

ORIGINAL RESEARCH

Feasibility of Portable Sleep Monitors to Detect Obstructive Sleep Apnea (OSA) in a Vulnerable Urban Population

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Purpose: Portable sleep monitors may offer a convenient method to expand detection of obstructive sleep apnea (OSA), yet few studies have evaluated this technology in vulnerable populations. We therefore aimed to assess the feasibility and acceptability of portable sleep monitors for detection of OSA in a prediabetic, urban minority population.

Methods: We recruited a convenience sample of participants at their 12-month follow-up for a community-partnered, peer-led lifestyle intervention aimed to prevent diabetes in prediabetic and overweight patients in this prospective mixed-methods pilot study. All participants wore portable sleep monitors overnight at home. We qualitatively explored perceptions about OSA and portable monitors in a subset of participants.

Results: We tested 72 people, predominantly non-White, female, Spanish speaking, uninsured, and of low income. Use of portable sleep monitors was feasible: 100% of the monitors were returned and all participants received results. We detected OSA in 49% (defined as an Apnea-Hypopnea Index [AHI] > 5) and moderate-severe OSA in 14% (AHI > 15) requiring treatment in 14%. In 21 qualitative interviews, participants supported increased use of portable sleep monitors in their community, were appropriately concerned that OSA could cause progression to diabetes, and thought weight loss could prevent or improve OSA.

Conclusions: Portable sleep monitors may represent a feasible method for detecting OSA in high-risk urban minority populations. (*J Am Board Fam Med* 2015;28:257–264.)

Keywords: Community-Based Participatory Research; Diabetes Mellitus; Monitoring, Sleep; Obesity; Sleep Disorders

Obstructive sleep apnea (OSA) is a major public health concern because it is associated with serious sequelae such as hypertension,¹ cardiovascular disease,² cerebrovascular disease,³ insulin resistance,⁴ decreased cognitive function,⁵ and increased rates

of traffic accidents.⁶ With general prevalence estimates of 15% in the United States,⁷ OSA is seen in even higher rates (50–78%) in patients who are obese and diabetic.^{8–10} Populations with high rates of obesity and diabetes, such as urban non-White populations, may suffer a disproportionate risk for OSA and its sequelae.¹¹ OSA has also been linked to the progression of diabetes independent of obesity via activation of the sympathetic nervous system. Each hypoxic event results in a surge of cortisol which over time alters glucose tolerance, thereby speeding progression to diabetes.^{12,13} As rates of these comorbidities continue to rise, so too does the need to implement a feasible strategy for expanding OSA diagnosis. Portable sleep monitors may represent a strategy for increasing detection of OSA, especially in communities with limited access to health care. Our study seeks to explore the feasibility, acceptability, and perceptions of the use of

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portable sleep monitors in low-income, urban, non-White populations with restricted access to health care.

Currently, despite the high and rising prevalence, OSA remains underdiagnosed, particularly in uninsured and other vulnerable populations.⁸ This may be because the standard for diagnosis remains overnight inpatient attended polysomnography (PSG), which can be costly, associated with wait times, and uncomfortable for patients.¹⁴ Subjective screening questionnaires, such as the Epworth Sleepiness Scale (ESS) and the Berlin Questionnaire (BQ), although easy to use, have low sensitivity and specificity (ESS, 46% and 60%; BQ, 73% and 44%, respectively), rendering them an unacceptable alternatives for screening.¹⁵ Portable sleep monitors have been validated with a higher sensitivity and specificity (76.9% and 92.5%, respectively)¹⁶ and are gaining momentum after the implementation of a billing code in 2008.¹⁷ Although PSG is the recommended followup for negative portable sleep monitor results in populations with a high-pretest probability to reduce the risk of false negatives, there is no standard for populations with lower risk and low access to PSG.¹⁸

Diagnosis of OSA is important because an effective treatment, continuous positive airway pressure (CPAP), successfully reduces the risk of its sequelae.⁷ However, compliance with CPAP is problematic.¹⁹ Therefore, to improve health outcomes, a screening strategy should be coupled with an educational component to motivate people who suffer from OSA to adhere to CPAP. In previous studies, factors associated with adherence to CPAP include the desire to alleviate symptoms, an understanding of medical consequences associated with OSA, and a belief in positive treatment outcomes.¹⁹ As a result, our study also explores the attitudes about portable sleep monitoring and OSA to design a more tailored approach to treatment with CPAP for similar communities in the future.

