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Real-world STOPBANG: how useful is STOPBANG for sleep clinics?

Keun Tae Kim [1] · Yong Won Cho [1]

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Abstract

Purpose The STOPBANG questionnaire has been widely used for screening obstructive sleep apnea (OSA) due to its time friendly, economic advantages over overnight polysomnography (PSG). The aim of this study was to analyze the usefulness of the items constituting the utility of STOPBANG in a sleep clinic and to establish the best assembly for OSA-screening methods in the Korean population.

Methods We retrospectively analyzed all patients who completed PSG as well as STOPBANG at a sleep center in a tertiary hospital from January 2016 to December 2017. The sensitivity and specificity of STOPBANG and its smaller counterparts (i.e., SOPBAG) were compared.

Results A total of 541 subjects completed PSG and STOPBANG. Two hundred thirty-five patients were diagnosed with OSA (OSA+) and were compared to those who were not (OSA−). The respective scores of STOPBANG in OSA+ versus OSA− were 4.29 ± 1.46 and 2.53 ± 1.48 ($p < 0.001$). There were significant differences in all factors except tiredness and age (SOPBNG). STOPBANG showed sensitivity of 89.1% and specificity of 57.4%. The AUC was 0.809. Excluding tiredness as well as neck circumference (SOPBAG), the AUC was 0.811. The sensitivity and specificity were 71.8% and 77.9%, respectively. The AUC of SOPBAG was neither superior nor inferior to that of STOPBANG.

Conclusion The screening value of STOPBANG for OSA did not perform as expected when compared to PSG for accuracy in Koreans. STOPBANG can be simplified to SOPBAG while maintaining comparable screening performance. It may be practical to consider performing PSGs without the use of the STOPBANG in Korea.

Keywords Obstructive sleep apnea · STOPBANG · Polysomnography · Diagnosis

Introduction

Obstructive sleep apnea (OSA) is a common sleep disorder leading to significant health issues due to the association of OSA with cardiovascular problems, stroke, and neurocognitive dysfunction, as well as a cause of traffic accidents. The reported prevalence of OSA ranged from 9 to 38% depending on target population and ethnic background [1, 2]. The diagnostic gold standard is the overnight polysomnography (PSG). Unfortunately, it is not possible to provide everyone with a PSG due to its time-consuming and financial obligations.

Several assessment tools have been developed to promote expeditious identification of patients at risk for OSA. One of these tools is questionnaires. STOPBANG questionnaires are widely used for detecting OSA [3, 4]. STOPBANG consists of 8 dichotomous items related to the clinical features of sleep apnea. These features include snoring (S), tiredness (T), observed apnea (O), high blood pressure (P), body mass index (BMI) (B), age (A), neck circumference (N), and gender (G).

STOPBANG suggests that a score of 0 to 2 can be classified as low risk for OSA, 3 to 4 is intermediate risk, and 5 to 8 is high risk [4]. A weighted model has been suggested to improve specificity, or to categorize OSA severity [5, 6]. However, the weighted model did not show any clinically significant advantages of sensitivity over the original questionnaire [5]. The proposed weighted models also did not show clinical significance in screening the disease, but rather a correlation between the severity of the disease and the results of the questionnaire [6]. Previous studies showed average AHI (apnea-hypopnea index) > 30, and mild to moderate OSA (AHI from 5 to 30) were under-represented. In addition, most

✉ Yong Won Cho
neurocho@gmail.com

[1] Department of Neurology, Keimyung University School of Medicine, 56 Dalseong-ro, Jung-gu, Daegu 41931, South Korea

of the studies used previous versions (lower than 2.4) of the American Academy of Sleep Medicine (AASM) scoring criteria [3, 6–8]. Although STOPBANG has been validated as an excellent screening tool specifically for OSA globally, there have been few studies confirming this for Koreans [9].

The aims of this study are (1) to analyze the usefulness of the STOPBANG questionnaire for Koreans and (2) to establish a more practical method of screening OSA for Koreans at sleep disorder centers.

Method

Participants

We retrospectively reviewed all consecutive subjects who received a PSG at a sleep clinic in a university hospital from January 2016 to December 2017. After excluding subjects who did not complete STOPBANG, cases including PSG were analyzed and subjects with OSA (OSA+) and without (OSA−) were compared. The diagnosis of OSA was based on AHI ≥ 5, according to the third edition of the International Classification of Sleep Disorders (ICSD-3) [10]. The sensitivity and specificity of STOPBANG and its smaller counterparts (i.e., SOPBAG) were also compared.

