

Handgrip Strength and Cognitive Decline in Older Mexican Americans

Ana Alfaro-Acha,^{1,10} Soham Al Snih,^{2,3} Mukaila A. Raji,^{3,4,5,6} Yong-Fang Kuo,^{6,7}
Kyriakos S. Markides,⁸ and Kenneth J. Ottenbacher⁹

¹Pan American Health Organization/World Health Organization Collaborating Center on Aging and Health,

²Rehabilitation Sciences Division at the School of Allied Health Sciences, ³Sealy Center on Aging,

⁴Memory Loss Clinics, ⁵Geriatric Fellowship Training Program, ⁶Department of Internal Medicine,

⁷Geriatrics Division, ⁸Preventive Medicine and Community Health, and

⁹Division of Rehabilitation Sciences at University of Texas Medical Branch, Galveston.

¹⁰Division of Geriatric Medicine, Hospital Virgen del Valle, Complejo Hospitalario de Toledo, Spain.

Background. Cognitive decline and dementia are associated with disability and premature death in old age. We examined whether low handgrip strength predicts subsequent cognitive decline in older Mexican Americans.

Methods. We worked with a 7-year prospective cohort of 2160 noninstitutionalized Mexican Americans aged 65 years or older from the Hispanic Established Population for the Epidemiological Study of the Elderly (H-EPESE) who had a Mini-Mental State Examination (MMSE) score ≥ 21 at baseline. Measures included: (i) sociodemographic factors (age, gender, and education), handgrip strength, and near and distant visual impairment from baseline interview; and (ii) MMSE, body mass index (BMI), and medical conditions (stroke, heart attack, diabetes, depression, and hypertension) from four waves of data collection.

Results. Using general linear mixed models, we found a significant trend with scores in the lowest quartile of handgrip strength at baseline to be associated with lower MMSE scores over time (estimate = -1.28 , standard error = 0.16 ; $p < .0001$). There was a significant handgrip Strength-by-Time interaction with MMSE scores. Participants in the lowest handgrip strength quartile had a greater cognitive decline over time (estimate = -0.26 , standard error = 0.07 ; $p < .001$) than did those participants in the highest quartile. This association remained statistically significant after controlling for potential confounding factors.

Conclusion. Older Mexican Americans with reduced handgrip strength at baseline demonstrated a statistically significant decline in cognitive function over a 7-year period. By contrast, participants in the highest handgrip strength quartile maintained a higher level of cognitive function.

LONGITUDINAL community studies have demonstrated that individuals with memory complaints or mild cognitive impairment have a more than 50% chance of developing clinical dementia over a 4-year period (1). As a result, recent research has focused on identifying risk factors that are prognostic of future cognitive decline. Several studies have found that older age, lower education, self-reported physical health, lower income, poor sensory functioning, reduced activity level, and chronic health conditions including hypertension, stroke, diabetes, and depression are associated with cognitive decline (2–7).

Handgrip strength is also associated with individual differences in cognitive performance in cross-sectional studies of elderly adults (8,9). Anstey and Smith (8) reported that noncognitive markers, such as grip strength, explained differences in cognitive performance in 180 women aged 60–90 years. The idea of using noncognitive markers in models of cognitive aging was introduced by Birren and Cunningham (10). The nature of the association between muscle strength and cognition is still uncertain, but one of the most remarkable hypotheses has been the “brain-related common cause,” which suggests that noncognitive variables (such as muscle strength) are related to cognitive variables because they also have central nervous system involvement.

Measures of muscle strength may be viewed as a general indicator of the integrity of the central nervous system as well as being sensitive to the aging process (11,12). What is unclear is whether noncognitive markers may also predict changes in cognitive function over time. Could reduced muscle strength be an early marker of a generalized decrease in nervous system processing with age that is reflected later in cognitive function? Conflicting results have been reported when data from longitudinal studies have been analyzed to determine whether handgrip strength was a predictor of cognitive decline (13–15). Albert and colleagues (13) did not find a significant association between handgrip strength and cognitive change over a 2.5-year period in 1192 older adults. By contrast, MacDonald and colleagues (15) reported that grip strength was associated with change in cognitive performance in 125 elderly persons over a 12-year period.

The theoretical rationale for this study is based on several considerations. First, it is still not known whether individuals who show marked decline in handgrip strength are at increased risk of subsequent cognitive decline over time. Second is the fact that cognitive functioning is vitally important for successful aging and independent living. Therefore, the identification of individuals at risk for

cognitive decline provides the opportunity to begin early therapeutic interventions to prevent further cognitive deficit. Finally, the third reason is the fact that no previous studies have addressed the potential confounding effects of ethnicity. Rantanen and colleagues have demonstrated that muscle strength differs in disabled elderly women by race (16). Similarly, using data from the Hispanic Established Population for the Epidemiological Study of the Elderly (H-EPESE) survey (4,17,18) we demonstrated that some factors that predict cognitive decline in Hispanic elderly persons appear to be different than those factors in non-Hispanic elderly persons (19,20). Older age, low education, living with others, and certain medical conditions has been shown to be predictors of cognitive deterioration among Hispanic elderly persons. To our knowledge, however, handgrip strength has not been analyzed over time as a potential predictor of cognitive decline in noncognitively impaired older Mexican Americans.

