The Hierarchy of Functional Loss Associated With Cognitive Decline in Older Persons

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Objectives. We studied a representative cohort of community-dwelling elderly persons to (i) examine the relationship between the loss of specific functional activities and cognitive status at the time of these losses, (ii) compare the cognitive status of participants who have and have not lost independence in these functional activities, and (iii) determine whether a hierarchical scale of functional loss is associated with declining cognitive status.

Methods. A cohort of 5874 community-dwelling persons aged 65 years and older from the Canadian Study of Health and Aging I and II were analyzed. At baseline and 5 years later, cognitive status with the Modified Mini-Mental State Examination (3MS) and functional status with 14 Older American Resources and Services (OARS) items were measured. For each OARS functional item, the mean 3MS scores for persons who lost independence during the 5-year period versus those who did not were compared.

Results. For each functional item, the 5-year decline in 3MS scores of persons who lost independence were significantly greater than those who remained independent (e.g., ability to do finances), with an 18-point decline for those who lost independence and a 2-point decline for those who retained independence. A hierarchy of functional items existed, with instrumental activities of daily living (ADLs) (e.g., shopping, banking, and cooking) being lost at higher cognitive scores than basic ADL items (e.g., eating, dressing, and walking), although there was some overlap.

Conclusions. This is the first prospective study using a large representative cohort of elderly persons to demonstrate that progressive cognitive decline is associated with a specific pattern of loss of functional tasks. Clear cognitive thresholds at which development of dependency in OARS functional items occurred. By providing estimates of the cognitive status of persons at the time at which they developed dependency in specific functional items, a natural hierarchy of functional loss associated with cognitive decline emerged. For caregivers, clinicians, and health policy makers, this information can help anticipate the pattern of functional decline and the subsequent care needs of persons with declining cognition, potentially improving the quality of life of these persons and their caregivers and playing an important part in health care planning.

ONE of the most important health care issues facing today's elderly population is cognitive impairment and its implications. The prevalence of dementia, the most common form of cognitive impairment, is approximately 10% for persons over 65 years of age, increasing to 30% for those over 90 years (1). Of all geriatric health care issues, cognitive decline is the most greatly feared by seniors (2). Growing evidence suggests that cognitive dysfunction is an important risk factor in the development of functional disability and loss of independence (3,4). Thus, further delineating the relationship between cognitive decline and the increased need for assistance with personal care may help determine future health care needs (5).

The association between cognitive impairment and functional disability has been examined extensively over the past two decades. Numerous cross-sectional studies (3–10) have demonstrated a relationship between cognitive status and functional ability that is independent of demographic, medical, and social factors. Instrumental activities of daily living (IADLs), such as doing one's finances and shopping, are highly dependent on adequate cognitive ability (9,11), whereas well-learned activities, such as dressing and bathing,

are also dependent on cognition but to a lesser extent (6). Also, longitudinal studies as summarized by Barberger-Gateau and Fabrigoule (7) have demonstrated that poor cognitive status at baseline predicts future functional disability, institutionalization, and even death. However, these studies were hampered by their inability to estimate the cognitive status of persons at the time of incidental loss of functional ability.

When Katz (12) introduced the concept of expressing functional status in terms of basic activities of daily living (ADLs), he hypothesized that there is a hierarchical structure to the specific functional tasks. That is, older persons with progressive cognitive decline lost the ability to perform these tasks in the opposite order to which they acquired them in childhood: bathing, dressing, toileting, transferring, continence, and feeding. Thus, elderly persons who are unable to feed themselves should be unable to perform any other task independently. Lawton (13) expanded our understanding of functional status by defining more complex functions as IADLs (e.g., shopping, banking, cooking, cleaning, and telephone use).

