The Mediating Effect of Pain and Fatigue on Level of Functioning in Older Adults

Jill A. Bennett ▾ Anita L. Stewart ▾ Jeanie Kayser-Jones ▾ Dale Glaser

- **Background:** Medical conditions and symptoms have been shown to predict level of functioning in older adults, but medical conditions and symptoms have rarely been investigated together in a comprehensive model that included both medical conditions and symptoms as predictors of functioning in older adults.
- **Objective:** The purpose of this study was to determine whether the adverse effect of medical conditions on different aspects of functioning in older adults is mediated by the level of symptoms (pain and fatigue). If so, level of functioning may improve if pain or fatigue can be mitigated, even when underlying medical conditions cannot be cured.
- **Method:** Data from 225 adults aged 65–90 were used to test whether medical conditions, symptoms (pain and fatigue), and six covariates predicted lower body performance, self-reported physical functioning, and self-reported role and social functioning. The fit of a series of models to the data was analyzed using structural equation modeling.
- **Results:** Medical conditions affected self-reported physical functioning and self-reported role and social functioning by increasing the level of symptoms, rather than by direct association. Further descriptive studies are needed to identify other symptoms and modifiable mechanisms by which medical conditions affect functioning. Researchers who investigate the causes of poor functioning in older adults are encouraged to include symptoms in models that hypothesize medical conditions as predictors of functioning outcomes.

- **Key Words:** activities of daily living • aged • fatigue • pain

Adults over age 65 comprise a rapidly growing segment of the United States population (Schneider, 1999; U.S. Bureau of the Census, 1993). Today, nearly 6.6 million people over the age of 65 receive help with daily activities, and the number of elders who need help will continue to increase as the population grows (Kassner & Bectel, 1998). It will become increasingly important for nurses and other healthcare providers to prevent disability in elders whenever possible. To provide the best preventive care, it is necessary to (a) understand the reasons why older adults limit their performance of daily tasks and activities; and (b) identify the modifiable factors that lead to disability.

The presence of medical conditions is a key predictor of functional limitations in older adults (Caruso, Silliman, Demissie, Greenfield, & Wagner, 2000; Nagi, 1976; Rozzini et al., 1997; Verbrugge & Jette, 1994). However, this knowledge has limited utility for planning interventions to improve functioning because many medical conditions cannot be cured. Some researchers have suggested that it is not the diseases per se that affect functioning, but their manifestations, such as symptoms (Stewart & Painter, 1998). If this is correct, level of functioning may improve if symptoms can be mitigated. The role of symptoms as an independent predictor of level of functioning in older adults has been established (Caruso et al., 2000; Strawbridge, Cohen, Shema, & Kaplan, 1996), but we are unaware of any studies that have explored the relationships between medical conditions, symptoms, and functioning in a single comprehensive model.

The purpose of this study was to determine whether the adverse effect of medical conditions on different aspects of functioning in older adults was mediated by two symptoms: pain and fatigue. Pain and fatigue are common symptoms that result from a variety of medical conditions in older adults (Hickie et al., 1996; Karlsen, Larsen, Tandberg, & Jorgensen, 1999; Liao & Ferrell, 2000; Won et al., 1999), and both are often undertreated (Liao & Ferrell, 2000; Lichstein, Means, Noe, & Aguillard, 1997; Morrison & Siu, 2000). If pain and fatigue play an important mediating role in the association between medical conditions and functioning, it is possible

Jill A. Bennett, PhD, RN, is Assistant Adjunct Professor, School of Nursing, University of California San Francisco.

Anita L. Stewart, PhD, is Professor, Institute for Health & Aging, University of California San Francisco.

Jeanie Kayser-Jones, PhD, RN, FAAN, is Professor, School of Nursing, University of California San Francisco.

Dale Glaser, PhD, is Senior Statistician, Pacific Science & Engineering Group, San Diego, California.

that interventions to reduce these symptoms may improve mobility and performance of activities of daily living (ADL) in older adults.

To investigate if pain and fatigue mediated the relationship between medical conditions and functioning in older adults, a theoretical model of the disability pathway was tested where three aspects of functioning were hypothesized to represent a sequence of functional decline. Decline occurs first in lower body performance, followed by self-reported physical functioning, followed by self-reported role and social functioning (Nagi, 1976; Stewart & Painter, 1998; Verbrugge & Jette, 1994). This sequence of functional decline has also been demonstrated empirically in longitudinal studies (Guralnik et al., 2000; Guralnik, Ferrucci, Simonsick, Salive, & Wallace, 1995).

Methods

Participants

This study used cross-sectional baseline data from older adults (aged 65 and over) who enrolled in either a randomized trial of the Community Healthy Activities Model Program for Seniors (CHAMPS II) (Stewart, Verboncoer, et al., 2001) or a parallel active cohort. CHAMPS was a physical activity promotion program designed to increase lifetime physical activity levels of older adults. Individuals from two Medicare HMOs within a large multispecialty practice were enrolled between January and June 1996. The CHAMPS trial cohort included persons who were sedentary or underactive and had no serious medical conditions that could limit participation in light to moderate physical activity (e.g., unstable angina, uncontrolled hypertension, type I diabetes, or recent chest pain, heart attack, heart surgery). An active cohort included persons who had engaged in moderate-intensity physical activity during the last three months at least three times weekly. Baseline data from both groups were used in this study. All methods were approved by the appropriate Institutional Review Boards.

Independent Variables

Medical conditions. Medical conditions were measured by the sum of eight self-reported medical conditions or syndromes: (a) arthritis or joint problems; (b) osteoporosis; (c) kidney or liver disease; (d) asthma, chronic bronchitis, or emphysema; (e) hypertension; (f) diabetes; (g) congestive heart failure or heart trouble; and (h) paralysis, stroke, Parkinson's, or other neurological problems.

Symptoms. Symptoms were measured as a latent variable by two causal indicators, the pain scale and the energy/fatigue scale of the SF-36 (McHorney, Ware, & Raczek, 1993). The indicators were conceptualized as causal because pain and fatigue predict symptom status, rather than the reverse. This relationship is different from the more common relationship between latent variable and "effect" indicators, in which the latent variable predicts the values of the indicators. The SF-36 scale scores were transformed to a 0–100 scale. For model testing, the values were reversed from the usual SF-36 scoring so high scores represented more pain or fatigue. The internal-consistency reliabilities of the pain and fatigue/energy scales in the current study were both .75.