The purpose of this analysis was to examine whether lower handgrip strength predicts decline in cognitive function over a 7-year period in a large cohort of older Mexican Americans. We hypothesized that lower handgrip strength would be associated with higher risk of cognitive decline and that higher handgrip strength would be associated with preservation of cognitive function over a 7-year period.

METHODS

Sample and Procedures

Data used are from the H-EPESE, a longitudinal study of Mexican Americans 65 years old or older, residing in Texas, New Mexico, Colorado, Arizona, and California. The sample and its characteristics have been described elsewhere (21,22). At the time of baseline (1993–1994) 2873 participants (94.2%) were interviewed in person and 177 (5.8%) were interviewed by proxy. The present study used baseline data and data obtained at 2-, 5-, and 7-year follow-up assessment.

Of the 3050 individuals interviewed at baseline, 449 had a Mini-Mental State Examination (MMSE) < 21 (15.7%) and 2403 had an MMSE score \geq 21 (84.3%). We excluded from the analysis 395 persons due incomplete data on handgrip strength, 198 due missing values in MMSE, and 171 persons due incomplete data on covariates. Persons excluded were significantly more likely to be older; to have ever had a heart attack, stroke, diabetes, near or distant vision impairment; and to have lower levels of education, low body mass index (BMI), and low handgrip strength. Thus, the final sample consisted of 2160 participants with complete data on handgrip strength, MMSE \geq 21 at baseline, and complete data on all covariates. At the end of the 7-year follow-up, 1303 were reinterviewed, 89 participants refused to be reinterviewed, 228 participants were lost to follow-up, and 540 participants were confirmed dead through the National Death Index (NDI) and reports from relatives. Of the 395 participants without handgrip strength data, 177 were interviewed via proxy, 69 had arm surgery, 66 refused to perform the task, 65 felt the procedure was

unsafe, and 18 had missing values on the handgrip strength measure.

Measures

Grip strength test.—Using a handheld dynamometer (Jaymar Hydraulic Dynamometer, model 5030J1; JA Preston Corp., Clifton, NJ), handgrip strength was measured in kilograms at baseline (1993–1994) as described elsewhere (23,24). The test was administered by a trained interviewer, and two trials were performed with the higher of the two handgrip scores used for scoring purposes. Because of gender differences in muscle strength, the analysis was conducted separately for men and women (25–27). Scores were divided into approximate quartiles, separately, for men and women. For men, grip strength of <22.00 kg received a score of 1, 22.01–30.00 kg a score of 2, 30.01–35.00 kg a score of 3, and \geq 35.01 kg a score of 4. For women, grip strength of <14.00 kg received a score of 1, 14.01–18.20 kg a score of 2, 18.21–22.50 kg a score of 3, and \geq 22.51 kg a score of 4. The handheld dynamometer has been shown to be a reliable and valid instrument in older persons (28,29).

Cognitive function.—Cognitive function was assessed with the MMSE (30). Interviewers fluent in both English and Spanish conducted all interviews. The choice of language depended on the respondent's preference (22.2% of the interviews were conducted in English and 77.8% in Spanish). Interviewers were thoroughly trained in administering and scoring the MMSE, through both workshops and videotaped instruction. The English and Spanish versions of the MMSE were adopted from the Diagnostic Interview Scale (DIS) used in prior community surveys (31). This Spanish version of the MMSE has met standard criteria for development of translated tests, including formal translation, back-translation, and consensus by committee for final item content. Additionally, the Spanish MMSE has been successfully used in community surveys of Mexican Americans (32). Owing to reported poor item equivalency, however, the serial-sevens item was not used in the present version. As has been recommended in the literature (33), responses of “don't know” and refusals were counted as errors. Scores range from 0 to 30, with lower scores indicating poorer cognitive ability. We divided the MMSE score based on two factors: the distribution in the 2731 participants at baseline assessments (34) and the cut points from past aging research in minority populations. We used MMSE score as a dichotomized variable (<21 for poor cognition vs \geq 21 for good cognition), a cut point frequently used in past studies in cognitive aging research among populations with low educational attainment and low English literacy (31,35–38). In the current study, only participants with an MMSE score of \geq 21 at baseline were included in the analysis.

Covariates.—Baseline sociodemographic variables included age, gender, and years of education. The presence of various medical conditions was assessed with a series of questions asking participants if they had ever been told by a doctor that they had diabetes, heart attack, stroke, or

Table 1. Baseline Characteristics of the Sample ($N = 2160$)

