Archives of Gerontology and Geriatrics 62 (2016) 68–74

Contents lists available at ScienceDirect

Archives of Gerontology and Geriatrics

journal homepage: www.elsevier.com/locate/archger

Relating wrist accelerometry measures to disability in older adults

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ARTICLE INFO

Article history:
Received 13 March 2015
Received in revised form 6 September 2015
Accepted 8 September 2015
Available online 16 September 2015

Keywords:
Accelerometry
Disability
Motor activity
Frail older adult
Self report

ABSTRACT

Objective: This analysis assessed the extent to which: (1) wrist accelerometer measures were associated with difficulty performing specific activities of daily living and instrumental activities of daily living and (2) these measures contributed important information about disability beyond a typical self-reported vigorous activity frequency question.
Methods: We used data from the National Social Life, Health and Aging Project (NSHAP) accelerometry sub-study ($n = 738$). Activity was assessed using two wrist-accelerometer measures assessed over 3 days (routine activity expressed as mean count/15 s epoch during wake time, and immobile time expressed as the proportion of wake time spent immobile), and self-reported average vigorous activity frequency. The association between routine activity, immobile time and difficulty performing fourteen activities of daily living (ADLs) and instrumental activities of daily living (IADLs) plus two summary measures (any ADL or IADL difficulty), was assessed using logistic regression models, with and without controlling for self-reported vigorous activity.
Results: Self-reported activity was mildly correlated with routine activity ($r = 0.27$) and immobile time ($r = -0.21$). Routine activity, immobile time, and self-reported vigorous activity were significantly associated with twelve, ten, and fourteen disability measures, respectively. After controlling for self-reported activity, significant associations remained between routine activity and eight disabilities, and immobile time and six disabilities.
Conclusion: Wrist accelerometry measures were associated with many ADL and IADL disabilities among older adults. Wrist acclerometry in older adults may be useful to help assess disability risks and set individualized physical activity targets.

1. Introduction

Physical activity (PA), whether done through formal exercise or routine every day activities, and limited sedentary time are important health indicators in older adults (Koeneman et al., 2012; Pavey, Peeters, & Brown, 2015). However, older adults face challenges to vigorous exercise participation due to higher rates of mobility limitations, vision loss, muscle weakness, social isolation, and endurance-limiting diseases (Rimmer, Riley, Wang, Rauworth, & Jurkowski, 2004). These limitations often result in changing patterns of activity with aging: reducing vigorous exercise, and spending more time doing low to moderate intensity exercise like walking or gardening, or routine activity like light housework or shopping, or being sedentary. Only half of adults over 65 report spending the recommended 150 min per week in moderate to vigorous activity (Adult participation in aerobic and muscle-strengthening physical activities—United States, 2013). Increasing activity and reducing sedentary time are both feasible interventions among seniors if programs are individualized (Rejeski et al., 2013).

Accurately assessing older adult physical activity patterns is challenging. Questionnaires designed to measure activity are limited to the specific activities evaluated, can become lengthy, and are subject to recall bias (Atkin et al., 2012; Kowalski et al., 2012). In older adults, cognitive impairment and fear of losing independence can also complicate the accuracy of self-report and may not reflect

Abbreviations: PA, physical activity; NSHAP, National Social Life, Health and Aging Project; W2, wave 2; NORC, National Opinion Research Center; CAPI, computer-assisted personal interview; ADL, activities of daily living; IADL, instrumental activities of daily living.

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http://dx.doi.org/10.1016/j.archger.2015.09.004
0167-4943/

true daily activity patterns (Sager et al., 1992; Seymour et al., 2001). Providers' time constraints further limit adequate activity assessment (Barnes & Schoenborn, 2012). National guidelines currently do not recommend a standard physical activity screen (Center for Disease Control and Prevention, 2011). Tools that measure vigorous activity, routine activity, and sedentary behavior simultaneously in older adults are limited (Atkin et al., 2012; Forsen et al., 2010; Washburn et al., 1993). Therefore, alternative mechanisms for assessing activity in older adults must be explored.

Accelerometry may be a useful objective assessment of activity in disabled adults. Prior work using hip accelerometers worn for 7 days showed that adults with mobility impairments spend less time in activity and more time sedentary than those without mobility impairments (Loprinzi, Sheffield, Tyo, & Fittipaldi-Wert, 2014). Duration of activity bouts using hip accelerometry was also associated with self-reported disability in older adults (Ortlieb et al., 2014). Accelerometry has been used to detect activity recovery following stroke (Gebruers, Vanroy, Truijen, Engelborghs, & De Deyn, 2010; Vanroy et al., 2014), to measure change in activity following pharmacotherapy for rheumatoid arthritis (Prioreschi, Hodkinson, Tikly, & McVeigh, 2014), and to assess activity adherence in multiple sclerosis patients (Klaren, Motl, Dlugonski, Sandroff, & Pilutti, 2013). Although hip accelerometry has a substantial body of evidence supporting its use in activity assessment, wrist accelerometers now firmly dominate the commercial markets. The relationship between wrist accelerometry measures and disability in older adults is not known despite a growing availability of these devices.