This study was approved by the institutional review board of a regional university hospital and patient consent was exempt due to the retrospective nature of the study.

Polysomnography

A standard overnight PSG was performed using the 32-channel Grass-Telefactor Comet digital recording polysomnographic system, which consisted of electroencephalography, submental as well as bilateral tibial electromyogram, electrooculography, electrocardiogram, oximetry, airflow (oronasal thermistor and nasal pressure transducer), snoring (microphone), respiratory effort (thoracic and abdominal), and body position. The PSG data were manually scored according to the AASM guidelines and OSA severity was classified as mild (5 ≤ AHI < 15), moderate (15 ≤ AHI < 30), or severe (AHI ≤ 30) [11].

Statistics

Data analysis was performed using SPSS version 22.0, and $p < 0.05$ was considered statistically significant. Chi-square test, independent *t* test, and Fisher's exact test were used to compare demographic data. Variables are presented as means ± SD. The performance of STOPBANG to diagnose OSA was evaluated using receiver operating characteristic (ROC) curves, and the diagnostic accuracy was measured below the ROC curve (AUC). The AUCs of each STOPBANG item were compared [12].

Results

Subjects and PSG

Of the total 1197 PSGs, we excluded 463 cases with incomplete STOPBANG, 30 non-Koreans, and 161 aged 18 or younger. There were two subjects who underwent PSGs twice. Eventually, 541 subjects were included who completed PSG as well as STOPBANG (Fig. 1). Included subjects visited the sleep center for sleep-disordered breathing (175, 32.35%), insomnia (148, 27.36%), parasomnia (57, 10.54%), hypersomnia (17, 3.14%), and sleep-related movement disorders such as restless legs syndrome (RLS) (144, 26.62%). PSG scores (Table 1) resulted in 238 (43.99%) OSA subjects with AHI ≥ 5. When comparing patients with OSA+ to OSA−, OSA+ showed shorter sleep latency; poorer sleep efficiency; longer N2, N3, and REM; but shorter N1. Minimum and average oxygen saturation was lower in OSA+, in which the AHI and snoring index were higher. There was no significant difference on total sleep time and REM latency. Gender difference in OSA is obvious. There were 296 males and 169 females. The sensitivity of STOPBANG in males was extremely high (97.0% by AHI ≥ 5, 99.0% by AHI ≥ 15); however, specificity was very low (32.3% by AHI ≥ 5, 23.3% by AHI ≥ 15). In females, respective sensitivity and specificity were 69.6% and 75.6% with AHI ≥ 5, 73.5% and 68.7% with AHI ≥ 15. The AUCs were under 0.8 in all settings (in males, 0.765 and 0.784 in AHI ≥ 5 and ≥ 15, respectively; in females, 0.787 and 0.764 in AHI ≥ 5 and ≥ 15, respectively).

Analysis of STOPBANG

Demographic characteristics and STOPBANG scores are presented in Table 2. There was no significant difference in age and alcohol use between OSA+ and OSA−. There were more smokers in OSA+ (34.3% of OSA+ vs. 17.3% of OSA−, $p =$ 0.001). The mean score of STOPBANG in total subjects was 3.43 ± 1.71; the respective scores of OSA+ and OSA− were 4.29 ± 1.46 and 2.53 ± 1.48 ($p < 0.001$). Comparing the STOPBANG scores between OSA+ and OSA−, there were significant differences in all questionnaire items except T and A. BMI showed significant differences between the two groups, but STOPBANG's B (BMI over 35) did not. Upon analyzing the combination of the STOPBANG items, the most ideal combination according to the absence of T and A was reviewed (SOPBNG).

