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Original Study

The Association Between Muscle Weakness and Incident Diabetes in Older Mexican Americans

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A B S T R A C T

Objectives: A natural decline of muscle strength occurs during the aging process; however, preserving muscle strength may lower the rate of many preventable diseases such as diabetes, especially in higher risk populations. The purpose of this study was to examine the sex-specific association between muscle weakness and incident diabetes in older Mexican Americans.
Design: Observational, longitudinal study.
Setting: Urban and rural households in the Southwestern United States.
Participants: A subsample of 1903 Mexican Americans aged at least 65 years without diabetes at baseline were followed for 19 years.
Measurements: Muscle weakness was assessed with a hand-held dynamometer and was normalized to body weight (normalized grip strength). Male and female participants were categorized as weak if their normalized grip strength was $\leq$0.46 and $\leq$0.30, respectively. Sex-stratified Cox proportional hazard regression models were used to determine the association between muscle weakness and incident diabetes (self-reported) when using age as an entry variable and after adjusting for education, employment status, instrumental activities of daily living disability, interview language, marital status, and obesity. A sensitivity analysis was performed to account for influential outliers for the outcome variable (incident diabetes) and the model was re-run.
Results: The hazard ratio for incident diabetes was 1.05 (95% confidence interval: 1.02–1.09; $P < .001$) in weak vs not-weak male participants and 1.38 (95% confidence interval: 1.35–1.41; $P < .001$) in weak vs not-weak female participants, after adjusting for relevant covariates.
Conclusions: Muscle weakness was associated with an increased rate of diabetes in older male and female Mexican Americans. Health professionals should encourage activities that preserve muscle strength, thereby preventing the incidence of diabetes in older Mexican Americans.

Obesity prevalence and life expectancy have steadily increased worldwide, engendering 2 of today's greatest public health burdens, the obesity epidemic and an aging population.[1,2] Sarcopenic obesity, a convergence of these 2 problems, is a condition often seen in older adults, whereby age-related changes in body composition leads to a decrease in fat free mass, relative to fat mass.[3] The simultaneous reduction of muscle mass and strength, increased abdominal fat mass, and age-related declines in physical function pose many health risks across populations.[1,4,5] Consequently, older adults that are weak and obese, and are at a greater risk for functional limitations and chronic cardiometabolic diseases such as diabetes.[6,7]

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In the United States from 1990 to 2010, there was more than a half-million years of life lost because of diabetes related-premature mortality, and about 35,900 more deaths attributed to diabetes alone, thus, diabetes remains a leading cause of death.[8] Globally, diabetes prevalence is projected to increase by over 200 million people between 2013 and 2035.[9] The current and future impact of diabetes highlights the need to continue identifying strategies to screen for diabetes risk while developing interventions that mitigate diabetes prevalence and diabetes related mortality. Participating in physical activities that preserve or improve muscle strength has been recognized as a strategy to prevent and treat diabetes across populations.[10] For example, previous cross-sectional investigations have identified that muscle weakness is associated with diabetes.[11–13] Furthermore, studies have determined that increases in hyperglycemia,[14] fat mass,[15] and diabetes prevalence[16] are associated with reduced muscle quality and weakness.

The lifetime risk of diabetes is elevated among Mexican Americans, a population projected to increase by nearly 115% between the years 2014 and 2060 in the United States.[17–19] Chronic hyperglycemia and obesity, 2 known predictors of diabetes, are associated with poor muscle strength and quality, respectively.[14,15] Obesity is 7.4% greater in Hispanic Americans aged at least 60 years, compared with the national average of that age group,[20] thus, older Hispanic Americans, including Mexican Americans, that are obese and weak may be at an elevated risk for diabetes. Therefore, the purposes of this study were to (1) determine the association between muscle weakness and incident diabetes among older male and female Mexican Americans, and (2) identify obesity prevalence among weak vs not-weak male and female Mexican Americans.

