ORIGINAL ARTICLE

The association between body mass index and risk of obstructive sleep apnea among patients with HIV

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Background: Although several studies show a positive association between body mass index (BMI) and a higher risk of obstructive sleep apnea (OSA) in the general population, there are limited data on that in patients living with HIV (PLHIV). The objective of the current study is to determine the prevalence of high risk for OSA and the association between BMI and OSA in PLHIV. **Materials and Methods:** The study was conducted on 316 confirmed HIV cases aged ≥ 18 years who attended consulting centers in Tehran during 2019. For the diagnosis of OSA we used the Persian version of the modified Berlin questionnaire that includes ten questions broken down into three categories. A high risk for breathing problems was defined if the total score is ≥ 2. Logistic regression models were used to evaluate the association between BMI and OSA risk groups. **Results:** Among PLHIV, 52.1% of men and 41.6% of women were considered as high risk for breathing problems during sleep at the time of the study. Patients with a higher risk for breathing problems had significantly higher BMI levels compared to those categorized as low-risk levels (25.2 vs. 24.3 kg/m^2). Each unit increase in the BMI increased the odds of being high risk for OSA by 6% in the multivariable model. (odds ratio [OR]: 95% confidence interval [CI]: 1.06: 1.01–1.13). Considering BMI categories, compared to the normal weight, being obese (BMI ≥ 30 kg/m^2) increased the high risk for OSA (OR [95% CI]: 2.54 [1.10–5.89]). **Conclusion:** We observed a significant association between general obesity and prevalence of OSA among PLHIV.

Key words: Body mass index, HIV, obstructive, sleep apnea

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INTRODUCTION

Sleeping, as a normal phenomenon, is one of the physiological needs in humans, which can be disrupted by underlying somatic or mental disorders. These disorders affect the regulation of normal physiologic sleep causing headache, fatigue, irritability, decreased attention, focus, physical and cognitive ability, and so, which may harm normal, healthy, and active life.[1] Obstructive sleep apnea (OSA) is a common form of sleep disorder, which is due to partial or complete obstruction in upper respiratory airways and often is accompanied by a decrease in oxygen saturation.

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There is a substantial variation among reported prevalence of OSA worldwide. A meta-analysis among the 27,684 Iranian population showed that the prevalence of sleep apnea was 44% (95% confidence interval [CI]: 35–53).[2] Concerning another meta-analysis among Asian adults, the prevalence of OSA ranged from 3.7% to 97.3%.[3] This wide range might be attributable to differing effects of the risk assessment methods as well as the study population heterogeneity. The prevalence of OSA is higher among men, older people, patients with cardiovascular diseases, and chronic conditions such as diabetes mellitus and HIV infection.[4,5] Some studies show that

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the prevalence of sleep disorders among patients living with HIV (PLHIV)/AIDS has been reported between 30% and 100%.[6-8]

Different factors such as unusual sleep patterns, obesity, underlying diseases, and psychological factors may cause the development or persistence of sleep disorders[9] and consequently increase the risk of cardiovascular disease.[10] This issue is rarely discussed among PLHIV/AIDS. Complaints of sleep disorders among PLHIV may negatively affect a patient's income/quality of life and therefore increase the risk of diabetes, cardiovascular disease, and stroke. It can also disrupt the patient's adherence to treatment, leading to disease progression, making it a challenge in the HIV control program.[7,11-13] Several studies show that due to secondary opportunistic infections among HIV-positive patients, the appetite is reduced, which additionally results in weight loss.[9,10] Therefore, considering the impact of potential risk factors such as body mass index (BMI), studies suggested that BMI may not be associated with OSA among PLHIV/AIDS. Since only one study has been published regarding the association between BMI and OSA among PLHIV,[11] limited epidemiological information is available regarding this issue.

For these reasons, a multicenter cross-sectional study was designed to explore the association between BMI and the prevalence of OSA among PLHIV.

