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Measuring Physical Activity in Older Adults with and without Early Stage Alzheimer's Disease

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Abstract

We compared subjective reports of physical activity with objective measures of physical fitness including cardiorespiratory capacity, body composition, and physical performance in 146 older adults with and without early stage Alzheimer's disease (ESAD). Respondents reported primarily unstructured and low-intensity activities, including walking and housework. Individuals with ESAD participated in fewer and lower intensity physical activities than those without ESAD. In those without ESAD, housework was related to lower body mass index, leisure walking was related to faster speed on a timed walking test, and participation in sports was related to higher peak oxygen intake. In individuals with ESAD, reported physical activities did not predict any of the physical fitness, body composition, or physical performance measures. We conclude that measures of physical activity require expansion of unstructured and low intensity activities to improve sensitivity in sedentary populations, especially in older adults with ESAD.

Keywords

physical activity; older adults; Alzheimer's disease; measurement sensitivity

As many as 25% of all adults in the U.S. are completely sedentary and more than half are insufficiently active to achieve health benefits (Nelson et al., 2007; Pate et al., 1995). Rates of physical activity decrease throughout adulthood and are particularly low in older adults (Caspersen, Pereira, & Curran, 2000; McAuley et al., 2009; Nelson et al., 2007), putting them at risk for functional decline (Morey, Pieper, & Cornoni-Huntley, 1998) and other poor outcomes. Older adults who are physically active have lower disease and mortality rates (McCullough et al., 2011; Paganini-Hill, 2011), better cognitive performance, (Barnes, Yaffe, Satariano, & Tager, 2003; Colcombe & Kramer, 2003; Dustman et al., 1984; Yaffe, Barnes, Nevitt, Lui, & Covinsky, 2001) and decreased risk of cognitive impairment and Alzheimer's disease (AD) (Laurin, Verreault, Lindsay, MacPherson, & Rockwood, 2001), decreased risk of falls (Campbell et al., 1997; Chang et al., 2004; Day et al., 2002), among

many other positive outcomes. Thus, it is important for researchers to accurately measure habitual activities that might contribute to these outcomes.

Though measures of physical activity in older adults are relatively new compared to those designed for other age groups (Sallis & Saelens, 2000), several measures of physical activity have been developed for use in older adults (Dipietro, Caspersen, Ostfeld, & Nadel, 1993; Stewart et al., 2001; Voorrips, Ravelli, Dongelmans, Deurenberg, & Van Staveren, 1991; Washburn, Smith, Jette, & Janney, 1993). Several of these measures have been evaluated side by side (Harada, Chiu, King, & Stewart, 2001; Sallis & Saelens, 2000) with the conclusion that most demonstrate acceptable reliability and validity against objective measures, performance tests, and other self-report measures. Most have been demonstrated to perform better for younger elderly (age <75) males living in retirement homes. The higher reliability among this group likely reflects more regular exercise at higher intensity levels. Measurement of low intensity activity typical of sedentary populations tends to have poor reliability and validity (Jacobs, Ainsworth, Hartman, & Leon, 1993; Shephard, 2003). Prior suggestions for improved measurement of physical activity in older adults include: 1) querying about household chores and other unstructured tasks that are not formally defined as exercise (Blair et al., 1993; Masse et al., 1998), 2) reducing recall burden by requiring recall over relatively short periods of time (Shephard, 2003), 3) ascribing biological meaning to terms such as light, moderate, and heavy exercise (i.e., measures of energy expenditure; (Shephard, 2003), and 4) recording low intensity activities typical of sedentary populations (Jacobs et al., 1993; Shephard, 2003).

The unprecedented growth of the older adult population and subsequent increases in the prevalence of AD demand strategies for the measurement and promotion of physical activity for healthy brain aging. Physical activity is a health behavior that shows promise for protection against cognitive decline and gray matter loss in healthy older adults and those with AD (Burns et al., 2008; Colcombe et al., 2003; Colcombe & Kramer, 2003; Heyn, Abreu, & Ottenbacher, 2004; Laurin et al., 2001). Despite evidence for the benefits of physical activity for individuals with AD, no existing measurement tool has been validated to subjectively measure physical activity in this group. A recent workshop convened by NIA and the Alzheimer's Association concluded that improved measurement tools are needed to assess predictors of the earliest stages of AD including physical activity (Silverberg, Ryan, Carillo, Sperling, & Petersen, 2011). Instruments that include dimensions of physical activity such as participation in leisure activity and in instrumental activities of daily living such as housework, both of which decline with the development and progression of dementia, may be a helpful starting point (Lechowski et al., 2008; Sorensen, Waldorff, & Waldemar, 2008).

