Independent and Joint Associations of Cardiorespiratory Fitness and Body Mass Index With Sleep Quality and Duration in Older Adults

Franchesca Porter, Joey M. Saavedra, Xiangyu Zhai, Taline R. Jouzi, Duck-chul Lee, FACSM
Iowa State University, Ames, IA.

INTRODUCTION

- Literature suggests that as individuals reach older adulthood, sleep duration *decreases*, while sleep quality problems (e.g. difficulties in falling and staying asleep) *increase*, both of which have been associated with **negative health outcomes.**
- Both **cardiorespiratory fitness (CRF)** and **body mass index (BMI) are risk factors** for short sleep and poor sleep quality. However, the joint association of CRF and BMI on sleep in older adults **remains unknown.** Further, most studies exclusively used self-reported sleep.
- The purpose of this study was to examine the **independent** and **joint** associations of **CRF** and **BMI** on <u>subjective</u> and <u>objective</u> sleep in a sample of older adults (≥65).

METHODS

- **Participants**: 819 older adults aged 72.3 ±5.9 (57.5% female). **CRF assessment:** Assessed via a 400m timed fast-walk test, shorter time indicating higher CRF, categorized into sex-specific quartiles (Q1-Q4) where Q1 is least fit and Q4 is most fit. **Body mass index (BMI):** Calculated from height and weight as kg/m^2, categorized as Normal weight (18.5 - 24.9 kg/m^2), Overweight (25 – 29.9 kg/m^2), Obese (≥ 30 kg/m^2). **Sleep Quality:** Assessed via the Pittsburgh Sleep Quality Index (PSQI) in a total sample (n=819), scored following standard procedures, with poor sleep quality defined as an overall score >5. **Sleep Duration:** Assessed objectively via smart watch (Fitbit Charge 2) worn over at least 4 nights in a subsample (n=771), sufficient sleep duration defined as 7-8 hours per night following the CDC guidelines for older adults. **Covariates:** Obtained self-report via questionnaire

STATISTICAL ANALYSIS

- **Multivariate logistic regression** was used to evaluate the independent and combined associations of CRF and BMI on poor sleep quality and sufficient sleep duration, adjusting for covariates as stated in Tables 2 and 3.
- **For Joint Analyses** participants were categorized as fit (Q2-Q4) vs. unfit (Q1) and normal weight vs. Overweight or obese.

Table 1. Participant characteristics

Characteristic	All	Poor Sleep Quality	Good Sleep Quality	P=Value	All	Sufficient sleep duration	Insufficient sleep duration	P-value
		Sleep Quality				Sleep Duration		
N	819	277	542		771	269	502	
Age (years)	72.3 ± 5.9	72.0 ± 5.7	72.5 ± 6.0	0.191	72.3 ± 5.8	72.3 ± 5.9	72.4 ± 5.8	0.987
Female, n (%)	471 (57.5)	184 (66.4)	287 (52.9)	<0.001	448 (58.1)	181 (67.3)	267 (53.2)	**<0.001**
400 m walk test time (min)	4.6 ± 1.0	4.7 ± 1.0	4.6 ± 1.0	0.142	4.6 ± 0.9	4.5 ± 0.8	4.6 ± 1.0	**0.050**
Body Mass Index, (kg/m²)	27.5 ± 4.8	27.8 ± 5.2	27.3 ± 4.6	0.224	27.4 ± 4.8	26.7 ± 4.8	27.8 ± 4.8	**0.005**
PSQI score	4.8 ± 2.9	8.0 ± 2.1	3.1 ± 1.4	**<0.001**	4.7 ± 2.9	4.6 ± 2.8	4.8 ± 2.8	0.560
Sleep Duration (hours)	6.9 ± 1.0	7.0 ± 1.1	6.9 ± 1.0	0.374	6.9 ± 1.0	7.5 ± 0.3	6.6 ± 1.2	**<0.001**
Smoking status, n (%)								
Never	586 (72.6)	195 (70.4)	391 (72.1)		553 (71.7)	186 (69.1)	367 (73.1)	
Former	223 (27.2)	77 (27.8)	146 (26.9)	0.523	210 (27.2)	78 (29.0)	132 (26.3)	0.171
Current	10 (2.3)	5 (1.8)	5 (0.9)		8 (1.0)	5 (1.9)	3 (0.6)	
Heavy alcohol consumptionᵃ, n (%)	67 (8.1)	29 (10.5)	38 (7.0)	0.088	64 (8.3)	29 (10.8)	35 (7.0)	0.068
Meeting aerobic PA Guidelinesᵇ, n (%)	250 (30.5)	97 (35.0)	153 (28.3)	**0.046**	235 (30.5)	78 (29.0)	157 (31.3)	0.51
Comorbiditiesᶜ, number	1.4 ± 1.0	1.5 ± 1.1	1.3 ± 1.0	**0.012**	1.4 ± 1.0	1.3 ± 1.1	1.4 ± 1.0	0.492
Sleep medication useᵈ, n (%)	130 (15.9)	108 (39.0)	22 (4.1)	**0.001**	125 (16.2)	47 (17.5)	78 (15.5)	0.487
Depressionᵉ, n (%)	90 (11.0)	42 (15.1)	48 (8.9)	**0.006**	86 (11.2)	28 (10.4)	58 (11.6)	0.630
Anxietyᵉ, n (%)	61 (7.5)	37 (13.4)	24 (4.4)	**<0.001**	58 (7.5)	24 (8.9)	34 (6.7)	0.281

