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Brief Report

Handgrip Strength Asymmetry and Weakness May Accelerate Time to Mortality in Aging Americans

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A B S T R A C T

Objectives: Assessing handgrip strength (HGS) asymmetry may provide insights into HGS as a prognostic assessment of strength capacity and vitality. This study sought to determine the associations of HGS asymmetry and weakness on time to mortality in aging Americans.
Design: Longitudinal panel.
Setting: Secondary analyses of data from participants aged ≥50 years from the 2006–2014 waves of the Health and Retirement Study.
Participants: The analytic sample included 19,325 Americans who identified hand dominance and had measures of HGS for both hands in a single wave.
Measures: A handgrip dynamometer was used to measure HGS. Men and women who were considered weak had HGS <26 kg and <16 kg, respectively. The highest HGS values from the dominant and nondominant hands were used to calculate HGS ratio: (nondominant HGS/dominant HGS). Those with HGS ratio <0.90 or >1.10 had any HGS asymmetry. Moreover, participants with HGS ratio <0.90 had dominant HGS asymmetry, whereas those with HGS ratio >1.10 had nondominant HGS asymmetry. The National Death Index and postmortem interviews verified date of death. Covariate-adjusted Cox models were used for analyses.
Results: Those with any HGS asymmetry had a 1.10 [95% confidence interval (CI) 1.03–1.17] higher hazard for mortality, while those with weakness had a 1.44 (CI 1.32–1.58) higher hazard for mortality. Likewise, participants with dominant HGS asymmetry had a 1.11 (CI 1.03–1.18) higher hazard for mortality, and those with weakness had a 1.45 (CI 1.32–1.58) higher hazard for mortality; however, the association was not significant for those with nondominant HGS asymmetry (hazard ratio: 1.07; CI 0.96–1.18).
Conclusions and Implications: HGS asymmetry and weakness are markers of impaired strength capacity that independently accelerate time to mortality, but the magnitude of these associations was more prominent for weakness. Nevertheless, assessments of asymmetric HGS are a simple adjunct analysis that may show promise for increasing the prognostic value of handgrip dynamometers.

Handgrip strength (HGS) is a simple and inexpensive assessment of overall strength capacity.[1] Several investigations have found that weakness, as measured by maximal HGS, is strongly and independently associated with arguably the most important health outcome, early all-cause mortality.[2–4] Although some evidence exists for the association between weakness and early mortality,[5,6] the physiological basis for how weakness and mortality are associated remains opaque,[3] and evaluating HGS in

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detail may help to provide clarity for the association between HGS and mortality.[7,8]

Examining differences in muscle strength between limbs may uncover insights for the association between strength capacity and mortality. For example, older adults with low knee extensor power and high-power asymmetry had impaired functional performance,[9] and asymmetric lower limb explosive power was greater in those with a history of falls compared with older women without a history of falling.[10] Given that strength asymmetry could be linked to factors associated with decreased longevity, evaluating measures of asymmetry in standardized HGS testing protocols could help improve the operationalization of strength capacity and sensitivity of HGS testing protocols in identifying those who are at risk for early mortality. Therefore, including HGS asymmetry may not only help to improve HGS as a clinically viable screening tool for overall strength capacity, but also provide additional information for the predictive utility of HGS. This study sought to determine the associations between HGS asymmetry and weakness on time to mortality in aging Americans.

Methods

Participants

Secondary analyses of publicly available data from the 2006–2014 waves of the Health and Retirement Study (HRS) were conducted. The HRS is a longitudinal-panel study that monitors economic and health factors during aging.[11] Data collections occur biennially and the HRS surveys a representative sample of Americans at least 50 years of age. Starting in the 2006 wave, the HRS expanded to include enhanced face-to-face data collections that included physical measures for providing greater detail in health assessments. To minimize participant burden, a random half sample of participants were selected to complete the enhanced face-to-face and core interviews, while the other half sample only completed core interview. The enhanced interviews alternated completion at each wave thereafter (eg, 2006 wave, 2010 wave, 2014 wave; 2008 wave, 2012 wave).[12] Interview response rates for the HRS have regularly been >80% at each wave.[11] Participants provided written informed consent before entering the HRS, and the University's Behavioral Sciences Committee Institutional Review Board approved study protocols. A detailed description of the HRS is available elsewhere.[13]

