81 m/s^2 at this location in The Netherlands[26]) because the sensors are calibrated relative to gravity. Calibration error was estimated based on static periods in the data and corrected if necessary.[27]

We used 2 vector magnitude-based measures to quantify the acceleration related to the movement registered. The first was the Euclidean norm minus 1 g with negative numbers rounded to zero.[21] In addition, we calculated the high-pass filtered vector magnitude, which applies a high-pass filter to the acceleration signal with a cut-off frequency of 0.2 Hertz, treating gravity as a low-frequency component to be filtered out.[20]

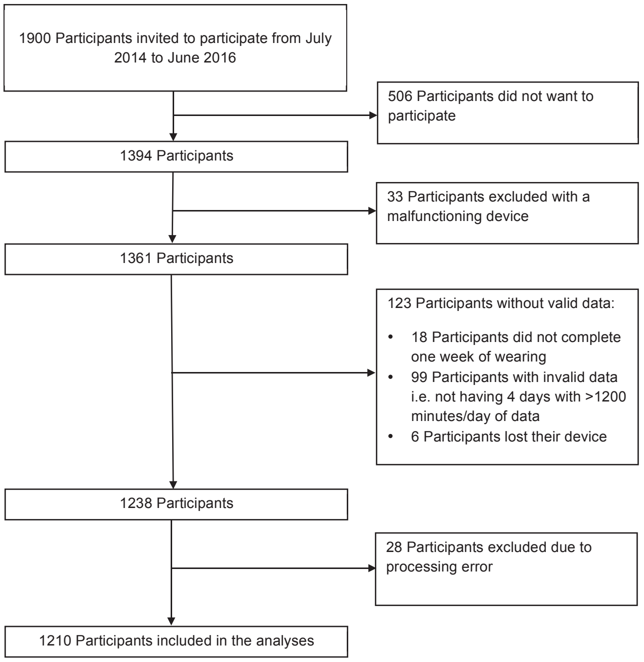

Fig. 1. Flow chart of participant inclusion for the Rotterdam Study.

Accelerometer data were processed in Python (2.6.6 https://www.python.org/) using the open access PAMPRO software (T.White, software available at: https://github.com/Thomite/pampro). PAMPRO is a software program for the systematic analysis of physical activity data collected in epidemiologic studies.[28] Data was extracted from the first wearing day up to 7 days later.

Nonwear time was estimated as time periods where the standard deviation (SD) of acceleration in all 3 axes fell below 13 mg for longer than 1 hour,[20] and any nonwear period was excluded from analyses. The pattern of nonwear time was accounted for by balancing the weighting of the data according to the diurnal profile.[29]

Assessment of Factors

Information on health behaviors was collected through home interviews or measured at the study center, as described previously.[30,31] Alcohol use was defined as the number of times drinking alcohol per time unit (ie, never drinking alcohol; drinking 1–4 per month; drinking 2–4 per week). Education was assessed in line with the International Standard Classification of Education and categorized as primary, lower, intermediate, and higher education.[32] Smoking was divided in 3 categories: current, former, and never. Height and weight were measured to calculate BMI (kg/m^2) and categorized as normal weight (<25 kg/m^2), overweight (25–30 kg/m^2), and obese (>30 kg/m^2). Marital status was defined as living with a partner or not. Functional capacity was assessed by the activities of daily living from the Stanford Health Assessment Questionnaire Disability Index (HAQ-DI).[33] In accordance with literature we used a HAQ-DI 0.5 ≥1.0 to define a participant as disabled and a HAQ-DI ≥ 1.0 to define a participant as severely disabled.[34] Use of sleep medication was obtained from the sleep diary and used as a binary variable (not in the past 7 days/at least 1 day in the past 7 days). The presence of cardiovascular disease, diabetes mellitus, and cancer were determined using medical records, to define presence of chronic disease. The LASA Physical Activity Questionnaire was used to determine total self-reported PA and was expressed in met·hours·week^{-1}. The