Continuous data presented as mean ± standard deviation, categorical data presented as count (%). ᵃHeavy alcohol consumption: >7 alcoholic drinks/week for women, >14 alcoholic drinks/week for men. ᵇMeeting aerobic PA guidelines: measured via self-report questionnaire (150 minutes moderate or equivalent per week) ᶜComorbidities: Sum of the number of chronic diseases present (arthritis, hypertension, asthma, diabetes, high cholesterol, myocardial infarction, congestive heart failure, stroke, COPD, kidney disease, cancer) ᵈSleep medication use: measured via PSQI ᵉDepression and anxiety: measured as current or past self-reported diagnosis or medication use

Table 2. Odds ratios (95% confidence intervals) of self-reported poor sleep quality by CRF and BMI

	Total	Cases (%)	Model 1ᵃ	Model 2ᵇ	Model 3ᶜ
Cardiorespiratory fitness (CRF)					
Q1 (Least fit)	206	73 (35.4)	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Q2	203	64 (32.0)	0.77 (0.50-1.18)	0.89 (0.57-1.40)	0.92 (0.58-1.46)
Q3	207	77 (37.2)	0.93 (0.61-1.44)	1.16 (0.74-1.83)	1.22 (0.76-1.98)
Q4 (Most fit)	203	62 (30.4)	0.68 (0.43-1.07)	0.95 (0.58-1.56)	1.03 (0.60-1.74)
P for linear trend			0.197	0.851	0.659
Body Mass Index (BMI)					
Normal weightᵈ	270	90 (33.3)	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Overweightᵉ	335	108 (32.2)	1.08 (0.76-1.53)	1.05 (0.73-1.50)	1.04 (0.73-1.50)
Obeseᶠ	214	79 (36.9)	1.36 (0.93-2.01)	1.07 (0.71-1.62)	1.05 (0.68-1.62)
P for linear trend			0.124	0.740	0.814

Abbreviations: OR, odds ratio; CI, confidence interval. Total sample: 819. Poor sleep quality is a PSQI score > 5. Quartiles of CRF were based on sex-specific distribution of 400M walk test time in the sample. ᵃ**Model 1** was adjusted for sex and age (years). ᵇ**Model 2** was adjusted for Model 1 plus education (highest level obtained from elementary to graduate degree), marital status (single, married, widowed, divorced, separated), heavy alcohol consumption (>7 drinks/week women, >14 drinks/week men), smoking status (never, former, or current), meeting the aerobic physical activity guidelines (>150 min/week of moderate and vigorous combined), depression, anxiety, and number of comorbid conditions (arthritis, hypertension, asthma, diabetes, cardiovascular disease (coronary heart failure, myocardial infarction, or stroke), COPD, kidney disease, and cancer). ᶜ**Model 3** was adjusted for Model 2 plus BMI (kg/m²) or CRF (minutes/400M walk). ᵈNormal weight (BMI 18.5 - 24.9 kg/m²), ᵉoverweight (BMI 25 – 29.9kg/m²), ᶠobese (BMI ≥ 30 kg/m²). Note: sleep medication use is **not** adjusted for as it is a component of PSQI.

