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Validation and Comparison of 2 Frailty Indexes: The MOBILIZE Boston Study

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Abstract

Objectives—To validate two established frailty indexes and compare their ability to predict adverse outcomes in a diverse elderly community-dwelling sample of men and women.

Design—Prospective observational study.

Setting—A diverse defined geographic area of Boston.

Participants—765 community-dwelling participants in the MOBILIZE Boston Study.

Measurements—Two published frailty indexes, recurrent falls, disability, overnight hospitalization, emergency room visits, chronic medical conditions, self-reported health, physical function, cognitive ability (including executive function) and depression. One index was developed from the Study of Osteoporotic Fractures (SOF) and the other from the Cardiovascular Health Study (CHS).

Results—The SOF frailty index classified 77.1% as robust, 18.7% as pre-frail and 4.2% as frail. The CHS frailty index classified 51.2% as robust, 38.8% as pre-frail and 10.0% as frail. Both measures of frailty (SOF; CHS) were similar in their ability to predict key geriatric outcomes such as recurrent falls (HR_{frail}=2.2 [1.2-4.0]; HR_{frail}=1.9 [1.2-3.1]), overnight hospitalization (OR_{frail}=3.5 [1.5,8.0]); OR_{frail}=4.4 [2.4-8.2]), emergency room visits (OR_{frail}=3.5 [1.4,8.8]); OR_{frail}=3.1 [1.6-5.9]) and disability (OR_{frail}=5.4[2.3,12.3]); OR_{frail}=7.7 [4.0,14.7]), as well as chronic medical conditions, physical function, cognitive ability and depression.

Conclusion—We validated two established frailty indexes using an independent elderly sample of diverse men and women and showed that both indexes are good at distinguishing relevant geriatric conditions and predicting recurrent falls, overnight hospitalization and emergency room visits by level of frailty. Though both indexes are good measures of frailty, the simpler SOF index may prove easier and more practical in a clinical setting.

Keywords

Frailty; community-dwelling; MOBILIZE Boston Study; Study of Osteoporotic Fracture; Cardiovascular Health Study

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Frailty has become a particularly important geriatric topic since a 1990 American Medical Association report emphasized the growing population of vulnerable older adults. [1] This vulnerable population has been identified as older adults with an intrinsic vulnerability to stressors and increased risk for decline and adverse health-related characteristics such as disability and comorbidity, and has been described as frail. For reasons related to difficulties distinguishing these entities, and because many factors have been reported to be associated with frailty in older adults, there is no single consensus definition of frailty despite numerous definitions proposed by researchers. There is general agreement in the literature that frailty is a biologic syndrome of decreased reserve and resistance to stressors resulting from cumulative declines across multiple physiologic systems that cause vulnerability to adverse outcomes. [2]

In an attempt to solidify the concept of frailty and operationalize its definition, Fried et al. [2] proposed a phenotype of frailty involving at least 3 of the following 5 components: unintentional weight loss, self-reported reduced energy level, reduced grip strength, slow walking speed, and a low level of physical energy. Using a frailty index based on this phenotype, Fried et al. and other researchers [2-8] have reported its association with falls, hospitalization, disability, and death.

This index has been useful in identifying frail older adults, though its use is impractical in the clinical setting. Assessing strength, walking speed, and physical activity (3 components of this index) not only depends on gender and body mass but also requires knowledge of the underlying distribution of the measure in a given population. Moreover, assessing some of these components may not be feasible. For example, physical activity assessments and timed walks are often impractical to evaluate in a clinic due to schedule and space constraints. [6]

Recently, Ensrud et al. [6] proposed a simpler frailty index, requiring at least 2 of 3 components (weight loss, the inability to rise from a chair 5 times without the use of arms, and self-reported reduced energy level). This index might be more suitable for assessing frailty in a busy clinical practice setting.

Based on a prospective cohort study (N=6701) designed to examine osteoporosis and fractures in older women, Ensrud et al. [6] compared their frailty index to the Fried et al. frailty index on outcomes such as falls, recurrent falls, disability, fractures and death. Both indexes were strongly associated with these outcomes and their effect measures (i.e., hazard ratios and odds ratios) were very similar. Ensrud et al. concluded that their simpler index had very similar predictive properties compared to the Fried et al. frailty index, provided a useful definition of frailty, and could be used to identify older women at risk of adverse health outcomes in clinical practice setting. However, one important shortcoming of this study was its limited generalizability, as it did not include men or African-American women.