Measures

Mortality

Date of death was verified in the HRS through linkage to the National Death Index. Postmortem interviews with a surviving family member or other informant were also conducted to verify death. The National Death Index and postmortem interviews captured approximately 99% of participant deaths for the HRS.[14]

Handgrip strength

A Smedley spring-type handgrip dynamometer (Scandidact; Odder, Denmark) was used to measure HGS. Participants reported hand dominance before testing, and starting with their nondominant hand, participants squeezed the dynamometer with maximal effort. Measures of HGS alternated between hands with 2 measurements completed for each hand. More details about HGS test protocols for the HRS are available elsewhere.[15] The single greatest HGS value from either hand was used in the analyses for determining weakness. Men with maximal HGS <26 kg and women with maximal HGS <16 kg were considered weak.[16]

Asymmetry

The greatest HGS values from the dominant and nondominant hands were used for calculating HGS ratio [(nondominant HGS (kg)/dominant HGS (kg)]. Although HGS varies between hands and is related to hand dominance, the "10% rule," which suggests that the HGS of the dominant hand is generally 10% stronger than the nondominant hand, was used to operationalize HGS asymmetry.[17] Therefore, those that had a HGS ratio of <0.90 or >1.10 (ie, 10%) were considered as having any HGS asymmetry. To determine HGS asymmetry dominance, participants with HGS ratio of <0.90 were classified as having dominant HGS asymmetry, whereas those with HGS ratio of >1.10 were considered as having nondominant HGS asymmetry. Participants with HGS ratio between 0.90 and 1.10 had symmetric HGS.

Covariates

Age, sex, race and ethnicity, height, and body mass were self-reported at each wave. Those with a body mass index ≥30 kg per meter squared were considered obese.[18] Participants told interviewers if a healthcare provider diagnosed hypertension, diabetes, cancer (excluding minor skin cancer), lung disease, heart condition, stroke, emotional or psychiatric problems, and arthritis or rheumatism. The number of affirmative morbid diagnoses were summed at each wave and included in the analyses as a continuous variable. Those who engaged in moderate-to-vigorous physical activity "once a week" or more were considered as participating in moderate-to-vigorous physical activity. Participants also self-reported if they drank alcohol, had ever smoked more than 100 cigarettes in their lifetime, and if they were current cigarette smokers. A single-item measure of perceived health was collected at each wave, with participants self-rating their health as either "excellent,", "very good,", "good," "fair," or "poor."

Social engagement was assessed by 3 items at each wave: (1) volunteer activities for at least 1 hour in the past year, (2) contact with parents or in-laws at least weekly, and (3) current employment status. Scores ranged from 0 to 3 with higher scores indicating more social engagement and these continuous scores were included in the analyses.[19] Depressive symptoms were examined using the 8-item Center for the Epidemiologic Studies Depression scale.[20] Scores ranged from 0 to 8, with higher scores suggesting more depressive symptoms. Those with scores ≥3 were considered depressed.[20]

Cognitive function was assessed with the Telephone Interview of Cognitive Status, a validated screening tool for population-based studies from the Mini-Mental State Examination.[21] A 27-point composite scale was used for those under 65 years of age and those with scores of <12 were considered as having a cognitive impairment.[22] A 35-point scale was used for those aged ≥65 years and those with scores <11 were considered as having a cognitive impairment.[23] Those indicating that they have difficulty or an inability to complete any activity of daily living (dressing, eating, transferring in or out of bed, toileting, bathing, and walking across a small room) were considered as having an activities of daily living limitation.