The objective of this analysis was to determine whether wrist accelerometer measures of activity and immobility are associated with difficulty performing activities of daily living (ADL) and instrumental activities of daily living (IADL). We also considered whether wrist accelerometry adds important information about disability beyond the traditional question on frequency of self-reported vigorous activity that might be used in a clinical encounter. Understanding whether and how wrist accelerometry measures are related to disability will help determine their clinical functionality and use in this population.

2. Methods

2.1. Study design

The National Social Life, Health and Aging project (NSHAP) is a longitudinal U.S. population-based survey that collected extensive information on physical, cognitive, and social health. A nationally-representative sample of 3005 community-dwelling older adults (ages 57–86) was recruited for Wave 1 (2005–2006) (O'Muircheartaigh, Eckman, & Smith, 2009). These participants and their partners ($n = 3377$) were re-interviewed in W2 (2010–2011). The NSHAP survey was conducted in the home by trained, non-medical interviewers and included a computer-assisted personal interview (CAPI), a biomeasure assessment, and a leave-behind questionnaire. The detailed sampling design and study methods have been reported elsewhere (O'Muircheartaigh et al., 2009). The data collection was approved by the local Institutional Review Board.

2.2. Study participants

A subset of 738 age-eligible (ages 62–91) W2 participants was included in a wrist accelerometer sub-study.

2.3. Wrist accelerometry sub-study

Respondents in the accelerometry sub-study wore the Actiwatch® Spectrum on their non-dominant wrist for 72 consecutive hours (not removed during water activities like bathing) (Chen et al., 2003; Philips Respironics. Actiwatch, 2013; Philips Respironics, 2008; Van Remoortel et al., 2012). It is an uniaxial, omnidirectional, piezo-electric, waterproof accelerometer used to measure sleep and (in) activity patterns (Philips Respironics. Actiwatch, 2013; Philips Respironics, 2008). A detailed description of the device and its use in NSHAP has been reported elsewhere (Huisingh-Scheetz et al., 2014). It continuously collects acceleration/deceleration data, which are averaged over 15-s intervals called "epochs" and recorded as an activity "count". If no activity occurs during the epoch, such as during sleep or rest, "0" is recorded for that activity count. Data were pre-processed using the Actiware® software available from the manufacturer (Philips Respironics. Actiwatch, 2013). Non-wear time was automatically excluded using a built-in galvanic sensor that identified when the device was worn. Rest and wake intervals were determined using manufacturer-suggested guidelines, cues from respondent recordings, data on ambient light in each epoch, and were manually curated by study investigators as described in detail elsewhere (Lauderdale et al., 2014). Actiwatch® accelerometer counts have been shown to be moderately and significantly correlated with indirect calorimetry-measured energy expenditure during routine activity in older adults with chronic disease and in middle-aged but sedentary adults (Chen et al., 2003; Rabinovich et al., 2013; Van Remoortel et al., 2012).

2.4. Routine activity and sedentary behavior

We calculated two summary measures from the accelerometer output to estimate "routine activity" and "immobile time". Routine activity was estimated by summing the activity counts per 15-s epoch for the wake intervals and dividing by the total number of epochs during wake time. Immobile time was estimated by the proportion of "0" activity counts among all activity counts during wake time, multiplied by 100%. Summary measures were used because equations predicting kilocalorie expenditure or METs from accelerometer activity count data have had inconsistent accuracy among older adults engaging in routine activity outside of the laboratory setting (Crouter, Churilla, & Bassett, 2006). Continuous summary measures were also chosen because wrist accelerometer count cut-offs that distinguish sedentary, mild, moderate, and vigorous metabolic equivalents were established in children rather than older adults for the Actiwatch® (Ekblom, Nyberg, Bak, Ekelund, & Marcus, 2012). Because we could not estimate sedentary time, we estimated time spent completely immobile. Immobile time underestimates actual sedentary time (e.g., a sedentary activity like watching television or reading will not be categorized as immobile due to low-level wrist movements) (Rosenberger et al., 2013). Using continuous accelerometry measures provides the highest resolution and most power for detecting significant pair-wise correlations.

2.5. Disability

Participants' self-reported degree of difficulty (4-point scale) completing seven ADLs and seven IADLs. ADL and IADL limitation was defined by the presence of any difficulty with each task (yes = 1/no = 0). The ADLs included: walking one block, dressing, walking across a room, transferring in/out of bed, toileting, bathing, and eating. The IADLs included: driving at night, driving during the day, light housework, shopping, meal preparation, managing money, and taking medications. Separate indicator variables were also created identifying participants with at least one ADL disability or at least one IADL disability.