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Self-Reported Physical Inactivity and Waist Circumference Independently Predict All-Cause Mortality in U.S. Adults

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Abstract **Background**: Physical inactivity (PIA) is a major risk factor linked to many chronic diseases as well as premature mortality. Waist circumference (WC) is a measure of abdominal obesity and is also associated with many health problems. The purpose of this study was to examine both PIA and WC as predictors of all-cause mortality in adults. **Methods**: Data for this research came from the 2001-02 National Health and Nutrition Examination Survey (NHANES) and linked mortality file. Only participants who were 18+ years of age and eligible for mortality linkage were used in the analysis. PIA status was determined from the answers to two questions that asked subjects if they participated in moderate and then vigorous physical activity. WC was assessed by a trained health professional. Cox proportional hazards regression was used to model the effects of PIA and WC on mortality while controlling for age, sex, race, and income. **Results**: Approximately 33% (SE=1.12) of adults were physically inactive at interview date with mean WC of 95.6 (SE=0.21) centimeters (cm). A total of 55,288 person-years of follow-up was observed with 965 deaths. In the unadjusted model, physically inactive adults were at greater risk of mortality (Hazard Ratio (HR) =2.42, 95% CI: 2.006, 2.928) as compared to their more active counterparts. A 2% increase in mortality (HR=1.02, 95% CI: 1.016, 1.025) was seen for each 1-cm increase in WC. The fully adjusted model showed a significant increase in mortality (HR=1.40, 95% CI: 1.130, 1.727) among those who were physically inactive independent of a 1% increase in mortality (HR=1.01, 95% CI: 1.002, 1.016) for each 1-cm increase in WC. **Conclusion**: Results from this study indicate that PIA and WC are independent predictors of mortality in adults. Health promotion programs should consider both physical activity as well as abdominal obesity in their programming objectives.

Keywords: *physical inactivity, waist circumference, survival analysis, NHANES*

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1. Introduction

Current guidelines for physical activity recommend the accumulation of 150 minutes of moderate-intensity physical activity, 75 minutes of vigorous-intensity physical activity, or an equivalent combination of moderate- and vigorous-intensity physical activity, each week by all U.S. adults [1]. *Healthy People 2020* is a U.S. Department of Health and Human Services derived plan that includes goals and objectives for improving health of all Americans for the year 2020 [2]. The current physical activity objective (PA-2.1) set for 2020 by *Healthy People* is to increase the percentage of adults who meet the latest guidelines. Despite this objective, as of 2015, approximately 49 percent of U.S. adults still do not meet physical activity guidelines [3].

Physical inactivity (PIA) is one risk factor associated with behavioral physical activity and can have many different definitions. One definition for PIA is an amount of physical activity that insufficiently meets current guidelines [4]. This definition is obviously different from that of sedentary behavior, which can be defined as waking behavior characterized by sitting or lying down [5]. Nevertheless, PIA is a well-established risk factor linked to many chronic diseases as well as premature mortality [6]. Furthermore, U.S. estimates of PIA indicate major disparities across sociodemographic subpopulations. For instance, greater rates of PIA have been estimated in women, older adults, Black races, less educated adults, and obese individuals [7].

Body composition is a physical trait that has strong links to physical activity behavior [8]. Waist circumference (WC), a specific measure of body composition, is an indicator of abdominal obesity and is also associated with many health problems [9]. Due to the relationship between PIA and WC [10], it is not clear if each are independently related to health outcomes. That is, after controlling for a person's PIA, can their WC still be considered a risk factor for negative health outcomes (and vice versa)? Therefore, the purpose of this study was to examine both

PIA and WC as independent predictors of all-cause mortality in adults.

2. Methods

2.1. Participants and Design

Data for this research came from the 2001-02 National Health and Nutrition Examination Survey (NHANES) and linked mortality file [11]. NHANES is a cross-sectional continuous survey that draws a complex multi-stage sample of all noninstitutionalized U.S. citizens. Participants of NHANES are assigned a mortality status based on National Death Index (NDI) death certificates, which are contained in a linked mortality file provided by the National Center for Health Statistics (NCHS). Therefore, this analysis can be considered longitudinal with a follow-up period ending in December 31, 2011. A total of 5,985 participants who were 18+ years of age, answered all relevant survey questions, had their WC measured, and who were eligible for mortality linkage were used in the analysis.

