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Received 28 February 2013; accepted in revised form 6 September 2013

*Age and Ageing* 2014; 43: 386–393  
doi: 10.1093/ageing/aft168  
Published electronically 29 October 2013

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## The association between retirement and age on physical activity in older adults

ALAN GODFREY, SUE LORD, BROOK GALNA, JOHN C. MATHERS, DAVID J. BURN, LYNN ROCHESTER

Institute for Ageing and Health, Newcastle University, Newcastle upon Tyne, UK

Address correspondence to: A. Godfrey. Tel: (+44) 1912081245; Fax: (+44) 1912081251. Email: alan.godfrey@ncl.ac.uk

### Abstract

**Background:** retirement is a major life change that is likely to affect lifestyles and yet little is still known about its influence on physical activity (PA). This study objectively quantified sedentary behaviour and ambulatory activity outcomes in retired and non-retired older, community-dwelling adults.

**Methods:** PA was quantified in 98 community-dwelling older adults ( $69.1 \pm 7.6$  years) who wore an activPAL™ PA monitor (accelerometer) for seven consecutive days. Outcomes representing the volume, pattern and variability of sedentary behaviour and ambulatory activity were derived from the cross-sectional accelerometer data. The association between retirement, ageing and their interaction on sedentary and ambulatory outcomes were examined.

**Results:** being retired was associated with a reduced percentage of sedentary behaviour; reduced long bouts of sitting (>55 min) and increased the percentage of ambulatory activity. The volume of sedentary behaviour increased with age, whereas ambulatory activity reduced with age. Measures of pattern and variability did not change with retirement or age. With respect to recommended amounts of PA, there was no difference between retired and employed adults and only 21% achieved the recommended 150 min/week (accumulated in  $\geq 10$  min bouts of walking).

**Conclusion:** while retirement was associated with a greater volume of PA, most older adults do not meet current recommended PA guidelines. Interventions are needed to increase PA in older adults in the years leading to and after the transition to retirement.

**Keywords:** retirement, ageing, physical activity, ambulatory activity, sedentary behaviour, accelerometer, older adults

### Introduction

Six hundred million people worldwide are aged 60 years or more and this number will increase to 1.2 billion by 2025 [1]. The World Health Organisation (WHO) reports that rising incomes and pensions enable individuals to retire earlier than

previous generations, with figures in the UK suggesting an average man or woman retiring in their mid-60s could expect ~18 and 22 years of retirement, respectively [2]. Where the traditional retirement age of 65 was considered the norm [3], it has been stated that ‘there is no necessary connection between the movement over time in age-specific labour force

participation rates and in the average age at retirement' [4, 5]. Thus, retirement is no longer limited to people in their mid-60s due to the many factors influencing retirement age (earnings, benefits, social security etc.) [5]. This, coupled with increased longevity, suggests that optimising the health of the individual during retirement is important from both personal and societal perspectives.

Increased physical activity (PA) is important for both those approaching and in retirement to ensure wellbeing in later life [6–8]. Increased levels of PA decrease risk of disease, falls, disability and immobility in older adults [1] and enhance physical function in middle-aged employees [9]. Levels of PA have also been identified as biomarkers of life expectancy in retirement [10]. A greater understanding of the relationship between retirement and PA will help identify optimal goals and methods of delivery to achieve suitable levels of PA and inform guideline development.

Employment impacts on PA with more people sedentary in the work place than ever before, a trend that is likely to continue [11]. Furthermore, while retirement may provide more time to allocate to physically active leisure activities and hence greater opportunities for achieving and maintaining recommended levels of PA, reduced income and social contact may prohibit participation [6, 12]. Research examining the effect of retirement on PA levels has shown mixed results [1, 13]. One study demonstrated that PA reduced with retirement because activity accumulated by walking or cycling to work was not compensated for by an increase in leisure-time PA [1]. In contrast, another study found that retirement was associated with increased moderate-intensity leisure-time PA (e.g. walking) and general activity [13]. One explanation for the differing conclusions may be the use of self-reported measures and non-standardised methods of self-report [1]. Furthermore, defining PA as the converse of inactivity may confound findings as sedentary behaviour (SB) and ambulatory activity (AA) are independent characteristics [14, 15].

