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Association of Self-reported Physical Activity with Obstructive sleep apnea: Results from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL)

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CONFLICT OF INTEREST

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Abstract

We examined associations of mild and moderate to severe obstructive sleep apnea (OSA; apnea-hypopnea index ≥5 and ≥15, respectively) with recommended amounts of moderate-vigorous physical activity (MVPA) or vigorous physical activity (VPA) and by type of activity (i.e., recreational, transportation, and work activity). The Hispanic Community Health Study/Study of Latinos (HCHS/SOL), a multicenter population-based study, enrolled individuals from 2008 to 2011 from four U.S. metropolitan areas (Bronx, New York; Chicago, Illinois; Miami, Florida; San Diego, California). Participants in this study included 14,206 self-identified Hispanic/Latino ages 18 to 74 years from theHCHS/SOL. Survey logistic regression analysis was used to compute odds ratios [OR] and 95% confidence intervals [CI], adjusting for sociodemographics, smoking status, and body mass index (BMI). Relative to being inactive, performing some MVPA (>0 to <150 minutes/week) or meeting the recommended MVPA (≥150 minutes/week) were associated with lower odds of mild OSA (ORs and 95% CIs 0.70 [0.61-0.82] and 0.76 [0.63-0.91], respectively), as well as moderate to severe OSA (ORs and 95% CIs 0.76 [0.62-0.93] and 0.76 [0.59-0.98], respectively). Associations of VPA with OSA were not significant. Engaging in medium or high levels of transportation activity was associated with lower odds of mild OSA (OR: 0.84, 95% CI: 0.74-0.96; OR: 0.64, 95% CI: 0.43-0.95, respectively). Performing some recreational MVPA was associated with lower likelihood of mild and moderate to severe OSA (OR: 0.82, 95% CI: 0.71-0.93; OR: 0.79, 95% CI: 0.64-0.97, respectively). Health promotion and OSA prevention efforts should encourage individuals to engage in at least some MVPA.

Keywords

motor activity; sleep apnea syndromes; Hispanic Americans

INTRODUCTION

Obstructive sleep apnea has been associated with a higher risk of cardiovascular disease morbidity and mortality [1-3]. Sleep-disordered breathing (SDB), which includes obstructive sleep apnea, is associated with diabetes and hypertension, which are highly prevalent in the Hispanic/Latino population and are risk factors for cardiovascular disease[4,5]. Previous studies have suggested that obstructive sleep apnea may be more prevalent in Hispanic/Latino persons compared to non-Hispanic whites, but these studies included only Mexican-Americans [6-9]. A recent study by Redline et al. (2014) observed a high prevalence of sleep-disordered breathing (prevalence of minimal SDB, moderate SDB, and severe SDB were 25.8%, 9.8%, and 3.9%, respectively) among diverse Hispanic/Latino adults although prevalence of obstructive sleep apnea varied by Hispanic/Latino background [5]. Specifically, the prevalence of SDB was highest among women of Puerto Rican background and Cuban men [5].

Research has suggested that exercise may reduce the risk of obstructive sleep apnea, through a reduction in the apnea-hypopnea index,[10-12] and that possible mechanisms between

activity and obstructive sleep apnea may include decreased nasal resistance,[13] and redistribution of adipose tissue.[14,15] Previous studies have shown an inverse association between duration and intensity of physical activity and sleep-disordered breathing, including obstructive sleep apnea [14,16]. For example, engaging in ≥3 hours of vigorous physical activity (VPA) per week was associated with lower odds of sleep-disordered breathing, primarily in men and obese individuals. Although weaker, an association between engaging in ≥3 hours of moderate-vigorous physical activity (MVPA) per week and lower odds of SDB has also been observed.[14] However, previous studies were based on predominantly non-Hispanic/Latino samples and primarily accounted for leisure-time and household activity [14,16,17]. Examining the association between different type of activity in relation to obstructive sleep apnea would be important because overall activity patterns among Hispanic/Latino individuals can differ (i.e., may engage in more work-related and less leisure-time physical activity [18-20], more time spent standing at work). Further, given the lower prevalence of meeting activity recommendations,[21] but higher prevalence of obstructive sleep apnea in Hispanics/Latinos,[6-8] compared with non-Hispanic whites, further research into the relationship of physical activity-obstructive sleep apnea in the Hispanic/Latino population is warranted to inform tailored interventions aimed at reducing the risk of obstructive sleep apnea through increased physical activity.

