Associations of Grip Strength and Change in Grip Strength With All-Cause and Cardiovascular Mortality in a European Older Population

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ABSTRACT

OBJECTIVE: (1) To examine the associations between 3 measures of grip strength: static grip strength, change in grip strength, and the combination of grip strength and its change, with all-cause and cardiovascular mortality, and (2) to determine which measure is the most powerful predictor of all-cause and cardiovascular mortality among the European older population.

METHOD: Data come from the first 4 waves of the Survey of Health, Ageing and Retirement in Europe (SHARE). A Cox proportional hazard model and a competing risk regression model were used to assess the associations. To determine the best predictor, Akaike information criterion was applied.

RESULTS: Grip strength and the combination of grip strength and its change were associated with all-cause and cardiovascular mortality. Change in grip strength was correlated with only all-cause mortality. Among the 3 measures, the static measure of grip strength was the best predictor of cardiovascular mortality whereas the combined measure is that of all-cause mortality.

DISCUSSION: Grip strength is a significant indicator of all-cause and cardiovascular mortality. The combination of grip strength and its change can be used to increase the accuracy for prediction of all-cause mortality among older persons.

KEYWORDS: Grip strength, mortality, cardiovascular, older adults

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Force of grip has received considerable attention from biomedical and social scientists. It indicates protein level, mass and strength of muscle, and therefore indicates physical capability, and overall health. Extensive literature has documented that a decline in grip strength is associated with injurious falls, malnutrition, longer periods of hospital stay, lower health-related quality of life, and higher risk of disability and mortality.[1–12] Moreover, the associations have been observed not only in general population but also in specific patient groups.[13,14] Accordingly, hand grip has been widely and increasingly recommended as a useful clinical means to stratify an individual's risk of dying from any cause,[1,8,11] as well as disease-specific causes, such as heart disease, stroke, and cancer.[8,11,15,16] Although there has been considerable evidence showing the usefulness of grip strength, fewer studies have examined other possible measurements of grip strength, such as change in grip strength, and their associations with morbidity and mortality.[9,17–19] Adopting the change in grip strength measure has been reported to offer a better understanding of how change in grip strength over time is related to the disease development.[20] Despite such an advantage, the application of this measurement is somewhat limited, as it requires longitudinal data. To our knowledge, no study has investigated the predictive power of different grip strength measures on the risk of disability and mortality using the same population.

Another research gap to address is the sex differences in physical strength, risk behaviors, illnesses, and mortality, as is evident in the literature.[21–31] However, very few studies account for possible differences between men and women in examining the association between grip strength and mortality, for which inconsistent results are reported.[4,32,33] For instance, Gale et al[4] reported that low grip strength can increase the risk of mortality for men, but not for women, whereas Sasaki et al[32] found a significant association between grip strength and all-cause mortality in both men and women. The latter study also indicated that grip strength can predict heart disease mortality and stroke mortality for both sexes.[32]

The present study aimed to identify the best predictor of all-cause mortality and cardiovascular mortality for older adults in Europe among the 3 different measures of grip strength, ie, grip strength, change in grip strength, and the combination of grip strength and change in grip strength. Three research questions were explored: (1) controlling for demographic, social, and health characteristics, we determined which measure of grip strength was significantly associated with all-cause mortality and cardiovascular mortality; (2) we also determined which measure of grip strength was the best predictor of all-cause mortality and cardiovascular mortality; and (3) we determined whether the results of (1) and (2) were different between men and women.

