

# Associations of Cardiorespiratory Fitness and Muscular Strength with Arterial Stiffness in Older Adults



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## ABSTRACT

**Purpose:** To evaluate the associations of cardiorespiratory fitness (CRF) and muscular strength (MS) with arterial stiffness (AS) in older adults.

**Methods:** This cross-sectional study included 390 older adults aged ≥65 years (mean age 72). Participants were free of diabetes and cardiovascular disease events that occurred within the past 2 years. CRF was assessed by time (minutes) to complete a 400-m walk test and MS by grip strength (Jamar Plus+ 12-064). Carotid-femoral pulse wave velocity (PWV) was used to assess AS (AtCor, Sphygmocor Xcel). High AS was defined as a PWV of 10 m/s or greater, as it has been established as a threshold for increased cardiovascular risk. Logistic regression was used to calculate odds ratios (ORs) and 95% confidence intervals (95% CIs) of having high AS across sex-specific tertiles of CRF and MS. Further, CRF and MS were dichotomized into either weak or unfit (lower one-third), or strong or fit (upper two-thirds) in a joint analysis of CRF and MS with high AS. All logistic regression models included age, mean arterial pressure, body mass index, physical activity, smoking, heavy alcohol consumption (>14 drinks per week for male, >7 for female), and MS or CRF for each other.

**Results:** Sixty-three (16%) adults were identified as having high AS. Compared to the lowest CRF tertile (lowest 33%), ORs (95% CIs) of having high AS were 0.38 (0.17-0.84) and 0.53 (0.22-1.27), for middle and upper CRF, respectively, after adjusting for the possible confounders including MS. Compared to the lowest MS tertile (lowest 33%), ORs (95% CIs) of having high AS were 0.69 (0.34-1.42) and 0.31 (0.13-0.75), for middle and upper MS, respectively, after adjusting for the possible confounders including CRF. In the joint analysis, compared to the unfit and weak group, ORs (95% CIs) for high AS were 0.41 (0.16-1.05) for unfit and strong, 0.34 (0.12-0.94) for fit and weak, and 0.27 (0.12-0.61) for fit and strong.

**Conclusion:** Higher levels of both CRF and MS were independently associated with reduced odds of having high AS in older adults. Future prospective studies could evaluate longitudinal associations of CRF and MS and attenuation of age-related AS, which is an emerging risk factor for cardiovascular diseases.

## INTRODUCTION

- Arterial stiffness is an emerging CVD risk factor.
- Higher levels of physical activity are associated with lower arterial stiffness in older adults; however, the majority of these studies use self-reported physical activity.
- The purpose of this study is to investigate the independent and combined associations of cardiorespiratory fitness and muscular strength with arterial stiffness in older adults using a prospective cohort, Physical Activity and Aging Study (PAAS), data collected since 2015 at Iowa State University Physical Activity Epidemiology Lab.

## METHODS

**Study Design:** Cross-sectional study  
**Participants:** 390 older adults, ≥65 years (mean age 72, range 65-92 years).

### BODY COMPOSITION:

- **Height:** Measured with a standard stadiometer
- **Weight:** Measured using a digital scale

### LIFESTYLE:

- **Smoking Status:** Self-reported smoking habits
- **Heavy Alcohol Intake:** Self-reported number of daily drinks of beer (12oz.), wine (5oz.), and liquor (1.5oz) > 14 per week for men and > 7 per week for women

### PHYSICAL ACTIVITY

- **Steps per day:** Accelerometer-based pedometer (Omron HJ-321 tri-axis pedometer) worn during waking hours for 7 days, providing daily step count.