Table 3 shows the performance of STOPBANG according to the cutoff value. For AHI ≥ 5, STOPBANG with cutoff

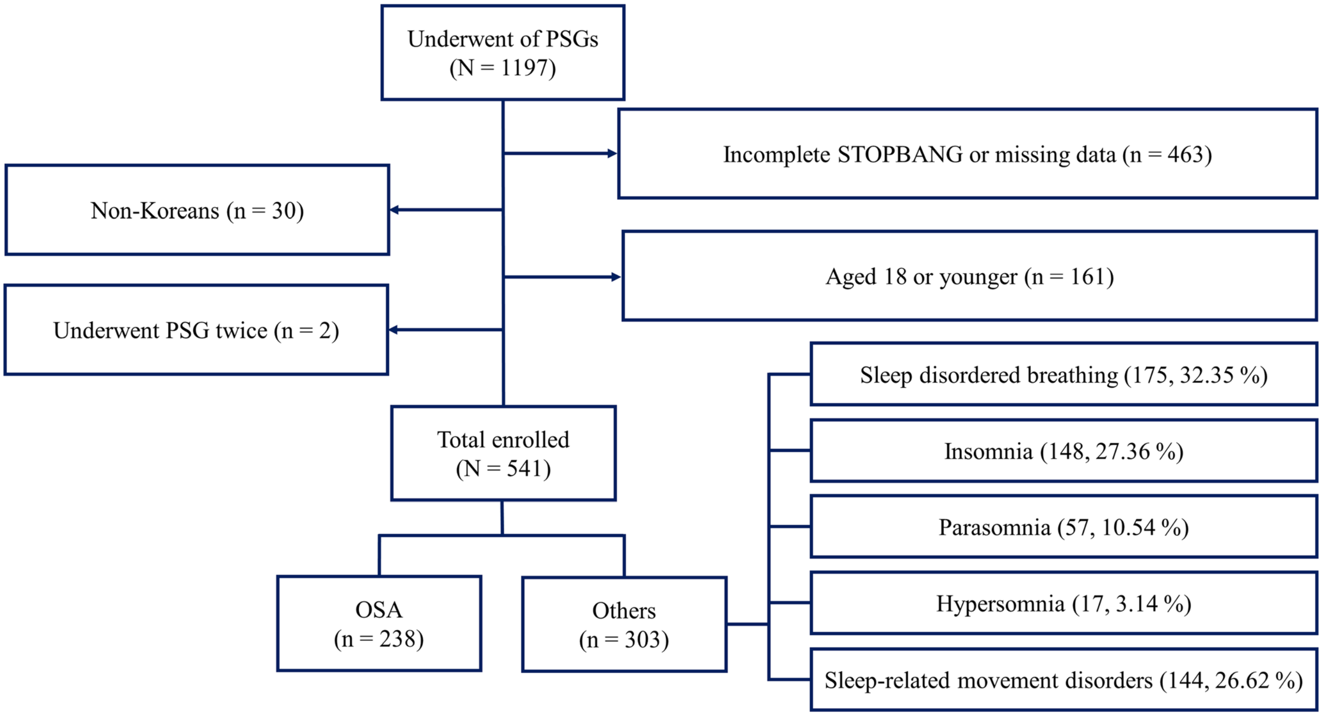

Fig. 1 Diagram of enrolled participants: PSG, polysomnography; OSA, obstructive sleep apnea

value of 2.5 showed sensitivity and specificity of 89.1% and 57.4%, respectively. The AUC was 0.809 (Fig. 2). The positive predictive value (PPV) and negative predictive value (NPV) were 62.2% and 87.0%, respectively. In addition, a cutoff value of 3.5 showed sensitivity and specificity of 64.3% and 82.2%, respectively. The AUC was equal to that of 2.5. The PPV and NPV were 73.9% and 74.6%, respectively. For AHI ≥ 15, STOPBANG with cutoff value of 2.5 showed sensitivity, specificity, and AUC of 92.7%, 47.0%, and 0.808 (Fig. 2), respectively. A cutoff of 3.5 showed lower sensitivity (75.2%) and higher specificity (74.3%). The AUC was equal to that of 2.5. In the logistic analysis of STOPBANG for AHI ≥ 5, T and N showed no significance (Table 4). The values of the combinations of STOPBANG are shown in Table 5 and Fig. 2. For AHI ≥ 5, STOPBANG excluding T (SOPBANG), with cutoff value of 2.5, showed sensitivity and specificity of 72.3% and 77.6%, respectively. The AUC was 0.815. The PPV and NPV were 71.7% and 78.1%, respectively. STOPBANG excluding N (STOPBAG), with cutoff value of 3.5, showed lower AUC (0.805). The sensitivity and specificity were 63.0% and 82.2%, respectively. Excluding T as well as N from STOPBANG (SOPBAG), the sensitivity, specificity, and AUC were 71.8%, 77.9%, and 0.811, respectively, and PPV