Methods

Data

Our data come from the Survey of Health, Ageing and Retirement in Europe (SHARE). The Survey of Health, Ageing and Retirement in Europe is a multidisciplinary, cross-national panel database containing a broad range of information on demographics, socioeconomic status, health, family networks, and housing of 123 000 European citizens aged 50 and older. There are currently 6 waves of data available. The baseline sample was collected in 2004-2005 (wave 1), consisting of persons born in 1954 and earlier. This is followed by the second wave in 2006-2007 (wave 2), which included refresher samples and 3 new countries to increase the net sample size and compensate for attrition loss. The third wave was carried out in 2008-2009 without additional samples, which focuses on people's life histories. This wave is known as SHARELIFE, in which more personal details concerning, for example, living circumstances during childhood, history of partners and marriages, history of pregnancy and children were additionally collected. The fourth, the fifth, and the sixth waves were conducted in 2010-2011, 2013, and 2015, respectively. This study uses data from all first 4 waves of SHARE and is restricted to the 10 only countries that have participated in the survey since the baseline survey (wave 1). These countries are Austria, Belgium, Denmark, France, Germany, Italy, Spain Sweden, Switzerland, and the Netherlands. An extensive description concerning the study design of SHARE can be found elsewhere.[34]

Ethical approvals for the first 3 waves of the SHARE project were granted by the Ethics Committee of the University of Mannheim. For the fourth and fifth waves, the SHARE projects were reviewed and approved by the Ethics Council of the Max-Planck Society.[35] In all of the SHARE countries, potential respondents would receive an advanced letter containing information on the SHARE project, as well as data confidentiality and protection rules the project adopted. Verbal informed consents were sought and recorded by the interviewers before the start of the interview and any physical health measures (eg, grip strength) were conducted. On the completion of the interview, respondents were asked to grant permission to be re-contacted for the future waves of survey.[34]

Analytic sample

Given our interest in examining the effect of change in grip strength on all-cause mortality and cardiovascular mortality, we first limited our analytical samples to respondents with valid information on grip strength in both waves 1 and 2. Respondents with unknown status (either alive or dead) at wave 3 or wave 4, and did not provide valid information to all covariates of interest, were excluded from all analyses. With these restrictions, the final analytic samples include 11 037 individuals for analyses of all-cause and cardiovascular mortality.

We recognize the negative effect of sample restrictions that could limit the generalization of our findings to all older populations; however, results from diagnostic analyses indicate no statistically significant differences in grip strengths and demographic and health characteristics between the complete male sample at baseline and the analytic male sample included in the analyses of all-cause mortality and cardiovascular mortality analyses. For women, in contrast, the results demonstrated somewhat modest differences between the 2 samples of both all-cause and cardiovascular mortality analyses. The analytic female sample of all-cause mortality analysis was significantly younger, with a lower prevalence of diabetes at 10%. This pattern is broadly consistent with cardiovascular mortality except diabetes. This is due to older women being more likely to have incomplete grip strength data.

Measurements

All-cause mortality and cardiovascular mortality. Analytic respondents were followed through waves 3 and 4 to determine whether they were dead or alive. In case of death, information regarding month and year of death, and cause of death was obtained from proxy interview with a family member, a household member, a neighbor, or any other person close to the deceased respondent. For cardiovascular mortality, causes of death were identified through the survey question: "What was the main cause of respondent's death?" Possible answers include cancer, heart attack, stroke, and other cardiovascular disease-related illnesses, such as heart failure and arrhythmia, respiratory disease, disease of the digestive system, severe infectious disease, and others. These answers were coded into a dichotomous variable: 1 represents death from cardiovascular diseases (ie, heart attack, stroke, and other cardiovascular diseases), and 0 indicates otherwise, which includes all other causes of death.

Grip strength. Grip strength was measured using a Smedley handheld dynamometer (100 kg) with respondents standing or sitting, their elbow fixed at a 90° angle, and a neutral wrist position. Respondents were asked to squeeze the dynamometer with each of their hands as hard as possible and maintain it for 5 seconds. The force of grip was recorded in kilograms.[36]

Three grip strength measures, namely, (1) grip strength, (2) change in grip strength, and (3) combination of grip strength and change in grip strength, were constructed by using the maximum force of grip of both the right and left hands. Because grip strength significantly differs between men and women, and declines with age,[37,38] we converted grip strength into age-sex-specific percentiles, in which higher percentiles indicate stronger grip strength for a particular sex. In addition, to account for the non-linear pattern of grip strength, grip strength was incorporated as a categorical, rather than continuous, variable: 1 indicates low grip strength (<20th percentile) and 0 indicates normal grip strength (≥20th percentile). The cutoff value was derived from the analysis of area under the receiver-operating characteristic curve (AUC). The highest AUC indicates the best cutoff percentile to classify the respondents with low/normal grip strength. The method and the cutoff at the 20th percentile were reported in previous studies with similar populations.[39,40]

