Cognitive Impairment and Effects on Upper Body Strength of Adults With Dementia

Sharon D. Rogers and Shannon E. Jarrott

The purpose of this investigation was to examine the association between cognitive ability and upper body muscle strength. Two sources of existing data were pooled for this examination. Thirty-eight older participants diagnosed with Alzheimer’s disease or dementia (25 women, 13 men; age = 83.2 ± 5.6 years, MMSE score = 16.75 ± 7.04, M ± SD) underwent an assessment of grip strength via handheld dynamometry. Multiple-regression analysis indicated that cognitive status was a significant predictor of strength and, when combined in a model with age and sex, explained 57% of the between-individuals variance in handgrip strength. The findings from this exploratory investigation suggest that dementia is associated with strength loss, a key contributor to functional disability; this further justifies efforts to investigate mechanisms responsible for this decay and to preserve muscle integrity by integrating physical activity interventions, notably, muscle strengthening, into the lifestyle of adults with dementia.

Keywords: functional disability, dementia and strength loss, grip strength, excess disability

It is well accepted that adults with Alzheimer’s disease or a related dementia (ADRD) are susceptible to “excess disability,” which is “a discrepancy that exists when a person’s functional incapacity is greater than that warranted by the actual impairment” (Brody, 1971, p. 125), such that the limitations these adults experience extend beyond cognitive faculties. These cognitively impaired adults exhibit diminished muscle mass (Nourhashémi et al., 2002) and experience functional declines and disability, independent of the effects of sociodemographic factors or other health conditions (Agüero-Torres et al., 1998; Agüero-Tores, Thomas, Winblad, & Fratiglioni, 2002; Barberger-Gateau et al., 2004; Greiner, Snowdon, & Schmitt, 1996; Raji, Al Snih, Ray, Patel, & Markides, 2004; Thomas, 2001). In people without a known or specified cognitive impairment, there is an established association between poor cognition and disability (Greiner, Snowdon, & Schmitt, 1996; Raji et al., 2005).
There are a variety of plausible explanations for this disability vulnerability of adults with ADRD, justifiably including the deleterious effects of Alzheimer’s disease or other demential condition that make it difficult to orchestrate and perform motor tasks that require and, consequently, help sustain muscle strength. Difficulty or inability to sequence movements compromises the type of activities that are performed, and, consequently, muscles receive inadequate use and lose mass and strength, thus substantiating a feedback cycle for functional decline and disability. In addition, other factors including advanced age or internal (e.g., apathy) and external resources (e.g., inappropriate types of assistance, lack of environmental supports) can be detrimental to the physical functioning of adults with ADRD.

Isometric hand dynamometry has been used by a number of other research teams to assess muscle strength in adults with ADRD (Milne & Maule, 1984; Phillips, 1986; Shechtman, Mann, Justiss, & Tomita, 2004). Handgrip strength is a valid measure of upper body strength (Schwartz, Cohen, Herbison, & Shah, 1992), is a reliable test of strength in adults with ADRD (Rogers, 2005a), and is measured with relative ease. Grip strength declines with advancing age beginning around age 40, the decline accelerating each subsequent decade of life after age 60 (Desrosiers, Bravo, Hébert, & Dutil, 1995; Mitninski, Graham, Moginer, & Rockwood, 1999). In addition, men on average have stronger grip than same-age women (Desrosiers et al., 1999).

As a means of more clearly defining the excess-disability phenomenon, the purpose of this exploratory investigation was to examine the association between cognitive ability and muscle strength in a cohort of people with known cognitive impairment. Based on Verbrugge and Jette’s (1994) disablement model and prior research on adults without known cognitive disease, we expected that cognitive impairment would have a negative relationship with upper body strength. Our findings would not only inform understanding of the excess-disability phenomenon but also suggest that handgrip strength might be a useful means of identifying individuals with ADRD who are at greatest risk for frailty.

**Method**

**Participants**

Data from the baseline examinations of two exploratory studies of exercise interventions for adults with ADRD were pooled and used for this investigation. The 38 sedentary participants (25 women, 13 men) were residents of an adult day-service facility or one of two assisted-living dementia-care facilities. All participants had a physician’s diagnosis of ADRD. The mean age of participants was 83.22 years (SD 5.60), and their overall range of ages was 74–95 years. All research was conducted with approval of our institutional review board.

**Procedures**

*Cognitive Ability.* A trained facility staff member administered the 30-item Mini-Mental State Examination (MMSE) to participants before the physical assessment
to determine extent of cognitive impairment. The MMSE (Folstein, Folstein, & McHugh, 1975) is a brief, standardized tool used in clinical and research settings to assess cognitive ability. Although the instrument is sensitive to age, education level, and cultural differences, a general scoring classification is widely accepted such that a maximum score of 30 indicates no cognitive impairment; scores from 25 to 29 indicate mild, if any, detectable impairment; scores of 17–24 suggest moderate impairment; and scores less than 17 reflect severe impairment. Participants in this study obtained a mean score of 16.75 (SD 7.04), indicative of moderate to severe cognitive impairment.

