



Use of the pictorial Sleepiness and Sleep Apnoea Scale in Chinese patients with suspected obstructive sleep apnoea syndrome

Yang Ji¹, Hongxia Wang¹, Min Liu¹, Martyn R. Partridge²

¹Division of Respiratory Medicine, University of Hong Kong-Shenzhen Hospital, Shenzhen, China; ²National Heart and Lung Institute, Imperial College London, UK

Contributions: (I) Conception and design: Y Ji, MR Partridge; (II) Administrative support: Y Ji; (III) Provision of study materials or patients: Y Ji, H Wang, M Liu; (IV) Collection and assembly of data: Y Ji, H Wang, M Liu; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Dr. Yang Ji. Division of Respiratory Medicine, The University of Hong Kong-Shenzhen Hospital, 1, Haiyuan 1st Road, Futian District, Shenzhen, China. Email: jiy@hku-szh.org.

Background: Sleep related breathing disorders represent a significant health burden. Being able to stratify patients according to their need for differing types of investigation and predicting the likelihood of obstructive sleep apnoea syndrome (OSAS) is helpful. This study attempts to assess the value of a pictorial Sleepiness and Sleep Apnoea Scale (pSSAS) in this process.

Methods: A total of 126 sequential patients attending a sleep service with suspected OSAS completed the pSSAS, the Epworth Sleepiness Score (ESS), and the Berlin Questionnaire (BQ) prior to full polysomnography.

Results: With Apnoea-hypopnea index (AHI) >15 as the positive diagnostic criterion, the area under the receiver operating characteristic curve (AUC) of the BQ was the highest (0.683), followed by pSSAS and ESS (AUC 0.648 and 0.516, respectively). With AHI >30 as the positive diagnostic criterion, the AUC of pSSAS was the highest (0.696), followed by BQ and ESS (AUC 0.653 and 0.510, respectively). With MiniSO₂ <80% as the positive diagnostic criterion, the AUC of pSSAS was the highest (0.736), followed by BQ and ESS (AUC 0.634 and 0.516, respectively).

Conclusions: This study shows that the pSSAS which was first tested in a European population performs equally well amongst a Chinese population. The pSSAS performed in a similar fashion to the BQ in predicting those likely to have OSAS and was superior at predicting those who have severe OSAS. Because it is a pictorial questionnaire, it has advantages for those who may have reduced health literacy, a problem which is under-recognized in most healthcare systems.

Keywords: Screening; sleep disorders; health literacy

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Introduction

The health burden associated with ventilatory abnormalities during sleep is considerable. The commonest problem, obstructive sleep apnoea syndrome (OSAS), represents a significant challenge to health systems globally. Previously promoted gold standard investigations such as full polysomnography (PSG) are unlikely to be available to

all and simpler methods of investigation have been shown to give equivalent results (1). There are similar reports of equivalent results being achieved by services offering diagnostic investigations and treatment in the community as opposed to within specialist hospital sleep services (2,3).

In developing such services, it is essential that patients are correctly channelled so that those at highest risk are seen promptly and that those with more complicated

conditions attend the more specialist services. No single screening test or management pathway has been recommended but there are widely used tools to assess the cardinal feature of sleepiness (4), and scoring systems which have been suggested to indicate a high probability of a patient having OSAS (5-7). One difficulty with some of these questionnaires is that self-completion may be difficult for those with impaired health literacy and the size of this problem may be very significant and underestimated in both general medical practice (8) and specifically amongst those attending sleep services (9).

Recently a pictorial Sleepiness and Sleep Apnoea Scale (pSSAS) has been investigated in the United Kingdom and in Switzerland and shown to be capable of correctly identifying patients with a high probability of having OSAS (10). It is not known whether such scales, which include images reflecting body size and neck circumference, are equally valid in a Chinese population where other morphological characteristics may contribute to OSAS, but a recent Chinese study using the NoSAS score, which also includes questions regarding Body Mass Index (BMI) and neck circumference, suggests such information is probably equally relevant in a Chinese population (11).

We present the following article in accordance with the STARD reporting checklist (available at <https://dx.doi.org/10.21037/jtd-20-2152>).