### FITNESS:

- **Cardiorespiratory Fitness (CRF):** 400m walk test (minutes)
- **Grip Strength (MS):** Handheld dynamometer (Jamar Plus+; average kg from 3 trials on each hand)

### CARDIOVASCULAR FUNCTION:

- **Mean Arterial Pressure:** Pulse wave analysis (AtCor, Sphygmocor XCEL)
- **Arterial Stiffness:** Pulse wave velocity (PWV) (AtCor, Sphygmocor XCEL; m/s)

### STATISTICAL ANALYSIS:

- Multivariable logistic regression and joint multivariable logistic regression. Case: "high arterial stiffness," PWV ≥ 10 m/s based on earlier studies)

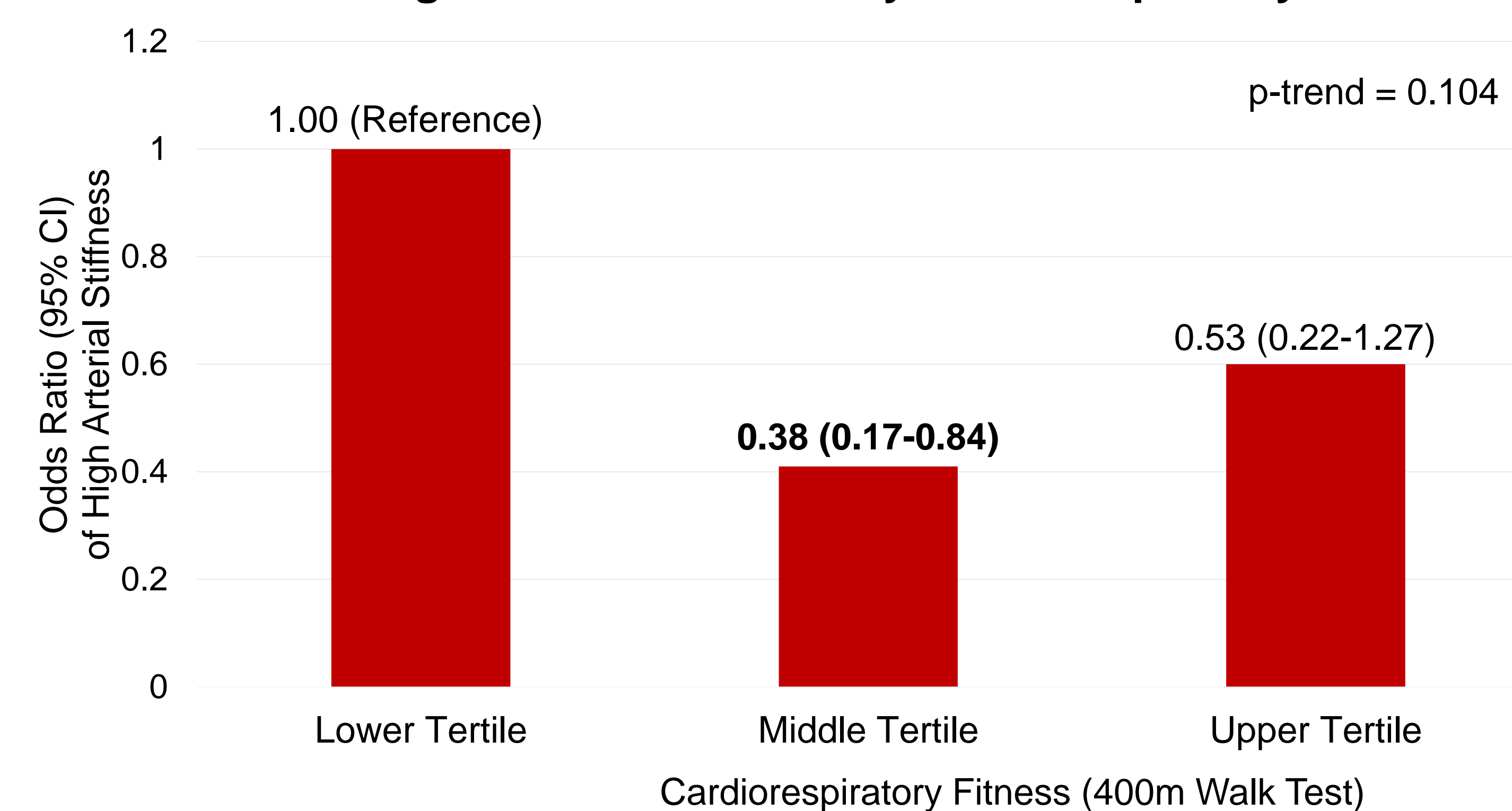
## RESULTS

Table 1. Participant Characteristics

	Total	Tertile of Cardiorespiratory Fitness				Tertile of Muscular Strength			
		Lower	Middle	Upper	p-value	Lower	Middle	Upper	p-value
<b>n</b>	390	129	129	132		130	130	130	
<b>Age, y</b>	72 (6)	75 (7)	71 (5)	70 (5)	<0.001	74 (7)	71 (5)	71 (5)	<0.001
<b>Weight, kg</b>	76.4 (15.9)	79.3 (17.4)	77.4 (15.9)	72.7 (13.7)	0.003	75.7 (16.4)	74.2 (14.2)	79.3 (16.7)	0.028
<b>Body mass index, kg/m<sup>2</sup></b>	27.4 (4.6)	28.8 (5.2)	27.9 (4.3)	25.5 (3.6)	<0.001	28.0 (4.5)	26.8 (4.8)	27.3 (4.4)	0.106
<b>Normal weight, n (%)</b>	123 (32)	32 (25)	34 (26)	57 (43)		36 (28)	47 (36)	40 (31)	
<b>Overweight, n (%)</b>	164 (42)	51 (39)	53 (41)	60 (46)		52 (40)	53 (41)	59 (45)	
<b>Obese, n (%)</b>	103 (26)	46 (36)	42 (33)	15 (11)		42 (32)	30 (23)	31 (24)	
