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Predictors of Change in Grip Strength Over 3 Years in the African American Health Project

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Abstract

Objectives—To examine factors associated with change in grip strength.**Method**—Grip strength was measured at baseline and 3 years later. Change was divided into “decreased 5 kg,” “increased 5 kg,” and “no change” and analyzed using multinomial multivariable logistic regression.**Results**—Decline in grip strength was more likely for men, those reporting having cardiovascular disease, and those with instrumental activities of daily living, lower body functional limitations, high diastolic blood pressure, higher physical activity, and greater body mass. Decline was less likely among those ever having Medicaid, those with basic activities of daily living disabilities, and those unable to see a doctor in past year due to cost. Gain in grip strength was more likely for men and those with instrumental activities of daily living disabilities, lower body functional limitations, high diastolic blood pressure, and higher physical activity; it was less likely for older participants.**Discussion**—Results can be used to design interventions to improve strength outcomes.

Keywords

aging; grip strength change over time; sarcopenia; African Americans; disablement process

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Grip strength is an important measure of hardiness as people grow older. It reflects strength in other muscle groups (Lauretani et al., 2003; Rantanen, Era, & Heikkinen, 1994) and declines with age (e.g., Bassey & Harries, 1993; Rantanen et al., 1998). In both cross-sectional and longitudinal studies, lower baseline grip strength has been associated with decreased physical functioning (both measured and self-reported), disability, injurious falls, higher fasting insulin, lower health-related quality of life, and mortality (e.g., Al Snih, Markides, Ray, Ostir, & Goodwin, 2002; Lazarus, Sparrow, & Weiss, 1997; Nevitt, Cummings, & Hudes, 1991; Rantanen et al., 1998, 1999; Visser, Deeg, Lips, Harris, & Bouter, 2000; Wolinsky, Miller, Andresen, Malmstrom, & Miller, 2004). For these reasons, low grip strength has been recommended as a cost-effective clinical marker of sarcopenia (Lauretani et al., 2003) and included in the definition of a well-accepted frailty phenotype (Fried et al., 2001). Notably, frailty has been found to be more prevalent in African Americans than in majority Whites (Cawthon et al., 2007; Hirsch et al., 2006). However, few studies have examined factors (other than age and sex) associated with decline in grip strength over time, and very few have addressed grip strength changes in African Americans (e.g., Kurina et al., 2004; Rimmer, Nicola, Riley, & Creviston, 2002). Accordingly, we use data from the African American Health (AAH) project that included extensive baseline risk assessment (including contextual measures) to model factors associated with either a decrease or an increase in grip strength over 3 years.

Method

Study Sample

AAH has been described in detail previously (Miller, Wolinsky, Malmstrom, Andresen, & Miller, 2005). In brief, it is a population-based panel study of 998 African Americans from two socioeconomically diverse areas of St. Louis (inner-city and near northwest suburbs). Participants were born between 1936 and 1950 and were 49 to 65 years of age at the Wave 1 baseline assessment. Inclusion criteria involved community-dwelling, self-reported Black or African American race, and Mini-Mental Status Exam (MMSE) scores of 16 or greater. Recruitment proportion (participants/enumerated eligible persons) was 76%. When data are weighted, the AAH sample represents the noninstitutionalized African American population from the two areas as of the 2000 census (Miller et al., 2005). Wave 1 was conducted at participants' homes between September 2000 and July 2001 and averaged 2.5 hr in length. Interviewers completed 26 hr of training on study-specific interviewing and physical performance measurements, with certification of performance testing that included grip strength measurements. In a randomly selected subsample of 80 participants 5 to 45 days after baseline, the test-retest reliability intra-class correlation coefficient (ICC) for grip strength was 0.81 (Wolinsky, Miller, Andresen, Malmstrom, & Miller, 2005). In-home assessments were repeated 36 months after baseline during Wave 4. Interviewers again completed study-specific training with certification of grip strength measurement. Of the original 998 participants, 853 were successfully reevaluated during Wave 4 (five by proxy report, with no attempt to obtain performance tests). As 51 participants died between Wave 1 and Wave 4, the proportion of surviving participants who were assessed was 90.1%. Attrition analysis (data available on request) indicated minimal potential for meaningful bias

(Miller, Wolinsky, Andresen, Malmstrom, & Miller, 2008). All procedures were approved by the institutional review boards at the involved institutions, and all participants provided written informed consent.