Our study examined the association between participation in recommended amounts of MVPA or VPA physical activity (including recreational, transportation, and work activity), per the *2008 Physical Activity Guidelines for Americans* [22], and obstructive sleep apnea, and determined whether associations if any, differed by presence of obesity, using data from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). We hypothesized that physical activity is inversely associated with the presence of obstructive sleep apnea, and meeting guidelines for aerobic activity based on the *2008 Physical Activity Guidelines for Americans* [22], specifically related to MVPA and VPA, would be associated with a lower prevalence of obstructive sleep apnea compared with being inactive.

METHODS

Sample

The HCHS/SOL is a multicenter community-based cohort study of chronic disease risk factors. HCHS/SOL examined 16,415 self-identified Hispanic/Latino persons ages 18 to 74 years at baseline (2008-2011), recruited in 4 cities (Bronx, New York; Chicago, Illinois; Miami, Florida; San Diego, California) from randomly selected households. A stratified 2-stage area probability sample design was used to select households. Participants were recruited from defined geographical areas selected to obtain a representative sample of the target population and diversity of the participants with regard to socioeconomic status and national origin or background. The study was approved by institutional review boards at each participating institution, and all participants provided written informed consent. The baseline examination included interviewer administered questionnaires, anthropometry, blood draw, and other measures; details of the cohort selection procedures, sampling design and baseline examination measures have been previously published [23,24].

Measures

Obstructive sleep apnea—Participants were provided instruction on using a sleep apnea monitor to obtain overnight recording (ARES Unicorder 5.2; B-Alert, Carlsbad, CA) [25]. This self-applied sleep apnea monitor uses a head position and movement (actigraphy), pulse rate and hemoglobin oxygen saturation (reflectance oximetry), a microphone to obtain snoring level recordings, and a nasal pressure cannula and transducer, to measure airflow. Sleep records were read and scored at the central sleep reading center. Manual edits of artifacts, identification of sleep periods, and annotation of respiratory events and associated oxyhemoglobin desaturation, were conducted by certified polysomnologists. A reduction of 50% or higher in airflow lasting a period of ≥10 seconds, was identified as a respiratory event. The Apnea/Hypopnea Index (AHI) was defined as the number of respiratory events with a desaturation of ≥3% (AHI3) per sleep hour. The sleep studies have been found to have good reliability in the HCHS/SOL sample. Additional details on the sleep studies have been previously published [5]. In our study, mild and moderate to severe obstructive sleep apnea was defined as having an AHI (AHI 3%) threshold of ≥5 and ≥15, respectively.

Physical Activity—Self-reported intensity and duration of total physical activity was ascertained using participants' responses to questions about vigorous and moderate activities on the Global Physical Activity Questionnaire. The Global Physical Activity Questionnaire assesses the time spent in a typical week performing moderate and vigorous physical activity during work and leisure-time, walking or biking for transportation, and sedentary time.[26,27] Information on moderate (i.e., cause small increases in breathing or heart rate) and vigorous (i.e., cause large increases in breathing or heart rate) physical activities performed for at least 10 minutes continuously, was obtained separately. For our analyses, we included work-related, transportation-related, and leisure-time physical activity (LTPA) in our moderate physical activity variable. In our vigorous physical activity variable, we only included work-related and LTPA. A moderate-vigorous physical activity (MVPA) variable was created based on the *2008 Physical Activity Guidelines for Americans* [22]. As suggested by the *2008 Physical Activity Guidelines for Americans* [22], reported minutes of vigorous-intensity activity were assigned twice the credit of reported moderate-intensity activity minutes to calculate an equivalent combination when moderate and vigorous-intensity activity were combined. To categorize activity, we used the *2008 Physical Activity Guidelines for Americans* for meeting the guidelines for MVPA and VPA. MVPA was categorized into three categories based on the criteria from the *2008 Physical Activity Guidelines for Americans* [22]: 1) met guidelines (≥150 minutes/week); 2) insufficiently active (>0 to <150 minutes/week); 3) inactive (0 minutes/week). Similarly, vigorous physical activity (VPA) was categorized as follows: 1) met guidelines (≥75 minutes/week); 2) insufficiently active (>0 to <75 minutes/week); 3) inactive (0 minutes/week).