The objective of this study was to validate and compare these two indexes using an independent diverse sample of men and women (including African-Americans). We examined the indexes' ability to predict recurrent falls, overnight hospitalizations, emergency room visits, and their association with disability, chronic medical conditions, self-reported health, physical function, cognitive function (including executive function) and depression. To our knowledge, this is the first validation and comparison of these two indexes using an independent data source that includes men and African-American women. It is also the first to examine executive function measures across frailty levels.

Methods

Study Sample

Subjects were participants in the MOBILIZE (Maintenance of Balance, Independent Living, Intellect, and Zest in the Elderly) Boston Study (MBS). The MBS is a prospective observational study designed to examine novel risk factors for falls among a large diverse population of aged individuals in the greater Boston area. The recruitment strategy targeted older persons living within a 5-mile radius of our Institute for Aging Research (IFAR) by using probability sampling from town lists and census information.

Eligibility criteria included age over 70 years, ability to speak and understand English, ability to walk across a room, visual ability to read written material, and the expectation that the participant will be living in the area for at least 3 years. Companions or spouses who were aged 65 or older living with a participant also were allowed to join the study, as it was recognized early on that recruitment of one spouse or companion without the other would limit participation. Study participation was limited to English speakers because it was not feasible to translate the study instruments and conduct the interviews in the many languages that are spoken within Boston's minority communities.

Once recruited through door-to-door visits, elders were contacted via telephone by research staff to confirm eligibility and schedule the 2-part baseline data collection. The 2-part baseline assessment included an extensive 3-hour in-home interview, followed within 4 weeks by a 3-hour in-clinic examination. During the home visit, participants were given a set of monthly falls calendar postcards, designed to record the number of falls, and instructed how to complete and mail them to IFAR at the end of each month during the 18-month follow-up.

The baseline MBS assessments of 765 participants are included in these analyses. The sex and racial distribution of these subjects matches that of the greater Boston metro-population area. Details of the study design have been previously published.[9] The results reported in this study utilized baseline measures, and recurrent falls, overnight hospitalization and emergency room visit measures during follow-up (average follow-up: 10.4 months; standard deviation: 8.2 months; maximum: 32.2 months). The Institutional Review Boards of Hebrew SeniorLife approved the MBS as well as this specific study.

Frailty Index Definitions (CHS and SOF)

CHS Frailty Index: The Fried et al. [2] frailty index was originally based on data from the Cardiovascular Health Study (CHS). We constructed an adaptation of this frailty index using the MBS data. The five components of the CHS frailty index were: unintentional weight loss, weakness, poor endurance or exhaustion (reduced energy level), slowness (slow gait), and low physical activity. Using the MBS data, self-reported unintentional weight loss was defined using the MBS question “In the last year, have you lost more than 10 pounds unintentionally, that is, not due to dieting or exercise?”). Weakness was defined by the sit-stand test time, a part of the Short Physical Performance Battery [10]. Time required to perform five repetitions of sit-to-stand was measured and used as a proxy for leg strength. The cohort was stratified by gender, then by body mass index (BMI) (in quartiles, 4 strata for each gender) to adjust for the effects of gender and BMI on leg strength. From each stratum, the highest quintile (20%) of sit-stand times (including participants who could not perform the task) was chosen to represent weakness. Reduced energy level was determined by the CESD (Center for Epidemiologic Studies Depression Scale, Hopkins Revision) question,[11] “Over the past week or so, did you feel like you could not get going?” Those who reported symptoms occurring 3 days or more in the past week were considered as demonstrating a reduced energy level. Slow gait was defined from the timed 4-meter walk. Two trials were performed, and the shortest time (i.e.,

fastest) was chosen for analysis. The time scores were stratified by sex, then by height (2 strata per gender). Participants who used ambulatory assistive devices were included. In each stratum, those in the highest (i.e., slowest) quintile were considered to have slow gait. Daily activity was determined using the Physical Activity Scale for the Elderly (PASE). [12] The PASE score is a weighted sum of hours spent doing activities of various vigor. The PASE score was stratified by gender and those who scored in the bottom quintile were considered as exhibiting low daily activity. Consistent with the original CHS frailty index, frailty status was defined as robust (previously referred to as "not frail") (0 components), pre-frail (previously referred to as "intermediate") (1-2 components), and frail (3-5 components).