The Grip Strength Measure

Grip strength testing was performed in the self-reported stronger hand using either a Jamar (Preston Corp, Jackson, MI) or Baseline (Fabrication Enterprises, Inc., Irvington, NY) isometric dynamometer (pretesting showed equivalent results using either instrument). Three trials were conducted at both Wave 1 and Wave 4 and recorded in kilograms. Results from both waves showed a learning effect from Trial 1 to Trial 2 but no significant difference between the last two trials. Therefore, the average of Trials 2 and 3 were used in these analyses. During both waves, participants were excluded from grip strength testing for blood pressure (BP) greater than 200 systolic or 90 diastolic, for surgery on the hand or arm on the stronger side in the prior 3 months, or for unwillingness to attempt grip strength testing due to excessive hand pain. As a result, 755 (89%) of the 853 participants completing Wave 4 assessments had data on grip strength at both waves and constitute the analytic sample.

Modeling the Risk of Change in Grip Strength Over 36 Months

Using an established conceptual approach (Wolinsky, 1994), the following risk factors from the baseline evaluation were considered. *Demographic measures* included age (continuous variable), gender, and marital status. *Socioeconomic factors* involved years of formal education, annual household income (<US\$20,000 or refused to report [4.3%] vs. US \$20,000), perceived income adequacy (comfortable or not enough vs. reference category of just enough to make ends meet), having Medicare now, ever having Medicaid, not having any health insurance, foregoing a needed visit to a physician in the past year due to cost, and sampling stratum (inner city vs. suburbs).

Health status and conditions included smoking status (previous and current smokers contrasted with never smoked) and a dichotomized self-rated assessment of hearing (fair or poor vs. excellent, very good, or good). A self-reported visual acuity scale (3 = *excellent* to 15 = *poor*) was coded as the lowest quintile versus all others. The presence of chronic disease was based on self-report of physician diagnosis for 11 conditions (hypertension, diabetes mellitus, stroke, heart attack, heart failure, angina, cancer other than a minor skin cancer, chronic obstructive pulmonary disease [COPD], asthma, kidney disease, and arthritis). As vascular disease, both evident and subclinical, has a strong association with physical function (e.g., Newman et al., 2001) and because the presence of diabetes acts like a “coronary artery disease equivalent” (Haffner, Lehto, Ronnema, Pyorala, & Laakso, 1998), we constructed a cardiovascular disease marker based on self-reported myocardial infarction, angina, or diabetes. Because heart failure can be caused by conditions other than vascular disease, self-reported heart failure was added as a separate condition. Whether the participant fell in the prior year was provided by self-report. Basic activities of daily living (ADL) disabilities were measured as the sum of reported difficulty for (or inability to perform) seven functions: bathing, dressing, eating, getting in and out of bed or chairs, walking across a room, getting outside, and using the toilet (0 = *no difficulties* to 7 =

difficulties on all activities). Instrumental ADL (IADL) disabilities involved having any difficulty with or inability to perform seven functions: preparing meals, shopping for groceries, managing money, making phone calls, doing light housework, doing heavy housework, getting to places outside of walking distance, and managing medications (0 = *no difficulties* to 7 = *difficulties on all activities*). Lower body functional limitations were measured as the sum of reported difficulty for (or inability to perform) six activities: walking one-quarter mile, going up and down 10 steps without stopping, standing for 2 hours, stooping-crouching-kneeling, pushing large objects, and lifting and carrying 10 pounds (0 = *no difficulties* to 6 = *difficulties on all activities*). Physical activity was measured with the seasonally adjusted summary index from the Yale Physical Activity Scale (YPAS; Dipietro, Caspersen, Ostfeld, & Nadel, 1993). The MMSE was used to measure cognitive function, with the lowest quintile contrasted with all others. BP was measured using an automated sphygmomanometer. High systolic BP was defined as ≥ 140 , and high diastolic BP was defined as ≥ 90 . Body mass index (BMI) was measured as a continuous variable (kg/m^2). Pain in the tested hand was reported from 0 (*no pain*) to 10 (*as bad as it could be*) at both waves, and the change from Wave 1 to Wave 4 was included as a continuous variable.