Explanatory Variables	N (%)
MMSE, mean \pm SD	26.2 \pm 3.0
Age, mean \pm SD	71.9 \pm 5.9
Gender	
Female	1242 (57.5)
Male	918 (42.5)
Marital status (married)	1,275 (59.0)
Education, mean \pm SD	5.3 \pm 3.9
Body mass index (kg/m^2), mean \pm SD	28.0 \pm 5.2
Handgrip strength (kg), mean \pm SD	
Women	18.9 \pm 6.2
Men	29.2 \pm 9.3
Handgrip strength (kg) quartiles	
Women, n (%), mean \pm SD	
I (<14.00 kg)	271 (21.8), 10.6 \pm 2.2
II (14.01–18.20 kg)	300 (24.2), 16.4 \pm 1.1
III (18.21–22.50 kg)	347 (27.9), 20.5 \pm 1.2
IV (\geq 22.51 kg)	324 (26.9), 26.8 \pm 3.2
Men, n (%), mean \pm SD	
I (<22.01 kg)	217 (23.6), 16.0 \pm 4.3
II (22.01–30.00 kg)	238 (25.9), 27.1 \pm 2.3
III (30.01–35.00 kg)	222 (24.2), 32.7 \pm 1.5
IV (\geq 35.01 kg)	241 (26.3), 40.1 \pm 3.6
Stroke	103 (4.8)
Heart attack	216 (10.0)
Diabetes	492 (22.8)
Depression (CES-D \geq 16), mean \pm SD	9.1 \pm 9.0
Hypertension	911 (42.2)
Near vision impairment	199 (9.2)
Distant vision impairment	101 (4.7)

Note: SD = standard deviation; MMSE = Mini-Mental State Examination; CES-D = Center for Epidemiologic Studies Depression Scale.

hypertension. BMI was computed as weight in kilograms divided by height in meters squared. Depressive symptomatology was measured with the Center for Epidemiologic Studies Depression Scale (CES-D) (39). We considered persons scoring ≥ 16 to experience high depressive symptomatology (40). Covariates other than age, gender, and education were collected at baseline and at each follow-up interview.

Near vision acuity was measured using a card with seven-digit “telephone numbers” of three different type sizes: 7-, 10-, and 23-point (41). Participants were allowed to hold the card at a comfortable distance for reading, but they were prohibited from holding the card closer than 7 inches from their eyes. The participants were asked to read the smallest size numbers, and if errors were made on any digits, a second trial was performed with the same size. If any digits were incorrect on the second trial, then the participant was tested for the larger size type, and so forth with the three type sizes. Participants who could read only the 10- or 23-point type size or who were unable to read the 23-point type size were considered to have near vision impairment, and participants who could read all seven digits correctly were considered to have an adequate near vision (41). Distance visual acuity was measured using a modified Snellen test using directional Es at 4 m to estimate acuity from 20/40 to

20/200; if visual acuity was greater than 20/200, a participant was classified as being functionally blind (41). Participants who could read only Es of 20/60 or greater were considered to have distance vision impairment, and participants who could read 20/40 or less were considered to have adequate distance vision. Near and distant vision acuity were collected only at baseline and at 2-year follow-up.

Statistical Analysis

Analysis of variance and post hoc Tukey test were used to examine the distribution of MMSE scores by handgrip muscle strength quartiles at baseline. General linear mixed model using the MIXED procedure in SAS (SAS Institute, Cary, NC) was used to examine the factors associated with decline in cognitive function over a 7-year period as a function of handgrip muscle strength. All the variables were analyzed as time-dependent covariates (potential to change as time progresses) except the variables of age, gender, and education. Mixed model was chosen for analysis of the H-EPESE data for several reasons. First, the model best accounted for missing or incomplete observations, thus enabling us to use all available information. Second, it allowed for modeling of time-dependent change in our variables as well as time-dependent change in the magnitude of association between the variables. Finally, because H-EPESE data included repeated measures over 7 years, mixed models allowed us more flexibility in modeling the effects of time on our outcome (42,43).

Three mixed models were constructed to test the relationship between handgrip muscle strength and cognitive decline over a 7-year period. Model 1 included time, age, gender, marital status, years of formal education, BMI, and handgrip strength. In Model 2, an interaction term (Handgrip Strength Quartiles * Time) was added to estimate the effect of handgrip strength on the rate of change on cognitive function (slope) over time. The time interactions represent the estimated effect of handgrip strength on the annual rate of change in cognitive function. In Model 3, we added stroke, heart attack, hypertension, diabetes, high depressive symptoms, and near and distant vision impairment. We also analyzed handgrip strength as a continuous variable to investigate if there was a gradient of risk on cognitive decline. Additional analyses were performed treating handgrip strength as a time-dependent covariate to investigate if change in handgrip strength predicts change in cognitive function over time. All analyses were performed using the SAS System for Windows (version 9.1.3; SAS Institute).

RESULTS

Table 1 presents baseline characteristics of the sample. The mean age was 71.9 years (standard deviation [SD] = 5.9), 57.5% were women, and 59% were married. The mean number of years of formal education was 5.3. The mean handgrip strength for men was 29.2 kg (SD = 9.3) and for women was 18.9 kg (SD = 6.2). Self-reported hypertension (42.2%), diabetes (22.8%), and heart attack (10%) were the most common medical conditions.

