Self-Rated Function, Self-Rated Health, and Postmortem Evidence of Brain Infarcts: Findings From the Nun Study

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Objectives. Self-rated function is a new global measure. Previous findings suggest that self-rated function predicts future functional decline and is strongly associated with all-cause mortality. We hypothesized that the strength of the relationship of self-rated function to all-cause mortality was in part due to functional decline, such as would occur with brain infarcts.

Methods. Self-ratings of function and health (on a 5-point scale, ranging from excellent to poor) were assessed annually on 630 participants in the Nun Study. Mortality surveillance extended from October 31, 1991 to March 1, 1998, and, among those who died, neuropathological examination determined postmortem evidence of brain infarcts. Cox regression modeling with self-rated function and health as time-dependent covariates and stratification by assessment period were used in these analyses.

Results. Self-rated function and health ratings of good, fair, and poor were significantly associated with doubling of the risk of mortality, compared with ratings of very good and excellent. Self-rated function ratings of fair or poor were associated with a threefold increase in the risk of mortality with brain infarcts, but self-rated function and health ratings of fair and poor were comparable in their association with all-cause mortality and mortality without brain infarcts.

Discussion. Self-rated function was significantly associated with mortality with brain infarcts, suggesting that brain infarcts may be experienced as functional loss but not recognized or labeled as disease. Our results suggest that self-rated function and health should be explored simultaneously in future research.

STUDIES in a variety of populations indicate a consistent association between self-ratings of health and risk of mortality (Idler & Kasl, 1991; Idler, Kasl, & Lemke, 1990; Leung, Tang, & Jue, 1997; Mossey & Shapiro, 1982; Rakowski, Mor, & Hirsh, 1991; Wolinsky, Callahan, Fitzgerald, & Johnson, 1993; Wolinsky & Johnson, 1992; Wolinsky, Johnson, & Stump, 1995; Yu et al., 1998). Those who self-rate their health as poor have an increased risk of mortality compared with those who self-rate their health as excellent. The stability of this association over repeated studies is striking. Even with the inclusion of multiple psychosocial, demographic, and objective health measures, this association is consistently demonstrated (Idler & Kasl, 1991; Wolinsky & Johnson, 1992). It has been suggested that the impact of objective health on self-rated health may be mediated by limitations in physical function (Johnson & Wolinsky, 1994), although a direct association between self-rated health and physical function has also been demonstrated (Idler & Kasl, 1995).

Recently, we investigated the association between baseline self-rated function (i.e., the ability to take care of oneself) and self-rated health and concurrent functional ability, functional decline, and all-cause mortality in elderly women participating in the Nun Study. As part of their annual assessments of function, participants were asked to self-rate their function and health on a 5-point scale, ranging from excellent to poor. We found that good, fair, and poor self-ratings of function were associated with an increased risk of functional decline and all-cause mortality. Self-rated function had a stronger association with concurrent function and functional decline than did self-rated health (Greiner, Snowdon, & Greiner, 1996).

A large community-based population survey of older adults, the National Survey of Self-Care and Aging (Bernard et al., 1997), demonstrated similar findings using a global self-rating of function. The researchers found an independent association between self-rated function and mortality that persisted in a complex multivariate model. These findings suggest that the association between self-rated function and mortality found in the Nun Study population is not unique, but can be seen in a larger, more diverse population as well.

These two questions, self-rated function and self-rated health, seem to be tapping constructs that are related, yet different (Bernard et al., 1997; Greiner et al., 1996). A person may experience a decline in physical function but not associate that decline with health unless a specific diagnosis is made by a practitioner. A medical diagnosis without recognized functional decline may not influence one’s self-rating of function, but may influence one’s self-rating of health. For example, stroke is one health event that can cause decline in physical function yet may escape medical diagnosis. Small infarcts (e.g., lacunar infarcts of 1.5 cm or less) can cause noticeable functional loss, yet are difficult to diagnose and document during life (Bryan et al., 1994; Petrovitch et al., 1995). It is also possible to downplay the health effects of a gradual decline in physical functioning caused by repeated ischemic attacks.

