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Explaining the Effect of Gender on Functional Transitions in Older Persons

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Abstract

Background—Women live longer but experience greater disability than men. The reasons for this gender difference in disability are not well understood.

Objective—Our objectives were to determine if the higher prevalence of disability in women is due to greater incidence of disability, longer duration of disability, or both; and to identify factors that potentially explain these gender differences.

Methods—754 community-living persons aged 70 and older who were nondisabled (required no personal assistance) in four essential ADLs were assessed monthly for disability for up to 6 years. A multi-state extension of the proportional hazards model was used to determine the effects of gender on transitions between states of no disability, mild disability, severe disability and death, and to evaluate potential mediators of these effects.

Results—Women were more likely to make the transition from no disability to mild disability and less likely to make the transitions from mild to no disability and from both mild and severe disability to death. The gender difference in the transitions between no disability and mild disability was largely explained by differences in gait speed and physical activity, but gender difference in transitions to death persisted despite adjustment for multiple potential mediators.

Conclusion—The higher prevalence of disability in women versus men is due to a combination of higher incidence and longer duration, resulting from lower rates of recovery and mortality among disabled women.

Keywords

epidemiology; gender differences; activities of daily living; disability

INTRODUCTION

Across the lifespan, women live longer than men but experience higher rates of disability. Life expectancy for women exceeds that for men by 5.3 years at birth, 3.0 years at age 65, and 1.1 years at age 85.[1] In contrast, women experience greater disability than men of the same age across a wide range of functional measures, including both basic activities of daily living, such as bathing and dressing, and instrumental activities of daily living, such as housework and shopping.[2,3] The reasons for these differences are not fully understood. Previous studies of gender differences in disability incidence have produced contradictory results; some studies

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have shown higher incidence in women[4,5] while others have shown no gender difference.[6] We set out in the current study to determine the effects of gender on transitions between states of no disability, mild disability, severe disability, and death, and to evaluate potential mediators of these effects. Our objectives were 1) to determine if the higher prevalence of disability in women is due to greater incidence of disability, longer duration of disability, or both, and 2) to identify factors that potentially explain these gender differences.

METHODS

Study population

The study population was drawn from members of an ongoing longitudinal study of 754 community-dwelling persons, aged 70 years or older, who were initially nondisabled (i.e. required no personal assistance) in four basic activities of daily living (ADLs)—bathing, dressing, walking inside the house, and transferring from a chair. The assembly of the cohort from members of a large Medicare HMO, which took place between March 1998 and October 1999, has been described in detail elsewhere.[7] Persons who required greater than 10 seconds to walk back and forth over a 10-foot course as quickly as possible (using an assistive device if needed) were oversampled to ensure a sufficient number of participants at increased risk for ADL disability.[8] The participation rate was 75.2%. The study protocol was approved by the Yale Human Investigation Committee, and all participants gave informed consent.

Data collection

Participants underwent comprehensive in-home assessments at baseline and every 18 months and had monthly telephone interviews for six years. Potential mediators of the effect of gender on functional transitions were evaluated during the comprehensive assessments, which were completed by trained research nurses using standard instruments. In addition to timed gait, data were collected on demographic characteristics, chronic conditions, body mass index (from self-reported height and weight), cognitive status (Mini Mental State Examination),[9] depressive symptoms,[10] habitual physical activity (Physical Activity Scale for the Elderly),[11] and social support (Medical Outcomes Survey).[12] Participants were considered to have slow gait speed if they required greater than 10 seconds to walk back and forth over a 10-foot course (approximately 0.61 m/s ignoring the turn), and to have high depressive symptoms if they scored 16 or greater on the Center for Epidemiologic Studies Depression scale.[10]

During monthly telephone interviews, participants were assessed for disability in the four basic ADL tasks, using standard questions of the form “At the present time, do you need help from another person to [perform the activity]?” [14] Participants who needed help from another person or were unable to complete a task were considered disabled in that ADL. Participants who only required an assistive device were not considered disabled. Complete details regarding the monthly assessments of disability, including formal tests of reliability, have been provided elsewhere.[13,14]

Two hundred thirteen participants (28%) died after a median follow-up of 40 months, and 32 (4%) dropped out of the study after a median follow-up of 21 months. Almost nine percent of the monthly telephone interviews were completed by a proxy respondent. As described elsewhere,[13] the accuracy of these proxy reports for disability was excellent, with Kappa = 1.0.