Methods

Study design and patients

A total of 152 sequential patients attending a specialist sleep service at University of Hong Kong-Shenzhen Hospital, Shenzhen, China with suspected OSAS were recruited for study and underwent investigation and completed the relevant questionnaires from January 2018 to April 2019. It was subsequently shown that 26 of these patients had some missing data and could not be included [19 missing a value in pSSAS, 15 in ESS, and 15 in Berlin Questionnaire (BQ)] leaving 126 patients with complete data including the pSSAS and the BQ (6). The English and Swiss German versions of the pSSAS can be found in the article by Edelmann and colleagues (10) and a copy of the English version is shown in [Figure S1](#). A copy of the Chinese version of the pSSAS used in this study may be requested from the corresponding author. Three Chinese native speakers with very good knowledge of the English language independently translated the text of the English version of

the pSSAS. The individual translations were then reviewed and differences in translation were addressed at a consensus meeting and an easily understandable style and wording was chosen that reflects the meaning of the original version as closely as possible. In the Chinese version, a third answer option “don’t know” represented by a question mark besides “breathing normally when asleep” and “stopping breathing when asleep” for question number 8 was added as this had been shown to be helpful in the Swiss German version of the pSSAS. The validated, Chinese language version of the ESS was used to measure excessive daytime sleepiness (12). The sleep nurses instructed the subjects to finish the three questionnaires including pSSAS. This study has documented review and approval from the University of Hong Kong-Shenzhen Hospital Institutional Review Board (approval number [2019]092) and is conducted in accordance with the Declaration of Helsinki (as revised in 2013). Written informed consent have been provided by the participants.

Sleep study and pSSAS scoring

All patients then underwent full-night attended PSG at the Sleep Medicine Centre during which the following measurements were continuously recorded: electrooculography, electroencephalography, mental and tibial electromyography, electrocardiography, nasal airflow, pulse oximetry, thoracic and abdominal movements, and snoring intensity (Alice 6, Philips Respironics, the United State). All data was stored on a personal computer and manually analysed in accordance with the published AASM Scoring Manual Version 2.4. According to the guidelines, apnoea was defined when there was a drop in the peak signal excursion by $\geq 90\%$ of pre-event baseline and the duration of the $\geq 90\%$ drop in sensor signal was ≥ 10 seconds, whereas in hypopnea airflow is decreased by more than 30% for at least 10 seconds, in combination with a reduction in haemoglobin oxygen saturation of at least 3% or the event is associated with an arousal. All full-night PSG measurements that lasted more than 6 hours were accepted.

The pSSAS was scored according to Scoring Scheme 1 in the original paper, because this scheme produced the best diagnostic performance in the original study ([Table S1](#)).

Statistical analysis

Normally distributed continuous data are expressed as mean

Table 1 Demographic and baseline characteristics

Clinical characteristics	Values
Age (years), median (IQR)	42 (14.3)
Gender, n (%)	
Female	22 (17.4)
Male	104 (82.6)
Height (cm), median (IQR)	170.58 (8.3)
Weight (kg), median (IQR)	78 (19.5)
BMI (kg/m ²), median (IQR)	24.2 (5.6)
Neck circumference (cm), median (IQR)	38.7 (4.6)
AHI (events/hour), n (%)	
0~5	15 (11.9)
5~15	30 (23.8)
15~30	25 (19.8)
>30	56 (44.5)
MiniSO ₂ , n (%)	
<80%	58 (46.0)
>80%	68 (54.0)
ESS (points), median (IQR)	9.4 (6.0)
BQ (points), median (IQR)	5.4 (3.0)
pSSAS (points), median (IQR)	13.4 (7.3)

BMI, body mass index; AHI, apnoea-hypopnea index; ESS, Epworth Sleepiness Scale; BQ, Berlin questionnaire; pSSAS, pictorial Sleepiness and Sleep Apnoea Scale.

± SD; categorical data are summarized by their observed frequencies and percentages. We used the BIM SPSS 23 to describe data and analyzed the correlations. Spearman correlations for the relation analysis. The ROC curve was drawn, and the corresponding area under the curve (AUC), sensitivity, specificity, and optimal threshold value were calculated by MedCalc software. All statistical tests were two-sided and the P value of <0.05 was considered as statistically.

