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Self-rated Health, Physical Activity, Measures of Physical Functioning and Mortality among Older U.S. Adults

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Abstract **Background:** Poor general health, inactivity, and functional limitations are three of the stronger predictors of mortality in older adults. Furthermore, the predictive power of functional limitation can depend on the specific measure assessed. **Purpose:** The objective of this study was to determine if different measures of physical functioning (PF) can predict mortality independent of self-rated health (SRH) and physical activity (PA). **Methods:** A baseline sample of 6,173 adults 65+ years of age was included from the 2001-2018 NHANES. An SRH variable was created with categories of excellent/very good, good, fair, and poor. PA status was based on participants reporting either no (inactive) or at least some (active) recreational PA. Seven different PF measures were used and included a 19-item total PF score (PFT), activities of daily living (ADL), instrumental activities of daily living (IADL), leisure and social activities (LSA), general physical activities (GPA), lower extremity mobility (LEM), and an IRT-derived total PF score (PFIRT). All PF measures were scored so larger values represented greater PF limitation. Seven Cox regression models were employed, each with a different PF measure and adjusted for age, sex, race, income, SRH, PA, BMI, BSI, smoking, alcohol consumption, and chronic disease status. **Results:** A total of 2,103 deaths occurred during a median follow-up of 10.3 years. Risk of death decreased for 1st (HR=0.70, 0.60-0.82), 2nd (HR=0.77, 0.64-0.93), and 3rd (HR=0.82, 0.72-0.94) PFIRT quartiles (reference: 4th), increased for poor (HR=2.11, 1.51-2.97), fair (HR=1.82, 1.54-2.15), and good (HR=1.20, 1.07-1.35) SRH (reference: excellent/very good), and increased for inactive (HR=1.27, 1.12-1.43) PA status (reference: active). Each PF model saw similar results, less LSA, where LSA lost its predictive ability in light of SRH. **Conclusion:** These findings indicate that SRH, PA, and PF are robust independent predictors of all-cause mortality in older adults.

Keywords: *Physical activity, Self-rated health, Physical functioning, Mortality, Gerontology*

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1. Introduction

Impaired physical functioning (PF) is a known risk factor for mortality among older adult populations [1,2,3]. Physical activity (PA) is an equally strong predictor of mortality as well as premature mortality in this population [4]. Self-reported measures of wellness, such as self-reported health (SRH), have been shown to predict mortality more strongly in aged populations than even objective health metrics [5,6]. Despite these known associations, data examining the independent effects of PF, PA, and SRH on survival in older adult populations are sparse [7]. Moreover, the magnitude of influence that PF has as a predictor of mortality appears to vary depending on the PF measure used [8]. Therefore, the purpose of this study was to examine the extent to which different measures of PF can predict mortality independent of SRH and PA.

2. Methods

Study design

This study used nine cycles (2001-2018) of National Health and Nutrition Examination Survey (NHANES) data along with National Center for Health Statistics (NCHS) 2019 public-use linked mortality files [9]. The initial dataset consisted of 101,316 adults 0+ years of age, and after excluding those under 65 years of age, those ineligible for linkage, or those with incomplete data, the result was a baseline sample of 6,173 older adults (Figure 1).

Self-rated health (SRH) and Physical activity (PA)

An SRH variable was created from a single question that asked participants to rate their general health as either "excellent," "very good," "good," "fair," or "poor." The new SRH variable was recoded using only four categories

of "excellent/very good," "good," "fair," or "poor". PA was assessed by first computing variables indicating if participants reported typically engaging in any weekly moderate PA (MPA) or vigorous PA (VPA) for at least 10 minutes continuously. Using these variables, a two-level PA status variable was created that categorized participants as either physically active in MPA, VPA, or both MPA and VPA (active) or physically active in neither MPA nor VPA (inactive).