The Physical Activity Scale for the Elderly (PASE) is one instrument that addresses most of the prior suggestions for improved measures by including reports about household chores and requiring recall only over the past week. It attempts to ascribe biological meaning to the self-reported activities by using a weighting algorithm from external predictors including Caltrac movement counts and daily energy expenditures (METS totals) from an activity diary. It has been successfully validated against objective measures, including doubly labeled water (Schuit, Schouten, & Saris, 1997). It has also been shown to have higher correlations with performance-based measures including lower body strength, balance, and walking compared to Yale Physical Activity Survey (YPAS; (Dipietro et al., 1993)) and Community Healthy Activities Model Program for Seniors (CHAMPS;(Stewart et al., 2001)). Despite the advantageous features in the design of the PASE, its sensitivity has not been demonstrated for unstructured or low activity levels in relatively sedentary populations such as older adults with dementia. The goal of the present study was to determine whether subjective reports of physical activity on the PASE can be used to predict objective physical

outcomes on a variety of fitness indicators including cardiorespiratory capacity, body composition, and physical performance in older adults with and without early stage AD (ESAD). To the degree that the PASE is a valid measure of physical activity, we would hypothesize it to be positively associated with these measures.

Methods

Participants

The Brain Aging Project is a longitudinal study of brain health and lifestyle factors in adults aged 60 and older. The present study includes $N = 72$ participants with early stage Alzheimer's disease (Clinical Dementia Rating (CDR) = 0.5 ($n = 58$) or 1 ($n = 14$), representing very mild or mild dementia) and $N = 74$ healthy control participants (CDR = 0) for a total $N = 146$. Baseline measures of individuals with a stable diagnosis over a 2-year study period are included in the present study. Institutionally approved informed written consent was obtained from each individual and their legal surrogate, if necessary. Exclusion criteria for the parent study consisted of neurologic diseases other than AD, diabetes mellitus (clinical diagnosis or use of anti-diabetic agent), ischemic heart disease history (e.g., acute coronary artery event, angina) in the last 2 years, schizophrenia, clinically significant depressive symptoms, B12 abnormalities, thyroid dysfunction, use of psychoactive and investigational medications, significant auditory or visual impairment, or systemic illnesses that could impair completion of the study. Physical and neurological characteristics of these participants have been presented previously (Burns et al., 2008).

The ESAD group had higher rates of hypertension (46% vs. 28%, $\chi^2 = 5.1$, $p < .05$) and depression (32% vs. 7%, $\chi^2 = 15.0$, $p < .001$) than the control group, but did not differ in rates of tobacco use, cardiovascular disease, heart attack, atrial fibrillation, angioplasty, cardiac bypass, pacemaker, congestive heart failure, stroke, head injury, parkinsonism, diabetes, psychiatric disorders (other than depression), B12 deficiency, thyroid disease, walking problems, abnormal movements, seizures, ulcers, or cancer. The ESAD group had higher rates of use of cholinesterase inhibitors (57% vs. 1%, $\chi^2 = 60.6$, $p < .001$), SSRIs (16% vs. 5%, $\chi^2 = 4.9$, $p < .05$), and beta-blockers (13% vs. 4%, $\chi^2 = 4.5$, $p < .05$), and lower rates of multivitamin use (52% vs. 68%, $\chi^2 = 4.2$, $p < .05$) than the control group, but did not differ in rates of benzodiazepines, sex hormones, medications for bone health, thyroid, or calcium, or vitamin D supplements.

Clinical Assessment

All participants underwent a comprehensive clinical assessment as detailed elsewhere (Burns et al., 2008). Briefly, AD diagnosis was made using National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association criteria and severity was determined using the Clinical Dementia Rating (CDR) scale (Morris, 1993). Only those participants without dementia (CDR = 0) or with very mild or mild dementia (CDR = 0.5 or 1) were enrolled. The Mini-Mental State Exam was administered as a brief cognitive test (Folstein, Folstein, & McHugh, 1975).

