Objectively Measured Physical Activity and Health-related Quality of Life as Predictors of Mortality in U.S. Adults

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Abstract **Background**: Few national-level studies have examined the effects of both physical activity (PA) and health-related quality of life (HRQOL) on mortality. The purpose of this study was to examine the ability of PA and HRQOL to predict all-cause mortality in U.S. adults. **Methods**: Data for this research came from the 2003-2004 National Health and Nutrition Examination Survey (NHANES) and its 2011 mortality-linked National Death Index (NDI) file. Moderate-to-vigorous PA (MVPA, min/day) was objectively determined by accelerometry and participants were categorized into low or high groups using the median. HRQOL was assessed by a single question asking participants to rate their general health. Participants rating their health as "good", "very good", or "excellent" were considered to have good HRQOL whereas those rating it "fair" or "poor" were considered to have poor HRQOL. Cox proportional hazard regression was used to determine the independent effects of MVPA and HRQOL on all-cause mortality while controlling for covariates. **Results**: In the fully adjusted females model, participants were at greater risk of mortality if they engaged in low amounts of MVPA (Hazard Ratio (HR)=2.82, 95% CI: 1.02-7.85) and had poor HRQOL (HR=7.19, 95% CI: 2.30-22.51) with no significant (*p*=.133) MVPA-by-HRQOL interaction. Conversely, the equivalent males model saw a significant (*p*=.002) MVPA-by-HRQOL interaction, resulting in an analysis of simple effects. In the fully adjusted males with good HRQOL model, participants were at greater risk of mortality if they engaged in low amounts of MVPA (HR=2.92, 95% CI: 1.56-5.49). However, in the males with poor HRQOL model, MVPA could not significantly predict mortality (HR=1.04, 95% CI: 0.49-2.24). **Conclusion**: Results from this study indicate that MVPA and HRQOL independently predict all-cause mortality in U.S. female adults. In U.S. male adults, MVPA predicts all-cause mortality only in those with good HRQOL.

Keywords: physical activity, Accelerometry, Health-related quality of life (HRQOL), Mortality

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1. Introduction

Physical activity (PA) is a universally known health behavior promoted to all adults for its positive health benefits including increased health-related quality of life (HRQOL) [1-5]. Despite this recommendation, the continual collection of data supporting the relationship between PA and health outcomes is important so as to improve the body of knowledge. This is especially true when a large portion of the current knowledge has come from research utilizing self-report assessments of PA, which may lack the same precision seen with objective assessments [6]. Additionally, many studies supporting the positive role of PA on health outcomes have used samples of convenience, which potentially bias certain generalizations [7]. Lastly, HRQOL is most commonly used as a patient-reported outcome and less so as a

predictor variable for survival studies [8,9,10]. Therefore, the purpose of this study was to examine the concurrent ability of objectively measured PA and HRQOL to predict all-cause mortality in a representative sample of U.S. adults.

2. Methods

2.1. Participants and Design

Data for this research came from the 2003-2004 National Health and Nutrition Examination Survey (NHANES) and associated mortality file [11,12]. Mortality data were linked to NHANES participants by the National Center for Health Statistics (NCHS) and for this study the mortality status follow-up ended December 31, 2011. Participants who were 20+ years of age, had complete PA data, and were eligible for mortality linkage were used in the analysis.

2.2. Measures

Moderate-to-vigorous PA (MVPA, min/day) was objectively determined by use of accelerometry [13] and participants were categorized into low and high groups using the median. Additionally, participants were categorized into MVPA quartiles where lower quartiles contained less-active participants. HRQOL was assessed by a single question asking participants to rate their general health [14]. In this study, participants rating their health as "good", "very good", or "excellent" were considered to have good HRQOL whereas those rating it "fair" or "poor" were considered to have poor HRQOL. Covariates were used to describe the sample and control confounding in the statistical models. These covariates included sex (male/female), age (yr), race/ethnicity (White/Black/Hispanic/Other), and income (U.S. $).