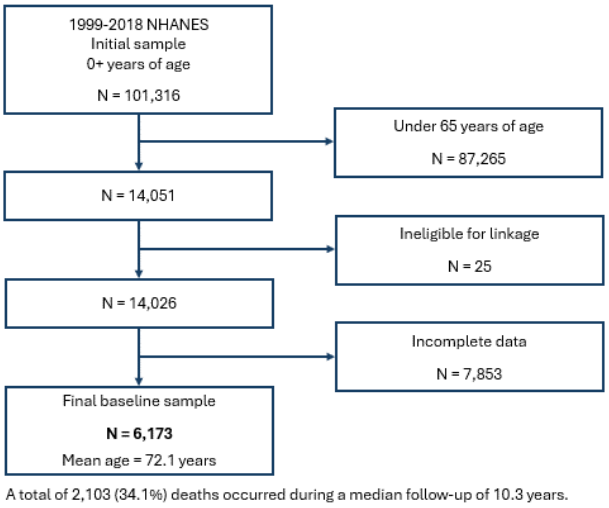

Figure 1. Schematic of study exclusions

Physical functioning (PF)

Six different PF measures were used and included a 19-item total PF score (PFT), activities of daily living (ADL), instrumental activities of daily living (IADL), leisure and social activities (LSA), general physical activities (GPA), and lower extremity mobility (LEM) [10,11]. Each of the 19 items contained a common response scale with categories of *no difficulty*, *some difficulty*, *much difficulty*, and *unable to do the activity*. Binary PF items were then created indicating no difficulty (0) or at least some difficulty (1). Summing the 19 binary PF items created the PFT variable. Summing the binary items related to 1) dressing themselves, 2) walking between rooms, 3) getting in and out of bed, and 4) eating with a knife, fork, and cup created the ADL variable. Likewise, summing binary items related to 5) managing money, 6) house chores, and 7) preparing meals created the IADL variable. Summing binary items related to 8) going out to events, 9) attending social events, and 10) home leisure activities created the LSA variable. Summing binary items related to 11) stooping, crouching, and kneeling, 12) standing from armless chair, 13) standing for long periods, 14) sitting for long periods, 15) reaching up, 16) grasping/holding small objects, and 17) lifting or carrying created the GPA variable. Finally, summing the binary items related to 18) walking a quarter of a mile and 19) walking up 10 stairs created the LEM variable. Each of the six PF measures above were also dichotomized to indicate if a participant had a PF limitation (score>0) or had no limitations (score=0).

A seventh PF measure was constructed using item response theory (IRT) factor scores (PFIRT) [12,13]. All 19 items were entered into a 2-parameter logistic (2PL) IRT model and evaluated for unidimensionality and item fit. A dominant factor was observed with an eigenvalue of 10.8 that accounted for 57% of item variation. Additionally, all inter-item polychoric correlations ranged between 0.238 and 0.892 with a Cronbach's alpha of 0.86. Finally, all 19 items significantly (all $p<0.0001$) fit the 2PL IRT model with item difficulty values ranging from 0.34 to 2.78 and item discrimination values between 1.25 and 3.25. For regression modeling purposes, PFIRT was converted to quartiles, where larger quartile group membership represented greater PF limitation.

Health-related covariates

Five different health-related covariates were used and included body mass index (BMI), body shape index (BSI), smoking, alcohol consumption, and chronic disease status. Four BMI (kg/m^2) categories were formed using the following BMI criteria: 1) underweight (BMI<18.5), 2) normal weight (18.5≤BMI<25.0), 3) overweight (25.0≥BMI<30.0), and 4) obese (BMI≥30.0). BSI was computed from objectively measured height, weight, and waist circumference (WC) using the following formula: BSI ($m^{11/6}/kg^{2/3}$) = WC / ($BMI^{2/3}$ × $height^{1/2}$) [14]. Smoking status was assessed using a series of questions asking participants about their lifetime and current smoking habits. From these responses, a smoking status variable was created that assigned participants to one of three categories: non-smoker, former smoker, or current smoker. Alcohol use was assessed using a series of questions asking participants about their alcohol consumption history and average alcohol consumption. From these responses, an alcohol status variable was created that assigned participants to one of three categories: non-drinker, light drinker, or moderate-to-heavy drinker. A chronic disease status variable was created from nine different disease conditions that included 1) coronary heart disease, 2) congestive heart failure, 3) coronary heart disease, 4) angina pectoris, 5) heart attack, 6) stroke, 7) emphysema, 8) chronic bronchitis, and 9) arthritis. A two-group chronic condition status variable was created with participants considered to either have no chronic conditions or at least one chronic condition.