2.2. Measures

Two main independent variables were used in this study: PIA status (yes/no) and WC (cm). PIA status was determined from the answers to two questions that asked subjects if they participated in moderate-intensity and then vigorous-intensity physical activity [12]. The vigorous physical activity question specifically asked: "Over the past 30 days, did you do any vigorous activities for at least 10 minutes that caused heavy sweating, or large increases in breathing or heart rate? Some examples are running, lap swimming, aerobics classes or fast bicycling." The moderate physical activity question specifically asked: "Over the past 30 days, did you do moderate activities for at least 10 minutes that cause only light sweating or a slight to moderate increase in breathing or heart rate? Some examples are brisk walking, bicycling for pleasure, golf, and dancing." In this study, those respondents answering "no" to both questions were considered physically inactive.

WC was assessed by a trained health professional [13]. The WC measurement site was first marked on the participant's skin just above the uppermost lateral border of the right ilium and at the midaxillary line. A mirror was used to ensure that the steel measuring tape remained parallel to the floor. Measurement was recorded to the nearest 0.1 cm after a normal expiration by the participant.

For descriptive purposes, several health status and health behavior variables were used in this study. General health was assessed from the self-reported rating of general health. Those respondents reporting "fair" or "poor" (as compared to "good", "very good", or "excellent") were considered to have poor perceived general health. High blood pressure, high cholesterol, heart disease, stroke, diabetes, and arthritis were considered health status (yes/no) variables, where a participant was considered to have this condition if they reported that a doctor told them they had it. A lifetime smoking status variable was used where participants who reported smoking at least 100 cigarettes in their entire life were consider smokers. An alcohol consumption variable was used where participants who reported consuming at least 12 drinks of any alcohol in any single year were considered alcohol consumers.

Finally, several variables were used for both descriptive purposes as well as to serve as covariates in the main analyses. Body mass index (BMI) was used and assessed by dividing a participant's weight (kg) by height (m^2). Demographic variables included age (yr.), sex (male/female), income (US $), race (white/non-white), and marital status (married/not married).

2.3. Statistical Analysis

Continuous variables were described using means and standard errors (SEs) and categorical variables were described using percentages (%s). Descriptive hypothesis testing included ordinary least squares regression to determine differences in means across categorical levels of an independent variable [14,15]. Pearson chi-square tests were used in a similar way when the dependent variable was categorical. Cox proportional hazards regression was used to model the effects of PIA and WC on mortality while controlling for age, sex, race, and income [16]. All models were post-fit checked to ensure the proportional hazards assumption was met. SAS survey procedures were used for all inferential analyses [17].

3. Results

Approximately 33% (SE=1.12) of adults were physically inactive at interview date with mean WC of 95.6 (SE=0.21) centimeters (cm). A total of 55,288 person-years of follow-up was observed with 965 deaths. Table 1 shows baseline characteristics of participating adults by survival status and by sex. In the overall analyses, participants who died were significantly ($p<.05$) older with significantly higher rates of poor health status, as compared to those who survived. As well, participants who died had a higher rate of smoking but a lower rate of consuming alcohol. BMI was not significantly different across survival status, however, WC was significantly greater among those who died. Many of the same findings were seen in the sex-specific analyses. However, females who died were significantly older than males who died.

Table 2 shows results of the survival analyses. In the unadjusted model, physically inactive adults were at greater risk of mortality (Hazard Ratio (HR) =2.42, 95% CI: 2.006, 2.928) as compared to their more active counterparts. A 2% increase in mortality (HR=1.02, 95% CI: 1.016, 1.025) was seen for each 1-cm increase in WC, in the unadjusted model. The adjusted model showed a significant increase in mortality (HR=1.40, 95% CI: 1.130, 1.727) among those who were physically inactive independent of a 1% increase in mortality (HR=1.01, 95% CI: 1.002, 1.016) for each 1-cm increase in WC.