2.3. Statistical Analysis

Prevalence estimates with their standard errors (SEs) were computed for HRQOL overall and across demographic groups. Means and their SEs were computed for MVPA overall and across demographic groups. Differences between sex groups were tested using chi-square tests of independence (HRQOL), logistic regression (HRQOL), and ordinary least squares regression (MVPA). Cox proportional hazards regression was employed separately for each sex group to model the effects of MVPA and HRQOL on mortality while controlling for age, race, and income. Finally, MVPA-by-HRQOL interactions were tested in adjusted models - and if found significant – resulted in simple effects modeling. SAS version 9.4 survey procedures were used to account for the sampling design [15-18]. All significance levels were set to p=.05.

3. Results

A total of 5,031 adults were initially included in the survival analysis with a mean (median) person-year follow-up of 7.4 (7.8) years and 726 assumed deaths by all causes. Table 1 contains baseline mean estimates and tests of mean differences by sex for continuous values of MVPA. Males (Mean MVPA=30.4 min/day) overall engaged in significantly (p<.05) more baseline MVPA than females (Mean MVPA=16.7 min/day). This same pattern was also significantly (ps<.05) consistent across all demographic groupings. Table 2 displays baseline prevalence estimates and tests of proportion differences by sex for poor HRQOL. There was a suggestive tendency for more females (18.8%) to report poor HRQOL at baseline as than males (15.8%, p=.70). With significantly more females reporting poor HRQOL than males if they were 18 to 24 years of age (p=.008), Black (p<.001), or had income less than $25,000 per year ($ps$<.05).

Table 1. Baseline moderate-to-vigorous physical activity (MVPA, min/day) across demographic characteristics and by sex, US adults 20+ years of age 2003-2004

Characteristics	Overall		Males		Females		Sex Diff
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*	*p*
Overall (*N* = 3,080)	23.3	0.89	30.4	0.98	16.7	0.74	<.001
Age Group (yr)							
20-24	34.0	2.14	44.5	4.16	24.9	1.28	<.001
25-34	31.6	1.34	39.6	1.61	22.5	1.78	<.001
35-44	30.0	1.58	39.1	1.45	20.7	1.36	<.001
45-54	24.1	0.89	30.9	1.26	17.4	0.90	<.001
55-64	17.0	0.94	20.7	1.24	14.2	1.29	.003
65+	8.5	0.60	10.5	0.83	6.9	0.66	.001
Race/Ethnicity							
White	22.2	0.85	28.6	0.99	16.1	0.70	<.001
Black	23.6	1.33	32.2	1.90	16.6	1.85	<.001
Hispanic	32.1	1.86	42.1	2.59	21.9	2.30	<.001
Other	21.2	2.62	27.4	3.64	16.2	2.62	.006
Annual Income ($)							
0-14,999	17.1	1.71	25.5	2.34	11.2	1.37	<.001
15,000-24,999	18.4	1.65	25.2	2.83	13.6	1.47	<.001
25,000-44,999	22.2	1.35	29.6	1.67	15.7	1.13	<.001
45,000-54,999	23.7	1.48	29.9	2.22	17.6	1.36	<.001
65,000-74,999	25.6	2.33	34.4	3.39	14.8	1.45	<.001
75,000+	28.7	0.82	34.0	1.06	22.6	0.76	<.001

Note. MVPA reported as means (se) and associated hypothesis tests are from ordinary least squares regression. Sex Diff p-values are testing for proportion differences between sex groups.

Table 2. Baseline health-related quality of life (HRQOL) across demographic characteristics and by sex, US adults 20+ years of age 2003-2004

