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Predicting sleep apnea in bariatric surgery patients

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Abstract

Background—Because of the high prevalence and potentially serious complications of obstructive sleep apnea (OSA) in obese individuals, several prediction models have been developed to detect moderate-to-severe OSA in patients undergoing bariatric surgery. Using commonly collected variables (body mass index [BMI], age, observed sleep apnea, hemoglobin A1c, fasting plasma insulin, gender, and neck circumference), Dixon et al. developed a model with a sensitivity of 89% and specificity of 81% for patients undergoing laparoscopic adjustable gastric band surgery suspected to have OSA. The present study evaluated the prediction model of Dixon et al. in 310 gastric bypass patients (mean BMI 46.8 kg/m², age 41.6 years, 84.5% women), with no preselection for OSA symptoms in a bariatric surgery partnership.

Methods—The patients underwent overnight limited polysomnography to determine the presence and severity of OSA as measured using the apnea-hypopnea index.

Results—Of the 310 patients, 44.2% had moderate-to-severe OSA (apnea-hypopnea index ≥ 15/h). Most variables in the Dixon model were associated with a greater prevalence of OSA. The sensitivity (75%) and specificity (57%) for the model-based classification of OSA were considerably lower in the present sample than originally reported. An alternate prediction model identified 10 unique predictors of OSA. The presence of 5 of these predictors modestly improved the sensitivity (77%) and greatly improved the specificity (77%) in predicting an apnea-hypopnea index of ≥ 15/h. When applied to the validation sample, the sensitivity (76%) and specificity (72%) were essentially the same.

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Conclusion—Although the Dixon model and our model included overlapping predictors (BMI, gender, age, neck circumference), when applied in our sample of gastric bypass patients, neither model achieved the sensitivity and specificity for predicting OSA previously reported by Dixon et al.

Keywords

Sleep apnea; Prediction; Bariatric surgery

Only 2–5% of women and 3–7% of men in the general population have obstructive sleep apnea (OSA) to the extent that it is accompanied by daytime drowsiness [1]. Among the severely obese seeking weight loss treatment, however, the OSA prevalence is as great as 60–94%, with 46–58% classified as moderate to severe [2–4].

In bariatric surgery patients, OSA has been associated with prolonged hospital stays [5], challenges with anesthesia [6], and postoperative complications [7,8]. Owing to the high prevalence of OSA and its associated risk in these patients, preoperative screening by overnight polysomnography has been routinely prescribed [9]. Several attempts have been made to develop a prediction model, using routinely collected demographic and clinical factors, to identify patients most at risk of significant sleep apnea [3,10–12]. An accurate prediction model for OSA could be a valuable screening tool to identify high-risk patients. One such prediction model was developed by Dixon et al. [10] in patients presenting for laparoscopic adjustable gastric band surgery who already had clinically suspected OSA. The Dixon model included 6 predictor variables (body mass index [BMI] $\geq 45 \text{ kg/m}^2$, age ≥ 38 years, observed OSA, hemoglobin A1c $\geq 6\%$, fasting plasma insulin ≥ 28 , and male gender) and demonstrated acceptable sensitivity (89%) and specificity (81%) compared with polysomnographic findings of moderate-to-severe OSA. A seventh variable—neck circumference—also independently predicted the presence of moderate-to-severe OSA. Dixon et al. [10] suggested that the neck circumference could be substituted for male gender and BMI to produce results with a similar predictive value.

Because their model was developed in a sample with previous selection for OSA symptoms, it is unclear whether the model could be applied to an unselected population of severely obese individuals. To our knowledge, the accuracy validation of this prediction has not yet been published. The purpose of the present study was to test the prediction model from Dixon et al. [10] in a general sample of gastric bypass candidates (i.e., no preselection for OSA symptoms).

Methods

Participants

The sample consisted of 310 gastric bypass surgery candidates recruited from a partnership of bariatric surgeons for the Utah Obesity Study, an ongoing prospective study [13]. The patients had a BMI of $\geq 40 \text{ kg/m}^2$ or $\geq 35 \text{ kg/m}^2$ with 2 co-morbidities. The exclusion criteria were previous gastric weight loss surgery, gastric/duodenal ulcers or myocardial infarction within the previous 6 months, active cancer within the previous 5 years (except for nonmelanoma skin cancer), and a history of alcohol/narcotic abuse. Participants with a previous diagnosis of OSA were not excluded from our analysis. However, we excluded participants who used nasal continuous positive airway pressure or oxygen during the limited overnight polysomnographic study.

