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Hospitalization and Change in Body Composition and Strength in a Population-Based Cohort of Older Persons

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Abstract

Objectives—To examine the association of hospitalization with annual changes in body composition and strength in older adults.

Design, Setting, & Participants—Participants in the Health, Aging and Body Composition study, a cohort study of well-functioning adults aged 70–79.

Measurements—Hospitalizations were reported at annual clinic visits and semi-annual phone interviews. In the event of death or reported hospitalization, hospitalizations were adjudicated by medical record review. Dual x-ray absorptiometry (DXA) assessments of total, lean, and fat mass were conducted in six annual exams, and measures of knee extensor strength were conducted in two annual exams.

Results—A total of 2309 hospitalizations were followed by DXA assessments. In men and women respectively, hospitalization in the previous year was associated with additional declines in total mass (−0.76 kg, −0.81 kg), fat mass (−0.41 kg, −0.54 kg) and lean mass (−0.33 kg, −0.25

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kg) ($p < .001$ for all) relative to non-hospitalized participants, after adjustment for demographics and baseline values. Hospitalization was associated with strength declines in men (-4.02 Nm, $p < 0.05$), but not in women. Relationships were similar adjusting for health behaviors and chronic conditions, although the association between hospitalization and strength was attenuated. Associations increased with number of days hospitalized; hospitalizations totaling ≥ 8 days in the previous year were associated with significantly greater loss of total, lean, and fat mass and loss of strength in both genders relative to non-hospitalized participants.

Conclusion—Hospitalization is associated with significant changes in body composition and strength in older persons. These effects appear particularly important among persons hospitalized for 8 or more days per year.

Keywords

lean mass; weight loss; function; hospitalization; strength

INTRODUCTION

Hospitalization is a common precursor of disability in older persons^{1–3}. This relationship derives in part from pre-existing vulnerability: hospitalized individuals are typically more frail and have less stable health status and a greater number and severity of chronic conditions than the general older population.^{4, 5} However, hospitalization itself may also pose risks for functional decline because of the deleterious effects of bed rest, restricted activity, and changes in diet on lean mass and muscle strength.^{6–8} Indeed, hospitalization is a major predictor of weight loss,⁹ with patients in one study losing an average of 5.4% of body weight in a single hospital stay.¹⁰

Previous research has shown that hospitalization predicts loss of lean mass, especially when accompanied by weight loss in men.¹¹ The magnitude of lean mass loss and strength decline is likely to increase with length of stay, but this hypothesis has not been tested. In this study, we used data from the Health, Aging and Body Composition (Health ABC) study to examine the relationship between hospitalization and one-year change in body composition (total mass, lean mass, and fat mass) and knee extensor strength.

METHODS

Study population

The Health ABC cohort included 3,075 black and white men and women aged 70–79 with no reported mobility difficulty or disability at baseline.¹¹ Whites were recruited from a random sample of Medicare beneficiaries living in zip codes surrounding Pittsburgh, PA and Memphis, TN. Blacks were recruited from all age-eligible residents in these areas. Eligibility criteria included: aged 70–79 in the recruitment period from March 1997 to July 1998; self-report of no difficulty walking one-quarter of a mile, climbing 10 steps without resting or performing basic activities of daily living; no reported use of a cane, walker, crutches, or other special equipment to get around; no history of active treatment for cancer in the previous 3 years; and no plan to move out of the area in the next 3 years. This analysis utilizes data from the first six annual exams. Hereafter, we refer to Exam 1 as “baseline.”

Hospitalization

Hospitalizations were reported at annual clinic visits and semi-annual phone interviews. In the event of any death or reported hospitalization, study staff obtained hospital records, which were abstracted for length of stay and discharge diagnoses. For analysis of total days hospitalized in a given year, participants were classified as having no hospitalization, 1–3

days hospitalized, 4–7 days hospitalized, or 8 or more days hospitalized. These categories correspond to tertiles of the number of days hospitalized in those with at least one hospitalization.

A total of 4,001 hospitalizations occurred in the study population over 5 years of follow-up. Of these, 436 were followed by death before the next exam, 765 were followed by a home or phone interview, rather than a complete exam, 272 were followed by a proxy interview, and 219 were missing a DXA exam at follow-up for other reasons, leaving a total of 2309 hospitalizations included in the analysis.

