Diagnostic Properties of the STOP-Bang and Its Modified Version in Screening for Obstructive Sleep Apnea in Thai Patients

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Objective: *To test the diagnostic properties of the original and a modified STOP-Bang, as well as testing the additional use of a waist-to-height ratio (WHtR) of ≥0.55 in screening for obstructive sleep apnea (OSA) in Thai patients.*
Material and Method: *Three hundred and three patients (186 males and 117 females) who underwent anthropometric measurement and standard polysomnography were asked to complete the STOP-Bang questionnaire. Subjects were considered high-risk if their scores were ≥3. Patients with significant co-morbidities were excluded.*
Results: *Screening for OSA involved measurements of STOP-Bang sensitivity, specificity, positive predictive value, and negative predictive value at several apnea-hypopnea index (AHI) cut-off points. At AHI 5, these values were 87.3%, 48.1%, 82.2%, and 52.2%, respectively. At AHI 15, these values were 92.6%, 36.4%, 58.5%, and 83.6%, respectively. The modified STOP-Bang (using a cut-off of BMI >30 kg/m^2) showed slightly increased sensitivities at the AHI cut-off points of 5 and 15 with values of 88.7% and 93.2%, respectively, with improved area under the curves. Furthermore, by applying the WHtR of ≥0.55 to those patients who were classified as high-risk by the questionnaires, the specificities for predicting OSA were improved to 85.2% and 76.1% for the aforementioned cut-off points, respectively.*
Conclusion: *Both STOP-Bang and its modified version were highly sensitive measures for OSA screening in medical or dental clinics. However, the modified version might be more suitable for Thais and Asians, and the additional use of WHtR ≥0.55 might be useful for reducing the unnecessary sleep investigation or management in those who were classified as high-risk patients.*

Keywords: *Screening, Obstructive sleep apnea (OSA), STOP-Bang, Modified STOP-Bang, waist-to-height ratio (WHtR), Thai patients*

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The prevalence of obstructive sleep apnea (OSA) in middle-aged adults is approximately 24% for males and 9% for females[1], and may be as high as one-third of patients in primary care clinics[2]. Nevertheless, more than 80% of patients with moderate to severe OSA are possibly undiagnosed[3], leading to the risk of several health consequences, including impaired quality of life[4,5], hypertension[6], and cardiovascular diseases[6,7]. Although overnight, technician-attended polysomnography (PSG) performed in a sleep laboratory remains the gold standard test for diagnosis[8], its high cost, long waiting list, and limited accessibility have made it impractical for OSA screening. This is particularly true for busy medical and dental clinics or preoperative areas where there is a potentially high prevalence of undiagnosed OSA[2,9]. In these situations, a simple and reliable screening tool is desirable for identifying high-risk patients, so that appropriated investigations or preventative care programs can be implemented in a timely manner.

Several methods, including questionnaires and clinical models, have been developed and validated for predicting OSA in various populations[10,11]. However, most of these have numerous items and use relatively complicated scoring systems, and some require computer assistance for mathematical calculations, making them unattractive for widespread use. Although there is currently no consensus as to which method is the best, a set of yes-or-no questionnaires termed the STOP-Bang has become one of the most popular screening tools for identifying OSA patients, because it is simple for physicians to remember and can be finished by patients within five minutes[9,10,12-17]. According to the guidelines of

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the original version, all items are phrased in English at a fifth-grade reading level (using the Flesch-Kincaid determination method)[13]. Therefore, these items are straightforward, making translation into other languages relatively easy. A STOP-Bang score of 3 out of 8 has been considered highly sensitive for distinguishing patients with OSA from those without OSA, which was comparable to the Berlin questionnaire, particularly for surgical patients[18]. Nonetheless, its specificity was reported as less than 50%, resulting in a high false-positive rate in patients with moderate to severe OSA[12,13,16,19].