Change in grip strength was constructed based on the respondent's grip strength measured at waves 1 and 2. The difference between the 2 grip strengths was divided by the value of grip strength at wave 1 and number of years between the 2 surveys, and multiplied by 100 to obtain a percent change per year. For similar reasons as grip strength, change in grip strength was converted into age-sex-specific percentiles and incorporated as a categorical variable, indicating how fast the respondent's grip strength declined. The cutoff percentile for change in grip strength was selected to be the same as that for grip strength to permit the combination of these 2 measures. Similar for male and female respondents, rapid decline refers to a decline greater than the 80th percentile and was coded as 1, whereas normal decline indicates the opposite and was coded as 0.

The combination of grip strength and change in grip strength is a composite variable constructed by aggregating the grip strength variable and the change in grip strength variable. Possible categories are (1) normal grip strength and normal decline in grip strength, (2) normal grip strength and fast decline in grip strength, (3) low grip strength and normal decline in grip strength, and (4) low grip strength and fast decline in grip strength. Because there is a possibility that strong grip strength is correlated with rapid decline in grip strength, to combine such 2 variables into 1 single variable would reduce multicollinearity, as well as remove floor and ceiling effects.[41]

Covariates. Covariates incorporated into the analysis represent baseline characteristics of respondents. They include age, height, obesity, region, chronic disease, and smoking cigarettes. Age was measured in years and was included in the analyses as a continuous variable. Height was self-reported and measured in centimeters. Obesity was measured as the respondents' body mass indexes (BMIs) provided by SHARE. A dichotomous variable was created, where 1 represented obesity (BMI ≥ 30) and 0 indicated otherwise. Region was constructed as a categorical variable based on the geographical locations of the study countries. The 10 countries were grouped into 3 regions, namely, West (Austria, Belgium, France, Germany, the Netherlands, and Switzerland), North (Denmark and Sweden), and South (Italy and Spain). Information on chronic diseases was obtained from the respondents' responses to questions asking whether their doctor had informed them of any health problems, including hypertension, high blood cholesterol, diabetes, chronic lung disease, osteoporosis, arthritis, cancer, hip fracture, heart attack, and stroke. A dichotomous variable was constructed for each disease, whereby 1 indicated yes and 0 indicated otherwise. Cigarette smoking was incorporated as a categorical variable indicating if the respondent was never a smoker, an ex-smoker, or a current smoker.

Analytical approach

First, we employed descriptive statistics to describe grip strength and health and social characteristics of the sample. Then, we used the Cox proportional hazards model to investigate the associations between each of the 3 grip strength measures and all-cause mortality. Our diagnostic analysis showed that the use of the Cox regression was appropriate to model all-cause mortality. Finally, we used competing risks regressions to determine cardiovascular mortality in the presence of multiple causes of death. Survival time was represented by person-year lived, which was constructed by counting the number of months starting from the date of interview at wave 2 until either death, end of follow-up, or up to 36 months of follow-up, whichever occurred first. All analyses were performed for men and women separately using STATA 13.0.

Results

Sample description

Median and mean values, and percentage distributions for all variables by sex and survival status for all-cause mortality and cardiovascular mortality are presented in Tables 1 and 2. The sample used in each analysis was the final analytic sample described earlier in the analytic sample section. At baseline, it was more common for elderly male adults in the 2 samples, for both all-cause mortality and cardiovascular mortality analysis, to have higher grip strength than elderly female adults. The median value of grip strength at wave 1 for men was 45 kg, whereas for women it was 27 to 28 kg. On average, the grip strength of the male sample decreased faster than that of the female sample. The median values of change of baseline grip strength were between −1.24% and −1%, and 0% per year for men and women, respectively. The average age of elderly male and female adults of both samples was 62 to 64 years. The average height of men was 174 to 175 cm, whereas that of women was 163 cm. About 16% to 18% of each sample was considered as obese. The proportion of obese women in each sample was slightly greater than that of men. The large majority of studied women (64%-65%) were smokers, with about 15% to 16% still smoking. The percentage

Table 1. Description of characteristics of all-cause mortality by sex and survival status.