Table 1 PSG data

	Total ($n = 541$)	OSA ($n = 238$)	Other sleep disorders ($n = 303$)	p value
Total sleep time	359.41 ± 97.95	367.42 ± 83.63	353.13 ± 107.60	0.083
Sleep latency	23.03 ± 37.12	18.88 ± 31.99	26.29 ± 40.45	0.018
REM latency	120.45 ± 76.67	122.24 ± 78.18	119.05 ± 75.56	0.632
Sleep efficiency	74.31 ± 18.08	76.62 ± 15.84	72.49 ± 19.49	0.007
TST N1	17.64 ± 11.87	23.47 ± 12.89	13.05 ± 8.56	< 0.001
TST N2	51.18 ± 11.06	47.89 ± 10.14	53.77 ± 11.08	< 0.001
TST N3	12.08 ± 8.20	10.84 ± 8.25	13.05 ± 8.04	0.002
TST REM	18.56 ± 7.21	17.71 ± 6.30	19.22 ± 7.79	0.012
Min O2 saturation	84.07 ± 14.68	77.69 ± 16.97	89.08 ± 10.11	< 0.001
Avg O2 saturation	94.18 ± 13.12	92.12 ± 16.28	95.79 ± 9.68	0.002
Snores index	59.21 ± 103.06	94.29 ± 117.99	31.66 ± 79.59	< 0.001
AHI total	13.11 ± 20.53	28.31 ± 23.32	1.18 ± 1.39	< 0.001

PSG overnight polysomnography, *OSA* obstructive sleep apnea, *REM* rapid-eye movement, *TST* total sleep time, *Min* minimum, *Avg* average, *AHI* apnea-hypopnea index

Table 2 Clinical characteristics and scores of STOPBANG

	Total ($n = 541$)	OSA ($n = 238$)	Other sleep disorders ($n = 303$)	p value
Age (years)	52.94 ± 14.22	54.20 ± 14.38	51.95 ± 14.04	0.068
Alcohol (yes, %)	194 (36.4)	96 (40.9)	98 (32.9)	0.058
Smoking (yes, %)	100 (19.0)	61 (26.2)	39 (13.3)	< 0.001
S: snoring (yes, %)	266 (49.2)	168 (70.6)	98 (32.3)	< 0.001
T: tiredness (yes, %)	397 (73.4)	184 (77.3)	213 (70.3)	0.067
O: observed apnea (yes, %)	201 (37.2)	145 (60.9)	56 (18.5)	< 0.001
P: pressure (hypertension) (yes, %)	141 (26.1)	94 (39.5)	47 (15.5)	< 0.001
BMI (kg/m^2)	24.32 ± 3.68	25.83 ± 4.02	23.13 ± 2.88	< 0.001
BMI ≥ 35*	9 (1.7)	8 (3.4)	1 (0.3)	0.012
A: age (> 50, %)	323 (59.7)	146 (61.3)	177 (58.4)	0.491
Neck circumference (cm)	37.80 ± 3.47	39.39 ± 3.47	36.55 ± 2.93	< 0.001
N: neck circumference (m, > 43 cm, f, > 41 cm)	40 (7.4)	32 (13.4)	8 (2.6)	< 0.001
G: gender (male, %)	296 (54.7)	169 (71.0)	127 (41.9)	< 0.001
Total STOPBANG score	3.09 ± 1.48	3.98 ± 1.23	2.40 ± 1.28	< 0.001