Sociodemographic covariates

Four different sociodemographic variables were used and included age, sex, race, and income. Age was used as a continuous variable, ranging from 65 years to 80+ years, as well as a grouping variable for descriptive purposes. Sex included male and female groups. Race/ethnicity was used as a categorical variable and included White, Black, Hispanic, and Other groupings. Lastly, income was used as a continuous variable and computed as a ratio of the family income to poverty, ranging from 0 to 5, as well as a grouping variable (quartiles) for descriptive purposes.

Statistical analyses

Weighted percentages of PF categories and PA status groups across sample characteristics were computed with 95% confidence intervals (CIs) and Rao-Scott chi-square (X^2) statistics (Table 1 and Table 2). Similar weighted percentages and inferential statistics were computed for any PF limitation across age groups by SRH and PA status (Table 3). To descriptively examine the influence of PA and SRH on PF across different age groups, mean PFT scores were computed and presented visually in a stacked column panel chart (Figure 2). Linear regression was used to formally test for differences in PF between the age groups for each PA status group. Specifically, contrast

statements were used to test for linear trend in means, and Tukey-Kraemer post-hoc tests used to test for group mean differences. Six (6) Cox proportional hazard models were employed, associating each PF measure along with PA status and SRH with all-cause mortality while adjusted for age, sex, race, income, BMI, BSI, smoking, alcohol consumption, and chronic conditions status (Table 4 and Table 5). A similar hazard regression model was employed using the IRT-derived PF quartile variable (PFIRT) and displayed visually as a forest plot (Figure 3). SAS version 9.4 was used for all analyses [15].

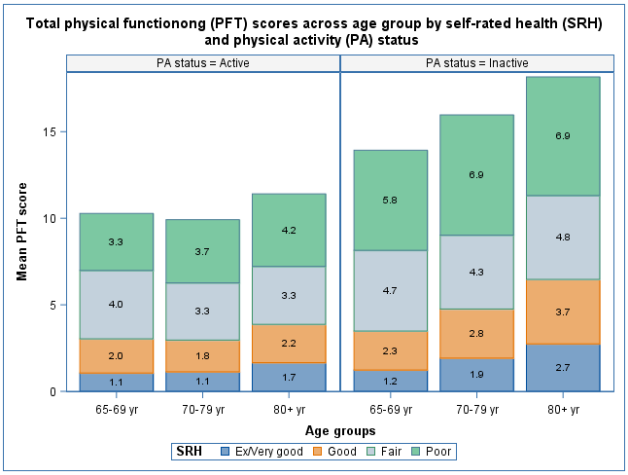

Figure 2. Stacked column panel chart of total physical functioning (PFT)

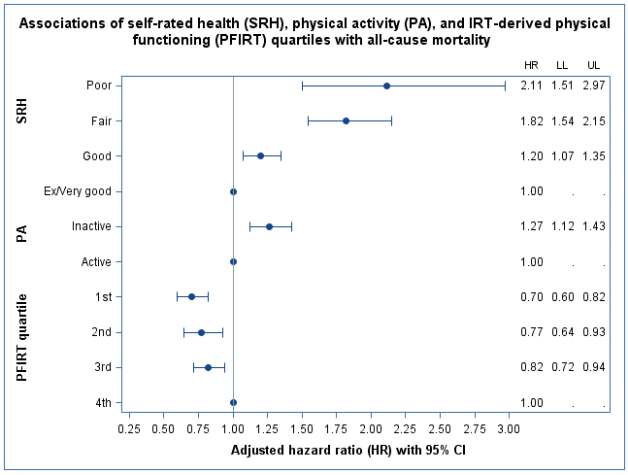

Figure 3. Forest plot of fully adjusted hazard ratio (HR) statistics

3. Results

Analysis of baseline characteristics revealed that approximately 24.8% (95% CI: 23.3-26.3) of older adults suffered a high number (PFT≥4) of physical limitations, with even greater percentages observed in female (30.1%), 80+ year-old (31.9%), lowest income quartile (34.7%), obese (32.2%), and chronic disease suffering (32.2%) populations (Table 1). Approximately 54.1% (95% CI: 51.9-56.2) of older adults were considered physically active at baseline, with even greater percentages observed in male (58.3%), 65-69 year-old (58.6%), Other race group (56.3%), highest income quartile (65.4%), normal weight (58.7%), and non-chronic disease suffering (55.7%) populations (Table 2). The oldest (80+ years) of older adults were more likely to report having any PF limitation, as compared to their counterparts (Table 3). However, among physically active older adults with "fair" or "poor" SRH, the oldest adults were less likely to report having any PF limitation.