	BASELINE			FOLLOW-UP					
	MEN	WOMEN	SIG.[a]	MEN			WOMEN		
				ALIVE	DEAD	SIG.[a]	ALIVE	DEAD	SIG.[a]
Average age (SD)	63.69 (9.00)	63.44 (9.32)	*	63.10 (8.64)	72.27 (9.63)	†††	63.03 (9.04)	73.41 (10.46)	†††
Average height (SD)	174.33 (7.33)	162.77 (6.58)	***	174.46 (7.31)	172.41 (7.45)	†††	162.83 (6.57)	161.22 (6.78)	†††
Median grip strength (IQR)	45.00 (13.00)	27.00 (9.00)	***	45.00 (13.00)	36.00 (13.50)	†††	27.00 (9.00)	22.00 (10.00)	††
Median percent change in grip strength (IQR)	−1.24 (7.86)	0.00 (10.29)	***	−1.16 (7.74)	−2.58 (10.37)	†††	0.00 (10.19)	−1.78 (12.42)	†††
Smoker[b]			***			†††			†††
% current smoker	21.35	15.36		20.97	46.99		15.35	15.88	
% ex-smoker	35.12	64.67		35.74	26.81		64.5	15.45	
Region[c]						††			††
% northern	20.43	19.62		20.09	25.30		19.33	26.61	
% southern	19.10	19.87		18.88	22.29		19.77	22.32	
Presence of									
% obesity	16.70	18.27	*	16.44	20.48		18.07	23.18	†
% hypertension	29.40	32.98	***	29.23	31.93		32.61	42.06	††
% diabetes	9.56	7.71	***	9.10	16.27	†††	7.47	13.73	†††
% cholesterol	21.44	21.38		21.61	18.98		21.45	19.74	
% CLD	5.44	4.50	*	4.84	14.16	†††	4.12	13.73	†††
% arthritis	13.81	24.88	***	13.48	18.67	††	24.67	30.04	
% osteoporosis	1.52	11.50	***	1.40	3.31	††	11.57	9.87	
% cancer	4.59	6.41	***	4.24	9.64	†††	6.15	12.88	†††
% hip fracture	1.68	1.62		1.50	4.22	†††	1.53	3.86	††
% heart attack	14.63	8.29	***	13.56	30.12	†††	7.98	15.88	†††
% stroke	3.38	2.96		2.98	9.04	†††	2.80	6.87	†††
Unweighted cases	5125	5912		4793	332		5679	233	

Abbreviations: CLD, chronic disease; GS, grip strength; IQR, Interquartile range; Sig, significance.
[a]Chi-square and Mann-Whitney *U* tests were conducted for continuous and categorical variables, respectively. *, **, and *** denote significant differences between sexes (baseline) under $P < .10$, $P < .05$, and $P < .01$, respectively. †, ††, and ††† denote significant differences between mortality status (follow-up) under $P < .10$, $P < .05$, and $P < .01$, respectively.
[b]Non-smoker is an omitted category.
[c]Western is an omitted category.
** is provided to show a complete picture of all levels of significance adopted in the analyses.

Table 2. Description of characteristics of cardiovascular mortality by sex and survival status from cardiovascular disease.

