

# Concurrent Relationship of Objectively Measured Physical Activity and Cardiorespiratory Fitness on Two Different Measures of Obesity in U.S. Adults

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**Abstract Background:** Few population-based studies have examined the relationship of both physical activity (PA) and cardiorespiratory fitness (CRF) on the growing health problem of obesity. The purpose of this study was to examine the concurrent relationship of PA and CRF on two different measures of obesity. **Methods:** This study used data from adults 20-49 years of age participating in the 2003-2004 National Health and Nutrition Examination Survey (NHANES). Moderate-to-vigorous PA (MVPA, min/day) was objectively determined by use of accelerometer and participants were categorized into low or high groups using the median. CRF (ml/kg/min) was assessed using a submaximal treadmill test and measures were categorized into low or high values by applying age- and sex-specific standards. Using body mass index (BMI), participants were categorized as obese if their values were 30 kg/m<sup>2</sup> or greater. Using waist circumference (WC), participants were categorized as obese if their values were greater than 88 (females) or 102 cm (males). Linear regression was used to test for mean CRF differences in study variables. Logistic regression was used to model the relationship between MVPA, CRF and obesity. **Results:** Participants in the high CRF group had significantly ( $p < .05$ ) greater MVPA across all obesity groupings. In BMI obese, neither BMI nor WC were significantly different between CRF groups. However, in WC obese, both BMI and WC were significantly ( $p < .05$ ) lower in the high CRF group. Among adults with low CRF, those with low MVPA were more than twice as likely to be obese than those with high MVPA using BMI (OR=2.48; 95% CI: 1.23-5.01) and WC (OR=2.06; 95% CI: 1.29-3.29). Among adults with high CRF, no MVPA and obesity relationship was seen. **Conclusion:** Results from this study indicate that PA is only related to obesity when CRF is low. Furthermore, high CRF may protect less physically active adults from both overall and abdominal obesity.

**Keywords:** physical activity, obesity, cardiorespiratory, epidemiology

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## 1. Introduction

Physical activity (PA) is a health behavior promoted to all individuals because of its preventive relationship with disease [1,2,3,4,5], its positive relationship with longevity [6,7,8,9,10], and its ability to enhance health-related quality of life (HRQOL) [11,12,13,14]. Cardiorespiratory fitness (CRF) is a trait possessed by individuals, characterized by the ability to engage in dynamic exercise of at least moderate intensity for prolonged periods [15], and is also related to positive health outcomes [16,17,18,19,20]. Obesity is a growing concern world-wide [21] with health promotion efforts directed toward increasing PA and modifying diet [22,23,24]. However, few efforts have been directed toward improving both PA along with CRF in the primary and tertiary prevention of obesity. Furthermore, data examining the obesity relationship with

both PA and CRF are sparse. Therefore, the purpose of this study was to examine the concurrent relationship of PA and CRF on two different measures of obesity.

## 2. Methods

### 2.1. Study Design

Data for this research came from the 2003-04 National Health and Nutrition Examination Survey (NHANES) [25]. The sample consisted of participants who were 20-49 years of age and had complete PA, CRF, and body composition data.

### 2.2. Variables Utilized

The two main independent variables were moderate-to-vigorous PA (MVPA) and CRF. The two main dependent variables were obesity status measured by body mass index

(BMI) and obesity status measured by waist circumference (WC). Covariates were age, sex, race, and income.

### 2.3. Assessment of MVPA and CRF

MVPA (min/day) was objectively determined by use of accelerometer and participants were categorized into low or high groups using the median. CRF (ml/kg/min) was assessed using a submaximal treadmill test and measures were categorized into low or high values by applying age- and sex-specific standards [26,27].

### 2.4. Assessment of Obesity

Using BMI, participants were categorized as obese if

their values were 30 kg/m<sup>2</sup> or greater. Using WC, participants were categorized as obese if their values were greater than 88 (females) or 102 cm (males) [28].

### 2.5. Statistical Analyses

Participant characteristics were described using means, percentages, standard errors (SEs) and 95% confidence intervals (CIs) (Table 1). Linear regression was used to test for mean CRF differences in study variables (Table 2). Multiple logistic regression was used to model the relationship between MVPA, CRF and obesity by computing adjusted odds ratios (ORs) and 95% CIs (Table 3 & Table 4). SAS version 9.4 was used for all analyses [29,30,31].