Table 3. Odds ratios (95% confidence intervals) of objectively measured sufficient sleep duration by CRF and BMI

	Total	Cases (%)	Model 1ᵃ	Model 2ᵇ	Model 3ᶜ
Cardiorespiratory fitness (CRF)					
Q1 (Least fit)	192	53 (27.6)	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Q2	198	63 (31.8)	1.34 (0.85-2.12)	1.36 (0.85-2.18)	1.29 (0.80-2.09)
Q3	189	79 (41.8)	**2.13 (1.33-3.42)**	**2.14 (1.32-3.47)**	1.98- (1.19-3.28)
Q4 (Most fit)	192	74 (39.5)	1.91 (1.18-3.08)	1.98 (1.19-3.29)	1.78 (1.03-3.07)
P for linear trend			0.003	0.003	0.017
Body Mass Index (BMI)					
Normal weightᵈ	260	106 (40.8)	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Overweightᵉ	312	109 (34.9)	0.89 (0.63-1.26)	0.91 (0.63-1.30)	0.93 (0.65-1.33)
Obeseᶠ	199	54 (27.1)	0.62 (0.41-0.93)	0.61 (0.49-0.93)	0.70 (0.45-1.10)
P for linear trend			0.025	0.029	0.143

Abbreviations: OR, odds ratio; CI, confidence interval. Total sample: 771. Sufficient sleep duration = 7-8 hours on average/night. Quartiles of CRF were based on sex-specific distribution of 400M walk test time in the sample. ᵃ**Model 1** was adjusted for sex and age (years). ᵇ**Model 2** was adjusted for Model 1 plus education (highest level obtained from elementary to graduate degree), marital status (single, married, widowed, divorced, separated), heavy alcohol consumption (>7 drinks/week women, >14 drinks/week men), smoking status (never, former, or current), meeting the aerobic physical activity guidelines (>150 min/week of moderate and vigorous combined), depression, anxiety, sleep medication use, and number of comorbid conditions (arthritis, hypertension, asthma, diabetes, cardiovascular disease (coronary heart failure, myocardial infarction, or stroke), COPD, kidney disease, and cancer). ᶜ**Model 3** was adjusted for Model 2 plus BMI (kg/m²) or CRF (minutes/400M walk). ᵈNormal weight (BMI 18.5 - 24.9 kg/m²), ᵉoverweight (BMI 25 – 29.9kg/m²), ᶠobese (BMI ≥ 30 kg/m²).