MATERIALS AND METHODS

Study population

This study was a cross-sectional study performed in 2019 among individuals with a confirmed HIV in HIV voluntary counseling and testing centers in Tehran. In these centers, all prevention, care, and treatment services are offered to PLHIV, confidentially and free of charge. To select a random sample from all HIV voluntary counseling and testing centers in Tehran, the city was divided into four geographic regions, and from each region, two centers were randomly selected. In each center, patients were randomly selected from the files of active patients. Contacts were made to the selected patients for the invitation. Patients were briefed about the study and the study objectives and assured about confidentiality and their right to quit the study whenever they want. Inform consent form was signed by all patients. To calculate this adequate sample size, the following formula with 95% confidence interval (CI) level was considered: $n = \frac{Z^2 P(1-P)}{d^2}$ where n is the sample size, the statistic value related to the 95% CI, P is the prevalence, and d is the precision value. The precision of 15% of the prevalence (0.0705) was selected.[12,13] The minimum sample size to satisfy the requirements was estimated to be 192 patients without considering the design effect. Considering the design effect 1.5[14,15] in addition to 20% probable loss of participants, the adequate sample size consisted of 346 individuals. Of total population, after removing those without written consent and missing covariates ($n = 30$), 316 patients with a confirmed HIV were recruited for this study.

The Ethics Committee of Tehran University of Medical Sciences had reviewed the study and approved the study protocol (IR.TUMS.VCR.REC.1398.312).

Demographic and clinical data

A checklist was used to collect demographic characteristics and clinical information including age, sex, and educational level, history of cardiac or pulmonary disease, hypertension, diabetes, and a list of medications. Further information including cluster of differentiation 4 (CD4) level, hepatitis B and C coinfection, and tuberculosis (TB) was collected from the patients' last visit recorded documents available in the centers. To measure BMI, patient weight and height were measured and BMI was calculated as weight (kilogram) divided by height (meter) to the power of 2. By the WHO definition, BMI was categorized into three levels: normal weight (<25 kg/m^2), overweight (25–29.99 kg/m^2), and obese (≥30 kg/m^2).

Obstructive sleep apnea questionnaire

There are several clinically helpful questionnaires for detecting patients at high risk for OSA such as the Berlin questionnaire.[3] In the current study, the Persian version of the Berlin questionnaire (modified Berlin questionnaire) was used to detect high risk for OSA in PLHIV. The modified Berlin questionnaire includes ten questions broken down into three categories. Category 1 with five questions on snoring, Category 2 with three questions on daily sleep, and Category 3 with two questions on hypertension and BMI over ≥30 kg/m^2. If there are two or more positive categories, the patient is considered at high risk for breathing problems during sleep, and if there is only 1 positive or no, the risk would be low. The validity and reliability of the modified Berlin questionnaire were assessed and approved in a study by Amra *et al*.[16]

Statistical approach

Baseline characteristics were reported by the mean (standard deviation [SD]) for continuous variables and by frequency (percent) for categorical variables. For comparison of categorical variables between high- and low-risk groups, the Chi-square test and, for continuous variables, *t*-test or Wilcoxon test were used for data with normal and nonnormal distribution, respectively. Besides, the comparison between baseline measurements was done for men and women

separately. The logistic regression model was considered to find the association between BMI and OSA groups. For this purpose, two models were designed: Model 1: included BMI, age, and gender and Model 2: further adjustment for marital status, educational level, duration of HIV infection (from date of diagnosis till the time of the study), CD4 count, substance use, history of CVD, history of T2DM, history of respiratory diseases, diagnosed as having TB, hepatitis B, hepatitis C, antiretroviral medications, antihypertensive medications, diabetes medications, mental illness medications, and sleeping medications. A forward stepwise approach was considered to keep significant covariates with $P < 0.2$ for "enter" and $P > 0.05$ for "remove." BMI was analyzed both as a categorical and continuous variable. The association was reported based on the odds ratio (OR: 95% CI). All analyses were conducted using STATA version 12 SE (StataCorp, TX, USA), and a two-tailed $P < 0.05$ was considered statistically significant, and $0.05 \leq P < 0.07$ was considered as tended to be significant.

RESULTS

Baseline characteristics

The study population consisted of 215 men and 101 women at baseline with a mean (SD) age of 40.5 (9.6) and 38.9 (9.5) years, respectively. A total of 316 almost half of the patients were married and the educational level was above a high school diploma. Mean (SD) CD4 and duration of infection were 577 cell/mm^2 (301.6) and 63 months (50.2), respectively. The mean (SD) for BMI in the study population was 24.7 kg/m^2 (4.1). Based on the WHO classification, 59.2% of patients had normal BMI, 31.6% were overweight, and 9.2% were obese. We redid our analysis using the Iranian suggested cutoffs of BMI (26.2 kg/m^2 for both sexes).[17] According to the Iranian suggested cut point, 31% of the study population were overweight/obese.

