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Hip Fractures among Elderly Women: Longitudinal Comparison of Physiological Function Changes and Health Care Utilization

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Introduction

Prevention of functional disability among older adults with hip fracture is a major goal for individuals as well as society as a whole. An important step in understanding the natural history of the disablement process among those who have been affected by hip fracture and are still living in the community is to observe how physiological and functional impairment changes over time and how health care resources are utilized. Hip fractures cause significant mortality, morbidity, and disability among the elderly.^{1,2,3} It has been demonstrated that the majority of hip fracture patients do not regain their pre-fracture level of functioning at one-year post-fracture.⁴⁻⁶ The loss of self-care ability and functional independence imposes a heavy burden on individuals, caregivers, and costly long-term care.^{2-3,7} The estimated lifetime risk of hip fracture is 15% for women and 5% for men;⁸ among those who live to age 90, 32% of women and 17% of men will suffer hip fracture.⁹

Given the unique demographic characteristics and high prevalence of functional disability among older women, they are a critical group to examine as they make up the majority of the older population, spend more years in a disabled state than men, make up a substantially larger proportion of the nursing home population than men, and have more vulnerability in terms of the need for formal and informal care. However, little is known about the ways in which hip fracture is associated with physiological impairment and functional disability in community-dwelling disabled older women, nor about their pattern of health resources utilization over time. Longitudinal data from national studies among elderly women provide an opportunity to address our research inquiries: (1) mortality rates, (2) longitudinal changes in physiological function (e.g., knee strength, functional reach) and functional impairment (e.g., ADLs), and (3) comparison of health care resource utilization between the community-dwelling disabled older women with and without hip fracture. We hypothesize that due to the fracture injury, the hip fracture group will have higher mortality rates, worse physiological measures, and thus higher functional impairments.

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Methods

Two sets of data were used: Women's Health and Aging Study I (WHAS-I) and Medicare Current Beneficiary Survey (MCBS) data. Briefly, we explain both studies as follows:

Women's Health and Aging Study I (WHAS-I)

WHAS-I is a prospective, observational study designed to determine the causes and course of physical disability.¹⁰ Subjects of the WHAS-I study were 1002 community-dwelling women aged 65 and over with moderate to severe physical disability residing in the eastern half of Baltimore City and County, Maryland.¹⁰ Eligibility for participation in the full study was based on the following criteria: (a) disabled in two or more of four domains of physical functioning, (b) not severely cognitively impaired, as determined by a mini-mental state examination (MMSE) score of 18 or greater,¹¹ and (c) able to give informed consent. Although the WHAS data was collected more than a decade ago (1992-1995), it is valued for its detailed information on physiological measures, disease adjudication, and biochemistry data. In fact, 26 articles utilizing this data were published in 2007-2009.

Of the 1002 women in the WHAS-I study, 81 had hip fractures and 921 had no hip fractures prior to baseline interview. During the subsequent three-year follow-up, five subjects in the hip fracture group sustained a second hip fracture, and among the non-hip fracture group, 31 subjects fractured their hips; the combined 36 subjects (with second or first hip fractures, respectively) were excluded from the analysis for the study. To determine whether the recency of the fracture introduced bias, one analysis stratified subjects by time to fracture according to selected characteristics. Time to fracture was dichotomized into two strata: recent fracture (two years prior to baseline interview) versus non-recent fracture (more than two years before baseline interview). The results show that there were no significant differences between these two groups in age ($p = 0.75$), race ($p = 0.98$), education attainment ($p = 0.97$), living arrangement ($p = 0.44$), comorbidity ($p = 0.94$), and baseline ADLs ($p = 0.71$).

Medicare Current Beneficiary Survey (MCBS)

Sponsored by the Center for Medicare and Medicaid Services (CMS), the Medicare Current Beneficiary Survey (MCBS) is a continuous, multipurpose survey of a nationally representative sample of aged, disabled, and institutionalized Medicare beneficiaries.¹² MCBS provides a comprehensive source of information on health status, utilization and expenditures, health insurance coverage, and socioeconomic and demographic characteristics of the entire spectrum of Medicare beneficiaries. To access the MCBS claims data, informed consent was obtained from each participant in the WHAS-I study. Information on health care utilization from the MCBS was obtained from CMS and linked to the WHAS-I study subjects, a process which was conducted in compliance with the CMS data request protocol. The health care utilization data during the WHAS-I study period (1992-1995) were abstracted from MCBS files.