Multi-state model of disability

Our multi-state model of disability includes four states: no disability, mild disability, severe disability, and death.[15] Transitions are possible among all of the non-decedent states, and from each non-decedent state to death. Disability in one or two ADLs was considered mild, while disability in three to four ADLs was considered severe.[16] An episode of mild or severe disability was defined as a period of one or more consecutive months in the state. We chose to focus on disability in basic ADLs because it is a key determinant of ability to stay in the community. Participants in the no disability category could still have significant functional limitations and difficulty with ADL tasks.

Statistical analysis

Data were available for 99.2% of the 45,481 monthly telephone interviews. Interval missing data on ADL disability were imputed using a method for multiple imputation that accounts for the correlation between repeated measures of disability, as suggested by Allison.[17]

We calculated the rates of each transition, defined as exits from a state per 1000 person-months in that state. Confidence intervals for the transition rates were calculated by bootstrapping, using sampling with replacement on the complete cohort. One thousand samples were drawn, and the 2.5^{th} and 97.5^{th} percentiles were used to form the confidence intervals.

We calculated the average duration of mild and severe disability episodes for each participant. Because the distribution was highly skewed with the majority of participants having short disability episodes, we compared these average durations for men versus women using the Wilcoxon rank-sum test.

We used an extension of the Cox proportional hazard model for repeated events to evaluate the effects of gender and potential mediating factors on the likelihood of subsequent functional transitions.[18] We employed a counting process which used the observed months of state entry and exit as the initiation and termination of the state [19] and estimated the effect of gender and other covariates on the individual transitions by including an interaction term of a dummy variable indicating the transition by each variable.[18] For each of the transitions, we exponentiated the coefficient for the interaction term to get the hazard ratio for each variable.[18] To account for the correlation among observations within participants, we used the robust sandwich variance estimators for standard errors of the coefficients.[20] For the multi-state proportional hazards models, all potential mediators except race were updated as indicated, using data from the comprehensive assessment immediately preceding entry into the state. The Cox model is fairly robust to the distribution of time to event and can be used for non-proportional hazards which may occur with time-dependent variables.[21] Because our models contained time-dependent variables and multiple transition events, standard methods are not available to check the proportional hazards assumption.

To serve as a mediator for the effect of gender on functional transitions, a factor must meet three statistical criteria: 1) be associated with gender; 2) be associated with functional transitions; and 3) decrease the magnitude of the coefficient for gender when included as a covariate in the statistical model.[22] Based on review of the literature to identify factors associated with disability,[8,23,24] recovery,[25-27] and mortality,[24,28] we considered the factors listed in Table 1 as potential mediators. We evaluated gender differences in the potential mediators using chi-square or t-tests as appropriate. We determined the association of the potential mediators that differed significantly by gender with functional transitions using the multi-state proportional hazards model described above. We then determined if including the potential mediators in the model altered the effect of gender on functional transitions.

All analyses were performed using SAS version 9.1 (SAS Inc., Cary, NC), and all p-values are two-tailed.

RESULTS

The baseline characteristics of the study participants by gender are shown in Table 1. Women were more likely to live alone, have high depressive symptoms, and have slow gait speed. Women also had less education, higher body mass index, better cognitive status, less social support, and lower levels of physical activity. Although there was no gender difference in the number of chronic conditions, the prevalence of specific conditions did differ by gender, with women having higher prevalence of arthritis and hip fracture and lower prevalence of prior myocardial infarction.