Finally, Figure 1 thru Figure 3 show HRs (95% CIs) associated with PIA status across WC quartiles. The overall graph shows an increased risk of dying among those who are physically inactive (as compared to those who are not physically inactive) for all WC groups. However, the mortality hazards associated with PIA tended to decrease as WC quartile increases. This pattern is approximately similar among males. In contrast, physically inactive females in the second WC quartile (Q2) have the greatest risk of dying, as compared to females in other WC quartiles.

Table 1. Baseline characteristics of adults participating in the 2001-02 NHANES survey by survival status and sex

	Overall			Males			Females			Sex Diff
Characteristics	Died	Survived	*p*	Died	Survived	*p*	Died	Survived	*p*	*p*
Sample Size (*n*)	965	5020	-	510	2330	-	455	2690	-	.477
Age (yr)	66.0 (1.05)	41.9 (0.47)	<.001	63.3 (1.62)	41.4 (0.55)	<.001	68.8 (1.2)	42.3 (0.43)	<.001	.042
White Race (%)	77.9	70.2	.006	76.7	71.6	.105	79.2	68.9	.011	.262
Married (%)	46.6	57.7	.003	58.3	59.4	.765	35.0	56.1	<.001	<.001
Physically Inactive (%)	53.4	31.2	<.001	48.7	28.3	<.001	58.7	33.9	<.001	.351
WC (cm)	100.4 (0.51)	95.0 (0.34)	<.001	103.6 (1.01)	98.1 (0.35)	<.001	97.3 (1.4)	92.2 (0.50)	.004	.857
BMI (kg/m^2)	28.4 (0.29)	27.9 (0.17)	.105	28.4 (0.42)	27.7 (0.15)	.131	28.5 (0.68)	28.0 (0.22)	.501	.894
Poor General Health (%)[b]	38.1	13.1	<.001	33.4	12.1	<.001	42.6	14.1	<.001	.356
High Blood Pressure (%)[c]	54.4	21.5	<.001	52.5	19.1	<.001	56.2	23.6	<.001	.541
High Cholesterol (%)[a,c]	44.8	34.1	<.001	42.4	38.2	.331	47.1	30.6	<.001	.008
Heart Disease (%)[a,c]	12.4	2.2	<.001	14.9	2.9	<.001	9.9	1.6	<.001	.749
Stroke (%)[a,c]	8.9	1.5	<.001	10.4	1.1	<.001	7.5	1.9	<.001	.013
Diabetes (%)[c]	19.0	5.1	<.001	21.3	5.0	<.001	16.7	5.2	<.001	.199
Arthritis (%)[a,c]	46.3	18.0	<.001	35.0	15.1	<.001	57.4	20.7	<.001	.012
Ever Smoked (%)[a,d]	64.1	47.8	<.001	76.1	53.8	<.001	52.3	42.3	.006	.001
Consumes Alcohol (%)[a,e]	63.9	73.0	.002	77.8	84.4	.038	50.4	62.4	.015	.859

Note. Continuous variables are reported as means (se) and associated hypothesis tests are from ordinary least squares regression. Categorical variables are reported as percentages and associated hypothesis tests are chi-square tests of independence and logistic regression. Sex Diff p-values are testing for mean or proportion differences between sex groups. [a]Assessed by adults 20+ years of age. [b]Assessed from a self-reported rating of general health and those reporting "fair" or "poor" were considered to have poor perceived general health. [c]Participants were considered to have this condition if they reported that a doctor told them they had it. [d]Participants who smoked at least 100 cigarettes in their entire life. [e]Consumed at least 12 drinks of any alcohol in any single year.