Results

A total of 126 patients were included in the study with the average age being 42 years (range, 22–78 years). Twenty-two were female (17.5%) and 104 were male (82.5%). The Apnoea-hypopnea index (AHI) scores were classified as mild if between 5 and 15, moderate between 15 and 30

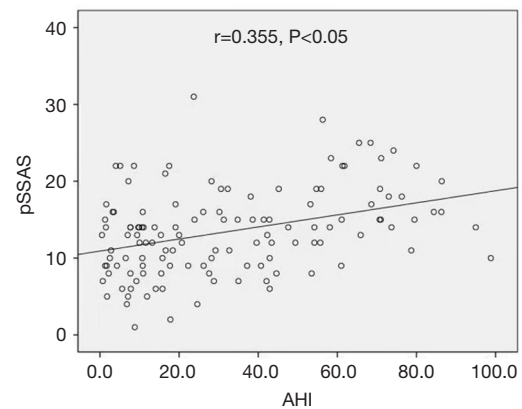


Figure 1 Correlation between AHI and pSSAS: Scatterplot. pSSAS, pictorial Sleepiness and Sleep Apnoea Scale; AHI, apnoea-hypopnea index.

and severe if greater than 30. PSG results showed that 15 patients had an AHI <5, 30 patients had an AHI in the range 5 to 15, 25 patients had an AHI between 15 and 30, and 56 severe cases had an AHI >30. More details are shown in *Table 1*.

Using these criteria our results showed that AHI had a positive correlation with pSSAS (*Figure 1*) but the relationship is medium. The relationship between pSSAS and the other scales is shown in *Figure 2* from which it can be seen that the pSSAS was moderately correlated with the ESS and BQ.

The comparison of the ability of each score to predict the likelihood of a significant ventilatory problem during sleep is shown in *Figures 3–5*.

With AHI >5 as the positive diagnostic criterion, the ROC curve is as shown in *Figure 3*. The AUC of BQ was the highest (0.730), with a certain degree of accuracy, followed by pSSAS and ESS (AUC 0.588, 0.574, respectively) and P value of BQ was less than 0.05 which shows that the diagnostic method has diagnostic value (*Table 2*). When pSSAS was compared with ESS and BQ, P was greater than 0.05, while BQ, ESS and pSSAS had no significant difference in these diagnostic criteria (*Table 3*).

With AHI >15 as the positive diagnostic criterion, the ROC curve is as shown above in *Figure 4*. The AUC of BQ was the highest (0.683), followed by pSSAS and ESS (AUC 0.648 and 0.516, respectively). Both the P value of the BQ and pSSAS were less than 0.05 which shows that the diagnostic method had diagnostic value, but low (*Table 4*). When pSSAS was compared with ESS and BQ,

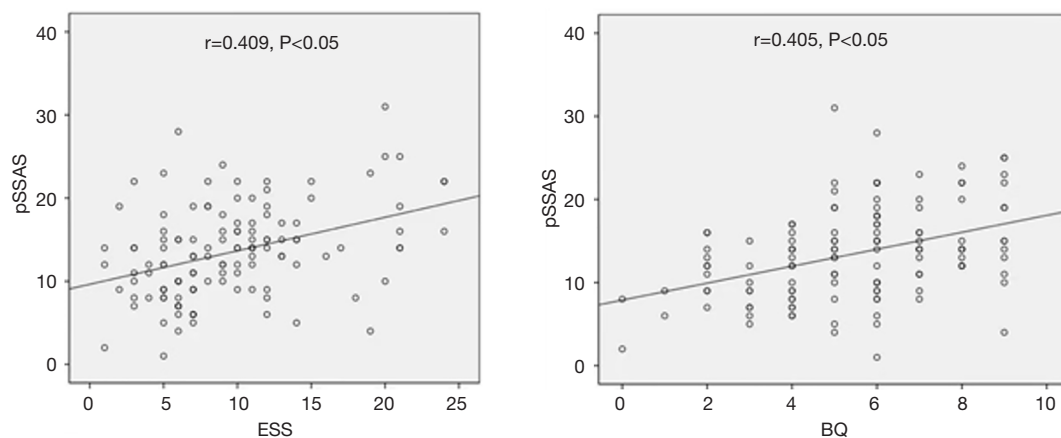


Figure 2 Showing relationship between pSSAS and ESS and BQ. pSSAS was moderately correlated with ESS and BQ ($r=0.409, P<0.05$; $r=0.405, P<0.05$). pSSAS, pictorial Sleepiness and Sleep Apnoea Scale; ESS, Epworth Sleepiness Scale; BQ, Berlin questionnaire.