Statistical Analyses

All analyses were conducted with SAS 9.4 software (SAS Institute, Cary, NC). Separate Kaplan-Meier estimators generated survival curves after study entry using either the any HGS asymmetry or HGS asymmetry dominance groups as the strata. Individual Cox models analyzed the associations of (1) any HGS asymmetry (reference: symmetric HGS) and weakness (reference: not weak), and (2) HGS asymmetry dominance (reference: symmetric HGS) and weakness (reference: not weak) on time to mortality. Cox models also determined if there was an interaction between (1) any HGS asymmetry

Table 1
Baseline Descriptive Characteristics of the Participants

	Overall (n = 19,325)	Symmetric HGS (n = 9231)	Any Asymmetric HGS (n = 10,094)
HGS (kg)	30.5 (24.0, 40.0)	31.0 (24.5, 41.5)	30.0 (24.0, 39.0)
Weak, n (%)	1241 (6.4)	524 (5.7)	717 (7.1)
HGS ratio	0.92 (0.84, 1.00)	0.97 (0.93, 1.01)	0.84 (0.78, 0.89)
Age (y)	64.0 (56.0, 73.0)	64.0 (56.0, 72.0)	65.0 (57.0, 74.0)
Obese, n (%)	6659 (34.5)	3182 (34.5)	3477 (34.5)
Morbidities	2.0 (1.0, 3.0)	2.0 (1.0, 3.0)	2.0 (1.0, 3.0)
Depressed, n (%)	4156 (21.5)	1889 (20.5)	2267 (22.5)
Social engagement	1.0 (1.0, 2.0)	2.0 (1.0, 2.0)	1.0 (1.0, 2.0)
Race and ethnicity, n (%)			
Hispanic black	54 (0.3)	27 (0.3)	27 (0.3)
Hispanic white	1388 (7.2)	604 (6.5)	784 (7.8)
Non-Hispanic black	3485 (18.0)	1532 (16.6)	1953 (19.3)
Non-Hispanic white	13,010 (67.3)	6396 (69.3)	6614 (65.5)
Other	1388 (7.2)	672 (7.3)	716 (7.1)
Male, n (%)	8373 (43.3)	4403 (47.7)	3970 (39.3)
Current smoker, n (%)	3029 (15.7)	1438 (15.6)	1591 (15.8)
Previous smoker, n (%)	11,014 (57.0)	5315 (57.6)	5699 (56.5)
Cognitive impairment, n (%)	2096 (10.9)	1011 (11.0)	
Activities of daily living limitation, n (%)	2952 (15.3)	1209 (13.1)	1085 (10.8)
Self-rated health, n (%)			
Excellent	2107 (10.9)	1113 (12.1)	994 (9.8)
Very good	5776 (29.9)	2863 (31.0)	2913 (28.9)
Good	6074 (31.4)	2877 (31.2)	3197 (31.7)
Fair	4014 (20.8)	1803 (19.5)	2211 (21.9)
Poor	1354 (7.0)	575 (6.2)	779 (7.7)
Moderate-to-vigorous physical activity, n (%)	11,302 (58.5)	5609 (60.8)	5693 (56.4)
Drinks alcohol, n (%)	10,684 (55.3)	5303 (57.5)	5381 (53.3)
Deaths, n (%)	3954 (20.5)	1731 (43.8)	2223 (56.2)
Age at death (y)	81.0 (73.0, 88.0)	80.0 (72.0, 87.0)	81.0 (74.0, 88.0)

Results are presented as median (quartile 1, quartile 3) or frequency (percentage) where indicated.

and weakness and (2) HGS asymmetry dominance and weakness for time to mortality.

All Cox models were adjusted using the following pre-specified covariates: age, race and ethnicity, sex, current smoking status, smoking history, cognitive impairment, activities of daily living limitation, self-rated health, morbidities, moderate-to-vigorous physical activity participation, alcohol consumption, social engagement, obesity, and depression. Age at baseline was also the entry variable. Data were left-truncated because participants entered the HRS at different ages and had to be at least 50 years of age to be included. Secondary analyses were performed to examine the associations of the HGS asymmetry and weakness groups on time to mortality for each age group (middle-age: 50–64 years; older adult: ≥65 years) and sex utilizing the same covariates as in our fully adjusted Cox models that were conducted for our primary analyses. An alpha level of 0.05 was used for all analyses.