Characteristics	Poor HRQOL: Overall		Poor HRQOL: Males		Poor HRQOL: Females		Sex Diff
	%	SE	%	SE	%	SE	p
Overall (N = 4,320)	17.3	1.18	15.8	1.21	18.8	1.65	.070
Age Group (yr)							
18-24	9.8	1.38	5.0	1.98	14.5	2.01	.008
25-34	10.1	1.53	10.4	1.46	9.9	2.20	.824
35-44	15.9	2.04	15.9	2.56	15.9	2.68	.996
45-54	18.8	1.64	17.5	2.20	20.1	2.72	.476
55-64	20.1	2.40	19.0	3.57	21.0	2.36	.574
65+	27.1	2.45	24.3	1.41	29.4	3.85	.130
Race/Ethnicity							
White	15.1	1.68	14.7	1.81	15.5	2.00	.645
Black	24.4	1.19	17.9	1.42	29.5	1.85	<.001
Hispanic	26.8	1.36	23.7	2.64	30.0	2.72	.173
Other	13.5	3.19	8.4	4.02	18.3	5.66	.195
Annual Income (US $)							
0-14,999	34.9	1.88	30.9	1.77	37.5	2.75	.029
15,000-24,999	28.6	2.61	24.7	2.41	31.5	3.35	.016
25,000-44,999	18.0	1.82	19.0	1.94	17.2	2.61	.545
45,000-54,999	13.1	1.69	14.2	3.20	12.0	2.12	.596
65,000-74,999	10.2	2.34	7.1	2.34	14.2	4.28	.110
75,000+	7.8	1.06	8.5	1.60	7.0	1.37	.479

Note. HRQOL reported as percentages (se) and associated hypothesis tests are chi-square tests of independence or logistic regression. Sex Diff p-values are testing for proportion differences between sex groups.

Table 3. Hazards of all-cause mortality associated with moderate-to-vigorous physical activity (MVPA, high/low) and health-related quality of life (HRQOL, good/poor), US adults 20+ years of age, baseline (2003-2004) thru follow-up (2011)

Grouping	Crude			Model 1			Model 2		
	HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
Females									
MVPA									
High	1.00	-		1.00	-		1.00	-	
Low	6.31	2.95-13.49	<.001	6.55	2.29-18.78	.002	2.82	1.02-7.85	.047
HRQOL									
Good	1.00	-		1.00	-		1.00	-	
Poor	4.87	3.65-6.49	<.001	8.54	2.31-31.57	.003	7.19	2.30-22.51	.002
MVPA*HRQOL						.225			.133
Males									
MVPA									
High	1.00	-		1.00	-		1.00	-	
Low	6.52	3.81-11.17	<.001	7.99	4.11-15.52	<.001	3.36	1.78-6.33	.001
HRQOL									
Good	1.00	-		1.00	-		1.00	-	
Poor	3.86	3.08-4.84	<.001	8.54	3.60-20.26	<.001	6.95	3.37-14.32	<.001
MVPA*HRQOL						.010			.002

Note. Crude column shows unadjusted HRs for MVPA and HRQOL in separate models. Model 1 column shows unadjusted HRs for both MVPA and HRQOL in same model. Model 2 column shows HRs for MVPA and HRQOL adjusted for age, race, and income. Cox regression was used for all models using PROC SURVEYPHREG to account for the complex sampling design.

Table 4. Hazards of all-cause mortality associated with moderate-to-vigorous physical activity (MVPA, high/low) and health-related quality of life (HRQOL, good/poor), US males 20+ years of age, baseline (2003-2004) thru follow-up (2011)

Grouping	Crude			Model 1		
	HR	95% CI	p	HR	95% CI	p
Males with poor health						
MVPA						
High	1.00	-		1.00	-	
Low	2.34	1.18-4.63	.018	1.04	0.49-2.24	.907
Males with good health						
MVPA						
High	1.00	-		1.00	-	
Low	7.99	4.12-15.50	<.001	2.92	1.56-5.49	<.001
Males with low MVPA						
HRQOL						
Good	1.00	-		1.00	-	
Poor	2.56	2.08-3.16	<.001	2.11	1.67-2.66	<.001
Males with high MVPA						
HRQOL						
Good	1.00	-		1.00	-	
Poor	8.67	3.58-21.00	<.001	5.87	2.34-14.70	<.001

Note. Crude column shows unadjusted HRs for MVPA and HRQOL in separate models. Model 1 column shows HRs for MVPA and HRQOL adjusted for age, race, and income. Cox regression was used for all models using PROC SURVEYPHREG to account for the complex sampling design.