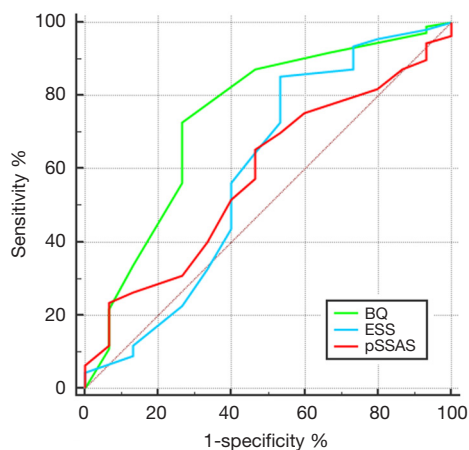


Figure 3 ROC curves showing the sensitivity and specificity for each of the scales when using an AHI >5 as the positive diagnostic criteria. BQ, Berlin questionnaire; ESS, Epworth Sleepiness Scale; pSSAS, pictorial Sleepiness and Sleep Apnoea Scale; AHI, Apnoea-hypopnea index.

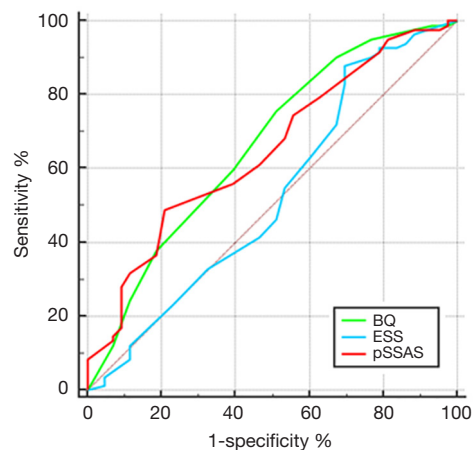


Figure 4 ROC curves showing the sensitivity and specificity for each of the scales when using an AHI >15 as the positive diagnostic criteria. BQ, Berlin questionnaire; ESS, Epworth Sleepiness Scale; pSSAS, pictorial Sleepiness and Sleep Apnoea Scale; AHI, Apnoea-hypopnea index.

P was greater than 0.05, while BQ, ESS and pSSAS had no significant difference (Table 5).

With AHI >30 as the positive diagnostic criterion, the ROC curve is as shown above in Figure 5. The AUC of pSSAS was the highest (0.696), followed by BQ and ESS (AUC 0.653 and 0.510, respectively). Both the P value of the BQ and pSSAS were less than 0.05 which shows that the diagnostic method had diagnostic value and the accuracy of pSSAS is approximate certain (Table 6). In the two comparisons, there was a difference between pSSAS

and ESS ($P<0.05$). The diagnostic efficiency of pSSAS was higher than that of ESS, while the P value of BQ and pSSAS was more than 0.05 (Table 7).

With $\text{MiniSO}_2 < 80\%$ as the positive diagnostic criterion, the ROC curve is as shown above in Figure 6. The AUC of pSSAS was the highest (0.736), followed by BQ and ESS (AUC 0.634 and 0.516, respectively). The P value of the BQ and pSSAS were less than 0.05 which shows that the diagnostic method had diagnostic value and the accuracy of pSSAS is certain (Table 8). In the two

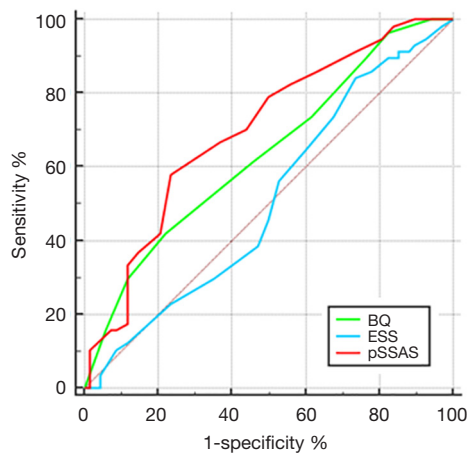


Figure 5 ROC curve showing the sensitivity and specificity for each of the scales when using an AHI >30 as the positive diagnostic criteria. BQ, Berlin questionnaire; ESS, Epworth Sleepiness Scale; pSSAS, pictorial Sleepiness and Sleep Apnoea Scale; AHI, Apnoea-hypopnea index.

comparisons, there was a difference between pSSAS and ESS ($P < 0.05$). The diagnostic efficiency of pSSAS was higher than that of ESS, while the P value of BQ and pSSAS was less than 0.05 (Table 9).