Table 2 shows the general linear mixed models estimates for MMSE score as a function of handgrip strength quartiles

over a 7-year period. In Model 1, the rate of decline in cognitive function was 0.72 points per year. There was a significant association between the first quartile (lowest) of handgrip strength (at baseline) and a lower MMSE score at each follow-up after adjusting for age, gender, marital status, education, BMI at baseline, and time. Model 2 tests for the interaction between handgrip strength quartile and time of follow-up (slope of MMSE score over time). There were significant interactions in participants with poor handgrip strength (quartiles I and II) indicating that participants with lower handgrip strength had a significantly greater decline in MMSE score over time compared with participants in the highest quartile (IV). The parameter estimates were -0.26 points per year ($SE = 0.07$; $p < .001$) for participants in quartile I (lowest) and -0.28 points per year ($SE = 0.06$; $p < .0001$) for those in quartile II compared with participants in quartile IV (strongest). In Model 3, after controlling for all covariates, the interaction terms remained statistically significant. The association between Handgrip Strength-by-Time interaction (quartiles I, II, and III) and decline in the cognitive status over time remained statistically significant after controlling for all covariates. Other factors such as older age, stroke, high depressive symptoms, and distant vision impairment were associated with decline in MMSE score. Higher levels of education and being female were associated with lower decline in MMSE scores. The parameter estimate for MMSE score as a function of handgrip strength analyzed as a continuous variable was 0.07 points ($SE = 0.01$, $p < .0001$) in Model 1, and Handgrip Strength-by-Time interaction was 0.01 points ($SE = 0.003$, $p = .01$) after controlling for covariates in Model 3. Predicted MMSE scores at 7 years for each quartile of handgrip strength adjusted for all covariates were 20.60 points for 1st quartile, 20.92 points for 2nd quartile, 22.01 points for 3rd quartile, and 22.87 points for 4th quartile.

Parameter estimates from the analyses of handgrip strength treated as time dependent to investigate if change in handgrip strength predicted change in MMSE score over time were -0.87 points ($SE = 0.16$, $p < .0001$) for 1st quartile, -0.29 points ($SE = 0.15$, $p = .05$) for 2nd quartile, and -0.25 points ($SE = 0.14$, $p = .07$) for 3rd quartile after adjustment for all covariates. Parameter estimates for the interaction between handgrip strength quartile and time of follow-up (slope of MMSE score over time) after adjustment for all covariates were 0.10 points ($SE = 0.05$, $p = .07$) for 1st quartile, 0.15 points ($SE = 0.05$, $p = .002$) for 2nd quartile, and 0.21 points ($SE = 0.05$, $p < .0001$) for 3rd quartile.

Figures 1 and 2 show the unadjusted and adjusted mean distribution of MMSE scores over a 7-year period by handgrip strength quartiles at baseline for men and women. Men and women in the lowest quartile of handgrip strength (I) had significantly lower MMSE scores compared to participants in the highest handgrip strength quartile (IV) during the follow-up period. The slope of MMSE scores in men (Figure 1A) with the lowest quartile of handgrip strength decreased steeply from baseline to the 5-year follow-up and then increased. However, after adjustment for all covariates (Figure 1B), men in the lowest quartile

Table 2. General Linear Mixed Model Estimates for MMSE Score as a Function of Handgrip Strength Quartiles Over a 7-Year Period Among Older Mexican Americans ($N = 2160$)

Explanatory Variables	Model 1 β (SE)	Model 2 β (SE)	Model 3 β (SE)
Intercept	29.06 (0.83)*	28.9 (0.83)*	28.80 (0.82)*
Time	-0.72 (0.02)*	-0.58 (0.04)*	-0.53 (0.04)*
Age, y	-0.06 (0.01)*	-0.06 (0.01)*	-0.05 (0.01)*
Gender, female	0.07 (0.12)	0.07 (0.12)	0.08 (0.12)
Marital status, married	0.16 (0.12)	0.16 (0.12)	0.12 (0.12)
Education, y	0.32 (0.01)*	0.32 (0.01)*	0.32 (0.01)*
Body mass index, kg/m ²	0.0001 (0.01)	0.0002 (0.01)	-0.001 (0.01)
Handgrip strength (kg) quartiles			
I	-1.28 (0.16)*	-1.13 (0.16)*	-1.01 (0.16)*
II	-0.68 (0.15)*	-0.51 (0.16) [†]	-0.46 (0.16) [†]
III	-0.29 (0.15)	-0.22 (0.15)	-0.21 (0.15)
IV	Reference	Reference	Reference
Handgrip Strength (kg)			
Quartile I * Time		-0.26 (0.07) [†]	-0.18 (0.06) [†]
Handgrip Strength (kg)			
Quartile II * Time		-0.28 (0.06)*	-0.21 (0.06) [†]
Handgrip Strength (kg)			
Quartile III * Time		-0.11 (0.06)	-0.09 (0.05)
Handgrip Strength (kg)			
Quartile IV * Time		Reference	Reference
Stroke			-0.33 (0.20)
Heart attack			0.03 (0.16)
Diabetes			-0.002 (0.12)
Depression (CES-D ≥ 16)			-0.50 (0.12)*
Hypertension			0.18 (0.10)
Near vision impairment			-0.37 (0.19)
Distant vision impairment			-1.02 (0.26)*

Notes: * $p < .0001$; [†] $p < .001$.