To improve the accuracy of STOP-Bang, addition of serum bicarbonate levels or use of a higher cut-off score has been proposed[19,20]. However, administering blood tests along with the questionnaires reduces its applicability, especially in new patients whose serum electrolyte reports may not be available. Data from the authors' previous study showed that a waist-to-height ratio (WHtR), a simple proportion of waist circumference divided by height, at a cut-off point of $\geq$0.55 was a good predictor of moderate to severe OSA in snoring patients and better than other physical findings such as pharyngeal characteristics and cervical measurement[21]. This proportion-WHtR, potentially represents central obesity or visceral fat levels better than body mass index (BMI), which neither distinguishes between muscle and fat accumulation nor provides information on fat distribution. The WHtR has also been reported by several studies as a useful parameter for predicting risks of mortality in cardiovascular events and metabolic syndromes[22-24]. Thus, incorporation of this simple parameter into the STOP-Bang may be an interesting option for improving OSA screening, which so far has not been investigated. In addition, a previous report has shown that Asians may exhibit sleep apnea even at lower BMIs and that using a BMI cut-off point of 30 kg/m^2 in the STOP-Bang should be considered[15]. The objectives of the present study were, therefore, to test the diagnostic properties of the STOP-Bang and its modified version, as well as test the additional use of a WHtR of $\geq$0.55 in screening for OSA in Thai patients. The authors believed that the result will be useful for not only Thai patients but also for other East Asians, who have comparable anthropometric features.

Material and Method

The presented study was conducted at Siriraj Hospital between February 2012 and July 2013, after obtaining approval from the Siriraj Institutional Review Board (SIRB). All participants were given an explanation of the study procedures before they signed the consent forms.

Subjects

Three hundred and three consecutive patients suspicious of having OSA (186 males and 117 females, aged $\geq$18 years old) whom underwent polysomnography (PSG) were recruited from the snoring clinic at Department of Oto-rhino-laryngology, Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand. Pregnant women, regular shift workers, or patients who had significant co-morbid medical conditions such as congestive heart failure, severe pulmonary disease, and neuromuscular disease were not included in this study. Any patients whose PSG reports had a total sleep time of less than two hours or had no rapid eye movement sleep were excluded from the study. Demographic data including age, sex, weight, height, neck circumference (NC), and waist circumference (WC) of all patients were routinely recorded by a trained nurse-assistant who was not aware of the PSG results under a standardized technique. Body weight and height were recorded while patients were wearing light clothes and no shoes. BMI was then calculated using the formula of weight (kg) divided by height in meter squared (m^2). The NC was measured with a cord tape at the cricoid level while patients were in an upright position. The WC was measured using the same cord tape at the umbilical level at the end of expiration while patients were standing. Waist-to-height ratio (WHtR) was calculated as WC (cm) divided by height (cm). All patients were asked to complete questionnaires regarding sleep habits and related medical history, Epworth Sleepiness Scale (ESS)[25], and the STOP-Bang questionnaire after their neck circumferences and BMI were provided by the nurse who recorded these data. Fifty patients were asked to repeat the STOP-Bang questionnaire twice at two to four weeks apart to check the test-retest reliability. Patients were further classified by their apnea-hypopnea index (AHI) as primary snoring (AHI = 0-4.99), mild OSA (AHI = 5-14.99), moderate OSA (AHI = 15-29.99), and severe OSA (AHI $\geq$30)[8].

Polysomnography

All patients underwent an overnight technician-attended standard full PSG, (Compumedics, Somte, Profusion III; Victoria, Australia) at Siriraj

Hospital. Apnea and hypopnea were defined according to standard criteria recommended by the American Academy of Sleep Medicine (2007), first version[26]. Both technologists and sleep specialists were blinded to patients' information regarding STOP-Bang and ESS scores.

Original and modified STOP-Bang

The STOP-Bang questionnaire consists of eight items regarding the presence or absence of loud snoring (S), daytime tiredness (T), observed apnea (O), high blood pressure (P), BMI of >35 kg/m^2 (B), age >50 years (A), neck circumference of >40 cm (N), and male gender (G). The original version consisted of only self-report questions or the "STOP" questionnaire, which was developed and validated for preoperative screening of OSA[13,18]. In the present study, the authors also modified the STOP-Bang by using a BMI cut-off of 30 kg/m^2 (modified STOP-Bang)[15] and added questions on the presence or absence of WHtR ≥0.55 to the STOP-Bang to determine whether these changes would improve diagnostic properties for OSA screening in Thai patients who were suspicious of having OSA. Forward translation from its original English into Thai for the presented study was kindly permitted and advised by the questionnaire developer (Dr. Frances Chung). Backward translation of the Thai version into English was approved by another native English speaker that the final Thai version (see appendix) had an acceptable meaning very close to its original.