Over the follow-up period, women experienced a median (range) of 3 (0 to 36) transitions while men experienced 2 (0 to 27). The overall rate of transitions was 83 per 1000 person-months of follow-up; rates (95% confidence interval (CI)) were 91 (81−101) and 70 (59−81) for women and men, respectively. For both men and women, rates were highest for transitions from mild to no disability and from severe to mild disability, and lowest for transitions from no disability to death and mild disability to death (Table 2). As shown in Figure 1, women were more likely than men to make the transition from no disability to mild disability (hazard ratio (HR) 1.42, 95% CI 1.11−1.83), and less likely to make the transitions from mild disability to no disability (HR 0.73, 95% CI 0.57−0.94), mild disability to death (HR 0.33, 95% CI 0.17−0.62) and severe disability to death (HR 0.54, 95% CI 0.34−0.85).

The median (intraquartile range (IQR), mean) values for participants' average durations of mild disability episodes was 1.9 (1.0−3.1, 3.3) months for women and 1.4 (1.0−2.4, 2.4) months for men, p=0.003. For severe disability episodes, the median (IQR, mean) was 1.6 (1.0−3.0, 3.8) months for women and 1.0 (1.0−2.0, 2.6) months for men, p=0.03.

The effects on functional transitions of the factors meeting the first criterion for mediation (i.e. association with gender) are summarized in Table 3. Given the large number of comparisons, strong associations are denoted by p<0.01 or <0.001. Physical activity and slow gait were strongly associated with both gender and most functional transitions. Depressive symptoms, hip fracture, arthritis, and education were strongly associated with one or two transitions. Prior myocardial infarction, living alone, body mass index, and social support had relatively weak or no association with functional transitions.

The unadjusted and adjusted associations between gender and each of the functional transitions are shown in Figure 2. We present effect of gender unadjusted (Model 1), adjusted for the two factors most strongly associated with both gender and transitions (Model 2), and adjusted for all factors associated with both gender and transitions (Model 3). In unadjusted analysis, women were more likely to make the transition from no disability to mild disability (HR 1.42, 95% CI 1.11−1.42), but after adjusting for physical activity and slow gait, the effect was no longer statistically significant (HR 1.07, 95% CI 0.83−1.38). Similarly, women were less likely to make the transition from mild disability to no disability in unadjusted analyses (HR 0.73, 95% CI 0.57−0.94), but after adjusting for physical activity and slow gait, this effect became non-significant (HR 0.91, 95% CI 0.71−1.17). Women were less likely to make the transitions from all states to death, although this effect was not statistically significant for the transition from no disability to death. Sequential adjustment for the potential mediators had relatively little effect on the magnitude of the corresponding hazard ratios.

DISCUSSION

We found that the higher prevalence of disability in older women, as compared with men, is attributable to both a higher incidence and a longer duration of disability, resulting from lower rates of recovery and death among disabled older women. While the gender differences in transitions between no disability and mild disability were explained by gender differences in physical activity and gait speed, the differences in transitions to death were not explained by a large array of potential mediators.

Our results confirm those of numerous studies that have reported a higher prevalence of disability among older women than men,[29] although a study of older adults in Sweden found gender differences only among the oldest-old.[30] The literature is less consistent regarding gender differences in the incidence of disability. Our results are consistent with those from the Longitudinal Study of Aging (LSOA) ,[4,29] the National Health Interview Survey (NHIS),[29] and the Established Populations for Epidemiologic Studies of the Elderly (EPESE),[5] which also found that women had a higher incidence of ADL disability. In contrast, there were no gender differences in the incidence of disability in the Alameda County Study,[6] although, given the 6-year interval between assessments, the higher mortality rate for men may account for this finding. These gender differences in incidence rates may be specific to ADL and IADL [29] disability, as studies of mobility disability[31] and physical performance limitations[32] have found no gender differences in incidence rates.