Measures of Physical Health

In accordance with the International Consensus Statement of Physical Activity, Fitness, and Health (Bouchard, 1993), we sought to assess the relationship of the PASE to four components of physical health: 1) cardiorespiratory capacity, 2) morphological measures (i.e., body composition), 3) muscular performance, and 4) motor ability. These physical health outcomes were measured within one month or less of completion of the self-reported physical activity scale for the elderly.

Cardiorespiratory Capacity—Participants performed a graded treadmill exercise test using a modified Bruce protocol, designed for older adults (Hollenberg, Ngo, Turner, & Tager, 1998). Participants began walking at a pace of 1.7 miles per hour at 0% incline. At each 2-minute interval, the grade, speed or both was increased. Subjects were attached to a 12-lead electrocardiograph (ECG) to continuously monitor heart rate and rhythm. Expired gases were collected continuously and oxygen uptake and carbon dioxide production was averaged at 15-second intervals (TrueOne 2400, Parvomedics, Sandy, UT). The exercise test was terminated if the participant reached volitional exhaustion or met absolute test termination criteria according to ACSM guidelines (ACSM, 2010). The peak oxygen consumption (VO_2 peak, $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) during the test was used as an index of cardiorespiratory capacity. Peak oxygen intake ranged from 11.99 to 44.60 in our sample ($M(\text{SD})= 20.65(5.24)$).

Morphological Measures—Total body mass and body composition including lean mass percentage were measured by using dual energy x-ray absorptiometry (DXA; Prodigy fan-beam densitometer, version 11. 2068, Lunar Corp., GE Medical Systems, Madison, WI) at the same facility on the same densitometry unit. Lean mass percentage represents the ratio of lean mass to the total body mass multiplied by 100. Whole body mass was determined using a digital scale accurate to ± 0.1 kg (Seca Platform Scale, model 707, Seca Corp., Columbia, MD). Height was measured by stadiometer with shoes off. BMI was calculated from these measures ($\text{BMI}=\text{whole body mass}/\text{height}^2$ [$\text{kg}\cdot\text{m}^{-2}$]). Morphological measures were performed in the morning after a voiding attempt. BMI in our sample ranged from 17.28 to 38.70 ($M(\text{SD}) = 25.93(3.91)$).

Muscular Performance and Motor Ability—The Physical Performance Test is a short, objective battery of timed physical tasks, usually provided as a composite measure of physical performance (Reuben & Siu, 1990). We used items in the modified PPT (Burns et al., 2008) to characterize components of physical health. We used the five times sit-to-stand measure of lower extremity strength (Segura et al., 2010) to index muscular performance. Motor ability was indexed using the 50 foot walk with midway turn, a measure of ambulatory agility, and a progressive Romberg test (feet together, then semi-tandem, then tandem, summed time of 10 seconds in each position) to measure balance. Scores on the five times sit to stand test ranged from 6.6 to 36.0 seconds ($M(\text{SD}) = 13.44(4.75)$). Scores on the 50 foot walk ranged from 8.30 to 29.40 seconds ($M(\text{SD}) = 15.11(3.41)$). Scores on the balance test ranged from 16 to 30 ($M(\text{SD}) = 27.91(3.19)$).

Self-Reported Physical Activity

Self-reported physical activity was measured by the Physical Activity Scale for the Elderly (PASE). The PASE is a commonly used geriatric self-report scale designed to assess weekly physical activity of older individuals in epidemiological studies (Washburn et al., 1993). Six items assess leisure activities (e.g., walking, sports), 6 items assess household activities (e.g. housework, gardening), and 1 item assesses paid or volunteer employment. The first section, leisure activity, asks participants to indicate how frequently (never, seldom, sometimes, often) and for how many hours per week (< 1 hour, 1–2 hours, 2–4 hours, 4+ hours) they engage in the leisure activities. Examples were given to illustrate each category. The second section, household activity, solicits information about household activities in which participants respond yes or no. Finally, participants are asked whether or not they work or volunteer outside the home (yes or no) and what degree of physical activity is required at work (mainly sitting, some walking, handling of light materials, heavy manual work). The total PASE score is computed by summation of weighted item scores combined in an algorithm (Washburn et al., 1993). As the total PASE score and many of the items have skewed distributions, we also used responses on individual items.