Covariates

Obesity. Obesity was measured as a Body Mass Index (BMI) of 29 or more, a categorization that is consistent with other studies of functioning in older adults (Galanos, Pieper, Cornoni-Huntley, Bales, & Fillenbaum, 1994). Body Mass Index was calculated from self-reported weight in kilograms divided by height in meters squared.

Age and sex. Age and sex were each measured by single self-reported items.

Socioeconomic status. Socioeconomic status was measured by two items: (a) income, a three-level ordinal item and (b) education, a six-level ordinal item. These variables were designated as causal indicators in the model, rather than the usual effect indicators used in structural equation modeling because logically, income and education predict socioeconomic status rather than the reverse.

Exercise capacity. Exercise capacity was measured by a six-minute walk, in which the subject walked around a course marked by traffic cones for six minutes. Participants were instructed to walk at a pace that allowed them to comfortably talk without being short of breath. They could stop and rest, but the stopwatch continued to run during rest periods. The distance walked was measured in feet; longer distances indicate better exercise capacity. The six-minute walk is considered a valid and reproducible test of exercise capacity based on correlations with other fitness and exercise capacity measures (e.g., cycle ergometry, peak oxygen consumption during exercise, spirometry) (Langenfeld et al., 1990; Steele, 1996).

Physical activity. Physical activity was measured by the CHAMPS Physical Activity Questionnaire, a self-report instrument designed to measure level of physical activity in older adults (Stewart, Mills, King, Haskell, Gillis, & Ritter, 2001). The measure used for this study estimated calories expended per week in a variety of physical activities typically performed by older adults for exercise (e.g., walking briskly, swimming, general conditioning, stretching, gardening). Higher scores indicate more caloric expenditure and thus higher levels of physical activity. Evidence of the construct validity of this measure has been reported (Stewart, Mills, et al., 2001).

Dependent Variables

Lower body performance. Lower body performance was measured by the Physical Performance Battery (PPB) developed for the Established Populations for Epidemiologic Studies of the Elderly (EPESE). The PPB produces a summary ordinal score based on three performance tests: (a) tandem stand, (b) chair rise-and-sit, and (c) 8-foot walk. In previous studies, the PPB has been associated with self-reported physical functioning, mortality, and nursing home admissions (Guralnik et al., 1995; Guralnik et al., 1994). Scores on the PPB range from 0–12, with higher scores indicating better lower body performance.

Self-reported physical functioning. Self-reported physical functioning was measured by the SF-36 physical functioning scale (McHorney et al., 1993), which assesses the extent to which health limits physical activities (e.g., self-care, walking, climbing hills and stairs, bending, lifting, moderate and vigorous activities). The scale score was transformed to 0–100, with higher scores representing better functioning. Internal-consistency reliability for the physical functioning scale was .74 in the current study.

Self-reported role and social functioning. Self-reported role and social functioning was a latent variable measured in terms of limitations in activities using two SF-36 scales (McHorney et al., 1993). The SF-36 role-physical scale assesses limitations in work or other regular daily activities due to physical health. The SF-36 social functioning scale assesses limitations in normal social activities due to physical health or emotional problems. The scale scores were transformed to 0–100, with higher scores indicating fewer limitations. Internal-consistency reliability in the current study was .77 for each of the scales.

More than 90% rated their health as very good or excellent

Statistical Analysis

A sequence of hypothesized models was analyzed with structural equation modeling conducted using AMOS 4.0 software (Arbuckle & Wothke, 1999). A model-generating approach (Hoyle & Panter, 1995) was used in which alternative pathways were examined based on evidence in the literature. The initial model was based on a theoretical framework proposed in the literature (Nagi, 1976; Verbrugge & Jette, 1994), where all independent variables predict the first aspect of functioning (lower body performance). Lower body performance predicts self-reported physical functioning, which, in turn, predicts self-reported role and social functioning.

Interim models were fit with independent variables directly predicting the other, self-reported, aspects of functioning. These associations were based on empirical findings from the literature of direct associations between independent variables and self-reported functioning variables (Beckett et al., 1996; Ferrucci, Guralnik, Pahor, Corti, & Havlik, 1997; Fries et al., 1994; Maddox, Clark, & Steinhauser, 1994). In other words, interim models were tested based on studies that supported pathways different from those in the sequential disability pathway in the initial model. The tests determined whether the relationships were stronger in an empirically based model than in the initial theoretical model. When the model with the best fit to the data was defined, symptoms were added as a mediator in any statistically significant direct relationship between medical conditions and a functioning variable.

The structural equation modeling analyses used a normal-theory method of estimation, maximum likelihood (ML). Maximum likelihood assumes multivariate normality of endogenous variables (the dependent variables in our model) and allows dichotomous exogenous variables (some of the independent variables in our model). Of the two ordinal exogenous variables in our model, education had six categories, which is a sufficient number to assume underlying normality (Kline, 1998), and income had three categories, which does not meet the assumption for ML. However, we could not use alternate estimation methods that do not assume normality (e.g., weighted least squares [WLS]), because those methods require very large sample sizes. It has been demonstrated that ML is robust when applied to non-normal data and there is a tendency to reject models when they are actually true (Kline, 1998). Therefore, we selected ML estimation because our model had only one non-normal exogenous variable and the tendency to reject models with non-normal variables made ML estimation a conservative estimate of model fit. In all models tested, exogenous variables were left free to covary between each other.

Five fit indices were selected to evaluate the fit of each model to the data. Two indices, chi-square and the goodness-of-fit index (GFI), are measures of absolute fit indicating how well the parameters in the model match the covariances in the data. A small, nonsignificant chi-square indicates good model fit. The GFI measures the proportion of observed covariances explained by the model. The GFI is analogous to an R^2 statistic in multiple regression and a value close to 1 indicates good model fit.

Two fit indices, the non-normed fit index (NNFI) and the comparative fit index (CFI), evaluate incremental fit by comparing the model being tested to a null model. Good fit is indicated by a value over .90 (Hu & Bentler, 1995), which means the tested model fits the data 90% better than a model that does not fit at all. Another fit index used in this analysis was the root mean square error of approximation (RMSEA), which evaluates model fit in relation to the number of pathways estimated. A RMSEA below 0.05 indicates a good model fit in relation to the number of pathways estimated (Hu & Bentler, 1995).

Results

Of the 249 people in the two cohorts of the CHAMPS study, 225 (90%) had complete data on all measures. Samples larger than 200 are generally considered adequate for analysis of structural equation models (Kline, 1998).