SOF Frailty Index: The Ensrud et al. [6] frailty index was originally derived using data from the Study of Osteoporotic Fractures (SOF) and was constructed from the MBS data using three components: weight loss (unintentional) (MBS question "In the last year, have you lost more than 10 pounds unintentionally, that is, not due to dieting or exercise?"); inability to rise from a chair 5 times without the use of arms; and reduced energy level. Reduced energy level was determined by interviewing participants using a question on the CESD (Center for Epidemiologic Studies Depression Scale, Hopkins Revision), [11] "Over the past week or so, did you feel like you could not get going?" Those who reported that this feeling occurred 3 days or more in the past week were considered as demonstrating a reduced energy level. Consistent with the original SOF frailty index, frailty status was defined as robust (0 components), pre-frail (previously referred to as "intermediate") (1 component), and frail (2 or more components).

Outcomes

Recurrent Fallers: Fall status was determined from the falls calendar where the participant recorded a fall each day it occurred during a given month throughout the follow-up. On any given month approximately one third of the participants have to be contacted by phone to return the completed calendars. This includes reminding participants to mail the calendars by the 15th of each month and asking questions related to filling in missing information on the previously received calendar. Less than 1% of calendars are missing each month. A participant was considered a recurrent faller if he/she recorded 2 or more falls during follow-up. The date of each fall was ascertained from the falls calendar. One-time fallers were treated as non-fallers.

Hospitalization and Emergency Room Visits: Overnight hospitalization was determined from a question included in the falls calendar that asked if the participant was hospitalized overnight during a given month throughout the follow-up. Emergency room visits were determined from a question included in the falls calendar that asked if the participant visited an emergency room during a given month throughout the follow-up.

Short Physical Performance Battery: The Short Physical Performance Battery (SPPB) was used to measure lower extremity mobility performance. [10] The SPPB includes measures of standing balance, 4-meter usual-paced walking speed, and ability and time to rise from a chair 5 times. The validity of this scale has been demonstrated by showing a gradient of risk for admission to a nursing home and mortality along the full range of the scale from 0-12. [13, 14]

Activities of Daily Living, Instrumental Activities of Daily Living and Disability: The Activities of Daily Living (ADL) scale included the following items: bathing, dressing, transferring, using the toilet and eating. [15] The Instrumental Activities of Daily Living (IADL) scale included the following items: shopping, preparing meals and housework. [16] Response options for the ADL and IADL items included asking individuals to identify their inability or level of difficulty (none, a little, some, or a lot) in performing each ADL and IADL activity. Each scale was classified into three levels: 1) no difficulty, 2) little or some difficulty, and 3)

a lot of difficulty or an inability to do one or more activities. Because MBS participants are community dwelling, we used IADL measures to define disability. IADL disability was defined as a lot of difficulty or an inability to do one or more instrumental activities of daily living.

Chronic Medical Conditions: A number of chronic medical conditions (yes=1 or no=0) were summed into a scale. This scale included: heart disease or heart attack or myocardial infarction, angina or chest pain, congestive or chronic heart failure, high blood pressure, diabetes or sugar diabetes, cancer other than skin cancer, osteoarthritis or degenerative arthritis, asthma or emphysema or chronic bronchitis or chronic obstructive lung disease, stroke, Parkinson's disease, and Alzheimer's disease or dementia. This variable was categorized as: 0, 1, 2, 3, 4, >=5 because the categories beyond 5 had very few participants in each category.

Self-Rated Health: The participants were asked, “In general, would you say your health is excellent (1), very good (2), good (3), fair (4) or poor (5). Lower scores indicate better self-rated health.

Cognitive Measures: Verbal memory functioning was assessed with the Hopkins Verbal Learning Test – Revised (HVLT-R). The HVLT-R is a 12-item wordlist learning test that has been identified as an ideal memory measure for elderly patients and those suspected of dementia. [17] Higher scores are better. Reliability and validity of the HVLT-R have been shown in both older adults and persons with frontal lesions. [18, 19] The Mini-Mental State Examination [20], a valid and reliable brief examination of generalized cognitive function, assesses memory, concentration, attention, and language yielding a maximum (best) score of 30. Verbal fluency was assessed with phonemic (word-list generation) and semantic (animal) fluency tasks.[21] 22 The Trail making Test (parts A and B), requires the individual to connect encircled items in sequential order in a timed test. This test is a measure of executive function, is frequently used in the clinical setting, and has been shown to be sensitive to the presence of frontal lobe pathology and increased cerebrovascular risk. [23] Higher values (seconds) indicate that it took longer to complete the test. The Clock-in-a-Box Test [24], a modification of the commonly used Clock Drawing test, [25, 26] was designed as a cognitive screening measure for use in the medical setting and has increasingly been used as a measure of executive function. [27] Higher scores represent better performance.