Statistical methods

Continuous data were presented as mean ± standard deviations (SD) and categorical data were presented as frequencies and percentages (%). One-way analysis of variance (ANOVA) was used to compare means between different groups, and Chi-square tests or Fisher's exact test were used to compare between dichotomous variables. The diagnostic properties of the original and modified STOP-Bang in the diagnosis of OSA, compared with the gold standard of PSG, were described with sensitivity, specificity, positive predictive values (PPV), and negative predictive values (NPV) with 95% confidence intervals (CI) at typical AHI cut-off points of 5, 15, and 30. To compare the diagnostic properties between the different screening models, the area under the curve (AUC) of receiver operating characteristics (ROC) were calculated. To measure the test-retest reliability of the STOP-Bang questionnaire at different time intervals, the intra-class correlation coefficient (ICC) was used. The computer program used for calculation was the Predictive Analytics Software (PASW) Statistics version 18.0 (New York, USA). The significance level was set at $p<0.05$ in 2-tailed tests. Tests for internal consistency were not applicable because each item of the questionnaire represented different aspects of the disease.

Results

Three hundred and three consecutive patients, 186 males and 117 females, with ages ranging from 20 to 76 years were recruited from the sleep clinic at Siriraj Hospital. Eighty-one and 202 patients were classified as non-OSA and OSA, respectively. Important demographic data and the sleep parameters of patients among different severities of OSA were shown in Table 1. Most of the parameters, except for age and ESS scores, had statistically significant differences between groups of patients. The means of the STOP and STOP-Bang scores significantly increased accordingly with the severity of OSA. The frequencies of positive responses in each of the items of the questionnaires compared between OSA and non-OSA are shown in Table 2. For most items, there were statistically significant differences between both groups, except for the questions regarding tiredness or fatigue during daytime (T) and age of >50 years (A). The properties of the original and modified STOP-Bang compared with the gold standard test for diagnosis of OSA at AHI cut-off points of 5, 15, and 30 are presented in Table 3-5. The modified STOP-Bang, which applied a BMI cut-off point at >30 kg/m^2, had the highest sensitivity and AUC, while the addition of WHtR ≥0.55 as a criterion to the STOP and STOP-Bang yielded the highest specificity among the various models in screening for OSA across all AHI cut-off points. The ROC curve between the STOP, STOP-Bang, and modified STOP-Bang (BMI >30) are demonstrated in Fig. 1-3. The test-retest reliability of the STOP-Bang questionnaire in 50 patients was excellent, as shown by an ICC of 0.95 (95% CI; 0.91-0.99).

Discussion

In settings such as medical or dental clinics, preoperative areas, and primary care settings where there are potentially high prevalence of undiagnosed OSA[2,9], but the availability of PSG is very limited, a simple and reliable screening tool would be desirable for identifying patients at high risk of OSA for appropriate management. Although some instruments

Table 1. Demographic data of patients among different severities of OSA

	Non-OSA (n = 81)	Mild OSA (n = 73)	Moderate OSA (n = 52)	Severe OSA (n = 97)	p-value
Age (year)	49.4±11.5	50.2±11.3	51.2±11.5	47.6±12.5	0.596
BMI (kg/m^2)	24.4±4.0	26.1±4.9	28.4±4.9	31.1±6.3	<0.001[a]
ESS scores	8.7±4.5	9.5±5.3	9.7±4.5	10.6±4.8	0.07
Neck circumference (cm)	34.2±3.2	36.3±4.0	37.9±3.5	39.8±4.6	<0.001[a]
Waist circumference (cm)	84.0±10.4	89.3±12.2	96.3±13.2	102.9±13.7	<0.001[a]
Height (cm)	161.6±7.6	164.2±8.6	164.7±8.3	167.0±8.6	<0.001[a]
Waist-to-height ratio	0.52±0.06	0.54±0.07	0.59±0.08	0.62±0.09	<0.001[a]
Total sleep time (min)	375.2±63.7	363.1±79.3	375.9±78.0	331.8±120.3	0.018[b]
Sleep efficiency (%)	83.3±11.7	81.1±12.9	83.9±10.2	82.0±12.2	0.494
Stage N1 (%)	17.3±11.8	20.1±9.6	24.5±10.6	40.5±20.3	<0.001[a]
Stage N2 (%)	49.1±9.8	48.0±10.0	47.8±10.6	38.6±14.3	<0.001[a]
Stage N3 (%)	13.7±8.6	13.8±8.2	12.3±7.9	7.1±9.5	<0.001[a]
Stage R (%)	19.5±5.8	17.2±6.4	14.6±5.6	13.5±7.9	<0.001[a]
AHI (events/hour)	1.9±1.5	9.6±2.8	22.5±4.4	62.6±25.9	<0.001[a]
Minimal O_2 (%)	90.0±3.5	83.6±5.0	77.5±8.6	65.1±14.9	<0.001[a]
STOP scores	1.7±1.1	2.1±1.1	2.4±1.1	2.9±0.9	<0.001[a]
STOP-Bang scores	2.6±1.4	3.6±1.4	4.2±1.5	5.1±1.5	<0.001[a]