The purpose of the present analyses is twofold. First, we wanted to explore the association between change in self-rated function, self-rated health, and mortality over time. The effect of self-rated function as it changes over time has yet to be reported in the literature. Second, we wanted to explore the association between self-ratings of function and health and the pres-
ence of infarcts in the brain at autopsy. Infarct status was of particular interest because strokes increase with age, are a common cause of functional decline and loss in older adults, and can escape medical diagnosis. Thus, they may be more strongly associated with self-ratings of function than of health.

METHODS

Study population.—The women included in our analyses are participants in the Nun Study, a longitudinal study of aging and Alzheimer’s disease. The design of this longitudinal study has been described in detail elsewhere (Snowdon, 1997; Snowdon et al., 1997; Snowdon et al., 1996), and will only briefly be described here. Each participant agreed to all aspects of the study, including review of her archival records, annual assessments of cognitive and physical function, and brain donation upon death. At the start of the study in 1991, the 678 participants were between 75 and 102 years of age. They did not differ from nonparticipants on mean age, percent annual mortality, race, or country of birth. In addition to being elderly women, all participants were similar in their lifestyles, marital status, religious commitment, life work as teachers, and access to health care.

Self-rated function and self-rated health.—All participants were given the opportunity to respond to the following questions at each annual assessment: “Compared to Sisters your age, would you say your ability to take care of yourself is excellent, very good, good, fair, or poor?” and “Compared to Sisters your age, would you say your health is excellent, very good, good, fair, or poor?” Responses were coded as separate categories, based on our initial findings indicating that there was a stepwise increase in the risk of mortality for each category of response. “Excellent” was used as the reference category in these analyses. Responses also were collapsed into dichotomous variables by combining excellent, very good, and good responses, and fair and poor responses. This coding scheme has been used for self-rated health (Leung et al., 1997; Wolinsky et al., 1993).

Mortality and autopsy.—Mortality surveillance for these analyses extended from October 31, 1991 to March 1, 1998. A total of 232 participants died during this surveillance period. After death and brain donation, examination of the brain was performed by one neuropathologist using standard neuropathological techniques for gross examination and dissection. This neuropathologist was blinded to neuropsychological and physical function testing results and to possible causes of death. Brain infarcts visible to the naked eye were identified by examination of the intact brain and of 1.5 cm thick coronal sections of the cerebral hemispheres, brain stem, and cerebellum. Infarcts were classified as either lacunar (≤1.5 cm) or larger.

Statistical methods.—Confidence intervals for proportions were derived by exact methods. Cox regression modeling with self-rated function and health as time-dependent covariates and stratification by assessment period was the method used to determine the association of self-rated function and health to mortality (Allison, 1993; SAS Institute, 1994). Relative risks were derived from these analyses based on the ratio of the hazard functions. This statistical approach does not assume that the hazards are proportional, allowing the time-dependent covariates to change at different times for different participants in the analysis. Stratification by assessment period (four annual assessments created three assessment periods: year 1 to year 2, year 2 to year 3, and year 3 to year 4) treats each assessment period as a distinct stratum and obviates the need to include age as a covariate in the model. Each participant was allowed to contribute to the risk calculation based on the length of time spent in each response category for each of the three assessment periods. Log likelihood model chi-square tests were calculated from these regression analyses (SAS Institute, 1994). The reduced models included the dummy variables for either self-rated function or health in calculating crude risk ratios. The full models included the dummy variables for both self-rated function and health in calculating multivariate-adjusted risk ratios.

RESULTS

Of the 678 participants, 630 were able to respond to questions regarding their self-ratings of function and health at the first annual assessment (i.e., “Compared to Sisters your age, would you say your ability to take care of yourself is excellent, very good, good, fair, or poor?” and “Compared to Sisters your age, would you say your health is excellent, very good, good, fair, or poor?”). The Pearson correlation between self-rated function and self-rated health at the initial assessment was 0.53 (p ≤ 0.001).

Compared with the 630 respondents, the 48 nonrespondents were older (mean of 88.9 vs 82.9 years), were lower in cognitive function (mean scores on Mini-Mental State Exam of 1.1 vs 25.9), and had a higher percent mortality than respondents (81% vs 35%). Of the 630 participants who were able to self-rate their health and function, 232 died during the surveillance period. A total of 191 had a complete neuropathological examination; of those, 65 had evidence of brain infarct.