Body Composition & Strength

Total body mass and composition were assessed annually using dual-energy x-ray absorptiometry (DXA) (Hologic QDR4500A, software version 8.21). Measures of body composition included total fat and total lean mass (sum of nonfat and nonbone tissue). Isokinetic knee extensor strength was assessed in years 1 and 2 using a Kin-Com 125 AP Dynamometer (Chatanooga, TN) at 60° per second. Maximal strength was calculated as the average of three reproducible and acceptable trials out of a maximum of six trials. Participants with a systolic blood pressure ≥ 200 mm Hg, diastolic blood pressure ≥ 110 mm Hg, or who reported a history of cerebral aneurysm or cerebral bleeding, bilateral total knee replacement, or severe bilateral knee pain were excluded from strength testing.

Potential confounders

Smoking status was assessed at baseline, and current smokers were compared to nonsmokers. Physical activity was measured annually based on minutes walking per week, coded in three categories (none, 1–150 minutes/week, 150+ minutes/week). Diabetes, cancer, and cardiovascular disease (CVD, including coronary heart disease, cerebrovascular disease, and stroke) were assessed annually and were ascertained based on algorithms incorporating self-report, medication use, clinical data, and medical records. Arthritis was based on annual self-report of osteoarthritis in the knee or hip. Data on lung disease was only gathered at years 1 and 5; participants were considered to have lung disease if they reported asthma, chronic bronchitis, COPD, or emphysema. Participants were considered depressed if they scored a 10 or higher on the 10-item CESD,¹² administered at all exams except Exam 2. When data were not gathered at every exam (for lung disease and depression), the most recent observation was used until a new assessment was available.

Statistical Analysis

Because men and women differ with regard to lean mass and hospitalization may be particularly detrimental to lean mass in men,¹¹ all analyses were stratified by sex. Change scores for body composition and strength measures were computed by subtracting mass (or strength) in a given year from mass (or strength) in the previous year. This approach allowed us to compare 1-year changes in outcomes among hospitalized participants to changes in participants with no hospitalization in a given year (see Figure 1).

Generalized estimating equations (GEE, SAS 9.1, Proc Genmod) models were used to assess the relationship of hospitalization in the last year with 1-year change in measures of body composition over the same period. Models specified a banded variance structure and robust standard errors. Hospitalization, diabetes, cancer, CVD, lung disease, arthritis, depression, and walking activity in the last year were incorporated as time-varying covariates; all other covariates (baseline age in years, study site, race, smoking, baseline values of dependent variable) were constant. Ordinary least squares regression was used to assess the relationship between hospitalization in the last year and change in knee extensor strength between the first two exams, controlling for baseline strength and covariates at follow-up.

Among the 1491 men and 1584 women enrolled in the study, 1386 men and 1450 women completed at least 2 consecutive DXA scans. The analytic N varies depending on which controls were examined. Participants were included in cross-sectional comparisons (Table 1) if they had at least 2 consecutive DXA scans and were not missing covariate data at baseline, yielding a sample of 1294 men (609 hospitalized, 685 not hospitalized) and 1337 women (519 hospitalized, 818 not hospitalized). Participants were included in regressions if they had any 2-year period with complete outcome and covariate data, yielding slightly higher sample sizes (1332 men, 1368 women). Strength measurement at baseline was obtained on 1291 men and 1355 women. Participants with strength data and complete covariates at baseline are included in cross-sectional comparisons (Table 1, 1138 men and 1161 women). Longitudinal strength analysis included participants who completed strength measurement in both of the first two years of the study (1106 men and 1114 women) and were not missing covariates at Year 2, yielding a sample of 1051 men and 1043 women.

RESULTS

A total of 2309 hospitalizations occurred in participants who underwent a DXA in the exam following the hospitalization. The most common reasons for hospitalization varied somewhat by sex (see Table 1). Angina, diseases of the circulatory and digestive systems, ill-defined conditions, congestive heart failure, and osteoarthritis were common causes of hospitalization among both genders.

Characteristics of participants by hospitalization status are provided in Table 2. Participants of both sexes who were hospitalized were more likely to have cardiovascular disease than participants with no hospitalization. Among men, hospitalized participants were more likely to be white and had higher fat mass. Among women, hospitalized participants were more likely to come from the Pittsburgh site and to have diabetes and arthritis. There were no baseline differences in total mass, lean mass, or strength by hospitalization group.

Table 3 provides regression coefficients for the association between hospitalization and body composition and strength adjusting for covariates. In Model 1, controlling only for age, race, study site, and baseline measures of body composition, a hospitalization in the previous year was associated with greater decline in total body mass in both men (-0.76 kg, $p<.001$) and women (-0.81 kg, $p<.001$). Hospitalization was associated with a loss of 0.41 kg of fat mass in men ($p<.001$) and 0.54 kg in women ($p<.001$), as well as a loss of 0.33 kg lean mass in men ($p<.001$) and 0.25 kg in women ($p<.001$). These relationships remained significant and essentially unchanged after controlling for confounders (Model 2). Hospitalization was associated with significant declines in knee strength in men, although this relationship was only marginally significant after controlling for potential confounders ($p=0.083$). There was no relationship between hospitalization and decline in knee strength in women.