MMSE = Mini-Mental State Examination; CES-D = Center for Epidemiologic Studies Depression Scale; SE = standard error.

showed a continuing decline in the slope from year 5 to year 7 of follow-up. Of 488 participants in the 1st quartile (lowest), 86 (26.1%) had MMSE scores < 21 at 2-year follow-up, 111 (43.7%) at 5-year follow-up, and 85 (41.7%) at 7-year follow-up.

DISCUSSION

Among initially noncognitively impaired Mexican American older adults, we found a statistically significant trend involving decreased handgrip strength and decline in cognitive function over a 7-year period. The association remained significant after controlling for relevant, potentially confounding variables. Participants in the lowest quartile of handgrip strength at baseline were significantly more likely to show a decrease in cognitive function over a 7-year period compared with participants in the highest (strongest) quartile. Participants in the highest handgrip strength quartile maintained a higher level of cognitive function over a 7-year period.

Our findings are similar to the results from previous studies suggesting a relationship between handgrip strength and cognition (8,9,14,15). For example, Christensen and colleagues (14) reported that weaker handgrip strength was associated with greater variability in memory change in a sample of 426 elderly community dwellers over 3.5 years.

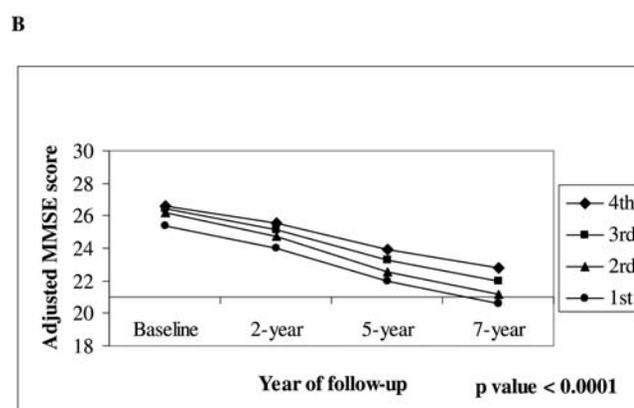
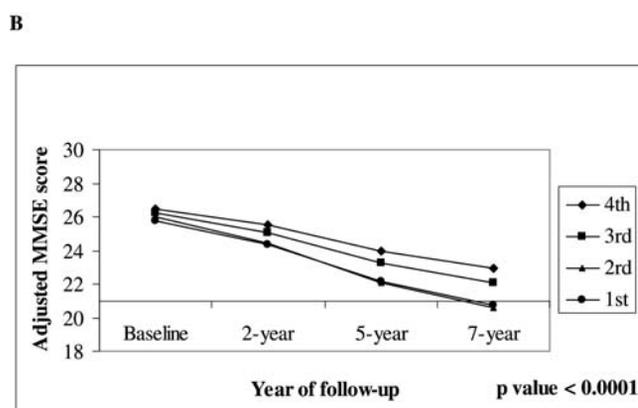
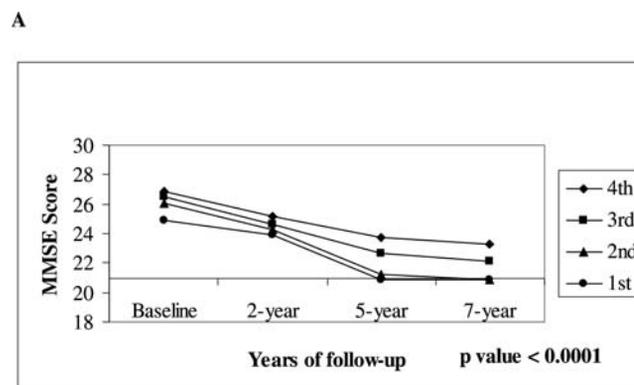
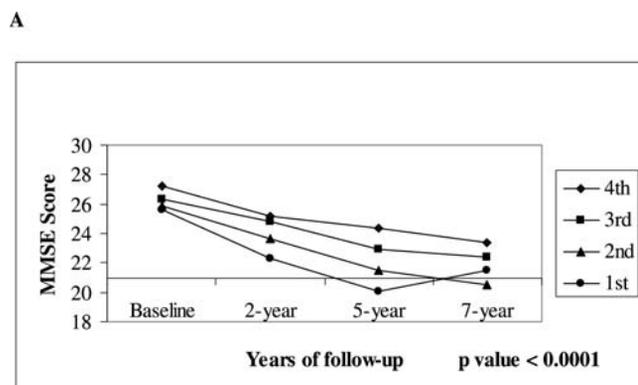


Figure 1. Unadjusted (A) and adjusted (B) means distributions of Mini-Mental State Examination (MMSE) score over a 7-year period by handgrip strength quartiles at baseline in men. In A, 1st = lowest handgrip strength quartile and 4th = highest handgrip strength quartile. In B, 1st = lowest handgrip strength quartile and 4th = highest handgrip strength quartile. Adjusted for age, gender, education, marital status, medical conditions, depression, near and distant vision impairment, and body mass index.