Covariates—Age was measured continuously, and educational level was dichotomized as less than a high school diploma versus having a high school diploma or more. Acculturation was measured categorically based on nativity and years of residence, as foreign-born with <10 years of residence in the US, foreign-born with ≥10 years in the US, and US-born. Hispanic/Latino background was categorized based on self-reported country of origin. Study site was categorized based on what city participants participated in the HCHS/SOL (i.e.,

Bronx, Chicago, Miami, or San Diego). Smoking status was measured categorically as never, former and current smoker. BMI (kg/m^2) was calculated from measured height (in meters) and weight (in kilograms), and BMI ≥30 kg/m^2 was classified as obese.

Of the 16,415 participants ages 18 to 74 years, only those with complete data on the variables of interest (n=14,206) were included into the analyses sample. Further, we excluded those who reported receiving treatment for sleep apnea (n=119). Compared with the excluded sample, adults included in the analytical sample were less likely to be U.S. born, have less than a high school education, and to be obese. Our final analytic sample was based on data from 14,087 participants.

Statistical analysis

The distribution of demographic characteristics, health behaviors, and prevalence of mild and moderate to severe obstructive sleep apnea among all participants and by level of physical activity were examined by calculating weighted means or proportions and 95% confidence intervals. Survey-specific procedures were used to compute 95% confidence intervals to account for the 2-stage sampling design, stratification, and clustering. Chi-squared tests or F-tests were used to detect statistically significant differences by physical activity categories. Survey logistic regression analysis was used to compute odds ratios and 95% confidence intervals for the association between physical activity and the presence of obstructive sleep apnea. Binary logistic models were used to estimate the association of mild obstructive sleep apnea and moderate to severe obstructive sleep apnea (vs. no obstructive sleep apnea), with meeting physical activity recommendations and engaging in some but not sufficient amounts of physical activity compared to engaging in no activity. Models were adjusted for age, sex and education (model 1); model 1 covariates plus Hispanic/Latino background group, study site, smoking status, and acculturation (model 2); and all covariates in model 2 plus BMI (model 3). Similarly, survey logistic regression analysis was used to compute odds ratios and 95% confidence intervals for the association between physical activity and the presence of obstructive sleep apnea by type of activity, in stratified models. Models were controlled for age, sex and education (model 1); and model 1 variables plus Hispanic/Latino background group, study site, smoking status, and acculturation (model 2). Also, effect modification by obesity was tested by including a multiplicative interaction terms of MVPA*BMI and VPA*BMI into fully adjusted models.

Analyses were adjusted for sampling probability and nonresponse to account for the complex survey sampling design and sampling weights [23,24]. All analyses were performed using SAS 9.4 software (SAS Institute, Cary NC).

RESULTS

Descriptive characteristics

Table 1 presents the distribution of descriptive characteristics and obstructive sleep apnea, overall and by categories of physical activity. The mean age of participants was 41.0 years, and those who reported meeting the recommendations for MVPA and VPA were younger than those who reported being inactive. Among women, 52.0% reported engaging in

insufficient MVPA and 78.3% reported being inactive for VPA. Cubans had the highest proportion of individuals who reported being inactive. Among those who were foreign-born, almost %50 reported engaging in insufficient MVPA, while almost 70% reported engaging in inactive levels of VPA. Among the HCHS/SOL sites, Chicago had the highest proportion of individuals who reported meeting MVPA recommendations (36.6%), while San Diego had the highest proportion of individuals meeting VPA recommendations (20.3%). Almost half of obese individuals engaged in insufficient MVPA activity and 69.2% reported being inactive for VPA. The percent of individuals who met MVPA recommendations were similar for those with AHI ≥5 and AHI ≥15 (29.8% and 28.3%, respectively). Similarly, the proportion of those who met VPA recommendations was similar for those with AHI ≥5 and AHI ≥15 (15.7% and 15.7%, respectively).