Outcome variables

Measures included performance-based and self-reported measures, and Medicare claims data.

Physiological performance measures—Performance-based measures of function in WHAS-I were objectively assessed at each examination by trained physical and occupational therapists using standardized protocols.^{10, 13} Objective performance measures included hip strength, knee strength, functional reach, five repeated chair stands, and usual and rapid walking speed. **Hip and knee strength**: Maximal hip flexion and knee extensor muscle strength were measured (in kilograms) by manual dynamometer for two trials on each side, and the average of measures on the dominant sides were used. Knee strength and hip strength were analyzed separately, with a higher ratio indicative of greater strength. **Functional reach** is an

indicator of dynamic balance and was determined by measuring the number of centimeters the participant could reach with her third right metacarpal, starting from an upright position with the arm extended at shoulder height, and then bending forward as far as possible without losing balance, keeping the arm parallel to the starting level. Feet were side-by-side and could not move during the test measurement. The test was performed three times, with the average of the three measures (in cm) used in the analysis. Higher number indicates better dynamic balance. **Five repeated chair stands** is the time to rise from a chair as rapidly as possible with arms crossed in front of chest (in seconds). Chair stand is a functional indicator of lower extremity strength. The test was performed five times and the average of the five measures used in the analysis. Shorter time indicates better lower extremity strength. **Usual and rapid walking speed:** is the time to walk 4 meters at usual pace (in seconds) and time to walk 4 meters at rapid pace (in seconds), using walking aids if needed (average of two trials). Walking time was converted to speed (meters/sec). A lower number indicates faster walking speed and thus better lower extremity function.

Self-reported function—Self-care ability at home was measured by activities of daily living (ADLs) and functional independence to live in the community was measured by instrumental activities of daily living (IADLs). Summary scores were created for each ADL (eating, grooming, dressing, walking, transferring, bathing, and toileting) and IADL (using telephone, taking medication, meal preparation, light housework, money management, mobility, and shopping). Scores ranged from 0-7 with higher scores indicating worse functioning.

Health care utilization—related information was obtained from MCBS Medicare claims data for the three-year study period. Four health care utilization variables were created: (1) total physician visits; (2) total hospital length of stay; (3) total skilled nursing facility length of stay; and (4) home health visits.

Control of effect modifiers

Demographics as well as physical and mental health factors related to hip fracture and functional outcomes were controlled for in the multivariate analysis. Demographic characteristics included **age, race, education attainment, and living arrangements** (living alone vs. living with others). Physical and mental health were measured by comorbidity and depression. **Comorbidity:** a summary variable based on the number of chronic conditions present (angina, CHF, PAD, MI, OA knee, OA hips, cancer, stroke, pulmonary disease, Parkinson's disease, and diabetes). **Depression** was measured using the Geriatric Depression Scale (GDS).¹⁴ Scores ranged from 0-30, with <12 indicating little to no symptoms and ≥12 indicating moderate to high levels of depression.

Statistical analysis

Univariate, bivariate, and multivariate analyses were conducted, and summary statistics were used to describe the data. Variables associated with outcomes of interest significant at the $p < 0.10$ level or clinically relevant were retained for subsequent analyses. The potential interaction effects of hip fracture with time, age, depression, and comorbidity and other potential variables were evaluated. Mixed-effects regression^{15 16} were used to model longitudinal data on mean differences in physiological and functional impairments and health care utilization at all observation times during the three-year period between hip fracture and non-hip fracture participants. The Generalized Estimating Equations (GEE)^{17, 18} approach was used for binary or count outcomes in the longitudinal data analysis.