Table 2. Hazards of all-cause mortality associated with physical inactivity (PIA) status and waist circumference (WC)

	Crude		Model 1		Model 2		Model 3	
Grouping	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
Overall								
PIA Status								
Active	1.00	-	1.00	-	1.00	-	1.00	-
Inactive	2.42	2.01-2.93	2.16	1.76-2.65	1.40	1.13-1.73	1.40	1.14-1.72
WC	1.02	1.02-1.03	1.02	1.01-1.02	1.01	1.00-1.02	1.03	1.01-1.05
Males								
PIA Status								
Active	1.00	-	1.00	-	1.00	-	1.00	-
Inactive	2.19	1.80-2.66	2.05	1.67-2.52	1.32	1.05-1.65	1.30	1.04-1.63
WC	1.02	1.01-1.03	1.02	1.01-1.03	1.01	1.00-1.02	1.03	1.00-1.07
Females								
PIA Status								
Active	1.00	-	1.00	-	1.00	-	1.00	-
Inactive	2.79	2.08-3.75	2.37	1.71-3.28	1.44	1.04-1.99	1.46	1.06-2.00
WC	1.02	1.01-1.03	1.02	1.00-1.03	1.01	1.00-1.03	1.04	1.02-1.06
Age 18 to 48 (yr)								
PIA Status								
Active	1.00	-	1.00	-	1.00	-	1.00	-
Inactive	2.63	1.48-4.66	2.3	1.27-4.17	1.69	1.00-2.95	1.63	1.00-2.84
WC	1.03	1.01-1.05	1.03	1.01-1.05	1.02	1.00-1.05	1.07	1.04-1.11
Age 50+ (yr)								
PIA Status								
Active	1.00	-	1.00	-	1.00	-	1.00	-
Inactive	1.87	1.53-2.29	1.75	1.43-2.13	1.34	1.07-1.69	1.35	1.07-1.69
WC	1.01	1.00-1.02	1.00	0.99-1.01	1.00	0.99-1.01	1.02	1.00-1.04

Note. Crude column shows unadjusted HRs for PIA and WC in separate models. Model 1 column shows unadjusted HRs for both PIA and WC in same model. Model 2 column shows HRs for PIA and WC adjusted for age, sex, race, and income. Model 3 column shows HRs for PIA and WC adjusted for BMI in addition to model 2 covariates. Cox regression was used for all models using PROC SURVEYPHREG to account for the complex sampling design.

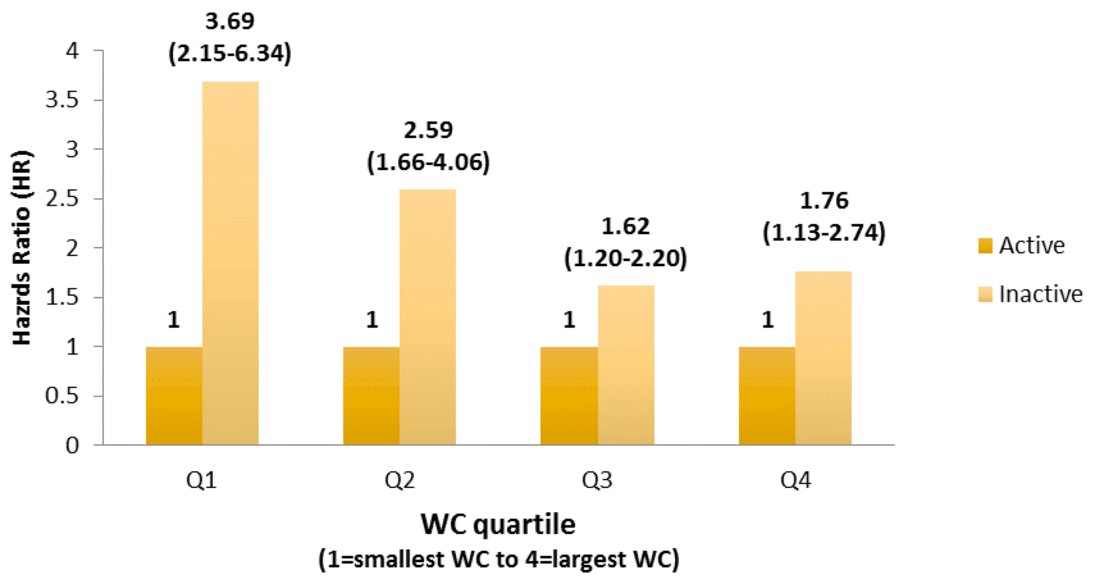

Figure 1. Overall Hazards of all-cause mortality associated with PIA status by WC quartile