Based on the modified Berlin questionnaire, the prevalence of high risk for OSA was 48.7% (52.1% in men and 41.6% in women). Compared with patients with low risk for OSA, those who were categorized as high risk had higher mean BMI levels (24.3 vs. 25.2 kg/m^2, respectively; $P = 0.04$). The cross-tabulation Table 1 shows that 12.3% of high-risk and 6.2% of low-risk groups are obese (≥30 kg/m^2). In addition, no significant association was observed between substance use, CD4 levels, and comorbidities such as TB, hepatitis B/C, CVD, hypertension, diabetes, or lung disease. We also did not find any association between using medications such as antiretroviral medications and sleeping medications. Moreover, the prevalence of mental medication was higher among those with a high risk of OSA compared with low risk (31.8% vs. 22.8%), however, it was not statistically significant.

Table 1: Demographics and clinical characteristics between the high and low risks of apnea defined by Berlin obstructive sleep apnea among positive HIV participants

	Total (*n*=316)	Low risk (*n*=162)	High risk (*n*=154)	*P*
Age (years)	40.0 (9.6)	39.1 (9.8)	40.9 (9.3)	0.09
Height (cm)	170.4 (8.6)	170.3 (8.2)	170.5 (8.9)	0.88
Weight (kg)	71.9 (12.8)	70.7 (12.6)	73.2 (12.8)	0.08
BMI (kg/m^2)	24.7 (4.1)	24.3 (3.6)	25.2 (4.5)	0.04
CD4 (cells/mm^2)	577.0 (301.6)	591.2 (312.3)	562.1 (290.1)	0.39
Duration of HIV (months)	63.0 (50.2)	63.5 (50.6)	62.6 (50.0)	0.88
Gender, male	215 (68.0)	103 (63.6)	112 (72.7)	0.08
Marital status				0.85
Single	100 (31.6)	53 (32.7)	47 (30.5)	
Married	161 (50.9)	80 (494)	81 (52.6)	
Divorced/ widow	55 (17.4)	29 (17.9)	26 (16.9)	
Education, ≥12 years	164 (51.9)	87 (53.7)	77 (50.0)	0.5
BMI category (kg/m^2)				0.13
<25	187 (59.2)	102 (63.0)	85 (55.2)	
25–30	100 (31.6)	50 (30.9)	50 (32.5)	
≥30	29 (9.2)	10 (6.2)	19 (12.3)	
Substance use, yes	157 (49.7)	76 (46.9)	81 (52.6)	0.31
CD4 <200 (cells/mm^2)	24 (7.6)	11 (6.8)	13 (8.4)	0.58
CD4 <500 (cells/mm^2)	140 (44.3)	69 (42.6)	71 (46.1)	0.53
Comorbidities, yes				
Tuberculosis	28 (8.9)	13 (8.0)	15 (9.7)	0.59
Hepatitis B	10 (3.2)	4 (2.5)	6 (3.9)	0.47
Hepatitis C	70 (22.2)	32 (19.8)	38 (24.7)	0.29
Disease history, yes				
Cardiovascular disease	79 (25.0)	39 (24.1)	40 (26.0)	0.7
Hypertension	75 (23.7)	37 (22.8)	38 (24.7)	0.7
Diabetes	73 (23.1)	34 (21.0)	39 (25.3)	0.36
Lung diseases	82 (25.9)	40 (24.7)	42 (27.3)	0.6
Treatments, yes				
Antiretroviral medications*	291 (92.1)	148 (91.4)	143 (92.9)	0.62
Sleeping medications	108 (34.2)	54 (33.3)	54 (35.1)	0.75
Mental medications	86 (27.2)	37 (22.8)	49 (31.8)	0.07

*Duration of antiretroviral medications: Median IQR (40 months [20–60]). Values are shown as mean (SD) and *n* (%) (for continuous and categorical variables, respectively). *P* value according to Chi-square or Fisher's exact test as appropriate for categorical variables and *t*-test or Mann–Whitney U-test for normal and nonnormal distributed variables, respectively. IQR=Interquartile range; SD=Standard deviation; BMI=Body mass index; CD=Cluster of differentiation

The cross-tabulation Supplementary Table 1 demonstrates the participant demographics and clinical characteristics between the high and low risks of apnea defined by the

Berlin OSA among men and women separately. According to the results, the mean BMI level was higher among women with a higher risk of OSA compared with lower risk; no significant differences were observed among men.

Distribution of modified Berlin questionnaire categories

The distribution of modified Berlin questionnaire categories is represented in Supplementary Table 2. Among 154 high-risk patients, 23 (15%) were categorized in this group based on snoring questions and 22 (14.4%) based on daily sleep questions.