Cognitive impairment can compromise information provided by individuals with AD (Wadley, Harrell, & Marson, 2003). Thus, each participant in the Brain Aging Project enrolled with a study partner knowledgeable about the participant's daily activities. Study partners were required to have 10 or more hours per week of contact with the participant including spouses, relatives, adult children of the participant, friends or professional caregivers. Results include self-reports for the participants without ESAD and study partner reports for those with ESAD.

Response Rates for Individual PASE Items—For regression analyses, we modified three items (sports, housework, lawn & garden) to combine overlapping items and create more continuous distributions with enough variability to enable analysis. Precedent for such combination of items is found in (Dallosso et al., 1988) who suggest that this results in fewer zeroes. Participation in sports at three levels of intensity (light, moderate, and strenuous) was combined together into a single indicator with a higher score representing participation in more strenuous sports. Because light housework was endorsed by nearly all respondents (limited variability in responses), light and heavy housework were combined such that a 0 represented no housework, 1 represented light housework only, and 2 represented light and heavy housework. The lawn and yard work item and the gardening item were each endorsed with a high degree of overlap ($X^2(df) = 202(1), p < .001$). Seventy-three percent who said “no” to one also said “no” to the other; 87% who said “yes” to one also said “yes” to the other, suggesting that they were largely accounting for the same activities. Thus, they were combined into a single item.

Data Analysis—Total PASE scores did not predict fitness outcomes (range = $-.17$ to $.11$, p range $.15$ to $.85$), perhaps due to the floor effect. Therefore, we used individual items from the PASE to determine which items were predictive of fitness outcomes. We used simultaneous regression (PASW Statistics v. 18.0, SPSS, Inc., 2009, Chicago, IL) to estimate the effect of the activities from the PASE on six indicators of physical health and fitness (VO_2^{peak} , BMI, %lean mass, chair rise test, Romberg progressive balance test, and fifty foot walking test) adjusting for age and sex. To obtain stable and precise estimates in our relatively small sample, regression coefficients were estimated using bootstrap estimation (5,000 samples) and 95% confidence intervals. We used the false discovery rate procedure (Benjamini & Hochberg, 1995) to adjust for multiple inferences drawn from the results of several multiple regression analyses. This procedure adjusts for the family-wise error rate for both type 1 and type 2 errors. As previous research suggests that types of activity engagement vary significantly by age and sex (Dallosso et al., 1988), we included these as covariates in all regression models.

Results

Demographic information and percent of respondents reporting participation in each of the questionnaire items are reported in Table 1. Participants with and without ESAD did not differ in mean age, distributions of sex, or body mass index. The group with ESAD had significantly fewer years of education ($t(df) = 2.64(146), p < .01$), as is typical. T-tests indicate that those with CDR = 0.5 did not differ in mean age or education from those with CDR=1, though the CDR=1 group had significantly lower BMI ($M(SD) = 23.1(3.5)$) than the CDR = 0.5 ($M(SD) = 26.0(4.0)$, $t = 2.45, p = .02$). Chi-square tests indicated no significant differences in the distributions of sex or race between the two groups.

Participation is defined as respondents' participation in the activity in the past 7 days. The majority of respondents reported non-participation in sports (light, moderate, strenuous), home repairs, gardening, and caring for another person. The majority of participants reported engagement in walking and light housework. Strength and endurance exercises,

lawn and yard work, and heavy housework were endorsed only in the majority of respondents without ESAD. The response distributions are highly skewed indicating that most of the questions referred to activities in which participants did not engage.

Cardiorespiratory Capacity

Higher peak oxygen intake (VO_2^{peak}) was predicted by participation in sports in participants without ESAD (Table 2). Few people reported participation in sports of any intensity. When all three levels of sports are combined 17% with ESAD (N=12) and 27% without ESAD (N=20) reported participation in sports.

Morphologic Measures

In individuals without ESAD, engagement in housework was reported by over 90% of men and women and predicted lower BMI (See Table 2). By contrast, 98% of females with ESAD reported housework compared to 52% of males with ESAD. Results split by sex did not reveal an effect on BMI or lean mass in individuals with ESAD.