PA has been studied extensively using objective measurement in healthy older adults [14, 16–18] but to date the association between retirement and ageing on PA has not been quantified. Therefore, we investigated the association between retirement and ageing on PA using the activPAL™ PA monitor to provide objective measurements. PA was measured over seven continuous days of monitoring in healthy working and retired older adults. For the purposes of this study, we defined PA as all AAs (e.g. bouts of walking). In addition, we include SB (e.g. bouts of sitting/lying) since this is a distinct behaviour independent from PA [14, 19]. Thus, the aims of this paper were to investigate (i) the effect of retirement, (ii) the effect of age and (iii) possible interactions between retirement and age on SB and AA in older adults.

## Methods

### Participants

The participants recruited were the healthy aged-matched controls from the larger Incidence of Cognitive Impairment

in Cohorts with Longitudinal Evaluation—Parkinson's Disease Gait study (ICICLE-PD GAIT). None of the healthy controls had a history of major psychiatric disorders, cognitive impairment, stroke or movement disorder. For full details of inclusion/exclusion criteria, please see Khoo *et al.* [20]. All the participants gave informed written consent with ethical consent granted by Newcastle and North Tyneside 1 Research Ethics Committee and Newcastle upon Tyne Hospitals NHS Foundation Trust.

### Experimental protocol

Participants were assessed during their visit to the Clinical Ageing Research Unit, Newcastle University. During their visit, demographic details, height and weight were recorded. Cognitive status and intellectual ability were assessed with the Mini-Mental State Exam (MMSE) [21] and the National Adult Reading Test (NART) [22]. Fatigue was assessed with the Multidimensional Fatigue Inventory [23]. In addition, balance confidence was assessed using the activities balance confidence scale [24]. Those not in full-time employment were deemed 'retired' for the purpose of this study. Lastly, participants were fitted with an activPAL™<sup>1</sup> PA accelerometer-based monitor which was worn for 7 days.

### Equipment

The activPAL is a small (53.0 × 35.0 × 7.0 mm), lightweight (20 g) uniaxial accelerometer-based sensor worn on the upper thigh, with a sampling frequency of 10 Hz. The device accurately identifies changes in posture from sitting/lying to standing and stepping (walking) and records the number of steps during walking bouts [25, 26]. The researcher programmed the device to record for 7 days after which it would stop recording. Once programmed, the device was attached directly to the skin with the manufacturer recommended PALstickies<sup>2</sup> (hydrogel adhesive) and subsequently covered with Hypafix<sup>3</sup> tape to ensure it remained in place. The device was worn continuously for 7 days; participants were instructed to remove the device only during bathing and were provided with replacement adhesives and tape to re-attach the device. Participants were asked to continue their daily activities as usual and not to change their routine. Upon completion of recording, the participant removed the device and posted it back to the researcher.

### PA outcome measures

Data were downloaded and exported to Excel<sup>4</sup>. A MATLAB<sup>®</sup> program collated daily Excel files into one file which contained the time spent: sitting/lying, standing, stepping and the number of steps, in bin-widths of 15 s for the entire 7

<sup>1</sup>PAL Technologies, Glasgow, UK.

<sup>2</sup>See footnote 1.

<sup>3</sup>BSN Medical Limited, Hull, UK.

<sup>4</sup>Microsoft Corp., Redmond, WA, USA.

days. The MATLAB® program extracted individual sedentary (sitting/lying), and ambulatory (stepping/walking) bouts. A ‘bout’ is the continuous length of time spent sedentary or walking and ranged in length from the smallest period of time recorded by the activity device (e.g. 0.1 s, determined by sampling rate of 10 Hz) up to a night spent sleeping (28,800 s or 8 h). SB and AA were further grouped into characteristics representing volume, pattern and variability described below.