Attempts have been made to try to combine all ADLs and IADLs to define a hierarchical scale from which loss of

function could be predicted. There has been considerable controversy over whether such a hierarchy can be constructed (6,14–18). Whereas some have confirmed this notion (18,19), others have refuted it (6,15,17), and others have shown that the hierarchy is only one of many approaches that are possible (20). Other studies (6,14,16,17) have examined the relationship of specific IADLs (e.g., telephone use, finances, shopping, cooking, and cleaning) within the hierarchy of basic functional activities. Several groups have proposed measurement scales that combine ADLs and IADLs into a single hierarchical structure, but these groups have achieved varying degrees of success, possibly due to the different patient populations studied. For example, a distinct hierarchy is difficult to determine using study populations in which the prevalence of physical disability and medical illness vary because these will confound the effect of cognition on function (6,14,17,18).

The Canadian Study of Health and Aging (CSHA) I measured both the cognitive and functional status of a representative sample of elderly persons at baseline. Five years later, a second study (CSHA II) remeasured these variables. This provided a unique opportunity to estimate the cognitive status of persons at the time of the loss of independence of specific ADLs and IADLs. Within the cohort of community-dwelling CHSA participants, the objectives of this study were to (i) examine the relationship between the loss of specific functional activities and cognitive status during the time period these losses occurred, (ii) compare the cognitive status of participants who had loss of specific functional activities with those who did not, and (iii) determine whether there is a predictable hierarchical scale of functional loss associated with declining cognitive status.

METHODS

Study Population

The study population was drawn from the CSHA I and II studies, which prospectively followed up a randomly selected, representative sample of 10,263 elderly Canadians for 5 years. A detailed description of CSHA methods has been reported previously (1). In summary, the CSHA was a multi-center study of the epidemiology of dementia, health, and disability among Canadians aged 65 years and over. It included elderly persons living both in the community and institutions. Only the community-dwelling sample ($n = 9008$) was included in our analysis, which was stratified by age (65–74 years, 75–84 years, and 85 years and older), with over-sampling of the older cohorts. Study nurses conducted face-to-face interviews with subjects and/or proxies in the subjects' own environment with demographic, medical, social, cognitive, and functional information systematically collected.

Definition of Variables

During face-to-face interviews, measurements of baseline clinical data, including cognitive and functional status, were obtained. Approximately 5 years later, repeat data collection was performed on available study participants. Demographic variables collected included gender, age, and level

of education. Prospective data regarding the cognitive status of the participants were collected using the Modified Mini-Mental State Examination (3MS) (21). The 3MS cognitive screen was derived from the Mini-Mental State Examination (MMSE). The 3MS screen includes four additional items and a score up to 100 points, which improves its ability to discriminate between those with and without dementia. However, with a cut-off score of 77 (out of 100), the 3MS cognitive screen has a better sensitivity and specificity than the MMSE in identifying persons with dementia (22). The functional status of participants was followed using the Older Americans Resources and Services (OARS) questionnaire (23). The OARS consists of 14 items pertaining to level of independence in both ADL and IADL (see Appendix). The ADLs were eating, dressing, grooming, walking, transferring in and out of bed, taking a bath or shower, and going to the bathroom. The IADLs were telephone use, transportation out of walking distance, shopping, preparing meals, doing housework, and taking medication. Each functional item can be categorized as independent, partially dependent, or completely dependent. The CSHA modified the OARS by substituting a single question regarding the "use of the bathroom" for two original OARS questions regarding continence.

Statistical Analysis

Only persons who were independent in a given ADL/IADL at baseline were included in the analyses. This cohort was then classified into the following two groups: those who remained independent at 5-year follow-up or those who became partially or completely dependent at 5-year follow-up.

In the first analysis, the objective was to describe the level of cognition associated with a loss of independence in a specific ADL/IADL. Therefore, subjects who were independent at baseline but who became dependent (partially or completely) in a given functional activity were identified. We assumed that functional loss occurred at the mid-point of the 5-year period. Therefore, the best estimate of their cognitive status at the time of this loss was the mean of their baseline and 5-year 3MS scores. Standard deviations (*SD*) and 95% confidence intervals (CIs) were calculated for each mean 3MS score.

