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Total daily activity declines more rapidly with increasing age in older adults

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ABSTRACT

Longitudinal studies of objectively measured physical activity are lacking in older adults. We tested whether objective measures of total daily activity decline more rapidly in older adults. This prospective, observational cohort study included 519 community-dwelling older persons from across metropolitan Chicago participating in the Rush Memory and Aging Project. Repeated total daily activity measures (leisure and non-leisure physical activity) were derived from actigraphic recordings for up to 10 days. Generalized estimating equation models which controlled for demographics measures were employed. At baseline, age was inversely related with the level of total daily activity (estimate, −0.014, S.E. 0.002, $p < 0.001$). During up to 6 years of follow-up, total daily activity declined by about 0.070×10^5 activity counts/day/yr (estimate −0.065, S.E. 0.005, $p < 0.001$). Total daily activity declined 3% more rapidly for each additional year of age at baseline (estimate −0.002, S.E. 0.001, $p = 0.027$). Thus, total daily activity declined almost twice as fast in an individual 91 years old at baseline versus an individual 71 years old. A higher level of education was associated with a slower rate of decline (estimate 0.004, S.E. 0.002, $p < 0.018$). The associations of age and education with the rate of declining total daily activity were unchanged when controlling for baseline level of motor and cognitive function, other late-life activities and chronic health conditions. These data suggest that total daily activity in very old adults declines more rapidly with increasing age. Thus, physical inactivity is likely to become a larger problem in our aging population.

1. Introduction

To meet the growing personal and social burden of declining health in our aging population, public health efforts have focused on increasing physical activity, a modifiable behavior with a wide range of potential health benefits (O'Donovan et al., 2010; Paterson, Jones, & Rice, 2007). There is sparse data about the trajectory of declining physical activity in very old adults (Timmons et al., 2010). Available studies have typically relied on self-reported physical activity questionnaires which are imprecise, lack sufficient variability, and are subject to recall bias, particularly in very old adults who may develop cognitive impairment (Langston, 2006; Siderowf & Lang, 2012; Stessman, Hammerman-Rozenberg, Cohen, Ein-Mor, & Jacobs, 2009). Furthermore, few studies have accounted for both leisure and non-leisure physical activity which is essential since the latter may constitute the majority of daily physical activity for many very old adults (Dong, Block, & Mandel, 2004; Lin et al., 2011; Robertson, 2013). Thus, in the absence of studies employing validated objective measures of total daily physical activity, the natural history of physical activity in older adults and its role as a modifiable risk factor will remain unclear (Baker, Francis, Soares, Weightman, & Foster, 2011; Daviglus, Plassman, & Pirzada, 2011).

To test the hypothesis that total daily activity declines more rapidly with increasing age, we used data from more than 500 older adults from the Memory and Aging Project. Actigraphs[a] were worn on the non-dominant wrist and recorded all movements 24 h/day for up to 10 days for 2 or more annual assessments. First, we documented longitudinal changes in total daily activity and then examined whether the rate of change varied with age, sex or education.

2. Methods

2.1. Participants

Participants were from the Rush Memory and Aging Project. The study recruited residents of continuous care retirement communities, subsidized housing, and through local churches and social

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service agencies serving minorities and low-income elderly in metropolitan Chicago. The aim was to recruit a cohort that was comparable to the 80-year old population in Chicago at the time of the 1990 census in terms of education (33% with 12 years or less), gender (75% women) and racial and ethnic minorities (10%). Written informed consent was obtained, and the study was conducted in accordance with the latest version of the Declaration of Helsinki and was approved by Rush University Medical Center Institutional Review Board.

Rolling admission for the Memory and Aging Project began in 1997, actigraphy data collection was added in August, 2005. Of 1336 living participants since actigraphy was added, 41 refused testing and 400 are awaiting testing. Participants undergoing actigraphy were older, had more education and better cognition, less disability, but had lower motor function and more chronic health conditions compared to participants without actigraphy. The groups did not differ by sex or levels of self-report physical activity. Of 895 participants assessed with actigraphy, there were 590 with 1 or more follow-up actigraphy assessments and eligible for these analyses. Of these 33 had missing clinical data and 38 had dementia at the time of the first Actical cycle leaving 519 for these analyses. These participants were younger, had higher levels of cognition, motor function and self-report physical activity with fewer chronic health conditions and less disability than cases with only 1 assessment with actigraphy. The two groups did not differ with respect to sex or education (results not shown).