The 225 participants were aged 65–90. More than 90% rated their health as very good or excellent, with a mean of 1.5 medical conditions. Approximately 90% reported their ethnicity as non-Hispanic White. The participants had high levels of education (66.2% had a college degree or higher). The demographic characteristics of the 24 participants who were excluded from this analysis were compared to those of the 225 who were included, using t-test for continuous variables and chi-square tests for categorical variables. As shown in Table 1, the groups were similar in most characteristics, though the excluded participants had higher levels of education. Only eight excluded participants reported income, too few to allow a comparison between the groups.

The mean scores in the sample on the dependent functioning variables and the key independent variables (medical conditions, pain, fatigue) are presented in Table 2. In the current study, the mean score on the SF-36 physical functioning scale was 9.6 points higher than the general population norm for adults aged 65-74, and the mean score on the social functioning scale was 11.7 points higher than the general population norm for adults aged 65–74

TABLE 1. Comparison of Subjects Excluded Due to Incomplete Data and Subjects Included in Structural Equation Modeling Analysis (*N* = 249)

Variable	Excluded % or Mean (*SD*) *N* = 24	Included % or Mean (*SD*) *N* = 225	*p* Value
Age	73.8 (5.7)	74.1 (5.6)	.86 (*t* test)
Female	70.8%	63.1%	.45 (χ^2)
Number of medical conditions	1.50 (1.29)	1.48 (1.16)	.92 (*t* test)
Education beyond high school	91.6%	84%	<.01 (χ^2)
BMI	25.31 (3.95)	24.90 (4.40)	.67(*t* test)
Obese (BMI 29 or more)	15%	13%	.79 (χ^2)
Exercise capacity (mean distance in feet for 6-minute walk)	1,488.24 (303.20)	1,408.35 (380.81)	.32 (*t* test)
Physical activity (mean calories expended in all activities per week)	2,899.22 (2431.22)	2,369.11 (1754.81)	.31 (*t* test)

Note. SD = standard deviation; BMI = body mass index; *t* tests were used to compare means of continuous variables and chi-square tests were used to compare categorical variables.

(Ware, 1998). A larger percentage of participants in the current study received the highest score, 12, on the physical performance battery than did a representative population aged 75 from the 4-site EPESE study (Guralnik et al., 2000), though scores ranged from a low of 1 to a high of 12 in the current study.

The distribution of each variable was examined to assess normality. Though some individual variables were skewed or kurtotic, none was outside the limits of normality (skew >2 or kurtosis >7) (Kline, 1998) and there were no outliers. Table 3 presents the correlation matrix for the variables in the model. All correlations were in the

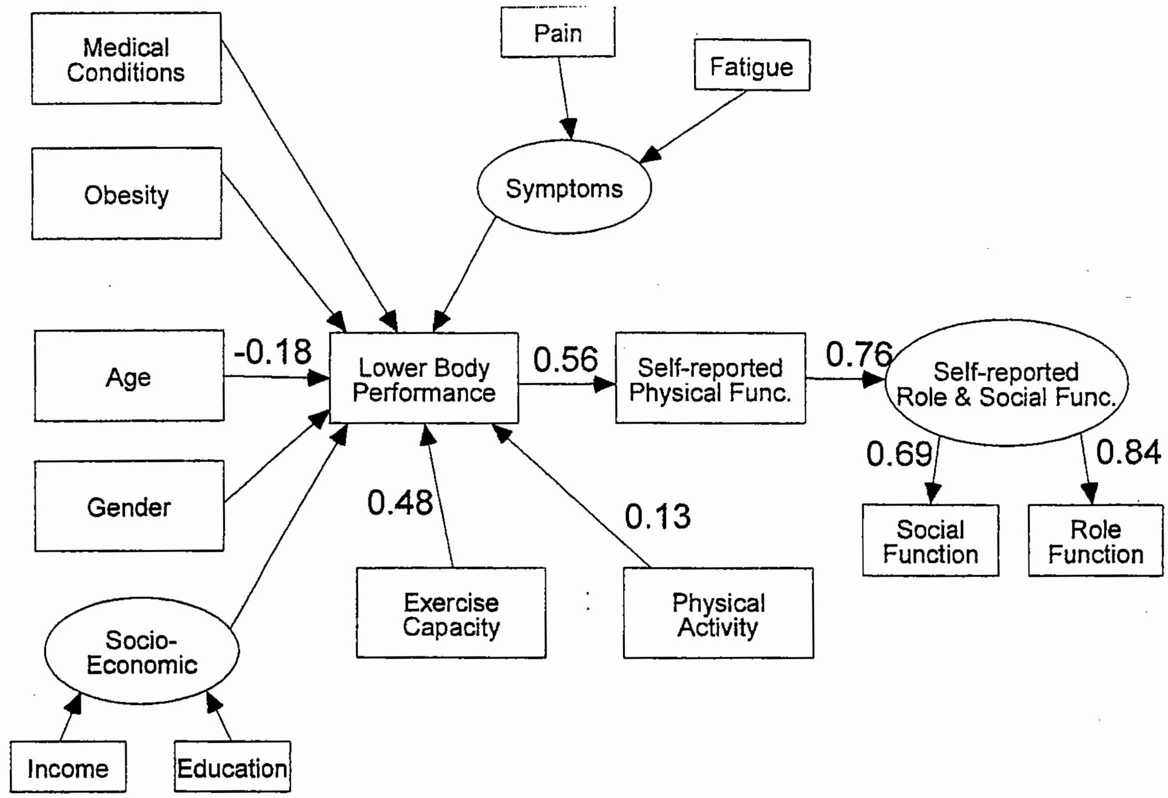
TABLE 2. Key Independent and Dependent Variables Descriptive Statistics (*N* = 225)

Variable Measure (Range)	Range	Mean (*SD*)
Medical conditions		
Sum of medical conditions (0–8)	0–5	1.48 (1.16) Most prevalent conditions reported by sample: arthritis 59%, hypertension 36%, heart disease 18%
Symptoms		
SF-36 pain scale (0–100) (reversed so higher score = more pain)	0–100	28.09 (22.50)
SF-36 energy/fatigue scale (0–100) (reversed so higher score = more fatigue)	0–100	36.84 (19.26)
Lower body performance		
Physical performance battery (0–12) (higher score = better lower body performance)	1–12	9.71 (2.12) 19% of sample scored 12
Physical functioning		
SF-36 physical functioning scale (0–100) (higher score = better physical functioning)	10–100	79.04 (21.72)
Role and Social Functioning		
SF-36 role-physical scale (0–100) (higher score = better role functioning)	0–100	65.89 (38.53)
SF-36 social functioning scale (0–100) (higher score = better social functioning)	37–100	92.28 (14.00)

Note. SF-36 = Medical Outcomes Study Short Form 36 health survey.