	BASELINE			FOLLOW-UP					
	MEN	WOMEN	SIG.[a]	MEN			WOMEN		
				ALIVE	DEAD	SIG.[a]	ALIVE	DEAD	SIG.[a]
Average age (SD)	62.47 (8.65)	62.50 (8.94)		62.35 (8.55)	71.42 (11.26)	†††	62.43 (8.90)	70.95 (9.87)	†††
Average height (SD)	174.53 (7.30)	162.88 (6.54)	***	174.58 (7.29)	170.96 (7.00)	†††	162.91 (6.54)	159.27 (6.72)	†††
Median grip strength (IQR)	45.00 (13.00)	28.00 (9.00)	***	45.00 (13.00)	35.00 (9.50)	†††	28.00 (9.00)	23.00 (8.00)	†††
Median percent change in grip strength (IQR)	–1.00 (7.65)	0.00 (10.08)	***	–1.00 (7.59)	–1.38 (10.36)		0.00 (10.08)	–2.67 (8.47)	
Smoker[b]			***						
% current smoker	22.13	16.03		21.99	32.69		16.06	12.20	
% ex-smoker	35.93	64.25		36.02	28.85		64.14	78.05	
Region[c]						††			
% northern	19.70	19.16		19.71	19.23		19.13	21.95	
% southern	19.88	20.08		19.68	34.62		20.04	24.39	
Presence of									
% obesity	15.98	17.13		15.83	26.92	††	17.09	21.95	††
% hypertension	26.85	29.90	***	26.90	23.08		29.81	41.46	
% diabetes	8.40	6.37	***	8.38	9.62		6.32	12.20	
% cholesterol	18.15	19.26		18.19	15.38		19.27	17.07	
% CLD	4.65	3.78	**	4.56	11.54	††	3.77	4.88	
% arthritis	12.25	22.82	***	12.21	15.38		22.83	21.95	
% osteoporosis	1.30	10.53	***	1.27	3.85		10.53	9.76	
% cancer	3.85	6.00	***	3.82	5.77		5.99	7.32	
% hip fracture	1.55	1.40		1.42	11.54	††	1.35	7.32	†††
Unweighted cases	4000	4996		3948	52		4955	41	

Abbreviations: CLD, chronic disease; GS, grip strength; IQR, Interquartile range; Sig, significance.
[a]Chi-square and Mann-Whitney *U* tests were conducted for continuous and categorical variables, respectively. *, **, and *** denote significant differences between sexes (baseline) under $P < .10$, $P < .05$, and $P < .01$, respectively. †, ††, and ††† denote significant differences between mortality status from cardiovascular disease (follow-up) under $P < .10$, $P < .05$, and $P < .01$, respectively.
[b]Non-smoker is an omitted category.
[c]Western is an omitted category.
"*" and "†" are provided to show a complete picture of all levels of significance adopted in the analyses.

Table 3. HRs and 95% CIs for Cox proportional hazard models predicting all-cause mortality.

	MEN			WOMEN		
	HR	95% CI	W_i	HR	95% CI	W_i
Model 1: level of GS			0.00			0.29
NGS	1.00			1.00		
LGS	2.04***	1.59-2.62		1.37**	1.00-1.88	
Model 2: level of GS change			0.00			0.30
NDGS	1.00			1.00		
FDGS	1.64***	1.29-2.08		1.36**	1.01-1.83	
Model 3: GS level and its change			1.00			0.41
NGS&NDGS	1.00			1.00		
NGS&FDGS	1.82***	1.37-2.41		1.38*	0.98-1.94	
LGS&NDGS	2.22***	1.67-2.94		1.40*	0.99-1.99	
LGS&FDGS	3.60***	2.29-5.67		2.10**	1.14-3.87	

Abbreviations: BMI, body mass index; CIs, confidence intervals; FDGS, fastest decline in grip strength; GS, grip strength; HRs, hazard ratios; LGS, low grip strength, NDGS, normal decline in grip strength, NGS, normal grip strength; w_i, Akaike weights. All models adjusted for age, height, BMI, smoking, regions, and chronic illness.
*$P \leq .10$; **$P \leq .05$; ***$P \leq .01$.

of male smokers was somewhat lower (35%-36%), yet more than 20% reported currently smoking. Regarding chronic diseases, hypertension, arthritis, osteoporosis, and cancer were more prevalent among women than men in the all-cause and cardiovascular mortality sample, whereas diabetes and chronic lung disease were more common for men than women.