2.2. Assessment of total daily activity

Total daily activity was measured with actigraphs. Actical®; (Philips Healthcare, Andover, MA) is a portable, battery-operated activity monitor similar in size to a wristwatch which was worn on the non-dominant wrist for 24 h/day. Actical accelerometers generate a signal proportional to the magnitude and duration of the detected motion. After its signal is digitized, it is rectified, integrated across 15 s and rounded to the nearest integer, to create an "activity count" for each 15-s period with motion.

Total daily activity was the average sum of all activity counts recorded during all days for which activity was recorded. We evaluated the day-to-day reliability of actigraphy by performing a variance components analysis for actigraphy obtained at baseline in the 895 participants with up to 10 days of data. The between-subject variance estimate was 2.40 and within-subject variance estimate was 0.45, such that less than one fifth (16%) of the total variance in daily actigraphy data was due to daily variation, suggesting the measure was stable across multiple days (intra-class correlation coefficient = 0.824).

For illustrative purposes, using standardized instructions and structured tasks, investigators have reported activity counts for several tasks including sitting and writing for 3 min (43 activity counts), floor sweeping for 3 min (1721 activity counts) and walking for 5 min at 2.5 m.p.h. (2355 activity counts) (Heil, 2006). Due to the large number of counts accumulated over 24 h, raw counts in the current study were divided by 1×10^5 (about 1 standard deviation [S.D.]) to facilitate presentation and interpretation of the results.

2.3. Other covariates

Age in years at the time of actigraphy was computed from self-reported date of birth and date of actigraphy collection. Sex and years of education were recorded at the study entry. Clinical diagnoses were made using a multi-step process, as previously described (Bennett et al., 2012). Cognitive function testing included 21 performance tests, 19 of which were summarized into a composite measure of global cognition using z scores as described previously (Bennett et al., 2012). Participants were then evaluated in person by an experienced physician who diagnosed dementia (McKhann et al., 1984), stroke (Adams et al., 1993), Parkinson's disease (Langston et al., 1992) based on published criteria. Self-report assessment of late-life physical activity was based on questions adapted from the 1985 National Health Interview Survey and expressed as hours of activity/week (Buchman et al., 2009). Frequency of participation in social activity was based on 6 items involving social interaction over the past year (Buchman et al., 2009). Frequency of participation over the past year in cognitively stimulating activities was based on 7 cognitive activities (Buchman et al., 2009). Motor function was based on 11 motor performance tests which were scaled and averaged to obtain a summary measure (Buchman et al., 2011). Activities of daily living were assessed using a modified version of the Katz scale (Katz & Akpom, 1976). Self-reported vascular risk factors and vascular diseases were used in these analyses (Boyle et al., 2005).

2.4. Statistical analysis

Pearson correlations were used to examine the associations between total daily activity, age and education. T-tests were used to compare men and women. Generalized linear models fit using the method of generalized estimating equations (GEE) were used to summarize cross-sectional and longitudinal information about level of, and the annual rate of change in total daily activity (Liang & Zeger, 1986; Zeger, Liang, & Albert, 1988). The models included a term for study time, measured as time in years from the study baseline. There were also terms for age (centered at the approximate mean of 81), sex (1 for male, 0 for female) and education (centered at the mean of 14) at baseline as well as terms for the interaction of each of these measures with study time. We added terms for other covariates as well as their interactions with time to see if these covariates affected the associations of age and education with the rate of declining in total daily activity. Model validation was performed graphically and analytically and there was no evidence of nonlinearity or non-proportionality. Programming was done in SAS (SAS Institute Inc., 2002–2003).

3. Results

3.1. Descriptive properties of total daily activity at baseline

There were 519 participants ($N = 394$, 76% female) with an average age of 81.6 (S.D. = 6.84, range 56–99) and 14.8 years of education (S.D. = 2.94 years, range 7–28; 29.5% 12 years or less); 29% reported income lower than $25K, 39% had income between $25K and $50K, and 32% had income over $50K and median income between $35K and $50K. Men had more vascular diseases than women but did not differ with respect to vascular risk factors or level of disability (results not shown). Additional baseline clinical characteristics are included in Table 1. On average, total daily activity was measured for 9 days (9.3 days; S.D. = 1.1 days. range 2–11). Total daily activity ranged from 0.16×10^5 counts/day to 11.06×10^5 counts/day (mean: 3.15×10^5 counts/day; S.D. = 1.47×10^5 counts/day). At baseline, total daily activity was associated with age ($r = -0.23$, $p < 0.001$) but not with education ($r = -0.02$, $p = 0.710$) and did not differ between men and women ($t[183] = 1.50$, $p = 0.134$).

3.2. Demographic measures and the level and rate of change of total daily activity

A generalized linear model fit using generalized estimating equations (GEE) was used to summarize both the cross-sectional and longitudinal associations of total daily activity with