Associations of Body Mass Index and Cardiorespiratory Fitness with Sleep Apnea in Older Adults

Joey M. Saavedra[1], Elizabeth C. Lefferts[1], Bong Kil Song[1], Duck-chul Lee[1], FACSM
[1]Iowa State University, Ames, IA.

ABSTRACT

PURPOSE: To estimate the independent and joint associations of body mass index (BMI) and cardiorespiratory fitness (CRF) with prevalent sleep apnea (SA) in older adults.
METHODS: This cross-sectional study included 569 individuals aged 65-90 (62% female, mean age 71 years), all of whom were free from myocardial infarction, stroke, and cancer. BMI was calculated as measured body mass (kg) divided by height squared (m^2). CRF was assessed by a 400m walk test. Participants were classified as normal weight (BMI<25), overweight (25≤BMI<30), obese class I (30≤BMI<35), or obese class II+ (BMI≥35). Participants were also divided into sex-specific quartiles (Q) of CRF (Q1: least fit, Q4: most fit). Cases of SA were identified by self-reported physician diagnosis from a medical history questionnaire. Multivariable logistic regression was used to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) of prevalent SA across the four groups of BMI and quartiles of CRF, adjusting for age, sex, smoking status, heavy alcohol drinking, and meeting the aerobic physical activity guidelines. Participants were further categorized as 'normal weight' (BMI<25) or 'overweight/obese' (BMI≥25), as well as 'fit' (Q2-Q4) or 'unfit' (Q1) to evaluate the joint association of BMI and CRF on prevalent SA.
RESULTS: There were 81 (14%) cases of SA. Compared to 'normal weight,' the ORs (95% CIs) of SA were 3.80 (1.61-8.95), 4.66 (1.82-11.92), and 12.50 (4.33-36.07) for the overweight, obese class I, and obese class II+ groups, respectively, after adjusting for potential confounders including CRF. Compared to Q1, the ORs (95% CIs) of SA were 0.86 (0.43-1.70), 0.88 (0.40-1.92), 0.80 (0.32-2.00), for Q2, Q3, and Q4, respectively, after adjusting for potential confounders including BMI. In the joint analysis, compared to 'normal weight & fit,' the ORs (95% CIs) of SA were 6.73 (2.34-19.4), 4.44 (0.88-22.47), and 10.56 (3.44-32.38) for the 'overweight/obese & fit,' 'normal weight & unfit,' and 'overweight/obese & unfit,' respectively.
CONCLUSIONS: In fully adjusted models, BMI, but not CRF, was significantly associated with prevalent SA in older adults, suggesting that the 'fat-but-fit' paradigm may not extend to sleep apnea. However, prospective studies are warranted.

INTRODUCTION

Sleep apnea (SA) is prevalent in 25% of older adults, and is associated with an increased risk of cardiovascular disease. One powerful risk factor of SA is elevated **body mass index (BMI).** High **cardiorespiratory fitness (CRF)** often attenuates the association between BMI and age-associated morbidities. However, the impact of CRF on the association between BMI on SA in older adulthood is not well-defined.

METHODS

PARTICIPANTS: 569 older adults (mean age of 71 years) enrolled in the Physical Activity and Aging Study (PAAS) who reported no history of myocardial infarction, stroke, or cancer.

BMI: Body mass in kilograms (kg) divided by height in meters squared (m^2).

CRF: Time to complete the 400m walk test (minutes), with participants subsequently categorized into sex-ranked quartiles (Q1 = least fit, Q4 = most fit).

SA: Self-reported, physician diagnosis using a medical history questionnaire.

STATISTICAL ANALYSIS

Participant characteristics were analyzed using **general linear models** for continuous variables and **chi-squared** (χ_2) for categorical variables. The independent and joint associations of CRF and BMI on SA were determined using **multivariate logistic regression** (adjusting for potential confounders).

Table 1. Participant characteristics

Characteristic	All (n=569)	Cases (n=81)	Non-cases (n=488)	*P*-value[a]
Age, years	71.4 (5.2)	71.2 (4.8)	71.5 (5.3)	0.676
Female	350 (61.5)	42 (51.9)	308 (63.1)	0.054
BMI	27.4 (4.9)	31.1 (5.2)	26.8 (4.6)	**<0.001**
BMI category[b]				
Normal weight	197 (34.6)	7 (8.6)	190 (38.9)	**<0.001**
Overweight	225 (39.5)	32 (39.5)	193 (39.6)	
Obesity class I	105 (18.5)	22 (27.2)	83 (17.0)	
Obesity class II	42 (7.4)	20 (24.7)	22 (4.5)	
Smoking status				
Never	393 (69.1)	55 (67.9)	338 (69.3)	0.970
Former	169 (29.7)	25 (30.9)	144 (29.5)	
Current	7 (1.2)	1 (1.2)	6 (1.2)	
Heavy drinking[c]	48 (8.4)	5 (6.2)	43 (8.8)	0.429
400m walk time, minutes	4.5 (0.9)	4.9 (1.4)	4.4 (0.8)	**<0.001**
Meets aerobic PAG[d]	407 (71.5)	47 (58.0)	360 (73.8)	**0.004**
Comorbidities				
Hypertension	339 (59.6)	61 (75.3)	278 (57.0)	**0.002**
Diabetes	54 (9.5)	15 (18.5)	39 (8.0)	**0.003**
Asthma	39 (6.9)	10 (12.3)	29 (5.9)	**0.035**
COPD	6 (1.1)	1 (1.2)	5 (1.0)	0.865

Abbreviations: BMI, body mass index; PAG, Physical Activity Guidelines for Americans (2018).
Continuous data are presented as mean (±standard deviation), while categorical data are presented as counts (%).
[a]*P*-value for the comparison between cases and non-cases.
[b]Normal weight: BMI<25; Overweight: 25≤BMI<30; Obesity Class I: 30 ≤ BMI<35; Obesity Class II: BMI≥35.
[c]Heavy drinking defined as >7 alcoholic drinks/week for women, and >14 alcoholic drinks/week for men.
[d]Self-reported, defined as accumulating a minimum of 150-minutes of moderate aerobic activity per week, 75-minutes of vigorous aerobic activity per week, or an equivalent combination of the two.