The influence of age on PF limitation was more apparent among physically inactive adults than their active counterparts (Figure 2). The linear trend in PF means across age group categories was stronger for the inactive group ($L'\beta$=1.22, F=35.38, p<0.0001) than the active group ($L'\beta$=0.41, F=7.19, p=0.0082). Moreover, Tukey-Kramer post-hoc comparisons indicated significant (all p<0.0200) differences between all age groups in inactive older adults. Whereas only the oldest (80+ years) group had significantly (both p<0.0200) different PF in active older adults.

Survival analysis revealed a total of 2,103 deaths during a median follow-up of 10.3 years. Risk of all-cause mortality decreased for older adults who were not limited with PFT (HR=0.80, 95% CI: 0.70-0.92), ADL (HR=0.86, 95% CI: 0.75-0.99), or IADL (HR=0.79, 95% CI: 0.69-0.91) (Table 4). Additionally, risk of all-cause mortality decreased for those not limited with GPA (HR=0.83, 95% CI: 0.73-0.95) or LEM (HR=0.68, 95% CI: 0.60-0.77) (Table 5). There was no significant change in all-cause mortality risk associated with LSA limitation status. However, after dropping SRH from the model, LSA regained its ability to predict mortality (HR=0.78, 95% CI: 0.67-0.91). Finally, risk of all-cause mortality decreased for 1st (HR=0.70, 95% CI: 0.60-0.82), 2nd (HR=0.77, 95% CI: 0.64-0.93), and 3rd (HR=0.82, 95% CI: 0.72-0.94) PFIRT quartiles (reference: 4th), increased for poor (HR=2.11, 95% CI: 1.51-2.97), fair (HR=1.82, 95% CI: 1.54-2.15), and good (HR=1.20, 95% CI: 1.07-1.35) SRH (reference: excellent/very good), and increased for inactive (HR=1.27, 95% CI: 1.12-1.43) PA status (reference: active) (Figure 3).

Table 1. Weighted percentages of physical functioning (PF) levels across baseline sample characteristics

	Physical functioning (PFT) categories									X^2
	None (0) (N = 2,565)			Moderate (1 to 3) (N = 2,048)			High (4+) (N = 1,560)			
Characteristic	*%*	*LL*	*UL*	*%*	*LL*	*UL*	*%*	*LL*	*UL*	*p*
Overall	41.7	39.74	43.75	33.46	31.75	35.17	24.8	23.31	26.29	<.0001
Sex										<.0001
Female	36.0	33.83	38.25	33.85	31.84	35.85	30.1	28.07	32.16	
Male	48.7	45.92	51.47	32.98	30.32	35.64	18.3	16.32	20.32	
Age (yr)										<.0001
65 to 69	48.8	45.23	52.42	29.10	26.22	31.98	22.1	19.68	24.48	

	Physical functioning (PFT) categories									
	None (0) (N = 2,565)			Moderate (1 to 3) (N = 2,048)			High (4+) (N = 1,560)			X^2
70 to 79	40.3	37.76	42.78	35.24	32.87	37.62	24.5	22.44	26.54	
80+	29.5	26.67	32.30	38.60	35.54	41.65	31.9	28.75	35.09	
Race/Ethnicity										.4070
White	41.3	38.98	43.60	33.73	31.74	35.73	25.0	23.30	26.65	
Black	46.4	42.95	49.77	31.86	28.38	35.34	21.8	18.86	24.70	
Hispanic	41.8	38.11	45.57	32.49	28.96	36.02	25.7	22.92	28.41	
Other	43.3	37.27	49.24	31.74	25.65	37.82	25.0	18.08	31.93	
Income quartile										.0479
1st	34.0	30.78	37.24	31.24	28.11	34.37	34.7	31.44	38.06	
2nd	37.9	34.76	41.09	32.83	29.89	35.77	29.2	26.40	32.10	
3rd	42.0	38.48	45.46	33.00	29.39	36.60	25.0	22.22	27.85	
4th	47.5	42.88	52.06	35.22	31.53	38.91	17.3	14.65	19.98	
BMI category										<.0001
Underweight	45.2	32.39	57.98	28.54	16.17	40.92	26.3	13.95	38.60	
Normal weight	48.1	44.96	51.22	32.36	29.58	35.13	19.6	16.81	22.29	
Overweight	43.9	40.72	47.12	33.87	31.02	36.72	22.2	19.82	24.60	
Obese	33.7	30.98	36.39	34.07	31.08	37.07	32.2	29.27	35.21	
Has a disease										<.0001
No	56.8	53.90	59.69	30.55	27.89	33.20	12.7	10.84	14.48	
Yes	32.5	30.21	34.87	35.24	33.16	37.32	32.2	30.24	34.20	