Women in our study had not only a higher incidence of mild disability, but also a lower likelihood of recovery or death once disabled. Women in EPESE were also less likely to recover from ADL disability than men,[5] while women in LSOA were more likely to recover (although the effect was not statistically significant).[29] No gender differences were noted in recovery in several smaller studies with fewer transitions,[25,26,33,34] although a study of recovery from fall-related injuries reported that disabled women were significantly less likely to recover ADL function.[35] The lower risk of mortality among women, independent of disability, has been consistently found across numerous studies.[27,36,37]

Higher prevalence of disability in a population can be due to either higher incidence of disability, longer duration of disability, or a combination of the two. Our monthly assessments of disability allowed us to determine the duration of disability directly, in addition to estimating it with recovery and mortality rates. Women in our cohort experienced longer episodes of disability than men, confirming that the higher prevalence of disability is due to a combination of higher incidence and longer duration.

Numerous explanations have been offered for gender differences in disability prevalence and mortality, including differences in the number and type of chronic medical conditions, in physiologic parameters (for example, differences in hormones or body composition), in reporting of disability, and in health behaviors.[2,3] We found that gender differences in the rates of transitions between no disability and mild disability were explained by differences in gait speed and levels of habitual physical activity. Among LSOA participants, adjustment for age and chronic conditions (particularly cerebrovascular disease and vision impairment) accounted for gender differences in incident disability.[38] Peek and Coward[39] found that gender differences in ADL disability among older persons with arthritis were explained by age and socioeconomic status. Among older adults in the British General Household Survey, gender differences in disability incidence persisted after adjustment for age and socioeconomic status.[40] A study of alumni of the University of Pennsylvania found that gender differences in disability were attributable to differences in chronic health conditions, but not in age, sociodemographic factors, or health behaviors.[41]

In our cohort, women were consistently less likely to make transitions to death, although this difference was not statistically significant among participants with no disability, who had relatively low mortality rates. In a study that included 11 cohorts four developed countries, gender differences in mortality persisted after adjustment for age and a “frailty index,” that represented the proportion of potential symptoms, signs, laboratory abnormalities and disabilities.[42] Among older Japanese adults, substantial gender differences in mortality persisted after adjustment for age, demographic characteristics, social characteristics, health behaviors, health problems, and functional impairments.[43] Women in the Cardiovascular Health Study had lower mortality rates than men even after adjusting for sociodemographic factors, health behaviors, a variety of cardiac risk factors, markers of subclinical cardiovascular disease, functional status, and cognitive status.[28] Interestingly, we found that greater physical activity, which was strongly associated with gender, was associated with decreased mortality among the non-disabled but increased mortality among the disabled. Future research should investigate the reasons for this differential association of physical activity with death and its role in gender differences in death rates.

Our finding that gender differences in incidence and recovery from mild ADL disability were attributable to differences in gait speed and physical activity does not mean that other factors do not play an important role. Differences in gait speed and physical activity are likely intermediate steps in the causal pathway between gender and ADL disability. For example, high depressive symptoms, more common among women than men, were associated with the onset of disability. Depressive symptoms could serve as a mediator of the association between gender and disability incidence, either directly or through effects on physical activity or physical performance. Nevertheless, physical activity and gait speed are both potentially modifiable.[44,45] Interventions to promote physical activity have the potential to decrease disability among high risk older women, directly and through improvements in gait speed.

Several aspects of our analyses warrant comment. First, we have used a self-reported measure of disability. However, two studies comparing self-reported function with observed performance found no gender differences in the reporting of disability.[46,47] Second, we chose to use a categorical measure of disability rather than a continuous measure of functional status. Thus, participants with function near the threshold of requiring help from another person likely required smaller absolute changes in function to make transitions than those far above or below the threshold of disability. However, we feel that the threshold of requiring help from another person has critical implications for an older person's ability to live alone, the burden upon caregivers, and the need for long-term care. Third, because our participants were members of a single health plan in a small urban area, our results may not be generalizable to older persons in other settings. However, our population did reflect the demographic characteristics of persons aged 70 years or older in New Haven county, which are comparable to the United States as a whole.[48] Fourth, the majority of disability episodes in our cohort were brief. Nevertheless, our prior work has demonstrated that even short episodes of disability (i.e. 1−2 months) are strong, clinically relevant predictors of subsequent disability.[49] Fifth, nearly nine percent of our monthly interviews were completed by proxies. While we have demonstrated high reliability for our proxy assessments,[14] previous research suggests that proxies tend to overestimate functional deficits, although this is less true for basic ADLs than other, potentially more subjective measures such as instrumental ADLs, cognitive status, and affective function.[50] Finally, we do not have information on the use of rehabilitative services among our participants. Although use of rehabilitation services would be expected to affect functional transitions, previous research has suggested that rehabilitation utilization does not differ by gender after adjustment for health and functional status.[51]