Figure 2. Unadjusted (A) and adjusted (B) means distributions of Mini-Mental State Examination (MMSE) score over a 7-year period by handgrip strength quartiles at baseline in women. In A, 1st = lowest handgrip strength quartile and 4th = highest handgrip strength quartile. In B, 1st = lowest handgrip strength quartile and 4th = highest handgrip strength quartile. Adjusted for age, gender, education, marital status, medical conditions, depression, near and distant vision impairment, and body mass index.

Unlike our findings, those of Albert and colleagues (13) did not show a significant association between a composite measure of physical performance (muscle strength, balance, and gait) and cognitive change over a 2.5-year period in 1192 older adults. One possible reason for the differences in their findings and ours may be our larger sample size and longer follow-up.

Several mechanisms might explain the relationship between handgrip strength and cognition. One possible explanation is that muscle strength may reflect the integrity of nervous system activity. Salthouse (44) demonstrated that slow reaction time was associated with poor cognitive function. More recently, Rosano and colleagues (45) found a significant correlation between poorer physical performance in gait speed, balance, and lower extremity muscle strength and poorer performance in cognitive function in 2893 older adults. Reduced muscle strength may be an early marker of a generalized decrease in nervous system processing with age that is reflected in cognitive function.

Another explanation for the association between low muscle strength and poor cognition functioning is the presence of some shared pathogenic factors like high oxi-

dative stress, high inflammatory markers, and low sex steroid levels that might contribute to both muscle loss and cognitive decline (46–49). For example, Weaver and colleagues (46) reported a significant association between elevated plasma inflammatory markers and risk for subsequent cognitive decline in 779 older adults during a 2.5-year follow-up. Cesari and colleagues (47) reported an inverse relationship between high levels of inflammatory markers and lower handgrip strength in 1020 older adults. These results suggest the presence of a common mechanism shared by cognitive decline and muscle loss with age. However, a critical issue is whether muscle strength decline occurs early in the pathogenesis of cognitive decline and precedes the clinical cognitive stage. We were not able to examine this hypothesis due to the lack of biomarkers in the H-EPESE sample. Further studies that incorporate blood markers are needed to explore this hypothesis.

The identification of early predictors of cognitive decline has important practical implications, especially if the predictors are modifiable. An exercise program that improves muscle strength might also help to prevent or slow cognitive decline in older adults, particularly those

with reduced grip strength. Lower handgrip strength may be an easy way to identify persons most likely to benefit from structured exercise programs. Several randomized controlled trials have demonstrated that exercise programs for older adults improve both physical strength and cognitive function (50,51). Other researchers, however, have found inconsistent results (52). This is an important area for future experimental research.

This study has some limitations in addition to the lack of biomarker data. First, we were limited to self-reports of medical conditions. Second, by including sample participants who were reinterviewed, we are examining the cohort of survivors over a 7-year period. This, theoretically, could lead to an underestimation of the effect of handgrip strength on the onset of decline in cognitive function, particularly for those participants in the lowest quartile. Participants with weaker handgrip strength are more frail and, as a result, may experience the onset of cognitive decline before attrition. This study has several strengths, including its large community sample size, the prospective design, and the 7-year period of follow-up.

Conclusion

This study demonstrated that poor handgrip strength in initially noncognitively impaired Mexican American older adults predicted decline in MMSE scores over a 7-year period, independent of confounding factors. Low handgrip strength may be an early indirect noncognitive marker of subsequent cognitive decline, independent of cultural and educational status. By contrast, higher handgrip strength was associated with a relative preservation of cognitive function over a 7-year period. Further studies are required to understand the possible shared mechanisms that might influence muscle strength and cognitive decline. A better understanding of how muscle strength and cognition are related may give us the opportunity to identify those individuals with early cognitive decline (the prodementia state) who could benefit from intervention programs.

ACKNOWLEDGMENTS

This study was supported by grants AG10939 and AG17638 from the National Institute on Aging and, in part, by the UTMB Center for Population Health and Health Disparities (1P50CA105631-02). Dr. Raji's work is supported by a Bureau of Health Professions' Geriatric Academic Career Award (1 K01 HP 00034-01).

Dr. Alfaro-Acha was a visiting scholar in the PAHO/WHO Collaborating Center on Aging and Health at UTMB during this study.

Address correspondence to Soham Al Snih, MD, PhD, Sealy Center on Aging, The University of Texas Medical Branch, Galveston, TX 77555-0460. E-mail: soalsnih@utmb.edu