Note. N = 6,173. PFT is a total PF score from all 19 PF items. p-values are from the Rao-Scott chi-square (X^2) statistic. % is the weighted estimate. LL and UL are the lower and upper limits, respectively, of the 95% confidence interval (CI) estimating the %.

Table 2. Weighted percentages of physical activity (PA) status across baseline sample characteristics

	Physical activity (PA) status						X^2
	Active (N = 3,038)			Inactive (N = 3,135)			
Characteristic	*%*	*LL*	*UL*	*%*	*LL*	*UL*	*p*
Overall	54.1	51.90	56.20	45.95	43.80	48.10	.0002
Sex							<.0001
Female	50.6	47.79	53.32	49.44	46.68	52.21	
Male	58.3	55.72	60.89	41.70	39.11	44.28	
Age (yr)							<.0001
65 to 69	58.6	55.48	61.81	41.35	38.19	44.52	
70 to 79	53.6	50.92	56.36	46.36	43.64	49.08	
80+	44.6	41.33	47.87	55.40	52.13	58.67	
Race/Ethnicity							<.0001
White	55.5	53.07	57.88	44.52	42.12	46.93	
Black	44.8	41.00	48.66	55.17	51.34	59.00	
Hispanic	42.0	37.46	46.56	57.99	53.44	62.54	
Other	56.3	49.35	63.33	43.66	36.67	50.65	
Income quartile							<.0001
1st	37.8	33.99	41.66	62.17	58.34	66.01	
2nd	46.7	43.29	50.19	53.26	49.81	56.71	
3rd	54.8	51.43	58.19	45.19	41.81	48.57	
4th	65.4	61.71	69.05	34.62	30.95	38.29	
BMI category							<.0001
Underweight	54.1	42.54	65.63	45.92	34.37	57.46	
Normal weight	58.7	55.21	62.23	41.28	37.77	44.79	
Overweight	56.7	54.04	59.38	43.29	40.62	45.96	
Obese	46.9	43.44	50.44	53.06	49.56	56.56	
Has a disease							.1324

	Physical activity (PA) status						
	Active (N = 3,038)			Inactive (N = 3,135)			X^2
No	55.7	52.97	58.48	44.28	41.52	47.03	
Yes	53.0	50.27	55.78	46.97	44.22	49.73	

Note. N = 6,173. PA status groups are based on self-reported PA of moderate and vigorous activities. p-values are from the Rao-Scott chi-square (X^2) statistic. % is the weighted estimate. LL and UL are the lower and upper limits, respectively, of the 95% confidence interval (CI) estimating the %.

Table 3. Weighted percentages of any physical functioning (PF) limitation across age groups by self-reported health (SRH) and physical activity (PA) status at baseline