In the second analysis, the objective was to compare the change in cognitive status between persons who remained independent in a specific ADL/IADL task and those who did not. Thus, for specific functional activities, the mean change in the 3MS score for each group was calculated by subtracting the mean 3MS score at baseline from that at 5 years. Analysis of covariance (ANCOVA) was used to compare the mean change 3MS score (dependent variable) between those who did and those who did not lose independence in a specific ADL/IADL (independent variable) while adjusting for mean baseline 3MS score in each cohort (covariate). We felt it was important to adjust for baseline cognitive status because this may affect the degree to which 3MS scores could change over time. Means, *SD*, and *p* values were generated from these analyses. All data were analyzed using SPSS software (SPSS Inc., Chicago, IL).

Table 1. Subject Characteristics at the Time of CSHA I ($n = 5874$)

Mean Age, y (*SD*)	75.7 (7.1)
Women, %	59.5
Percentage With Self– or Proxy-reported	
Cardiac and circulation problems	30.2
Diabetes	9.7
Lung problems	17.3
Vision problems	28.7
Previous stroke	4.9
Arthritis	56.4
Parkinson's disease	1.4
Renal disease	12.2
Previous fracture	5.9
Urinary incontinence	12.2
Bowel incontinence	4.8
Dementia	13.8

Note: CSHA I = Canadian Study of Health and Aging I.

RESULTS

Population

From the total community cohort in CSHA I ($n = 9008$), a total of 5874 persons were independent in at least 1 of the 14 OARS functional items and available for follow-up 5 years later. Within this cohort, there were some missing data for each functional item; however, the percentage never exceeded 4% of the total. Subject characteristics are shown in Table 1.

Descriptive Analysis

The mean 3MS scores and 95% CIs for persons during the time period of incidental loss of the 14 specific functional activities (ADLs and IADLs) are shown in Figure 1. The order of loss of independence in ADLs, from the least to the most impaired cognitive status, was bathing, walking, toileting, transferring, dressing, grooming, and eating. Again on the basis of cognitive status, the order of loss of independence in IADLs was homemaking, shopping, ability to use transportation, meal preparation, telephone use, finances, and medication use. For the seven IADL tasks, the 3MS scores at the time of dependency overlapped with those associated with the ADL tasks. However, there was a tendency for dependency for IADL activities to occur at higher 3MS scores (mean 84/100) compared with ADLs (mean 67/100). Furthermore, a greater number of persons became dependent in at least one IADL ($n = 5218$) compared with ADLs ($n = 2652$) over the 5 years.

Comparison of Subjects Who Remained Independent Versus Those Who Lost Independence

Figure 2 illustrates that there was a significantly greater 5-year decline in cognitive scores for persons who became dependent in each functional task compared with those who remained independent ($p < .001$). For all 14 functional tasks, the change in cognitive scores over the 5-year study period reflected a similar hierarchy of losses as the previous analysis. For ADLs, the decline in cognition for subjects who lost the ability to perform a functional item independently was (greatest to least) eating, grooming, transferring, dressing, toileting, walking, and bathing. These differences remained significant even after adjustment for baseline cognitive scores ($p < .001$).
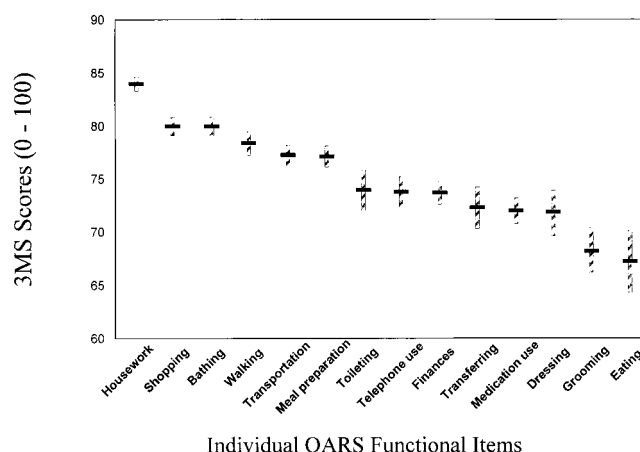

Figure 1. Mean ■ (▨ 95% confidence intervals) Modified Mini-Mental State (3MS) scores for persons with incidental loss in Older American Resources and Services (OARS) functional items over a 5-year period.