Results

Table 1 summarizes the sociodemographic and medical characteristics of the study sample. The mean age of subjects at baseline was 78 years, with an average of 10 years education. The majority of the study subjects were Caucasian (71%), 48% lived alone, 23% were depressed, and the mean number of chronic conditions was 2.1. The most frequently reported comorbidities were high blood pressure (58%), chest pain (40.7%), heart attack or myocardial infarction (20.3%), angina (19.8%), and diabetes (18.7%, data not shown). The mean number of ADL difficulties was 2.1 and IADL difficulties 1.9. In comparison of selected characteristics, the results showed that hip fracture patients were older ($p < .001$), more likely Caucasian ($p < .001$), and more disabled in ADLs ($p < .05$) and IADLs ($p < .01$) than the non-hip fracture group.

Mortality

Table 2 presents mortality rates between the hip fracture and non-hip fracture groups. Over the course of the three years of study, 179 subjects (19%) died. Of these, 25% (19/76) were from the hip fracture group and 18% (160/890) from the non-hip fracture group. The results of Cox proportional hazards model shows that the relative risk crude mortality rate was significantly higher in the hip fracture group than in the non-hip fracture group ($RR = 1.8$; $p = 0.03$). However, statistical significance did not persist after adjusting for age, race, education, living arrangement, depression, and comorbidity ($RR = 1.5$; $p = 0.17$).

Physiological function changes over time

After adjusting for potential confounders, the GEE results suggested that several physiological measures showed deterioration over time, regardless of hip fracture status (Table 3). Hip strength is one such example ($\beta = -0.03$, $p < 0.001$); the negative regression coefficient indicates declining strength over time. For other measures, a positive regression coefficient meant worsening functional disability, such as with time required to complete five repeated chair stands ($\beta = 0.03$, $p < 0.001$). Compared to those without a hip fracture, those who did have a hip fracture had significantly worse knee strength ($\beta = -0.91$, $p = 0.03$), usual walking speed ($\beta = 0.01$, $p = 0.01$) and rapid walking speed ($\beta = -0.05$, $p = 0.02$).

Similar to physiological function, both ADL ($\beta = 0.02$, $p = 0.001$) and IADL ($\beta = 0.01$, $p = 0.001$) functions declined over time, regardless of presence or absence of hip fractures. Compared to the non-hip fracture group, the hip fracture group had significantly worse IADL ($\beta = 0.26$, $p = 0.002$). We further examined the trajectory in IADL function over time between the groups: the hip fracture group was significantly worse in IADL function over time compared to non-hip fracture patients ($\beta = 0.45$; $p = 0.01$, Figure 1), and the rate of additional deterioration for both hip fracture and non-hip fracture groups was 0.013 IADL units per month ($p = 0.001$).

Health care utilization

Regardless of hip fracture status, health care utilization increased over time for length of stay in hospital and skilled nursing facilities, number of home health visits and physician visits (Table 4). Although hip fracture subjects were significantly impaired in physiological and IADL function compared to non-hip fracture subjects, they did not consume more health care resources than their non-fracture counterparts.

Discussion

Maintaining functional independence and autonomy is an important goal for all older adults regardless of functional disability or age. Knowing the optimal level of function and health resources utilization could help design intervention programs and appropriate scant resources.

Several features distinguish this study from previous studies: (1) WAHS-I is a representative sample of the 1/3 of moderately to severely disabled women living in the community, (2) subjects were followed prospectively for three years, (3) health status and function was paired with utilization data, and (4) study assessed the independent effect of hip fracture. Our findings shed new light on the natural course of disablement.

Mortality

In our study, the one-year mortality rate of 9.2% in the hip fracture group seemed to be low compared to previous literature. Depending on specific population studied, previous studies reported that between 14-33% of older hip fracture patients die within one year of their fracture.^{19,20,21,22,23,24,25} However, one recent study of post-hip fracture mortality predictors showed one-year mortality was 11.9% and two-year was 18.5%;²⁶ this is more comparable to our 9.2% and 18.4% mortality rates, respectively. After adjusting for covariates, the different mortality rates between the two groups disappeared. While we expected that hip fracture patients would have a higher mortality rate than their no-fracture peers, this discrepancy may be explained by two considerations: first, our study subjects experienced their hip fracture between 1-7 years prior to the study baseline measures, and second, small sample sizes may have obscured significance. Previous studies indicate the effect of hip fracture on mortality may be concentrated in the first six months post-fracture;⁶ our subjects survived the first year following hip fracture and thus may have been better off at baseline. While the adjusted relative risk showed a 50% higher mortality rate, the small sample reduced significance.