Methods

Participants

Data were used from the Hispanic Established Population for the Epidemiological Study of the Elderly (HEPESE), an ongoing study of noninstitutionalized Mexican Americans aged at least 65 years living in Arizona, California, Colorado, New Mexico, and Texas. The HEPESE was modeled after other previous epidemiologic studies of the elderly that were conducted in Connecticut, Iowa, Massachusetts, and North Carolina.[21] As previously described,[22] the HEPESE used an area probability sampling procedure to ensure representativeness of the older Mexican American population in the Southwestern region of the United States. Sample weights are provided to account for the sampling method, and they were used in all analyses. These weights compensate for the differential probability selection that was applied during data collection. HEPESE participants represent about 500,000 Mexican Americans aged at least 65 years living in participating states as a result of weighting the dataset. Starting in 1993–1994 (wave 1), 3050 older Mexican Americans participated in interviews and limited medical assessments (2873 in person and 177 by proxy) with an 83.0% response rate, which is comparable to previous epidemiologic studies of the elderly.[20] Baseline data were followed up in waves: (2) 1995–1996 (n = 2438), (3) 1998–1999 (n = 1980), (4) 2000–2001 (n = 1682), (5) 2004–2005 (n = 1167), (6) 2006–2007 (n = 921), (7) 2010–2011 (n = 659), and (8) 2012–2013 (n = 452). New participants from wave 5 (n = 902), wave 6 (n = 621), wave 7 (n = 419), and wave 8 (n = 292) who did not participate in baseline measures were excluded. The HEPESE protocols were approved by the University of Texas Medical Branch Institutional Review Board, and informed consent was provided by participants.

Measures

Anthropometric characteristics

Body weight and height was collected in the participant's home using similar methods as other epidemiologic studies of the elderly. A Metro 9800 scale (Metro Scale and Systems Inc, Fort Myers, FL) was used to determine body weight, and height was measured with a tape that participants stood next to against a wall. Body mass index (BMI) was calculated as body weight in kilograms (kg) divided by height in meters-squared.

Exposure variable

Muscle strength was measured with a hand-held dynamometer (Jamar Hydraulic Dynamometer; J.A. Preston Corporation, Clifton, NJ), as previously described in detail.[23,24] A trained interviewer explained and demonstrated the protocol to each participant, then adjusted the grip size of the dynamometer to each participant's hand size, and asked participants to perform a practice trial. While seated, participants performed the test with their dominant hand, exhaling while squeezing. During the test, interviewers verbally encouraged participants to squeeze the dynamometer with maximal effort. Two trials were performed, and the higher of the 2 measurements were included in analyses. A hand-held dynamometer has been shown to be a reliable and valid instrument for measuring muscle weakness in older adults.[23] Handgrip strength was normalized to body weight [normalized grip strength (NGS)] to account for the proportion of strength relative to body weight [grip strength (kg)/body weight (kg)].

For male participants, those with a NGS $\leq$0.46 were categorized as weak; whereas, participants with a NGS $>$0.46 were categorized as not-weak. Among female participants, those with a NGS $\leq$0.30 were classified as weak, while participants with a NGS of $>$0.30 were classified as not-weak. These NGS cut points were used from a previous investigation that studied a population that was similar in age and ethnicity.[11] Handgrip strength was adjusted to the corresponding body weight ascertained at baseline testing for each participant.

Covariates

Baseline, self-reported sociodemographic variables were included: education level, employment status, and marital status. Measures of instrumental activities of daily living (IADL) disability, interview language, and obesity were also included. A modified version of the Older Americans' Resources and Services IADL scale was used to assess IADL disability.[25]

Outcome variable

The primary outcome variable of interest was incident diabetes. Participants that self-reported that a doctor told them they have diabetes were classified as having diabetes. The time variable was the age at which participants responded affirmatively to having diabetes. In the event that a participant was re-interviewed, but their age was missing for a particular wave, age was imputed by adding the median difference in age between the current wave and the previous wave for the cohort (1 year for wave 2; 4 years for wave 3; 3 years for wave 4; 4 years for wave 5; 2 years for wave 6; 3 years for wave 7; and 3 years for wave 8).

Censoring and truncation mechanisms

Since participants had to be at least 65 years of age to be included in the HEPESE and participants entered the study at different ages, data were left truncated. Participants with prevalent diabetes at baseline were considered left-censored and removed from analyses because the present investigation was addressing the incidence of diabetes among older Mexican Americans. Right censoring occurred if participants did not have diabetes at the end of follow-up, were lost to follow-up, or died before getting diabetes.

Statistical Analysis

All statistical analyses were performed using SAS v 9.4 software (SAS Institute, Cary, NC). Independent *t*-tests (continuous