Physical Activity and Mortality among Middle-Aged and Older Adults across Racial/ethnic Groups in the United States

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Physical inactivity has been found to be only second to smoking as the most threatening behavioral factor predictive of morbidity and mortality in old age[1]. For middle-aged men and women, regular physical activity (PA) has been linked to lower all-cause mortality[2-5] plausibly via delaying or avoiding risk factors of chronic conditions such as cardiovascular and respiratory diseases and cancer[2, 6-10]. However, evidence on the relative impacts of non-vigorous versus vigorous PA on all-cause mortality is mixed. Some studies reported that only vigorous PA is associated with greater old age survival[3], whereas others found similar effects across intensity levels of PA[11, 12] or smaller but still significant effects of light to moderate PA compared to vigorous PA[4, 9, 13]. However, most of these studies were based on non-representative samples with limited generalizability.

Moreover, few studies have examined whether the merits of leisure-time PA in middle-aged adults on their survival into old ages vary across different racial/ethnic groups. Compared to non-Hispanic whites, minorities are less socioeconomically advantaged and more likely to be discriminated due to racism[14]. It is possible race/ethnicity may moderate the activity-longevity link as individuals of different racial or ethnic groups on average face vastly different social circumstances which may exert powerful impacts on health and well-being thereby altering the effects of a specific behavioral factor. Alternatively, it is also possible that a nearly universal benefit of PA exists consistent across racial/ethnic groups net of unobserved differences in social realities associated with race/ethnicity. If this is the case, it would be evident to support a salient health-promoting role of active living style, despite individuals' differential life circumstances,

transcending the impacts of a myriad of health-related factors of various social and behavioral realms.

Using longitudinal data from the Health Retirement Survey, a large, nationally representative, prospective cohort study of middle-aged to older adults, we examined the associations of leisure-time PA with all-cause mortality and evaluated racial/ethnic differences in these associations. We also compared the merits of moderate versus vigorous PA for lowering all-cause mortality in the whole sample as well as in the subgroup samples distinguished by race and ethnicity. This study is among the first to analyze a nationally representative sample presenting longitudinal evidence of the effects of vigorous and non-vigorous PA at middle ages on subsequent mortality risks across racial/ethnic groups in the United States.

MATERIALS AND METHODS

Study population: The Health and Retirement Study

The Health and Retirement Study (HRS) is an ongoing longitudinal study funded by the National Institute on Aging that collects information on a wide array of topics including demographics, economic and financial conditions, health status, health behaviors, as well as their changes over time. To ensure its representativeness, the HRS utilizes a national area probability sample of households in the contiguous United States, with oversamples of blacks and Hispanics. Institutionalized individuals are excluded from the survey population[15].

The first wave of data collection started in 1992, soliciting information from 12,544 respondents of ages 51 to 61 at the time of the survey. The response rate was 81.6 percent[16]. These respondents were then followed every other year for updated information. By the year of 2008, 2,661 or 21.2 percent of the baseline sample died and 1,123 or 9 percent were lost to

follow up. Previous research suggests that sample attrition in the HRS is not severe or selective to the extent that it compromises the representativeness of the sample[16, 17].

The longitudinal design of the HRS allows for the merge of the 1992 baseline data with the 2008 tracker and exit file for information on vital status and its timing. The working HRS sample in this study contains 6,870 white, 1,635 black, and 886 Hispanic respondents who were between ages of 51 and 61 in 1992 and were followed through 2008.

Measures

Dependent Variable: Mortality in the 1992-2008 Period

The HRS updates information on vital status and its timing at each wave. In the event where death was reported, an exit interview was attempted, which was most often accomplished with the widow(er) or with another close relative of the deceased respondent[16]. Records on mortality and its timing were verified by linking the HRS data to the National Death Index. In our study, we related physical activities at the 1992 baseline to mortality in the subsequent 16 years.

Key Explanatory Variable: Physical Activities at the 1992 Baseline

The 1992 wave of the HRS contains three questions on physical activities of different levels of intensity. 1) How often do you participate in light PA such as walking, dancing, gardening, golfing, bowling, etc.? 2) How often do you participate in vigorous physical exercise or sports such as aerobics, running, swimming, or bicycling? 3) How often do you do heavy housework like scrubbing floors or washing windows? Each question comes with five frequency categories: 1) three times a week; 2) one to two times a week; 3) one to three times a month; 4) less than once a month; 5) never. Based on these questions, we constructed a new categorical variable that differentiates physical activities at three levels: no PA, moderate PA, and vigorous

PA. Respondents who reported ‘never’ to all three questions were coded as ‘no PA’; those who reported any light physical activities or heavy housework but with no vigorous PA, were coded as ‘moderate PA’; those who reported any vigorous PA or sports were coded as ‘vigorous PA’.