*Fisher's exact test results are reported for the contingency tables where at least one expected cell count was below 5. *OSA* obstructive sleep apnea, *BMI* body mass index

and NPV were 71.8% and 77.9%, respectively. The AUCs of SOPBANG (0.815) and SOPBAG (0.811) were not statistically different from that of STOPBANG (0.809) (Table 5). The SOPBAG with cutoff 2.5 shows the best performance with the age cutoff 55.5 (data not shown). For AHI ≥ 15, STOPBANG excluding T (SOPBANG), with cutoff value of 2.5, showed the AUC was 0.823. The sensitivity and specificity were 83.2% and 68.8%, respectively. The PPV and NPV were 47.5% and 92.4%, respectively. STOPBANG excluding N (STOPBAG), with cutoff value of 3.5, showed lower AUC (0.797). The sensitivity and specificity were 73.7% and 74.5%, respectively. In STOPBANG excluding T as well as N (SOPBAG), the cutoff value 2.5 showed the AUC was 0.809. The sensitivity and specificity were 82.5% and 69.1%, respectively. And PPV and NPV were 47.5% and 92.1%, respectively. However, the AUCs of SOPBANG, SOPBAG, and STOPBANG were not statistically different in AHI ≥ 5, even in ≥ 15: for AHI ≥ 5, 0.815, 0.811, and 0.809, respectively; for AHI ≥ 15, 0.797, 0.823, and 0.808, respectively (Table 5). Table 6 shows the performance of the questionnaires according to BMI. For AHI ≥ 5 with BMI > 24.09, the AUC was the best: 0.823. The sensitivity was best (85.3%) with BMI ≥ 23, and the PPV was best with BMI ≥ 30. As presented in Table 5, BMI ≥ 35 provides sensitivity of 71.8% and specificity of 77.9%. For AHI ≥ 15 with BMI ≥ 23, sensitivity, specificity, and AUC were 94.2%, 54.7%, and 0.830 respectively. With BMI ≥ 25, AUC was best at 0.830. However, despite stratifying BMI, there was no significant difference between the AUC of each BMIs and STOPBANG (BMI ≥ 35).

Discussion

Since OSA is a common type of sleep disorder, it is important to predict or dismiss the presence of OSA in the sleep clinic. A common concern faced in sleep clinics is whether sleep apnea is a factor or not. Although the gold standard for diagnosis of OSA is PSG, it has some limitations the questionnaire cannot overcome. There have been numerous studies about sleep questionnaires; however, most studies regarding the

Table 3 STOPBANG for AHI ≥ 5 and ≥ 15

	Cutoff	Sensitivity	Specificity	AUC (95% CI)	PPV (95% CI)	NPV (95% CI)
AHI ≥ 5 ($n = 238$)	2.5	0.891	0.574	0.809 (0.773–0.845)	0.622 (0.594–0.644)	0.870 (0.822–0.909)
	3.5	0.643	0.822	0.809 (0.773–0.845)	0.739 (0.688–0.786)	0.746 (0.714–0.774)
AHI ≥ 15 ($n = 137$)	2.5	0.927	0.470	0.808 (0.768–0.848)	0.372 (0.350–0.386)	0.950 (0.912–0.974)
	3.5	0.752	0.743	0.808 (0.768–0.848)	0.498 (0.451–0.538)	0.898 (0.869–0.923)

AHI apnea-hypopnea index, *AUC* area under the receiver operating characteristic curve, *CI* confidence interval, *PPV* positive predictive value, *NPV* negative predictive value