	Age groups											
	65-69 yr (N = 2,066)				70-79 yr (N = 2,825)				80+ yr (N = 1,282)			
Characteristic	*%*	*LL*	*UL*	*p*	*%*	*LL*	*UL*	*p*	*%*	*LL*	*UL*	*p*
Overall (p <.0001)	51.2	47.58	54.77	-	59.7	57.22	62.24	-	70.5	67.70	73.33	-
Self-reported health (SRH)				<.0001				<.0001				.0007
Excellent/Very good	40.3	35.07	45.45		49.7	46.13	53.33		65.5	61.02	69.90	
Good	55.7	50.55	60.82		63.8	59.94	67.59		72.5	68.36	76.57	
Fair	78.3	73.10	83.43		80.1	76.05	84.17		80.9	74.91	86.92	
Poor	75.8	57.72	93.93		83.5	70.27	96.81		83.4	66.23	100.00	
Physical activity (PA) status				.0024				<.0001				<.0001
Active	46.6	41.51	51.61		52.4	49.10	55.64		60.1	55.10	65.08	
Inactive	57.7	52.68	62.77		68.2	65.02	71.46		78.9	75.41	82.40	
PA status: Active												
SRH:				<.0001				<.0001				.8676
Excellent/Very good	39.0	32.12	45.90		45.2	40.70	49.70		58.5	51.78	65.13	
Good	50.7	43.34	57.98		57.2	51.63	62.81		61.1	52.40	69.71	
Fair	77.7	69.40	86.03		77.9	70.86	84.90		64.8	50.04	79.56	
Poor	77.7	47.46	100.00		64.4	26.63	100.00		68.2	19.71	100.00	
PA status: Inactive												
SRH:				<.0001				<.0001				.0005
Excellent/Very good	42.9	34.03	51.71		58.1	52.31	63.81		72.6	66.64	78.65	
Good	61.6	54.51	68.66		69.7	64.25	75.11		81.1	76.57	85.53	
Fair	78.6	72.04	85.20		81.4	76.35	86.38		88.1	82.60	93.56	
Poor	74.8	50.89	98.61		90.3	82.18	98.49		88.8	76.12	100.00	

Note. N = 6,173. Any PF limitation was based on a PFT score of 1 or greater. p-values are from the Rao-Scott chi-square (X^2) statistic. % is the weighted estimate. LL and UL are the lower and upper limits, respectively, of the 95% confidence interval (CI) estimating the %.

Table 4. Cox proportional hazard models associating self-rated health (SRH), physical activity (PA), and physical functioning (PF) measures (PF, ADL, IADL) with all-cause mortality

	Physical functioning (PF) measure								
	PFT			ADL			IADL		
Predictor	*HR*	*LL*	*UL*	*HR*	*LL*	*UL*	*HR*	*LL*	*UL*
Self-reported health (SRH)									
Excellent/Very good	1.00	ref		1.00	ref		1.00	ref	
Good	1.22	1.09	1.37	1.24	1.11	1.39	1.23	1.10	1.38
Fair	1.89	1.61	2.23	1.94	1.65	2.29	1.91	1.62	2.24
Poor	2.28	1.64	3.19	2.34	1.68	3.25	2.21	1.58	3.10
Physical activity (PA) status									
Active	1.00	ref		1.00	ref		1.00	ref	
Inactive	1.28	1.14	1.44	1.29	1.14	1.45	1.28	1.14	1.44
Physical functioning (PF) status									
Not limited	0.80	0.70	0.92	0.86	0.75	0.99	0.79	0.69	0.91
Limited	1.00	ref		1.00	ref		1.00	ref	

Note. N = 6,173. PFT is a total PF score from all 19 PF items. ADL is activities of daily living. IADL is instrumental activities of daily living. Cox proportional hazard models estimate the hazard ratio (HR) and its 95% CI. LL and UL are the lower and upper limits, respectively, of the 95% CI estimating the HR. All models are adjusted for BMI, BSI, smoking, alcohol consumption, chronic conditions status, age, sex, race, and income.

Table 5. Cox proportional hazard models associating self-rated health (SRH), physical activity (PA) status, and physical functioning (PF) measures (LSA, GPA, LEM) with all-cause mortality

	Physical functioning (PF) measure								
	LSA			GPA			LEM		
Predictor	*HR*	*LL*	*UL*	*HR*	*LL*	*UL*	*HR*	*LL*	*UL*
Self-reported health (SRH)									
Excellent/Very good	1.00	ref		1.00	ref		1.00	ref	
Good	1.24	1.11	1.40	1.23	1.09	1.38	1.21	1.08	1.35
Fair	1.95	1.66	2.29	1.91	1.63	2.25	1.79	1.53	2.10
Poor	2.32	1.66	3.25	2.31	1.65	3.22	2.06	1.47	2.88
Physical activity (PA) status									
Active	1.00	ref		1.00	ref		1.00	ref	
Inactive	1.29	1.14	1.45	1.28	1.14	1.44	1.24	1.09	1.40
Physical functioning (PF) status									
Not limited	0.89	0.76	1.04	0.83	0.73	0.95	0.68	0.60	0.77
Limited	1.00	ref		1.00	ref		1.00	ref	