Figure 2 shows the association between the number of days hospitalized and change in body composition and knee extensor strength. In men, hospitalizations of four days and over were associated with significant declines in total and fat mass, but significant reductions in lean mass were only observed after eight days of hospitalization. Men with eight or more days of hospitalization lost more total mass (-2.36 kg, $p<.001$), due to a greater loss of fat mass (-1.55 kg, $p<.001$) and lean mass (-0.81 kg, $p<.001$) relative to men who were not hospitalized. In women, hospitalizations of any length were associated with increased loss of total and fat mass, and significantly lower lean mass was observed for hospitalizations of four or more days. Women with eight or more days of hospitalization lost an average of 1.64 kg ($p<.001$) more than those who were not hospitalized, due to greater declines fat mass (-1.17 kg, $p<.001$) and lean mass (-0.43 kg, $p<.001$). Hospitalizations of eight days or more

were significantly associated with loss of knee extensor strength in both men (-7.89 Nm, $p=0.037$) and women (-7.47 Nm, $p=0.038$).

This analysis examined each period in which a hospitalization occurred independently. However, it is possible that the effects of a hospitalization depend on an individual's hospitalization history. For instance, the effects of the first hospitalization may differ from the effects of subsequent hospitalizations. Supplemental analysis examined the effect of multiple periods of hospitalization, by comparing one-year intervals in participants who had been hospitalized in previous years (i.e., repeat hospitalizations) to one-year intervals in which the first hospitalization was observed within an individual and intervals with no hospitalizations. The association between hospitalization and changes in body composition was generally stronger for the first period in which a hospitalization occurred; subsequent periods of hospitalization had smaller but generally significant associations with changes in body composition. It was not possible to conduct this sensitivity analysis for strength, because only one period of hospitalization was observed.

Previous research in this cohort has shown that many older persons who lose weight regain it within 6 months.¹³ Thus, participants who were hospitalized earlier in an observation interval may have regained mass and strength prior to the examination. Among participants hospitalized within the 6 months before an exam, declines in total mass and fat mass were approximately double the declines observed for participants hospitalized more than 6 months before an exam, and this difference was consistent in men and women. For example, men hospitalized within 6 months of an exam lost an average excess of 1.01 kg ($p<0.001$ holding all covariates from Model 2 constant) relative to men who were not hospitalized, while men hospitalized more than 6 months before an exam lost of an average excess of 0.46 kg compared to men who were not hospitalized ($p=0.009$). A similar difference was observed for lean mass declines in men, but not in women. No clear association was observed related to the timing of hospitalization and strength loss.

DISCUSSION

Little research has addressed the association between hospitalization and change in body composition in community-dwelling older persons. In this population of initially well-functioning older persons, hospitalization in the previous year was associated with significant declines in total mass (-0.76 kg in men, -0.81 kg in women), fat mass (-0.41 kg in men, -0.54 kg in women) and lean mass (-0.33 kg in men, -0.25 kg in women) during the same period. The association of hospitalization with changes in body composition increased with the length of hospitalization. Hospitalization for 8 or more days in the previous year was associated with lower total, lean, and fat mass in both men and women. In analysis of examining the association between hospitalization in the previous year and knee extensor strength, significant declines were only observed among men. However, in analysis that considered days hospitalized, significant strength declines were observed in both men and women hospitalized for eight or more days in a given year (-7.89 Nm in men, -7.47 Nm in women). This finding suggests that sex differences in the association between hospitalization and strength change may be due to characteristics of the hospitalization, including frequency and length of hospitalization.

Hospitalization-associated differences in lean mass and strength in this study, although statistically and substantively significant, were less than those associated with prolonged bed rest in experimental studies,^{7, 14} even among persons hospitalized for eight or more days. Many hospitalizations are not associated with complete immobility, and even a moderate amount of activity may partially mitigate the effects of bed rest on lean mass and strength.¹⁵ Nonetheless, hospitalization has been associated with reduced functional capacity, even in

patients not restricted to bed,¹⁶ and reductions in lean mass and strength associated with hospitalization are likely to contribute to future health events. Low strength is associated with reduced mobility^{17, 18} and increased risk of hospitalization.¹⁹ Thus, hospitalization may be part of a cycle of accelerated decline, in which hospitalization leads to reduced weight and strength, which in turn predisposes individuals to future hospitalization episodes.

