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Cognitive Status, Body Mass Index and Hip Fracture in Hispanic Older Adults

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Abstract

Background—Poor cognition and low body weight are independent predictors of hip fracture in older persons.

Objective—Examine the interactive effect of cognition and body weight on hip fracture.

Design—A 7-year (1993 – 2000) prospective cohort study.

Setting—Five southwestern states (Texas, New Mexico, Arizona, Colorado, and California).

Participants—Non-institutionalized Mexican Americans (n = 2,653) 65 years or older, hip fracture free at baseline interview.

Measurements—Incidence of hip fracture at 2-, 5- and 7-year follow-up interviews. Body weight and cognition were measured with the body mass index (BMI) and Mini-Mental State Exam (MMSE), respectively. Covariates included sociodemographics, self-reported medical conditions, visual acuity and Short Physical Performance Battery.

Results—A significant interaction between BMI and hip fracture was found in persons with cognitive impairment (HR = 0.91; 95% CI = 0.85 – 0.98; $p = 0.02$), after adjusting for covariates. In the lowest BMI category, the hip fracture rate in cognitively impaired subjects was more than four times the hip fracture rate for non-cognitively impaired subjects with the same BMI (34.6% vs. 8.7%). Hip fracture rates in the highest BMI category were similar in persons with and without cognitive impairment (9.3% versus 6.1%).

Conclusion—Low cognitive function increased the conditional association between BMI and hip fracture in Mexican American older adults. The relationship between BMI and cognition is potentially important in identifying persons at risk for hip fracture and support the need to include cognitive and anthropometric measures in the assessment of hip fracture risk into osteoporosis screening programs.

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Keywords

aging; dementia; disability; fracture; minority health

Introduction

It is well-established that hip fractures increase with age. By age 90, one-third of women and one-sixth of men in the U.S. will experience a hip fracture.¹ The incidence of hip fracture is projected to increase dramatically in the next 20 years (US Bureau of the Census, 2000). The increase will be most evident among persons 85 years and older. This is the fastest growing segment of the U.S. population.² By 2040, the number of hip fractures will exceed 500,000.³

Less than 40% of patients experiencing a hip fracture recover their pre-fracture mobility.⁴ One-year mortality rates are also high, ranging from 15 to 20 percent⁵ and life expectancy is decreased by almost 2 years among those aged 80 or older.⁶ The estimated per patient cost of hip fracture ranges from \$19,335 to \$66,000 (1995 dollars).⁷

Risk factors for hip fracture include age, female gender, chronic medical conditions, heredity, smoking, medications and impaired visual function.^{8,9} These factors are associated with falls or loss of bone mineral density (BMD) in older adults. Weight loss and poor cognition are also predictors of hip fracture. In a prospective case-controlled study,¹⁰ a significant association between low body mass index (BMI) and hip fracture was found. An association has also been reported between low cognitive function and hip fracture. In a large community-based study of adults 75 and older, Guo and colleagues¹¹ reported the risk of hip fracture was twofold higher among persons identified as cognitively impaired.

The possible interactive effect of BMI and cognition on hip fracture risk has not been examined. It is not known, for instance, if good cognitive function modulates the risk of hip fracture among underweight older adults. The purpose of this study was to examine evidence of an association between cognition and body weight on hip fracture risk using data from a large cohort of community-living Mexican American older adults. The aims were to determine the association between body weight and hip fracture, and examine whether cognition modified this association. We hypothesized that low BMI would be associated with increased risk of hip fracture in Mexican American older adults and this association would be moderated by cognitive function over a 7-year follow up.

Method

Sample

Data were obtained from the Hispanic Established Population for the Epidemiologic Study of the Elderly (H-EPESE), a longitudinal, population-based study of non-institutionalized Mexican Americans aged 65 and over, residing in five southwestern states: Texas, California, New Mexico, Colorado and Arizona.¹² Individuals were selected by a multistage area probability cluster sample design that involved the selection of counties, census tracts and households. Initially, counties were selected if at least 6.6% of the population was Mexican American. In the second stage, census tracts from the 1990 U.S. census counts were selected with a probability proportional to the size of their older (age 65+) population. In the third stage, census blocks were randomized to obtain at least 400 households within each census tract. The sample represented approximately 500,000 Mexican Americans aged 65 and older living in the southwest. The Institutional Review Board of University of Texas Medical Branch, Galveston, Texas, granted approval of the study.

Informed consent was obtained from participants and in-home interviews were completed in Spanish or English by trained, bilingual interviewers. The total number of individuals surveyed at baseline was 3,050, with 2,873 interviewed in person and 177 (5.8%) by proxy.¹³ The response rate at baseline (1993/1994) was 83%.