OSA = obstructive sleep apnea; BMI = body mass index; ESS = Epworth sleepiness scales; N = non-rapid eye movement sleep; R = rapid eye movement sleep; AHI = apnea-hypopnea index; O_2 = oxygen saturation
The data are presented in mean ± standard deviation
[a] The mean difference is significant at the level of <0.001 (2-tailed)
[b] The mean difference is significant at the level of <0.05 (2-tailed)

Table 2. Positive responses in each question compared between OSA and non-OSA

Questions	Non-OSA, n (%)	OSA, n (%)	p-value
Snoring (louder than talk)?	43 (14.2)	96 (64.7)	<0.001[a]
Tired or fatigue?	49 (16.2)	154 (50.8)	0.146
Observed apnea?	23 (7.6)	114 (37.6)	<0.001[a]
Pressure: hypertension?	20 (6.6)	99 (32.7)	0.002[b]
BMI >35 kg/m^2?	2 (0.7)	31 (10.2)	0.004[b]
Age >50 years?	35 (11.6)	112 (37.0)	0.264
Neck circumference >40 cm?	3 (1.0)	77 (25.4)	<0.001[a]
Gender: male?	31 (10.2)	155 (51.2)	<0.001[a]
BMI >30 kg/m^2?	5 (1.7)	71 (23.4)	<0.001[a]
WHtR ≥0.55?	15 (5.0)	136 (44.9)	<0.001[a]

OSA = obstructive sleep apnea; BMI = body mass index; WHtR = waist to height ratio
The data are presented in frequencies (percentages)
[a] The mean difference is significant at the level of <0.001 (2-tailed)
[b] The mean difference is significant at the level of <0.05 (2-tailed)

such as the Berlin questionnaire have been validated for prediction of OSA among various populations[11,18,27], their scoring systems may be confusing and difficult to remember, which have made them relatively unattractive. The STOP-Bang questionnaire, which is easier to use and remember, may be more suitable in

Table 3. Properties of Stop-Bang and its modification compared to gold standard polysomnography in diagnosis of obstructive sleep apnea at AHI cut-off point ≥5

	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	AUC (95% CI)
STOP ≥2	82.4 (76.6-87.1)	48.1 (37.0-59.5)	81.3 (75.5-86.1)	50.0 (38.6-61.4)	0.709 (0.644-0.775)
STOP-Bang ≥3	87.3 (82.1-91.3)	48.1 (37.0-59.5)	82.2 (76.6-86.7)	58.2 (45.5-69.9)	0.784 (0.728-0.839)
Modified STOP-Bang ≥3	88.7 (83.6-92.4)	48.1 (37.0-59.5)	82.4 (76.9-86.9)	60.9 (47.9-72.6)	0.795 (0.741-0.849)
STOP ≥2 plus WHtR ≥0.55	51.8 (45.0-58.5)	85.2 (75.2-91.8)	90.6 (83.7-94.8)	39.2 (32.0-46.9)	0.685 (0.621-0.749)
STOP-Bang ≥3 plus WHtR ≥0.55	55.0 (48.2-61.6)	85.2 (75.2-91.8)	91.0 (84.6-95.1)	40.8 (33.4-48.7)	0.701 (0.638-0.763)

AHI = apnea-hypopnea index; PPV = positive predictive value; NPV = negative predictive value; AUC = area under curve; CI = confidence interval; WHtR = waist to height ratio
The data of sensitivity, specificity, PPV, and NPV are presented in percentages

Table 4. Properties of Stop-Bang and its modification compared to gold standard polysomnography in diagnosis of obstructive sleep apnea at AHI cut-off point ≥15

	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	AUC (95% CI)
STOP ≥2	89.3 (82.9-93.5)	40.3 (32.5-48.5)	59.1 (52.4-65.5)	79.5 (68.5-87.5)	0.720 (0.662-0.777)
STOP-Bang ≥3	92.6 (86.9-96.0)	36.4 (28.9-44.5)	58.5 (51.9-64.8)	83.6 (72.1-91.1)	0.787 (0.736-0.837)
Modified STOP-Bang ≥3	93.2 (87.7-96.6)	35.0 (27.7-43.2)	58.2 (51.6-64.4)	84.4 (72.7-91.9)	0.796 (0.746-0.845)
STOP ≥2 plus WHtR ≥0.55	65.1 (56.8-72.6)	80.5 (73.2-86.3)	76.4 (67.9-83.3)	70.5 (63.0-77.0)	0.728 (0.670-0.786)
STOP-Bang ≥3 plus WHtR ≥0.55	68.5 (60.3-75.7)	79.2 (71.8-85.2)	76.1 (67.8-82.9)	72.2 (64.7-78.7)	0.738 (0.681-0.796)