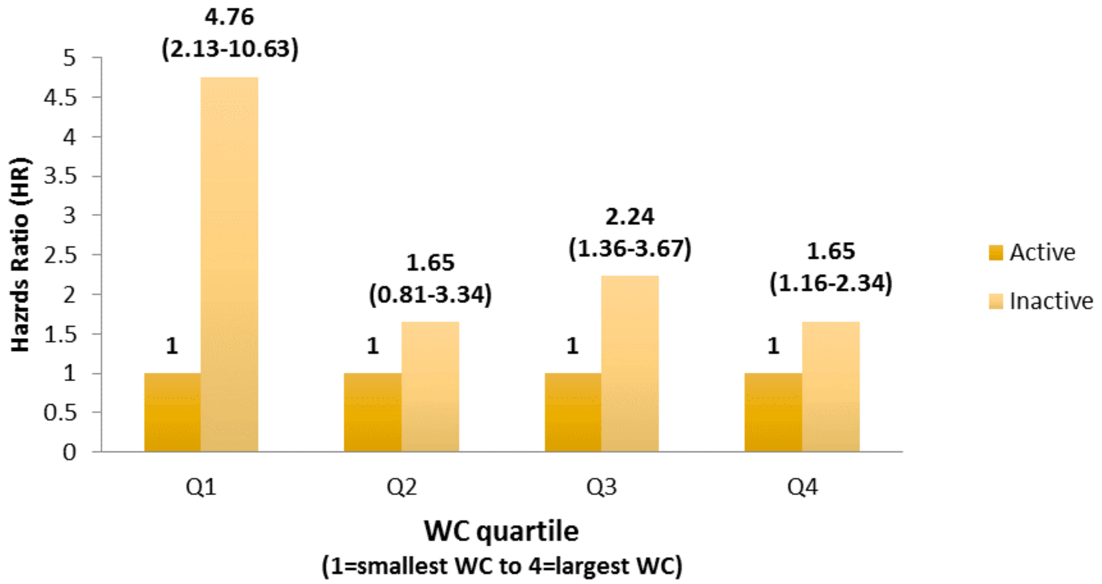

Figure 2. Males Hazards of all-cause mortality associated with PIA status by WC quartile