The current study included individuals who were interviewed in-person, with complete information on the primary variables of interest, and who did not report a physician diagnosis of hip fracture at the baseline interview ($n = 2,653$). At the end of the 7-year follow up, 1,525 subjects were re-interviewed, 434 (16.4%) subjects refused to be re-interviewed or were lost to follow up, and 694 (26.2%) subjects were confirmed dead through the National Death Index (NDI) and reports from relatives. Subjects who refused to be re-interviewed or were lost to follow up did not significantly differ from the current sample by sociodemographic characteristics including age, sex, marital status or years of schooling, or by number of medical conditions.

Measures

Outcome

Hip Fracture: Incidence of hip fracture was assessed over a 7-year follow up period. Individuals were asked if they had a physician diagnosis of hip fracture since the last interview. If the response was positive, follow-up questions were asked regarding hospitalization and related services. At the 2, 5, and 7-year follow-up assessment interview, 30, 31, and 47 first-time hip fractures were reported, respectively. Main Independent Variables

Cognitive Function: Cognition was assessed using the *Mini Mental State Exam* (MMSE). The MMSE is one of the most frequently used cognitive screening measures in studies of older adults.¹⁴ The English and Spanish versions of the MMSE were adopted from the Diagnostic Interview Scale (DIS) used in previous community surveys.¹⁵ The MMSE has a potential range of 0 to 30, with lower scores indicating poorer cognitive status. The MMSE was used both as a continuous and categorical variable (< 21 and $= 21$), based on previously established cut-points in older Mexican Americans.¹⁶ Individuals with MMSE scores < 21 were classified as low cognitive status and those with MMSE scores $= 21$ as high cognitive status.

Body Mass Index: Body Mass Index (BMI) was computed by dividing weight in kilograms by height in meters squared. The BMI was used as a continuous variable and as a categorical variable, based on previously established criteria. Four BMI categories were created: underweight ($< 22 \text{ kg/m}^2$), normal weight ($22 \text{ to } < 25 \text{ kg/m}^2$), overweight ($25 \text{ to } < 30 \text{ kg/m}^2$) and obese ($= 30 \text{ kg/m}^2$).¹⁷

Covariates—Baseline sociodemographic variables included age, gender, marital status (married and unmarried), smoking status (current, former, or never), and education (0 to 6, 7 to 11 and 12 or more years). The presence of various medical conditions was assessed with a series of questions asking subjects if they had ever been told by a doctor that they had diabetes, heart attack, stroke or arthritis. A summary scale was created by summing the four medical conditions (range 0–4). A modified Snellen test using directional Es assessed distant visual acuity.¹⁸ Four visual categories were created and included individuals who were functionally blind ($> 20/200$), severely impaired ($> 20/60$ to $20/200$), moderately impaired ($> 20/40$ to $20/60$), and those with adequate vision ($\geq 20/40$). Lower extremity function was tested using the Short Physical Performance Battery (SPPB), which is comprised of three lower-body activities, a timed 4-meter walk, rising from a chair 5 times, and a hierarchical standing balance task.¹⁹ Performance on each lower body activity was classified on a scale ranging from 0 to 4, and when summed, the overall summary performance measure was scored from 0 to 12, where higher scores represented better lower-extremity functioning. The reliability of the

assessment has been established with inter-rater and test-retest values ranging from .84 to .96.¹⁹

Statistical Analysis

Sociodemographic, health-related and functional status variables were examined using descriptive and univariate statistics. Chi-square analysis assessed the number and percent of individuals who experienced a hip fracture over the 7-year follow-up period. The BMI cognition interaction, in relation to hip fracture, was tested using Cox proportional hazard models with and without adjustment for relevant risk factors. Model assumptions for the survival analysis were tested and met. All analyses used the SAS statistical software package version 9.0. (SAS Institute, Inc. Cary, North Carolina).

Results

Of the 2,653 study participants, 57.90% were female, 56.5% were married, 41.3% were current smokers, 73.5% reported 0 to 6 years of schooling, and the mean age was 72.5 ($\pm$ SD 6.3). Self-reported arthritis (39.5%) and diabetes (27.1%) were the most common medical conditions. Adequate distant vision was found in 85.4%. Mean SPPB score was 6.93 ($\pm$ SD 3.19).

Table 1 shows the baseline characteristics of the sample stratified by low and high MMSE score (< 21 and ≥ 21). Older age, unmarried, fewer years of schooling, visual impairment, stroke and lower SPPB score were significantly associated ($p < .05$) with lower MMSE score (< 21). Non-significant associations with MMSE score were found for gender, smoking status, and number of medical conditions.

