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Featured Articles

Unobtrusive assessment of activity patterns associated with mild cognitive impairment

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Abstract

Background: Timely detection of early cognitive impairment is difficult. Measures taken in the clinic reflect a single snapshot of performance that might be confounded by the increased variability typical in aging and disease. We evaluated the use of continuous, long-term, and unobtrusive in-home monitoring to assess neurologic function in healthy and cognitively impaired elders.

Methods: Fourteen older adults 65 years and older living independently in the community were monitored in their homes by using an unobtrusive sensor system. Measures of walking speed and amount of activity in the home were obtained. Wavelet analysis was used to examine variance in activity at multiple time scales.

Results: More than 108,000 person-hours of continuous activity data were collected during periods as long as 418 days (mean, 315 ± 82 days). The coefficient of variation in the median walking speed was twice as high in the mild cognitive impairment (MCI) group (0.147 ± 0.074) as compared with the healthy group (0.079 ± 0.027; $t_{11} = 2.266$, $P < .03$). Furthermore, the 24-hour wavelet variance was greater in the MCI group (MCI, 4.07 ± 0.14; healthy elderly, 3.79 ± 0.23; $F = 7.58$, $P \leq .008$), indicating that the day-to-day pattern of activity of subjects in the MCI group was more variable than that of the cognitively healthy controls.

Conclusions: The results not only demonstrate the feasibility of these methods but also suggest clear potential advantages to this new methodology. This approach might provide an improved means of detecting the earliest transition to MCI compared with conventional episodic testing in a clinic environment.

Keywords: Assessment of cognitive disorders/dementia; MCI (mild cognitive impairment); Cognitive aging; Technology and aging; In-home assessment

1. Background

Early detection of cognitive decline preceding the onset of dementia or functional impairment is important for many reasons [1,2]. Cognitive changes in the elderly might have immediately remediable causes such as medication complications or unsuspected medical illnesses. Failure to recognize some of these causes in a timely manner might lead to irreversible damage. Mild cognitive decline can also be an early indicator of dementia, and timely recognition of cognitive impairment provides an opportunity to focus on strategies for treatment, compensation, and coping [3,4] and might allow an individual to maintain greater independence than would otherwise be the case. In addition, early recognition is an opportunity for those with irreversible decline to proactively plan for their future and avoid being forced into crisis management.

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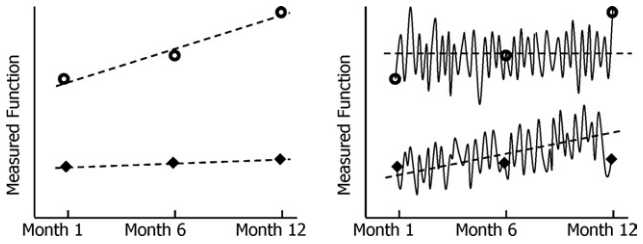

Fig. 1. Problem with infrequent measurements. Left panel depicts test scores taken during a standard clinic visit, taken at 6-month intervals, for 2 patients. Right panel depicts how continuous assessment could reveal a very different picture.

Unfortunately, early detection of cognitive impairment is problematic, because patients might be unaware of their impairment, or if noted, uncomfortable discussing their concerns. In addition, cognitive testing is not a routine part of an elder's visit to their physician. Fully 50% of people age 75 or older seeing a primary care practitioner have no diagnosis or evaluation of their memory complaint [5,6], and in fact, even the patient or family report memory problems in only a small percentage of cases in which the patient has clinically detectible cognitive impairment [7]. Thus, alternative means of identifying early cognitive decline are needed.

Further confounding our ability to detect cognitive decline early are the facts that both cognitive and motor functional measures in the elderly become increasingly more variable as people age [8–10], and that this variability increases differentially in Alzheimer's disease (AD) and other neurologic disorders [11]. For example, variability in mobility measures such as walking speed or stride length have been shown to increase with age and even more so in AD and other dementias [8,10]. Measures taken in the clinic reflect a single snapshot of performance that might be confounded by such variability; identification of a decline might require many visits over months or years to obtain an accurate picture of true changes. As can be seen in Fig. 1, test scores taken during a periodic clinic visits (left panel) might show changes in performance that do not reflect true change but are instead simply reflective of normal variability for each subject. The true trend is clearly apparent when many more measures are available. We hypothesized that measures taken consecutively in an elder's home on a frequent or continuous basis would provide a much better picture of true functional performance. Not only would such an approach allow better understanding of normal daily variability for an individual, but change in the variability itself could herald cognitive decline.

Clearly, frequent or continuous measures of cognitive function would be difficult to collect by using conventional time- and location-restricted methods. However, motor measures such as walking speed and movement-related activity might be better suited for continuous measurement because they are part of an individual's normal daily functioning. It is becoming increasingly evident that motor and activity measures, which are important measures of functional ability in the elderly [12–14], are also correlated with cognitive function [15]. Even measures as simple as gait speed or timed walking have been shown to be independent predictors of cognitive impairment [16–20]. However, the precise relationship between motor and cognitive function in aging and cognitive decline is not well-understood, and further research is needed to better understand this relationship.

Recent research has shown that intraindividual variability in motor measures such as walking tasks correlates with cognitive performance [8,21]. These studies have examined frequent (eg, biweekly) clinic-based measures such as timed walking and have suggested that the short-term variance (week-to-week) in motor measures might be a sensitive indicator of cognitive health. These latter studies underscore the value of assessing intraindividual variability through more frequent measures. However, conducting frequent clinic-based assessments is impractical and labor-intensive. Alternatively, the collection of measures of motor activity gathered in the home on a continuous basis can be done unobtrusively and automatically, without requiring the presence or involvement of a health care provider. Furthermore, measures gathered in the home might be more representative of an individual's normal daily functioning.

To determine the feasibility of using continuous measurement of motor activity for early detection of cognitive decline, we carried out a cross-sectional study in which we gathered measures of walking speed and of total movement within the home by using unobtrusive in-home technology. Two groups of community-dwelling elders were compared, those with mild cognitive loss and those who were cognitively healthy.

2. Methods

2.1. Subjects

All subjects provided informed consent to participate. Protocol and consent forms were approved by the Oregon Health and Science University Institutional Review Board. Fourteen older adults (age, 89.3 ± 3.7 years) were recruited from ongoing studies at the National Institute on Aging–Layton Aging and Alzheimer's Disease Center (LAADC) (OHSU IRB #1487). All participants were ambulatory adults aged 65 years or older, living independently and alone in the community. Subjects were clinically assessed during regular LAADC visits by using a standardized battery of tests consisting of neurologic and psychometric assessments including tests of motor performance. Neurologic tests of motor function consisted of Tinetti gait and balance scales [22], finger tapping, timed one-leg standing, the motor portion of the Unified Par-