Objectives

The primary objective of this study was to investigate the feasibility of using portable sleep monitors to diagnose OSA in an urban, non-White, prediabetic population and the population's receptiveness to this technology. Secondarily, we sought to explore the population's understanding of and attitudes toward OSA as well as the expected prevalence to inform future studies.

Methods

Study Design

We conducted a prospective mixed-methods (quantitative and qualitative) study of a convenience sample from a larger study on prediabetes in East Harlem, New York. Local academics, including a physician board certified in sleep medicine, partnered with community leaders using a community-based participatory research approach to design the study and evaluate all materials to ensure they were appropriate for and specific to the East Harlem community.

We recruited participants at their 1-year follow-up appointment for the parent study at community-based sites such as churches, schools, and community organizations. Inclusion criteria were age \geq 18 years, overweight/obese (body mass index [BMI] \geq 25 kg/m²) and prediabetic by oral glucose tolerance testing (fasting glucose fingerstick $<$ 126 mg/dL with repeat finger stick 2 hours after 75-g glucose load 140–199 mg/dL).²⁰ Exclusion criteria included pregnancy; any prior diagnosis of OSA or other sleep disorder including central apnea, insomnia, parasomnia, narcolepsy, periodic limb movement disorder and circadian rhythm disorder; and comorbidities that precluded the use of auto-titrating CPAP such as congestive heart failure or chronic obstructive pulmonary disease.²¹ Eligible participants were offered sleep testing with a portable sleep monitor. The Icahn School of Medicine at Mount Sinai Internal Review Board (IRB) approved this study.

We used the ApneaLinkPlus, which is a type III portable sleep monitor with four leads measuring nasal airflow, snoring, arterial oxygen saturation, pulse, and respiratory effort that has been validated to screen for OSA.¹⁶ Based on the signals recorded, the associated software generates a modified AHI value. With the understanding that portable sleep monitors underestimate the degree of apnea because they use total recording time rather than total sleep time in the calculation, we chose to use this technology.²²

After obtaining informed consent, a trained study coordinator, fluent in English and Spanish, taught participants about OSA and the portable sleep monitor with specifically designed educational tools. All participants also received counseling on healthy sleep hygiene. Before leaving with the device, participants demonstrated their ability to successfully use the portable sleep monitor.

They were instructed to wear the portable sleep monitor overnight and to return it to the study coordinator the next day.

We followed the American Academy of Sleep Medicine Clinical Guidelines for the use of unattended portable sleep monitors.¹⁸ Participants with studies containing < 240 minutes of valid data were offered one opportunity to repeat the study after reviewing proper monitor use technique and demonstrating proficiency to the study coordinator. A trained and certified polysomnographic technician under the supervision of a board certified sleep medicine physician reviewed the raw data and excluded any time points that did not capture all four leads. The AHI was auto-calculated by the portable sleep monitor and edited by the sleep technician after manual review of the data. Results were stratified by severity of OSA using the American Academy of Sleep Medicine classification system of OSA defined as mild, ≥ 5 ; moderate, ≥ 15 ; and severe, ≥ 30 respiratory events per hour.²³

When participants returned to receive their results, they were given the opportunity to participate in a 20-minute open-ended qualitative interview with an interviewer fluent in English and Spanish. After theoretical saturation was reached, we did not continue to offer these interviews.