Association between physical activity and obstructive sleep apnea

Table 2 displays the results from the multivariable adjusted analyses on associations of MVPA and VPA with obstructive sleep apnea. Individuals who engaged in insufficient MVPA and those who met recommended guidelines for MVPA had very similar levels of both mild and moderate to severe obstructive sleep apnea. Both groups had close to an estimated 40% lower likelihood of obstructive sleep apnea than participants with no activity before adjustment for confounders and about 24-30% lower likelihood of obstructive sleep apnea after adjustment for sociodemographic factors, smoking, and BMI. With regard to only VPA, those who performed insufficient VPA had the lowest odds of mild and moderate to severe obstructive sleep apnea in unadjusted models and after adjustment for sociodemographic factors and smoking. However, after adjusting for sociodemographic factors, smoking, and BMI, the associations were attenuated and no longer significant. There was no evidence of a significant statistical interaction in the association between physical activity and obstructive sleep apnea by obesity when the interaction terms MVPA*BMI and VPA*BMI were entered into fully adjusted models ($p>0.05$).

Table 3 presents the results from the multivariable adjusted analyses on associations of MVPA and VPA with obstructive sleep apnea by type of activity. Compared with those were inactive, individuals who engaged in insufficient levels of recreational MVPA had an 18-21% lower likelihood of mild obstructive sleep apnea and moderate to severe obstructive sleep apnea after adjustment for sociodemographic factors, smoking, and BMI. Those who engaged in medium levels of transportation activity had a 16% lower likelihood of mild obstructive sleep apnea. Individuals who engaged in high levels of transportation activity had a 36% lower likelihood mild obstructive sleep apnea. Similarly, medium and high levels of transportation activity were associated with lower likelihood of moderate to severe sleep apnea after adjustment for demographics and smoking. However, after adjustment for BMI, associations were attenuated and not significant.

DISCUSSION

The HCHS/SOL provides insight into the association of physical activity with obstructive sleep apnea among Hispanic/Latino adults living in the U.S. Our findings indicate that engaging in any MVPA and meeting the guidelines for MVPA, relative to being inactive, are

associated with a lower likelihood of experiencing mild and moderate to severe obstructive sleep apnea, regardless of obesity status. Our findings also suggest that recreational MVPA and transportation activity may be important to consider in the activity-obstructive sleep apnea association given that engaging at least some recreational MVPA was associated with a lower likelihood of mild and moderate to severe obstructive sleep apnea, while engaging in at least some transportation activity was associated with a lower likelihood of mild obstructive sleep apnea. To our knowledge, this is one of the first studies to examine the association of activity with obstructive sleep apnea in a diverse Hispanic/Latino population and to assess activity beyond LTPA by including transportation and work activity in the examination of the activity-obstructive sleep apnea association. Given that Hispanics/Latinos activity levels differ from non-Hispanic/Latino populations (i.e., Hispanics/Latinos engage in lower levels of LTPA), our findings may provide insight into how performance of activity potentially contributes to disparities observed in obstructive sleep apnea.

Our findings are generally consistent with previous findings, which show an inverse association between physical activity and obstructive sleep apnea. Similarly, previous research has also found that engaging in higher amounts of physical activity is associated with lower severity of sleep disordered breathing, including obstructive sleep apnea, even after controlling for potential confounders such as obesity [14,28]. Given that obesity is a risk factor for obstructive sleep apnea [29], we adjusted for BMI in our models. The results suggested that engaging in at least some MVPA may reduce the risk of obstructive sleep apnea, independent of BMI. This is also supported by clinical trials that indicate that engaging in an exercise program may be related to modest improvements in sleep disordered breathing [10,11]. While the association between physical activity and obstructive sleep apnea was partly explained by BMI, part of the effect remained after controlling for BMI indicating that being physically active may be protective against obstructive sleep apnea via other mechanisms beyond BMI. Further, it is possible that obesity status, being obese versus not obese, is not an informative enough classification or measure. However, due to the cross-sectional nature of our study, a causal relationship between physical activity and obstructive sleep apnea, as well as the role BMI plays in this association cannot be established.

In contrast to previous research that indicated a significant association between VPA and obstructive sleep apnea [14], we observed no association between VPA and obstructive sleep apnea. This could be related to inclusion of only LTPA and household activity in the examination of VPA in previous research, versus the inclusion of work-related and LTPA in the measure of VPA in our study. This finding may also be explained by individuals with a higher BMI engaging in lower levels of VPA [30]. However, significant inverse associations were observed between VPA and obstructive sleep apnea but became non-significant after the addition of BMI into the models. Further, findings from a study by Kline et al. (2011) indicated that exercise provides benefits for obstructive sleep apnea by reducing AHI, beyond weight loss[31].