AHI = apnea-hypopnea index; PPV = positive predictive value; NPV = negative predictive value; AUC = area under curve; CI = confidence interval; WHtR = waist to height ratio
The data of sensitivity, specificity, PPV, and NPV are presented in percentages

Table 5. Properties of Stop-Bang and its modification compared to gold standard polysomnography in diagnosis of obstructive sleep apnea at AHI cut-off point ≥30

	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	AUC (95% CI)
STOP ≥2	95.9 (89.2-98.7)	35.9 (29.5-42.9)	41.3 (34.9-48.1)	94.9 (86.7-98.3)	0.735 (0.724-0.832)
STOP-Bang ≥3	96.9 (90.6-99.2)	31.1 (24.9-37.9)	39.8 (33.6-46.4)	95.5 (86.6-98.8)	0.793 (0.740-0.845)
Modified STOP-Bang ≥3	96.9 (90.6-99.2)	29.6 (23.6-36.4)	39.3 (33.2-45.9)	95.3 (86.0-98.8)	0.796 (0.744-0.848)
STOP ≥2 plus WHtR ≥0.55	74.4 (64.7-82.3)	73.3 (66.6-79.1)	56.7 (47.6-65.4)	85.8 (79.6-90.4)	0.738 (0.676-0.799)
STOP-Bang ≥3 plus WHtR ≥0.55	75.3 (65.3-83.2)	70.4 (63.6-76.4)	54.5 (45.7-63.0)	85.8 (79.4-90.5)	0.728 (0.667-0.790)

AHI = apnea-hypopnea index; PPV = positive predictive value; NPV = negative predictive value; AUC = area under curve; CI = confidence interval; WHtR = waist to height ratio
The data of sensitivity, specificity, PPV, and NPV are presented in percentages

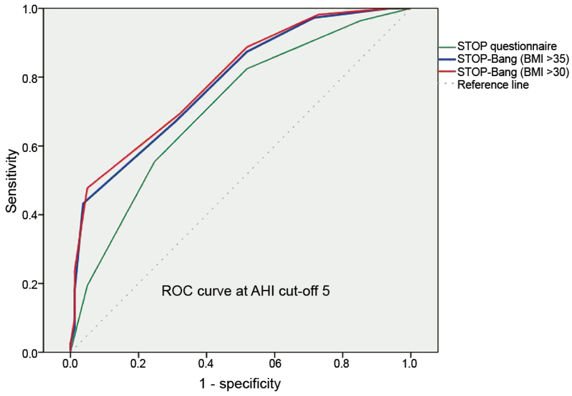

Fig. 1 Receiver operating characteristics (ROC) comparing of STOP, STOP-Bang, and modified STOP-Bang (BMI 30) at AHI cut-off point at 5.

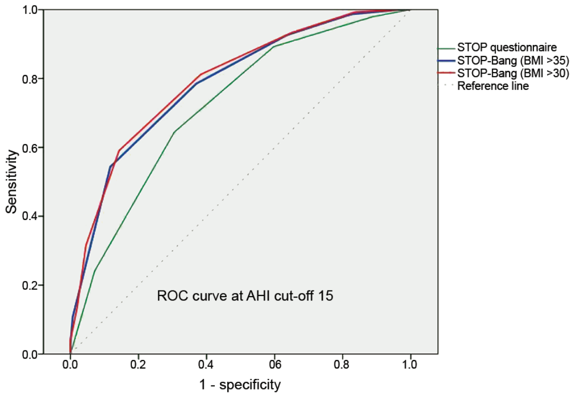

Fig. 2 Receiver operating characteristics (ROC) comparing of STOP, STOP-Bang, and modified STOP-Bang (BMI 30) at AHI cut-off point at 15.