Procedure

The University of Utah institutional review board approved the study, and all participants provided informed consent. The participants underwent limited overnight polysomnographic study (i.e. no electroencephalography) using an Embletta Portable Diagnostic System (Embla Systems, Broomfield, CO) that included measures of nasal airflow, thoracic and abdominal effort, snoring, motion detection, body position, oxygen saturation, and heart rate. The Embletta Portable Diagnostic System is ergonomically designed so the subject is not connected to external cables or electrodes. A single, board-certified sleep specialist analyzed all records to eliminate interscorer variability, and the records were scored with the specialist unaware of the clinical findings. Apnea was defined as a cessation of airflow for 10 seconds, and hypopnea was defined as a reduction of airflow for 10 seconds in association with a 4% decline in oxygen saturation. The apnea-hypopnea index (AHI) was defined as the number of apnea events plus the number of hypopnea events divided by the hours of recording time. Moderate-to-severe OSA was defined as an AHI of ≥ 15 .

Statistical analysis

Patients with and without clinically measured OSA were compared using demographic characteristics, anthropometric measures, laboratory assessments, blood pressure, patient-reported outcomes, and medical history using Fisher's exact or independent sample *t* tests. Odds ratios and 95% confidence intervals (CIs) for prevalent moderate-to-severe OSA were calculated separately for each of Dixon's prediction criteria (BMI ≥ 45 kg/m², age ≥ 38 years, hemoglobin 1Ac $\geq 6\%$, insulin level ≥ 28 μ U/mL, male gender, and neck circumference ≥ 43 cm). We did not include observed sleep apnea as a predictor variable, because this variable was not a part of the data we collected. The sensitivity and specificity were calculated for the number of Dixon's criteria met (range 0–6), for both AHI ≥ 15 and AHI ≥ 30 . The sample was randomly divided into a developmental sample ($n = 155$) and a validation sample ($n = 155$). A receiver operating characteristic (ROC) analysis was performed on the development sample to evaluate the ability of the demographic and clinical variables to distinguish between those with and without moderate-to-severe OSA (AHI ≥ 15). Only variables available in routine clinical practice were included in the ROC analyses. The area under the curve (AUC) and 95% confidence intervals were calculated for each predictor variable using a nonparametric ROC model. The cutpoint for each significant predictor ($P < .05$) was determined, selecting the score that most closely balanced the sensitivity and specificity. In addition, correlations were calculated between the predictor variables and AHI as a continuous variable (Pearson correlations were used for continuous predictor variables and point biserial correlations for dichotomous predictors). Finally, the sensitivity and specificity for every possible score from this new model were determined in both the development and the validation samples.

Results

Patient characteristics stratified by OSA status

A total of 137 patients (44.2%) had moderate-to-severe OSA. The demographic, anthropometric, and clinical characteristics are presented in Table 1 stratified by OSA status (AHI <5 , 5–14.9, 15–29.9, and ≥ 30). The prevalence of moderate-to-severe sleep apnea was much greater in men (83.3% men, 37.0% women). Marital status (57.1% married), race (88.9% white), and years of education (mean 14.0 ± 2.1) were not significantly associated with the AHI category. Those with OSA were also more likely to be older and larger for all anthropometric characteristics, except for hip circumference. Those with moderate-to-severe OSA had a significantly greater systolic blood pressure at rest, lower oxygen saturation, and a greater prevalence of self-reported hypertension, menopause, and loud snoring. A total of

40 participants had been previously diagnosed with OSA. Not surprisingly, a greater percentage of participants with an AHI of ≥ 30 had a previous diagnosis of sleep apnea.

Evaluation of Dixon model

An evaluation of the Dixon model and the sensitivity and specificity for the number of criteria met in the present sample are presented in Table 2. All the variables in the Dixon model, except for insulin $>28 \mu\text{U/mL}$, were significantly associated with an increased risk of having moderate-to-severe OSA. The odds ratios for the significant variables ranged from 1.97 (age, 95% CI 1.22–3.17; $P = .005$) to 8.51 (male gender, 95% CI 3.82–18.92; $P < .001$). The AUC for the Dixon model in the present sample was .730 (95% CI .675–.786). For an AHI of ≥ 15 , a cutoff score of ≥ 2 criteria met produced a sensitivity of 75.2% and a specificity of 57.2% in the present sample, substantially lower than the corresponding values of 89% and 81% reported for the Dixon sample. For an AHI of ≥ 30 , a cutoff score of ≥ 3 produced a sensitivity of 63.9% and specificity of 76.5% in the present sample, again substantially lower than the corresponding values of 96% and 71% reported for the Dixon sample.