	Lower Body Performance	Physical Functioning	Role Activities	Social Activities	Medical Conditions	Pain (Reversed)	Fatigue (Reversed)	Obesity (dichot. 1 = obese)	Age	Sex (dichot. 1 = female)	Income (3 categ.)	Education (6 categ.)	Exercise Capacity	Physical Activity
Lower body performance	9.71 (2.12)													
Physical functioning	.56**	79.04 (21.72)												
Role activities	.38**	.64**	65.89 (38.53)											
Social activities	.29**	.53**	.58**	92.28 (14.00)										
Medical conditions	−.34**	−.45**	−.38**	−.35**	1.48 (1.16)									
Pain (reversed)	−.34**	−.61**	−.58**	−.48**	.38**	28.09 (22.50)								
Fatigue (reversed)	−.35**	−.60**	−.63**	−.53**	.34**	.47**	36.83 (19.26)							
Obesity (1 = obese)	−.12	−.31**	−.12	−.18**	.19**	.23**	.18	.15 (.36)						
Age	−.40**	−.19**	−.18**	.01	.19**	.09	.16	−.16*	74.07 (5.59)					
Sex (1 = female)	−.22**	−.23**	−.19**	−.12	−.02	.07	.16	.01	.06	.63 (.48)				
Income (3 categ.)	.28**	.29**	.19**	.18**	−.14*	−.12	−.20	−.03	−.09	−.26**	2.24 (.72)			
Education (6 categ.)	.23**	.18**	.12	.10	−.11	−.09	−.13	−.11	−.06	−.19**	.38**	4.10 (1.42)		
Exercise capacity	.67**	.69**	.46**	.32**	−.39**	−.40**	−.44**	−.20**	−.37**	−.29**	.26**	.26**	14.08 (3.80)	
Physical activity	.27**	.27**	.15*	.07	−.05	−.03	−.16*	−.03	−.12	−.24**	.17*	−.03	.22**	23.69 (17.55)

Note. dichot. = dichotomous; categ. = categories
*$p < .05$ (two-tailed). **$p < .01$ (two-tailed)



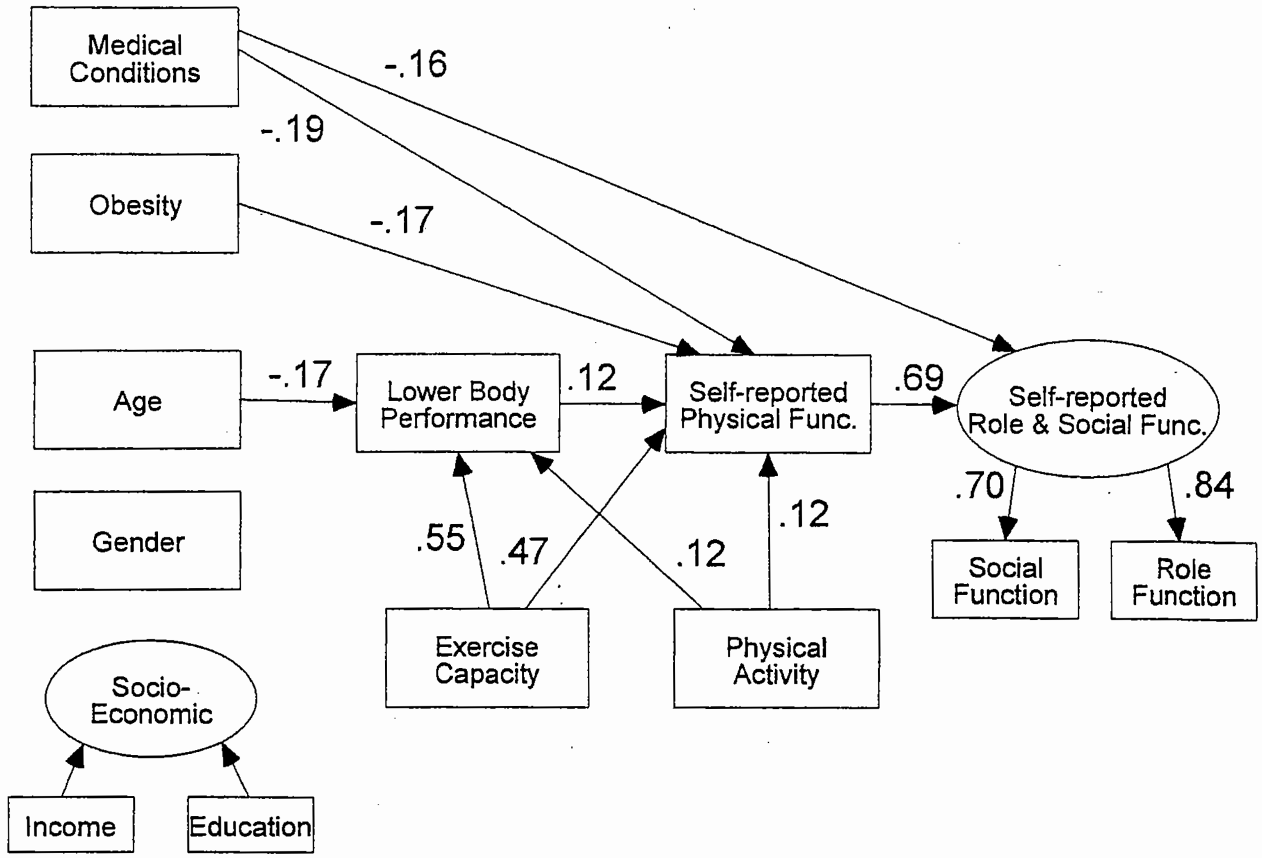
	Degrees of freedom	Chi-square (χ^2)	*p* Value	Goodness of fit	Non-normed fit	Comparative fit	RMSEA
Full model fit	32	272.99	<.01	.89	.33	.76	.18

FIGURE 1. Initial structural equation model based on theoretical model, in which all independent variables affect the earliest functioning variable in a sequential disability pathway. Path coefficients are standardized, paths shown without coefficients were < .10. SF-36 Pain and Fatigue scores were reversed so a higher score indicates a higher level of pain or fatigue. RMSEA = root mean square error of approximation.

expected direction and there was no multicollinearity between exogenous variables (highest r = .47). The four measures of the dependent functioning variables were significantly, but moderately, correlated (r ranging from .29 to .64).