We also tested the diagnosis accuracy of the pSSAS with a cut-off of 14 points when taking different AHI value as the positive diagnostic criteria (Table 10). The result shows that with the AHI criterion increased, the diagnosis accuracy is getting higher.

Discussion

OSAS and questionnaires

OSAS is now widely recognized as a major public health concern with numerous and widespread societal consequences. It is associated with many chronic medical conditions that contribute to poor quality of life, morbidity, and mortality, including hypertension, diabetes, coronary

Table 2 The predictive value of the pSSAS, BQ and ESS when using an AHI >5 as a cut-off for the positive diagnostic criteria

Questionnaire	AUC	Sensitivity	Specificity	P	Youden index	Optimal cut points
ESS	0.574 (0.483–0.662)	85.59	46.67	0.4646	0.3225	3.5
BQ	0.730 (0.634–0.805)	72.07	73.33	0.0028	0.4541	4.5
pSSAS	0.588 (0.497–0.675)	64.86	53.33	0.2588	0.1820	11.5

pSSAS, pictorial Sleepiness and Sleep Apnoea Scale; BQ, Berlin questionnaire; ESS, Epworth Sleepiness Scale; AHI, apnoea-hypopnea index; AUC, area under curve.

Table 3 The comparison between pSSAS and BQ, ESS respectively when using an AHI >5 as a cut-off for the positive diagnostic criteria

pSSAS	ESS	BQ
P	0.9272	0.0888

With AHI >5 as the positive diagnostic criterion, the ROC curve is as shown in Figure 3 above. The AUC of BQ was the highest (0.730), with a certain degree of accuracy, followed by pSSAS and ESS (AUC 0.588, 0.574, respectively) and P value of BQ was less than 0.05 which shows that the diagnostic method has diagnostic value. Compared pSSAS with ESS and BQ, In the two comparisons, P was greater than 0.05, while BQ, ESS and pSSAS had no significant difference in these diagnostic criteria. pSSAS, pictorial Sleepiness and Sleep Apnoea Scale; BQ, Berlin questionnaire; ESS, Epworth Sleepiness Scale; AHI, apnoea-hypopnea index; AUC, area under curve.

Table 4 The predictive value of the pSSAS, BQ and ESS when using an AHI >15 as a cut-off for the positive diagnostic criteria

Questionnaire	AUC	Sensitivity	Specificity	P	Youden index	Optimal cut points
ESS	0.516 (0.425–0.606)	87.65	28.89	0.7826	0.1654	7.5
BQ	0.683 (0.594–0.763)	76.54	51.11	0.0003	0.2765	4.5
pSSAS	0.648 (0.558–0.731)	48.15	77.78	0.0036	0.2593	14.5

pSSAS, pictorial Sleepiness and Sleep Apnoea Scale; BQ, Berlin questionnaire; ESS, Epworth Sleepiness Scale; AHI, apnoea-hypopnea index; AUC, area under curve.

Table 5 The comparison between pSSAS and BQ, ESS respectively when using an AHI >15 as a cut-off for the positive diagnostic criteria

pSSAS	ESS	BQ
P	0.1429	0.5663

With AHI >15 as the positive diagnostic criterion, the ROC curve is as shown above in *Figure 4*. The AUC of BQ was the highest (0.683), followed by pSSAS and ESS (AUC 0.648 and 0.516, respectively). Both the P value of the BQ and pSSAS were less than 0.05 which shows that the diagnostic method had diagnostic value, but a little low. In the two comparisons, P was greater than 0.05, while BQ, ESS and pSSAS had no significant difference. pSSAS, pictorial Sleepiness and Sleep Apnoea Scale; BQ, Berlin questionnaire; ESS, Epworth Sleepiness Scale; AHI, apnoea-hypopnea index; AUC, area under curve.