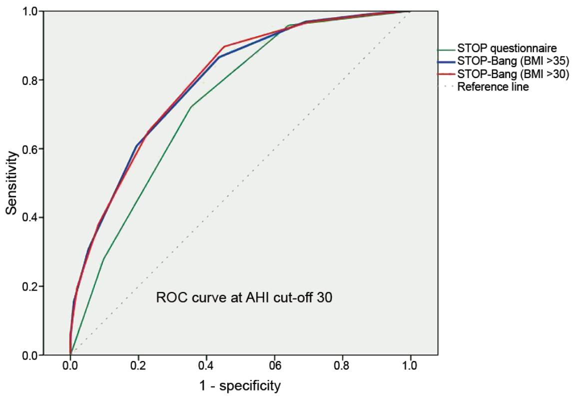

Fig. 3 Receiver operating characteristics (ROC) comparing of STOP, STOP-Bang, and modified STOP-Bang (BMI 30) at AHI cut-off point at 30.

these contexts. The present study confirmed that the STOP, STOP-Bang, and the modified STOP-Bang (with a BMI cut-off point of >30 kg/m^2) were excellent in the detection of OSA in Thai patients referred to sleep clinic; the authors' results were comparable to the original report on the validation of the STOP-Bang by Chung et al[13] as well as several subsequent studies among various populations[10,12,15,18]. The sensitivities and NPV of these questionnaires (STOP score ≥2 or STOP-Bang score ≥3) in the diagnosis of moderate to severe OSA patients ranged from 89.3% to 96.9% and 79.5% to 95.5%, which are considered very high values. This means if patients were classified as low-risk by this screening tool, the possibility of having moderate to severe OSA could be excluded with high confidence. Among these screening tools, the modified STOP-Bang (BMI >30 kg/m^2) had the best diagnostic properties, as demonstrated by its highest sensitivities and AUC in screening for OSA at all AHI cut-off points. These results are in agreement with the report of Ong et al in Asian patients referred to a sleep disorder unit[15]. Therefore, the authors recommend routine use of the modified STOP-Bang, which is easier to remember for Asian populations referred to sleep clinic who possibly have comparable anthropometric features with Thais.

Although the sensitivity of the STOP, STOP-Bang, and modified STOP-Bang were considered very high, their specificities were somewhat poor, ranging from 29.6% to 48.1%, indicating high false-positive rates. This is similar to other reports[13,15,16,18,20]. Thus, using only these questionnaires to screen for OSA may not sufficiently prevent unnecessary or excessive investigations. To solve this problem, some authors have proposed the additional use of sodium bicarbonate levels as a second step to increase diagnostic accuracy[20]. However, this electrolyte data is often unavailable, and requesting additional blood tests for this purpose may be inconvenient for some patients. Instead, the authors used a criterion of a WHtR ≥0.55 in conjunction with the STOP and STOP-Bang as an additional measure and found that it increased the specificities of OSA diagnosis up to 85.2%, which was comparable measure to sodium bicarbonate level at a cut-off of 28 mmol/L[20]. Since WHtR is a very simple proportion of waist circumference divided by height, which were better than other physical findings such as pharyngeal characteristics and cervical measurement in predicting of moderate to severe OSA and also reported as a useful predictor of other metabolic syndromes[22-24], the author recommend its use in high-risk patients as classified by the STOP or modified STOP-Bang questionnaires to decrease the possibility of having false-positive results. Prioritizing this group of patients for sleep investigation and initiating treatment seems reasonable, particularly for situations with limited medical facilities.

The means of STOP and STOP-Bang scores in the authors' study increased significantly as OSA severity increased. Patients with higher scores on both questionnaires tended to have more severe forms of OSA, which was in accordance with the present study by Chung et al in preoperative patients[19]. The positive responses of patients to most items of the STOP-Bang questionnaire, including its modification, were significantly greater in OSA than non-OSA groups. Nevertheless, their responses to questions regarding tiredness or fatigue during daytime (T) and age of >50 years (A) were not different between both groups, which was also found in the ESS scores. Although there was a trend in ESS scores to be higher in patients with more severe forms of OSA, its accuracy in screening for OSA was limited, which was in accordance with previous studies[25,28]. This poor relationship between daytime sleepiness and OSA severity may be explained by the complexity of sleep-wake mechanisms such as night-to-night variability of sleep physiology, degrees of sleep deprivation, consumptions of caffeinated beverages, and the effects of comorbid psychological or medical diseases[28,29].