A major strength of our study was the examination of the inclusion of various types of activity in our examination of the association between physical activity and obstructive sleep apnea. Although previous research had examined the association between activity and obstructive sleep apnea, activity measured was based primarily on leisure-time and

household activity. Our findings add to our current understanding of this relationship by accounting for activity performed during work, transportation, and leisure-time. Given the variation in the prevalence of activity across types of activity in Hispanics/Latinos (i.e., more work-related and less leisure-time physical activity [18-20,32]), it is important to take into consideration the various types of activities performed outside of leisure-time. By examining multiple types of activity in the activity-obstructive sleep apnea association, it provides further insight into how activity performed throughout the day is related to the likelihood of experiencing obstructive sleep apnea. In our study we examined the activity-obstructive sleep apnea association by type of activity and our findings showed that those who engaged in at least some recreational MVPA had a lower likelihood of experiencing mild and moderate to severe obstructive sleep apnea. One potential explanation is that those who engage in at least some recreational MVPA live in walkable neighborhoods, which have been shown to be related to sleep apnea. For example, research has shown that living in a neighborhood with an unfavorable walking score (i.e., low walking environment score) is related to a greater severity of sleep apnea.[33] Additionally, we found that individuals who engaged in at least some transportation activity were less likely to experience mild obstructive sleep apnea. This finding suggests that it is important to consider overall physical activity, beyond LTPA when examining the role of physical activity in obstructive sleep apnea. Further research is warranted examining factors related to various types of activity that may explain differences in activity-obstructive sleep apnea association by type of activity.

After adjusting for age, sex, and education in our models, several of the associations of MVPA and VPA with obstructive sleep apnea were attenuated and no longer significant, highlighting the importance of considering sociodemographic factors in the physical activity-obstructive sleep apnea association. It is also important to consider that the association between activity and obstructive sleep apnea may be bidirectional and include mediating factors driving the association between physical activity and obstructive sleep apnea not measured in our study. For example, individuals who have obstructive sleep apnea may be too fatigued to engage in physical activity due to the daytime sleepiness that is often experienced by those suffering from obstructive sleep apnea. Future research should consider examining whether daytime sleepiness plays a mediating role in the association between physical activity and obstructive sleep apnea.

Study limitations and strengths

Strengths of our study include a large sample of individuals from diverse Hispanic/Latino groups, strict procedures for quality control and standardized measurements, including the objective measures of obstructive sleep apnea [5]. For example, data was scored at a designated central reading center with high scorer reliability and scorers were blinded to participant clinical status. Physical activity measures used in our study included measures of leisure-time physical activity, transportation-related physical activity, and occupational-related physical activity. Including measures of activity beyond simply leisure-time physical activity provides a better assessment of activity performed regularly. Limitations include the cross-sectional nature of analyses, limiting causal inferences. The findings are limited to self-reported physical activity, which can introduce measurement error from self-report

compared with objectively measuring physical activity. However, the recommended amount of physical activity in the *2008 Physical Activity Guidelines for Americans* is based on self-reported physical activity [22]. Also, utilizing a different measure of obesity instead of BMI, such as the pattern of obesity or fat deposition (i.e., central fat), may predict more of the risk of obstructive sleep apnea in the physical activity-obstructive sleep apnea association and may partly explain some of the unexplained variance in this association. Lastly, HCHS/SOL did not include individuals from other US racial/ethnic groups to allow comparisons.

Our study supports findings from previous studies that physical activity is associated with obstructive sleep apnea, and contributes new information based on the *2008 Physical Activity Guidelines for Americans* by examining various types of activity and examining the activity-obstructive sleep apnea association in a large diverse group of Hispanic/Latino individuals. Our findings support the importance of engaging in at least some moderate-to-vigorous physical activity versus being inactive to potentially reduce the risk of obstructive sleep apnea, and other conditions that are comorbid with obstructive sleep apnea. Health promotion and obstructive sleep apnea prevention efforts should encourage individuals to engage in at least some moderate-to-vigorous physical activity.

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HIGHLIGHTS

1) We studied associations between physical activity and OSA in Hispanics/Latinos

2) Engaging in MVPA was associated with lower odds of mild and moderate to severe OSA

3) Findings showed variation in physical activity-OSA association by type of activity

Table 1

Distribution of Demographics, Health Behaviors, and Obstructive Sleep Apnea by Physical Activity: The Hispanic Community Health Study/Study of Latinos (HCHS/SOL), 2008-2011.