**Table 1. Participant characteristics, U.S. adults 20 to 49 years of age (2003-2004)**

Characteristic	N	Mean/%	SE	95% CI	
Age (years)	1386	36.0	0.29	35.44	36.65
Sex (Males)*	1386	50.0	1.79	46.14	53.77
Race/ethnicity (White)*	1386	71.0	3.20	64.16	77.82
Income (<45K US \$)*	1303	40.8	2.18	36.17	45.44
BMI (kg/m <sup>2</sup> )	1385	27.9	0.21	27.46	28.36
WC (cm)	1363	95.3	0.42	94.37	96.18
MVPA (average min/day)	1386	30.1	1.08	27.77	32.37
ST (average min/day)	1386	458.9	4.72	448.86	468.96
CRF (ml/kg/min)	684	39.1	0.51	37.99	40.17

Note. \*indicates percentages (%) were reported. SE is standard error. BMI is body mass index (kg/m<sup>2</sup>). WC is waist circumference (cm). MVPA is objectively measured moderate-to-vigorous physical activity (average min/day). ST is sedentary time (average min/day). CRF is cardiorespiratory fitness as measured by VO<sub>2max</sub> (ml/kg/min).

**Table 2. Participant characteristics by CRF level and obese status, U.S. adults 20 to 49 years of age (2003-2004)**

Characteristic	Obese					Not Obese				
	Lower CRF		Higher CRF		p	Lower CRF		Higher CRF		p
	Mean/%	SE	Mean/%	SE		Mean/%	SE	Mean/%	SE	
Using BMI										
Age (years)	35.3	0.88	36.7	0.70	.398	33.9	0.76	34.2	0.58	.774
Sex (Males)*	62.9	6.35	59.0	3.54	.576	53.3	2.91	47.1	3.95	.162
Race/ethnicity (White)*	70.4	6.62	68.3	4.49	.808	67.8	4.96	79.5	2.95	<b>.014</b>
Income (<45K US \$)*	39.4	7.24	33.2	6.17	.388	34.7	3.08	37.1	2.68	.551
BMI (kg/m <sup>2</sup> )	34.9	0.56	33.6	0.29	.055	25.0	0.26	24.0	0.24	<b>.006</b>
WC (cm)	111.2	1.71	108.7	0.94	.157	88.7	0.77	85.4	0.75	<b>.001</b>
MVPA (average min/day)	25.2	2.11	34.1	2.27	<b>.003</b>	33.1	1.55	40.3	1.87	<b>.009</b>
ST (average min/day)	451.9	13.34	433.7	11.71	.248	451.2	6.92	448.7	9.22	.833
CRF (ml/kg/min)	32.8	0.63	44.7	1.16	<b>&lt;.001</b>	33.8	0.43	45.2	0.73	<b>&lt;.001</b>
Using WC										
Age (years)	35.9	0.49	37.7	0.66	.119	33.2	0.80	33.1	0.54	.948
Sex (Males)*	52.8	5.96	46.0	3.56	.339	58.3	3.03	52.0	4.36	.202
Race/ethnicity (White)*	72.9	5.21	69.6	4.39	.513	65.5	5.24	81.4	2.18	<b>.003</b>
Income (<45K US \$)*	36.5	5.17	34.5	5.75	.763	35.9	3.07	37.0	3.72	.823
BMI (kg/m <sup>2</sup> )	32.8	0.70	31.2	0.48	<b>.011</b>	24.6	0.23	23.4	0.24	<b>&lt;.001</b>
WC (cm)	107.9	1.55	103.8	1.10	<b>.016</b>	86.5	0.52	83.2	0.71	<b>.002</b>
MVPA (average min/day)	24.3	1.68	34.4	2.63	<b>.004</b>	35.1	1.50	41.5	1.44	<b>.001</b>
ST (average min/day)	451.0	13.15	449.5	8.91	.992	450.9	7.57	442.4	11.04	.516
CRF (ml/kg/min)	32.1	0.58	43.5	0.47	<b>&lt;.001</b>	34.6	0.42	46.1	0.79	<b>&lt;.001</b>

Note. \*indicates percentages (%) were reported. SE is standard error. BMI is body mass index (kg/m<sup>2</sup>). WC is waist circumference (cm). Obese status was defined as a BMI of 30 or greater and a WC > 102 cm for males or > 88 cm for females. MVPA is objectively measured moderate-to-vigorous physical activity (average min/day). ST is sedentary time (average min/day). CRF is cardiorespiratory fitness as measured by VO<sub>2max</sub> (ml/kg/min). Least squares regression was performed on continuous variables to determine CRF-related differences. Rao-Scott Chi-square tests were performed on categorical variables to determine CRF-related differences. p-values in bold indicate significant differences at the .05 level.