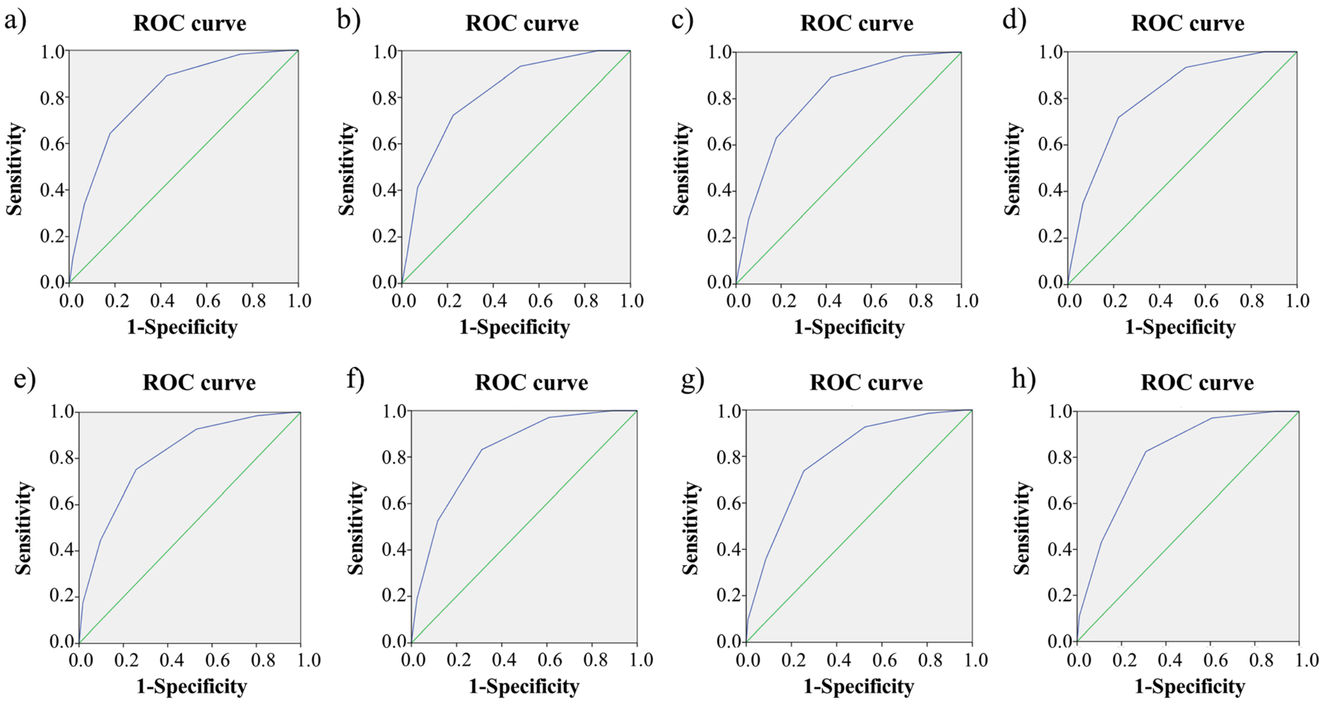

Fig. 2 ROC curve plots. For AHI ≥ 5: **a** STOPBANG, **b** SOPBANG, **c** STOPBAG, **d** SOPBAG; for AHI ≥ 15: **e** STOPBANG, **f** SOPBANG, **g** STOPBAG, **h** SOPBAG. Cutoffs are 2.5, except STOPBAG's which is 3.5. The areas below each curve are not statistically different from that of STOPBANG, detailed in Table 5

performance of questionnaires thus far have only shown comparisons between patients with and without sleep apnea [8, 13]. There is a difference between sampling the general population versus screening patients who specifically visited a clinic to see a doctor. Moreover, there is only one STOPBANG study for Koreans [9]. In this study, the ethnic background of Koreans was taken into consideration, Korean patients who came to a sleep clinic complaining of sleep problems was evaluated, and the best combination of STOPBANG to discern OSA from other sleep disorders was analyzed.

Comparing the PSG data, total sleep time, and REM latency is not different from other sleep disorders. OSA+ showed shorter sleep latency and N1, poorer sleep efficiency, and longer N2, N3, and REM. A clear comparison was unavailable as the other sleep disorders are heterogeneous; nonetheless, minimum and average oxygen saturation was lower in OSA, as expected. This should be due to a higher AHI and snoring index. Different characteristics according to gender in OSA have been discussed in previous studies, and in this study, STOPBANG also differed in sensitivity and specificity according to gender. However, neither gender showed improvement in AUC of STOPBANG.

There are approximately 10 screening tools for OSA [14–16], but none has been proven to be particularly accurate for screening sleep disorders. In addition, the data are still limited in the performance of the questionnaires: the

Table 4 Logistic regression analysis of STOPBANG

	B	S.E.	Wald	*p*	OR	95% CI interval
S	0.727	0.242	9.022	0.003	2.070	1.288–3.327
T	0.311	0.248	1.568	0.210	1.364	0.839–2.219
O	1.439	0.256	31.505	< 0.001	4.215	2.551–6.967
P	0.933	0.253	13.639	< 0.001	2.542	1.549–4.171
BMI	0.177	0.057	9.738	0.002	1.194	1.068–1.335
Age	0.042	0.009	22.314	< 0.001	1.043	1.025–1.062
Neck circumference	− 0.036	0.080	0.198	0.657	0.965	0.825–1.129
G	1.048	0.398	6.932	0.008	2.853	1.307–6.225