Characteristic	Total	Moderate-Vigorous Physical Activity				Vigorous Physical Activity			
		Inactive[a]	Insufficient Activity[b]	Met Recommendations[c]	*P*-value	Inactive[d]	Insufficient Activity[e]	Met Recommendations[f]	*P*-value
n	14087	3137	6699	4251		9974	2231	1882	
Age (Years)	41.0(40.5-41.5)	45.2(44.4-46.0)	41.8(41.1-42.4)	37.4(36.7-38.0)	<0.001	44.3(43.8-44.8)	34.9(34.1-35.6)	35.2(34.4-36.1)	<0.001
Women (%)	52.4(51.3-53.6)	25.3(23.8-26.7)	52.0(50.1-53.9)	22.7(21.2-24.2)	<0.001	78.3(76.7,80.0)	14.6(13.2,15.9)	7.1(6.0,8.1)	<0.001
Hispanic/Latino background group (%)					<0.001				<0.001
Mexican	40.3(37.0-43.7)	17.6(15.9-19.3)	45.9(43.6-48.2)	36.5(34.3-38.7)		57.0(55.0,59.0)	24.4(22.7,26.0)	18.7(16.9,20.4)	
Cuban	18.7(15.4-21.9)	32.0(29.3-34.6)	43.5(40.8-46.2)	24.6(22.3-26.8)		78.6(76.1,81.0)	11.1(9.0,13.1)	10.4(8.8,11.9)	
Puerto Rican	15.2(13.7-16.7)	17.8(15.6-20.1)	48.4(45.4-51.4)	33.8(30.7-36.9)		65.9(62.8,69.0)	17.5(15.1,19.8)	16.7(14.1,19.3)	
Dominican	9.8(8.4-11.3)	17.9(15.3-20.6)	50.9(46.8-55.0)	31.2(27.0-35.4)		68.6(64.5,72.7)	14.5(12.0,17.0)	16.9(13.1,20.6)	
Central American	7.2(6.2-8.3)	16.8(14.6-19.0)	43.7(40.6-46.8)	39.5(36.0-43.0)		67.5(63.8,71.2)	13.1(10.8,15.4)	19.4(16.2,22.6)	
South American	5.0(4.3-5.6)	18.4(15.4-21.4)	49.9(45.7-54.0)	31.7(27.5-35.9)		62.9(58.5,67.3)	23.4(19.7,27.1)	13.7(10.3,17.1)	
Other	3.8(3.3-4.3)	14.8(10.7-18.9)	47.6(40.1-55.0)	37.6(30.4-44.9)		53.3(45.9,60.6)	25.0(18.7,31.3)	21.7(15.6,27.9)	
Acculturation (%)					<0.001				<0.001
Foreign born, <10 years in US	28.2(26.2-30.1)	21.5(19.6-23.5)	45.2(42.8-47.6)	33.3(30.9-35.6)		66.3(63.7-69.0)	17.5(15.2-19.8)	16.2(14.4-17.9)	
Foreign born, ≥10 years in US	49.7(48.1-51.4)	22.3(20.8-23.8)	47.0(45.1-48.9)	30.7(29.1-32.3)		69.8(68.0-71.5)	16.2(14.9-17.6)	14.0(12.8-15.2)	
U.S. born	22.1(20.6-23.6)	13.9(12.0-15.7)	46.6(43.5-49.7)	39.5(36.6-42.5)		49.9(47.2-52.7)	27.3(24.7-29.9)	22.8(20.0-25.5)	
Site					<0.001				<0.001
Bronx	27.7(24.8-30.5)	16.1(14.4-17.7)	49.8(46.9-52.7)	34.1(31.5-36.8)		65.8(63.1,68.4)	17.0(15.1,18.8)	17.3(15.4,19.2)	
Chicago	16.8(14.7-18.9)	17.1(15.6-18.5)	46.3(44.3-48.3)	36.6(34.8-38.4)		59.9(57.4,62.3)	23.4(21.4,25.5)	16.7(14.8,18.6)	
Miami	27.5(23.3-31.6)	28.1(25.8-30.5)	43.8(41.6-46.1)	28.0(25.9-30.2)		76.0(73.8,78.3)	12.1(10.2,13.9)	11.9(10.6,13.2)	
San Diego	28.1(24.4-31.7)	18.5(16.4-20.6)	45.7(42.5-48.9)	35.8(32.8-38.9)		54.4(52.1,56.7)	25.3(23.1,27.4)	20.3(18.0,22.7)	
Less than High School (%)	32.0(30.5-33.5)	22.8(20.9-24.7)	46.7(44.6-48.9)	30.5(28.4-32.5)	0.001	71.2(69.1,73.2)	14.4(12.7,16.0)	14.5(13.0,16.0)	<0.001
BMI ≥30 kg/m^2 (%)	39.0(37.6-40.3)	22.7(21.0-24.4)	44.9(42.7-47.1)	32.4(30.2-34.6)	0.001	69.2(67.3,71.0)	15.2(13.8,16.7)	15.6(14.2,17.0)	<0.001
Smoking status (%)					<0.001				<0.001