Depression: Depression symptomatology was measured using a modification of the 20-item Centers for Epidemiologic Studies Depression (CESD) scale. [11] The instrument has been shown to be valid, reliable and sensitive to change in older populations [28, 29] In the MBS, we used a modification of the Hopkins Revision of the CESD (CESD-R). We calculated depressive syndrome burden scores using item response theory [30, 31] and the metric was set relative to the mean and variance of the MBS sample aged 70-74 years at baseline interview using a mean of 50, standard deviation of 10. The items that comprise the CESD-R had high internal consistency (coefficient alpha = 0.86).

Covariates—A number of variables were included in adjusted analyses. These included age, gender, race, education, income, diabetes, stroke, hypertension and hyperlipidemia,. Race was defined as Caucasian versus non- Caucasian as nearly 80% were Caucasian, 16% African-American, and the remaining categories less than or equal to 2%. Education was defined as less than high school, high school graduate, and college graduate. Income was measured in ordinal categories ranging from less than $5,000 to greater than $45,000 by $5,000 increments. Education and income were used as proxies for social economic status. Diabetes and stroke were self-reported. Hypertension was defined as either: 1) systolic blood pressure >= 140 mm Hg or diastolic blood pressure >= 90 mm Hg, 2) told by participant's physician that he/she has high blood pressure or hypertension, 3) receiving any hypertensive medication.

Hyperlipidemia is considered positive if cholesterol is >= 200 mg/dl or low-density lipoprotein >= 130 mg/dl or the participant is receiving a cholesterol lowering drug. Except for stroke and hyperlipidemia, covariates were chosen because they were reported to be associated with frailty in the CHS or SOF study.

Statistical Analysis

Means (standard deviations) and frequencies (percentages) were calculated to describe the study sample. A weighted kappa was calculated to estimate the association between the frailty categories of the two indexes. Analysis of variance was used to compare mean values across frailty status groups, and multiple comparison tests were performed when appropriate. Cox proportional hazards analyses (unadjusted and adjusted) were performed, and hazard ratios and corresponding 95% confidence intervals were calculated to estimate the association between frailty status and recurrent falls. Recurrent fallers were coded positive if they fell 2 or more times during follow-up, and 0 otherwise. One-time fallers were coded as non-fallers. The analysis modeled time to first fall among recurrent fallers. Indicator variables (dummy variables) were created using robust as the referent group.

Logistic regression analyses (unadjusted and adjusted) were performed, and odds ratios and corresponding 95% confidence intervals were calculated to estimate the association between frailty status and overnight hospitalization, emergency room visits, and disability. Indicator variables (dummy variables) were created using robust as the referent group. The adjusted models included age, gender, diabetes, stroke, hypertension and hyperlipidemia. An alpha level of 0.05 was used in all analyses to determine statistical significance and guide inference. SAS, Version 9.1 for Windows (SAS Institute, Inc., Cary, NC) was used for statistical analyses.

Results

The study sample of 765 participants is characterized in Table 1. The average age was 78, 64% of participants were women, 78% were white and 21% were disabled. Thirty percent of participants fell at least twice (recurrent faller), 35% were hospitalized overnight and 45% visited an emergency room during follow-up. Table 1 also lists information on chronic medical conditions, self-reported health, physical and cognitive ability, depression, and the distribution of frailty categories for each index. The weighted kappa for the agreement between the two indexes was .51, which represents a moderate association.

Table 2 presents the means of participant characteristics, clinical conditions, and functional and cognitive ability, and depression across frailty categories for each index. The frailty group characteristics for each index were similar. Increasing age, the number of chronic medical conditions and worse self-reported health were associated with increasing frailty status. Greater impairments in physical (SPPB, ADL, IADL) and cognitive functions (MMSE, HVLT, Word Generation, Trails A, Trails B, Clock-in-a-Box) were associated with increasing frailty status. Finally, frailty was associated with greater depression scores. There was a statistically significant difference between mean values of each variable across the frailty groups for both indexes.

Table 3 presents the unadjusted and adjusted hazard ratios and corresponding 95% confidence intervals for the association between frailty groups and recurrent falls for each index. In the adjusted analysis, frail participants were 2.19 [1.19-4.03] (SOF) and 1.90 [1.17-3.10] (CHS) times more likely to experience a recurrent fall than robust participants. Pre-frail participants were 1.62 [1.14-2.32] (SOF) and 1.10 [0.80-1.50] (CHS) times as likely to experience a recurrent fall relative to robust participants.