There were some potential limitations in the present study. First, the validation processes of questionnaires were done in sleep clinic patients who were possibly preselected as a high-risk group for OSA, therefore the authors' results may not be representative of the general population. However, the prevalence of OSA (AHI >5 diagnosed by PSG) in the present study was comparable to those of preoperative patients reported by Chung et al[13] as well as those of a sleep disorder unit reported by Ong et al[15]. Thus, the application of STOP, STOP-Bang, and the modified STOP-Bang are possibly more useful for patients in similar clinical settings where the prevalence of OSA is expected to be high, and a diagnosis of OSA would be important, such as hospitals or medical offices crowded with patients who have hypertension, morbid obesity, diabetes mellitus, metabolic syndromes, and cardiovascular disease. A further limitation is that the WHtR cut-off point of ≥0.55 used in the presented study may not be similar to those recommended in Western populations, where obesity is more prevalent[30]. Nonetheless, this value comes from the best point of the ROC curve in the authors' previous study[21], and it also falls within the range suggested by some authors (0.5 to 0.6)[22,24]. Future research is required to determine whether similar results or cut-off points are consistent across different populations.

An ideal diagnostic test in screening for OSA in a healthy population should have a high sensitivity to exclude patients at low risk while having an acceptable specificity to prevent excessive investigation. It should also be inexpensive and easy to remember and score. The present study showed that the STOP-Bang and its modified version, at a score of ≥3, were very sensitive in ruling out patients with OSA, but were relatively non-specific. However, the use of WHtR as a complementary measure decreased the false-positive rates and may help clinicians or dentists to confirm that high-risk patients, as classified by the questionnaire, are worth of further investigations such as PSG or portable sleep monitoring. Further validation studies in various populations, particularly for the general population, are required. However, the authors believed that the combination of these questionnaires might facilitate rapid diagnosis and management of OSA patients.

Conclusion

The present study confirmed both STOP-Bang and its modified version are highly sensitive measures for OSA screening in busy medical or dental clinics. However, the routine use of the modified version with a lower BMI cut-off point (30 kg/m^2) may be more suitable for Asians. In addition, the use of a WHtR of ≥0.55, as a second step, may be helpful in determining whether those patients classified as high-risk should proceed through further sleep investigation or management.

What is already known on this topic?

Although several methods, including questionnaires and clinical models, have been developed and validated for predicting OSA in various populations, most of these have numerous items and use relatively complicated scoring systems making them unattractive for widespread use. The STOP-Bang has become one of the most popular screening tools for identifying OSA patients, because it is simple for physicians to remember and can be finished by patients within five minutes. Nonetheless, its specificity was reported as less than 50%, resulting in a high false-positive rate in patients with moderate to severe OSA.

What this study adds?

The presented study confirmed that both STOP-Bang and its modified version are highly sensitive measures for OSA screening in busy medical or dental clinics. However, the routine use of the modified version with a lower BMI cut-off point (30 kg/m^2) may be more suitable for Asians. In addition, the use of a WHtR of $\geq$0.55, as a second step, may be helpful in determining whether those patients who are already classified as high-risk should proceed through further sleep investigation or management.

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Potential conflicts of interest

None.

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Appendix. STOP-Bang scoring model

แบบประเมินภาวะหยุดหายใจขณะหลับ STOP-Bang ฉบับภาษาไทย

ส่วนสูง ________________ *ซม., น้ำหนัก*_________________ *กก.*

เพศ ❐ *ชาย* ❐ *หญิง*

*เส้นรอบวงคอ*_________________*ซม.*

1. Snoring	
คุณนอนกรนดังหรือไม่ ? (ดังกว่าเสียงพูด หรือ ดังพอที่จะได้ยินออกไปนอกห้อง)	❐ *ใช่* ❐ *ไม่ใช่*
2. Tired	
คุณมักจะรู้สึกอ่อนเพลีย ล้า หรือ ง่วงนอนในระหว่างกลางวันบ่อยๆ หรือไม่?	❐ *ใช่* ❐ *ไม่ใช่*
3. Observed	
มีคนเคยสังเกตเห็นว่าคุณหยุดหายใจขณะที่คุณหลับอยู่หรือไม่?	❐ *ใช่* ❐ *ไม่ใช่*
4. Blood pressure	
คุณมีความดันโลหิตสูง หรือกำลังรักษาโรคความดันโลหิตสูงอยู่ หรือไม่?	❐ *ใช่* ❐ *ไม่ใช่*
5. BMI	
ดัชนีมวลกายมากกว่า 35 หรือไม่?	❐ *ใช่* ❐ *ไม่ใช่*
6. Age	
อายุมากกว่า 50 ปี หรือไม่?	❐ *ใช่* ❐ *ไม่ใช่*
7. Neck circumference	
เส้นรอบวงคอมากกว่า 40 ซม. หรือไม่?	❐ *ใช่* ❐ *ไม่ใช่*
8. Gender	
เป็นเพศชายหรือไม่?	❐ *ใช่* ❐ *ไม่ใช่*