The fit of the initial theoretical model (Figure 1) was poor, as shown by the significant Chi-square and other fit indices. The lack of significant associations between lower body performance and the independent variables of medical conditions, pain, and fatigue suggested that further testing of pathways that were supported in the literature might generate a model that fit the data better. An interim structural equation model without pain and fatigue, shown in Figure 2, fit the data well. This model showed that more medical conditions were directly associated with lower self-reported physical functioning and lower self-reported role and social functioning. When pain and fatigue were added to the model as exogenous variables (Figure 3), model fit was similar, but associations within the model changed. In this model, more pain and more fatigue were associated with lower levels of self-reported physical functioning and lower self-reported role and social functioning, but the number of medical conditions had only a weak association (standardized path coefficient <.10) with the self-reported functioning variables. Because the direct relationships between medical conditions and self-reported physical functioning and self-reported role and social functioning changed from moderate to small when pain and fatigue were added to the interim model, the interim models suggested that pain and fatigue were mediators in the model. The mediating effect was tested in the final model.

The final model (Figure 4) included a latent variable for symptoms, measured by pain and fatigue, as a mediator in the relationship between medical conditions and self-



	Degrees of freedom	Chi-square (χ^2)	*p* Value	Goodness of fit	Non-normed fit	Comparative fit	RMSEA
Full model fit	23	25.99	.30	.98	.99	.99	.02

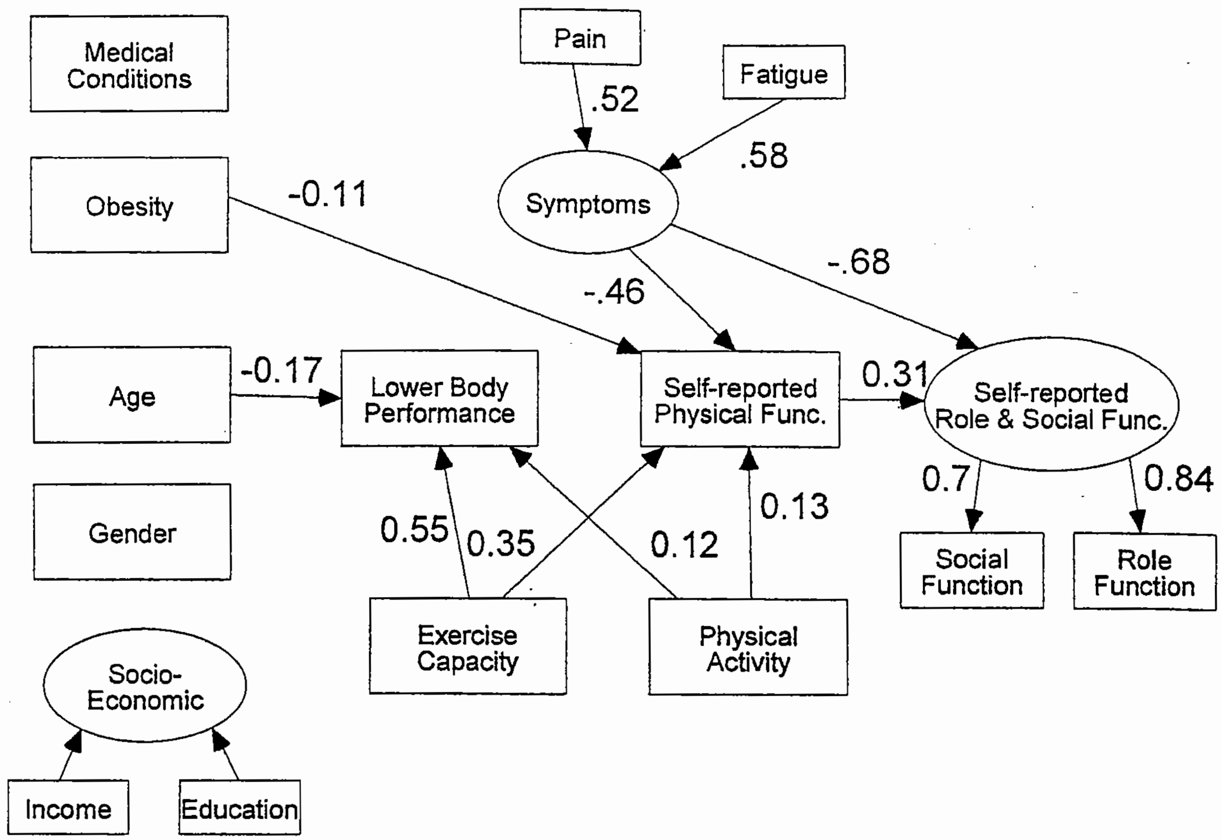
FIGURE 2. Interim structural equation model with medical conditions and six covariates as exogenous variables. Pain and fatigue are not in the model. Path coefficients are standardized. Paths with coefficients < .10 are not shown. SF-36 Pain and Fatigue scores were reversed so a higher score indicates a higher level of pain or fatigue. RMSEA = root mean square error of approximation.

reported physical functioning and self-reported role and social functioning. The fit of the final model was good, and the path coefficients for medical conditions and symptoms were strongest in this model. Medical conditions were only weakly related to any functioning variable (standardized path coefficient <.10). Instead, medical conditions were moderately associated with symptoms, which, in turn, were strongly associated with self-reported physical functioning and self-reported role and social functioning.

In the final model, obesity was associated with poor self-reported physical functioning. Older age was associated with poorer lower body performance. Higher levels of exercise capacity and physical activity were associated with better lower body performance and self-reported physical functioning. In this final model, the association between lower body performance and self-reported physical functioning was small (standardized path coefficient <.10) and the association between self-reported physical functioning and self-reported role and social functioning was moderate (.23).