Adjusting for STOPBANG_S, STOPBANG_T, STOPBANG_O, STOPBANG_P, BMI, Age, Neck circumference, STOPBANG_G

BMI, body mass index; OR, odds ratio

Table 5 Combinations of STOPBANG for AHI ≥ 5 and ≥ 15

	AHI ≥ 5 (*n* = 238)			AHI ≥ 15 (*n* = 137)		
	SOPBANG (except T)	STOPBAG (except N)	SOPBAG (except T, N)	SOPBANG (except T)	STOPBAG (except N)	SOPBAG (except T, N)
Cutoff	2.5	3.5	2.5	2.5	3.5	2.5
Sensitivity	0.723	0.630	0.718	0.832	0.737	0.825
Specificity	0.776	0.822	0.779	0.688	0.745	0.691
AUC (95% CI)	0.815 (0.780–0.851)	0.805 (0.769–0.842)	0.811 (0.775–0.847)	0.823 (0785–0.860)	0.797 (0.756–0.837)	0.809 (0.771–0.848)
PPV (95% CI)	0.717 (0.672–0.757)	0.735 (0.683–0.783)	0.718 (0.673–0.760)	0.475 (0.437–0.505)	0.495 0.447–0.537	0.475 (0.436–0.506)
NPV (95% CI)	0.781 (0.745–0.813)	0.739 (0.707–0.768)	0.779 (0.743–0.811)	0.924 (0.893–0.948)	0.893 0.864–0.919	0.921 (0.890–0.945)
vs. STOPBANG with cutoff value of 2.5*	0.825	0.884	0.941	0.652	0.747	0.976

*The AUC was compared

AHI apnea-hypopnea index, *AUC* area under the receiver operating characteristic curve, *PPV* positive predictive value, *NPV* negative predictive value

questionnaires were conducted only in certain demographic groups and only used for moderate to severe OSA [17]. When STOPBANG was first introduced, the sensitivity and specificity for AHI > 5 were 83.6% and 56.4%, respectively; for AHI > 15, 92.9% and 43.0%, respectively [3]. Pataka et al. (2014) evaluated the performance of five questionnaires for assessing sleep apnea in a sleep clinic in Greece [13]. The sensitivity and specificity of STOPBANG (3 or more positive items) for AHI ≥ 5 were 90% and 4.9%, respectively; for AHI ≥ 15, 97.6% and 12.7%, respectively. There have been several reports on the Asian population. Ong et al. (2010) suggested simplifying STOPBANG for the Asian population [7]. The sensitivity and specificity of STOPBANG for AHI > 5 were 84.7% and 52.6%, respectively; for AHI > 15 were 91.1% and 40.4%, respectively. AUC was 0.775 at AHI > 5 as well as AHI > 15. In another study of STOPBANG, Tan et al. (2016) evaluated the performance of STOPBANG in the general population [18]. In their report, the AUC of STOPBANG ≥ 3 to detect moderate to severe OSA (AHI ≥ 15) was 0.704 and its sensitivity and specificity was 66.2% and 74.7%, respectively. In addition, the positive predictive value was only 50.6%. The performance of STOPBANG in our study was comparable to

Table 6 SOPBAG with stratified BMI

	AHI ≥ 5 (*n* = 238)				AHI ≥ 15 (*n* = 137)		
	BMI > 24.085	BMI ≥ 23	BMI ≥ 25	BMI ≥ 30	BMI ≥ 23	BMI ≥ 25	BMI ≥ 30
Cutoff	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Sensitivity	0.819	0.853	0.790	0.706	0.942	0.905	0.818
Specificity	0.690	0.640	0.739	0.809	0.547	0.646	0.718
AUC (95% CI)	0.823 (0.788–0.858)	0.822 (0.787–0.857)	0.823 (0.788–0.858)	0.823 (0.788–0.858)	0.821 (0.784–0.857)	0.830 (0.794–0.866)	0.827 (0.790–0.864)
PPV (95% CI)	0.675 (0.639–0.707)	0.651 (0.618–0.678)	0.704 (0.665–0.739)	0.743 (0.696–0.786)	0.413 (0.390–0.427)	0.464 (0.434–0.485)	0.496 (0.455–0.529)
NPV (95% CI)	0.829 (0.788–0.866)	0.847 (0.803–0.885)	0.818 (0.779–0.852)	0.778 (0.744–0.808)	0.965 (0.933–0.983)	0.953 (0.923–0.973)	0.921 (0.891–0.944)
vs. STOPBANG with cutoff value of 2.5*	0.602	0.629	0.602	0.602	0.696	0.505	0.566