Characteristic	Total	Moderate-Vigorous Physical Activity				Vigorous Physical Activity			
		Inactive[a]	Insufficient Activity[b]	Met Recommendations[c]	*P*-value	Inactive[d]	Insufficient Activity[e]	Met Recommendations[f]	*P*-value
Never	62.6(61.3-63.8)	20.0(18.6-21.3)	48.6(46.8-50.4)	31.4(29.8-33.1)		64.7(63.1,66.4)	20.3(18.8,21.8)	15.0(13.7,16.3)	
Former	17.4(16.5-18.3)	22.3(20.2-24.5)	43.8(41.0-46.6)	33.9(31.1-36.8)		67.4(64.4,70.4)	15.8(13.4,18.3)	16.8(14.5,19.1)	
Current	20.0(18.9-21.1)	19.1(16.8-21.5)	42.0(39.1-44.8)	38.9(35.8-42.0)		60.8(57.5,64.2)	17.9(15.4,20.3)	21.3(18.4,24.1)	
AHI									
AHI≥ 5, (%)	25.4(24.2-26.5)	26.6(24.5-28.6)	43.6(41.4-45.8)	29.8(27.7-32.0)	<0.001	71.1(68.8,73.3)	13.2(11.7,14.8)	15.7(14.0,17.4)	<0.001
AHI≥15, (%)	9.5(8.7-10.3)	28.4(25.1-31.8)	43.4(39.8-47.0)	28.2(24.7-31.7)	0.001	72.5(69.2,75.8)	11.8(9.4,14.2)	15.7(13.0,18.4)	<0.001

Note. AHI=apnea-hypopnea index; BMI=body mass index

[g] AHI≥ 5=mild obstructive sleep apnea

[h] AHI≥15=moderate to severe obstructive sleep apnea

[a] Inactive=0 minutes of combined moderate-and vigorous-intensity activity per week.

[b] Insufficient activity= >0 to <150 minutes of combined moderate-and vigorous-intensity activity per week.

[c] Met Recommendations= ≥150 minutes of combined moderate-and vigorous-intensity activity per week.

[d] Inactive=0 minutes of vigorous-intensity activity per week.

[e] Insufficient activity= >0 to <75 minutes of vigorous-intensity activity per week.

[f] Met Recommendations= ≥75 minutes of vigorous-intensity activity per week.

Table 2

Associations of Physical Activity and Obstructive Sleep Apnea: The Hispanic Community Health Study/Study of Latinos (HCHS/SOL), 2008-2011.

	AHI >=5 vs. AHI <5				AHI >=15 vs. AHI <5			
	Unadjusted	Model 1[a]	Model 2[b]	Model 3[c]	Unadjusted	Model 1[a]	Model 2[b]	Model 3[c]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
MVPA								
Inactive[d]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Insufficient Activity[e]	0.63(0.55-0.71)	0.65(0.57-0.75)	0.65(0.56-0.75)	0.70(0.61-0.82)	0.63(0.53-0.76)	0.66(0.54-0.80)	0.66(0.54-0.80)	0.76(0.62-0.93)
Met Recommendations[f]	0.59(0.51-0.68)	0.71(0.60-0.84)	0.71(0.60-0.84)	0.76(0.63-0.91)	0.57(0.46-0.71)	0.67(0.52-0.87)	0.68(0.53-0.87)	0.76(0.59-0.98)
VPA								
Inactive[g]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Insufficient Activity[h]	0.55(0.48-0.64)	0.81(0.69-0.95)	0.80(0.67-0.94)	0.90(0.75-1.08)	0.52(0.41-0.67)	0.73(0.57-0.94)	0.72(0.56-0.94)	0.84(0.64-1.11)
Met Recommendations[i]	0.82(0.70-0.96)	1.10(0.92-1.31)	1.10(0.92-1.32)	1.18(0.98-1.43)	0.83(0.66-1.04)	1.06(0.83-1.36)	1.07(0.83-1.38)	1.17(0.90-1.53)