Discussion

In this analysis of cross-sectional data from a sample of community-living older adults, the best model fit was obtained when symptoms (pain and fatigue) were tested as mediators of the relationship between medical conditions and self-reported physical functioning; and between medical conditions and self-reported role and social functioning. In this model, there was only a small direct association (standard-



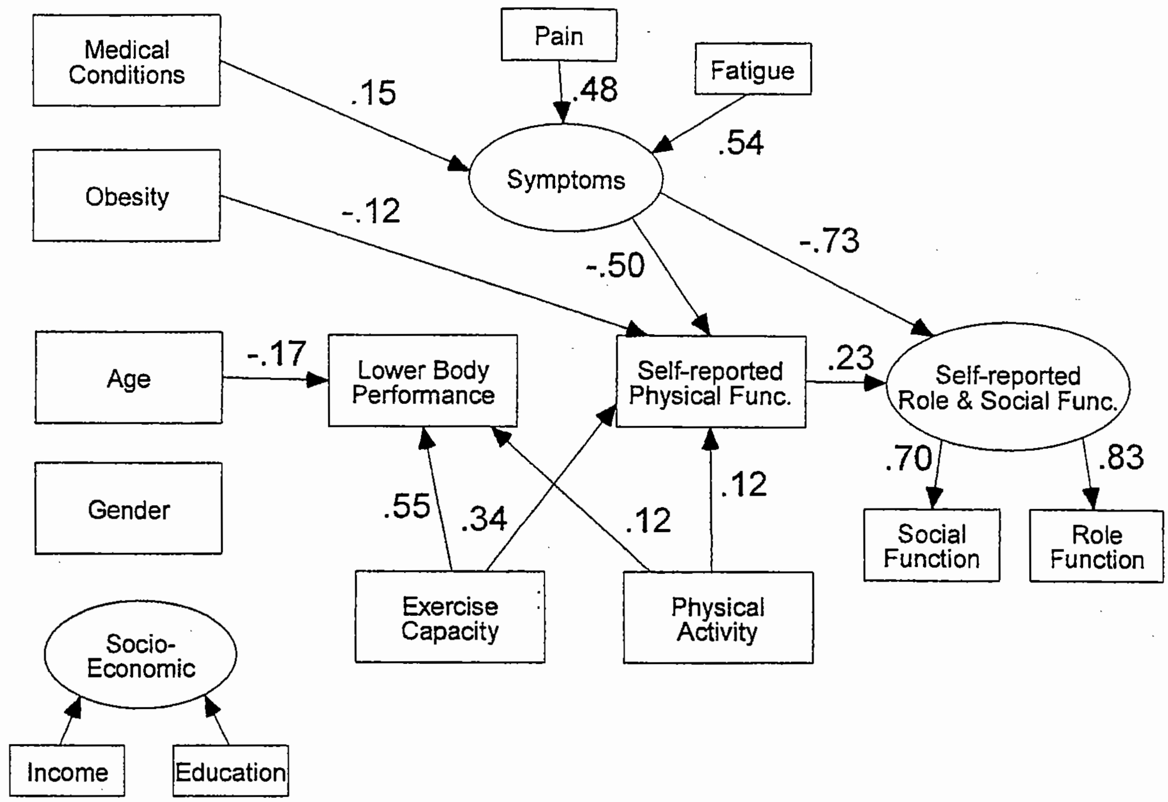
	Degrees of freedom	Chi-square (χ^2)	*p* Value	Goodness of fit	Non-normed fit	Comparative fit	RMSEA
Full model fit	27	30.25	.30	.98	.99	.99	.02

FIGURE 3. Interim structural equation model with medical conditions, pain, fatigue, and six covariates as exogenous variables. Path coefficients are standardized. Paths with coefficients < .10 are not shown. SF-36 Pain and Fatigue scores were reversed so a higher score indicates a higher level of pain or fatigue. RMSEA = root mean square error of approximation.

ized path coefficient < .10) between medical conditions and any of the dependent functioning variables, confirming that the mediated relationship was stronger than any direct relationship between medical conditions and any functioning variable.

Our finding that pain and fatigue resulting from medical conditions were strongly associated with lower levels of self-reported physical functioning and self-reported role and social functioning, suggests that modifiable mechanisms, such as pain and fatigue, are more important in determining whether an older adult functions independently than are medical conditions, which often cannot be modified. Pain and fatigue are common in older adults for a variety of reasons, such as changes in sleep patterns and the presence of some medical conditions, including arthritis (Hickie et al., 1996; Liao & Ferrell, 2000). To our knowledge, our study is the first to report the relationships of pain, fatigue, and medical conditions in a comprehensive model of functioning in older adults. Earlier studies have reported that pain and fatigue were associated with poor functioning, without medical conditions as a covariate (Hickie et al., 1996; Karlsen et al., 1999; Liao & Ferrell, 2000; Won et al., 1999) or that medical conditions were associated with poor functioning without symptoms as a covariate (Fried, Bandeen-Roche, Kasper, & Guralnik, 1999). Other symptoms (e.g., shortness of breath or depressive symptoms) may also mediate the relationship between medical conditions and functioning. Further studies of other symptoms and mechanisms, such as medications or stress, may increase our understanding of potentially modifiable factors that may mediate the relationship between medical conditions and functioning in older adults.

 Nursing Research July/August 2002 Vol 51, No 4



	degrees of freedom	Chi-square (χ^2)	*p* Value	Goodness of fit	Non-normed fit	Comparative fit	RMSEA
Full model fit	28	30.30	.35	.98	.99	.99	.02

FIGURE 4. Final structural equation model with symptoms (measured by formative indicators pain and fatigue) as mediator of medical conditions. Path coefficients are standardized. Paths with coefficients < .10 are not shown. SF-36 Pain and Fatigue scores were reversed so a higher score indicates a higher level of pain or fatigue. RMSEA = root mean square error of approximation.

The findings reported here relied on a summary score of medical conditions. It is possible that some medical conditions cause symptoms that influence level of functioning, while other medical conditions do not. Future studies with larger numbers of participants with each medical condition may disentangle the specific medical conditions and related symptoms that are most likely to negatively affect functioning in older adults. The relatively healthy older adults in this study reported a mean of 1.5 medical conditions. The somewhat small relationship between medical conditions and symptoms in the final model (standardized path coefficient = .15) suggests that the pain and fatigue in this sample may have been partially caused by other factors, but the strong associations between symptoms and self-reported physical functioning (standardized path coefficient = −.50) and self-reported role and social functioning (standardized path coefficient = −.73) clearly demonstrate the importance of pain and fatigue as predictors of functioning. Further research in older adults with more medical conditions is needed to confirm that most of the association between medical conditions and functioning is mediated by pain and fatigue in frail elders. Meanwhile, our findings support the importance of including pain and fatigue, which are often undertreated (Liao & Ferrell, 2000; Lichstein et al., 1997; Morrison & Siu, 2000), as part of functional assessment.

Our model included covariates that have been reported as predictors of level of functioning in older adults. Though others have found that female sex (Smith & Baltes, 1998) and low level of education (Maddox et al., 1994) predicted lower levels of functioning, our data did not show these relationships. Our results may be due to the limited variability in level of education in our sample. Earlier findings that (a) obesity (Galanos et al., 1994), (b) older age (Beckett et al., 1996), (c) lower exercise capacity (Guyatt et al., 1985), and (d) lower physical activity level (Ettinger et al., 1997; Fries et al., 1994; Seeman et al., 1995) were associated with a reduced level of functioning in older adults were confirmed.