Development of new model

The ROC analyses revealed that 13 of the potential predictor variables (i.e., variables listed in Table 3) were significantly associated with OSA status (Table 3), with AUC values ranging from .611 (male gender, 95% CI .520–.702) to .729 (neck circumference, 95% CI .649–.810). The cutoff values for each variable were then determined to best balance the sensitivity and specificity in the development sample. The correlations between the predictor variables and AHI revealed positive and significant associations between AHI and all but 2 (glucose and hemoglobin 1Ac) of the 13 variables listed in Table 3.

Owing to the redundancy of some variables (e.g., weight and BMI), weight, hypertension, and hemoglobin 1Ac were removed from the final model, leaving 10 variables (Table 4). The sensitivity and specificity were calculated in both the development and the validation samples for the number of criteria met (possible range 0–10) according to our established cutoffs (Table 4). A cutoff score of ≥ 5 criteria met produced a sensitivity of 77.1% and specificity of 76.5% in the development sample and a sensitivity of 76.1% and specificity of 71.6% in the validation sample for an AHI of ≥ 15 . The AUC for the prediction model was .821 (95% CI .755–.886) in the development sample and .780 (95% CI .707–.853) in the validation sample. For an AHI of ≥ 30 , a cutoff score of ≥ 5 criteria met resulted in a sensitivity of 85.4% and specificity of 65.8% in the development sample and a sensitivity of 83.9% and specificity of 59.7% in the validation sample.

Discussion

In the present study of gastric bypass patients from the Utah Obesity Study, the classification of moderate-to-severe OSA using the Dixon prediction model resulted in lower predictive accuracy than was reported in the original study by Dixon et al. [10]. Differences in the study participants and methods used might account for this inconsistency of findings. Specifically, the participants in the study by Dixon et al. [10] sought laparoscopic adjustable gastric banding in Australia and were preselected for inclusion if they were symptomatic for OSA. In contrast, the present study participants sought gastric bypass surgery in the United States and were not preselected on the basis of suspected OSA. In addition, differences in the prevalence of the predictor variables in the Dixon sample versus the present sample could also have influenced the performance of the models.

Owing to the high prevalence and risks associated with moderate-to-severe OSA in obese individuals, especially bariatric surgery patients, a prediction model for OSA that can be used in diverse bariatric surgery settings would have clinical and practical utility. The alternate prediction model developed in the present study identified 10 unique predictors of OSA. The presence of 5 of these factors resulted in a prediction sensitivity of 77.1% and specificity of 76.5%. In the validation sample, both the sensitivity and the specificity decreased somewhat (76.1% and 71.6%, respectively). Thus, our prediction model was unable to identify the presence of OSA in about 25% of the patients and the absence of OSA in about 30% of the patients, suggesting the model might be of some utility but is far from perfect.

Others have also developed prediction models for OSA in nonbariatric surgery settings. Palla et al. [3] investigated 101 consecutive inpatients with a BMI ≥ 40 kg/m² referred to an obesity clinic. Using a model based on gender, age, diurnal sleepiness, and minimal nocturnal saturation, these investigators obtained a sensitivity of 97% and specificity of 77%. However, the diagnosis of OSA was determined using an AHI of ≥ 5 /h (i.e., at least mild apnea), and all patients underwent a cardiorespiratory sleep study, with only those with negative findings plus the presence of diurnal sleepiness studied using complete polysomnography. Unlike the study by Palla et al. [3], the present model used an AHI of ≥ 15 /h (i.e., moderate-to-severe OSA).

Sareli et al. [4] developed prediction models for 3 levels of OSA severity in 342 consecutive patients undergoing bariatric surgery. They determined that by using even the most stringent cutoff values, OSA could not be predicted with enough certainty to be clinically useful. Instead, they advocated routine polysomnography for these patients.