<b>Steps per day</b>	5847 (3099)	4675 (2406)	5870 (3108)	6970 (3287)	<0.001	5494 (2688)	6218 (3295)	5839 (3264)	0.171
<b>Not meeting PA guidelines<sup>a</sup>, n (%)</b>	288 (74)	112 (87)	96 (74)	80 (61)	<0.001	105 (81)	87 (67)	96 (74)	0.043
<b>Current Smoker, n (%)</b>	4 (1)	1 (1)	2 (1)	1 (1)	0.770	1 (1)	2 (2)	1 (1)	0.779
<b>Heavy Alcohol Intake<sup>b</sup>, n (%)</b>	28 (7)	6 (5)	12 (9)	10 (8)	0.343	7 (5)	9 (7)	12 (9)	0.490
<b>Cardiovascular Disease<sup>c</sup>, n (%)</b>	19 (5)	11 (9)	6 (5)	2 (2)	0.031	11 (9)	6 (5)	2 (2)	0.011
<b>Mean arterial pressure, mmHg</b>	92 (10)	93 (11)	93 (9)	91 (10)	0.166	93 (10)	92 (8)	92 (11)	0.549
<b>Systolic BP, mmHg</b>	132 (15)	135 (16)	132 (14)	128 (13)	<0.001	134 (15)	131 (13)	129 (15)	0.021
<b>Diastolic BP, mmHg</b>	75 (8)	75 (9)	76 (8)	75 (9)	0.760	75 (8)	75 (8)	75 (9)	0.993
<b>Hypertensive<sup>d</sup>, n (%)</b>	163 (42)	63 (49)	60 (47)	40 (30)	0.004	60 (47)	53 (41)	50 (38)	0.401
<b>Pulse wave velocity<sup>e</sup>, m/s</b>	8.5 (1.6)	9.2 (1.8)	8.3 (1.5)	8.1 (1.4)	<0.001	8.9 (1.8)	8.4 (1.6)	8.1 (1.3)	<0.001
<b>Cardiorespiratory Fitness<sup>f</sup> (400m walk time, min)</b>	4.5 (0.7)	5.3 (0.7)	4.4 (0.2)	3.8 (0.3)	<0.001	4.9 (0.8)	4.4 (0.6)	4.2 (0.7)	<0.001
<b>Average Grip Strength<sup>g</sup> (kg)</b>	32.3 (11.5)	27.8 (10.0)	32.9 (11.3)	36.0 (11.5)	<0.001	23.7 (7.3)	31.5 (7.9)	41.6 (10.9)	<0.001