- (1) *Volume*: five outcomes were defined according to total percentage of time or number of bouts per week. These included:
  - (a) percentage of time spent sedentary and walking (total time %);
  - (b) total number of sedentary bouts per week;
  - (c) number of sedentary bouts per week (between 8 a.m. and 8 p.m.) >20, 30 and 55 min [27];
  - (d) total number of ambulatory bouts per week;
  - (e) number of ambulatory bouts per week >10 min [12, 28].
- (2) *Pattern*: We used two outcomes to describe patterns of SB and AA based on their respective bouts and the methods of analysis have been described in detail elsewhere [14, 29, 30]. The pattern outcomes included Alpha (*a*) which describes the distribution of sedentary/ambulatory bouts according to their time and is described by the power law distribution exponent *a* and Gini index (*G*) describes accumulation (by bout length) of sedentary or walking time (*G<sub>w</sub>*). A high *G<sub>w</sub>* indicates a greater contribution of long bouts. Both *a* and *G* have been used previously in Parkinson’s disease (PD) research [29, 31] and in healthy older adults [14]. For a more complete description, see Supplementary data available in *Age and Ageing* online, Appendix A.
- (3) *Variability* (*S<sub>2</sub>*): This was used to represent the ‘within subject’ variability of bout length. This was calculated using a maximum likelihood technique because the data were log normally distributed [31] and was determined for both sedentary (*S<sub>2s</sub>*) and ambulatory (*S<sub>2w</sub>*) bouts. For a more complete description, see Supplementary data available in *Age and Ageing* online, Appendix B.

**Data analysis**

ANOVA was used to determine differences in demographic and clinical characteristics as well as to establish the impact of retirement status (employed, retired), age (<65, 65–70, 70–75, 75+ years) and sex on AA and SB. While the primary aim of this study was to study the effects of retirement and age, sex was also included as it has been suggested previously that it is one of the most consistent predictors of PA in retirement [8]. Tukey *post hoc* tests were performed to examine between group comparisons for different age ranges. Mann–Whitney *U* (employed, retired) and Kruskal–Wallis *H* (age groups) tests were used for non-parametric testing where data were not normally distributed. We measured sustained activity with reference to public health recommendations

(duration of sustained activity accumulated in bouts of 10 min or greater to a minimum threshold of 150 min/week) [28, 32]. A significance level of *P* = 0.05 was used to guide interpretation of the statistical tests.

**Results**

Ninety-eight older adults aged 48–89 years (50 males, 48 females) and living independently in the community took part in the study. Thirty-two were employed and 66 were retired. Previous employment details were available for 83% (*n* = 55) of the retired group and revealed mainly sedentary occupations (e.g. civil servants, administrators and management, Table 1) which were similar to those in the employed group. There were no group differences for clinical characteristics but those who were retired were slightly older and had a reduce BMI (Table 2). Summary statistics for SB and AA across retirement status and age brackets are shown in Table 2, along with the results of the corresponding ANOVA and non-parametric statistics.

**Sedentary behaviour**

*Retirement*

There were significant changes in the volume (total time %) of SB with respect to retirement but not the pattern or variability. Those who were retired had a significantly lower percentage of sedentary time than those who were employed (Figure 1 and Table 2) largely because those who were employed had a greater number of longer bouts of SB (>55 min, Table 2). However, there was no difference between retired and employed in the number of shorter bouts.

*Age*

There was also a significant main effect of age on the volume (total time %) of SB but not the pattern and variability. *Post hoc* analyses showed that those who were 70–75 years old were more sedentary than younger adults (65–70 years, *P* = 0.01).

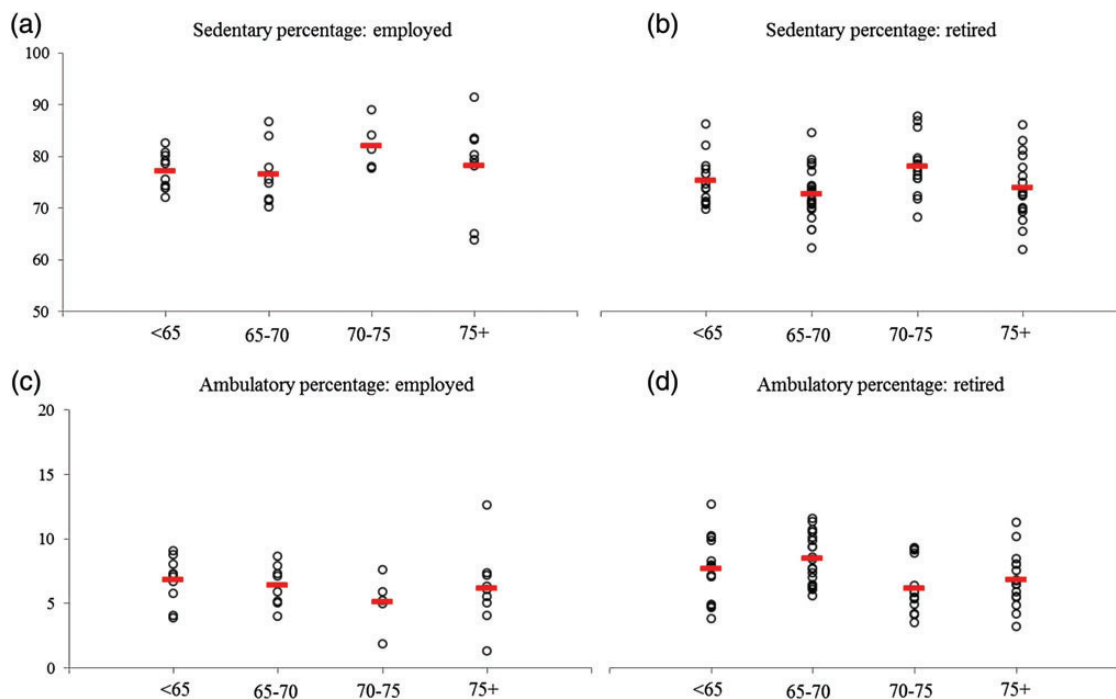
**Table 1.** Occupational descriptives for employed and retired groups