Race and Ethnicity

Respondents in the HRS were asked to report their own racial/ethnic background from the following seven categories: 1) White/Caucasian; 2) Black/African American; 3) American Indian or Alaskan Native (including combination of 1 and 2); 4) Asian or Pacific Islander; 5) Hispanic/Latino; 6) Brown; "Moreno"; Trigueno; "de color" (of color); combination of Black and American Indian; and 7) Other (Specify). The working HRS sample in this study selected only those who identified with “1”, “2” or “5” in the racial/ethnic categories listed. Other groups are too small for solid statistical inferences.

Socio-demographic variables

Four demographic variables were controlled including age, gender, nativity (US-born versus foreign-born), and marital status (currently married versus unmarried) as they are well-known significant factors of mortality and may confound the activity-mortality link. Socioeconomic status at the 1992 baseline was included as an additional confounder and was characterized by three variables including years of education (continuous), annual household income (ordinal; 4 levels), and health insurance status (insured versus non-insured). Household income was calculated by adding income from all sources and was categorized into four levels: less than $20,000, $20,000 to $40,000, $40,000 to $65,000, and more than $65,000. Since these variables were used only as the control variables in the regression analyses, we did not code them in more detailed categories.

Health at the 1992 Baseline

The baseline health status was captured by five variables including self-rated health, personal history of chronic conditions, functional difficulties or limitations, current smoking status, and body mass index (BMI). In the 1992 HRS, information on self-rated health was based on the question "Would you say that your health is excellent, very good, good, fair, or poor?" Respondents were also asked if they were told by their doctors that they had hypertension, diabetes, cancer, chronic lung diseases, arthritis or rheumatism, and other chronic conditions. A dummy variable was then created denoting whether or not a respondent reported any chronic condition. In terms of functional difficulties or limitations, respondents were asked if they had any difficulty dealing with a variety of activities such as running, jogging, walking, sitting, climbing stairs, carrying things and so forth. We collapsed these variables into a single dummy variable indicating if a respondent reported any functional difficulty/limitation or not. Besides information on these variables, the 1992 HRS also collected information on whether or not a respondent was currently smoking at the time of the survey. BMI at the baseline was calculated based on self-reported height and weight.

Statistical analysis

Life table method was used to estimate survival rates from 1992 to 2008 by levels of PA at the baseline in the whole sample as well as in each of the three racial/ethnic groups. Comparisons of these survival curves across racial/ethnic groups were preformed to explore variations in the PA-mortality link by race and ethnicity.

Then a series of group-specific Cox Proportional Hazards (CPH) models were ran, where we modeled the relative risk of mortality in the 1992-2008 period as a function of baseline PA and selected controls on demographics, socioeconomic status, and health conditions at the

baseline. An important assumption of the CPH analysis is the proportionality of hazard, that is, the effect of changing values for a certain explanatory variable on the hazard rate is constant, independent of time. This assumption was tested for all the explanatory variables in the CPH models by relating the Schoenfeld residuals to time. The test results indicate that the proportionality assumption holds for all the explanatory variables used in the CPH models.

RESULTS

Table 1 presents sample statistics by race and ethnicity. Whites have the highest level of vigorous PA and are least likely to have no PA; they also have the best baseline health on average. Whites are also advantaged in socioeconomic status in terms of education, income and health insurance. Hispanics have the lowest level of vigorous PA and highest proportion of no PA but have more or less similar levels of baseline health as whites. They are, however, socioeconomically most disadvantaged in terms of education and family income and are most likely to have no insurance.

(Table 1 about here)

The crude survival patterns corresponding to the three PA levels are shown in Figure 1. The magnitude of the survival disadvantage for the no-PA group is remarkable. At the end of the 16 year follow-up, when the age range of the sample reaches from 67 to 77, the survival rate of the no-PA group is about 14 percentage point lower than that of the moderate-PA group and nearly 20 percentage point lower than that of the vigorous-PA group. Therefore, when the full sample is considered, a dose-response relationship between PA intensities and mortality risks is clear in this prospective middle-aged sample followed up to old ages and the gaps in survival rate are getting greater as the follow-up duration increases. That said, group-specific patterns reveal variations by race and ethnicity. The gradient is most evident and temporally consistent for

blacks. For whites and Hispanics, the no-PA group disadvantage remains clear but the differences between vigorous- and moderate-PA groups are smaller especially for Hispanics. For whites, the survival advantage of the vigorous-PA group versus the moderate-PA group started since the 6th year of follow up and eventually reached the same magnitude at the end of the follow-up, converging to the pattern for blacks.