**Muscle Strength.** A Baseline hydraulic hand dynamometer was used to assess all participants’ handgrip strength. The Baseline is considered to have interinstrument reliability and concurrent validity comparable to the Jamar dynamometer (Mathiowetz, Vizenor, & Melander, 2000), the instrument most frequently used to assess grip strength. The grip-strength assessment was administered only to participants who did not present with upper body musculoskeletal or neuromuscular conditions (e.g., arthritis, peripheral neuropathy) that would compromise test performance. Before testing, participants were familiarized with the purpose of the study and the equipment. They were tested at their respective centers. Participants performed the test from a seated position, and the standard test protocol recommended by the American Society of Hand Therapists (Fess, 1992) was followed. In this position, the shoulder is adducted and neutrally rotated, the elbow is flexed at 90°, the forearm is neutral, and the wrist is dorsiflexed 0–30°. The dynamometer remained fixed in the second handle position. Each participant was given one practice trial before the recorded trials. The test was administered three times in the dominant arm, with 30-s rest periods between trials. Because of symptoms attributable to ADRD, such as limited attention and motivation, adults were assessed using the dominant hand only. The best score of the three trials was recorded in kilograms. Men achieved a mean grip strength of 19.2 kg (SD 7.87), and women, 14.85 kg (SD 9.56).

**Statistical Analysis**

Multiple-regression analysis was used to determine the predictive contributions of age, sex, and cognitive impairment (MMSE score) to grip strength. Age, sex, and MMSE test score were entered simultaneously into the model. While examining model assumptions, we observed a nonlinear relationship between age and grip strength. Consequently, we included a quadratic term for age in the model. To meaningfully interpret the association between cognitive status and grip strength, MMSE scores were rescaled using the interquartile range; using this procedure, the regression coefficient represents the expected difference in grip strength between a person in the middle of the upper half in the predictor distribution and a person in the middle of the lower half (Harrell, 2001).

The assumptions underlying multivariate regression were met by examining outliers, interactions, conditions of nonlinearity, and analysis of the residuals. Significance level was selected a priori and set at \( p \leq .05 \). All analyses were conducted using SAS 9.1.
Results

As shown in Table 1, the full model was significant and explained 57% of the variance in grip strength (adjusted $R^2 = .50$, $F = 8.65$, $p = .000$). Although the quadratic term for age was marginally significant ($t = -1.83$, $p = .078$), it was maintained in the model and, notably, exhibited an inverted-U shape. Cognitive status was significantly related to grip strength, independent of age and gender ($t = 2.42$, $p = .023$), such that participants in the middle of the upper half of the predictor distribution were stronger than those in the middle of the lower half by nearly 3 kg. After we adjusted for age, sex also contributed significantly to grip strength ($t = 3.60$, $p = .001$); on average being male was associated with greater strength than being female by approximately 7.6 kg. The interactions of age with cognitive status and gender with cognitive status were tested, found not to be significant ($t = 0.51$, $p = .612$; $t = 1.33$, $p = .195$, respectively), and therefore not included in the model.

Discussion

Our cross-sectional study showed that age, sex, and cognitive status combined were robustly related to grip strength in adults with ADRD, reaffirming the previously described relationship between poor cognition and impaired strength (Greiner et al., 1996; Raji et al., 2005; Thomas, 2001). Although these prior studies were prospective, our finding offers a more specialized view than previous work in that our sample was composed entirely of people with cognitive impairment.

Although only marginally statistically significant at conventional levels, the nonlinear, inverted-U relation between age and grip strength suggests that younger older adults who experience severe ADRD might exhibit more severe losses in strength, as do the oldest older adults. Because the relation was only marginally significant, however, this insight will need to be replicated in a new sample before we can be more confident in this finding. Although curious, the effect in younger older adults might be explained by more pronounced physical manifestations when the onset of a cognitively impairing disease occurs earlier in older adulthood; for the oldest adults, greater weakness is reasonably explained by the detrimental contribution of natural degradation of muscle fibers. The lack of significance between age and cognitive status might be explained by the restricted age range in this sample, a factor known to affect the significance value of age (Miller, 1994).