Table 4 presents the unadjusted and adjusted odds ratios and corresponding 95% confidence intervals for the association between frailty indexes and both emergency room visits and overnight hospitalization. In adjusted analyses, frail participants were 3.49 [1.53-7.98] (SOF) and 4.45 [2.42-8.18] (CHS) times more likely to experience an overnight hospitalization relative to robust participants. Pre-frail participants were 2.64 [1.74-4.01] (SOF) and 1.97 [1.37-2.84] (CHS) times more likely to experience an overnight hospitalization relative to robust participants. In adjusted analyses, frail participants were 3.54 [1.43-8.79] (SOF) and 3.10 [1.64-5.86] (CHS) times more likely to experience an emergency room visit relative to robust participants. Pre-frail participants were 2.19 [1.43-3.33] (SOF) and 1.34 [0.95-1.89] (CHS) times more likely to experience an emergency room visit relative to robust participants.

Table 5 presents the unadjusted and adjusted odds ratios and corresponding 95% confidence intervals for the association between frailty groups and prevalent IADL disability for each index. In adjusted analyses, frail participants were 5.38 [2.34-12.35] (SOF) and 7.68 [4.01-14.74] (CHS) times more likely to be disabled relative to robust participants. Pre-frail participants were 2.88 [1.81-4.58] (SOF) and 2.73 [1.64-4.40] (CHS) times as likely to be disabled relative to robust participants.

Due to concern that the 5 missing values in the CHS frailty index might have differentially affected the comparison with the SOF frailty index, we reran all SOF frailty index analyses excluding the 5 participants who had missing CHS frailty index values. The results of these analyses were nearly identical to the original analyses.

Discussion

The results of this study demonstrate that the CHS and SOF frailty indexes provide useful definitions of frailty, are associated with cognitive and functional deficits and are good predictors of adverse outcomes. Both indexes were very similar in their ability to distinguish the incidence of recurrent falls, overnight hospitalization, emergency room visit, and the prevalence of IADL disability, chronic medical conditions, self-reported health, physical function, cognitive ability and depression on the basis of different frailty levels. The simpler SOF frailty index may be more useful in a clinical practice because its components are easier to define and do not require knowledge of population distributions. The results of our study validate the findings of the SOF and CHS studies in a diverse elderly community-dwelling population that, unlike the previous SOF/CHS comparison, included men and African-American women in the comparison.

It is not surprising that the SOF and CHS frailty indexes are similar as the 3 items used in the SOF index are very similar to 3 of the 5 items included in the CHS index. This is particularly true in our modified CHS index since chair stand time was substituted for a measure of weakness. However, it is interesting to note that the weighted kappa for the agreement between the two indexes was .51, which represents a moderate rather than a high association. Furthermore, though the associations between the indexes and various outcomes are similar, in the same direction, and statistically significant, the magnitude of the association varies slightly across indexes. For example, using the robust frailty category as the referent, the SOF frail individuals were 2.19 as likely to be a recurrent faller compared to 1.90 for CHS frail individuals. Similar small differences were observed with the outcomes overnight hospitalization (CHS has a higher risk), emergency room visits (SOF has a higher risk) and IADL defined disability (CHS has a higher risk).

Results from Table 2 shows that the percent Caucasian (white) was not significantly different among categories of the SOF frailty index but it was significantly different among categories of the CHS frailty index. This may lend support to a recent study [32] suggesting that

standardization of frailty items without consideration of ethnic variations is problematic and may lead to misclassification of frailty categories for non-Caucasians. Moreover, the fact that body mass was not significantly different among categories of the SOF frailty index but it was significantly different among categories of the CHS frailty index may support the perspective that higher body mass index values in African Americans than Caucasians may lead to overclassification of weakness in African Americans, which could partially account for the higher prevalence of frailty found in the CHS classification of frailty. [32]

The strengths of this study include its prospective ascertainment of recurrent falls, overnight hospitalization and emergency room visits, and its inclusion of men and African-American subjects. Furthermore, this is the first study to compare these two established frailty indexes (SOF and CHS) using a third source of data.

One limitation of our study is that it did not have the exact same measures used in the originally reported indexes. Another limitation is that outcomes such as falls, overnight hospitalizations and emergency room visits were ascertained by self-report. Also, as in the SOF and CHS studies, the MBS data were collected for other purposes that are not directly related to the study of frailty. Like the SOF and CHS results, the generalizability of our findings may be limited to community-dwelling elders. Finally, the MBS data did not contain an adequate number of deaths to include mortality as an outcome.

