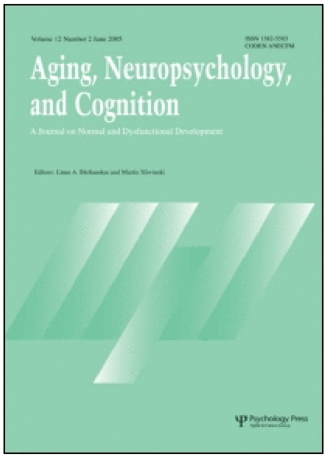

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Walking Speed and Global Cognition: Results from the OKLAHOMA Study

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ABSTRACT

Executive functioning and processing speed have been related to physical functioning in non-demented, elderly samples; however, the relationship between walking speed and global cognition has not been examined. Six hundred and seventy-five community dwelling older adults were enrolled through their primary care physicians. Walking speed was assessed on a 50-foot course at usual pace. Global cognition was assessed with the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) Total Scale score. After adjusting for age, gender, and education, there was a strong inverse relationship between walking speed and global cognition, with slower walkers performing worse on the cognitive measures, faster walkers performing better on the cognitive measures, and the intermediate walkers performing in the middle. In these older adults, global cognition was related to walking speed.

Keywords: walking speed; cognition; elderly

INTRODUCTION

The relationship between physical functioning and cognition has been reported in a number of non-demented, elderly samples (Binder, Storandt, & Birge, 1999; Ble et al., 2005; Carlson et al., 1999; Tabbarah, Crimmins, & Seeman, 2002). Executive functioning and processing speed have been the two cognitive tasks that are most strongly related to physical performances (Binder et al., 1999; Ble et al., 2005; Carlson et al., 1999). Physical functioning, such as walking speed, might prove to be a particularly important proxy

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of cognition, as it has recently been associated with "catastrophic" disability in performing activities of daily living (Onder et al., 2005). Unfortunately, some of these past studies have important limitations that possibly restrict the generalizability and applicability of their findings (e.g., selected samples of "successful aging" participants, lengthy physical performance tests that are unlikely to be used in clinical examinations, lack of a global cognitive score, lack of scores from other cognitive domains, e.g., visuospatial construction, language).

Therefore, the current study assessed the relationship between walking speed and global cognition using a large sample of community dwelling older adults, and investigated the role of cognitive specificity. It was hypothesized that global cognition, as assessed by a standardized neuropsychological battery, would be related to walking speed, above and beyond demographic information. In addition to global cognition, it was expected that other cognitive domains would be related to walking speed.

METHODS

Study Sample

Data for the present study represents a subsample of the Oklahoma Longitudinal Assessment of Health Outcomes in Mature Adults (OKLAHOMA) Studies cohort. For this cohort, individuals were recruited from the practices of family physicians throughout central Oklahoma to assess various indicators of health across time and the impact of various symptoms, medical conditions, and health care delivery qualities on health outcomes. Patients 65 years or older with a visit in the past 18 months were identified from billing records. The physicians then eliminated patients who were thought to be too confused to understand and sign informed consent. Initial invitation letters were sent by the physicians to the 2,553 individuals remaining on their lists. These were followed by a phone call from the project coordinator, who was able to contact 1,836 patients. A total of 810 were willing to participate. Eleven individuals who were unable, in the opinion of the study coordinator, to consent to enrollment were excluded, which left a total sample of 799.

Of the 799 enrollees, 21 were unable to perform the 50-foot walk due to physical disabilities, and their data was not included in the analyses. Additionally, 103 individuals were eliminated from analyses due to a variety of self-reported co-morbid medical conditions that would be likely to negatively impact cognitive functioning and/or walking speed (stroke or transient ischemic attack = 52; head injury = 33; concussion = 19; seizures = 12; Parkinson's disease = 5; brain hemorrhage = 1; note that some participants reported more than one exclusionary condition). Demographic information and medical information for the final sample (n = 675) are provided in Table 1. Two additional participants were unable to complete all of the subtests of the RBANS due to sensory difficulties, which precluded the calculation of Total Scale and some Index scores for these individuals. Their available data, however, was used in the final analyses.