There were 565 all-cause deaths and 169 cardiovascular deaths during the mean follow-up period of 2.8 (SD = 0.52) years and 2.8 (SD = 0.46) years, respectively. Results from Tables 1 and 2 also indicate that elderly male and female adults who died during the follow-up period had weaker grip strength. As expected, they were older and more were obese. Around 33% to 47% of the deceased men were current smokers compared with only 12% to 16% of their female counterparts. The deceased's health status at baseline was, as expected, worse than older adults who were alive at follow-up. In the all-cause mortality sample, deceased men had higher prevalence of diabetes, chronic lung disease, arthritis, osteoporosis, cancer, hip fracture, heart attack, and stroke than those who were alive. These diseases, except arthritis and osteoporosis, were also observed in the deceased women. For the cardiovascular mortality sample, deceased men and women from cardiovascular disease had greater prevalence of obesity and hip fracture than those who were alive or dead from other causes. In addition, hypertension, diabetes, and chronic lung disease were observed in women who died from cardiovascular disease.

All-cause mortality

In Table 3, we used the Cox proportional hazards regression model to examine the associations between each of the grip strength measures and all-cause mortality. Table 3 reports hazard ratios for men and women for each grip strength measure, adjusted for age, height, BMI, risk behavior (smoking), region, and chronic illness. A hazard ratio greater than 1 indicates a higher hazard of death associated with a particular category relative to the reference category, whereas a value of less than 1 suggests the opposite. In Table 3, we also report 2 sets of Akaike weights (w_i's), one for men and the other for women. The highest weight value within each set indicates the best grip strength measure for predicting all-cause mortality.

We found that the 3 different measures of grip strengths were significant predictors of all-cause mortality for both men and women. Lower grip strength and fast decline in grip strength significantly increased the risk of dying for older men and women. Men with grip strength and percent change in grip strength higher than the 80th percentile had 2.04 and 1.64 times the hazard ratio of those with grip strength and percent change in grip strength less than the 80th percentile. Similar results with smaller magnitude and significant level were found among women. The comparison among 4 categories of the combined measure reveals that the hazard ratios of dying for elderly men with grip strength lower than the specified normal level, regardless of the speed of decline over time, were at 2.22 to 3.60 times the risk of dying of those with normal and normal decline grip strength. This finding was also true for women, with smaller magnitude and significance level at 10%.

For men, the Akaike weights of the 3 models corresponding to 3 grip strength measures were 0.00, 0.00, and 1.00, whereas for women, the Akaike weights were 0.29, 0.30, and 0.41. This suggests that the combination of grip strength and change in grip strength, compared with treating grip strength and change

Table 4. SHRs and 95% CIs for Cox proportional hazard models predicting cardiovascular mortality.

	MEN			WOMEN		
	SHR	95% CI	w_i	SHR	95% CI	w_i
Model 1: level of GS			0.25			0.76
NGS	1.00			1.00		
LGS	2.24***	1.43-3.52		2.02**	1.17-3.50	
Model 2: level of GS change			0.00			0.04
NDGS	1.00			1.00		
FDGS	1.50*	0.96-2.32		1.27	0.72-2.22	
Model 3: GS level and its change			0.75			0.20
NGS&NDGS	1.00			1.00		
NGS&FDGS	1.99**	1.18-3.35		1.37	0.69-2.75	
LGS&NDGS	2.78***	1.67-4.61		2.07**	1.12-3.84	
LGS&FDGS	2.74**	1.11-6.75		3.09**	1.12-8.52	

Abbreviations: BMI, body mass index; FDGS, fastest decline in grip strength; LGS, low grip strength; NDGS, normal decline in grip strength; NGS, normal grip strength; SHRs, subdistribution hazard ratios; w_i, Akaike weights. All models adjusted for age, height, BMI, smoking, regions, and chronic illnesses, including hypertension, cholesterol, and diabetes.
*$P \leq .10$; **$P \leq .05$; ***$P \leq .01$.

in grip strength independently, was the best predictor of all-cause mortality for men and women.