In conclusion, we validated and compared two established frailty indexes using an independent data source that included men and African-American women, and showed that both indexes are equally good at distinguishing relevant geriatric conditions, functional and cognitive impairments, and predicting adverse outcomes and acute care service use by level of frailty. Both indexes are good measures of frailty and are able to distinguish differences by level of frailty. The simpler SOF index may prove easier to use in a clinical setting compared to the CHS index.

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Table 1
Descriptive information on MOBILIZE Boston Study participants (N=765)

Characteristic	Mean (SD) or N (%)
Age (years)	78.13 (5.44)
Height (meters)	1.64 (0.10)
Weight (kilograms)	73.08 (15.40)
Body Mass Index	27.32 (5.16)
Diabetes	141 (18.70)
Stroke	76 (10.00)
Hypertension	598 (79.10)
Hyperlipedemia	359 (46.93)
Women	489 (63.92)
Education	
< High School	85 (11.13)
High School Graduate	178 (23.30)
College Graduate	501 65.58)
Income	
< $5,000 Per Year	18 (2.59)
$5,000 to $9,999 Per Year	70 (10.09)
$10,000 to $14,999 Per Year	82 (11.82)
$15,000 to $24,999 Per Year	114 (16.43)
$25,000 to $34,999 Per Year	75 (10.81)
$35,000 to $44,999 Per Year	77 (11.10)
$45,000 or More Per Year	258 (37.18)
Race	
Caucasian (White)	596 (78.01)
African American	121 (15.84)
Asian	10 (1.31)
American Indian	4 (0.52)
Multi-Racial	17 (2.23)
Other	16 (2.09)
Chronic Medical Conditions (#)	
0	125 (16.34
1	278 (36.34)
2	212 (27.71)
3	109 (14.25)
4	28 (3.66)
>= 5	13 (1.70)
Self Reported Health	
Excellent	126 (16.47)
Very Good	251 (32.81)
Good	274 (35.82)
Fair	100 (13.07)
Poor	14 (1.83)
Recurrent fallers	233 (30.46)
Disability	162 (21.20)
Overnight hospitalization	266 (34.77)
Emergency room visit	344 (44.97)
Physical Function	
SBBP	9.31 (2.51)
ADL	0.30 (0.60)
IADL	0.62 (0.81)
Cognitive Function	
MMSE	27.06 (2.66)
Hopkins Verbal Learning Test	0.02 (0.76)
Word Generation (FAS) (number of words)	36.59 (14.46)
Word Generation (animals) (number of words)	15.76 (5.16)
Trails A (seconds)	57.30 (35.48)
Trails B (seconds)	143.60 (78.64)
Clock-in-a-Box	6.29 (1.52)
Depression (CESD-R)	50.65(10.03)
Items Used in Frailty Indexes	
Weight Loss (unintentional)	56 (7.36)
Inability to Rise From a Chair 5 Times	87 (11.39)
Reduced Energy Level	67 (8.77)
Sit-Stand Time (seconds)	12.94 (3.81)
Gait Speed (seconds)	4.61 (1.56)
PASE	107.42 (70.94)
SOF Frailty Index	
Robust	590 (77.12)
Pre_Frail	143 (18.69)
Frail	32 (4.18)
CHS Frailty Index	
Robust	389 (51.18)
Pre_Frail	295 (38.82)

Characteristic	Mean (SD) or N (%)
Frail	76 (10.00)

MOBILIZE = Maintenance of Balance, Independent Living, Intellect, and Zest in the Elderly

SOF = Study of Osteoporotic Fractures (Ensrud et al., 2008)

CHS = Cardiovascular Health Study (Fried et al., 2001)

SPPB = short physical performance battery (lower scores indicate more impairment)

ADL = activities of daily living (higher scores indicate more impairment)

IADL = instrumental activities of daily living (higher scores indicate more impairment)

Hopkins Verbal Learning Test (lower scores indicate more impairment)

MMSE = mini-mental state examination. (lower scores indicate more impairment)

Trails A = part A of the Trail Making Test (higher scores indicate more impairment)

Trails B = part B of the Trail Making Test (higher scores indicate more impairment)

Clock-in-a-Box = a modification of the Clock Drawing test (lower scores indicate more impairment)

Word Generation (words starting with the letters F, A & S) (lower scores indicate more impairment)

Word Generation (animals – independent of letter starting the name) (lower scores indicate more impairment)

CESD = centers for epidemiologic studies depression scale (revised) (higher scores indicate more depression)

PASE = Physical Activity Scale for the Elderly (higher score indicates more activity)

Note: Reduced energy level was assessed using the CESD (Center for Epidemiologic Studies Depression Scale) question, “Over the past week or so, did you feel like you could not get going”

Table 2

Mean (standard deviation) or percent for select variables stratified by frailty status (robust, pre-frail, frail) for 2 frailty indexes (SOF, CHS).