Participants with no or mild OSA (AHI <15) were counseled on lifestyle changes to prevent or reduce OSA including weight loss, sleep position, and avoiding alcohol and benzodiazepines before bed. Those with moderate or severe OSA (AHI ≥ 15) were counseled about the above lifestyle changes and given an auto-titrating CPAP machine donated by Fisher & Paykel Health care, Inc. for treatment of OSA after a mask-fitting session.

All participants completed an ESS and BQ at baseline. After initiating the study, we determined a need for quantitative assessment of the ease and comfort of using the portable monitor. Therefore, we developed a questionnaire and submitted an IRB amendment to our study. The final 24 participants were offered this questionnaire. We also utilized demographic, clinical (mean systolic and diastolic blood pressures calculated from three successive measures at 2-minute intervals in a seated position, and hemoglobin A1c) and survey data including depressive symptoms measured using the Patient Health Questionnaire–8 with the validated cutoff of 10 as a marker for moderate depression

from the parent study, collected on the day of enrollment in to our sleep study.²⁴

Participants received \$10 gift certificates to local supermarkets as incentives for each appointment they attended for this study.

Outcome Measures

Our primary outcome measure was feasibility, measured by percentage of machines returned and percentage of patients obtaining > 240 minutes of reliable data after 1 and 2 attempts. Secondary outcomes included percentage of participants with mild, moderate, and severe OSA, and correlation of OSA diagnosis with the ESS and the BQ as well as comorbid medical conditions.

Statistical Analysis

We analyzed the data using SPSS v22. We conducted means and standard deviations for continuous variables and proportions for categorical variables. We made group comparisons using χ^2 and student's *t* tests.

Qualitative interviews were transcribed and translated then manually coded for 19 variables with an inter-rater reliability of 85%. Emergent themes were based on codes and field notes.

Results

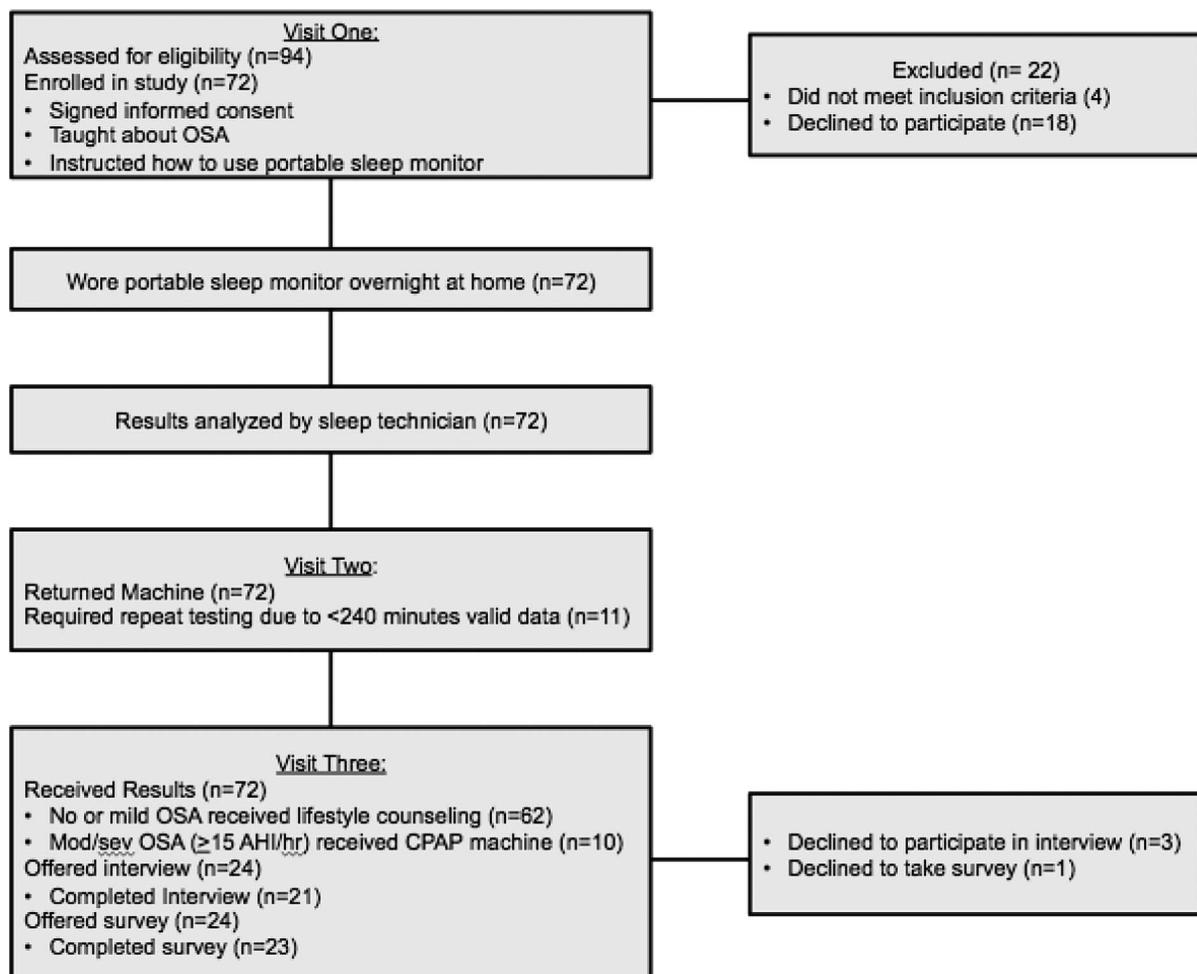
We recruited 72 participants over 9 months and all participants completed the study (Figure 1). Our demographic data show that our population was predominantly female, Spanish-speaking, under-educated, of low-income, and uninsured (Table 1). There were no significant differences in demographics of participants who completed qualitative interviews compared with the sample as a whole ($P > 0.1$).