Several other studies have attempted to predict OSA on the basis of clinical formulas. A report by the American Society of Anesthesiologist Task Force used clinical signs (e.g., BMI, neck circumference, craniofacial abnormalities, and tonsils), a history of apparent airway obstruction during sleep (e.g., loud or frequent snoring), and daytime somnolence to determine the probability of moderate OSA, with a scoring system to estimate to what degree a patient had an increased perioperative risk of complications [14]. Rowley et al. [15] prospectively evaluated the utility of 4 clinical prediction models [16–19] for OSA in patients referred to a sleep disorder center. They found that the clinical prediction models did not discriminate well between patients with and without OSA [15].

Although the model developed in the present study and the model developed by Dixon et al. [10] had overlapping predictors (BMI >45 kg/m², male gender, age, and neck circumference), our cutoff for age was somewhat greater and for neck circumference somewhat lower. Nevertheless, the presence of these particular predictors in both models highlights the relevance of these variables for OSA screening.

One strength of the present study was that we developed the prediction model using one half of our patient sample and validated the model using the other half. Because the patients were not preselected for OSA risk, our prediction model is likely to have broader applicability to other bariatric surgery samples. Another strength was the wide range of predictor variables that were evaluated. One limitation of the present study was that limited overnight polysomnography did not include electroencephalography evaluations.

Conclusion

It is important to identify bariatric surgery patients who are at high risk of moderate-to-severe OSA because of their greater than normal risk of postoperative complications that can be exacerbated by sedative, analgesic, and anesthetic agents [7,20]. If these patients can be

treated successfully before, during, and after surgery, evidence has shown that surgically-induced weight loss improves OSA and sleep quality [21,22]. Although previous research by Dixon et al. [10] reported a simple model to predict moderate-to-severe OSA, this model performed with much lower sensitivity and specificity in the present sample. In the proposed model, the sensitivity and specificity were less than ideal, suggesting that until a more accurate prediction model is established, the routine use of polysomnography should be recommended for this high-risk population as a part of the preoperative screening process.

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Table 1
Participant demographic, anthropometric, and clinical characteristics stratified by sleep apnea status

Characteristic	AHI				Significance
	<5 (n = 58)	5–14.9 (n = 115)	15–29.9 (n = 65)	30 (n = 72)	
Gender (n, %)					
Female	56 (96.6) [*]	109 (94.8) [*]	55 (84.6) [‡]	42 (58.3) [‡]	$\chi^2_{(3)} = 53.40$ $P < .001$
Male	2 (3.4)	6 (5.2)	10 (15.4)	30 (41.7)	
Age (mean, SD)	38.3 ± 10.8 [*]	40.1 ± 9.9 [*]	44.4 ± 9.5 [‡]	44.0 ± 10.7 [‡]	$F_{3,306} = 5.83$ $P = .001$
BMI (kg/m ²) (mean, SD)	42.6 ± 5.3 [*]	46.7 ± 7.9 [‡]	47.4 ± 6.4 ^{‡§}	49.7 ± 7.8 [§]	$F_{3,306} = 10.62$ $P < .001$
Weight (lb) (mean, SD)	261.6 ± 44.7 [*]	282.1 ± 49.2 [‡]	290.2 ± 49.6 ^{‡§}	322.7 ± 60.3 [§]	$F_{3,306} = 16.56$ $P < .001$
Waist (cm) (mean, SD)	125.8 ± 14.7 [*]	133.9 ± 16.4 [‡]	137.9 ± 14.9 ^{‡§}	142.1 ± 15.7 [§]	$F_{3,306} = 12.64$ $P < .001$
Hip (cm) (mean, SD)	135.8 ± 10.3 [*]	141.5 ± 14.2 [‡]	141.4 ± 12.9 [‡]	143.1 ± 15.1 [‡]	$F_{3,306} = 3.44$ $P = .017$
Neck (cm) (mean, SD)	38.6 ± 3.2 [*]	40.0 ± 3.2 [‡]	41.5 ± 3.6 [‡]	44.5 ± 4.2 [§]	$F_{3,306} = 36.82$ $P < .001$
Insulin (μU/mL) (mean, SD)	16.2 ± 18.9	15.7 ± 14.1	16.5 ± 15.1	20.8 ± 17.6	$F_{3,306} = 1.63$ $P = .184$
HbA1c (%) (mean, SD)	5.8 ± 1.4	5.8 ± .9	5.9 ± 1.0	6.1 ± 1.2	$F_{3,306} = 1.44$ $P = .232$
Cholesterol (mg/dL) (mean, SD)	188.0 ± 36.0	188.1 ± 32.4	193.7 ± 37.5	187.9 ± 34.4	$F_{3,306} = .46$ $P = .712$
Triglycerides (mg/dL) (mean, SD)	176.5 ± 70.0	175.7 ± 126.8	208.1 ± 133.1	205.3 ± 102.7	$F_{3,306} = 1.84$ $P = .140$
HDL (mg/dL) (mean, SD)	46.9 ± 11.9	47.2 ± 11.0	45.7 ± 12.4	44.6 ± 9.5	$F_{3,306} = .89$ $P = .445$