Table 3 displays sex-specific hazards of all-cause mortality associated with MVPA (high/low) and HRQOL (good/poor) for both crude and adjusted analyses. In the fully adjusted females model (adjusted for age, race, and income), females were at greater risk of mortality if they engaged in low amounts of MVPA (Hazard Ratio (HR)=2.82, 95% CI: 1.02-7.85) and had poor HRQOL (HR=7.19, 95% CI: 2.30-22.51) with no significant (*p*=.133) MVPA-by-HRQOL interaction. Conversely, the equivalent males model saw a significant (*p*=.002) MVPA-by-HRQOL interaction. Table 4 displays the resulting analysis of simple effects for males. In the fully adjusted males with good HRQOL model, males were at greater risk of mortality if they engaged in low amounts of MVPA (HR=2.92, 95% CI: 1.56-5.49). However, in the males with poor HRQOL model, MVPA could not significantly predict mortality (HR=1.04, 95% CI: 0.49-2.24).
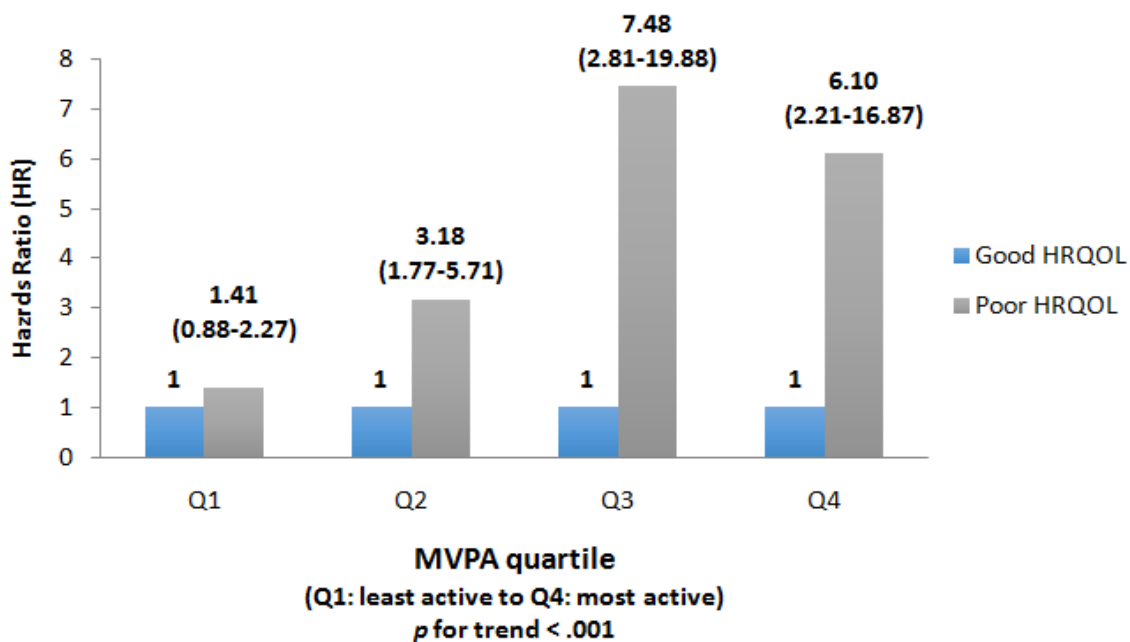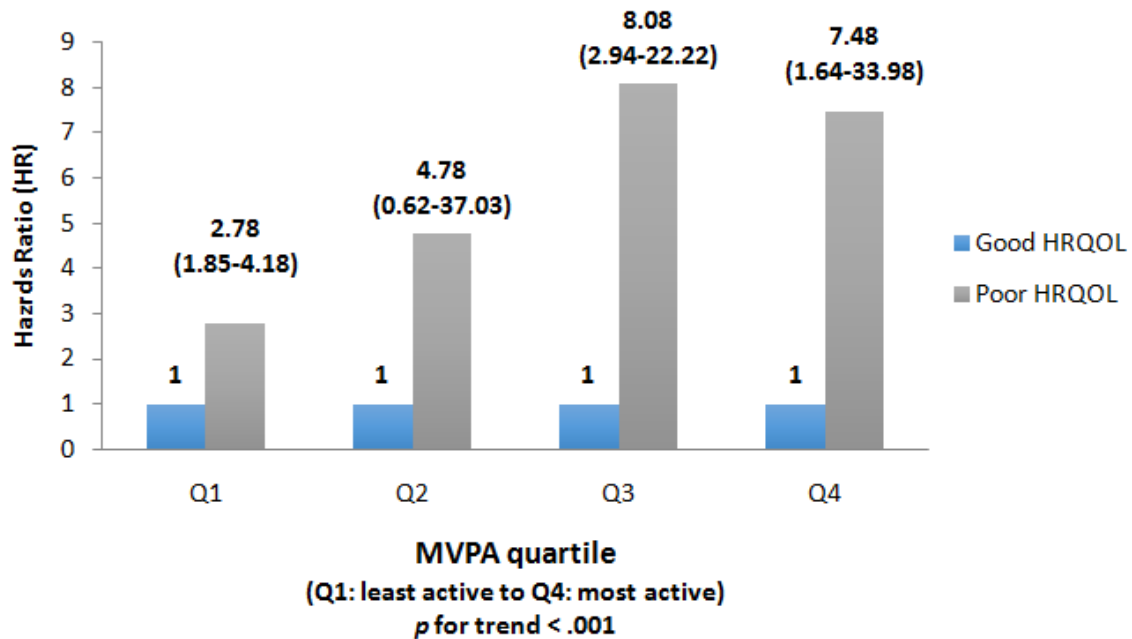