Psychosocial measures included the following. The 11-item Center for Epidemiologic Studies Depression Scale (CES-D) short form was used to measure depressive symptoms and coded as 1 if ≥ 9 points (suspected clinical depression) versus 0 if <9 (Miller et al., 2004). Fear of falling was measured using the Falls Efficacy Scale (Tinetti, Mendes de Leon, Doucette, & Baker, 1994), contrasting the lowest quintile versus all others. A 5-item social support scale was derived from the Medical Outcomes Study (5 = *worst* to 25 = *best*; Sherbourne & Stewart, 1991) and coded as lowest quintile or missing (0.4%) versus all others. The religiosity scale (5 = *highest* to 33 = *lowest*) was based on five items from the Fetzer Institute/National Institute on Aging Working Group measures (Miller et al., 2004) and coded as the lowest quintile or missing (0.8%) versus all others. Race consciousness was measured by asking participants how often they thought about their race (Jones, 2000), with those responding never or only once a year (42.2%) contrasted with all others.

Health-related quality-of-life measures included the 5-item general health perceptions, 4-item vitality, and 5-item mental health scales from the SF-36 (Ware & Sherbourne, 1992; Wolinsky et al., 2004). *Health services use* was measured by whether the respondent had been hospitalized in the prior year, based on self-report. Doctor visits in the past year were obtained from self-reports and truncated at 13 or more.

Contextual measures included the following. Neighborhood desirability was assessed by a self-reported four-item scale (4 = *excellent* to 21 = *poor*), which was coded to contrast living in the least desirable quintile versus all others. Home assessment was a five-item scale of the interviewer's ratings of the interior and exterior of the home (5 = *excellent* to 20 = *poor*), and the lowest quintile was contrasted to all others. Neighborhood assessment was a five-item scale of the interviewer's ratings of block face conditions (5 = *best* to 20 = *worst*), and the lowest quintile was contrasted with all others. More details of the covariate measurements are available in previous publications (Andresen, Malmstrom, Miller, & Wolinsky, 2006; Miller et al., 2004, 2005; Wolinsky et al., 2004, 2005).

Statistical Analysis

All analyses were performed using SPSS, version 16.0 (SPSS Inc., Chicago). We used the absolute change in grip strength over the 36 months as the outcome in both genders based on the following considerations. First, we examined the relationships separately by gender between Wave 1 and Wave 4 grip strength using scatterplots. The initial value did not appear to affect the amount of change over time (i.e., scatterplots were not conical in shape), and both genders demonstrated similar relationships between the two values. Second, absolute changes are generally easier to apply clinically than relative changes or changes adjusted by gender (or other characteristics). We based the change criterion of ± 5 kg on three considerations. First, it approximated the standard error of measurement (SEM) for grip strength in this population (5.6 kg), and SEM has been shown to be a general measure of meaningful intraindividual change in health-related factors (Wyrwich, Tierney, & Wolinsky, 1999). Second, it was substantially greater than the average test–retest difference in grip strength (0.4 kg; Wolinsky et al., 2005), and third, it represented an effect size approximately one-half way between small and medium, which was our aim. Based on these considerations, we trichotomized the outcome into three groups: decreases of 5 kg or more, increases of 5 kg or more, and “no change” group between 5 kg loss and 5 kg gain (the referent group).

Risk factors for changes in grip strength over 36 months were assessed using multinomial multivariable logistic regression. We sequentially entered covariates in the following prespecified model vector sequence using an established conceptual approach (Wolinsky, 1994): demographic measures, socioeconomic factors, health status and conditions, psychosocial factors, health-related quality-of-life measures, health services use, and contextual measures. Variables showing statistical independence within their vector were retained for a final forced-entry regression analysis. As an added safe-guard, forced entry of all originally specified variables was undertaken, and those results (not shown) were consistent with the reduced model presented herein. We also ran the models for men and women separately; as we did not find any meaningful differences between the two gender-specific models, we have presented the gender-combined results only. Except where noted, all analyses used weighted data.

Results

Descriptive Data

At baseline, the mean age was 56.6 years, and 59% were women. The average years of formal education was 12.6, 25% had less than US\$20,000 in annual household income, 48% reported being comfortable with their income, 38% noted having just enough income to make ends meet, and 14% indicated that their income was inadequate for their needs. Obesity (BMI ≥ 30) was noted in 44%, and 4% had a BMI < 20 . Stroke was reported by 6%, heart attack by 8%, angina by 7%, diabetes by 24%, heart failure by 3%, COPD by 5%, cancer by 6%, and arthritis by 43%. Thirty percent of study participants met the criterion for the composite cardiovascular disease measure. The mean number of physician visits \pm standard deviation in the prior year was 5.1 ± 7.7 , and 14% of participants experienced one

or more hospitalizations in the prior year. Baseline values (by outcome category) of variables that were retained in the final model of grip strength change are noted in Table 1.