Muscular Performance and Motor Ability

None of the activities predicted performance on the chair rise or Romberg balance test for participants with or without ESAD.

Discussion

We tested the ability of individual items on the PASE to predict health and fitness outcomes for older adults with and without early stage AD in four categories: 1) cardiorespiratory capacity, 2) morphologic measures, 3) muscular performance, and 4) motor ability. Overall, the items were not predictive of these health and fitness outcomes, though we identified a few unstructured and low intensity items that were related. Unstructured and low intensity physical activities (i.e., walking and household chores) were reported as the primary or only source of physical activity for the majority of respondents. The questionnaire items for measuring unstructured activities were limited in number and detail, requiring only a yes or no response. Thus, we were unable to distinguish between individuals with different levels of unstructured activity. Our results are consistent with studies that suggest a floor effect when measuring physical activity in sedentary populations. Although a few questionnaires include items regarding unstructured activities, no questionnaire has been designed to clearly measure the types, frequencies, and intensities of unstructured activities in which older adults engage.

We confirm previous reports (Clark, 1999; Tudor-Locke & Myers, 2001) of the existence of a floor effect in self-report measures of physical activity and add that this floor effect is greater among individuals with ESAD. Scales that have a floor effect have low sensitivity and thus, a high rate of false negatives. Scores indicate low levels of physical activity, but this may be false if the items on the scale are more difficult than the activities in which respondents actually engage. If surveyed regarding less physically demanding or more age-relevant items, a different conclusion might be drawn about the physical activity levels of respondents. The age-irrelevant items call into question the construct validity of the scale for sedentary older adults with and without ESAD.

Floor effects are found in nearly all self-report measures of physical activity when used in primarily sedentary populations such as older adults and individuals with chronic health problems and disability (Dallosso et al., 1988; Tudor-Locke & Myers, 2001). For example, a study of individuals over 55 with type 2 diabetes found that most respondents reported less than an hour of daily activity, which was lower than the lowest possible score on the PASE

(Hays & Clark, 1999). A study conducted among a low income population of community dwelling older adults found that the types of activities described on the PASE and the Yale Physical Activity Scale were very rare and some completely unreported (Clark, 1999). Over 75% of participants in that study were at the floor for walking and only 13% reported any leisure activity other than walking. Presumably the sample was less healthy and less well-educated than the sample on which those instruments were created and validated. In the present study, several items had such a low number of responses that meaningful predictions could not be made about them.

Individual items, especially walking and housework, proved more useful than total scores for predicting fitness outcomes in the present study. Analysis of individual questionnaire items demonstrated differential prediction of health and fitness outcomes. An Item Response Theory approach may be valuable in the design of self-report scales for physical activity and allow for better estimation of the contributions of each item as well as the overall fit of the items to the constructs being studied. Unstructured activities including housework, gardening, and walking showed near significant trends for prediction of physical outcomes, but power to detect these relationships may have been limited due to the lack of detailed measurement for these items (i.e., only yes/no responses, limited number of items). These types of unstructured activities warrant further exploration in future studies.

Physical Activity in Older Adults without ESAD

In older adults without ESAD, housework predicted healthier BMI, but did not impact cardiorespiratory or other outcomes. Light housework and carrying groceries require only 40–50% of peak aerobic capacity (Arnett, Laity, Agrawal, & Cress, 2008), well below levels recommended to maintain health in older adults (Nelson et al., 2007). Physical activities that do not enhance cardiovascular fitness may still have other important benefits including improved balance, strength, motor coordination, flexibility, and maintenance of function. Further study is needed to replicate the association between body composition and housework and clarify whether housework provides a sufficient level of physical challenge in older adults to impact health and fitness outcomes. It is also possible that individuals with healthier BMI are more likely to engage in housework.

None of the reported physical activities predicted balance or muscular performance. As the present study did not include comprehensive indicators of muscular performance that might include power, strength, and muscular endurance, we cannot draw conclusions about the effect of physical activities on other measures of muscular performance. These outcomes are important to physical activity research in older adults and future questionnaire design should include items that would relate to them.