Primary Outcome

We found that use of a portable sleep monitor in this population with low levels of income and education was feasible as 100% of machines were returned. Although 15% of participants had to repeat testing due to less than 240 minutes of viable data, all participants were able to achieve this threshold on repeat testing.

We offered questionnaires about the ease, comfort and importance of portable sleep monitors for diagnosis of OSA to the final 24 participants, from whom we collected 23 responses. Of these, 87%

Figure 1. Components of each study visit and patients included in each component. OSA, obstructive sleep apnea.



(20) recommended the portable sleep monitor for OSA screening, 91% (21) believed they understood how the machine works, and 96% (22) thought OSA testing is important. Participants rated the portable sleep monitor as very easy to use (median score, 2.5; range, 1–5) on a 10-point Likert scale (1 = extremely easy to 10 = extremely difficult). Participants rated the portable sleep monitor as somewhat comfortable (median score, 3.5; range, 1–7) on a 10-point Likert scale (1 = extremely comfortable to 10 = extremely uncomfortable). Our qualitative interviews further support these data revealing that participants found use of portable sleep monitors an acceptable method for OSA detection in their community.

Secondary Outcomes

Based on the modified AHI, we found that 49% (35) of our study population had at least mild OSA

(AHI >5 events/hour). Among participants with OSA, disease severity was 71% (25) mild, 20% (7) moderate, and 9% (3) severe as defined by the American Academy of Sleep Medicine classification. All 10 participants with moderate or severe OSA (AHI ≥ 15) were offered an auto-titrating CPAP machine and 100% accepted treatment. All 10 participants had used their CPAP machine at least three nights successfully at their 30-day follow-up appointment.