Men and participants with cardiovascular disease, more instrumental ADL disabilities, more lower body functional limitations, elevated diastolic BP, and higher physical activity scores were at risk for both decreases and increases in grip strength (Table 2). Decline in grip strength was also associated with greater BMI and increase in hand pain, although it was less likely among those ever having Medicaid, those with basic ADL disabilities, and those unable to see a doctor in past year due to cost. Younger participants were more likely to experience an increase in grip strength.

Discussion

Grip strength is a robust measure of vitality, but there are very few longitudinal studies examining factors associated with declines in grip strength and none with as comprehensive of a list of potential covariates of grip strength change as in the current study. Data are lacking particularly for African Americans. In one of the few available investigations that included African Americans, Kurina et al. did show that perimenopausal African American women had higher grip strength than their White counterparts, but the relationship between menopausal status and longitudinal changes in grip strength did not differ significantly between the two races (Kurina et al., 2004). It is important to conduct studies of change in grip strength to gain insight into pathophysiological processes that may be involved in strength change over time and ultimately to design interventions to prevent declines or to augment stability or improvement. This study has helped fill these gaps by demonstrating factors associated with declines, improvements, or (in some cases) both declines and improvements in grip strength.

Men were more likely to experience both declines and improvements in grip strength than women. Although study designs and populations examined differ considerably, several studies have found that women lose more grip strength than men (e.g., Bassey & Harries, 1993; Rantanen, Era, & Heikkinen, 1997), although some identified greater losses in men than in women (e.g., Frederiksen et al., 2006), and one study found that the average percentage loss of strength was similar in men and women (Sehl & Yates, 2001). Thus, our finding may be in part a function of the greater mean grip strength at baseline in men (45.2) than women (29.2). It may also be that men experience greater volatility in their grip strength than do women. Participants with increased instrumental ADL disabilities, more lower body functional limitations, greater physical activity participation, and high diastolic BP also showed greater volatility, with greater likelihood for both grip strength decline and improvement. It may be that these categories include different subgroups, one more susceptible to declines and another positioned for improvements. For example, participants with greater lower body functional limitations may include some persons who are experiencing age-associated functional decline (causing the association with decline) while other persons may be recovering from an acute illness (explaining the increased likelihood of grip strength increase). Recovery from acute illness (e.g., pneumonia or cancer treatment) might also explain the association of basic ADL disabilities with lower likelihood of grip strength decline and of IADL disabilities with increased likelihood of improved grip

strength. Our statistically significant basic ADL findings are in contrast to most of the literature. Several cross-sectional studies have shown greater grip strength to be associated with lower likelihood of ADL problems (e.g., Curb et al., 2006), and longitudinal studies have demonstrated that lower grip strength predicts incident ADL problems (e.g., Rantanen et al., 1999).

Declines in grip strength associated with cardiovascular disease, increased BMI, and increased hand pain from baseline to follow-up were less surprising and are consistent with previous literature (e.g., Rantanen et al., 1994, 1998; Spencer, Albert, Bear-Lehman, & Burkhardt, 2008). For example, in the Honolulu Heart Study that involved nearly 4,000 men of Japanese descent, Rantanen et al. found that steeper declines in grip strength over 27 years were associated with chronic conditions such as stroke, arthritis, coronary heart disease, and COPD (Rantanen et al., 1998). However, the *decreased* likelihood of experiencing a decline in grip strength that we found in participants who had ever been on Medicaid or were unable to see a doctor due to cost in the past year was more surprising, is harder to explain, and in particular deserves additional investigation to better understand the mechanisms behind these findings. It was not unexpected to see that older age was associated with lower likelihood of experiencing improvements in grip strength, as is consistent with prior literature (Bassey & Harries, 1993; Frederiksen et al., 2006; Rantanen et al., 1997, 1998).

This study has several strengths, including the high recruitment and retention rates in this cohort, involvement of an important underserved minority population (African Americans) who experience more disability than majority Whites (Miller et al., 2005), a comprehensive set of candidate risk factor (including several measures of socioeconomic status and contextual variables that have proved useful in prior studies; e.g., Schootman et al., 2007), and a well-designed and tested method for model trimming (Wolinsky, 1994). In addition, the age of the cohort is an important advantage. For example, we have shown that disability and sarcopenia are already evident by late middle age in this population (Miller et al., 2005, 2009) and strength is an essential part of both of these phenomena. Therefore, it is crucial to understand factors that are associated either with declines or improvements in strength to gain greater insight into how to help people preserve their strength as they enter their senior years. The study also has limitations. It involved a single race in a single Midwestern city with a relatively restricted age range that some would consider “pregeriatric.” This relative homogeneity limits external generalizability while it simultaneously bolsters internal validity.