The magnitude of the association between hospitalization and loss of lean mass and strength increased with increasing days hospitalized and was strongest in participants hospitalized for 8 or more days in the previous year. It is not possible to know from these analyses whether the association between hospitalization duration and loss of lean mass and strength is due to severity of illness or to characteristics of the hospitalization, such as extended bed rest and reduced food intake. Nevertheless, these results suggest the need to develop and test strategies for maintaining lean mass and strength during and after extended or repeated hospital stays.

One such strategy may be to closely monitor weight in older persons admitted to the hospital to identify participants at risk of muscle loss and weakness. A variety of approaches may be considered to manage unintentional weight loss, including an assessment of potentially modifiable causes of inadequate intake.^{20, 21} Research increasingly suggests that exercise interventions can be implemented safely and may be effective in increasing strength and function even among frail older persons and recently hospitalized older persons.^{22–25} However, additional research is needed to develop and test safe and effective strategies to reduce weight and strength loss in hospitalized older persons.

This study has several limitations. First, knee extension strength was measured on a subset of relatively healthy participants. Participants missing strength data were older, more likely to be hospitalized, and had higher rates of chronic conditions. Additionally, only two years of consecutive strength measurement were available, limiting power to assess changes in strength. In order to evaluate the implications of shorter follow-up in strength data, we examined the association between hospitalization and changes in body composition, limiting body composition data to one year of follow-up (analogous to the period of observation for strength). In men, the effect of hospitalization estimated based on this shorter follow-up was larger than the effect estimated based on all years were combined. However, in women, the effect of hospitalization on body composition in the first year was smaller, suggesting that use of only one year of data in women may have underestimated the association between hospitalization and strength declines.

An additional limitation is that hospitalization was associated with reduced participation in DXA exams. Although 88% of participants contributed at least one segment in which to observe changes in body composition, only 58% of participants contributed data between years 5 and 6. The main sources of missing data included mortality (N=378) and use of alternative interview types, including home, phone, and proxy interviews. Because healthier participants were more likely to return for DXA follow-ups, results may underestimate the effect of hospitalization on body composition. Additionally, we do not know the amount of weight lost during the hospitalization; we can only observe the weight lost in the year in which a hospitalization occurred. Sensitivity analysis suggested that some participants have recovered weight in the time since discharge, such that results are likely to underestimate of the full consequences of hospitalization.

Finally, it is difficult to determine whether weight loss is associated with hospitalization *per se* or to the health problem responsible for hospitalization. Many of the most common causes of hospitalization, including circulatory disease, congestive heart failure, and cancer, are also associated with weight loss. Nonetheless, bed rest studies in otherwise healthy older

adults have found more extreme changes in body composition than those reported here, and analyses accounted for the presence of several major diseases as potential confounders in an attempt to identify the unique effect of hospitalization on outcomes, separate from disease status.

Despite these limitations, these findings provide important information on the association between hospitalization and changes in body composition in community-dwelling older adults. Although hospitalization appears to be associated with small differences in total mass, body composition, and knee extensor strength in the majority of older persons, the effects of hospitalization were particularly important persons hospitalized for 8 or more days in a given year. These results suggest that strategies for maintaining lean mass and strength during and after extended or repeated hospital stays will be important in reducing the deleterious functional effects of hospitalization in older persons.

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Figure 1.
Longitudinal Study Design

Figure 2. Adjusted 1-year changes in body composition and strength by days hospitalized in the last year (v. no hospitalization)[†]

[†]All models control for demographics, health behaviors (smoking, walking for exercise), and comorbidities (diabetes, cancer, cvd, arthritis, chronic lung disease, depression) and baseline values (of mass, fat mass, lean mass, or strength). Body composition N=1322 (men) and 1368 (women). Strength N=1051 (men) and 1043 (women).

Table 1**Causes of Hospitalizations over 5 Years**

Cause	Men		Women	
	Number hospitalizations, N (%)	Rank	Number hospitalizations, N (%)	Rank
Angina/other ischemic disease	161 (13.4)	1	106 (9.5)	2
Diseases of circulatory system [†]	125 (10.4)	2	107 (9.6)	1
Cancer	82 (6.8)	3	37 (3.3)	12
Symptoms, signs & ill defined conditions	78 (6.5)	4	101 (9.1)	3
Osteoarthritis	67 (5.6)	5	73 (6.6)	4
Diseases of digestive system	64 (5.3)	6	47 (4.2)	7
Congestive heart failure	56 (4.7)	7	65 (5.9)	5
COPD/emphysema/asthma	50 (4.2)	8	37 (3.3)	12
Diseases of genitourinary system	47 (3.9)	9	45 (4.1)	8
Myocardial infarction	44 (3.7)	10	26 (2.3)	17
Diseases of musculoskeletal system & connective tissues	41 (3.4)	11	53 (4.8)	6
Pneumonia	36 (3.0)	12	44 (4.0)	9
Fracture	15 (1.3)	23	43 (3.9)	10
Other	332 (27.7)		327 (29.4)	
Total	1198 (100.0)		1111 (100.0)	