Many earlier studies did not measure or report on three separate aspects of functioning. It is important for future studies to distinguish the different conceptual aspects of functioning, because in our sample, age, obesity, exercise capacity, and physical activity affected some aspects of functioning and not others (Figure 4). For example, exercise capacity had a strong association with both lower body performance and self-reported physical function, yet the role and social functioning latent variable was not affected. Physical activity showed similar, albeit weaker, relationships with the three functioning variables. These findings support the theoretical model that difficulty in physical functioning, both performance and self-report, may precede difficulty in role and social functioning. Though additional studies that measure all three aspects of functioning are needed to confirm the specific relationships in our model, the results demonstrate the importance of considering the three conceptual aspects of functioning as outcomes in studies of older adults.

It is important for future studies to distinguish the different conceptual aspects of functioning

The three functioning variables in the model had significant bivariate correlations ($p < .01$), and they were strongly associated in the initial theoretical model (Figure 1). However, in subsequent models with better fit to the data, the associations between the three aspects of functioning weakened. In the final model, the association between lower body performance and self-reported physical functioning was small (standardized path coefficient <.10). The reduction in the associations between the functioning variables can be explained by the shared causes of all functioning variables. For example, exercise capacity and physical activity each predicted both lower body performance and self-reported physical functioning; obesity, medical conditions, pain, and fatigue were more likely to affect self-reported functioning than lower body performance. This raises an intriguing question for future research; perhaps obesity, medical conditions, pain, and fatigue make older adults perceive functional limitations, but are less likely to affect actual performance. These findings suggest that the three functioning variables in the model measured related, but distinct, aspects of functioning and that each aspect is likely to have a different set of associated independent variables. Thus, structural equation modeling analysis separated the effects of many predictors on three separate functioning outcomes and showed distinct relationships that would have been difficult to elucidate with other methods of analysis.

Exercise capacity and physical activity were related to physical functioning

The common aspects of our findings may be limited by the homogeneity of our sample. Most of the participants were White, well-educated, and reported their health as good or excellent. Though our sample cannot represent all older adults, our model is a first step toward a better understanding of the factors that lead to functioning decline in healthy older adults. Further studies are needed in older adults of different ethnicities and in those in poorer health.

The model-generating approach of our structural equation modeling analysis has the potential to capitalize on the idiosyncrasies of our sample. Pathways selected for inclusion were based on evidence in the literature; thus, the model represents plausible relationships, though the model fit should be tested in other samples. The data in this study were cross-sectional, so causal relationships cannot be proven by our structural equation modeling analysis. However, causal relationships are implied between many variables in the model. For example, pain and fatigue are likely to cause declines in function rather than the reverse. Likewise, advancing age is likely to cause decline in lower body performance because the reverse cannot be true. Other relationships are more ambiguous and causal relationships can be assumed based on prior longitudinal studies. For example, our model shows that low levels of physical activity lead to poor lower body performance and self-reported difficulty in physical functioning, and is supported by reports in the literature (Ettinger et al., 1997; Fries et al., 1994; Seeman et al., 1995). It is possible that the association goes the other way; poor performance and difficulty in functioning lead to lower levels of physical activity. It is not possible to explore the possibility with cross-sectional data.

It is encouraging that even though chronic medical conditions predict poor functioning, most of the relationship is explained by the presence of pain and fatigue, which may be amenable to interventions. If symptoms, or other modifiable mechanisms, are important to maintaining or improving functioning in older adults, then methods to measure those mechanisms and interventions to mitigate their adverse effects on functioning may improve the quality of life of older adults, even if the underlying medical conditions remain unchanged. Though descriptive models may lead to a better understanding of the relationship between medical conditions and level of functioning in older adults, the findings must be confirmed by experimental or longitudinal studies that test whether symptom management improves functioning in older adults.

Accepted for publication March 18, 2002.

Data analyzed in this study was from CHAMPS II study funded by NIA AG09931.

Corresponding author: Jill A. Bennett, PhD, RN, UCSF School of Nursing, 2 Koret Way, N631, San Francisco, CA 94143-0610 (e-mail: jillben@itsa.ucsf.edu).

References

Adams, P. F., Hendershot, G. E., & Marano, M. A. (1999). *Current estimates from the National Health Interview Survey, 1996* (10 (200)): National Center for Health Statistics. Vital Health Statistics 10(200).

Arbuckle, J. L., & Wothke, W. (1999). AMOS (Version 4.0) [Computer software]. *http://www.smallwaters.com:* Smallwaters.

Beckett, L. A., Brock, D. B., Lemke, J. H., et al. (1996). Analysis of change in self-reported physical function among older persons in four population studies. *American Journal of Epidemiology, 143*, 766-778.

Caruso, L., Silliman, R., Demissie, S., Greenfield, S., & Wagner, E. (2000). What can we do to improve physical function in older persons with type 2 diabetes? *The Journals of Gerontology: Medical Sciences, 55A*, M372-M377.

Ettinger, W. H., Jr., Burns, R., Messier, S. P., et al. (1997). A randomized trial comparing aerobic exercise and resistance exercise with a health education program in older adults with knee osteoarthritis. The Fitness Arthritis and Seniors Trial (FAST). *Journal of the American Medical Association, 277*, 25-31.

Ferrucci, L., Guralnik, J. M., Pahor, M., Corti, M. C., & Havlik, R. J. (1997). Hospital diagnoses, Medicare charges, and nursing home admissions in the year when older persons become severely disabled. *Journal of the American Medical Association, 277*, 728-734.

Fried, L. P., Bandeen-Roche, K., Kasper, J. D., & Guralnik, J. M. (1999). Association of comorbidity with disability in older women: The Women's Health and Aging Study. *Journal of Clinical Epidemiology, 52*, 27-37.

Fries, J. F., Singh, G., Morfeld, D., Hubert, H. B., Lane, N. E., & Brown, B. W., Jr. (1994). Running and the development of disability with age. *Annals of Internal Medicine, 121*, 502-509.

Galanos, A. N., Pieper, C. F., Cornoni-Huntley, J. C., Bales, C. W., & Fillenbaum, G. G. (1994). Nutrition and function: Is there a relationship between body mass index and the functional capabilities of community-dwelling elderly? *Journal of the American Geriatrics Society, 42*, 368-373.