Characteristic	AHI			Significance	
	<5 (n = 58)	5–14.9 (n = 115)	15–29.9 (n = 65)	30 (n = 72)	
LDL (mg/dL) (mean, SD)	109.5 ± 27.1	109.1 ± 26.6	111.5 ± 28.9	105.1 ± 26.3	$F_{3,306} = .67$
Glucose (mg/dL) (mean, SD)	99.6 ± 37.5	98.9 ± 24.4	106.6 ± 30.0	110.9 ± 38.2	$P = .571$ $F_{3,306} = 2.58$
GGTP (IU/L) (mean, SD)	40.0 ± 44.3	36.8 ± 29.2	32.4 ± 19.7	45.4 ± 29.1	$P = .054$ $F_{3,306} = 2.17$
AST (IU/L) (mean, SD)	25.1 ± 14.5	24.0 ± 13.3	24.0 ± 11.6	29.5 ± 18.1	$P = .092$ $F_{3,306} = 2.48$
ALT (IU/L) (mean, SD)	25.3 ± 20.9*	24.4 ± 15.3*	25.6 ± 14.0*	33.1 ± 23.7†	$P = .061$ $F_{3,306} = 3.68$
Systolic BP (mm Hg) (mean, SD)	120.6 ± 15.4*	120.7 ± 16.2*	125.8 ± 16.0**†	131.2 ± 19.5†	$P = .013$ $F_{3,306} = 6.94$
Diastolic BP (mm Hg) (mean, SD)	70.8 ± 8.9	69.0 ± 9.5	70.1 ± 9.2	71.9 ± 11.2	$P < .001$ $F_{3,306} = 1.37$
Hypertension (n, %)	7 (11.1)*	22 (19.1)*†	19 (29.2)†‡	28 (38.9)‡	$P = .251$ $\chi^2_{(3)} = 15.48$
Diabetes (n, %)	8 (13.8)	14 (12.2)	14 (21.5)	15 (20.8)	$P < .001$ $\chi^2_{(3)} = 4.06$
Menopause ^a (n, %)	9 (16.1)*†	13 (11.9)*	18 (32.7)†	13 (31.0)†	$P = .255$ $\chi^2_{(3)} = 13.57$
Loud snoring (n, %)	17 (29.3)*	54 (47.0)*†	39 (60.0)†‡	54 (75.0)‡§	$P = .004$ $\chi^2_{(3)} = 30.01$
SpO ₂ (%) (mean, SD)	93.3 ± 2.0*	92.5 ± 1.8*	91.2 ± 2.4†	88.8 ± 4.2‡	$P < .001$ $F_{3,306} = 37.27$
SpO ₂ <90% (mean, SD)	7.5 ± 17.5*	11.3 ± 17.5*	25.7 ± 25.3†	41.9 ± 26.5‡	$P < .001$ $F_{3,306} = 38.65$
SpO ₂ <80% (mean, SD)	.0 ± .0*	.1 ± .4*	1.2 ± 2.3*	7.6 ± 14.8†	$P < .001$ $F_{3,306} = 18.77$

Characteristic	AHI	5–14.9 (n = 115)	15–29.9 (n = 65)	30 (n = 72)	Significance
Previous OSA diagnosis (n, %)	<5 (n = 58)	5–14.9 (n = 115)	15–29.9 (n = 65)	30 (n = 72)	
	2 (6.3) [*]	11 (15.3) [*]	7 (18.9) [*]	20 (39.2) [†]	$\chi^2_{(3)} = 16.01$
					$P < .001$

AHI = apnea-hypopnea index; BMI = body mass index; HbA1c = hemoglobin A1c; HDL = high-density lipoprotein; LDL = low-density lipoprotein; GGTP = gamma-glutamyltransferase; AST = aspartate aminotransferase; ALT = alanine aminotransferase; BP = blood pressure; SpO₂ = oxygen saturation; OSA = obstructive sleep apnea.