Table 6 The predictive value of the pSSAS, BQ and ESS when using an AHI >30 as a cut-off for the positive diagnostic criteria

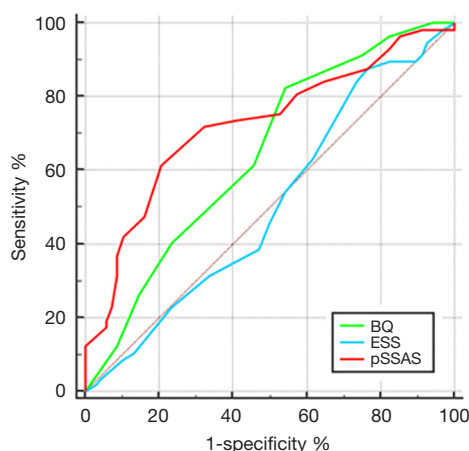
Questionnaire	AUC	Sensitivity	Specificity	P	Youden index	Optimal cut points
ESS	0.510 (0.420–0.601)	83.93	25.71	0.8401	0.0964	7.5
BQ	0.653 (0.563–0.736)	42.86	78.57	0.0015	0.2143	6.5
pSSAS	0.696 (0.608–0.775)	57.14	75.71	<0.0001	0.3286	14.5

AHI, apnoea-hypopnea index; ESS, Epworth Sleepiness Scale; BQ, Berlin questionnaire; pSSAS, pictorial Sleepiness and Sleep Apnoea Scale; AUC, area under curve.

Table 7 The comparison between pSSAS and BQ, ESS respectively when using an AHI >30 as a cut-off for the positive diagnostic criteria

pSSAS	ESS	BQ
P	0.028	0.4248

With AHI >30 as the positive diagnostic criterion, the ROC curve is as shown above in *Figure 5*. The AUC of pSSAS was the highest (0.696), followed by BQ and ESS (AUC 0.653 and 0.510, respectively). Both the P value of the BQ and pSSAS were less than 0.05 which shows that the diagnostic method had diagnostic value and the accuracy of pSSAS is approximate certain. In the two comparisons, there was a difference between pSSAS and ESS ($P < 0.05$). The diagnostic efficiency of pSSAS was higher than that of ESS, while the P value of BQ and pSSAS was more than 0.05. pSSAS, pictorial Sleepiness and Sleep Apnoea Scale; BQ, Berlin questionnaire; ESS, Epworth Sleepiness Scale; AHI, apnoea-hypopnea index; AUC, area under curve.

**Figure 6** ROC curve showing the sensitivity and specificity for each of the scales when using an MiniSO₂ <80% as the positive diagnostic criteria. BQ, Berlin questionnaire; ESS, Epworth Sleepiness Scale; pSSAS, pictorial Sleepiness and Sleep Apnoea Scale.

artery disease, and diminished cognitive ability. Patients with untreated OSAS have been shown to have increased risk of road traffic incidents and to contribute significantly to increase healthcare costs and resource use (13).

OSAS is reported to be frequently underdiagnosed (14–16), but its prevalence in the population is high (17). The prevalence of moderate to severe OSA is reported to be 6–17%, being as high as 49% with advanced age (17).

The gold standard for the diagnosis of OSAS is overnight polysomnography performed in sleep laboratories. Polysomnography lasts at least 6 hours and includes a variety of invasive-like recordings such as electroencephalography, electro-oculography, chin electromyography, nasal and oral airflow by thermistors, snoring by microphone, electrocardiogram, pulse oximetry and tibialis anterior electromyogram. These diagnostic procedures are costly and lengthy, which may partly explain

Table 8 The predictive value of the pSSAS, BQ and ESS when using an MiniSO₂ <80% as a cut-off for the positive diagnostic criteria

Questionnaire	AUC	Sensitivity	Specificity	P	Youden index	Optimal cut points
ESS	0.516 (0.425–0.606)	12.07	76.47	0.7577	0.1146	7.5
BQ	0.634 (0.544–0.718)	81.03	45.59	0.0061	0.2662	4.5
pSSAS	0.736 (0.650–0.811)	62.07	80.88	<0.0001	0.4295	14.5

pSSAS, pictorial Sleepiness and Sleep Apnoea Scale; BQ, Berlin questionnaire; ESS, Epworth Sleepiness Scale.

Table 9 The comparison between pSSAS and BQ, ESS respectively when using an MiniSO₂ <80% as a cut-off for the positive diagnostic criteria

pSSAS	ESS	BQ
P	<0.0001	0.0638

With MiniSO₂ <80% as the positive diagnostic criterion, the ROC curve is as shown above in *Figure 6*. The AUC of pSSAS was the highest (0.736), followed by BQ and ESS (AUC 0.634 and 0.516, respectively). The P value of the BQ and pSSAS were less than 0.05 which shows that the diagnostic method had diagnostic value and the accuracy of pSSAS is certain. In the two comparisons, there was a difference between pSSAS and ESS (P<0.05). The diagnostic efficiency of pSSAS was higher than that of ESS, while the P value of BQ and pSSAS was less than 0.05. pSSAS, pictorial Sleepiness and Sleep Apnoea Scale; BQ, Berlin questionnaire; ESS, Epworth Sleepiness Scale.