Table 1 Summary of Multiple-Regression Analysis for Variables Predicting Upper Body Strength in Adults With Dementia ($N = 38$)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unstandardized $B$</th>
<th>$SE B$</th>
<th>$\beta (p)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>8.48</td>
<td>4.57</td>
<td>1.86 (.07)</td>
</tr>
<tr>
<td>Age $\times$ Age</td>
<td>-0.05</td>
<td>0.03</td>
<td>-1.83 (.078)</td>
</tr>
<tr>
<td>Sex</td>
<td>7.57</td>
<td>2.13</td>
<td>3.60 (.001)*</td>
</tr>
<tr>
<td>Cognitive status</td>
<td>2.95</td>
<td>1.22</td>
<td>2.42 (.023)*</td>
</tr>
</tbody>
</table>

Note. $R^2 = .57$; adjusted $R^2 = .50$; Model 1 $p = .000$.

*p < .05.
Our research also characterizes the effect of cognitive impairment on strength for people with an identified cognitive impairment such that those with the least impaired abilities are stronger by 3 kg than those who have more impaired cognition. As the disease advances and cognition continually fails, strength losses likely become more evident, thus provoking functional inabilities. For people with Alzheimer’s disease, scores on the MMSE decline annually approximately 3 points (Han, Cole, Bellavance, McCusker, & Primeau, 2000). Because grip strength of 9 kg is considered necessary for functional tasks (Rice, Leonard, & Carter, 1998), adults with ADRD might expeditiously experience significant and rapid declines in strength, which could preclude having sufficient upper body strength to complete everyday functional tasks of daily living. The value of strength training in this population has been largely understudied, but it appears to have potential benefit (Arkin, 1999; Francese, Sorrell, & Butler, 1997; Hageman & Thomas, 2002; Rogers, 2005b; Thomas & Hageman, 2003).

Our results also support widely documented findings that men retain greater absolute strength than women in older adulthood; also as expected, there was no interaction of sex and cognitive status. National statistics suggest that of all nursing-home residents, women account for approximately 75%, a great majority of whom are oldest old and cognitively impaired and manage compromised functional abilities (Gabrel, 2000). This identified group reflects key risk factors that predict weakness and functional dependence and would benefit from the implementation of a strength-training program, even to maintain current levels of dependence.

Grip-strength testing is a physical-performance test that is appropriate for assessing adults with ADRD because these individuals demonstrate the ability to be motivated and give a maximal effort. An examiner should deliver individualized, simple instructions immediately preceding expected movements to maximize competent participation of an adult with ADRD. Feedback such as “keep squeezing!” during the actual gripping movement will also help ensure that the participant has ongoing cognitive awareness of what action should be performed. These sorts of modifications or supports might be necessary to assess adults with ADRD and do not appear to invalidate the integrity of the test (Tappen, Roach, Buchner, Barry, & Edelstein, 1997).

A limitation of this study was that it did not include collection of data on certain factors known to influence strength. Examples of such factors include anthropometric data, comorbid conditions (e.g., arthritis), perceived or actual health status (Desrosiers et al., 1995), and a precise indicator of type and level of physical activity. Collection of such data was beyond the scope and resources of our exploratory study. Furthermore, it is possible that age is a proxy for another more precise indicator of competence, such as the aforementioned variables for health status.

Although exploratory, these findings support prior research that identified dementia as a significant contributor to physical inabilities (Agüero-Torres et al., 2002; Barberger-Gateau et al., 2004) and improve on current knowledge by highlighting strength as a link in the disablement process of adults with ADRD. There might be physiological processes unique to adults with ADRD (i.e., nutritional deficiencies) or related to the etiology of the cognitively impairing disease (i.e., inflammation, vascular infarcts) that affect strength. Although these factors warrant further consideration, ensuring that physical activity is incorporated into the
lifestyles of individuals with ADRD is one strategy to mitigate the disablement process and prolong physical and functional abilities.

A recent meta-analysis (Heyn, Abreu, & Ottenbacher, 2004) indicated that exercise training of all types positively affects a variety of outcomes of adults with dementia (Hedge’s $g = .62$). More specifically, strengthening exercise, which has the potential to prolong muscle integrity and slow strength losses, yielded an effect size of .75. Caregivers should be educated about the effectiveness of supporting individuals’ efforts to perform basic activities of daily living and should be reminded to use care and caution when restricting activities, which might initiate a cascade of disabling processes and excessive care needs. In addition, strength training effectively improves older adults’ muscle strength and neuromuscular competence. In spite of cognitive limitations, adults with ADRD have demonstrated competence to appropriately engage in a resistance-training intervention (Heyn, 2003; Rogers, 2005b); hence, valuable effects such as strength gains and perceived improvements in physical function and psychosocial outcomes can reasonably be expected.

Acknowledgments

We would like to acknowledge Michael A. Babyak, PhD, at Duke University Medical Center for his statistical oversight and contributions.

References


Dementia’s Effects on Strength