|                     | Employed ( <i>n</i> = 32) | Retired ( <i>n</i> = 66) |
|---------------------|---------------------------|--------------------------|
| .....               |                           |                          |
| Sedentary (%)       |                           |                          |
| Administration      | 18.8                      | 19.7                     |
| Architect/engineer  | 6.3                       | 4.5                      |
| Finance/accounting  | 15.6                      | 9.1                      |
| Management          | 6.3                       | 10.6                     |
| Other               | 3.1                       | 3.5                      |
| Ambulatory (%)      |                           |                          |
| Social worker/carer | 12.5                      | 7.1                      |
| Lecturer/teacher    | 15.6                      | 10.6                     |
| Mechanic            | 3.1                       | 1.5                      |
| Medical             | 6.3                       | 9.1                      |
| Other               | 9.3                       | 9.1                      |
| Not specified       | –                         | 15.2                     |

**Table 2.** Summary statistics [mean (SD)] for group characteristics, sedentary behaviour and ambulatory activity across retirement status and age bracket, along with the results of the corresponding ANOVA and non-parametric statistics

| Characteristics                                      | Retirement status         |                          | Age group            |                        |                        |                      | ANOVA results ( <i>F</i> ( <i>p</i> ))         |  |   |
|--|---------------------------|--------------------------|----------------------|------------------------|------------------------|----------------------|--|--|---|
|  | Employed ( <i>n</i> = 32) | Retired ( <i>n</i> = 66) | <65 ( <i>n</i> = 24) | 65–70 ( <i>n</i> = 29) | 70–75 ( <i>n</i> = 20) | 75+ ( <i>n</i> = 25) | Retirement                                     | Age  | Retirement × Age  |
| Sex (Men/women)                                      | 16/16                     | 34/32                    | 13/11                | 13/16                  | 9/11                   | 15/10                |  |  |   |
| Age (years)  | 67.72 (9.12)              | 69.91 (6.94)             | 59.38 (4.282)        | 67.07 (1.486)          | 71.90 (1.518)          | 78.92 (3.707)        | <b>5.139 (0.026)</b>                           | 193.040 (0.000)                                | <b>2.909 (0.039)</b>  |
| BMI (kg/m <sup>2</sup> )                             | 27.89 (4.30)              | 27.84 (5.44)             | 28.71 (8.154)        | 27.95 (3.882)          | 27.99 (4.134)          | 26.83 (2.712)        | 0.168 (0.683)                                  | 0.824 (0.484)                                  | <b>5.088 (0.003)</b>  |
| Mini-Mental State Exam (MMSE) <sup>a</sup>           | 29.34 (0.97)              | 29.33 (0.98)             | 29.50 (1.022)        | 29.52 (0.738)          | 29.45 (0.826)          | 28.88 (1.166)        | 0.049 (0.825)                                  | 2.302 (0.082)                                  | 0.047 (0.987)   |
| Specific balance confidence scale (ABC) <sup>b</sup> | 93.28 (8.70)              | 91.59 (12.40)            | 95.02 (6.769)        | 94.89 (6.071)          | 88.57 (11.524)         | 89.04 (16.926)       | 0.225 (0.636)                                  | 2.109 (0.105)                                  | 0.303 (0.823)   |
| National adult reading test (NART) <sup>c</sup>      | 116.25 (8.22)             | 116.48 (8.31)            | 118.62 (5.724)       | 116.45 (9.179)         | 114.75 (8.391)         | 115.56 (8.996)       | 0.031 (0.860)                                  | 0.691 (0.560)                                  | 0.146 (0.932)   |
| Multidimensional fatigue inventory <sup>d</sup>      | 37.78 (12.94)             | 38.45 (14.07)            | 41.17 (18.067)       | 33.59 (10.20)          | 42.40 (12.076)         | 37.48 (12.380)       | 0.009 (0.924)                                  | 1.779 (0.157)                                  | 2.143 (0.100)   |
| Sedentary measures                                   |                           |                          |                      |                        |                        |                      |  |  |   |
| Volume   |                           |                          |                      |                        |                        |                      |  |  |   |
| Total time (%)                                       | 78.00 (6.17)              | 74.73 (5.77)             | 76.05 (4.27)         | 73.69 (5.58)           | 79.06 (5.43)           | 75.4 (7.57)          | <b>7.457 (0.008)</b>                           | <b>2.860 (0.041)</b>                           | 0.228 (0.876)   |
| Number of bouts                                      | 298 (88)                  | 293 (68)                 | 319 (89)             | 275 (53)               | 292 (78)               | 297 (76)             | 0.034 (0.855)                                  | 1.985 (0.122)                                  | 1.413 (0.244)   |
| Number of bouts (8 a.m. to 8 p.m.)                   |                           |                          |                      |                        |                        |                      |  |  |   |