In conclusion, gender differences in the prevalence of disability are due to a combination of higher incidence and longer duration of disability among older women. Gender differences in incidence of and recovery from mild ADL disability can be explained by differences in physical activity and gait speed, but mortality differences persist despite adjustment for multiple factors. Interventions to promote physical activity and improve gait speed have the potential to decrease disability among older women.

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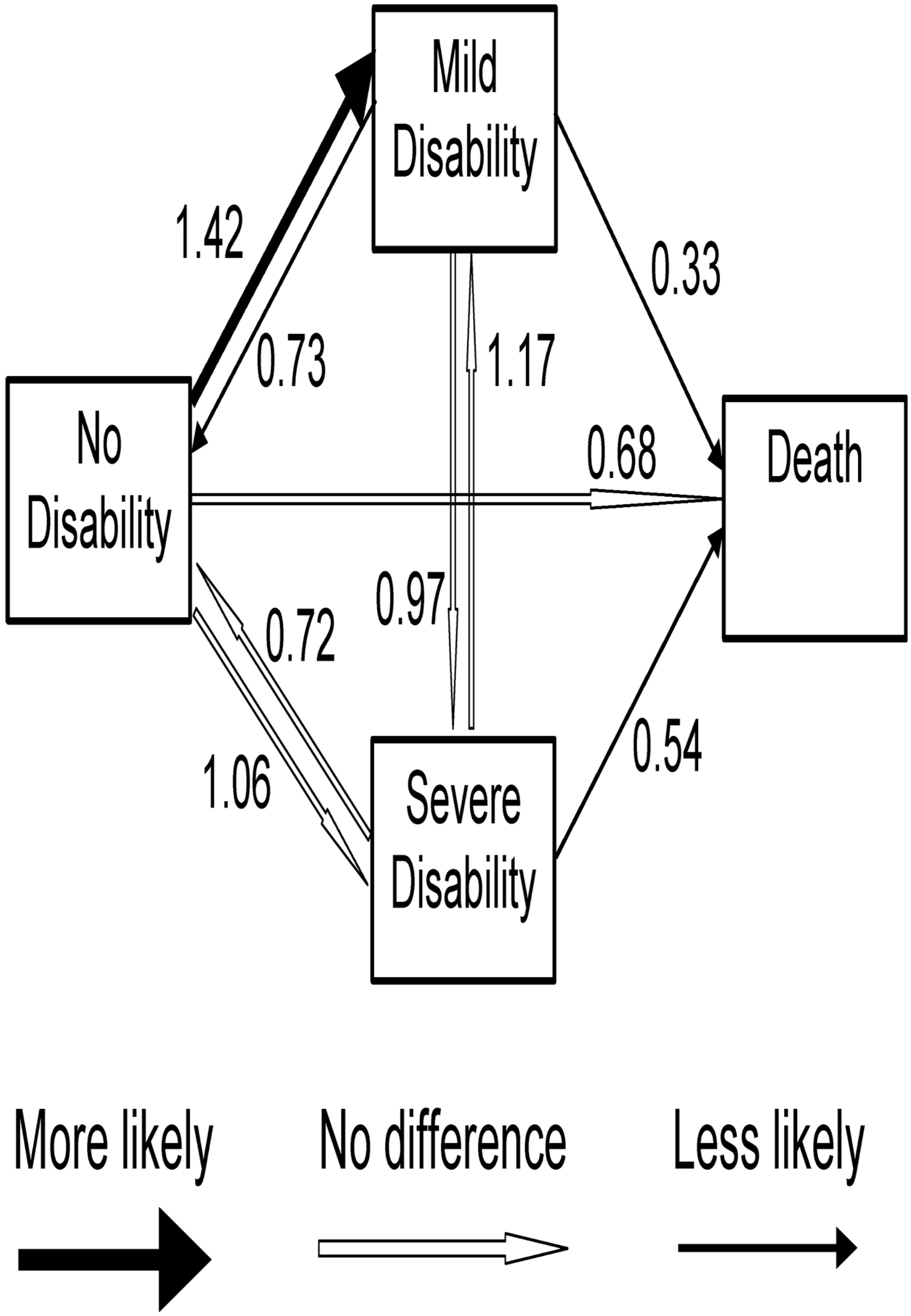