Next, the interaction effect between BMI and cognition on hip fracture was tested. Unadjusted results showed a significant interaction between the continuous BMI and MMSE variables ($p = .02$). Figure 1 shows the interaction between the 4-level BMI measure and low (< 21) and high (≥ 21) MMSE scores on hip fracture incidence. Low MMSE scores were associated with a higher risk of hip fracture across each of the 4 BMI levels. The largest difference was observed in the underweight (BMI < 22) category. For individuals classified with higher MMSE scores, the association between BMI and hip fracture was similar ranging from 8.7% in the underweight group (BMI < 22) to 6.1% in the obese group (BMI ≥ 30). For individuals classified with lower MMSE scores, the association between BMI and hip fracture was statistically significantly ($p < .001$), ranging from 34.6% in the underweight group to 9.3% in the obese group.

Table 2 shows the association between BMI and hip fracture by lower and higher MMSE scores, with adjustment for demographic and health factors. In Model 1, each 1-unit increase in BMI was associated with 9% decreased risk of hip fracture (HR = 0.91; 95% CI = 0.85 – 0.98) for persons with lower MMSE scores. In Model 2, a non-significant association was found between BMI and hip fracture (HR = 0.98; 95% CI = 0.94 – 1.03) for persons in the higher MMSE group.

Discussion

We found cognition modified the association between BMI and hip fracture in a large cohort of community-living older Mexican Americans over a 7-year follow-up period. Though underweight (BMI < 22) individuals were at the greatest risk for hip fracture, the risk was greater among persons with lower MMSE (< 21) scores. For persons in the higher and lower MMSE groups, higher BMI was associated with a lower risk of hip fracture. Among those categorized as obese (BMI ≥ 30) the risk of hip fracture was approximately equal.

Previous studies have reported an inverse relationship between body weight and risk of hip fracture.^{9,10,20} Ensrud et al.²⁰ found a 10% loss in weight significantly increased the risk of hip fracture in persons over 65 years. In a study of older non-Hispanic white women, Grisso et al. (1991) found higher BMI significantly reduced the risk of hip fracture. These studies, however, did not analyze whether cognition modulates the risk of hip fracture among underweight older adults.

Several mechanisms have been proposed to explain the association between BMI and hip fracture. One hypothesis suggests that low weight may be a marker of underlying clinical conditions, including declining physical health status, frailty, subclinical disease or chronic inflammation, all of which may increase the risk of falls and fractures. Another hypothesis suggests that being underweight is associated with loss of bone mineral density, which in turn increases the risk of hip fracture. Numerous studies have found higher bone mineral density among heavier individuals; and conversely lower bone mineral density among those who are underweight.^{21,22}

Our results confirm low BMI is a marker for hip fracture in older Mexican American adults; however, BMI may need to be considered in combination with other potential risk factors including cognitive ability, where the incidence of hip fracture, especially in older adults, is high. In a study of older women with poor cognition, the hip fracture rate was 70 per 1000 patient-years compared with a rate of 3 per 1000 patient-years for a reference population aged between 70 and 79 years.²³ When we stratified our analysis by MMSE scores, a modest association was found between BMI and hip fracture for persons in the higher MMSE group. In contrast, a strong association between BMI and hip fracture was found among persons in the lower MMSE group.

Low cognition has been shown to compromise the adaptive and coping ability of older adults to environmental demands or medical stressors. This lack of ability to adapt may translate into less physical activity, poor adherence to treatment regimen, and poor motivation to engage in healthy lifestyles. Malnutrition, especially common in older cognitively impaired adults²⁴, can lead to metabolic disturbances such as negative calcium balance and promote osteoporosis. On the other hand, our findings suggest that cognitively impaired older adults who maintain good mobility function may reduce their risk of hip fracture. This finding is of interest and warrants further study, as it offers the possibility that exercise intervention programs (e.g., balance or strength training) designed for underweight older adults in cognitive decline may protect against hip fracture.

The investigation has the following strengths. We collected longitudinal information from a large, well-defined sample representative of 500,000 Mexican Americans in the southwestern United States. The reliability and consistency of the data collection procedures in the Hispanic EPESE investigation are well established. Our sample included both men and women whereas, many previous studies on risk factors for hip fracture have focused on non-Hispanic white women.