*The AUC was compared

BMI body mass index, *AHI* apnea-hypopnea index, *AUC* area under the receiver operating characteristic curve, *PPV* positive predictive value, *NPV* negative predictive value its performance in previous studies. To detect mild OSA, a questionnaire of a higher level of sensitivity than a conventional questionnaire is needed. However, there are limitations in the questionnaire: some items in the questionnaire are subjective. Indeed, if sensitivity is increased, specificity is reduced. In this study, STOPBANG was completed by all patients who visited the sleep clinic as a screening tool to determine the likelihood of OSA. The defining characteristics of fatigue are too broad because almost all patients visiting the sleep clinic were already feeling tired daily. In addition, it is very rare in South Korea to have a BMI of 30 or higher. Therefore, some STOPBANG items were not suitable or useful for Koreans.

The question arises as to what can be done with the different STOPBANG assembly possibilities. Since T and N showed no significance in the logistic analysis of STOPBANG for AHI ≥ 5, the analysis was performed by subtracting N only (STOPBAG), T only (SOPBANG), and N as well as T (SOPBAG) to find non-inferiority compared to STOPBANG. As exclusion of T as well as N did not change the performance, STOPBANG may be simplified to SOPBAG in a sleep clinic setting in Korea. While BMI was found to be a significant factor in the logistic analysis, the performance of the questionnaire was not statistically different even though the BMI was changed from 35 to 23. This is not because BMI is unimportant, but sleep apnea can occur even in Koreans with normal BMI. In the previous study of STOPBANG for Koreans [9], STOPBANG had extremely high sensitivity (97% for AHI ≥ 5/h) but the specificity was very low (19%). This was due to the selection bias of the study (all the patients were suspected of OSA) and higher AHI (30.4/h).

From July 2018, the National Health Insurance Service in South Korea has begun to provide financial support for patients who are suspected of having OSA. PSGs for OSA patients cost about 111,000 KRW, or approximately $100 USD. The criteria for support are those who are suspected of sleep-disordered breathing rather than objective figures in the questionnaire [19]: if the patient satisfied (1) and (2) or (1) and (3), (1) one or more of the following: daytime sleepiness, habitual snoring, nonrestorative sleep, stopped breathing during sleep, frequent tossing and turning, and frequent arousal during sleep; (2) modified Mallampatti score grade 3 or more; (3) one or more of the following: hypertension, heart disease, cerebrovascular disease, diabetes mellitus, and BMI over 30 kg/m^2. This is a symptoms-based indication encouraging more evaluation, including patients who are suspected of having OSA or who may worsen their OSA. STOPBANG for screening OSA has yet to reach reliable accuracy. Since PSGs can now be performed at a lower cost, it is difficult to say whether questionnaire screening with questionable accuracy is cost or time-effective in Korea. Therefore, it is reasonable to suggest that PSGs be actively performed for suspected OSA patients without the screening questionnaire. If the questionnaire is still needed and used in the clinic, we suggest using SOPBAG.

The STOPBANG questionnaire has been used globally for screening OSA, but its accuracy has not been as good as expected in the Korean population. Our study showed the value of STOPBANG in a Korean sleep disorder center is limited. While a variety of questionnaires were developed and are used to screen for OSA, the patients' level of sensitivity should be assessed. Whether a patient needs to be examined for OSA should be determined with active consideration of including PSG.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the Keimyung University Dongsan Medical Center human ethics committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

This article does not contain any studies with animals performed by any of the authors.

Informed consent This study was approved by the institutional review board of a regional university hospital (#2018-03-030), and patient consent was exempt due to the retrospective nature of the study.

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Comments This is a meaningful study of STOP-Bang, one of the most widely used questionnaire of OSA but rarely validated in Korean population.
Seong Min Oh
Seoul, Korea
Given the low specificity of the STOPBANG questionnaires, a more specific pre-test screening tool is warranted to make an early diagnosis of OSA in a cost-effective manner.
Yung-Che Chen
Taiwan