Physiological function change over time

With respect to physiological functional change, all aspects of performance function declined in both hip fracture and non-hip fracture groups during the three year study. However, hip fracture patients had significant physiological function loss in knee strength and slower walking speeds which may implicate weaker lower extremity function. This is consistent with previous findings. Previous studies examining the change in muscle strength and muscle mass after a hip fracture found that loss of muscle strength is an independent predictor of poorer mobility recovery after a hip fracture,^{27,28} and walking velocity continues to decline over 4 years.²⁹ These substantial losses in physiological performance measures may be attributable to the aging process disease progression and not necessarily hip fracture.

Functional impairments

Despite medical science and technology advancements that lead to successful surgical repair, hip fracture still leads to physiological impairments which compromise functional independence and autonomy. Previous studies indicate that hip fracture patients had significantly worse ADL and IADL functional recovery at one year compared to stroke and medical/surgical patients.²³ We hypothesized that subjects with previous hip fracture would have worse ADL and IADL function than their counterpart; the first hypothesis floundered but the second held firm. There may be multiple pathways to late-life functional disability due to various health reasons such as increasing age, progression of diseases, physiological impairments, or mental function deterioration. In this study, 91% of hip fracture subjects had 1+ and 63% had 2+ chronic conditions and with an average of 2.5 ADL difficulties at baseline. These comorbidities and disabilities may interfere with ADL and IADL function recovery, yet once the hip fracture was resolved, they learned to cope with ADL and IADL deficits using various mechanisms; similarly, the non-hip fracture group ADL disability effect disappeared after adjusting covariates. However, the IADL measures of independent living showed that the hip fracture group declined significantly compared to those who did not experience a hip fracture. These IADL tasks involve cognitive function and physical health and strength beyond sheer mobility measures.

Health care utilization

Despite their greater impairments in physiological function, the hip fracture group did not consume more health care resources than their no-fracture counterparts. Our study results did not confirm previous studies which indicated ongoing care of hip fracture patients consumes more medical resources as functional decline and mortality increases,^{6, 22, 23} which increase the likelihood of subsequent hospitalization and hospital days⁶ and longer length of stay skilled nursing facilities.²³

The consequence of hip fracture is devastating. It affects not only the individual's quality of life but also incurs costly long-term care. Government agencies have stressed the importance of improving physiological function and promoting functional independence among older adults. The U.S. Department of Health and Human Services (DHHS, 2000) is committed to promoting physical activities and fitness to improve musculoskeletal function, for example, muscle strength, endurance, and flexibility. (U.S. Department of Human Services). Our study results are in line with the DHHS recommendations that to improve IADL function, health care professionals need to pay attention to the physiological function interventions to improve hip and knee strength and balance among older adults with hip fracture.

Limitations—The proposed study is restricted to older, moderately to severely disabled women. These restrictions may limit generalizability to younger age groups and male hip fracture patients. Also, this proposed study is restricted to community-dwelling elderly women thereby limiting the generalizability to nursing home and other institutionalized elderly. We also recognize that multidimensional aspects (e.g., caregiver stress, social support networks) involved during the recovery process may have potential impact on the women's functional disability. However, given the available resources, we focused our study on functional changes and health care utilization over time between the hip fracture and non-hip fracture groups.