There were limitations to the study, we did not have access to medical records or x-rays to confirm the occurrence of hip fracture; however, previous research has reported good validity for self-reported medical conditions confirmed by physician diagnosis.²⁵ Because this was a community-based study, no information was available on institutionalized older Mexican Americans. The relation between low body weight and cognition may be particularly important for institutionalized individuals who are at highest risk for diminished cognition and also at high risk for hip fracture.²⁶ Finally, no measure of falls was included in the first three waves of the H-EPESE database. Future studies are needed to examine the possible moderating effect

falls may have on the association between BMI and hip fracture among those with declining cognitive abilities.

Our findings also suggest the need to look at predisposing factors in combination and to include cognitive and anthropometric measures in the assessment of hip fracture risk into osteoporosis screening programs. Additional research is necessary to verify these findings and to begin examining whether nutritional or other intervention programs can reduce the risk of hip fracture in older adults, particularly among those with reduced cognition.

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Author Contributions:

Ana Alfaro-Acha: Concept, analysis of data, interpretation of data and preparation of manuscript.

Glenn V. Ostir: Writing original and revising drafts of manuscript, contributed to data analysis and interpretation of data.

Kyriakos S. Markides: Contributed to revisions of manuscript, interpretation of data, and funding.

Kenneth J. Ottenbacher: Concept and hypothesis development, revising manuscript, and interpretation of data.

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Figure 1.
Percent of hip fractures over seven years by MMSE score and BMI.

Table 1
Demographic and selected health characteristics by MMSE score (N = 2,653).

Baseline Characteristic	MMSE		p-value
	Low (< 21) N (%)	High (≥ 21) N (%)	
Overall	389 (14.7)	2264 (85.3)	
Age			
65–74	182 (10.1)	1621 (89.9)	.0001
75–84	155 (21.9)	552 (78.1)	
≥85	52 (36.4)	91 (63.6)	
Sex			.19
Male	152 (13.6)	965 (86.4)	
Female	237 (15.4)	1299 (84.6)	
Marital Status			.0001
Married	163 (10.9)	1335 (89.1)	
Unmarried	226 (19.6)	929 (80.4)	
Education (years)			.0001
0–6	345 (17.9)	1583 (82.1)	
7–11	27 (6.1)	418 (93.9)	
≥12	6 (2.4)	244 (97.6)	
Smoking Status			.11
Current	175 (16.0)	920 (84.0)	
Former/Non	214 (13.7)	1344 (86.3)	
Vision Scale			.0001
Functionally blind	63 (48.8)	66 (51.2)	
Severely impaired	36 (37.1)	61 (62.9)	
Moderately impaired	31 (18.1)	140 (81.9)	
Adequate vision	259 (11.5)	1997 (88.5)	
Medical Conditions			.23
0	155 (14.1)	944 (85.9)	
1	153 (14.3)	915 (85.7)	
≥ 2	81 (16.7)	405 (83.3)	
SPPB			.0001
0–3	135 (33.2)	272 (66.9)	
4–6	84 (13.5)	538 (86.5)	
7–9	112 (10.8)	926 (89.2)	
10–12	58 (9.9)	528 (90.1)	

MMSE = Mini Mental State Exam

SPPB = Short Physical Performance Battery

Medical Conditions = heart attack, stroke, diabetes, and arthritis

Table 2

Multivariate analysis assessing risk of hip fracture, over a 7-year period, in cognitive and non-cognitive impaired older Mexican-Americans hip fracture free at baseline interview, adjusting for relevant risk factors (N = 2,653).

	Hip Fracture			
	Model 1 MMSE < 21 (N = 389) Hip Fracture events = 28		Model 2 MMSE ≥ 21 (N = 2,264) Hip Fracture events = 80	
	HR	95% CI	HR	95% CI
BMI (Kg/m ²)	0.91	0.85 – 0.98	0.98	0.94 – 1.03
Age (years)	1.03	0.97 – 1.10	1.03	0.99 – 1.07
Female	1.05	0.43 – 2.58	1.45	0.85 – 2.49
Unmarried	1.39	0.59 – 3.28	0.90	0.55 – 1.47
Current Smoker	1.20	0.53 – 2.71	0.81	0.49 – 1.34
Vision Scale	1.05	0.74 – 1.49	1.08	0.74 – 1.59
SPPB (0 – 12)	0.89	0.79 – 1.00	0.94	0.87 – 1.02
Medical conditions (0 – 4)	0.82	0.47 – 1.41	1.30	1.00 – 1.68

MMSE = Mini Mental State Exam

BMI = Body Mass Index

SPPB = Short Physical Performance Battery

Medical conditions = heart attack, stroke, diabetes, and arthritis

HR = Hazard Ratio; CI = Confidence Interval