(Figures 1 and 2 about here)

Table 2 shows group-specific results of the survival analyses. Three models were fitted. Model 1 adjusted only for demographic variables including age, gender, and nativity. For each racial/ethnic group, the overall pattern observed for the full sample is confirmed, indicating that both moderate and vigorous activities are protective against mortality ($p<0.01$). Moreover, the effects of vigorous PA are visibly stronger than those of moderate PA for whites and blacks, but for Hispanics, the protective effects of PA are comparable across the two intensity levels. Model 2 adjusted for socioeconomic factors in addition to demographics. The effects of moderate PA are hardly changed from Model 1 to Model 2 but the effects of vigorous PA are rendered slightly weaker for all three groups. Model 3 further controlled for the baseline health. Not surprisingly, the PA effects become much smaller because these hazard ratios represent prospective effects of PA on mortality net of cross-sectional impacts of baseline lifestyle and environmental factors of health and mortality that Models 1 and 2 are not able to disentangle. Only for whites, the effect of moderate PA remains significant ($p<0.05$). By contrast, the effects of vigorous PA remain significant for whites and blacks ($p<0.05$) and marginally significant for Hispanics ($p<0.1$). The larger p-values of the hazard ratios for Hispanics may have been due to their smaller sample sizes. The point estimate of effect size of moderate PA for Hispanics is comparable to that for whites and the effect size for vigorous PA for Hispanics is even greater than those for whites and

blacks. Hence, it follows to observe that PA effects net of selected baseline confounding factors are more or less similar across racial/ethnic groups. In other words, holding baseline socioeconomic and health circumstances constant, the same pattern arises for all three groups such that prospective and protective effects of vigorous PA appear more robust and stronger compared to those of moderate activities with no-PA lifestyle most detrimental.

DISCUSSION

Although beneficial effects of PA on mortality are well-known, few studies have specifically compared the relative mortality impacts of moderate versus vigorous activities[13]. Meanwhile, extant research is largely based on local or non-representative samples[4, 5, 18], affording limited generalizability. Moreover, despite growing recognition that policy interventions should be tailored to specific groups to be more effective[19], evidence is not readily available as to whether and how the PA-mortality link varies across major racial/ethnic groups in the United States. The current study helps fill this knowledge gap by distinguishing moderate PA from vigorous PA in terms of their impacts on subsequent survival in the whole sample as well as in subsamples of whites, blacks, and Hispanics respectively.

In this prospective study of non-institutionalized American men and women aged 51 to 61 at the baseline, vigorous PA was prospectively associated with mortality reduction by an average of 20 percent over the 16-year study period; and the corresponding figure for moderate PA was about 14 percent. Based on the face value, the dose-response gradient of PA in mortality risks seemed more apparent for whites and blacks than for Hispanics. However, after controlling for the baseline socioeconomic and health status, the dose-response gradient of PA effects on mortality also held for Hispanics. The long-term benefits of vigorous PA on mortality apparently outweigh those of non-vigorous PA for each racial/ethnic group. This finding lends credence to

the findings from the Harvard Alumni Studies where vigorous PA rather than moderate PA exhibited mortality advantage among an earlier sample of white and male Harvard Alumni[2, 3, 4, 11, 13].

If confirmed in other representative studies in the United States, our finding that the survival benefit of vigorous PA is consistent across racial/ethnic groups is encouraging as it shows that a lifestyle behavior can have such a salient role in contributing to survival in later life irrespective to differential social circumstances whites and minorities are facing throughout the life course. Like socioeconomic status, race and ethnicity have been viewed as a fundamental cause of health and mortality because it signals differential access to health-enhancing resources such as good education and quality care as well as exposure to health-detrimental hazards such as racism and poor neighborhood conditions[20]. According to the fundamental cause theory, health disparities are reproduced over time and place and cannot be explained simply by a set of proximate determinants such as lifestyle factors; therefore, unless changes are made to reduce structural inequalities, promoting healthful lifestyles *per se* would not help reduce health disparities. Seemingly contradictory to the implications of this theory, the key public health message from our study is to forcefully promote vigorous PA in the middle-aged to enhance longevity, making a lifestyle-oriented policy recommendation. However, this message is not necessarily a counterargument of the fundamental theory which emphasizes the need of making our distribution systems more egalitarian. Our study findings highlighted the salubrious role of vigorous PA for middle-aged adults regardless of race and ethnicity rather than explaining racial or ethnic disparities in mortality. We have no doubt that increasing PA alone will not do away with health disparities as they are deeply rooted in a myriad of factors throughout the life course. That said, while health inequality across social groups is an important public health and social

justice concern, improving overall population health via lifestyle modifications is also a weighty goal of human development.