Logistic regression results

The results from the logistic models for high risk of OSA among PLHIV are shown in Table 2. After adjustment for age and gender, each unit increase in BMI significantly increases odds for standing in the high-risk category for OSA by 7% (OR [95% CI]: 1.07 [1.01–1.13]). In Model 2 after including other variables, OR BMI remained significant (OR [95% CI]: 1.08 [1.05–2.86]).

Table 3 demonstrates the association of BMI categories with being high risk of diagnosing OSA. After age and gender adjustment, being obese (BMI ≥30 kg/m^2) has 2.5 times higher odds to be categorized in the high-risk group for sleep apnea (OR [95% CI]: 2.54 [1.10–5.89]). In Model 2 after including other variables, this increase remained significant (OR [95% CI]: 2.78 [1.18–6.38]).

Table 2: Logistic regression (95% confidence interval) analysis of body mass index with being high risk of diagnosing obstructive sleep apnea

	Total population	
	OR (95% CI)	*P**
Model 1		
BMI (kg/m^2)	1.07 (1.01–1.13)	0.02
Age (years)	1.02 (0.99–1.04)	0.18
Gender, male	1.70 (1.03–2.80)	0.038
Model 2 (forward stepwise model)		
BMI (kg/m^2)	1.08 (1.02–1.14)	0.012
Gender, male	1.74 (1.05–2.86)	0.03
Mental medications	1.62 (0.97–2.69)	0.06

Model 1: Included BMI, age, and gender; Model 2: Model 1+marital status, educational level, duration of HIV infection (from date of diagnosis till the time of the study), CD4 count, substance use, history of CVD, history of T2DM, history of respiratory diseases, diagnosed as having tuberculosis, hepatitis B, hepatitis C, antiretroviral medications, antihypertensive medications, diabetes medications, mental illness medications, and sleeping medications. BMI=Body mass index; CI=Confidence interval; OR=Odds ratio; CVD=Cardiovascular disease; T2DM=Type 2 diabetes; *P < 0.05 was considered statistically significant, and 0.05 ≤ P < 0.07 was considered as tended to be significant

Table 3: Logistic regression (95% confidence interval) analysis of body mass index categories with being high risk of diagnosing obstructive sleep apnea

	Total population	
	OR (95% CI)	*P**
Model 1		
BMI categories (kg/m^2)		
<25	Reference	
25–30	1.21 (0.74–2.0)	0.44
≥30	2.54 (1.10–5.89)	0.03
Age (years)	1.02 (0.99–1.04)	0.17
Gender, male	1.65 (1.0–2.70)	0.048
Model 2 (forward stepwise model)		
BMI categories (kg/m^2)		
<25	Reference	
25–30	1.21 (0.74–1.98)	0.44
≥30	2.78 (1.18–6.38)	0.02
Gender, male	1.68 (1.02–2.76)	0.04
Mental medications	1.59 (0.96–2.65)	0.07

Model 1: Included BMI, age, and gender; Model 2: Model 1+marital status, educational level, duration of HIV infection (from date of diagnosis till the time of the study), CD4 count, substance use, history of CVD, history of T2DM, history of respiratory diseases, diagnosed as having tuberculosis, hepatitis B, hepatitis C, antiretroviral medications, antihypertensive medications, diabetes medications, mental illness medications, and sleeping medications. BMI=Body mass index; CI=Confidence interval; OR=Odds ratio; CD=Cluster of differentiation; CVD=Cardiovascular disease; T2DM=Type 2 diabetes; *P < 0.05 was considered statistically significant, and 0.05 ≤ P < 0.07 was considered as tended to be significant

DISCUSSION

In the current study, we aimed to assess the association between BMI and OSA among PLHIV in Tehran. The study showed that, based on the modified Berlin questionnaire, almost half of HIV-positive patients are classified as high risk for sleep apnea. According to our findings, each unit increase in BMI can increase odds for classification in the high-risk group for sleep apnea by 6%; this odd for obese patients is more than 2.5 folds.