All-cause mortality.—The association between self-ratings of function and health and the risk of all-cause mortality over the three assessment periods is described in Table 1. Both self-rated

| Table 1. All-Cause Mortality Associated With Self-Rated Function and Self-Rated Health Over Three Assessment Periods in 630 Participants in the Nun Studya |
|---------------------------------|---------------------------------|---------------------------------|
| Self-Rating                     | Crude risk ratio of mortality   | Multivariate-adjusted          |
|                                 | (95% CI)                        | risk ratio of mortality         |
|                                 |                                 | (95% CI)                        |
| Function                        |                                 |                                 |
| Excellent                       | 1.0                             | 1.0                             |
| Very Good                       | 1.2 (0.8-1.8)                   | 1.0 (0.7-1.6)                   |
| Good                            | 2.3 (1.6-3.5)**                 | 2.0 (1.2-3.1)**                 |
| Fair                            | 2.8 (1.7-4.6)**                 | 2.1 (1.2-3.8)*                  |
| Poor                            | 4.2 (2.2-8.0)**                 | 2.8 (1.4-5.8)**                 |
| Health                          |                                 |                                 |
| Excellent                       | 1.0                             | 1.0                             |
| Very Good                       | 1.6 (0.9-3.0)                   | 1.5 (0.8-2.8)                   |
| Good                            | 2.2 (1.2-4.0)*                  | 1.6 (0.9-3.1)                   |
| Fair                            | 2.7 (1.5-5.1)**                 | 1.7 (0.9-3.4)                   |
| Poor                            | 5.2 (2.5-11.0)**                | 2.8 (1.2-6.5)*                  |

*aMultivariate-adjusted findings include self-rated function and self-rated health.

*p value less than or equal to 0.05.

**p value less than or equal to 0.01.

***p value less than or equal to 0.001.
function and health demonstrated similar associations with the risk of all-cause mortality, with a statistically significant risk of mortality increasing across the response categories from good to fair to poor. This dose-response association between self-rated function and risk of all-cause mortality persisted in the full Cox regression model and is consistent with our previous findings (Greiner et al., 1996) as well as those described by Bernard and associates (1997). Self-rated health showed a similar dose-response relationship in the full model, although only the poor response category achieved statistical significance.

To test the difference between the full and the reduced models, log likelihood chi-square tests were conducted (SAS Institute, 1994). For self-rated function there was no significant difference between the reduced model and the full models (χ² difference = 6.9, with 4 degrees of freedom; \( p = \text{NS} \), not significant). In comparison, for self-rated health, there was a significant difference between the reduced model and the full model (χ² difference = 17.1, with 4 degrees of freedom; \( p \leq 0.01 \)).

**Collapsed categories.**—Additional analyses were done using excellent, very good, and good as the reference category (Table 2). Both self-rated function and health ratings of fair or poor demonstrated similar associations with the risk of all-cause mortality in the reduced models, as shown. In the full model, both self-rated function and health ratings of fair or poor retained significant risk ratios of 1.9 (\( p \leq 0.01 \)) and 1.5 (\( p \leq 0.05 \)), respectively (results not shown).

Analyses were rerun using excellent and very good as the reference category. Here, both self-rated function and health ratings of good, fair, or poor demonstrated similar associations with the risk of all-cause mortality in the reduced models as before, with a risk ratio of 2.4 (\( p \leq 0.001 \)) and 1.7 (\( p \leq 0.01 \)), respectively. Only self-rated function retained statistical significance in the full model, with a risk ratio of 2.1 (\( p \leq 0.0001 \); results not shown).

**Mortality with brain infarct.**—Additional analyses were done to investigate the association of self-ratings of function and health and the risk of mortality with postmortem evidence of brain infarct over the three assessment periods. In the reduced models, self-rated function responses in the fair and poor categories had 3.4 times the risk of mortality with brain infarct compared with responses in the excellent, very good, and good categories. The risk of mortality with brain infarct associated with self-rated health responses in the fair and poor categories demonstrated similar associations with the mortality with brain infarct (82%) of these women had at least one lacunar infarct, with 33 (51%) having lacunar infarcts only. These small brain infarcts are not as easy to recognize clinically or identify during life using current imaging techniques, as are larger brain infarcts. This increased risk of mortality with brain infarct associated with fair and poor self-ratings of function supports our suggestion that, although many of these women were aware of decrements in function during life, this functional decline was not necessarily interpreted as health.