DISCUSSION

This study is the first to demonstrate that progressive cognitive decline is associated with a specific pattern of loss of functional tasks among a large prospective cohort of community-dwelling elderly persons. For all ADLs and IADLs examined over the 5-year study period, persons who lost independence in a particular task had lower 3MS scores and significantly greater declines in cognition than those who retained independence. The strong relationship between cognitive status and functional ability persisted even after adjusting for baseline cognitive status.

By prospectively estimating the cognitive status of persons before and after the loss of ability to perform specific functional tasks, this study furthers previous work examining the relationship between cognitive status and functional ability. The precision (i.e., 95% CIs) of the estimates of cognitive status at the time of incidental loss of specific functional items supports the concept of a hierarchical structure to functional loss associated with cognitive decline. Our results confirm that there is a tendency for IADLs to be lost at higher cognitive levels compared with ADLs, but there is overlap. There appeared to be three levels of functioning ability associated with cognitive ability. The first level corresponded to 3MS scores of 75 or greater (out of 100) and included mostly IADL items (housework, shopping, outside transportation, and meal preparation). The second level corresponded to 3MS scores between 70 and 75 (out of 100) and included a mixture of IADL and ADL items (toileting, telephone use, finances transfers, medication use, and dressing). The third level corresponded to 3MS scores of less than 70 (out of 100) and included only ADL items (grooming and feeding). To capture a greater range of functional disability, these results support the view that a composite measure of IADLs and ADLs may be best measured on one scale (12,24).

The hierarchy of functional items found in this study was also similar but not identical to others that have been reported (14–18). For the seven specific ADL tasks, the hierarchy found in this study differed from the one proposed by
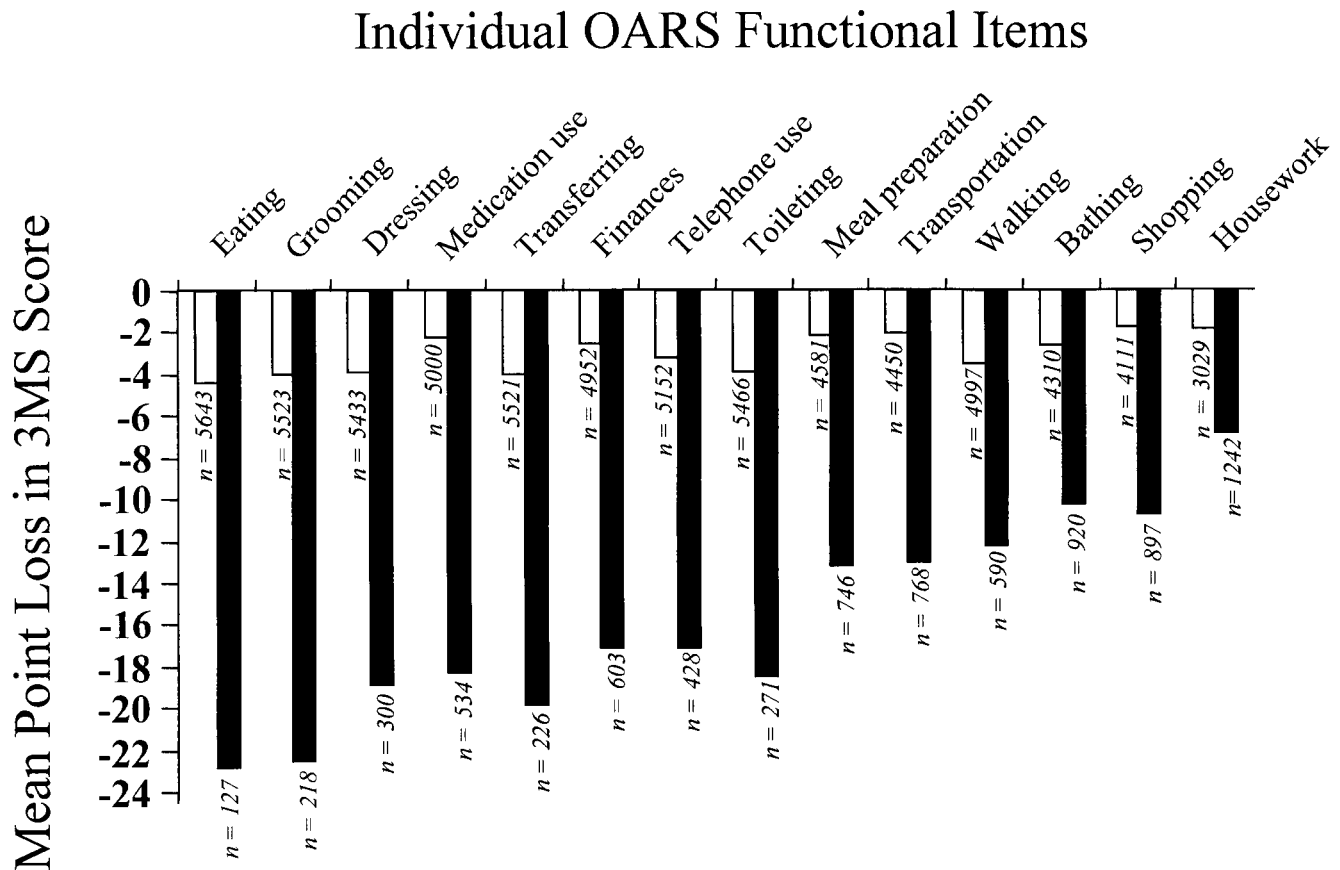
Individual OARS Functional Items