Based on a literature review on 37 studies, the prevalence of OSA among Iranian people was 44% (95% CI: 35–53) which varies based on underlying diseases, 61% prevalence among cardiovascular patients, and 55% among diabetics.[2] Our findings showed the prevalence of OSA among HIV-positive patients as 48.7%. In the current study a significant difference was not found between underlying diseases like diabetes, pulmonary, and cardiovascular diseases. In the study by Njoh *et al.*,[11] 43.6% of HIV-positive patients are classified in the high-risk group which is significantly higher than healthy individuals (14%). Furthermore, there are some other studies reporting a higher prevalence of sleep apnea among HIV-positive patients in comparison with healthy individuals.[18,19] One study in Taiwan[4] has reported a lower prevalence of sleep apnea among HIV-positive patients in comparison with healthy individuals (1.9 vs. 2.26 in 1000 person-years), but the difference may mostly be due to difference in the geographic area, demographic characteristic of participants, inclusion and exclusion criteria, and data collection tools. It seems that OSA is a major challenge for a considerable portion of HIV patients which may affect their quality of life.

In this study, a significant positive relation was between BMI and risk for sleep apnea which is in the same line as

other studies.[6,20] Brown *et al*.[20] assessed the power of the BMI, waist circumference, and neck circumference in the prediction of sleep disordered breathing only among men. They showed that these variables may have better predictive values for sleep disordered breathing in HIV-uninfected men compared to HIV-infected men. In a 2006 study in the United States, overweight and obesity increased the risk of sleep apnea in HIV-positive patients.[18] Another study had findings against ours and detected no relation between BMI and risk for sleep apnea in HIV-positive patients.[11] Furthermore, our study did not detect any relationship between CD4 count and age, educational level, and duration of disease which is not consistent with some other published studies.[7,13,18,21] Despite our finding, Njoh AA *et al*.[11] showed that there was no significant difference between BMI levels between those with and without risk of OSA. They did not also found any significant effect of gender on OSA, which we showed that men were at higher odds of OSA.

Other risk factors such as age, snoring, heart rate, and excessive daytime sleepiness are affected sleep quality,[22,23] but it seems that such risk factors are not important among PLHIV. Abdeen *et al*.[24] reported that BMI shows a significant positive association with the apnea-hypopnea after adjustment for age, sex, race, and neck circumference among HIV patients.

This study had several strengths. First, to the best of our knowledge, this is the first study evaluating the relation between BMI and OSA among PLHIV in Iran, and second, this association was evaluated in a multivariable model considering BMI as both continuous and categorical covariates.

This study has limitations that may need to be addressed in future studies. First, the participants were selected from HIV voluntary counseling and testing centers and HIV-positive individuals who are not registered or linked to services were not included, so the sample may not be representative of PLHIV. Second, in the current study, the modified Berlin questionnaire was used instead of standard polysomnography or other sleeping monitoring methods. Although this questionnaire has been standardized in Iran, it was evaluated to be used in the general population and no specific questionnaire for OSA in this population has been assessed yet. Third, our results underscore the potential limitations of self-reports, particularly for underlying diseases such as TB or respiratory disease in addition to the detailed information on the medication such as antiretroviral therapy. Forth, there was no inadequate sample size for analyzing men and women separately, however, with adjusting the gender, male shows a significant association with a higher risk of OSA.

To determine the effect of anthropometric variables and causal relations, for future research, further studies using BMI, waist, and neck circumference among patients and healthy individuals are suggested.

CONCLUSION

Almost half of PLHIV are classified as high risk for sleep apnea. Moreover, this study has detected a significant association between BMI and sex with a higher risk for sleep apnea but no relation with age, educational level, marriage status, duration of disease, and CD4 count. Hence, because sleep disorders may decrease income and quality of life and increase the risk for diabetes, cardiovascular disease, and stroke among people living with HIV, it is useful to include BMI screening for sleep apnea in the routine clinical evaluation.

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Conflicts of interest

There are no conflicts of interest.

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Supplementary Table 1: Participant demographics and clinical characteristics between the high and low risks of apnea defined by Berlin obstructive sleep apnea among men and women separately