Table 10 Comparing the diagnostic accuracy of different AHI criteria which use a pSSAS cut-off of 14 points

Criterion and cut-off	Sensitivity	Specificity	LR+	LR–	Youden index	Diagnosis accuracy
AHI criterion >5, pSSAS cut-off =14	39.6%	66.6%	1.19	0.91	0.062	42.9%
AHI criterion >15, pSSAS cut-off =14	48.8%	79.5%	2.38	0.64	0.283	59.5%
AHI criterion >30, pSSAS cut-off =14	57.9%	76.8%	2.50	0.55	0.347	68.3%

LR+, likelihood ratio positive; LR–, likelihood ratio negative.

why 82% of men and 92% of women in the USA who are likely to have moderate or severe OSAS have yet to be diagnosed (18,19).

An ideal screening tool would be easy to complete by all patients and have a sensitivity and specificity that neither suggested a diagnosis in those without the condition or missed cases requiring investigation and treatment. Such a tool then permits those with a high likelihood of the condition to have simple confirmatory tests and institution of appropriate management leaving complex investigations for those with equivocal scores or comorbidities. Screening tools such as the BQ, STOP-BANG questionnaire (SBQ), and STOP questionnaire have been widely promoted for detecting OSA. The Epworth sleepiness scale (ESS), which was originally designed to assess the risk of daytime sleepiness, has been extensively used in the community prior to specialist referral in many countries as part of the screening process (4), but has not been shown to be a satisfactory screening test by itself.

The recently published European Respiratory Society

statement on sleep apnoea, sleepiness and driving risk (20) concludes that certainly with regards to driving none of the existing screening questionnaires is satisfactory and calls for more research on new questionnaires. In the general population, extreme variation can be found in the sensitivities and specificities for all established questionnaires (ESS sensitivity 18–85%, specificity 22–98% (21–23); BQ sensitivity 40–97%, specificity 6–100% (24–30); STOP sensitivity 33–98%, specificity 10–95% (31); STOP-Bang sensitivity 0–100%, specificity 0–100% (25,31–33), even taking into account the cut-off thresholds for OSA (AHI ≥5 events/h, AHI ≥15 events/h, AHI ≥30 events/h).

Sensitivity was highest in sleep clinic samples for all questionnaires, while the ESS showed an overall poor predictive value. In clinical population samples (i.e., patients admitted or followed for disease other than OSAS), on average the BQ showed a higher sensitivity compared to the STOP-Bang. Clearly, the data indicate that questionnaires neither reliably rule in nor rule out OSA (20).

Therefore, developing a new questionnaire with higher

sensitivities and specificities is one of the future research priorities of OSAS.

pSSAS

Written questionnaires can be difficult for some patients to complete, and studies have shown that reduced literacy is common in patients attending a sleep clinic (9). In addition to the effect of increased sleepiness, verbal episodic memory can be impaired in patients with OSAS (34). This led to the development of a pictorial Epworth Sleepiness Scale (pESS) in 2011, and the same team further developed a pSSAS questionnaire that consists of eight items to be used for OSAS screening, four common to the pESS and four related to body morphology, blood pressure and witnessed apnoea (35-37).

Its simple structure, scoring rules and the use of pictograms make it an alternative to more complex and long questionnaires in clinical practice and in patients with reduced literacy. The validation study has shown good internal consistency, repeatability and construct validity when compared with established tools for the diagnosis of excessive daytime sleepiness (EDS) and OSAS (10).

Pictures with words have been shown to enhance the understanding and translation of medical information, and a pictorial translation of the ESS produces scores comparable with the traditional ESS and may be a suitable alternative for those with normal or diminished literacy (35). To elicit the best possible understanding, combining both pictures and words to maximize intended meaning is important and necessary (38-41). Another type of pictorial sleepiness scale has recently been reported for use amongst indigenous Australian adults (42).