In addition to grip strength (data not shown), the multivariate results from 3 models corresponding to 3 grip strength measures of both elderly men and women consistently showed that age, BMI, smoking behavior, region, and chronic illness affected all-cause mortality. Age was a very strong predictor for both men and women, whereas BMI and residing in northern countries were more significant for men than women. Being a current smoker was another highly significant risk factor, roughly doubling the chance of dying for both men and women. All-cause mortality was also determined by several illnesses, as expected. For men, lung problems, heart attacks, and strokes were strong predictors. Cancer was also an important factor yet less significant compared with the previous 3 illnesses. Diabetes was associated with all-cause mortality only for the change in grip strength and the combined grip strength models, whereas hip fracture significantly affected the grip strength and the combined grip strength models. For women, fewer illnesses had significant impact on all-cause mortality. Moreover, the significance patterns were similar across the 3 models: lung disease was the most significant, whereas diabetes was the least.

Cardiovascular mortality

Table 4 shows the results of the cardiovascular mortality analysis. We used competing risk models to examine the associations between each of the grip strength measures and cardiovascular mortality. Table 4 shows subdistribution hazard ratios (SHRs) for men and women for each grip strength measure, adjusted for age, height, BMI, risk behavior (smoking), region, and chronic illness. The interpretation of the SHR is similar to that of the Cox hazard ratios. An SHR greater than 1 indicates that higher values of grip strength are associated with a higher hazard of cardiac death, controlling for all other covariates and competing risks being present, whereas a value of less than 1 indicates the opposite. We also report 2 sets of Akaike weights (w_i's), one for men and the other for women. The highest weight value within each set indicates the best grip strength measure for predicting cardiovascular mortality.

We found that after controlling for age, height, BMI, risk behavior (smoking), region, and chronic conditions, grip strength and the combination of grip strength and change in grip strength were significantly associated with cardiovascular mortality for both men and women. Lower grip strength (≤20th percentile) increased the hazard of cardiac death by about 2.2 times for elderly men and 2.0 times for elderly women. The chance of dying was significantly increased to almost 2.7 times for men and 3.1 times for women if their grip strength was low and in fast decline. No significant difference in cardiovascular mortality was found across 2 categories of grip strength change for both sexes. For the Akaike weights, we found that grip strength, compared with the other 2 measures, was the best predictor of cardiovascular mortality for women, whereas the combination of grip strength and its change was the best predictor of cardiovascular mortality for men.

In terms of demographic and health background (data not shown), we found age, BMI, smoking behavior, and diabetes to be significantly associated with men's cardiovascular mortality for all 3 measures of grip strength. Men who were older, were current smokers, had higher BMI values, and had reported having diabetes were more likely than their counterparts to die from cardiovascular diseases. For women, age and diabetes significantly worsened the chance of dying for all 3 models of grip strength measures. Unlike men, neither BMI nor smoking behavior had a significant impact on women's chances of dying from cardiovascular diseases.

Discussion

This study demonstrated the measurements of grip strength and their associations with all-cause mortality and cardiovascular mortality in a sample of elderly European people in 2 ways. First, our results showed that the combined measure of grip strength and change in grip strength was a viable predictor of all-cause mortality and cardiovascular mortality. Second, based on the Akaike information criterion test results, the combined measure was the best predictor of all-cause mortality for both men and women. However, a static measure of grip strength was the best at stratifying for women, whereas the combination of grip strength and its change was the predictor for men for cardiovascular mortality risks.