Figure 2. Comparison of mean absolute declines in Modified Mini-Mental State (3MS) scores for subjects who did and did not lose independence for individual Older American Resources and Services (OARS) functional items over a 5-year period. Scores were adjusted for baseline 3MS score. ■ persons who lost independence; □ persons who did not lose independence.

Katz (12). Most notably, the onset of the inability to dress independently occurred much earlier in the process of cognitive decline than Katz described. For specific IADL tasks, dependency for activities outside the home (shopping and walking outside) tended to occur at higher cognitive scores than activities within the home (medication management and telephone use). A reason for this inconsistency may be that different studies examined varied populations of elderly persons. Another possible reason may be the availability of resources for assistance with each of the functional tasks. For example, in Canada, home care services for house cleaning, shopping, and bathing are relatively readily available to all elderly persons regardless of socioeconomic status. This ease of access may explain the earlier than expected dependency for housework and shopping (IADLs) and bathing (ADLs) in our population. Future studies are needed to examine the relationship between dependency in functional activities and the availability of formal and informal support for these activities.

Our study has several limitations. Besides cognitive function, other factors, such as patients' physical abilities, motivation, and environment, have an impact on their functional status. Thus, it is inappropriate to use the results of our study to predict the functional status of individual patients from their cognitive test scores. Also, we were only able to measure the cognitive and functional status of the participants at two time points that were 5 years apart. Thus, we needed to assume that the decline in cognition over the 5-year period was linear. Our estimates of the cognitive status of persons at the time of functional dependency would have been even more precise if we had been able to follow participants with greater frequency. Considering the costs associated with following such a large cohort, feasibility issues prevented performing more repeated measures of cognition and function. If this assumption of linearity was not correct, the relationship between cognitive decline and functional status would not have been as strong. However, we believe that the pattern of functional decline found in the study would have remained intact.

Additionally, we used the 3MS to measure the cognitive status of patients, a scale not as widely used clinically as the MMSE. However, given its superior measurement properties and that it can significantly improve the accuracy of screening elderly persons for dementia (22), use of the 3MS may have significant clinical benefit despite its slightly greater response burden.

Another limitation is that the assessment of individuals' "functional abilities" using the OARS scale relied on proxy reports. Therefore, informants' perceptions and not the actual ADL abilities of the subjects were assessed. Moreover, with the use of globally defined ADL task categories, items

such as meal preparation may be interpreted quite differently by different raters. For example, a rating of "independent" may be viewed by some as the ability to prepare full-course meals but by others as the ability to heat frozen foods. Whereas both individuals may be independent in preparing meals, they do not have the same level of ADL independence. In addition, informants' ratings may be influenced more by what they allow individuals to perform than by the individuals' actual level of ADL ability. That is, informants who perceive family members as forgetful may reduce their opportunities to perform ADL tasks.