Individuals who agreed to participate were asked to complete a questionnaire sent to them 2 weeks prior to their enrollment visit. The questionnaire included demographic information (age, gender, ethnicity/race, education, income, history of military service), habits (use of alcohol and

TABLE 1. Demographic information on the sample

Variable	
n	675
Age	73.2 (5.8)
Gender (*n*)	
Males	288
Females	387
Education (*n*)	
8th grade or less	26
Some high school	66
Completed high school	185
Some college	211
Completed college	73
Some graduate school	40
Completed graduate school	74
Race (*n*)	
African-American	61
Hispanic/Latino-American	6
Native American	15
White, non-Hispanic	593
Medical conditions (%)	
Arthritis	60%
Cancer	15%
Depression	15%
Diabetes	17%
Heart disease	25%
Hypertension	45%
Indexes	
Immediate memory	95.4 (18.0)
Visuospatial/Constructional	102.9 (17.7)
Language	95.6 (11.4)
Attention	100.2 (16.1)
Delayed memory	98.8 (17.1)
Total scale	98.2 (16.1)

Note: Unless otherwise noted, values represent means and standard deviations (in parentheses). Age is in years. Index scores were age-corrected scaled scores based on the RBANS manual.

tobacco, dietary habits), medical conditions (diabetes mellitus, B12 deficiency, chronic hepatitis, renal failure, auto-immune diseases, peripheral neuropathy, etc.), physical symptoms (numbness or weakness of extremities, trouble with balance, pain in extremities, restless legs, orthostatic lightheadedness, incontinence, etc.), history of recent falls (within 3 months), functional status (activities of daily living, instrumental activities of daily living), and measures of health related quality of life.

At the enrollment visit, participants were interviewed by a research nurse, who obtained informed consent, reviewed the questionnaires for completeness and accuracy, and checked vital signs, hearing, vision, gait, balance, and peripheral sensation/reflexes. She also administered Form A of the RBANS, which she had been previously trained in its administration and scoring. Subjects also completed the 50-foot walk at this time.

Walking Speed

Participants were asked to walk a pre-measured straight distance of 25 feet, turn around, and return (for a total of 50 feet) at their usual walking speed. This task was conducted indoors, on a flat surface. Assistive devices (e.g., canes, walkers) were allowed. A research nurse timed the walk using a stopwatch, recording the time to the nearest second.

Cognitive Measure

The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) (Randolph, 1998) is a brief, individually administered test measuring attention, language, visuospatial/constructional abilities, and immediate and delayed memory. It consists of 12 subtests (List Learning, Story Memory, Figure Copy, Line Orientation, Picture Naming, Semantic Fluency, Digit Span, Coding, List Recall, List Recognition, Story Recall, and Figure Recall), which yield 5 Index scores (Immediate Memory, Visuospatial/Constructional, Language, Attention, and Delayed Memory) and a Total Scale score. Normative information from the manual for the Index and Total scores is based on 540 healthy adults who ranged in age from 20 to 89 years old. All subtests were administered and scored as defined in the manual, with the exception of the Figure Copy and Figure Recall, which is more thoroughly described elsewhere (Duff et al., 2003, 2007).

Statistical Analysis

Walking speed, as a continuous measure, was abnormally distributed (e.g., skewness = 4.5, kurtosis = 34.8). Therefore, it was divided into tertiles for the final sample, which yielded the following groups: <14 s (n = 186), 14 – 17 s (n = 279), and >17 s (n = 210). Comparisons between these groups on demographic variables (age, gender, education) were analyzed with ANOVA and χ^2. Since significant differences were found among the groups, these variables served as covariates in ANCOVAs, which compared the groups on RBANS Total score. A MANCOVA was also used to assess group differences on the five RBANS Indexes, again with age, education, and gender as covariates. Univariate tests were used if the MANCOVA was statistically significant. Bonferroni-corrected pairwise comparisons were used to further evaluate differences between groups if the overall test was statistically significant. Correlations between gait time and RBANS Indexes were also assessed, after controlling for age, gender, and education. Fisher *r*-to-*z* transformations were used to compare these partial correlations. Age has been included as a covariate in these analyses despite using age-corrected standard scores based on our experience that age-corrections do not always eliminate the effects of age (e.g., $r_{\text{age, RBANS Total}} = -.09$, $p < .05$, unpublished data).