Figure 1.
Effect of gender on functional transitions. Boxes represent the four states and arrows represent the transitions between states. Values represent hazard ratios for the comparison of women versus men. The direction and statistical significance of the associations are shown schematically by the type of arrow (no difference represents p>0.05).

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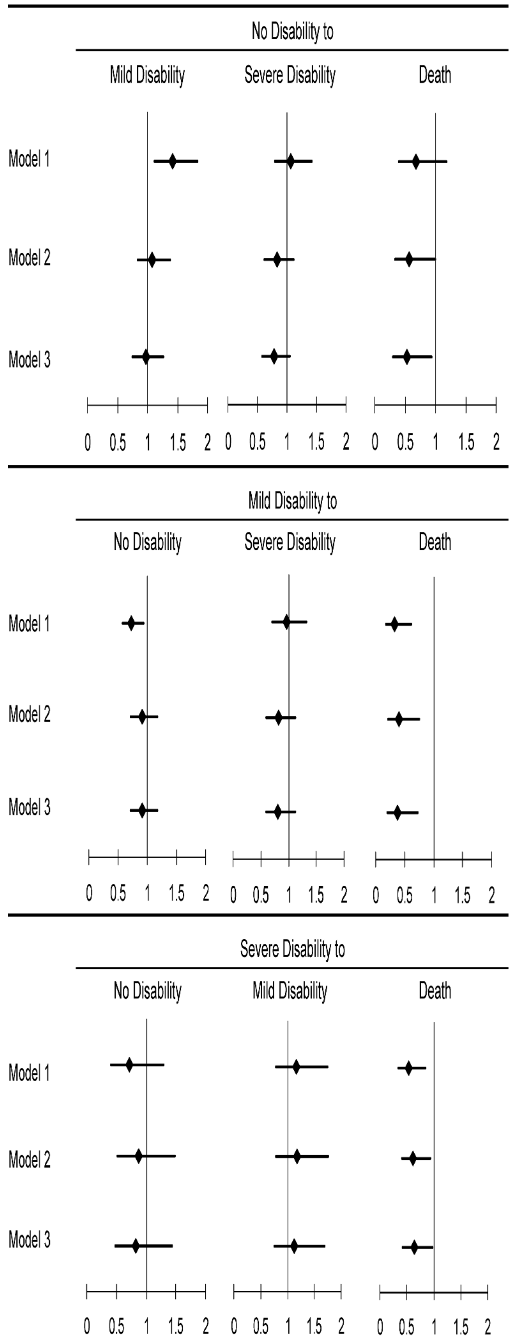

Figure 2.
Unadjusted and adjusted effects of gender on functional transitions. Hazard ratios from multi-state proportional hazard models are presented, with the diamonds representing the point estimates and the lines the 95% confidence intervals. Model 1 is unadjusted. Model 2 is adjusted for physical activity and slow gait. Model 3 is adjusted for physical activity, slow gait, high depressive symptoms, hip fracture, arthritis, and education.