Guralnik, J. M., Ferrucci, L., Pieper, C. F., et al. (2000). Lower extremity function and subsequent disability: Consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. *The Journals of Gerontology: Medical Sciences, 55*, M221-231.

Guralnik, J. M., Ferrucci, L., Simonsick, E. M., Salive, M. E., & Wallace, R. B. (1995). Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. *New England Journal of Medicine, 332*, 556-561.

Guralnik, J. M., Simonsick, E. M., Ferrucci, L., et al. (1994). A short physical performance battery assessing lower extremity function: Association with self-reported disability and prediction of mortality and nursing home admission. *The Journals of Gerontology, 49*, M85-94.

Guyatt, G. H., Thompson, P. J., Berman, L. B., et al. (1985). How should we measure function in patients with chronic heart and lung disease? *Journal of Chronic Disease, 38*, 517-524.

Hickie, I. B., Hooker, A. W., Hadzi-Pavlovic, D., Bennett, B. K., Wilson, A. J., & Lloyd, A. R. (1996). Fatigue in selected primary care settings: Sociodemographic and psychiatric correlates. *Medical Journal of Australia, 164*, 585-588.

Hoyle, R. H., & Panter, A. T. (1995). Writing about structural equation models. In R. H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues, and applications* (pp. 158-176). Thousand Oaks, CA: Sage.

Hu, L. T., & Bentler, P. M. (1995). Evaluating model fit. In P. M. Bentler (Ed.), *Structural equation modeling: Concepts, issues, and applications* (pp. 76-99). Thousand Oaks, CA: Sage Publications.

Karlsen, K., Larsen, J. P., Tandberg, E., & Jorgensen, K. (1999). Fatigue in patients with Parkinson's disease. *Movement Disorders, 14*, 237-241.

Kassner, E., & Bectel, R. (1998). *Midlife and older Americans with disabilities: Who gets help?* Public Policy Institute, AARP.

Kline, R. B. (1998). *Principles and practice of structural equation modeling*. New York: The Guilford Press.

Langenfeld, M., Schneider, B., Grimm, W., et al. (1990). The 6-minute walk: An adequate exercise test for pacemaker patients? *Pacing and Clinical Electrophysiology, 13*, 1761-1765.

Liao, S., & Ferrell, B. A. (2000). Fatigue in an older population. *Journal of the American Geriatrics Society, 48*, 426-430.

Lichstein, K. L., Means, M. K., Noe, S. L., & Aguillard, R. N. (1997). Fatigue and sleep disorders. *Behaviour Research and Therapy, 35*, 733-740.

Maddox, G. L., Clark, D. O., & Steinhauser, K. (1994). Dynamics of functional impairment in late adulthood. *Social Science and Medicine, 38*, 925-936.

McHorney, C. A., Ware, J. E., Jr., & Raczek, A. E. (1993). The MOS 36-Item Short-Form Health Survey (SF-36): II. Psychometric and clinical tests of validity in measuring physical and mental health constructs. *Medical Care, 31*, 247-263.

Morrison, R. S., & Siu, A. L. (2000). A comparison of pain and its treatment in advanced dementia and cognitively intact patients with hip fracture. *Journal of Pain and Symptom Management, 19*, 240-248.

Nagi, S. Z. (1976). An epidemiology of disability among adults in the United States. *Milbank Memorial Fund Quarterly Health and Society, 54*, 439-467.

Rozzini, R., Frisoni, G. B., Ferrucci, L., Barbisoni, P., Bertozzi, B., & Trabucchi, M. (1997). The effect of chronic diseases on physical function. Comparison between activities of daily living scales and the physical performance test. *Age and Ageing, 26*, 281-287.

Schneider, E. L. (1999). Aging in the third millennium. *Science, 283(5 Feb)*, 796-797.

Seeman, T. E., Berkman, L. F., Charpentier, P. A., Blazer, D. G., Albert, M. S., & Tinetti, M. E. (1995). Behavioral and psychosocial predictors of physical performance: MacArthur studies of successful aging. *The Journals of Gerontology: Medical Sciences, 50*, M177-183.

Smith, J., & Baltes, M. M. (1998). The role of gender in very old age: Profiles of functioning and everyday life patterns. *Psychology and Aging, 13*, 676-695.

Steele, B. (1996). Timed walking tests of exercise capacity in chronic cardiopulmonary illness. *Journal of Cardiopulmonary Rehabilitation, 16*, 25-33.

Stewart, A. L., Mills, K. M., King, A. C., Haskell, W. L., Gillis, D., & Ritter, P. L. (2001). CHAMPS physical activity questionnaire for older adults: Outcome for interventions. *Medical Science in Sports and Exercise, 33*, 1126-1141.

Stewart, A. L., & Painter, P. L. (1998). A conceptual framework for studying functional decline, disability, and health-related quality of life in exercise studies. Paper presented at the Symposium entitled "Physical activity and function among older adults" C.J. Caspersen, E.W. Gregg, A.L.Stewart, A.Z. LaCroix, and M.A. Pereira, American College of Sports Medicine 45th Annual Meeting, Orlando FL: 30 (Suppl):s86.

Stewart, A. L., Verboncoeur, C. J., McLellan, et al. (2001). Physical activity outcomes of CHAMPS II: A physical activity promotion program for older adults. *The Journals of Gerontology: Medical Sciences, 56A*, M465-M470.

Strawbridge, W. J., Camacho, T. C., Cohen, R. D., & Kaplan, G. A. (1993). Gender differences in factors associated with change in physical functioning in old age: A 6-year longitudinal study. *Gerontologist, 33*, 603-609.

Strawbridge, W. J., Cohen, R. D., Shema, S. J., & Kaplan, G. A. (1996). Successful aging: Predictors and associated activities. *American Journal of Epidemiology, 144*, 135-141.

U.S. Bureau of the Census. (1993). Current Population Reports, P-25 Series: Population Projections by Age, Sex, Race, and Hispanic Origin: 1993-2050 (1104). Washington, DC: U.S. Bureau of the Census.

Verbrugge, L. M., & Jette, A. M. (1994). The disablement process. *Social Science and Medicine, 38*, 1-14.

Ware, J. E. (1998). *The SF-36 Health Survey (Vol. 1998)*. Boston, MA: The Health Institute, New England Medical Center.

Won, A., Lapane, K., Gambassi, G., Bernabei, R., Mor, V., & Lipsitz, L. A. (1999). Correlates and management of nonmalignant pain in the nursing home. SAGE Study Group. Systematic Assessment of Geriatric drug use via Epidemiology. *Journal of the American Geriatrics Society, 47*, 936-942.