Figure 1. Males (Age-adjusted hazards of all-cause mortality associated with poor HRQOL by MVPA quartile)

Figure 2. Females (Age-adjusted hazards of all-cause mortality associated with poor HRQOL by MVPA quartile)

Figure 1 and Figure 2 show the HRs (95% CIs) associated with HRQOL status across MVPA quartiles. Both graphs indicate a similar trend of increased risk of mortality among those who report poor HRQOL (as compared to those who report good HRQOL). However, the mortality risk associated with poor HRQOL tended to increase as MVPA increased. This linear trend (*p*s for trend<.001) was similar for both sex groups.

4. Discussion

This research reports several noteworthy findings. Firstly, MVPA and HRQOL were shown to independently predict all-cause mortality in the female analysis. Furthermore, the independent association of both predictors withstood the model adjustment for age, race, and income. This finding indicates that regardless of a women's HRQOL status, participation in MVPA is likely to increase her longevity. Similarly, regardless of a women's MVPA status, improving her HRQOL to "good" status is likely to increase her longevity. Secondly, and conversely, MVPA and HRQOL were not found to independently predict all-cause mortality in the male analysis. What this part of the results revealed is that HRQOL is a necessary predictor of all-cause mortality in adult males. That is, regardless of a males MVPA status, poor HRQOL predicts mortality. However, only among adult males with good HRQOL, can MVPA predict mortality. This finding implicates HRQOL as a more important protective factor than PA for adult males. Thirdly, and lastly, when considering MVPA in ordinal groupings of quartiles, it appears that poor HRQOL strength as a predictor of mortality increased as the amounts of MVPA increased. This relationship was noticed in both sex-specific analyses with significant linear trends. These findings also highlight the possibility that large amounts of MVPA may not protect against the mortality-predictive power of poor HRQOL.

A strength of this study is that it examined the concurrent impact of two major risk factors (PA and HRQOL) on mortality and examined their independence as predictors. Therefore, this study adds to the science above those studies that examine only a single risk factor. Another strength of this study is its use of a nationally representative sample of adults 20+ years of age. Hence, this study has an advantage over similar studies that examine relationships between PA, HRQOL and mortality in specific subpopulations or in samples of convenience.

This study also has at least one weakness - which may be the use of self-reported general health to assess HRQOL. Therefore, this study must accept the possibility of some HRQOL misclassification due to the subjective nature of the assessment. Given this shortcoming, HRQOL is a perceived concept that is typically measured by self-report [19]. Additionally, the single general health item used in this study has been validated and assumed to be a reliable measure of HRQOL [20]. Regardless, because of this limitation, findings from this study should be interpreted with caution.

5. Conclusions

Results from this study indicate that MVPA and HRQOL independently predict all-cause mortality in U.S. female adults. In U.S. male adults, MVPA predicts all-cause mortality only in those with good HRQOL. Health promotion advocates promoting PA should focus equally on improving HRQOL when longevity is of concern, especially among men.

Acknowledgements

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