Results

The baseline descriptive characteristics of the 19,325 participants are presented in Table 1. Supplementary Figure 1 shows a data flow diagram for our study. Overall, the mean and mode HGS ratio was 0.93 ± 0.17 and 1.00, respectively. The Kolmogorov-Smirnov test for normality was significant ($P < .01$), thereby indicating HGS ratio was not normally distributed. Survival curves for the HGS asymmetry and weakness groups are in Figure 1. Significant differences existed for both the any HGS asymmetry (log-rank $P < .0001$; Wilcoxon $P < .0001$) and HGS asymmetry dominance groups (log-rank $P < .0001$; Wilcoxon $P < .0001$).

Table 2 shows the results for the associations of the HGS asymmetry and weakness groups on time to mortality. Those with any HGS asymmetry had a 1.10 [95% confidence interval (CI) 1.03–1.17] higher hazard ratio for mortality, while those with weakness had a 1.44 (CI 1.32–1.58) higher hazard ratio for mortality. Similarly, participants with dominant HGS asymmetry had a 1.11 (CI 1.03–1.18) higher hazard ratio for mortality, and those with weakness had a 1.45 (CI 1.32–1.58) higher hazard ratio for mortality; however, the association was not-significant for those with non-dominant HGS asymmetry (hazard ratio 1.07; CI 0.96–1.18). There also was not a significant interaction between weakness and any HGS asymmetry ($P = .63$), nor was there a significant interaction between weakness and dominant HGS asymmetry ($P = .68$) or nondominant HGS asymmetry ($P = .80$). Supplementary Table 1 presents the results for the associations of the HGS asymmetry and weakness groups on time to mortality by age group and sex. Differential associations for time to mortality existed for the HGS asymmetry and weakness groups after stratifying the analyses by age group and sex.

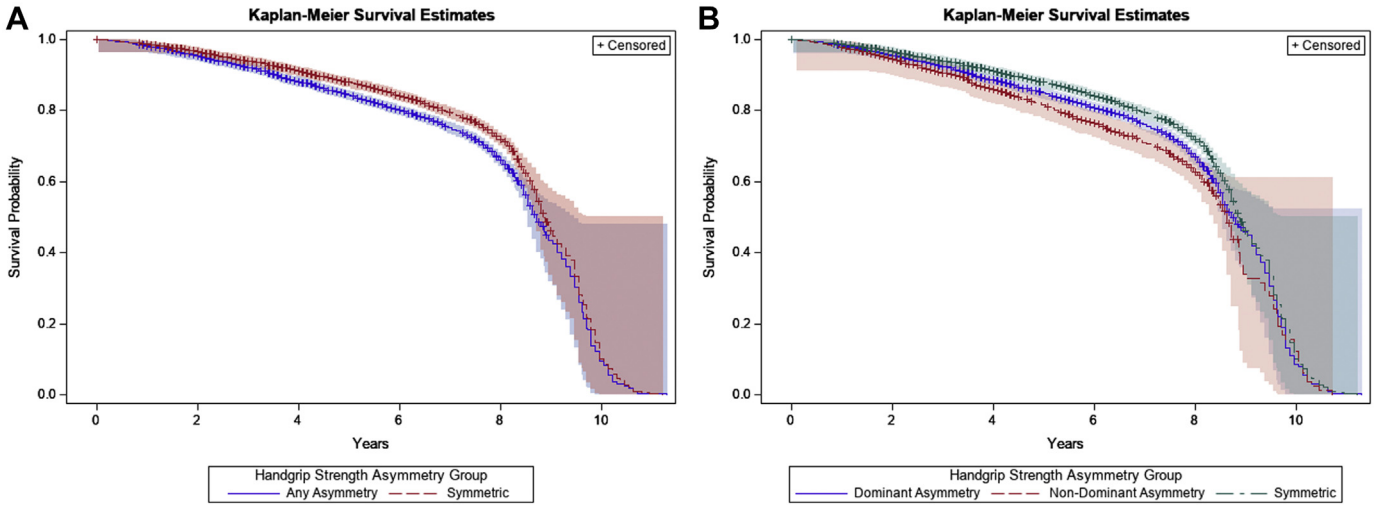

Fig. 1. Survival curves for time to mortality after study entry: (A) those with any HGS asymmetry had a lower survival probability than those with symmetric HGS ($P < .0001$); (B) those with dominant or nondominant HGS asymmetry had a lower survival probability than those with symmetric HGS ($P < .0001$).