Bernard and colleagues (1997) have found that, of all the diseases and chronic health conditions included in their multivariate analyses of self-rated function and mortality, only a self-reported history of diabetes mellitus or hypertension had significance. Hypertension is a strong risk factor for stroke and is the best recognized risk factor for lacunar infarcts (Graham & Lantos, 1997). Diabetes mellitus is also a known risk factor for stroke because it can lead to small vessel disease. The findings of Bernard and associates suggest that diseases that contribute to vascular change may provide a link in the association of self-rated function and mortality.

Some studies have shown brain infarcts to be more prevalent than indicated by clinical records (Bryan et al., 1994; Petrovitch et al., 1995), suggesting that infarcts, especially the smaller lacunar infarcts, are often unrecognized clinically. Bernard and colleagues (1997) found that the self-reported history of a stroke was not a significant variable in their multivariate analyses of self-rated function and mortality. Therefore, replication of our findings should include evidence of brain infarcts such as brain scans or postmortem data.

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**Table 2. Mortality Associated With Fair and Poor Self-Rated Function and Health Over Three Assessment Periods in 630 Participants in the Nun Study**

<table>
<thead>
<tr>
<th></th>
<th>Function</th>
<th>Health</th>
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<tbody>
<tr>
<td>Age-Adjusted Risk Ratio</td>
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<tr>
<td>Self-Rating</td>
<td>All-Cause Mortality</td>
<td>Mortality With Infarct</td>
</tr>
<tr>
<td>Function</td>
<td>2.3 (1.6–3.3)***</td>
<td>3.4 (1.9–6.1)***</td>
</tr>
<tr>
<td>Health</td>
<td>1.8 (1.3–2.4)**</td>
<td>1.7 (1.0–3.0)</td>
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</table>

*Compared to self-ratings of Excellent, Very Good, and Good.

*p value less than or equal to 0.05.

**p value less than or equal to 0.01.

***p value less than or equal to 0.001.
rather than relying on medical history or self-report of stroke. Our findings also add a new dimension to what is known about self-rated function and health. Prior studies have used baseline self-ratings of function or health to predict subsequent mortality. In these analyses, we have allowed self-ratings of function and health to change over three assessment periods. This change over time should reflect more closely the association between self-rated function and health and mortality. Our analyses showed that, when considered alone, self-rated function and self-rated health have similar associations with all-cause mortality. Self-rating responses of good, fair, and poor function or health were associated with similar risks of all-cause mortality. However, the log likelihood model chi-square testing indicated that the reduced model containing self-rated function alone fit the data as well as the full model for all-cause mortality and mortality with infarct. When exploring the association between these measures and mortality without brain infarcts, self-rated health alone fit the data best. These results suggest that these two measures are tapping different, but related, areas. When categories were collapsed, and fair and poor responses were compared with the reference category of excellent, very good, good, and fair, both self-rated measures were similar in their associations with all-cause mortality in the reduced and full Cox regression models. These findings are most likely due to the significant contribution of the poor category in self-rated health and the combined contribution of the fair and poor categories for self-rated function. However, when good, fair, and poor responses were compared with the reference category of excellent and very good, only self-rated function retained a significant association with all-cause mortality. This suggests that the good response category in self-rated function is more similar to fair and poor response categories, whereas the good response category in self-rated health more closely reflects very good and excellent responses to that measure. Findings from our initial work on self-rated function in the Nun Study population have been confirmed in another study using a large national database of elderly men and women (Bernard et al., 1997). While the uniqueness of the Nun Study population may limit the generalizability of our findings, this limitation may be offset by the absence of numerous confounding factors found in community-dwelling populations. In conclusion, we found that self-rated function responses of fair and poor were associated with an increased risk of mortality with postmortem evidence of lacunar and larger brain infarcts, whereas self-rated function and health had similar relationships to risk of all-cause mortality. Our findings suggest that both self-ratings of function and health should be simultaneously explored in future research. Our findings also support the need to prevent cerebrovascular disease in older adults, especially those who report decline in function, even in the absence of reported changes in health.

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