As has been previously shown, a positive score on the ESS defined as ≥ 10 did not predict OSA (OR, 1.47; 95% CI, 0.4–5.5) in our study population, nor did the BQ (OR, 0.62; 95% CI, 0.16–2.44).¹⁵

We analyzed the relationship of OSA (mild–severe) with comorbid conditions and sequelae of OSA (Table 2). The group with OSA (n = 35) was significantly older. In this small population, we did

Table 1. Demographics and Group Characteristics of All Participants Enrolled in the Study and Subset of Participants Who Completed Interviews

Characteristic	Total (n = 72)	Interviews (n = 21)
Mean age (range)	46 (25–72)	52 (27–71)
Male % (n)	11% (8)	24% (5)
Spanish speaking	49% (35)	48% (10)
Black race	21% (15)	33% (7)
Hispanic	67% (48)	62% (13)
Income ≤ \$30,000	58% (42)	48% (10)
< High school degree	33% (24)	38% (8)
No health insurance	40% (29)	24% (5)

The participants in our study were mostly middle aged, Hispanic females with a high proportion who speak Spanish. They are of low socioeconomic status with low income, low levels of education, and many lack health insurance. These characteristics are true of both the total group who participated in the study as well as the subset of participants who completed interviews.

show a significant difference in both mean systolic and diastolic blood pressures, as has been previously shown.¹ We also found a trend toward significance for both depression and BMI, which have also been established in prior studies and may be shy of statistical significance due to our small sample size.^{8,10} However, we did not find a statistically significant difference in cholesterol or hemoglobin A1c according to OSA status.

Qualitative Interviews

Qualitative interviews revealed that participants lacked prior knowledge about OSA, but after testing, they could appropriately identify risk factors and felt motivated to change their behavior to decrease their OSA risk. Interestingly, the most commonly reported fear was instant death during sleep.

Commenting on a lack of prior knowledge about OSA, a 56-year-old black male said, "My mind was not even on sleep apnea... sometimes we perish for our lack of knowledge" (Participant 2).

After education and testing, participants also indicated concern that OSA could facilitate the progression to diabetes and other poor health outcomes. One 36-year-old Latina woman said, "I think that [OSA] is something you all need to press, especially in the minority community... if you all show the danger signs of that, diabetes... smoking... overweight..., it should be a more urgent call. I think you need to make this very urgent because they are all intertwined" (Participant 7).

The participants also recognized that weight loss could prevent or reduce OSA and they reported a motivation to lose weight as a result of screening. A 29-year-old Black woman said, "[I need to] keep working on my weight. This kinda gave me another wake-up call, and I am gonna start" (Participant 16).

An impressive majority (62%) of participants expressed fear that OSA would cause them to die in their sleep. A 42-year-old Latina woman said, "I think what really scares or triggers a problem with me is just the fact that you stop breathing... if it is untreated, it could lead to death, if you stop breathing for any period of time. So it is something like that that would jar me to want to get [treatment]" (Participant 11). Interestingly, although none of our educational materials linked OSA to sudden death, this was the strongest motivator for testing and treatment.

Discussion

We set out to determine whether portable sleep monitors could serve as a feasible method for expanding access to OSA testing in an urban, non-White, non-English-speaking population. Our study is unique for several reasons. We evaluated a difficult-to-study population of non-White, non-English-speaking adults with low income and levels of education. Even though minority populations have a higher risk for OSA, they have historically re-

Table 2. Comorbidities and risk factors of those with and without obstructive sleep apnea (OSA) (n = 72)

	OSA (n = 35)	No OSA (n = 37)	P-Value
Age (years)	51 (9)	41 (11)	.001*
Mean BP (mm Hg)			
Systolic	178 (17)	165 (16)	.002*
Diastolic	113 (15)	106 (13)	.03*
BMI (kg/m ²)	34.1 (8.8)	31.4 (3.5)	.10
Total cholesterol (mg/dL)	187 (33)	181 (41)	.46
LDL	106 (34)	106 (33)	.99
HDL	54 (15)	54 (15)	.93
Moderate depression (PHQ-8)	52% (13)	30% (8)	.10
Mean Hgb A1c	5.8 (0.5)	5.7 (0.4)	.14

HDL, high-density lipoprotein; LDL, low-density lipoprotein. Those with OSA were older and suffered from higher blood pressures. Those with OSA also had a higher mean BMI and higher scores on the PHQ-8.