| >20 min  | 48.41 (1.23)              | 46.45 (1.73)             | 46.29 (9.1)          | 44.31 (9.99)           | 52.15 (1.32)           | 47.04 (11.81)        | 1.164 (0.284)                                  | 2.387 (0.074)                                  | 0.202 (0.895)   |
| >30 min  | 31.19 (7.53)              | 29 (9.08)                | 29.33 (7.76)         | 27.93 (7.24)           | 32.65 (9.77)           | 29.8 (9.76)          | 2.264 (0.136)                                  | 1.840 (0.146)                                  | 1.005 (0.394)   |
| >55 min  | 15.16 (4.75)              | 12.98 (5.28)             | 13.08 (3.55)         | 13.59 (4.94)           | 15.5 (6.19)            | 12.96 (5.87)         | <b>4.796 (0.031)</b>                           | 1.354 (0.262)                                  | 0.924 (0.432)   |
| Pattern  |                           |                          |                      |                        |                        |                      |  |  |   |
| Alpha ( <i>a</i> )                                   | 1.278 (0.032)             | 1.288 (0.028)            | 1.284 (0.039)        | 1.285 (0.027)          | 1.286 (0.027)          | 1.285 (0.026)        | 2.646 (0.107)                                  | 0.067 (0.977)                                  | 0.372 (0.773)   |
| Gini ( <i>G</i> )                                    | 0.643 (0.027)             | 0.635 (0.023)            | 0.640 (0.032)        | 0.637 (0.022)          | 0.637 (0.022)          | 0.637 (0.021)        | 2.725 (0.102)                                  | 0.088 (0.966)                                  | 0.385 (0.764)   |
| Variability  |                           |                          |                      |                        |                        |                      |  |  |   |
| Variability ( <i>S</i> <sub>2</sub> )                | 1.791 (0.150)             | 1.763 (0.148)            | 1.750 (0.140)        | 1.810 (0.150)          | 1.760 (0.180)          | 1.760 (0.130)        | 1.050 (0.308)                                  | 0.659 (0.579)                                  | 0.238 (0.869)   |
| Ambulatory measures                                  |                           |                          |                      |                        |                        |                      |  |  |   |
| Volume   |                           |                          |                      |                        |                        |                      |  |  |   |
| Total time (%)                                       | 6.24 (2.18)               | 7.34 (2.27)              | 7.28 (2.25)          | 7.86 (2.04)            | 5.86 (2.05)            | 6.57 (2.43)          | <b>5.766 (0.018)</b>                           | 2.579 (0.059)                                  | 0.475 (0.701)   |
| Number of bouts                                      | 1236 (395)                | 1355 (355)               | 1308 (270)           | 1386 (388)             | 1185 (344)             | 1348 (441)           | 2.846 (0.095)                                  | 1.365 (0.259)                                  | 0.273 (0.845)   |
| Pattern  |                           |                          |                      |                        |                        |                      |  |  |   |
| Alpha ( <i>a</i> )                                   | 1.353 (0.024)             | 1.354 (0.029)            | 1.352 (0.026)        | 1.346 (0.022)          | 1.357 (0.03)           | 1.362 (0.031)        | 0.053 (0.819)                                  | 0.763 (0.518)                                  | 1.466 (0.229)   |
| Gini ( <i>G</i> )                                    | 0.587 (0.016)             | 0.586 (0.020)            | 0.588 (0.018)        | 0.591 (0.015)          | .584 (0.02)            | .581 (0.021)         | 0.031 (0.860)                                  | 0.715 (0.546)                                  | 1.408 (0.246)   |
| Variability  |                           |                          |                      |                        |                        |                      |  |  |   |
| Variability ( <i>S</i> <sub>2</sub> )                | 1.230 (0.070)             | 1.240 (0.100)            | 1.220 (0.070)        | 1.270 (0.090)          | 1.210 (0.090)          | 1.230 (0.090)        | 2.860 (0.822)                                  | 1.249 (0.297)                                  | 0.409 (0.747)   |
| Physical activity guidelines                         |                           |                          |                      |                        |                        |                      |  |  |   |
| Ambulatory activity ≥10 min (min) <sup>e</sup>       | 2488 (157, 7352)          | 3714 (1535, 8873)        | 7163 (2821, 9300)    | 3649 (995, 9773)       | 2069 (186, 3161)       | 2723 (313, 8142)     | <i>P</i> = 0.119                               | <b><i>P</i> = 0.038</b>                        | See the ambulatory activity section of the results <sup>e</sup> |
| Walked >150 min in bouts ≥10 min <sup>e</sup>        | 5 (16%)                   | 16 (24%)                 | 7 (29%)              | 8 (28%)                | 1 (5%)                 | 5 (20%)              | <i>X</i> <sup>2</sup> = 0.95, <i>P</i> = 0.330 | <i>X</i> <sup>2</sup> = 4.70, <i>P</i> = 0.192 |   |