High risk of OSA: answering yes to three or more items

Low risk of OSA: answering yes to less than three items

คุณสมบัติด้านการวินิจฉัยของแบบประเมิน STOP-Bang และแบบดัดแปลงของ STOP-Bang ในการตรวจคัดกรองภาวะหยุดหายใจขณะหลับชนิดอุดกั้นในคนไทย

วิชญ์ บรรณหิรัญ, อนุช ดุรงค์พันธ์, ช่อเพชร สาลีสิงห์, จีระสุข จงกลวัฒนา

วัตถุประสงค์: *การศึกษานี้มีจุดประสงค์เพื่อทดสอบคุณสมบัติด้านการวินิจฉัยของแบบประเมิน STOP-Bang และแบบดัดแปลงของ STOP-Bang ซึ่งรวมถึงการใช้สัดส่วนรอบเอวต่อส่วนสูงที่มากกว่า 0.55 ในการตรวจคัดกรองภาวะหยุดหายใจขณะหลับชนิดอุดกั้นในคนไทย*

วัสดุและวิธีการ: *ในการศึกษานี้ มีผู้ป่วยจำนวน 303 ราย (ชาย 186 ราย และหญิง 117 ราย) ซึ่งได้รับการตรวจวัดทางร่างกายและทดสอบการนอนหลับเข้าร่วมโครงการ โดยทุกรายจะได้รับการขอความร่วมมือเพื่อตอบแบบประเมิน STOP-Bang ผู้ป่วยที่มีค่าคะแนนอย่างน้อย 3 คะแนน จากแบบประเมินนี้จะถือว่าเป็นกลุ่มที่มีความเสี่ยงสูงต่อโรค ผู้ป่วยที่มีโรคประจำตัวรุนแรงจะได้รับการคัดกรองออกจากการศึกษา*

ผลการศึกษา: *ที่เกณฑ์การวินิจฉัยภาวะหยุดหายใจขณะหลับชนิดอุดกั้น (OSA) ด้วยค่าดัชนีการหยุดหายใจและหายใจแผ่ว (apnea-hypopnea index; AHI) อย่างน้อย 5 ครั้งต่อชั่วโมง พบว่าคุณสมบัติของแบบประเมิน STOP-Bang ในด้านต่าง ๆ คือ sensitivity, specificity, positive predictive value และ negative predictive value เป็นร้อยละ 87.3, 48.1, 82.2 และ 52.2 ตามลำดับ แต่หากใช้เกณฑ์ AHI 15 จะพบว่าค่าคุณสมบัติดังกล่าวอยู่ที่ร้อยละ 92.6, 36.4, 58.5 และ 83.6 ตามลำดับ สำหรับแบบดัดแปลงของ STOP-Bang ซึ่งในค่าดัชนีมวลกายที่ 30 กิโลกรัมต่อตารางเมตร เป็นจุดตัด จะพบว่ามีคุณสมบัติของการวินิจฉัยดีขึ้นซึ่งดูจากพื้นที่ใต้กราฟเพิ่มขึ้น โดยเฉพาะอย่างยิ่งจะพบว่าค่า sensitivity จะสูงขึ้นกว่าเป็นร้อยละ 88.7 และ 93.2 ที่จุดตัด AHI 5 และ 15 ตามลำดับ นอกจากนี้พบว่าหากใช้สัดส่วนรอบเอวต่อส่วนสูงมากกว่า 0.55 มาใช้ในผู้ป่วยที่ถูกจัดอยู่ในเกณฑ์ความเสี่ยงสูงต่อโรคจะพบว่า ค่า specificity ในการพยากรณ์การเป็นโรค OSA จะเพิ่มขึ้นเป็นร้อยละ 85.2 และ 76.1 ที่จุดตัด AHI 5 และ 15 ตามลำดับ*

สรุป: *ทั้งแบบประเมิน STOP-Bang ต้นฉบับและแบบดัดแปลง มีคุณสมบัติการวินิจฉัยที่ดีโดยเฉพาะอย่างยิ่งในส่วนของ sensitivity ในการตรวจคัดกรอง OSA ในคลินิกเวชกรรม อย่างไรก็ตามแบบดัดแปลงของ STOP-Bang อาจมีความเหมาะสมสำหรับคนไทยและเอเชียมากกว่า นอกจากนี้การใช้สัดส่วนรอบเอวต่อส่วนสูงมากกว่า 0.55 ยังมีประโยชน์ในการช่วยลดการตรวจเพิ่มเติมที่ไม่จำเป็นในผู้ป่วยที่มีความเสี่ยงสูงต่อ OSA อีกด้วย*