Mean (SD)	SOF Frailty Index (n=765) Robust n=590 (77.1%)	Pre-frail n=143 (18.7%)	Frail n=32 (4.2%)	P-value*	CHS Frailty Index (n=760) Robust n=389 (51.2%)	Pre-frail n=295 (38.8%)	Frail n=76 (10.0%)	P-value*
Age	77.56 (5.31)	79.71 (5.36)	81.41 (5.86)	.0001 (1,2)	76.79 (4.96)	79.15 (5.59)	80.82 (5.48)	.0001 (1,2,3)
Body Mass Index	27.37 (5.11)	27.07 (5.28)	27.547(5.58)	.82	26.85 (4.71)	27.53 (5.14)	28.90 (6.92)	.005 (2,3)
Chronic Medical Conditions (#)	1.49 (1.09)	1.81 (1.16)	2.25 (1.59)	.0001 (1,2,3)	1.31 (1.02)	1.77 (1.09)	2.22 (1.47)	.0001 (1,2,3)
Self-Reported Health	2.35 (0.91)	2.96 (0.98)	3.37 (1.04)	.0001 (1,2,3)	2.20 (0.87)	2.71 (0.94)	3.24 (0.99)	.0001 (1,2,3)
SPPB	10.02 (1.81)	7.32 (2.95)	5.00 (2.34)	.0001 (1,2,3)	10.74 (1.18)	8.48 (2.30)	5.29 (2.33)	.0001 (1,2,3)
ADL	0.18 (0.47)	0.66 (0.75)	1.03 (0.86)	.0001 (1,2,3)	0.10 (0.36)	0.41 (0.67)	0.95 (0.78)	.0001 (1,2,3)
IADL	0.49 (0.74)	0.99 (0.90)	1.28 (0.89)	.0001 (1,2)	0.35 (0.65)	0.80 (0.85)	1.26 (0.88)	.0001 (1,2,3)
MMSE	27.31 (2.51)	26.27 (2.98)	26.00 (2.94)	.0001 (1,2)	27.61 (2.30)	26.78 (2.72)	25.39 (3.21)	.0001 (1,2,3)
Hopkins Verbal Learning Test	0.07 (0.75)	-0.13 (0.79)	-0.16 (0.70)	.007 (1)	0.16 (0.72)	-0.08 (0.75)	-0.30 (0.83)	.0001 (1,2,3)
Word Generation (FAS)	37.35 (14.45)	34.77 (14.41)	30.69 (13.04)	.01 (2)	38.68 (14.23)	35.64 (14.25)	29.27 (13.36)	.0001(1,2,3)
Word Generation (animals)	16.18 (5.14)	14.66 (5.00)	12.84 (4.65)	.0001 (1,2)	16.77 (5.09)	15.29 (4.97)	12.56 (4.62)	.0001(1,2,3)
Trails A	53.37 (31.11)	69.84 (44.08)	77.10 (50.00)	.0003 (1,2)	48.03(23.79)	60.29 (31.39)	94.36 (65.39)	.0001 (1,2,3)
Trails B	135.67 (75.85)	168.43 (81.28)	190.85(84.81)	.0001 (1,2)	128.4 8 (71.25)	153.00 (79.25)	205.52 (81.11)	.0001 (1,2,3)
Clock-in-a-Box	6.40 (1.48)	6.00 (1.58)	5.48 (1.75)	.0002 (1,2)	6.51 (1.38)	6.23 (1.44)	5.33 (2.12)	.0001 (1,2,3)
CESD-R	49.00 (9.06)	55.10 (10.86)	61.21 (10.83)	.0001(1,2,3)	48.21 (9.12)	52.50 (9.83)	59.94 (11.81)	.0001(1,2,3)
Women	63.73	65.73	59.38	.78	63.24	64.07	64.47	.96
Caucasian (White)	78.78	75.52	75.00	.64	80.67	76.95	67.11	.03
Disability	14.94	39.16	56.25	.0001	9.51	27.55	55.26	.0001
Overnight Hospitalization	29.15	51.75	62.50	.0001	24.68	40.34	64.47	.0001
Emergency Room Visit	39.66	60.14	75.00	.0001	36.76	48.14	73.68	.0001

SOF = Study of Osteoporotic Fractures (Ensrud et al., 2008)

CHS = Cardiovascular Health Study (Fried et al., 2001)

SPPB = short physical performance battery (lower scores indicate more impairment)

ADL = activities of daily living (higher scores indicate more impairment)

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CESD = centers for epidemiologic studies depression scale (revised) (higher scores indicate more depression)

* P-values from overall test of group differences in analyses of variance

Specific group differences (p<.05)
1 = robust & pre-frail
2 = robust & frail
3 = pre-frail & frail

Note: the CHS frailty index could not be created for 5 participants due to missing values.