Compared to vigorous PA, the effects of moderate PA appeared weaker but not negligible. The directions of the moderate PA effects were consistently beneficial for all the groups, suggesting even a modest amount of PA could confer some long-term survival advantages. This is good news to individuals who are functionally limited due to chronic conditions that can only afford moderate PA. Moreover, moderate PA is likely beneficial to many aspects of health and well-being that are contributory to quality of life and healthy aging. These outcomes were not addressed in the current study.

The study limitations are noteworthy. Although the study is strong in design given its longitudinal nature and national representativeness, annual sample attrition due to lost-to-follow-up is an unavoidable problem in cohort studies. Future studies can assess if the likelihood of lost-to-follow up differs across PA intensity levels and the extent to which this might influence the robustness of our findings. The PA measures used in this study were intuitive instead of being quantitatively precise. It should bear in mind that the differences in expended kilocalories per week between vigorous and non-vigrous PA were not quantifiable in our study. For a national sample with long follow-up period, it is technically and financially challenging to collect lab-based measures of PA intensity levels. Future studies should strive for collecting more objectively measured PA intensity levels to more accurately assess the PA-mortality relationship. It would also be valuable to test the protective effects of PA on other health outcomes and explore the underlying mechanisms.

Despite these limitations, the current study is among the first to provide evidence on long-term effects of PA levels on mortality across three major racial/ethnic groups in the United

States, using a nationally representative longitudinal sample of middle-aged and older Americans. The key take-home message from this study is that vigorous PA is an effective preventive measure against mortality disregarding one's racial/ethnic background, socioeconomic positions, and baseline health status. To a lesser extent, non-vigorous PA is also beneficial, leaving no-PA lifestyle most detrimental in the long run.

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Table 1. A Description of Used Variables at the 1992 HRS Baseline by Race/Ethnicity (Mean or %)

Variables	Race/Ethnicity			
	Whites	African-Americans	Hispanics	Total
Physical Activities				
No Physical Activities	18.5	29.8	33.5	20.9
Moderate or Mild	26.9	34.6	35.6	29.0
Vigorous	54.6	35.5	30.9	49.1
Age, years	55.8	55.8	55.5	55.7
Gender				
Male	48.7	42.3	45.1	47.2
Female	51.3	57.7	54.9	52.8
Nativity				
Not Born in the U.S.	4.4	5.0	54.5	9.2
Born in the U.S.	95.6	95.0	45.5	90.8
Marital Status				
Unmarried	20.6	47.7	29.8	26.2
Married	79.4	52.3	70.2	73.8
Years of Education	12.7	11.2	8.4	12.0
Total Family Annual Income				
Less than $20,000	19.3	40.7	41.4	25.1
$20,000 to $40,000	25.0	26.5	34.2	26.2
$40,000 to $65,000	27.3	19.2	15.0	24.8
More than $65,000	28.3	13.5	9.4	23.9
Health Insurance Status				

Insured	90.1	82.0	64.4	86.2
Uninsured	9.9	18.0	35.6	13.8
Personal History of Chronic Conditions				
Yes	66.7	77.8	64.6	68.4
No	33.3	22.2	35.4	31.6
Self-rated Health Status				
Excellent	24.7	11.2	15.0	21.4
Very Good	31.3	20.6	14.6	27.9
Good	26.6	32.2	31.5	28.0
Fair	11.0	22.8	25.3	14.4
Poor	6.4	13.2	13.7	8.3
Functional Difficulty				
Yes	39.8	43.2	39.6	40.3
No	60.2	56.8	60.4	59.7
Currently Smoking				
Yes	26.8	30.3	23.1	27.1
No	73.2	69.7	76.9	72.9
Body Mass Index				
Underweight (BMI<18.5)	1.4	1.4	1.1	1.4
Normal weight (25>BMI>=18.5)	37.5	24.5	27.7	34.5
Overweight (30>BMI>=25)	40.7	40.0	43.6	40.6
Obese (BMI>=30)	20.4	34.1	27.7	23.6
Number of Cases	6,870	1,635	886	9,391

Abbreviation: HRS, Health and Retirement Study.