<sup>a</sup>Ranges from 0 to 30 with a satisfactory cut-off >26.<sup>b</sup>Ranges from poor (0) to good (100).<sup>c</sup>Ranges from poor (69) to good (131).<sup>d</sup>Ranges from good (20) to poor (100).<sup>e</sup>Non-parametric distributions described using median (quartiles) or *n* (%) and the presence and nature of interactions are discussed in the ambulatory activity section of the results. Significant values are indicated in bold.



**Figure 1.** Scatter plots of the sedentary and ambulatory percentages (volumes) between those employed and retired and for the different age groups.

#### Retirement\*age

There were no interaction effects between retirement and age for any SB.

#### Ambulatory activity

##### Retirement

There was a significant main effect of retirement on the volume (total time %) of AA but not the pattern or variability. Those who were retired spent a greater percentage of their time engaged in AA compared with employed people (Figure 1 and Table 2).

##### Age

There were no main effects of age on the volume, pattern or variability of AA, although the percentage of AA showed a trend towards a reduction with age in older adults.

#### Retirement\*age

We also considered AA with respect to public health guidelines [28] which advocate accumulating 150 min of activity per week made up of 10 min bouts or greater. When considering the total number of AA bouts  $\geq 10$  min, we found a significant effect of age but not of retirement and there were no interaction effects. A Kruskal–Wallis test for age showed that younger adults (<65 years) accumulated significantly more time walking in the number of ambulatory bouts  $\geq 10$  min than those aged 65–70 years ( $P = 0.038$ ) and 70–75 years ( $P = 0.003$ ). There was no difference in the number of adults achieving 150 min

AA per week with respect to retirement or across the age groups and there were no interaction effects. However, it is worth noting that in total only 21 participants (21%) reached the AA guidelines of 150 min of activity per week.