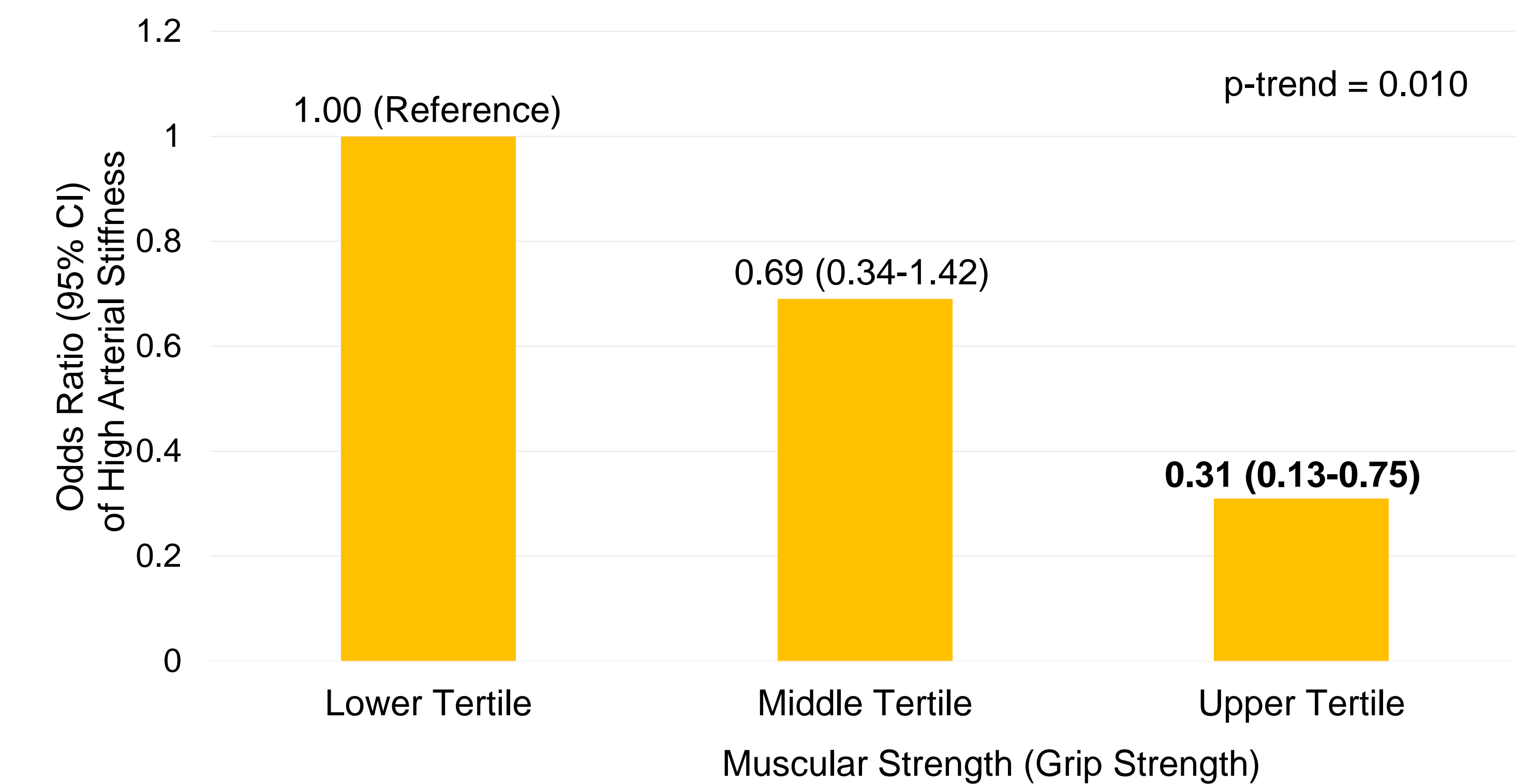
Unless otherwise indicated, values are presented as mean (SD)  
<sup>a</sup> < 7500 steps/day; <sup>b</sup> > 14 drinks/week for men, >7 drinks/week for women; <sup>c</sup> history of myocardial infarction and/or stroke; <sup>d</sup> self-reported: diagnosed hypertension and/or taking blood pressure medication; <sup>e</sup> carotid-femoral pulse wave velocity; <sup>f</sup> time (min) to complete 400m walking test; <sup>g</sup> maximum value (out of 3 trials) from each hand, averaged. BP, blood pressure; PA, physical activity.