Table 2. Physical Activities in 1992 and Adjusted Hazard Ratios of Mortality in the 1992-2008 Period, Health and Retirement Study

Physical Activities	Race and Ethnicity					
	Whites		Blacks		Hispanics	
	Estimates	95% CI	Estimates	95% CI	Estimates	95% CI
Adjusting Only For Demographics in 1992[a]						
No Physical Activities	1.00		1.00		1.00	
Moderate	0.64***	0.56,0.74	0.61***	0.49,0.75	0.58**	0.39, 0.87
Vigorous	0.42***	0.37,0.48	0.44***	0.35,0.55	0.56**	0.38, 0.82
Adjusting For Demographics & Socioeconomic Status in 1992[b]						
No Physical Activities	1.00		1.00		1.00	
Moderate	0.65***	0.56,0.75	0.66***	0.53,0.82	0.61*	0.41, 0.90
Vigorous	0.50***	0.44,0.57	0.50***	0.40,0.63	0.59*	0.40, 0.88
Adjusting For Demographics, SES, & Baseline Health in 1992[c]						
No Physical Activities	1.00		1.00		1.00	
Moderate	0.82*	0.71,0.96	0.89	0.70,1.12	0.81	0.52, 1.24
Vigorous	0.75***	0.65,0.86	0.73*	0.57,0.94	0.68	0.45, 1.03

Abbreviation: CI, confidence interval.

* $p<0.05$; ** $p<0.01$; *** $p<0.001$.

[a] Adjusting for the effects of age, gender, and nativity.

[b] Adjusting for the effects of age, gender, nativity, marital status, education, income, and health insurance status.

[c] Adjusting for the effects of age, gender, nativity, marital status, education, income, health insurance status, personal history of chronic conditions, self-rated health, functional difficulty, current smoking status, and BMI.

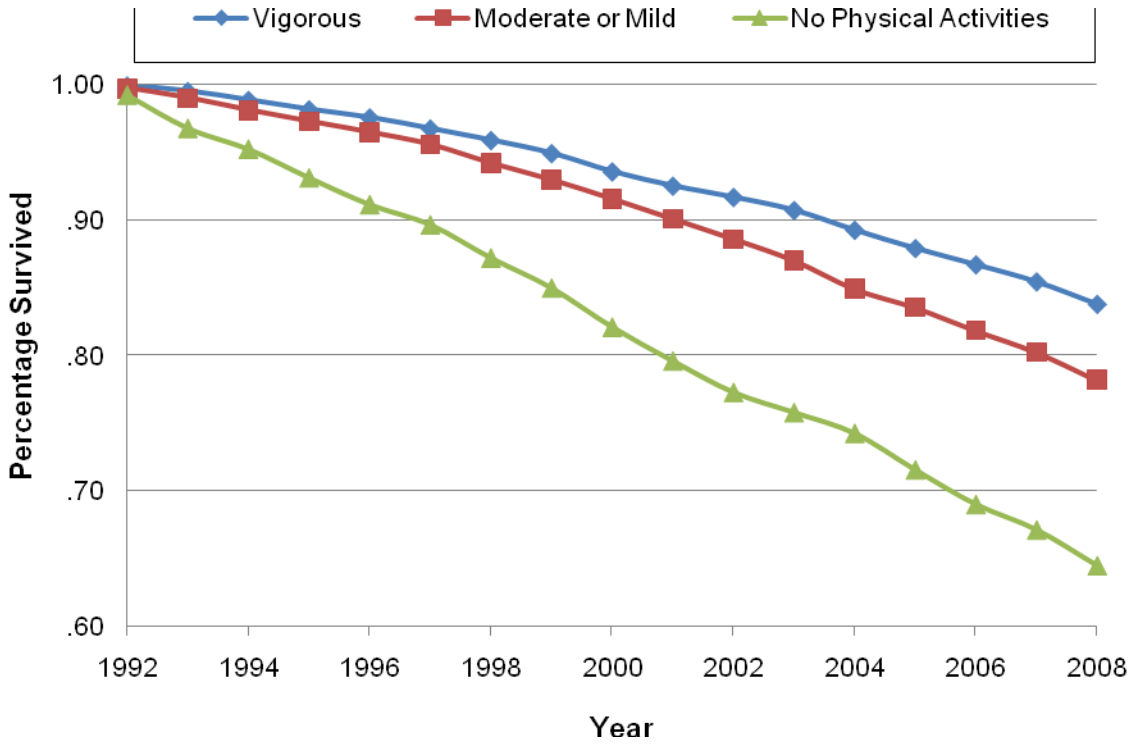

Figure 1. Physical activities in 1992 and subsequent survival in the Health and Retirement Study, 1992-2008.