RESULTS

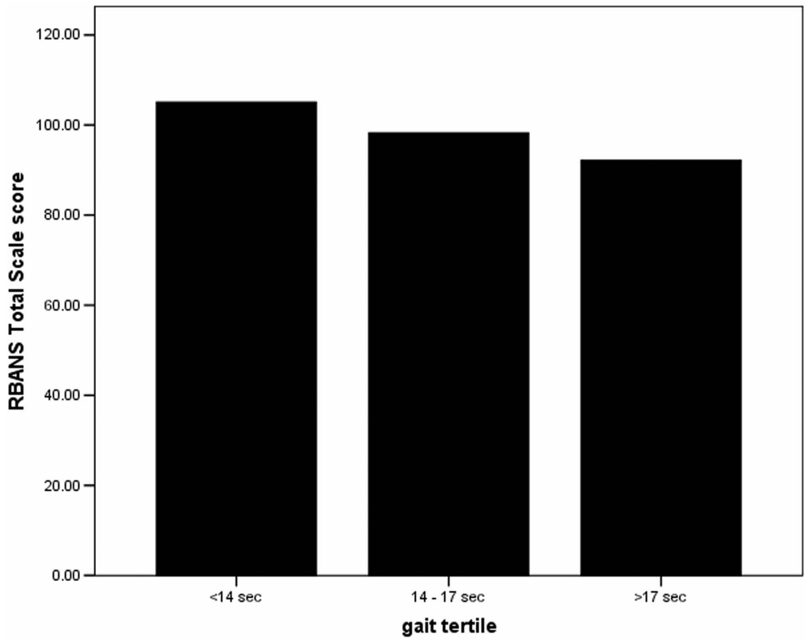
RBANS Total and Index scores, which have a mean of 100 and a standard deviation of 15, are presented in Table 1 in for the entire sample. RBANS Total scores for each gait tertile group were: <14 s group = 105.0 (15.3), 14 – 17 s group = 98.2 (14.9), and >17 s group = 92.1 (15.9). All of these group means are "average" scores.

As noted earlier, there were significant differences between the walking speed tertile groups on age [$F(2, 674) = 19.8$, $p < .001$], gender [$\chi 2(2) = 44.0$, $p < .001$], and education [$\chi 2(12) = 32.0$, $p < .01$]. Results of the ANCOVA, controlling for age, gender, and education, revealed significant differences between the walking speed tertile groups on the RBANS Total score [$F(2, 673) = 28.5$, $p < .001$, see Figure 1]. Pairwise comparisons indicated significant differences between all three groups ($p < .01$).

The overall MANCOVA was also statistically significant [$F(10, 1328) = 5.7$, $p < .001$], indicating that the RBANS Indexes were significantly different across the tertile groups. Follow-up univariate tests indicated that all five Indexes were statistically different among groups ($p < .001$). Pairwise comparisons indicated that all of the groups were statistically different from one another across the Indexes ($p < .05$). The only pairwise comparison that was not statistically different was between the two highest tertiles on the Visuospatial/Constructional Index.

Partial correlations, controlling for age, gender, and education, identified statistically significant relationships ($p < .01$) between gait times and all of the RBANS Indexes [Total partial $r(668) = -.25$; Immediate Memory partial $r(668) = -.20$; Visuospatial/Constructional partial $r(668) = -.18$; Language partial $r(668) = -.12$; Attention partial $r(668) = -.21$; Delayed Memory partial $r(668) = -.15$]. Using Fisher *r*-to-*z* transformations, all partial correlations were comparable, with the exception of statistical differences

FIGURE 1. RBANS Total Scale score by gait time tertiles. *Note:* Sec, seconds. Differences between all groups are statistically significant (p < .01).



(p < .05) between RBANS Total and Language, and Total and Delayed Memory.