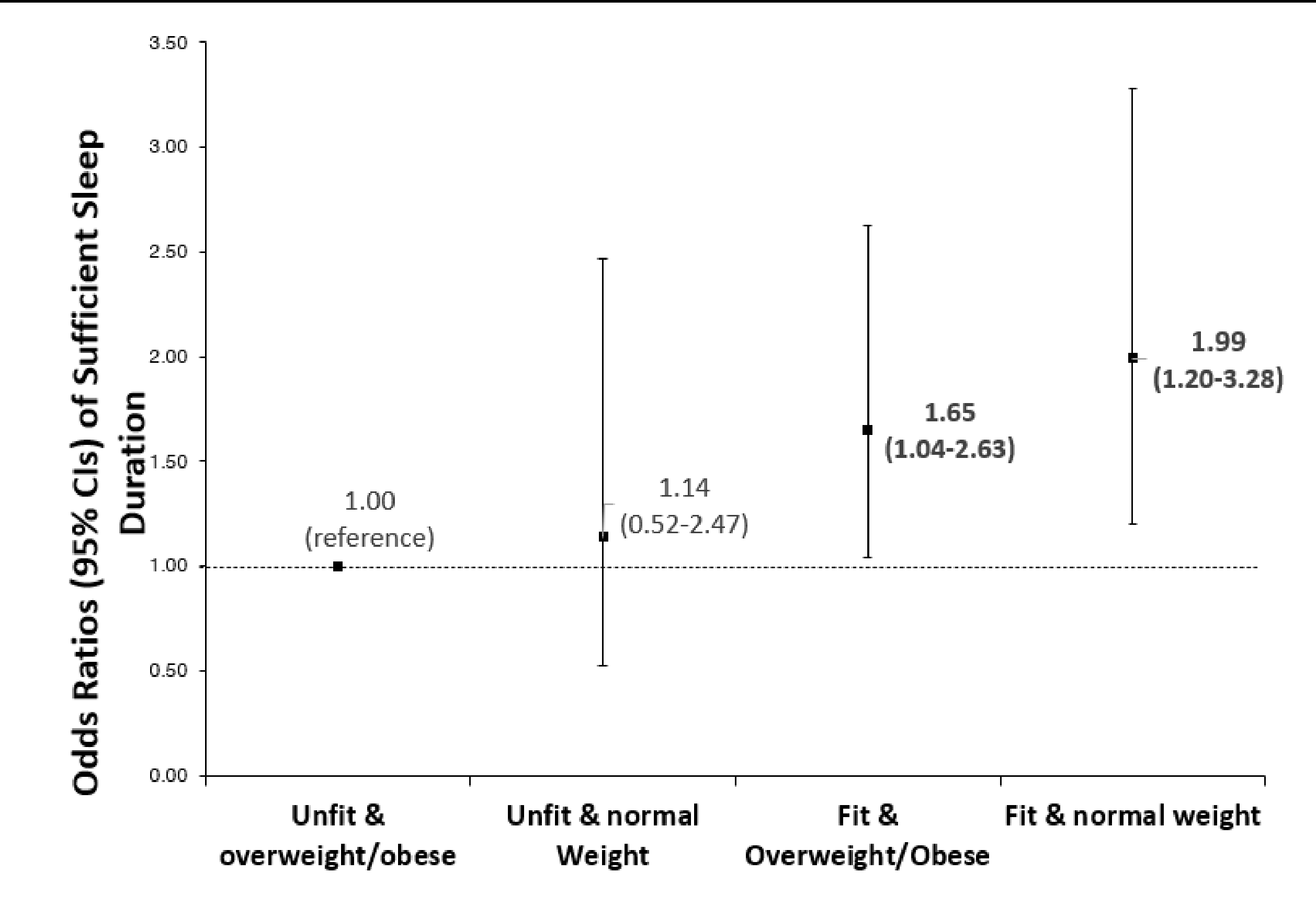

Figure 1. The joint associations of CRF and BMI on the odds of objectively measured sufficient sleep duration in older adults.
Unit: quartile 1 of CRF distribution, **Fit:** quartiles 2-4 of CRF distribution

CONCLUSIONS

- Neither CRF nor BMI were significantly associated with subjective (self-reported) sleep quality in this sample
- The upper two quartiles (Q3&4) of higher CRF were significantly associated with higher prevalence of objectively measured sufficient sleep duration, even after adjustment for BMI category
- Obesity was significantly associated with lower prevalence of objectively measured sufficient sleep duration, but this association was fully attenuated when adjusting for CRF
- Regardless of BMI categories, fit older adults show higher prevalence of objectively measured sufficient sleep duration, suggesting fitness may have a stronger relationship with sleep duration than fatness
- Future research should explore the prospective relationship of CRF and BMI on components of sleep quality and additional objective sleep measures in older adults

LIMITATIONS

- Cross-sectional study (not causal)
- Predominantly white, well-educated sample
- Objective sleep duration did NOT include measures of sleep duration from daytime napping
- Components of PSQI not evaluated individually

PUBLIC HEALTH MESSAGE

Greater CRF may have favorable implications for sufficient sleep duration in older adults, independent of BMI.