Grip strength is associated with overall body strength, including the strengths of arms, backs, and legs, which could be generalized to muscle strength of the entire body.[42] Because reduced muscle strength is correlated with physical inactivity, which is further linked to higher risks of chronic diseases and mortality, grip strength, as a measure for muscle strength, has been widely used as an indicator of all-cause mortality and cause-specific mortality, such as cancer and cardiovascular mortality. Our findings are generally in line with previous studies in different settings, indicating that grip strength, regardless of how it is measured (ie, level, change, or combination of level and change), has a significant predictive power of all-cause mortality[2,4,6,8,9,11,17–19,26,32,33,43] and cardiovascular mortality.[4,8,10,11] This is true for both men and women, though the pattern is not the same for mortality due to different factors.

Unlike grip strength, the association between the change in grip strength and mortality is rather mixed and warrants further investigation. In our study, we found that a rapid decline in grip strength was significantly associated with an increased risk of all-cause mortality for both men and women. However, the rate of change in grip strength had no significant relation to cardiovascular mortality in either sex. This could be due to the short-term follow-up of cardiovascular mortality based on samples with non-cardiovascular disease, which affects relatively small numbers of cardiovascular deaths in male and female samples. Moreover, it is possible that a decline in grip strength may be a symptom produced during pathogenesis,[32,44] which makes people aware of their health. In such cases, people may visit their doctor or take an active role to improve their health, and thus an association between change in grip strength and mortality is not seen.

There were some similarities and differences in grip strength measurements between men and women. For example, age and risky health behavior, ie, smoking cigarettes, were strong predictors of all-cause mortality and cardiovascular mortality for both sexes, as also observed in other studies.[21,22,24–27,29,31] Regarding the anthropometric measures, our study suggests that BMI is a significant predictor of all-cause mortality and cardiovascular mortality for men only. Similar to previous studies,[2,4,8–11,19,32] our study has incorporated chronic diseases into all-cause mortality and cardiovascular mortality analyses. We found that lung disease significantly increased the risk of death for both men and women, whereas diabetes significantly increased the risk of death from all-cause mortality and cardiovascular mortality for both men and women. In addition, the sex differences in heart attack, stroke, and cancer showed that these conditions predicted all-cause mortality for men only.

Nevertheless, this study has some limitations. First, SHARE adopts a self-report measure of body weight and height, and chronic illnesses. The reliability of the results thus depends on accurate reporting of this information. For chronic illness, for example, even though the question asked whether the illness had been diagnosed by a physician, respondents might fail to report certain symptoms due to recall bias or social desirability bias, as they wanted to be viewed as strong by the interviewer. Second, our analyses did not use sampling weights because there is no automatic gain in efficiency from using weights in the causal relationship of interest.[45] Moreover, there are some missing longitudinal weights due to respondents not belonging to the selected balanced sample, which is problematic, as the process generating missing observations is not random. Third, as reported in other studies,[46–48] there is a possibility that grip strength is associated with hypertension and diabetes, causing a multicollinearity problem in all-cause mortality analysis. In an effort to avoid this problem, a sensitivity analysis was conducted by dropping all chronic diseases from the model. This analysis did not yield different results from those presented earlier. Finally, there are many other important variables that have been identified in the literature to have direct or indirect impact on grip force but were not included in our analyses due to data unavailability. These variables are, for example, drugs and medical treatment taken by the respondents.[49–51]

In conclusion, grip strength measures yield important associations with all-cause mortality and cardiovascular mortality. Assessments of a combination of static grip strength and a change in grip strength among older adults are implicative of clinically viable information that can be used to increase accuracy for prediction of all-cause mortality, whereas the simply static grip strength could be a predictor of cardiovascular mortality. Nonetheless, further research is needed to investigate the association between grip strength and all-cause mortality and cardiovascular mortality in other older populations with different demographic and health characteristics.

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Author Contributions

OP conceived and designed the study, and conducted all statistical analyses. WP wrote the manuscript text. Two authors discussed results and jointly revised the manuscript.

Ethical Approval

Ethical approval was provided by the Survey of Health, Ageing and Retirement in Europe (SHARE) Project (http://www.share-project.org/data-access/share-conditions-of-use.html). All activities involving human participants were guided by international ethics principles.

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