**Table 3. Odds of being obese (from BMI) when comparing those with low objectively measured MVPA to those with high objectively measured MVPA, U.S. adults 20 to 49 years of age (2003-2004)**

MVPA groups	Model I			Model II			Model III					
	OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>			
Overall												
Low	<b>1.72</b>	1.14	2.58	.013	<b>1.67</b>	1.12	2.51	.020	<b>2.10</b>	1.25	3.54	.009
High	1.00	-	-		1.00	-	-		1.00	-	-	
Lower CRF												
Low	<b>2.02</b>	1.08	3.78	.030	<b>1.98</b>	1.05	3.75	.037	<b>2.48</b>	1.23	5.01	.015
High	1.00	-	-		1.00	-	-		1.00	-	-	
Higher CRF												
Low	1.18	0.62	2.25	.583	1.12	0.57	2.20	.716	1.34	0.56	3.19	.488
High	1.00	-	-		1.00	-	-		1.00	-	-	

*Note.* Obese status in this table was defined as a BMI of 30 or greater. MVPA is objectively measured moderate-to-vigorous physical activity. Model I is unadjusted. Model II is age-adjusted only. Model III is fully adjusted for age, sex, race, and income. OR is odds ratio. CI is confidence interval. Low MVPA represents those with objectively measured MVPA below the median. High MVPA represents those with objectively measured MVPA above the median. Values in bold are significantly different from 1.00, with 95% confidence. CRF is cardiorespiratory fitness. Lower CRF represents those with measured VO2max rated at age-sex-specific low to moderate fitness. Higher CRF represents those with measured VO2max rated at age-sex-specific high fitness.

**Table 4. Odds of being obese (from WC) when comparing those with low objectively measured MVPA to those with high objectively measured MVPA, U.S. adults 20 to 49 years of age (2003-2004)**

MVPA groups	Model I			Model II			Model III					
	OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>			
Overall												
Low	<b>1.82</b>	1.27	2.61	.003	<b>1.75</b>	1.23	2.49	.004	<b>1.64</b>	1.03	2.62	.040
High	1.00	-	-		1.00	-	-		1.00	-	-	
Lower CRF												
Low	<b>2.25</b>	1.49	3.41	.001	<b>2.18</b>	1.39	3.41	.002	<b>2.06</b>	1.29	3.29	.005
High	1.00	-	-		1.00	-	-		1.00	-	-	
Higher CRF												
Low	1.32	0.73	2.39	.339	1.21	0.66	2.22	.517	1.01	0.38	2.66	.988
High	1.00	-	-		1.00	-	-		1.00	-	-	

*Note.* Obese status in this table was defined as a WC > 102 cm for males or > 88 cm for females. MVPA is objectively measured moderate-to-vigorous physical activity. Model I is unadjusted. Model II is age-adjusted only. Model III is fully adjusted for age, sex, race, and income. OR is odds ratio. CI is confidence interval. Low MVPA represents those with objectively measured MVPA below the median. High MVPA represents those with objectively measured MVPA above the median. Values in bold are significantly different from 1.00, with 95% confidence. CRF is cardiorespiratory fitness. Lower CRF represents those with measured VO2max rated at age-sex-specific low to moderate fitness. Higher CRF represents those with measured VO2max rated at age-sex-specific high fitness.

### 3. Results

Participants in the high CRF group had significantly ( $p < .05$ ) greater MVPA across all obesity groupings. In BMI obese, neither BMI nor WC were significantly different between CRF groups. However, in WC obese, both BMI and WC were significantly ( $p < .05$ ) lower in the high CRF group. Among adults with low CRF, those with low MVPA were more than twice as likely to be obese than those with high MVPA using BMI (OR=2.48; 95% CI: 1.23-5.01) and WC (OR=2.06; 95% CI: 1.29-3.29). Among adults with high CRF, no MVPA and obesity relationship was seen.

### 4. Discussion

The purpose of this study was to examine the relationship between concurrent PA and CRF on two different measures of obesity in middle-aged adults. Results showed, as expected, that adults with higher CRF also had greater amounts of MVPA. Additionally, this

same trend was seen in both obese and non-obese adults using both BMI and WC. However, a not expected finding, was that non-BMI-obese adults with higher CRF had significantly smaller mean BMI and significantly smaller mean WC than their lower CRF counterparts. This same trend was also seen in the non-WC-obese adults. These findings suggest that CRF may be related to body weight among adults who are not classified as obese. Although not analyzed in this study, it is possible that CRF may differentiate between normal (BMI: < 25) and overweight (BMI: 25 to 29.99) adults.

Another interesting finding in this study was that among adults with lower CRF, those with low MVPA were approximately twice as likely to be obese (by both BMI and WC), as compared to their high MVPA counterparts. Whereas, among adults with higher CRF, no MVPA and obesity relationship was seen. These findings suggest that CRF may protect adults from both types of obesity, regardless of MVPA behavior. Finally, these findings should be considered in light of the limitations associated with NHANES data [32].

## 5. Conclusions

Results from this study indicate that PA is only related to obesity when CRF is low. Furthermore, high CRF may protect less physically active adults from both overall and abdominal obesity. Health promotion programs should advocate for the improvement of CRF as well as increased PA in combating obesity.

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