We did not find significant associations between walking and health outcomes among older adults with or without ESAD. This is in contrast to several studies demonstrating the benefits of walking including delayed onset of functional limitation (Lawrence & Jette, 1996), and cognitive function (Weuve et al., 2004). Though walking is one of the most important activities to assess in older adults because of its continued frequency despite declines in other activities, walking behavior is difficult to measure accurately via self-report (Tudor-Locke & Myers, 2001). Self-report of walking is especially poor at capturing intensity and distance walked due to recall bias and other errors associated with self-report (Durante & Ainsworth, 1996).

In terms of practicality, expense, and other considerations, pedometer or accelerometer technologies are preferable forms of measurement for walking behaviors (Tudor-Locke & Myers, 2001). Where more objective measures such as pedometers are not possible, self-report of walking might be improved by collection of additional details regarding intensity,

duration, purpose (e.g., leisure, shopping), surface (e.g., gravel, pavement, sand), and carrying or pushing objects that add variation in metabolic equivalent levels. To help respondents evaluate intensity, descriptions of exertion that are observable by the respondent can be included. For example, endorsement for statements such as, "I broke a sweat" or "I was breathing too hard to have a conversation" may give an indication of the level of intensity. Duration, though difficult to estimate accurately by memory recall, is critical. Addition of clearer definitions of walking may also be helpful. For example, Dollosso et al (Dollosso et al., 1988) found that subtracting out time spent walking while shopping actually improved correlations of self-reports with pedometer reports of walking. Our results have several implications for improved measures of physical activity in sedentary older adults. Questionnaire items regarding unstructured and lower intensity activities need to be expanded to capture the activity engagement of a less active population. Combining measures of physical activity with measures of activities of daily living (ADLs) may also better span the lower end of activities. The PASE records only yes or no responses regarding participation in household chores, yard work, and other unstructured activities. Addition of more detailed information about the type, duration, frequency, and intensity of unstructured activities such as household chores would allow for more variation in responses to better discriminate between individuals with different levels of activity. For example, gardening activities such as digging, hedge clipping, pushing a mower, raking, and watering all require different degrees of energy expenditure. For housework, mopping floors, dusting, laundry, washing windows, and vacuuming require different degrees of energy expenditure and the number of rooms or size the rooms in the house, might also contribute additional information. Estimates of the energy expenditure required for such tasks could be used in a weighting algorithm to calculate a more accurate degree of physical activity (Ainsworth et al., 1993). Since these estimations are calculated based on a person's body mass, questionnaires might include body weight in the questionnaire to aid in calculation of expenditure.

Additional low intensity items should be identified that are age-relevant to older adults. To adequately sample the lower end of the physical activity spectrum, it is essential to gain a clear understanding of what activities older adults do engage in and with what frequency. One study conducted in England in the late 1980s collected detailed profiles of activity among over 1,000 older adults age 65 to over 80, with the oldest age groups over-sampled (Dollosso et al., 1988). They reported that 91% were ambulatory outside the house at least once every two weeks including those who used walking aids or walked with difficulty. The remaining 9% of respondents were completely non-ambulatory. Existing measures of physical activity for older adults do not capture activity that occurs with a frequency less than once per week. For example, strenuous activities such as sports were reported by very few participants in the present study. This might reflect the wording of the questionnaire that limits reports of engagement in activities that occur weekly. The shorter time scale required for accurate recall must be balanced with the low frequency with which activity participation occurs. Future studies might investigate the lower bounds of activity frequency by including response options for activities completed routinely from <1 month to more than once per day. Validation studies are needed to evaluate the minimum frequency required to predict health and fitness outcomes.

Physical Activity in Early Stage AD

None of the reported physical activities predicted physical fitness, body composition, or physical performance in our sample of individuals with ESAD. Although this reflects a lack of physical activity in this group, we argue that failure to adequately measure unstructured and low intensity activities contributes to this lack of association. Although self-reported walking in participants with ESAD did not predict fitness outcomes, walking may be

beneficial in adults with ESAD who engage in few other activities. Additional research, including controlled intervention studies, can help clarify the potential gains that can be achieved by this safe and appropriate low intensity activity.

Because older adults with ESAD have unique symptoms, behaviors, and health conditions, there are additional implications for measuring physical activity in this group. Physical activity and fitness levels are expected to decline with increasing severity of the disease, increasing comorbid conditions, and decreasing ability for self-care. Individuals with dementia taking cholinesterase inhibitors are at greater risk for slower heart rate (bradycardia). However, Billinger et al. (Vogelzangs et al., 2009) reported that individuals with AD, 84% of whom were on cholinesterase inhibitors, demonstrated physiologic responses to submaximal exercise effort that were not significantly different than individuals without dementia, though differences were apparent with extreme levels of effort.