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Additional impairments/ month	Between group differences
0.013 (P=.001)	0.45 (P=.01)

Figure 1.
IADLs Function Change Over Time between Hip Fracture and non-Hip Fracture Subjects

Table 1

Study Population Characteristics

Women's Health and Aging Study-I

Characteristics	Overall (n=966) # (%)	Hip fracture (n=76) # (%)	Non-hip fracture (n=890) # (%)	p-value
Age (mean $\pm$ sd)	78.1 $\pm$ 8.0	82.6 $\pm$ 7.7	77.7 $\pm$ 7.9	0.001
65-74	383 (40)	14 (18)	369 (41)	0.001
75-84	304 (29)	20 (26)	284 (32)	
85+	279 (29)	42 (55)	237 (27)	
Race				
Caucasian	684 (71)	66 (87)	618 (69)	0.001
African-American	282 (29)	10 (13)	272 (31)	
Education (mean no. yrs)	9.7 $\pm$ 3.6	10.5 $\pm$ 3.6	9.6 $\pm$ 3.6	0.06
Living alone	484 (48)	40 (53)	424 (48)	0.40
Chronic disease (mean $\pm$ sd)	2.1 $\pm$ 1.4	1.9 $\pm$ 1.1	2.1 $\pm$ 1.4	0.43
0	111 (12)	7 (9)	104 (12)	0.81
1	261 (27)	21 (28)	240 (27)	
2+	594 (61)	48 (63)	546 (61)	
Depression (GDS $\geq$ 12)	225 (23)	16 (21)	209 (23)	
ADL (mean $\pm$ sd)	2.1 $\pm$ 1.8	2.5 $\pm$ 1.8	2.1 $\pm$ 1.8	0.05
IADL (mean $\pm$ sd)	1.9 $\pm$ 1.5	2.3 $\pm$ 1.6	1.9 $\pm$ 1.5	0.01

Table 2

Mortality Between Hip Fracture and non-Hip Fracture Subjects

Women's Health and Aging Study-I

Month	Overall (n=966)	Hip fracture (n=76)	Non-hip fracture (n=890)	RR [*]
Baseline	0	0	0	
6 months	30	3	27	
12 months	36	4	32	
18 months	24	4	20	
24 months	34	3	31	
30 months	23	2	21	
36 months	32	3	29	
Mortality	19%	25%	18%	1.8 (p=0.03) [†]

^{*} Cox proportional hazards model

[†] When adjusting for covariates (age, race, education, living arrangement, comorbidity, depression, and baseline information corresponding to each outcome), RR=1.5; p=0.17.

Table 3

Comparisons on selected physiological impairments measures and functional disability change over time between hip fracture and non-hip fracture groups using Generalized Estimating Equations (GEE).

Measurement	Parameter Estimate β (SE) ¹	
	Time	Group ²
Hip strength	-0.03(0.01) [‡]	-0.43(0.34)
Knee strength	-0.01 (0.01)	-0.91 (0.28) [‡]
Functional reach	0.004 (0.01)	-0.19 (0.54)
Five repeated chair stands	0.03 (0.01) [‡]	0.003 (0.41)
Usual Walking speed	0.01 (0.00) [‡]	-0.04 (0.01) [‡]
Rapid walking speed	-0.00 (0.00)	-0.05 (0.02) [*]
ADL function	0.02 (0.00) [‡]	0.18 (0.10)
IADL function	0.01 (0.00) [‡]	0.26 (0.09) [‡]

¹ Model adjusted for age, race, education, living arrangement, comorbidity, depression, and baseline information corresponding to each outcome.

² Group (Hip fracture = 1; non-hip fracture = 0)

^{*} p<.05;

[‡] p<.01;

[‡] p<.001

Table 4

Comparisons on selected health care utilization patterns between hip fracture and non-hip fracture groups using Generalized Estimating Equations (GEE).

Measurement	Parameter Estimate β (SE) ¹	
	Time	Group ²
Number of hospitalization	0.01 (0.00) [‡]	0.11 (0.06)
Number of home health visits	0.01 (0.00) [‡]	0.15 (0.10)
LOS in skilled nursing facilities	0.04 (0.01) [‡]	0.90 (0.69)
Number of physician visits	0.01 (0.01)	0.16 (0.21)

¹ Model adjusted for age, race, education, living arrangement, comorbidity, depression, and baseline information corresponding to each outcome.

² Group (Hip fracture = 1; non-hip fracture = 0)

* P<.05;

[†] p<.01;

[‡] P<.001