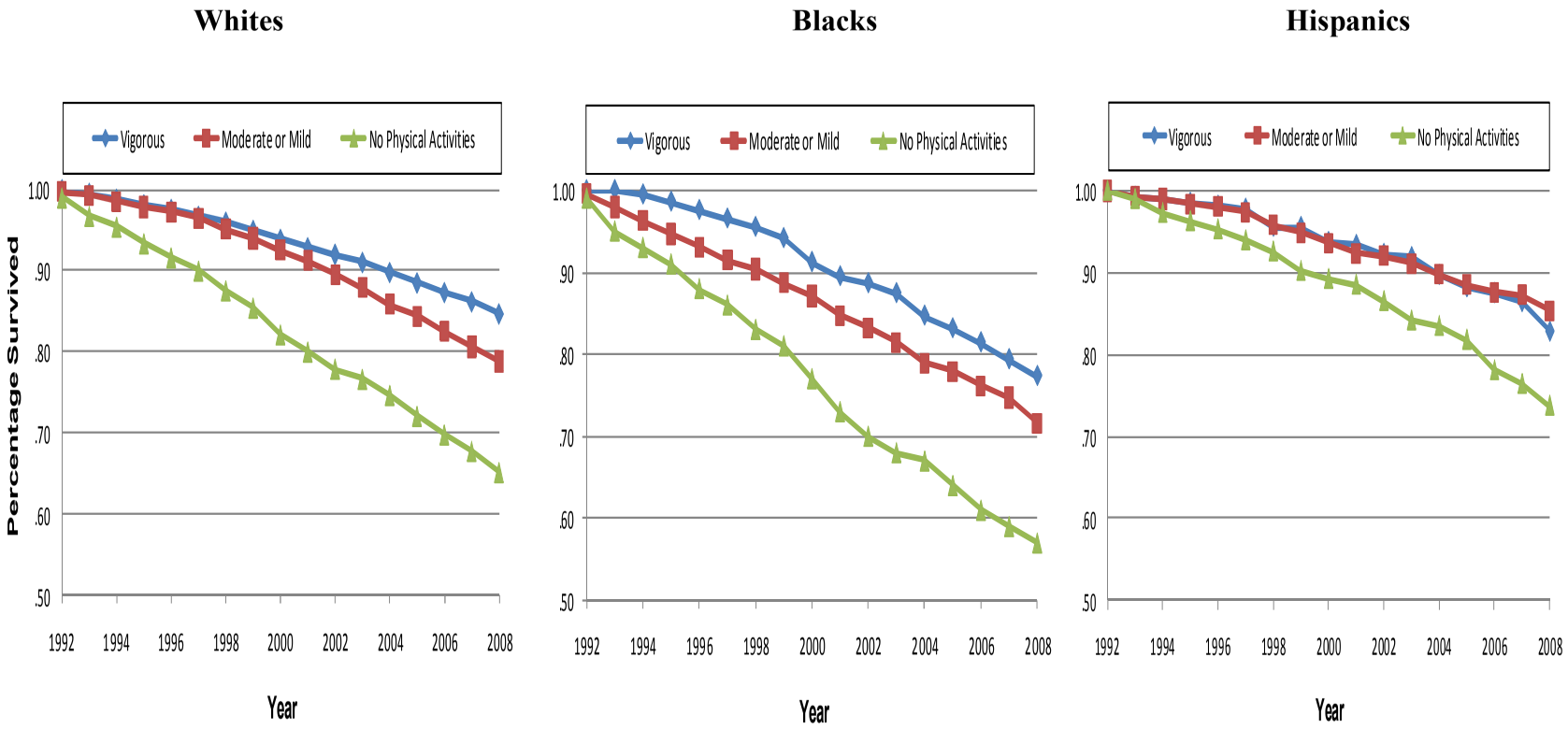

Figure 2. Physical activities in 1992 and subsequent survival by race and ethnicity in the Health and Retirement Study, 1992-2008.