Figure 1. Odds Ratios of High Arterial Stiffness by Cardiorespiratory Fitness Tertiles\*



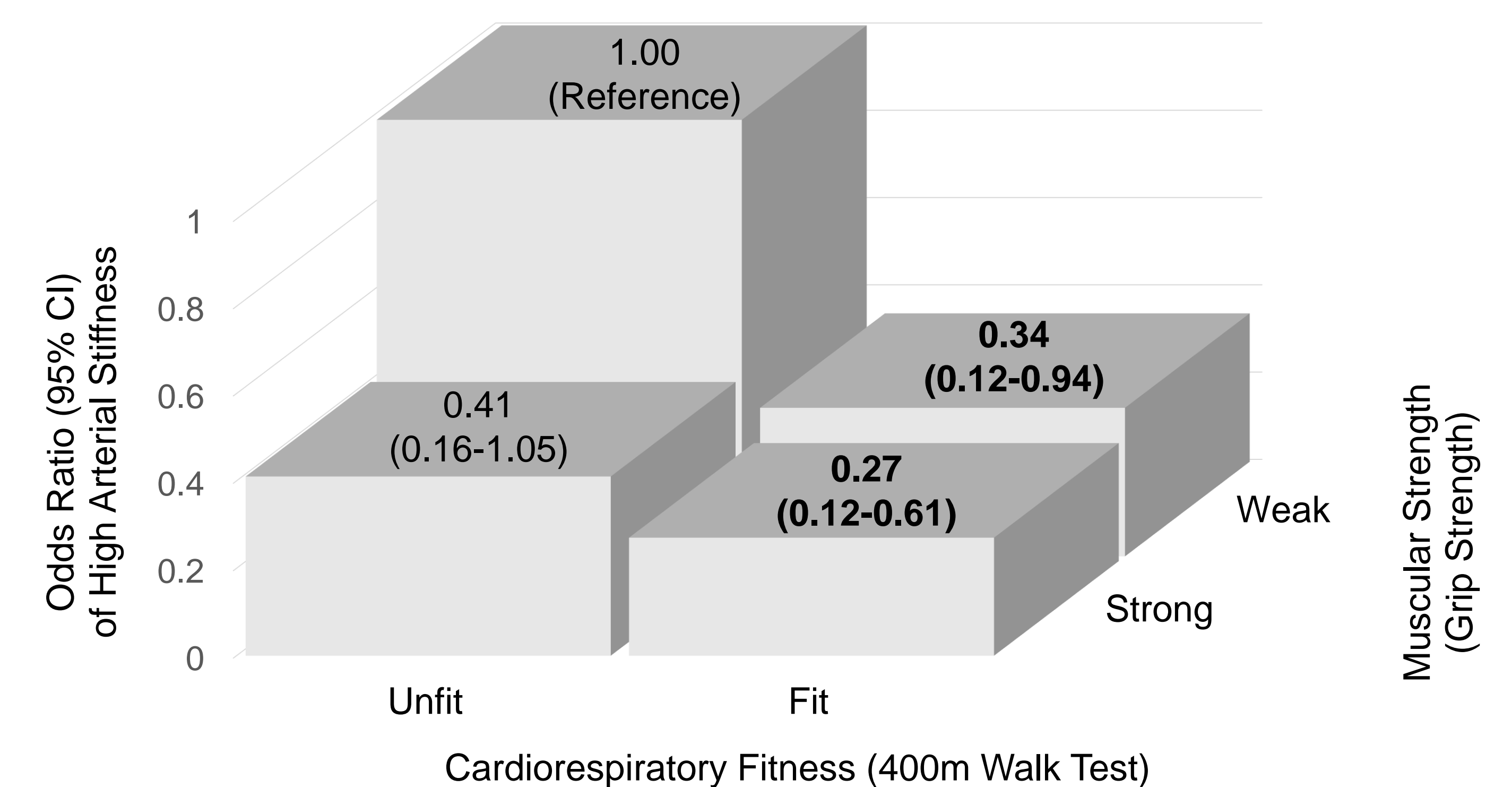
\*Adjusted for age (years), sex, mean arterial pressure (mmHg), body mass index (kg/m<sup>2</sup>), not meeting physical activity guidelines (<7500 steps/day, yes or no), current smoking status (yes or no), heavy alcohol intake (yes or no), and muscular strength (kg). The number of individuals (cases of high arterial stiffness) in Low, Middle, and High CRF were 129 (36), 129 (14), and 132 (14), respectively. CI, confidence interval.