In individuals with ESAD, more research is needed to establish whether self-report of physical activity is reliable and valid, particularly as the disease progresses and cognitive impairment worsens. Most research on individuals with ESAD relies on proxy-report, which may or may not be more reliable and valid than self-report of patients. In our sample, self-report of individuals with early stage AD were similar to proxy-reports, and self-reports were actually more strongly associated with objective measures such as cardiorespiratory fitness and bone mineral density. Research in individuals with ESAD nearly always requires the use of a study partner who may already be burdened with their care duties. Thus, researchers must find creative solutions for integrating caregivers into research and intervention plans, such as studies that benefit both caregivers and the individuals with ESAD they care for.

Limitations and Future Directions

Some limitations of the present study should be noted. First, the study did not include measures of activities of daily living (ADLs) which may provide additional information about typical physical activity in older adults. The AD cases were all early stage, so no conclusions may be drawn about the changes in physical activity with increasing levels of disease severity. The present study did not include objective measures of physical activity such as a pedometer or accelerometer. While such measures would improve accuracy and decrease recall bias, it is not always feasible or cost effective to use accelerometers. More importantly, accelerometers do not indicate the types of activities in which individuals engage. Our ultimate goal is to prescribe increases in physical activities. A general prescription to “increase activity levels” is unlikely to impact behavior as effectively as instruction to increase specific unstructured behaviors that can occur in the home environment and still impact health outcomes. Different types of physical activity such as gardening, walking, housework, and so on, should be investigated individually to determine the optimal means for measurement and quantification of its effects on health outcomes. We expect that different activities would impact different physical outcomes. For example, carrying groceries may increase muscle strength and balance, gardening may influence flexibility and joint mobility, and walking might improve cardiorespiratory fitness and walking speed.

In the next phase of research, we will obtain detailed characterization of the types (unstructured) and intensity of activities (low to moderate) in which this population engages. To evaluate the degree to which unstructured and low intensity activities are underreported, accelerometers will objectively measure the frequency, intensity, and duration of all movement in a 7 day period corresponding to collection of physical activity diaries. We will use structured interviews and telephone check-ins to align the objective accelerometry data

with diary reports and investigate any unreported or underreported diary activities that register on the accelerometer. For example, if accelerometer data suggests a burst of activity during a particular time epoch that is not recorded on the diary, participants will be queried regarding their activity during that time. Wireless accelerometry data downloading will allow more timely interaction with participants while activity is occurring and may thus reduce the recall bias associated with recalling activity afterward. Developing a sensitive measurement tool for unstructured activities is an essential step in advancing the mission to increase physical activity to improve health in older adults. Health behavior change is most successful when it capitalizes on ecologically valid targets, like unstructured physical activities, that people can do within their own environment without additional equipment, resources, or support. Even modest increases in unstructured activity could convey meaningful health benefits and potentially delay the onset of AD.

Conclusions

Our study offers a unique contribution by comparing the correlates of physical activity in older adults with and without ESAD. The goal of the present study was to determine whether subjective reports of physical activity on the PASE can be used to predict objective physical outcomes on a variety of fitness indicators including cardiorespiratory capacity, body composition, and physical performance in older adults with and without early stage AD (ESAD). To the degree that the PASE is a valid measure of physical activity in sedentary older adults with and without ESAD, we hypothesized that it would be positively associated with these measures. Few of the subjectively reported activities predicted healthy outcomes in those without ESAD and none predicted outcomes in those with ESAD.

Older adults without ESAD reported participation in unstructured, but few structured physical activities and mostly at low intensity levels. Individuals with ESAD participated in fewer and lower intensity physical activities than those without ESAD. We propose it is valuable to further investigate unstructured and low intensity physical activities in this population such as gardening, walking, and housework. Increased power to detect such relationships may be improved by more detailed assessment of these and other unstructured activities. We found individual questionnaire items more valuable than total score at predicting fitness outcomes, suggesting that an Item Response Theory approach may be valuable in the design of self-report scales for physical activity. We conclude that measures of physical activity require an expansion of unstructured and low intensity activities to improve sensitivity in sedentary populations, especially in older adults with ESAD.