Note. AHI= apnea-hypopnea index; MVPA=moderate-vigorous physical activity; OR=odds ratio; VPA=vigorous physical activity

[a]Adjusted for age, sex, education

[b]Adjusted for Model 1 covariates, smoking status, Hispanic/Latino background group, site, acculturation

[c]Adjusted for Model 2 covariates, body mass index

[d]Inactive=0 minutes of combined moderate-and vigorous-intensity activity per week.

[e]Insufficient activity= >0 to <150 minutes of combined moderate-and vigorous-intensity activity per week.

[f]Met Recommendations= ≥150 minutes of combined moderate-and vigorous-intensity activity per week.

[g]Inactive=0 minutes of vigorous-intensity activity per week.

[h]Insufficient activity= >0 to <75 minutes of vigorous-intensity activity per week.

[i]Met Recommendations= ≥75 minutes of vigorous-intensity activity per week.

Table 3

Associations of Physical Activity and Obstructive Sleep Apnea by Type of Activity: The Hispanic Community Health Study/Study of Latinos (HCHS/SOL), 2008-2011.

	AHI >=5 vs. AHI <5				AHI >=15 vs. AHI <5			
	Unadjusted	Model 1[a]	Model 2[b]	Model 3[c]	Unadjusted	Model 1[a]	Model 2[b]	Model 3[c]
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Recreational MVPA								
Inactive[d]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Insufficient Activity[e]	0.62(0.55-0.70)	0.74(0.65-0.84)	0.72(0.63-0.82)	0.82(0.71-0.93)	0.59(0.49-0.72)	0.71(0.58-0.86)	0.68(0.56-0.84)	0.79(0.64-0.97)
Met Recommendations[f]	0.41(0.27-0.63)	0.80(0.50-1.30)	0.79(0.49-1.29)	1.00(0.60-1.67)	0.44(0.25-0.79)	0.84(0.46-1.53)	0.81(0.44-1.50)	1.11(0.61-2.01)
Work MVPA								
None[d]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Medium[e]	0.85(0.73-0.99)	1.03(0.88-1.21)	1.03(0.88-1.21)	1.02(0.87-1.20)	0.87(0.66-1.13)	1.05(0.79-1.38)	1.06(0.81-1.40)	1.07(0.83-1.39)
High[f]	0.96(0.84-1.10)	1.17(1.01-1.36)	1.18(1.01-1.36)	1.12(0.96-1.31)	0.93(0.76-1.15)	1.13(0.91-1.41)	1.16(0.92-1.45)	1.09(0.86-1.38)
Transporation PA								
None[g]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Medium[h]	0.81(0.73-0.91)	0.81(0.73-0.91)	0.81(0.72-0.91)	0.84(0.74-0.96)	0.82(0.69-0.97)	0.81(0.68-0.97)	0.81(0.68-0.97)	0.87(0.72-1.05)
High[i]	0.64(0.49-0.82)	0.62(0.45-0.85)	0.62(0.45-0.84)	0.64(0.43-0.95)	0.59(0.40-0.87)	0.58(0.38-0.89)	0.59(0.37-0.92)	0.63(0.37-1.05)

Note. AHI= apnea-hypopnea index; MVPA=moderate-vigorous physical activity; OR=odds ratio; PA=physical activity

[a]Adjusted for age, sex, education

[b]Adjusted for Model 1 covariates, smoking status, Hispanic/Latino background group, site, acculturation

[c]Adjusted for Model 2 covariates, body mass index

[d]None=0 minutes of combined moderate-and vigorous-intensity work activity per week.

[e]Medium= >0 to <150 minutes of combined moderate-and vigorous-intensity work activity per week.

[f]High= ≥150 minutes of combined moderate-and vigorous-intensity work activity per week.

[g]None=0 minutes of moderate-intensity transportation activity per week.

[h] Medium= >0 to <150 minutes of moderate-intensity transportation activity per week.

[i] High= ≥150 minutes of moderate-intensity transportation activity per week.