#### Effect of sex on SB and AA

There was a significant main effect for sex on the variability of SB ( $F = 5.136$ ,  $P = 0.026$ ) and AA ( $F = 16.926$ ,  $P < 0.001$ ) with women having a more varied  $S_{2s}$  and reduced  $S_{2w}$ . In addition, women had a lower BMI ( $F = 4.370$ ,  $P = 0.039$ ) compared with men. However, there was no interaction between retirement status and sex on any of the clinical or SB and AA outcomes when controlling for age.

## Discussion

### Key findings

To our knowledge, this is the first study to examine objectively the association between retirement and age on both SB and AA. Our results show that retired people were more active than their employed counterparts, spending more time ambulatory and less time sedentary. Age was a factor with younger, retired adults showing the greatest levels of AA and the least amount of SB. Importantly, only 21% of participants achieved public health recommendations for AA—with no differences associated with retirement status or age—highlighting a continuing public health need to promote even moderate levels of PA, i.e. prolonged walking. While women were found to have a more varied pattern of SB and

AA compared with men, sex was not shown to be predictive of volume of SB or AA in retirement.

### Strengths and limitations

A strength of this study was that all forms of AA were captured (monitor worn continuous for 7 days) and the data presented are therefore independent of intensity or task in keeping with an 'active living' approach which embraces the broader concept of health [12, 33]. We found that retirement was associated with greater AA levels and, therefore, retirement may increase opportunities to become more active, as seen in previous work [6]. In addition, we found little differences in AA between age groups among those remaining in employment in agreement with a previous study which included a range of employment types [13]. Our results show that those with sedentary occupations do not compensate for a lack of work-based activity with increased leisure-time AA.

A limitation of the present study is that it was a cross-sectional investigation of associations between both retirement status and age and SB and AA in older adults. As such it is subject to potential confounding, e.g. to the circumstances leading to retirement, or not. We investigated potential confounding by characterising our participants carefully and, as shown in Table 2, we did not identify any systematic demographic or clinical differences between the two groups. Longitudinal accelerometer-based activity data collected pre- and post-retirement would give greater insight into the effect of retirement on activity patterns and we plan to employ this approach in future research using this longitudinal cohort. Most participants in this cohort had sedentary occupations and future studies should consider a wider range of types of employment since those with predominantly physically active jobs may show a different response in PA pattern following retirement [34]. Finally, the participants in the present study were from higher socio-economic groups, in the main, and further research will be needed to determine whether the findings can be generalised to other socio-economic groups.

### Interpretation of the study's findings

In the present cohort and similar to a previous study [13], retired people, in particular younger retirees, were more active and exhibited less SB than their employed counterparts but only a small proportion (21%) of the participants achieved recommended levels of ambulatory PA. Surveys suggest that there is a linear decline in activity levels with age [12] and objectively measured PA levels are consistently low in older adults [8]. Our results concur with these findings. We also found that mean activity levels (Table 2) were very low irrespective of retirement or age which is consistent with other European studies of those aged 50+ [6, 35].

SB was similar between retired and employed groups which also highlights the need for work-based interventions to reduce SB which has been shown to be associated with a range of poor health outcomes such as obesity and diabetes as well as cardiovascular disease [36, 37]. The combination of high levels of SB and low AA in the employed group is of concern.

Whether increased activity earlier in the life-course brings greater health benefits which are sustained into later life is currently unclear [38, 39]. The finding that sedentary time increased with age in the retired group is unsurprising and illustrates the challenge in changing SB to promote healthy ageing.

We described SB and AA by outcomes which represented features relating to their volume, pattern and variability. We found that the pattern and variability of bouts do not vary with age for those aged approximately >50 years, but the volume (amount) of SB and AA was sensitive to both age and retirement status. Volume outcomes such as those described may therefore represent useful measures of SB and AA for future studies in this age range. However, volume was not able to distinguish between sexes and in our study and we found that variability ( $S_2$ ) was a more suitable measure to distinguish between male and female groups. While the pattern and variability techniques adopted in this study were unable to successfully determine the effect of retirement status and age in this instance, more investigation is required into these techniques to quantify differences in this area.

### Conclusion and implications for policy

Retirement has been recognised as a major life event which may influence PA and which may present a critical 'window' for promoting PA through interventions [8]. While this study cannot inform us about the optimum time in the life-course to implement PA interventions, our findings show that younger employed adults have low levels of AA and therefore it may be worth considering the years approaching retirement as a period in which to initiate strategies to increase PA. Epidemiological evidence indicates that even low levels of less intensive activities such as walking can be health-protective in older adults [32, 33]. Furthermore, those activities along with more moderate forms of PA, such as brisk walking, may be easier to implement and more attractive to mid-life and older adults [28, 32].