Data presented as mean ± standard deviation or numbers of patients, with percentages in parentheses.

^{*,†,‡,§} Cells without common superscripts were significantly different statistically ($P < .05$) using Tukey's HSD post hoc tests or pairwise chi-square test.

[¶] Women only (n = 262).

Table 2

Evaluation of Dixon model using individual prediction criteria and number of criteria met

Individual predictors			Full model						
Dixon's prediction criteria	OR for AHI 15 (95% CI)	P value	Prevalence AHI 15 (n, %)	Prevalence AHI <15 (n, %)	Criteria met (n)	AHI 15 (n = 137)		AHI 30 (n = 72)	
						Sensitivity (%)	Specificity (%)	Sensitivity (%)	Specificity (%)
BMI 45 kg/m ²	2.86 (1.80–4.56)	<.001	89 (65.0)	68 (39.3)	0	100	0	100	0
Age 38 y	1.97 (1.22–3.17)	.005	98 (71.5)	97 (56.1)	1	96.4	21.4	97.2	16.8
Hb1Ac 6%	1.98 (1.20–3.29)	.008	48 (35.0)	37 (21.4)	2	75.2 *	57.2 *	83.3	50.8
Insulin 28 µU/mL	1.69 (.912–3.11)	.096	27 (19.7)	22 (12.7)	3	51.8	82.1	63.9 *	76.5 *
Male gender	8.51 (3.82–18.92)	<.001	40 (29.2)	8 (4.6)	4	28.5	93.6	37.5	90.3
Neck 43 cm	5.67 (3.24–9.93)	<.001	62 (45.3)	22 (12.7)	5	12.4	97.1	16.7	95.8
	—	—	—	—	6	2.2	99.4	4.2	99.6

OR = odds ratio; CI = confidence interval; AHI = apnea-hypopnea index; BMI = body mass index; HbA1c = hemoglobin A1c.

* Best fit (best sensitivity and specificity) for Dixon criteria in those with AHI 15 and AHI 30.

Table 3

Significant predictors of AHI 15 in development sample using ROC analyses and correlations of each predictor with AHI as continuous variable

Variable	AUC (95% CI)	Cutoff	Correlation (<i>P</i> value) with AHI
Neck circumference	.729 (.649–.810)	40.75	.561 (<.001)
Systolic blood pressure	.685 (.601–.768)	123.5	.316 (<.001)
Waist/hip ratio	.682 (.596–.767)	.956	.331 (<.001)
Waist	.675 (.589–.761)	134.4	.348 (<.001)
Glucose	.677 (.593–.761)	96.5	.112 (.167)
Loud snoring	.663 (.577–.749)	—	.376 (<.001)
Age	.649 (.562–.736)	41.5	.182 (.024)
Frequent snoring	.648 (.562–.735)	6.5	.315 (<.001)
Weight (lb)	.637 (.548–.727)	278.5	.347 (<.001)
HbA1c	.617 (.529–.706)	5.65	.123 (.127)
BMI	.616 (.526–.706)	45.17	.252 (.001)
Hypertension	.612 (.522–.702)	—	.267 (.001)
Male gender	.611 (.520–.702)	—	.376 (<.001)

ROC = receiver operating characteristic; AUC = area under curve; CI = confidence interval; AHI = apnea-hypopnea index; BMI = body mass index; HbA1c = hemoglobin A1c.

Table 4

Evaluation of prediction model in development and validation samples^{*}

Criteria met (n)	AHI 15		AHI 30	
	Development sample (n = 155)		Development sample (n = 155)	
	Sensitivity (%)	Specificity (%)	Sensitivity (%)	Specificity (%)
0	100	0	100	0
1	100	7.1	100	5.3
2	100	16.5	100	12.3
3	94.3	36.5	100	30.7
4	88.6	58.8	95.1	49.1
5	77.1 [†]	76.5 [†]	85.4 [†]	65.8 [†]
6	58.6	83.5	68.3	76.3
7	40.0	91.8	51.2	87.7
8	21.4	100	29.3	97.4
9	12.9	100	22.0	100
10	4.3	100	7.3	100

AHI = apnea-hypopnea index.

^{*} Criteria and cutoffs were those included in Table 3, with exception of weight, hypertension, and hemoglobin 1Ac, which were not included owing to redundancy with other criteria.

[†] Best fit (best sensitivity and specificity) for those with AHI 15 and AHI 30.