Finally, the generalizability of our results to other countries is not known. Clearly, the availability of different formal and informal supports may have an influence on the hierarchy of functional loss. Finally, from the data set, we could not determine the cause of functional or cognitive decline. However, the intent of the analyses was to describe the association between incidental functional loss and cognitive decline regardless of the etiology.

This study also has some strengths. Using a very large representative cohort of elderly persons followed prospectively over 5 years, this study describes a natural hierarchy of functional loss associated with cognitive decline. For caregivers, clinicians, and health policy makers, this pattern of loss can help anticipate the pattern of functional decline and the subsequent care needs of persons with declining cognition. Thus, this information could potentially improve the quality of life of these persons and their caregivers and could play an important part in the health care planning process.

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Appendix

Canadian Study of Health and Aging OARS Questionnaire

Now, I would like to ask you a few questions about activities of daily living, things that we all need to do as a part of our daily lives. I would like to know if, today, you can do these activities without any help, or if you need some help to do them, or if you can't do them at all. Please tell me about your situation today when answering these questions.

(For each item, show the cue card and ask them to select the best answer. If the respondent has difficulty in selecting a response category, you can read the examples in parentheses below each option. Use these only when help is required, however: do not read them routinely).

a.   Can you eat . . .
2. without any help?   1. with some help (need some help with cutting, etc)?   0. or are you completely unable to feed yourself?

b.   Can you dress and undress yourself . . .
2. without any help (pick out clothes, dress and undress self)?   1. with some help?   0. or are you completely unable to dress yourself?

c.   Can you take care of your own appearance, for example, combing your hair and (for men) shaving . . .
2. without any help?   1. with some help?   0. or are you completely unable to take care of your own appearance?

d.   Can you walk . . .
2. without any help (except for a cane)?   1. with some help (from a person or using a walker, crutches or chair)?   0. or are you completely unable to walk?

e.   Can you get in and out of bed . . .
2. without help?   1. with some help (from a person or device)?   0. or can't you get in and out of bed unless someone lifts you?

f.   Can you take a bath or shower . . .
2. without help?   1. with some help (from a person or device)?   0. or are you completely unable to bathe yourself?

g.   Can you go to the bathroom or a commode . . .
2. without any help?   1. with some help?   0. or are you completely unable to use the bathroom or commode unless someone helps you?

h.   Can you use the telephone . . .
2. without help (including looking up numbers and dialing)?   1. with some help (can answer phone, dial operator in an emergency, but needs a special phone or help in getting numbers or dialing)?   0. or are you completely unable to use the phone?

i.   Can you get to places out of walking distance . . .
2. without help (can travel alone on buses, taxis, or drive your own car)?   1. with some help (need someone to help you or go with you when travelling)?   0. or are you completely unable to travel unless special arrangements are made?

j.   Can you go shopping for your groceries or clothes . . . (assuming they have transportation)
2. without help (can you take care of all your shopping yourself)?   1. with some help (need someone to go with you on all shopping trips)?   0. or are you completely unable to do shopping?

k.   Can you prepare your own meals . . .
2. without help (can plan and cook full meals)?   1. with some help (can do some things but not full meals)?   0. or are you completely unable to prepare meals?

l.   Can you do your housework . . .
2. without help (can scrub floors, etc)?   1. with some help (can do light work but not heavy work)?   0. or are you completely unable to do housework?

m.   Can you take your own medicine . . .
2. without help (in the right doses at the right time)?   1. with some help (can take medication if someone prepares it for you and/or reminds you to take it)?   0. or are you completely unable to take your own medicine?

n.   Can you handle your own money . . .
2. without help (write cheques, pay bills, etc.)?   1. with some help (can manage day-to-day buying but need help with your cheque book and paying bills)?   0. or are you completely unable to handle money?