Note. N = 6,173. LSA is leisure and social activities. GPA is general physical activities. LEM is lower extremity mobility. Cox proportional hazard models estimate the hazard ratio (HR) and its 95% CI. LL and UL are the lower and upper limits, respectively, of the 95% CI estimating the HR. All models are adjusted for BMI, BSI, smoking, alcohol consumption, chronic conditions status, age, sex, race, and income. PF became significant in the LSA model after dropping SRH (HR=0.78, 95% CI: 0.67-0.91).

4. Discussion

This study had three important findings worth highlighting, including 1) the mitigated influence of age on PF in physically active participants, 2) the independent association between PF and all-cause mortality in six of the seven fully adjusted PF measure models, and 3) seeing PA and SRH as robust independent predictors of all-cause mortality in all seven fully adjusted PF measure models. The first finding is considered novel due to the fact that PA moderated the well-known age and PF relationship. This finding is supported with results from a 20-year longitudinal study that investigated the association between changes in PA and frailty in community-dwelling older adults [16]. Specifically, participants that increased their PA across the 20-year period had the lowest frailty scores. Moreover, participants that decreased their PA across the same period had the highest frailty scores. Thus, results from this longitudinal study corroborate the moderating effect of PA on the age and PF relationship found in the current study. The second finding addressed the main purpose of the study and showed that six different measures of PF (PFT, ADL, IADL, GPA, LEM, and PFIRT) were each individually associated with all-cause mortality risk independent of PA, SRH, health, and demographic covariates. These results are the first, to date, to show such a robust PF and mortality relationship after adjusting for two major predictors (PA and SRH) of survival in older adults. Interestingly, LSA lost its ability to predict mortality after adjusting for PA, SRH, and covariates. It was found in post-hoc testing of the LSA model, however, that SRH was responsible for the loss of significance. Although no studies to date have specifically corroborated this finding, the relationship between measures of social activity and measures of perceived health are well established [17,18,19]. The third and last finding was addressed to support the study's aim and showed that PA and SRH both independently predicted mortality in all seven fully adjusted PF measure models. This finding supports the study's objective by providing clear evidence for PA and SRH as important predictors of mortality in older adult populations. Evidence that is also well established [20,21,22].

There are three main strengths regarding this study that support its credibility. Firstly, the data used in this analysis come from the NHANES series of health surveys and are collected in a way that allow for generalizations to all older noninstitutionalized U.S. adults 65+ years of age. This data attribute improves the study's external validity and allows its inferences to be considered for related program planning and evaluation. Secondly, NHANES data collection includes a variety of methods that are both objective and subjective in nature. The current study used objective measures of BMI and BSI as well as subjective measures of PF, PA, SRH, smoking, alcohol consumption, and chronic disease status. This data attribute allowed for a deeper understanding of the study's main variables and related covariates. Thirdly, this study was strengthened by its use of seven different PF measures. This study attribute helped determine that PF was indeed a robust predictor of all-cause mortality whereas single-measure studies may be influenced by measurement error. There are two primary limitations in this study that require discussion. The first limitation is that many of the study variables were assessed using self-report methods and may suffer from reporting bias. Specifically, objective measures such as functional exams could improve the validity of PF assessment. Despite this limitation, NHANES questionnaire items have a long-standing reputation for being valid and reliable in assessing health concepts. The second limitation is that a large percentage of NHANES participants were excluded from this study due to missing data. This limits the study's inferences because large amounts of missing data can be an indication of systematic bias. Despite this limitation, several of the study's findings were corroborated by other studies from similar populations. Thus, it is reasonable to assume the current sample resembles its intended population. In sum,

the findings from this study should be interpreted along with its limitations and with caution.

5. Conclusions

This study found that PA moderated the influence of age on PF in older U.S. adults. Additionally, it was found that SRH, PA, and PF are robust independent predictors of all-cause mortality in older adults. Finally, socialization and leisure activity may not be as important to survival after considering perceived health in older adults. Health promotion strategies should collectively target improving SRH, PA, and PF in this population.

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