Table 3

Hazard ratios and 95% confidence intervals estimating the association between frailty (two indexes) and recurrent falls. Indicator (dummy) variables represent pre-frail and frail groups relative to robust.

	Risk of Recurrent Falls					
	SOF Frailty Index (N=765)			CHS Frailty Index (N=760)		
	Hazard Ratio	CI 95%	P-value	Hazard Ratio	CI 95%	P-value
Unadjusted						
Pre-frail	1.43	1.04-1.95	.03	1.06	0.80-1.40	.71
Frail	1.55	0.88-2.72	.13	1.61	1.09-2.39	.02
Adjusted						
Pre-frail	1.62	1.14-2.32	.008	1.10	0.80-1.50	.57
Frail	2.19	1.19-4.03	.01	1.90	1.17-3.10	.01

SOF = Study of Osteoporotic Fractures (Ensrud et al., 2008)

CHS = Cardiovascular Health Study (Fried et al., 2001)

CI = confidence interval

Adjusted for age, gender, race, diabetes, stroke, hypertension, hyperlipidemia, education and income.

Table 4

Odds ratios and 95% confidence intervals estimating the association between frailty (two indexes) and both overnight hospitalization and emergency room visits. Indicator (dummy) variables represent pre-frail and frail groups relative to robust.

	Overnight Hospitalization					
	SOF Frailty Index (N=765)			CHS Frailty Index (N=760)		
	Odds Ratio	CI 95%	P-value	Odds Ratio	CI 95%	P-value
Unadjusted						
Pre-frail	2.61	1.79-3.78	.0001	2.06	1.49-2.86	.0001
Frail	4.05	1.94-8.47	.0002	5.54	3.28-9.35	.0001
Adjusted						
Pre-frail	2.64	1.74-4.01	.0001	1.97	1.37-2.84	.0003
Frail	3.49	1.53-7.98	.003	4.45	2.42-8.18	.0001
	Emergency Room Visits					
	SOF Frailty Index (N=765)			CHS Frailty Index (N=760)		
	Odds Ratio	CI 95%	P-value	Odds Ratio	CI 95%	P-value
Unadjusted						
Pre-frail	2.29	1.58-3.33	.0001	1.60	1.17-2.17	.003
Frail	4.56	2.02-10.33	.0003	4.82	2.78-8.35	.0001
Adjusted						
Pre-frail	2.19	1.43-3.33	.0003	1.34	0.95-1.89	0.10
Frail	3.54	1.43-8.79	.006	3.10	1.64-5.86	.0005

SOF = Study of Osteoporotic Fractures (Ensrud et al., 2008)

CHS = Cardiovascular Health Study (Fried et al., 2001)

CI = confidence interval

Adjusted for age, gender, race, diabetes, stroke, hypertension, hyperlipidemia, education and income.

Table 5

Odds ratios and 95% confidence intervals estimating the association between frailty (two indexes) and IADL disability. Indicator (dummy) variables represent pre-frail and frail groups relative to robust.

	IADL Disability					
	SOF Frailty Index (N=765)			CHS Frailty Index (N=760)		
	Odds Ratio	CI 95%	P-value	Odds Ratio	CI 95%	P-value
Unadjusted						
Pre-frail	3.66	2.44-5.49	.0001	3.62	2.37-5.53	.0001
Frail	7.32	3.51-15.25	.0001	11.75	6.68-20.67	.0001
Adjusted						
Pre-frail	2.88	1.81-4.58	.0001	2.73	1.69-4.40	.0001
Frail	5.38	2.34-12.35	.0001	7.68	4.01-14.74	.0001

IADL = Instrumental Activities of Daily Living

SOF = Study of Osteoporotic Fractures (Ensrud et al., 2008)

CHS = Cardiovascular Health Study (Fried et al., 2001)

Disability = A lot of difficulty or an inability to do 1 or more instrumental activities of daily living

CI = confidence interval

Adjusted for age, gender, race, diabetes, stroke, hypertension, hyperlipidemia, education and income.