REFERENCES

- Petersen RC, Smith GE, Waring SC, Ivnik RJ, Tangalos EG, Kokmen E. Mild cognitive impairment: clinical characterization and outcome. *Arch Neurol*. 1999;56:303–308.
- Butler SM, Ashford JW, Snowdon DA. Age, education, and changes in the Mini-Mental State Exam scores of older women: findings from the Nun Study. *J Am Geriatr Soc*. 1996;44:675–681.
- Christensen H, Jorm AF, Henderson AS, MacKinnon AJ, Korten AE, Scott LR. The relationship between health and cognitive functioning in a sample of elderly people in the community. *Age Aging*. 1994; 23:204–209.
- Reyes-Ortiz CA, Kuo YF, DiNuzzo AR, Ray LA, Raji MA, Markides KS. Near vision impairment predicts cognitive decline: data from the Hispanic Established Population for Epidemiologic Studies of the Elderly. *J Am Geriatr Soc*. 2005;53:681–686.
- Weuve J, Kang JH, Manson JE, Breteler MM, Ware JH, Grodstein F. Physical activity, including walking, and cognitive function in older women. *JAMA*. 2004;292:1454–1461.
- Tilvis RS, Kahonen-Vare MH, Jolkkonen J, Valvanne J, Pitkala KH, Strandberg TE. Predictors of cognitive decline and mortality of aged people over a 10-year period. *J Gerontol A Biol Sci Med Sci*. 2004;59A:268–274.
- Wilson RS, Mendes de Leon CF, Bennett DA, Bienias JL, Evans DA. Depressive symptoms and cognitive decline in a community population of older persons. *J Neurol Neurosurg Psychiatry*. 2004;75:126–129.
- Anstey KJ, Smith GA. Interrelationship among biological markers of aging, health, activity, acculturation, and cognitive performance in late adulthood. *Psychol Aging*. 1999;14:605–618.
- Nourhashemi F, Andrieu S, Gillette-Guyonnet S, et al. Is there a relationship between fat-free soft tissue mass and low cognitive function? Results from a study of 7,105 women. *J Am Geriatr Soc*. 2002; 50:1796–1801.
- Birren JE, Cunningham W. Research on the psychology of aging: principles, concepts and theory. In: Birren JE, Schaie W, eds. *Handbook of the Psychology of Aging*, 2nd Ed. New York: Van Nostrand Reinhold; 1985:3–34.
- Salthouse TA, Hambrick DZ, McGuthry KE. Shared age-related influences on cognitive and noncognitive variables. *Psychol Aging*. 1998;13:486–500.
- Christensen H, Mackinnon AJ, Korten A, Jorm AK. The “common cause hypothesis” of cognitive aging: evidence for not only a common factor but also specific associations of age with vision and grip strength in a cross-sectional analysis. *Psychol Aging*. 2001;16:588–599.
- Albert MS, Jones K, Savage CR, et al. Predictors of cognitive change in older persons: MacArthur Studies of Successful Aging. *Psychol Aging*. 1995;10:578–589.
- Christensen H, Mackinnon AJ, Korten AE, et al. An analysis of diversity in the cognitive performance of elderly community dwellers: individual differences in change scores as a functional age. *Psychol Aging*. 1999;14:365–379.
- MacDonald SW, Dixon RA, Cohen AL, Hazlitt JE. Biological age and 12-year cognitive change in older adults: findings from the Victoria Longitudinal Study. *Gerontology*. 2004;50:64–81.
- Rantanen T, Guralnik JM, Leveille S, et al. Racial differences in muscle strength in disabled older women. *J Gerontol Biol Sci*. 1998;53A:B355–B361.
- Black SA, Espino DV, Mahurin R, et al. The influence of noncognitive factors on the Mini-Mental State Examination in older Mexican-Americans: findings from the Hispanic EPESE. *J Clin Epidemiol*. 1999;52:1095–1102.
- Nguyen HT, Black SA, Ray LA, Espino DV, Markides KS. Predictors of decline in MMSE scores among older Mexican Americans. *J Gerontol Med Sci*. 2002;57A:M181–M185.
- Hohl U, Grundman M, Salmon D, Thomas R, Thal L. Mini-Mental State Examination Mattis Dementia Rating Scale performance differs in Hispanic and non-Hispanic Alzheimer's disease patients. *J Int Neuropsychol Soc*. 1999;5:301–307.
- Mulgrew C, Morgensten N, Shetterly S, Baxter J, Hamman R. Cognitive functioning and impairment among rural elderly Hispanic and non-Hispanic Whites as assessed by the Mini-Mental State Examination. *J Gerontol Psychol Sci*. 1999;54B:P223–P230.
- Cornoni-Huntley J, Brock DB, Ostfeld AM, Taylor JO, Wallace RB, eds. *Established Populations for Epidemiologic Studies of the Elderly, Resource Data Book*. NIH Publication No. 86-2443. Bethesda, MD: National Institutes of Health; 1986.
- Markides KS, Stroup-Benham CA, Black SA, Satish S, Perkowski LC, Ostir G. The health of Mexican American elderly: selected findings from the Hispanic EPESE. In: Wykle M, Ford A, eds. *Planning Services for Minority Elderly in the 21st Century*. New York: Springer; 1999.
- Al Snih S, Markides KS, Ray LA, Ostir GV, Goodwin JS. Hand grip strength and mortality in older Mexican Americans. *J Am Geriatr Soc*. 2002;50:1250–1256.