Table 2. Adjusted odds ratios (95% confidence intervals) of SA by BMI and CRF

	Cases (%)	No. of participants	Model 1[a]	Model 2[b]	Model 3[c]
BMI					
Normal weight	7 (3.6)	197	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Overweight	32 (14.2)	225	**4.32 (1.85-10.06)**	**3.88 (1.65-9.13)**	**3.80 (1.61-8.95)**
Obesity class I	22 (21.0)	105	**6.78 (2.76-16.64)**	**5.50 (2.20-13.80)**	**4.66 (1.82-11.92)**
Obesity class II	20 (47.6)	42	**24.12 (9.14-63.99)**	**17.08 (6.22-46.91)**	**12.50 (4.33-36.07)**
P for linear trend			**<0.001**	**<0.001**	0.094
CRF[d]					
Q1 (Least fit)	33 (23.1)	143	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Q2	21 (14.9)	141	**0.51 (0.27-0.95)**	0.60 (0.32-1.14)	0.86 (0.43-1.70)
Q3	16 (11.2)	143	**0.34 (0.17-0.68)**	**0.47 (0.23-0.95)**	0.88 (0.40-1.92)
Q4 (most fit)	11 (7.7)	142	**0.21 (0.10-0.47)**	**0.33 (0.14-0.74)**	0.80 (0.32-2.00)
P for linear trend			**<.0001**	**0.005**	0.650

Abbreviations: No., number; BMI, body mass index; CRF, cardiorespiratory fitness.
[a]Model 1 adjusted for age (continuous) and sex (male or female). [b]Model 2 adjusted for Model 1 + smoking status (never, former, current(>7 alcoholic drinks/week for women, >14 alcoholic drinks for men), meeting the 2018 aerobic physical activity guidelines (yes or no), and comorbidity number (0, 1, 2, 3, or 4). [c]Model 3 adjusted for Model 2 + CRF (in the BMI analysis) or BMI (in the CRF analysis). [d]Quartiles of CRF were based on the sex-ranked distribution of 400m walk time among the current sample (faster completion indicates greater CRF).

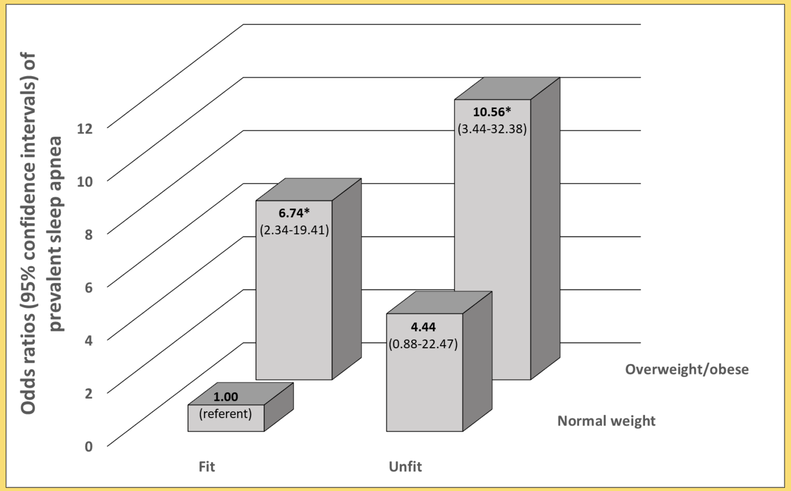

Figure 1. The combined associations of BMI and CRF on prevalent SA in older adults.
Participants were divided into four groups based on combined categories of BMI (category 1: normal weight , category 2: overweight, obesity class I, and obesity class II) and CRF (fit and unfit). 'Fit' constituted the upper 75% of the sex-ranked distribution of 400m walk time, while 'unfit' constituted the lowest 25%. The model was adjusted for age (contiguous), sex (male or female), smoking status (never, former, smoker), heavy drinking (>7 alcoholic drinks/week for women, >14 alcoholic drinks for men), meeting the 2018 aerobic physical activity guidelines (yes or no), and comorbidity number (0, 1, 2, 3, or 4). Bars with an asterisk (*) indicate $P < 0.05$.

CONCLUSIONS

- **Higher BMI** was significantly associated with greater odds of prevalent SA, even after adjusting for CRF.
- **Higher CRF** was significantly associated with lower odds of prevalent SA, however this relationship was attenuated when adjusting for BMI.
- Being **unfit and overweight/obese** had the greatest odds of prevalent SA, suggesting this is the worst phenotype for SA in older adulthood.
- Being **fit and overweight/obese** was also associated with high odds of prevalent SA, suggesting the **'fit-but-fat'** phenotype may not be protective against SA in older adulthood.
- **Prospective studies** with larger sample sizes are needed to confirm our findings.

LIMITATIONS

- Cross sectional design (cannot establish causation).
- Predominantly white and well-educated sample (low external validity).
- SA was self-reported (potential for misclassification bias).

PUBLIC HEALTH MESSAGE

Maintain a normal BMI (healthy body weight) to reduce the likelihood of SA in older adulthood, but don't discount the potential added benefits of high CRF.