It is important for future research to replicate these analyses in cohorts from different age groups and racial-ethnic groups and to explain some of the identified phenomena. Chief among these are the mechanisms by which cardiovascular disease and increased BMI are associated with decreases in grip strength. In the meantime, these findings can be used to identify persons who are likely to experience volatility in their grip strength, and especially those at increased risk for declines in grip strength and, by logical extension, likely declines in general strength.

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Table 1
Variables in the Final Multivariable Multinomial Logistic Regression Model at Baseline
(Weighted, Unadjusted)

Variable	5 kg loss in grip strength (<i>N</i> = 252)	No change in grip strength (<i>N</i> = 364)	5 kg gain in grip strength (<i>N</i> = 112)
Age	57.00 (4.3)	56.76 (4.6)	55.25 (4.4)
Male gender	47%	34%	52%
Medicaid use in last year	6%	12%	18%
Unable to see doctor due to cost	3%	10%	10%
CAD	41%	25%	24%
ADL disabilities (0-7)	0.35 (0.99)	0.42 (1.15)	0.90 (1.68)
IADL disabilities (0-7)	0.59 (1.16)	0.41 (1.03)	0.96 (1.54)
Lower body limitations (0-6)	1.63 (2.01)	1.22 (1.86)	2.10 (2.33)
Seasonally adjusted YPAS score	38.08 (21.9)	34.84 (20.0)	39.04 (23.5)
Diastolic blood pressure < 90	32%	21%	37%
Body mass index	30.98 (6.1)	29.32 (6.6)	30.22 (7.8)
Change in hand pain (-10 to 10)	0.48 (2.49)	-0.04 (2.44)	-0.19 (2.63)
Baseline grip strength	41.8 (13.5)	33.0 (10.3)	30.7 (14.2)

Note: ADL = activities in daily living; IADL = instrumental activities of daily living; YPAS = Yale Physical Activity Scale. Values are presented as mean (standard deviation), unless noted as percentage.

Table 2
Baseline Factors Independently Associated With 36-Month Loss or Gain of 5 or More Kilograms in Grip Strength From Final Multivariable Multinomial Logistic Regression (Weighted, Adjusted)

Variable	5 kg loss in grip strength aOR (95% CI; N = 252)	No change in grip strength (Reference) OR (N = 364)	5 kg gain in grip strength aOR (95% CI; N = 112)	Overall <i>p</i>
Age	0.99 (0.95-1.03)	1.000	0.92** (0.87-0.97)	.009
Male gender	1.99*** (1.38-2.85)	1.000	2.57*** (1.58-4.18)	.001
Medicaid	0.50* (0.26-0.96)	1.000	1.70 (0.88-3.27)	.005
Unable to see doctor due to cost	0.28** (0.12-0.68)	1.000	0.59 (0.25-1.39)	.008
CVD	1.74** (1.17-2.57)	1.000	0.72 (0.41-1.29)	.002
ADL disabilities (0-5)	0.72** (0.57-0.90)	1.000	0.89 (0.70-1.14)	.013
IADL disabilities (0-5)	1.28* (1.00-1.65)	1.000	1.37* (1.03-1.84)	.048
Lower body limitations (0-5)	1.16* (1.01-1.32)	1.000	1.25* (1.05-1.48)	.021
Diastolic blood pressure 90	1.60* (1.08-2.36)	1.000	1.77* (1.09-2.89)	.018
Seasonally adjusted YPAS	1.01* (1.00-1.02)	1.000	1.02** (1.00-1.03)	.010
Body mass index	1.04* (1.01-1.07)	1.000	1.02 (0.98-1.06)	.028
Change in hand pain	1.09* (1.01-1.17)	1.000	1.02 (0.93-1.12)	.059

Note: CVD = cardiovascular disease measure; ADL = activities in daily living; IADL = instrumental activities of daily living; YPAS = seasonally adjusted Yale Physical Activity Scale; OR = odds ratio; aOR = adjusted odds ratio. Results are adjusted for all other variables in the final model. Overall *p* refers to whether all three groups are equivalent, and comparisons within the two change groups with referent group are indicated separately, as reported by the statistical software program.

* *p* < .05.

** *p* < .01.

*** *p* .001.