24. Al Snih S, Markides KS, Ottenbacher KJ, Raji MA. Hand grip strength and incident ADL disability in elderly Mexican Americans over a seven-year period. *Aging Clin Exp Res*. 2004;16:481–486.
25. Baumgartner RN, Waters DL, Gallagher D, et al. Predictors of skeletal muscle mass in elderly men and women. *Mech Ageing Dev*. 1999;107:123–136.
26. Metter EJ, Conwit R, Tobin J, Fozard JL. Age-associated loss of power and strength in the upper extremities in women and men. *J Gerontol Biol Sci*. 1997;52A:B267–B276.
27. Gallagher D, Heymsfield SB. Muscle distribution: variations with body weight, gender, and age. *Appl Radiat Isot*. 1998;49:733–734.
28. Rantanen T, Era P, Heikkinen E. Physical activity and the changes in maximal isometric strength in men and women from the age of 75 to 80 years. *J Am Geriatr Soc*. 1997;45:1439–1445.
29. Peolsson A, Hedlund R, Oberg B. Intra- and inter-tester reliability and reference values for hand strength. *J Rehabil Med*. 2001;33:36–41.
30. Folstein MF, Folstein SE, McHugh PR. “Mini-Mental State.” A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. 1975;12:189–198.
31. Bird HR, Canino G, Rubio-Stipec M, Shrout P. Use of the Mini-Mental State Examination in a probability sample of a Hispanic population. *J Nerv Ment Dis*. 1987;175:731–737.
32. Escobar J, Burnam A, Karno M, Forsythe A, Landsverk J, Golding M. Use of the Mini-Mental Status Examination (MMSE) in a community population of mixed ethnicity: cultural and linguistic artifacts. *J Nerv Ment Dis*. 1986;174:607–614.
33. Fillenbaum L, George L, Blazer D. Scoring nonresponse on the Mini-Mental State Examination. *Psychol Med*. 1988;18:1021–1025.
34. Raji M, Al Snih S, Ray LA, Patel KV, Markides KS. Cognitive status and incident disability in older Mexican Americans. *Ethn Dis*. 2004;14:26–31.
35. Greiner PA, Snowdon DA, Schmitt FA. The loss of independence in activities of daily living: the role of low cognitive function in elderly nuns. *Am J Public Health*. 1996;86:62–66.
36. Leveille SG, Guralnik JM, Ferrucci L, et al. Black/white differences in the relationship between MMSE scores and disability: the Women’s Health and Aging Study. *J Gerontol Psychol Sci*. 1998;53B:P201–P208.
37. Uhlmann RF, Larson EB. Effect of education on the Mini-Mental State Examination as a screening test for dementia. *J Am Geriatr Soc*. 1991;39:876–880.
38. Raji MA, Kuo YF, Al Snih S, Markides KS, Peek MK, Ottenbacher KJ. Cognitive status, muscle strength, and subsequent disability in older Mexican Americans. *J Am Geriatr Soc*. 2005;53:1462–1468.
39. Radloff LS. The CED-S Scale: a self-report depression scale for research in the general population. *J Appl Psychol Meas*. 1977;1:385–401.
40. Boyd JH, Weissman M, Thompson W, Meyers JK. Screening for depression in a community sample. *Arch Gen Psychiatry*. 1982;39:1195–1200.
41. Salive ME, Guralnik J, Christen W, et al. Functional blindness and visual impairment in older adults from three communities. *Ophthalmology*. 1992;99:1840–1847.
42. Liang KY, Zeger SL. Longitudinal data analysis using generalized linear models. *Biometrika*. 1986;73:13–22.
43. Zeger SL, Liang KY. Longitudinal data analysis for discrete and continuous outcomes. *Biometrics*. 1984;40:121–130.
44. Salthouse TA. The processing-speed theory of adult age differences in cognition. *Psychol Rev*. 1996;103:403–428.
45. Rosano C, Simonsick EM, Harris TB, et al. Association between physical and cognitive function in healthy elderly: the Health, Aging and Body Composition Study. *Neuroepidemiology*. 2005;24:8–14.
46. Weaver JD, Huang MH, Albert M, Harris T, Rowe JW, Seeman TE. Interleukin-6 and risk of cognitive decline: MacArthur Studies of Successful Aging. *Neurology*. 2002;59:371–378.
47. Cesari M, Penninx BW, Pahor M, et al. Inflammatory markers and physical performance in older persons: the InCHIANTI study. *J Gerontol A Biol Sci Med Sci*. 2004;59A:242–248.
48. Hogervorst E, Bandelow S, Combrinck M, Smith AD. Low free testosterone is an independent risk for Alzheimer’s disease. *Exp Gerontol*. 2004;39:1633–1639.
49. Szule P, Duboeuf F, Marchand F, Delmas PD. Hormonal and lifestyle determinants of appendicular skeletal muscle mass in men: the MINOS study. *Am J Clin Nutr*. 2004;80:496–503.
50. Hassmen P, Koivula N. Mood, physical working capacity and cognitive performance in the elderly as related to physical activity. *Ageing (Milano)*. 1997;9:136–142.
51. Williams P, Lord SR. Effects of group exercise on cognitive functioning and mood in older women. *Aust N Z J Public Health*. 1997;21:45–52.
52. Emery CF, Gatz M. Psychological and cognitive effects of an exercise program for community-residing older adults. *Gerontologist*. 1990;30:184–188.

Received August 22, 2005

Accepted February 4, 2006

Decision Editor: Luigi Ferrucci, MD, PhD