*Signifies significant P-values defined as < 0.05.

ceived less testing and treatment.²⁵ Prior studies have shown promising results for the feasibility of use of portable sleep monitors for the diagnosis of OSA, yet no studies have been conducted among non-White populations.²⁶ This may be because portable sleep monitors are thought to be complex and difficult to learn how to use, and clinicians may think this would be a barrier to efficacy in the undereducated population we studied, although this was not the case. We had to repeat testing in 15% of the participants due to collection of < 240 minutes of valid data; however, all participants achieved this threshold with a repeat test. Our results are within the results achieved in prior studies demonstrating poor data quality in 5% to 20% of portable studies.²⁷ In addition, these monitors are a relatively expensive technology that is sent home with patients, which could present the opportunity for theft or loss, although we had a 100% return of equipment with minimal effort. Thus, this technology may represent a feasible strategy for increasing access to OSA detection in high-risk, underserved communities that may have difficulty accessing traditionally attended polysomnography.

In addition, this is the first study to evaluate the rate of OSA in an overweight/obese, prediabetic population. In this small sample, our team found a high prevalence (49%), which approaches expected rates for patients with obesity and diabetes and is much higher than the national prevalence.^{7,8} Given that our population was predominantly female, this may represent an underestimate of the true prevalence and signifies a need to expand testing initiatives in similar communities to verify these findings. A recent cross-sectional study showed a high prevalence of undiagnosed OSA in the Latino population with a strong correlation with obesity and diabetes.²⁸ Thus, our study adds to the growing body of literature that supports expansion of testing in these populations which may be at higher risk than previously estimated.^{29,30}

Our study provides a rich assessment of the thoughts and fears about OSA in this vulnerable community. Our qualitative analysis supports the use of portable sleep monitors because the participants found use of the monitors acceptable and identified a need for testing in their community. Furthermore, the interviews suggest that education and testing for OSA could motivate weight loss,

which may indicate a wider public health implication of testing for OSA.

Qualitative interviews also revealed fears about sudden death during sleep. None of our educational materials indicated that this was a risk of OSA, yet a majority of our participants described this fear. A prior study of Black residents in Brooklyn, New York identified several misunderstandings about OSA but did not characterize fears associated with OSA diagnosis.³¹ This illuminates an interesting trend of misunderstanding among vulnerable populations that should be further explored.

Future Studies

Future studies should evaluate how vulnerable populations diagnosed with OSA respond to CPAP treatment, especially given the challenges of adherence in the general population. In addition, studies should evaluate the impact of treating OSA on the progression to diabetes in prediabetic populations.

Limitations

Our small sample was recruited from within an already existing lifestyle modification study, which may have artificially increased compliance and may limit the generalizability of our results. In addition, we provided incentives for each visit, which may have increased compliance and thereby reduce our ability to measure feasibility. Our educational materials were designed for a fourth grade reading level, but this may still exclude those with lower levels of education. Portable sleep monitors have been found to have a lower sensitivity and specificity (76.9% and 92.5% respectively) as compared with attended in-lab polysomnography (100% and 92.5% respectively) potentially distorting our estimated prevalence.¹⁶ Portable sleep monitors underestimate the degree of apnea because they use total recording time instead of total sleep time as a denominator in the calculation of AHI.²²

Conclusions

Our study concludes that portable sleep monitors may represent a feasible and acceptable approach for diagnosing OSA in this underserved population with risk factors such as prediabetes and increased weight. In addition, the high proportion with at least mild OSA suggests that there may be a need to

expand testing in non-White, overweight/obese, prediabetic populations.

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