[†] Not including myocardial infarction, angina, and congestive heart failure

Table 2Baseline Characteristics of Cohort by Hospitalization status: % or Mean ($\pm$ SD)[†]

Characteristic	Men		Women		p
	Not Hospitalized	Hospitalized	Not Hospitalized	Hospitalized	
N	685	609	818	519	
Age, mean ($\pm$ SD), y	73.7 ($\pm$ 2.8)	73.7 ($\pm$ 2.9)	73.5 ($\pm$ 2.9)	73.4 ($\pm$ 2.8)	0.524
Race (% white)	62.2	67.5	57.6	53.4	0.131
Study site (% Pittsburgh)	48.5	51.4	43.6	55.7	<0.001
Current smoker (%)	11.1	9.9	8.2	10.2	0.208
Walking category					0.111
None	35.8	39.7	43.5	44.1	
Low (1–150 min/wk)	31.0	28.4	30.7	34.7	
High (150+ min/wk)	33.3	31.9	25.8	21.2	
Comorbidities					
Diabetes	20.3	23.8	12.8	18.9	0.003
Cancer	19.0	19.9	13.8	15.8	0.316
Cardiovascular disease	26.0	37.6	17.6	28.5	<0.001
Arthritis	5.4	7.7	10.9	16.8	0.002
Lung disease	14.3	18.1	17.2	22.9	0.010
Depression	4.4	3.9	6.7	6.6	0.902
Total mass, mean ($\pm$ SD), kg	80.7 ($\pm$ 13.1)	81.8 ($\pm$ 12.8)	69.9 ($\pm$ 14.4)	71.1 ($\pm$ 14.1)	0.138
Fat mass, mean ($\pm$ SD), kg	23.7 ($\pm$ 7.1)	24.5 ($\pm$ 7.1)	28.8 ($\pm$ 9.2)	29.4 ($\pm$ 9.2)	0.282
Lean mass, mean ($\pm$ SD), kg	54.3 ($\pm$ 7.2)	54.6 ($\pm$ 6.9)	39.2 ($\pm$ 6.0)	39.8 ($\pm$ 5.8)	0.069
Strength, mean ($\pm$ SD), Nm [‡]	134.6 ($\pm$ 34.0)	132.8 ($\pm$ 35.5)	82.2 ($\pm$ 22.2)	82.1 ($\pm$ 21.9)	0.909

[‡] Sample size=606 non-hospitalized men, 532 hospitalized men, 725 non-hospitalized women, 436 hospitalized women

Table 3

Changes in Body Composition and Strength for Hospitalized Relative to Non-hospitalized Participants: Beta coefficient (95% Confidence Interval)

	Men				Women			
	N	Model 1	p	Model 2	N	Model 1	p	Model 2
Total mass (kg)	1322	-0.76 (-1.02, -0.51)	<0.001	-0.79 (-1.04, -0.54)	1368	-0.81 (-1.08, -0.54)	<0.001	-0.79 (-1.07, -0.51)
Fat mass (kg)	1322	-0.41 (-0.58, -0.24)	<0.001	-0.45 (-0.62, -0.28)	1368	-0.54 (-0.75, -0.34)	<0.001	-0.53 (-0.74, -0.32)
Lean mass (kg)	1322	-0.33 (-0.46, -0.20)	<0.001	-0.31 (-0.44, -0.18)	1368	-0.25 (-0.35, -0.14)	<0.001	-0.24 (-0.35, -0.13)
Strength (Nm)	1051	-4.02 (-7.97, -0.08)	0.046	-3.57 (-7.59, 0.46)	1043	-1.99 (-5.08, 1.10)	0.206	-0.59 (-3.77, 2.59)

Model 1 controls for: demographics (age, race, study site) and baseline values (of mass, fat mass, lean mass, or strength)

Model 2 controls for: demographics, health behaviors (smoking, walking for exercise), and comorbidities (diabetes, cancer, cvd, arthritis, chronic lung disease, depression) and baseline values (of mass, fat mass, lean mass, or strength)