Table 2
Results for the Associations of the HGS Asymmetry and Weakness Groups on Time to Mortality

	Number of People	Number of Deaths	Mean and 95% CI Follow-Up Years	Mortality Rate per 1000 Person-Years	Hazard Ratio (95% CI)
Any HGS Asymmetry and Weakness Groups					
Any HGS asymmetry					
Symmetric HGS	9231 (44.8%)	1731 (43.8%)	5.0 (4.9–5.0)	37.8	Reference
Any HGS asymmetry	10,094 (52.2%)	2223 (56.2%)	4.8 (4.7–4.8)	45.8	1.10 (1.03–1.17)*
Weakness					
Not weak	18,084 (93.6%)	14,803 (81.9%)	4.9 (4.8–5.0)	36.9	Reference
Weak	1241 (6.4%)	673 (54.2%)	4.3 (4.2–4.5)	124.8	1.44 (1.32–1.58)*
HGS asymmetry dominance and weakness groups					
HGS asymmetry dominance					
Symmetric HGS	9231 (47.8%)	1731 (43.8%)	5.0 (4.9–5.0)	37.8	Reference
Dominant HGS asymmetry	8430 (43.6%)	1784 (45.1%)	4.8 (4.7–4.9)	44.1	1.11 (1.03–1.18)*
Nondominant HGS asymmetry	1664 (8.6%)	439 (11.1%)	4.9 (4.7–5.0)	54.3	1.07 (0.96–1.18)
Weakness					
Not weak	18,084 (93.6%)	14,803 (81.9%)	4.9 (4.8–5.0)	36.9	Reference
Weak	1241 (6.4%)	673 (54.2%)	4.3 (4.2–4.5)	124.8	1.45 (1.32–1.58)*

Each Cox model was adjusted for age, race and ethnicity, sex, current smoking status, smoking history, cognitive impairment, activities of daily living disability, self-rated health, morbidities, moderate-to-vigorous physical activity, alcohol consumption, social engagement, obesity, and depression.
*$P < .01$.

Discussion

The principal results of this investigation revealed that HGS asymmetry and weakness were independently associated with accelerated time to mortality in aging Americans. Although findings are compatible with other studies that have found weakness is associated with early mortality in aging Americans,[3,7] we also found that HGS asymmetry was associated with time to mortality. Low HGS often represents onset frailty and precedes other components of frailty such as slow gait speed.[24] Lower limb strength asymmetry, gait asymmetry, and gait variability are all related with poor mobility and falls in older adults.[25] Measures of HGS are also intricately connected to the neural systems that mediate the control of coordinated movement.[26] Ataxia is characterized by impaired coordination of voluntary muscle movement that typically occurs on 1 side of the body, often because of cerebellar and related neurologic dysfunction.[27] The presence of ataxia is associated with a variety of life-threatening consequences.[27] Nevertheless, more research is needed to identify the underlying causal pathways for HGS asymmetry and mortality.

Indeed, the results of our investigation revealed that older Americans with weakness or HGS asymmetry have a potentiated risk for premature mortality. Although our findings suggest that weakness has a more robust association with time to mortality, HGS asymmetry may still have similar health consequences that exacerbate mortality risk. Future research should continue examining how different HGS methodologies and health are associated, and how HGS asymmetry may factor into decision algorithms for determining sarcopenia and dynapenia. Moreover, given that temporal trends in HGS have declined over the last few decades,[28] temporal trends in HGS asymmetry are unavailable and should be generated.

Some limitations of this study should be acknowledged. To calculate HGS ratio, hand dominance had to be established. Hand dominance was self-reported by participants without details regarding changes in hand dominance and hand usage for completing tasks. Although self-report data are common in larger epidemiologic studies such as the HRS, self-report biases may exist for our study. Further stratifying our sample for HGS asymmetry dominance and the secondary analyses (ie, age and sex) led to wider CIs for our findings. Although the "10% rule" was used as a cut-point for determining HGS asymmetry in our study, individual-level HGS differences may vary between hands.[29] Opportunities exist for other studies to generate health-related criterion-referenced HGS asymmetry cut-points. Our study determined weakness from HGS, which could be part of frailty assessments.[30] Future research should examine how HGS asymmetry and frailty are associated with health conditions and early mortality during aging.