Figure 2. Odds Ratios of High Arterial Stiffness by Muscular Strength Tertiles\*



\*Adjusted for age (years), sex, mean arterial pressure (mmHg), body mass index (kg/m<sup>2</sup>), not meeting physical activity guidelines (<7500 steps/day, yes or no), current smoking status (yes or no), heavy alcohol intake (yes or no), and cardiorespiratory fitness (min). The number of individuals (cases of high arterial stiffness) in Low, Middle, and High MS were 130 (34), 130 (19), and 130 (11), respectively. CI, confidence interval.

Figure 3. Odds Ratios of High Arterial Stiffness by Combined Cardiorespiratory Fitness and Muscular Strength\*



\*Adjusted for age (years), sex, mean arterial pressure (mmHg), body mass index (kg/m<sup>2</sup>), not meeting physical activity guidelines (<7500 steps/day, yes or no), current smoking status (yes or no), and heavy alcohol intake (yes or no). Participants were divided into four groups based on CRF and MS, where Unfit and Weak were the lower 1/3 of CRF and MS, respectively, and Fit and Strong were the upper 2/3 of CRF and MS, respectively. The number of individuals (cases of higher arterial stiffness) in the Unfit & Weak, Unfit & Strong, Fit & Weak, and Fit & Strong groups were 76 (26), 54 (11), 54 (8) and, 206 (19), respectively. CI, confidence interval.

## CONCLUSIONS

### Independent associations:

- The middle tertile of cardiorespiratory fitness was associated with significantly reduced odds of having high arterial stiffness, independent of muscular strength.
- The upper tertile of muscular strength was associated with significantly reduced odds of having high arterial stiffness, independent of cardiorespiratory fitness.

### Combined associations:

- Being both Fit & Strong and Fit & Weak were associated with significantly reduced odds of having high arterial stiffness.

**Limitations:** overall somewhat active and healthy population of older adults

**Future prospective studies could evaluate longitudinal associations of CRF and MS and attenuation of age-related arterial stiffness, which is an emerging risk factor for cardiovascular diseases.**