DISCUSSION

Consistent with prior research (Binder et al., 1999; Ble et al., 2005; Carlson et al., 1999; Tabbarah et al., 2002), physical functioning was related to cognitive functioning in this sample of non-demented, community-dwelling older adults, even after controlling for age, gender, and education. Similarly, global cognition was at least as strongly related to walking speed as were individual cognitive domains (e.g., attention, visuospatial perception and construction). There are three possible hypotheses that could explain the relationship between walking speed and cognition. First, walking (or physical activity, in general) affects cognition, either directly or indirectly. For example, greater involvement in exercise, either through intervention (Hassmen & Koivula, 1997) or lifestyle (Hultsch, Hammer, & Small, 1993), has been linked to better performance on cognitively demanding tasks in elders. Second, cognition affects walking speed. In patients with Parkinson's disease, for example, it has been demonstrated that walking speed and stride decrease when they encounter cognitively demanding activities (Rochester et al., 2004). Lastly, both walking speed and cognition are affected by some other "common cause", in which some common factor, such as general degeneration of the central nervous system, is responsible for the decline in both areas. Although this theory has been applied to the relationship between sensory changes and cognition (Christensen, Mackinnon, Korten, & Jorm, 2001), it likely has broader applicability to physical activity as well. Regardless of the directionality of the relationship, decrements in walking speed and cognition have a host of negative outcomes. For example, walking speed is significantly associated with the onset of a catastrophic disability in activities of daily living (Onder et al., 2005). Similarly, increasing walk times have been related to increased risk for persistent cognitive impairment across 6 years (Marquis et al., 2002). Not only does this information have prognostic implications, it might also guide interventions, as training in physically frail elders can improve walking speed and quality of life (Helbostad, Sletvold, & Moe-Nilssen, 2004), and perhaps cognition.

The current study used the time to complete a 50-foot walking course on a flat surface as its physical functioning test. Other studies (Binder et al., 1999; Ble et al., 2005; Carlson et al., 1999; Marquis et al., 2002; Onder et al., 2005; Tabbarah et al., 2002) have used a variety of walk lengths (10 feet, 4 m, 7 m) and conditions (usual vs. fast pace, obstacles vs. no obstacles, flat surface vs. stairs). Regardless of which walking task provides the most useful information, in less than 30 s, clinicians have the opportunity to indirectly assess cognition. Cut-off scores for gait time could be developed to suggest when further cognitive assessment is indicated, although the utility of such cut-off scores would require empirical validation. And if the physical functioning task is brief and straightforward, then it is likely to have greater clinical applicability.

Baseline cognitive functioning is inversely related to walking speed. The amount of variance shared, however, is limited. In the current study, as well as in prior research, less than 20% of the variance was explained, even when including age, gender, and education in the model. It is likely that the addition of other variables (e.g., medications, medical illnesses, race) could improve this relationship. Finally, most studies, including the current one, used baseline cognitive and physical functioning measures, when longitudinal changes in these variables might be more informative. For example, Tabbarah et al. (2002) observed that changes in physical functioning tasks across 7 years was more highly related to changes in cognition than were baseline physical functioning tasks. Future studies should strongly consider repeated evaluations of both cognition and physical functioning.

Some limitations of these findings should be noted. First, the RBANS, which was used to assess cognition in the OKLAHOMA study, does not include measures of executive functioning. Therefore, direct comparisons between the current results and other cognition and gait studies that did use executive functioning measures cannot be made. Nonetheless, many cognitive abilities, including executive functioning, are inter-related (Duff, Schoenberg, Scott, & Adams, 2005), and future studies might include a more comprehensive assessment of cognition to clarify these relationships. A second limitation is the possible generalizability of the sample. These participants were all regular attendees in primary care and were mostly white, well-educated, and "young" elderly. All participants reported having a number of chronic medical conditions. In this way, the sample likely represents "typical" aging, rather than "optimal" aging (APA Working Group on the Older Adult, 1998). Additionally, individuals with major neurological dysfunction were excluded from the analyses, and individuals deemed to be noticeably cognitively impaired were not enrolled in the study. Overall, this group was "cognitively intact", with even the worst performing walking tertile having mean RBANS Total Scale scores in the average range. The applicability of these findings to individuals who do not conform to this sample's characteristics is unclear. Additionally, the participants were more likely than non-participants to be younger, male, better educated, and in better self-reported health, which could skew the sample. Finally, walking speed was assessed in the primary care physician's office with a stopwatch. Other, more sophisticated methods are available for collecting this data (e.g., photocells with a recording chronometer). Despite these limitations, the current study provides additional information about the relationship between physical and cognitive functioning, especially the role of global cognition and simple walking speed.

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