	Women			Men		
	High risk (*n*=42)	Low risk (*n*=59)	*P*	High risk (*n*=112)	Low risk (*n*=103)	*P*
Age (years)	40.5 (9.5)	37.8 (9.3)	0.16	41.1 (9.2)	39.8 (10.1)	0.34
Marital status			0.9			0.56
Single	5 (11.9)	8 (13.6)		42 (37.5)	45 (43.7)	
Married	24 (57.1)	35 (59.3)		57 (50.9)	45 (43.7)	
Divorced/widow	13 (31.0)	16 (27.1)		13 (11.6)	13 (12.6)	
Education, ≥12 years	23 (54.8)	32 (54.2)	0.96	54 (51.8)	55 (53.4)	0.45
Height (cm)	162.1 (5.9)	163.8 (7.5)	0.24	173.6 (7.8)	174.1 (5.9)	0.61
Weight (kg)	73.8 (14.6)	65.9 (12.1)	0.004	72.9 (12.2)	73.4 (12.2)	0.79
BMI (kg/m^2)	28.1 (5.6)	24.5 (3.4)	<0.0001	24.2 (3.5)	24.2 (3.8)	0.93
BMI category (kg/m^2)			<0.001			0.89
<25	14 (33.3)	39 (66.1)		71 (63.4)	63 (61.2)	
25–30	15 (35.7)	17 (28.8)		35 (31.2)	33 (32.0)	
≥30	13 (31.0)	3 (5.1)		6 (5.4)	7 (6.8)	
Substance use, yes	14 (23.7)	9 (21.4)	0.81	62 (60.2)	72 (64.3)	0.57
Duration of HIV (months)	62.2 (54.6)	63.9 (40.9)	0.85	62.7 (48.4)	63.2 (55.6)	0.95
CD4 (cells/mm^2)	613.8 (282.5)	661.8 (310.6)	0.43	542.7 (291.8)	550.7 (307.5)	0.85
CD4<200 (cells/mm^2)	1 (2.4)	3 (5.1)	0.64	12 (10.7)	8 (7.8)	0.46
CD4<500 (cells/mm^2)	16 (38.1)	17 (28.8)	0.39	55 (49.1)	52 (50.5)	0.84
Comorbidities, yes						
Tuberculosis	3 (7.1)	5 (6.8)	0.9	12 (10.7)	9 (8.7)	0.63
Hepatitis B	2 (4.8)	1 (1.7)	0.57	4 (3.6)	3 (2.9)	0.9
Hepatitis C	1 (2.4)	3 (5.1)	0.65	37 (33.0)	29 (28.2)	0.44
Disease history, yes						
Cardiovascular disease	4 (9.5)	12 (20.3)	0.14	34 (30.4)	25 (24.3)	0.32
Hypertension	10 (23.8)	14 (23.7)	0.9	30 (26.8)	25 (24.3)	0.67
Diabetes	10 (23.8)	12 (20.3)	0.68	29 (25.9)	22 (21.4)	0.43
Lung diseases	5 (11.9)	13 (22.0)	0.19	37 (33.0)	27 (26.2)	0.27
Treatments, yes						
Antiretroviral medications	37 (88.1)	55 (93.2)	0.37	106 (94.6)	93 (90.3)	0.22
Sleeping medications	11 (26.2)	18 (30.5)	0.63	43 (38.4)	36 (35.0)	0.6
Mental medications	16 (27.1)	9 (21.4)	0.64	21 (20.4)	40 (35.7)	0.015
Berlin score*	4.0 (2.8–5.0)	0.0 (0.0–1.0)	<0.001	3.0 (2.0–4.0)	0.0 (0.0–1.0)	<0.001

*Data are shown as median (IQR). Values are shown as mean (SD) and *n* (%) (for continuous and categorical variables, respectively). *P* value according to Chi-square or Fisher's exact test as appropriate for categorical variables and *t*-test or Mann–Whitney U-test for normal and nonnormal distributed variables, respectively. Duration of antiretroviral medications: Median IQR: Men (37 months [19–60]); Women (47 months [22–76]). IQR=Interquartile range; SD=Standard deviation; BMI=Body mass index; CD=Cluster of differentiation

Supplementary Table 2: Distribution of diagnosing obstructive sleep apnea among positive HIV participants

	Total (*n*=316)	Low risk (*n*=162)	High risk (*n*=154)
Category 1: Snoring			
Cat 1	71 (22.5)	35 (21.5)	36 (23.5)
Cat 2	40 (12.7)	0	40 (26.1)
Cat 3	28 (8.9)	0	28 (18.3)
Cat 4	19 (6.0)	0	19 (12.4)
Cat 5	2 (0.6)	0	2 (1.3)
None of above	156 (49.4)	128 (78.5)	28 (18.3)
Category 2: Daytime somnolence			
Cat 1	83 (26.3)	33 (20.2)	50 (32.7)
Cat 2	58 (18.4)	0	58 (37.9)
Cat 3	10 (3.2)	0	10 (6.5)
None of above	165 (52.2)	130 (79.8)	35 (22.9)
Category 3			
Hypertension or BMI >30 kg/m^2	54 (17.1)	11 (6.7)	43 (28.1)
None of above	262 (82.9)	152 (93.3)	110 (71.9)

BMI=Body mass index