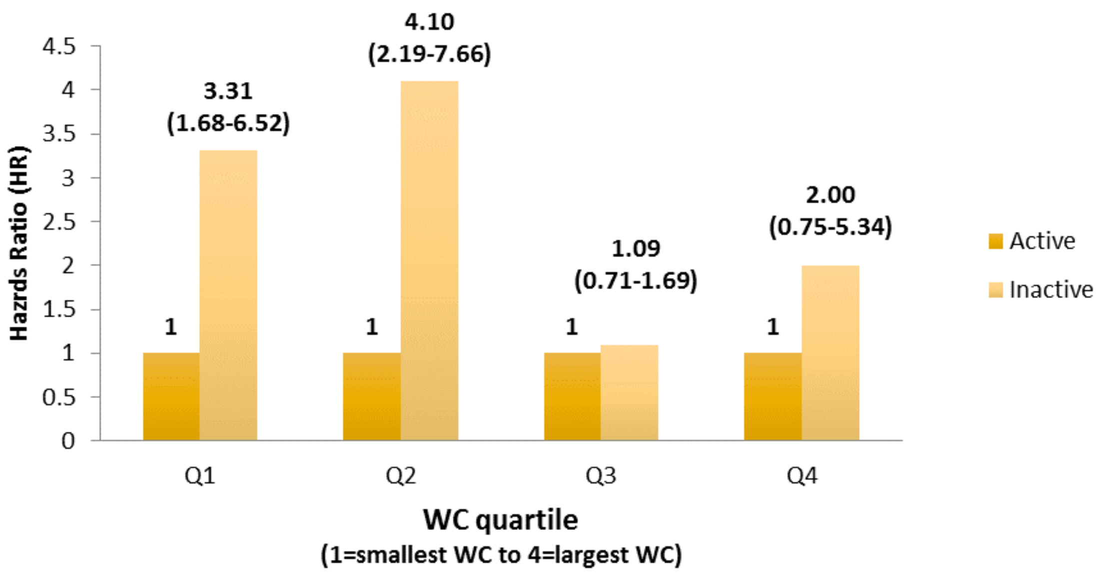

Figure 3. Females Hazards of all-cause mortality associated with PIA status by WC quartile

4. Discussion

The purpose of this study was to examine the relationship between PIA, WC, and all-cause mortality. More specifically, this research attempted to examine the independent predictive ability that both PIA and WC has on all-cause mortality. The crude evidence clearly supported both PIA and WC as predictors of mortality, in their separate models. Physically inactive adults had over twice the risk of dying, as compared to their non-inactive counterparts. Similarly, for each additional 1-cm increase in WC, risk of mortality increased by two percent. Said differently, for every 1-inch increase in WC, risk of dying increased by five percent. These findings remained similar when both predictors were included in the same model, hence, providing evidence for their independent relationship to all-cause mortality. Furthermore, these findings remained similar in the fully adjusted model, which included the potential sociodemographic confounders as well as BMI. Albeit, the predictive ability of PIA decreased, it however, remained significant. These results have major implications, in that, WC can be seen here as an independent predictor of mortality after controlling not just for PIA but also for weight status as assessed by BMI. That is, after removing the potential confounding effect that obesity (for example) may have on mortality, WC still predicts all-cause mortality. Similar findings have been reported from a large meta-analysis of eleven prospective studies, pooling over 650,000 adults followed on average (median) for nine years [18]. Results from this study also found a significant direct relationship between WC and mortality hazards, after controlling for several confounding variables including physical activity and BMI.

Furthermore, these findings remained across the various stratified analyses. For example, in the fully adjusted models, males and females both separately saw the same increased risk of dying if they were physically inactive and had larger WC. Similar results were seen across age groups, however, those participants in the younger age group had a seven percent increase in risk of dying for each 1-cm increase in WC, after controlling for PIA, BMI and other variables. This equates to an almost eighteen percent increase in risk for each additional 1-inch increase in WC. The implications for these findings suggest an alarming increased risk of mortality for younger adults when they have larger WC measures. Similar relationships have been reported, where younger adults with larger WC appear to be at greater risk for mortality, as compared to their older counterparts [18,19].

A final result in this study worth addressing is the increase in mortality associated with PIA across ranked WC groups. The hazards associated with PIA were generally much larger in the lower WC groups, as compared to the larger WC groups. These findings would suggest that inactivity has a more severe mortality consequence among adults with lower measures of abdominal obesity. Similar findings were reported in a study of Canadian adults, where the only increased risk of mortality seen in physically inactive adults were among those with low WC measures [20].

The strengths of this study include the use of WC as a measure of body composition in a prospective study over the more commonly used BMI. WC is a measure of abdominal obesity and can be a very useful predictor for metabolic syndrome, diabetes, and cardiovascular disease [21]. Also, data in this study are representative of all U.S. adults, non-institutionalized, which allow for much wider generalizations. There are, however, some limitations worth mentioning. One limitation is the use of self-reported physical activity data. Objective measures, such as pedometers and accelerometers, may provide more valid measures of PIA than the self-reporting from two questions provided in this study. A second limitation was the use of only a single baseline measure of both PIA and WC, without follow-up assessments. This design flaw does not allow the research to account for the possibility that participants may change their behavior and/or change their body weight after the initial interview.

5. Conclusions

Results from this study indicate that PIA and WC are independent predictors of all-mortality in adults. Health promotion programs should consider both physical activity as well as abdominal obesity in their programming objectives.

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