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Table 1
Participant Demographics and PASE Item Frequencies by Dementia Status and Sex

	Controls (N=74)		Men (N=32)		Women (N=42)		Early stage AD (N=72)		Men (N=27)		Women (N=45)	
	Total M(SD)		Men (N=32)		Women (N=42)		Total M(SD)		Men (N=27)		Women (N=45)	
Age (yrs)	74.0 (7.2)		73.6 (6.9)		74.3 (7.5)		74.9 (6.4)		76.7 (6.2)		73.8 (6.4)	
Education (yrs)	16.4 (2.8) *		17.2 (3.1)		15.8 (2.4)		15.1 (3.1)		16.0 (3.5)		14.5 (2.7)	
BMI	26.4 (3.8)		26.5 (3.7)		26.4 (3.8)		25.4 (4.0)		26.3 (3.2)		24.9 (4.4)	
Sex (% female)	57		--		--		63		--		--	
Race (% Caucasian)	100		100		100		94.4		93.3		96.3	
	Self-Report						Study Partner					
	Total		Men		Women		Total		Men		Women	
	% (N)						% (N)					
Walking	74(55)		75(24)		74(31)		68(45)		70(19)		60(27)	
Light Sports	5(4)		6(2)		5(2)		8(6)		7(2)		9(4)	
Moderate Sports	8(6)		12(4)		5(2)		6(4)		7(2)		4(2)	
Strenuous Sports	22(16) *		22(7)		21(9)		6(4)		11(3)		2(1)	
Strength & Endurance	54(40) * †		41(13)		64(27)		33(39) †		44(12)		27(12)	
Light Housework	95(70)		91(29)		99(40)		81(58) †		52(14)		99(44)	
Heavy Housework	57(42)		56(18)		57(24)		47(34)		44(12)		49(22)	
Home Repairs	18(13) †		34(11)		5(2)		4(3)		7(2)		2(1)	
Lawn/Yard work	53(39) †		69(22)		40(17)		37(27) †		59(16)		24(11)	
Gardening	35(26)		34(11)		36(25)		29(21)		41(11)		22(10)	
Caring for another person	39(29)		37(12)		40(17)		15(11)		11(3)		18(8)	

Notes: 1. For each activity, the table reflects respondents reporting a response other than "never." 2. Early stage AD includes participants with CDR scores of 0.5 and 1.

* differs by dementia status, p<.05

† differs by sex, p<.05

Table 2
Standardized Regression Coefficients for PASE Items Predicting Physical Outcomes accounting for Age and Sex

	Controls	BMI	% lean mass	Chair Rise	50 Foot Walk	Balance Test	VO2 peak	Early stage AD	BMI	% lean mass	Chair Rise	50 Foot Walk	Balance Test
Continuous Items													
Walking	.10	-.09	.11	-.10	-.32**	.12	.18		.01	.10	-.04	-.18	.07
Sum of Sports	.36**	-.11	.14	-.12	.04	-.004	.17		.08	.01	-.02	-.09	-.10
Strength & Endurance	.14	-.06	.16	-.08	.03	-.002	-.04		-.02	-.15	.24	-.01	.10
Yes/No Items													
Housework	.10	-.37**	.19	-.02	-.18	.05	-.02		.27	-.25	.07	-.03	-.01
Lawn, Yard & Garden	.10	-.08	.08	-.23	-.23	-.16	.06		-.24	.15	.04	.02	.18
Home Repair	.03	.09	.01	.11	.17	.001	.08		-.21	.13	-.08	.27	-.07
Caring for another	.01	.15	-.18	-.17	.07	.20	-.04		.18	-.13	.14	-.03	.08
Covariates													
Age	-.47***	-.14	-.03	.45	.31**	-.20	-.49***		-.01	-.05	.20	.21	-.46***
Sex (Male = 1)	.45***	-.01	.60***	-.10	-.24	.03	.50***		.37	.37	.10	-.34	-.04

** p<.01,

*** p<.001;

p-values and significance tests adjusted for bootstrapped 95% confidence intervals and family-wise error rate

Note: Lower scores on chair rise and 50 foot walk test represent faster performance.