Table 1

Baseline characteristics of participants by gender.

Characteristic	Women (n=487)	Men (n=267)	p-value*
Age, mean ± SD	78 ± 5	79 ± 5	.34
White, n (%)	439 (90)	243 (91)	.70
Living alone, n (%)	239 (49)	59 (22)	<.001
Education (years), mean ± SD	11.8 ± 2.8	12.3 ± 3.0	0.03
Chronic conditions, mean ± SD†	1.7 ± 1.2	1.7 ± 1.1	.80
Hypertension, n (%)	272 (56)	144 (54)	.61
Arthritis, n (%)	160 (33)	67 (25)	.03
Diabetes, n (%)	84 (17)	53 (20)	.38
Prior myocardial infarction, n (%)	69 (14)	67 (25)	<.001
Non-skin cancer, n (%)	81 (17)	43 (16)	.85
Lung disease, n (%)	53 (11)	24 (9)	.41
Stroke, n (%)	38 (8)	27 (10)	.28
Heart failure, n (%)	33 (7)	16 (6)	.68
Prior hip fracture, n (%)	31 (6)	3 (1)	<.001
Body mass index, kg/m^2, mean ± SD	27 ± 6	26 ± 4	.03
Self-rated health fair or poor, n (%)	142 (29)	69 (26)	0.33
Cognitive status, mean ± SD‡	27 ± 2	26 ± 3	.08
High depressive symptoms, n (%)	122 (25)	34 (13)	<.001
Social support, mean ± SD§	22 ± 6	23 ± 5	.009
Physical activity, mean ± SD//	81 ± 52	107 ± 64	<.001
Slow gait speed, n (%)	227 (47)	95 (36)	.003

*P-values for the comparison between women and men from chi-square tests for categorical variables and t-tests for continuous variables.

†Number of nine self-reported, physician-diagnosed conditions, listed in the table in order of prevalence.

‡Assessed with the Folstein Mini-Mental State Exam, range 0 to 30 with higher scores representing better cognition.

§Assessed with the MOS scale, range 0 to 28 with higher scores representing greater support.

//Assessed with the Physical Activity Scale for the Elderly, range 0 to 360 with higher scores representing greater physical activity.

Table 2

Number and rates of transitions by gender.

Transition	Women		Men	
	Number	Rate*	Number	Rate*
No disability to				
Mild disability	921	37.3	362	26.4
Severe disability	162	6.6	85	6.2
Death	28	1.1	23	1.7
Total person-months	24,664		13,731	
Mild disability to				
No disability	824	214.7	315	280.7
Severe disability	329	85.7	99	88.2
Death	21	5.5	18	16.0
Total person-months	3,838		1,122	
Severe disability to				
No disability	66	41.8	29	53.1
Mild disability	312	197.5	93	170.3
Death	77	48.7	46	84.2
Total person-months	1,580		546	

*Rates per 1000 person-months in the initial state.

Table 3

Effects of potential mediating factors on functional transitions.*

	No Disability to			Mild Disability to			Severe Disability to		
	Mild Disability	Severe Disability	Death	No Disability	Severe Disability	Death	No Disability	Mild Disability	Death
Physical activity	↓↓↓	↓↓↓	↓	↑↑↑	↓↓↓	↑↑↑	↑↑↑		↑↑↑
Slow gait	↑↑↑	↑↑↑		↓↓↓	↑↑		↓		↓↓
High depressive symptoms	↑↑↑	↑↑↑							
Prior hip fracture	↑↑↑	↑	↑					↑	
Arthritis	↑↑↑	↑↑↑							
Greater education	↓↓	↓↓							
Prior myocardial infarction	↑		↑			↑			
Living alone					↓				
Body mass index			↓	↑					
Social support									

*The direction of the arrows represents the direction of the effect: up represents increased likelihood of the transition and down, decreased likelihood. The number of arrows represents the statistical strength of the association (↑=p<0.05; ↑↑=p<0.01; ↑↑↑=p<0.001).