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### Key points

- Retirement may have a positive effect on AA.
- Older retired adults spend less time sedentary and more time ambulatory than those of similar age and non-retired.
- Many older adults do not meet the current recommendations for weekly PA levels to promote healthy living.
- There is a need for suitable PA interventions targeting those in the over 50 age group.

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### Conflicts of interest

None declared.

## Funding

A.G. is supported by the LiveWell program a research project funded through a collaborative grant from the Lifelong Health and Wellbeing (LLHW) initiative, managed by the Medical Research Council (MRC) on behalf of the funders: Biotechnology and Biological Sciences Research Council, Engineering and Physical Sciences Research Council, Economic and Social Research Council, Medical Research Council, Chief Scientist Office of the Scottish Government Health Directorates, National Institute for Health Research (NIHR)/The Department of Health, The Health and Social Care Research & Development of the Public Health Agency (Northern Ireland), and Wales Office of Research and Development for Health and Social Care and the Welsh Assembly Government (grant number G0900686). L.R. and J.C.M. are investigators on the LiveWell project. S.L. and L.R. are supported by the NIHR, Newcastle Biomedical Research Centre and Unit based at Newcastle upon Tyne Hospitals NHS Foundation Trust and Newcastle University. The views expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health.

## Supplementary material

Supplementary material is available at *Age and Ageing* online.

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Received 28 February 2013; accepted in revised form 6 September 2013

*Age and Ageing* 2014; 43: 393–399

doi: 10.1093/ageing/aft192

Published electronically 8 December 2013

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## Job strain in the public sector and hospital in-patient care use in old age: a 28-year prospective follow-up

MIKAELA BIRGITTA VON BONSDORFF<sup>1</sup>, MONIKA VON BONSDORFF<sup>1</sup>, JENNI KULMALA<sup>1</sup>, TIMO TÖRMÄKANGAS<sup>1</sup>, JORMA SEITSAMO<sup>2</sup>, PÄIVI LEINO-ARJAS<sup>2</sup>, CLAS-HÅKAN NYGÅRD<sup>3</sup>, JUHANI ILMARINEN<sup>4</sup>, TAINA RANTANEN<sup>1</sup>

<sup>1</sup>Gerontology Research Center and Department of Health Sciences, University of Jyväskylä, Finland

<sup>2</sup>Finnish Institute of Occupational Health, Helsinki, Finland

<sup>3</sup>Gerontology Research Center and School of Health Sciences, University of Tampere, Finland

<sup>4</sup>Juhani Ilmarinen Consulting, 01650 Vantaa, Finland

Address correspondence to: M. B. von Bonsdorff. Tel: +358 400 342 692; Fax: +358 14 617 422. Email: [mikaela.vonbonsdorff@jyu.fi](mailto:mikaela.vonbonsdorff@jyu.fi)

### Abstract

**Background:** high job strain increases the risk of health decline, but little is known about the specific consequences and long-term effects of job strain on old age health.

**Objectives:** purpose was to investigate whether physical and mental job strain in midlife was associated with hospital care use in old age.

**Methods:** study population included 5,625 Finnish public sector employees aged 44–58 years who worked in blue- and white-collar professions in 1981. The number of in-patient hospital care days was collected from the Finnish Hospital Discharge Register for the 28-year follow-up period.

**Results:** rates of hospital care days per 1,000 person-years for men were 7.78 (95% confidence interval [CI] 7.71–7.84) for low, 9.68 (95% CI 9.50–9.74) for intermediate and 12.56 (95% CI 12.47–12.66) for high physical job strain in midlife. The corresponding rates for women were 6.63 (95% CI 6.57–6.68), 7.91 (95% CI 7.87–7.95) and 10.35 (95% CI 10.25–10.42), respectively. Rates were parallel but lower for mental job strain. Reporting high physical job strain in midlife increased the risk of hospital care in old age compared with those who reported low job strain, fully adjusted incidence rate ratio 1.17 (95% CI 1.00–1.38) for men and 1.42 (95% CI 1.25–1.61) for women. These associations were robust in analyses confined to hospital care that took place after the employees had turned 65 years.