Conclusions and Implications

This study found that HGS asymmetry and weakness were associated with time to mortality in aging Americans. Asymmetric HGS could be regarded as another marker of impaired strength capacity that signifies deteriorating health. We suggest that HGS asymmetry be evaluated in HGS test protocols, especially because many extant HGS test protocols already recommend that data be collected for the dominant and nondominant hands. Such a suggestion may improve the prognostic sensitivity of handgrip dynamometers as a convenient assessment of strength capacity and vitality.

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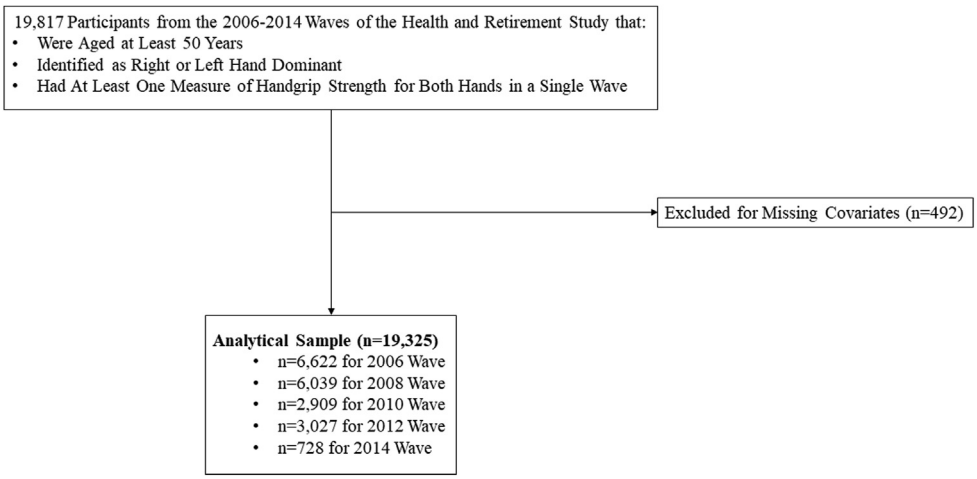

Supplementary Figure 1. Data diagram

Supplementary Table 1
Results of the Associations for the HGS Asymmetry and Weakness Groups on Time to Mortality by Age Group and Sex

	Hazard Ratio	95% CI
Any HGS Asymmetry and Weakness Groups		
Middle-age adults		
Any HGS asymmetry*	1.00	0.85–1.17
Weak†	1.40	1.02–1.92
Older adults		
Any HGS asymmetry*	1.12	1.32–1.59
Weak†	1.44	1.32–1.59
Male		
Any HGS asymmetry*	1.05	0.96–1.15
Weak†	1.58	1.38–1.81
Female		
Any HGS asymmetry*	1.14	1.04–1.24
Weak†	1.40	1.24–1.57
HGS asymmetry dominance and weakness groups		
Middle age adults		
Dominant HGS asymmetry*	1.02	0.86–1.21
Nondominant HGS asymmetry*	0.91	0.68–1.21
Weak†	1.42	1.04–1.96
Older adults		
Dominant HGS asymmetry*	1.12	1.04–1.21
Nondominant HGS asymmetry*	1.09	0.98–1.23
Weak†	1.45	1.32–1.59
Male		
Dominant HGS asymmetry*	1.07	0.97–1.18
Nondominant HGS asymmetry*	0.99	0.85–1.15
Weak†	1.59	1.39–1.83
Female		
Dominant HGS asymmetry*	1.14	1.03–1.25
Nondominant HGS asymmetry*	1.14	0.98–1.32
Weak†	1.40	1.24–1.57

Each Cox model was adjusted for age, race and ethnicity, sex (for age groups only), current smoking status, smoking history, cognitive impairment, activities of daily living disability, self-rated health, morbidities, moderate-to-vigorous physical activity, alcohol consumption, social engagement, obesity, and depression.

*Reference: symmetric HGS.

†Reference: not weak.