In this report we have demonstrated that a pictorial sleep apnoea screening score which was originally validated in a British and a Swiss population (10) appears to be as useful in a Chinese population of patients with suspected OSAS. This confirms the suggestion from another recent paper from China (11) that morphological risk factors such as neck circumference and BMI that apply in European populations are also important in a Chinese population. The results show that the pSSAS is as effective as the BQ in predicting those likely to have OSAS and that the pSSAS is better at predicting those who have severe OSA (AHI >30).

Proving that a new test performs in a similar fashion to existing tests is a worthwhile exercise and equivalence increases choice but does the pSSAS have advantages? Administering some questionnaires can be very time

consuming for health professionals and the pSSAS has the potential advantage that it is pictorial. Our previous work has shown that a third of new patients make quantifiable errors when completing written sleepiness scores and a preference for a pESS was shown by 55% of users who found it easier to complete than the worded version (35). It is not possible for health professionals to predict which patients have impaired health literacy (8,43) and formal assessment is both time consuming and potentially distressing to patients. Universal precautions should therefore be applied with the simplest tools offered to all. The pSSAS can be self-completed but in our experience some patients benefit from assistance with the risk questions (Questions 5, 6, 7 and 8). Problems associated with health literacy (and numeracy) lead to poorer health outcomes which can be expensive for health care systems (44) and yet literacy sensitive approaches have shown that such approaches in several respiratory conditions enable those with impairment to develop equal outcomes to those not so affected (45,46).

BMI, gender and OSA

Among Chinese, OSA occurs at lower body mass indices (BMIs) than in Caucasians, suggesting that craniofacial differences within the Chinese population play a major role. In Singapore (47), a multiethnic nation, Chinese had a significantly higher prevalence of OSA [apnoea-hypopnea index (AHI) of ≥ 15 events/h] despite having a lower BMI than both Indians and Malays. This is supported by the Multi-Ethnic Study of Atherosclerosis (MESA) Sleep Cohort (48). As to why Chinese may have OSA at a lower BMI, a study (49) comparing Caucasians in Australia to Chinese in Hong Kong (matched for OSA severity) found Caucasians to be more overweight with larger tongues whereas Chinese exhibited more craniofacial bony restriction. Our study also shows that Chinese OSA patients (confirmed by PSG) have a lower BMI when compared with Caucasians. We also should pay more attention to the different cut-offs of obesity between the different populations. Chang's study demonstrated that Chinese Taiwan subjects had a relatively lower BMI but a higher percent body fat than Caucasians. In general, the newly proposed Asia-Pacific BMI cut-offs for overweight (≥ 23 kg/m²) and obesity (≥ 25 kg/m²) may be acceptable to both male and female Chinese Taiwan subjects (50). However, obesity in China is progressively increasing with the development of the economy and the concomitant

changes in Chinese life style. Future research focusing on the differences between obese and non-obese patients may provide useful targets for specific treatments for each of these groups.

Besides these risk factors such as obesity, increased age, cigarette smoking, and craniofacial abnormalities, male gender is recognized as an independent risk factor for the development of the syndrome. Consequently, and unsurprisingly, OSAS has thus been considered a male disease, with male: female ratios ranging from 3:1 to 5:1 in the general population and from 8:1 to 10:1 in selected clinical populations (51). In our study, the male: female ratio is 4.7 which is in the range of the above studies. However, according to our experience, female OSA patients are underdiagnosed in medical practice. Failure to recognize the distinct clinical presentation and sex-specific differences in sleep studies may lead to underdiagnosis or misdiagnosis of OSAS in females (52,53). Future studies should focus on the specific female OSA characteristics.

Conclusions

We have demonstrated that the use of a literacy sensitive tool in risk stratification in suspected OSAS produces results equivalent to, or indeed better than more complicated written questionnaires which patients may need significant assistance to complete without errors.

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study has documented review and approval from the University of Hong Kong-Shenzhen Hospital Institutional Review Board (approval number [2019]092). Written informed consent have been provided by the participants.

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Patient name _____ Hospital Number _____ Date of Birth _____ Today's Date _____

The pictorial Sleepiness and Sleep Apnoea Scale (pSSAS)

Tick **one box only in each different situation** that best represents you.

How likely are you to **doze off or fall asleep** in the following situations?

1. Sitting and Reading



2. Watching TV or listening to the radio



3. Sitting quietly after a meal



4. As a passenger in a car or bus

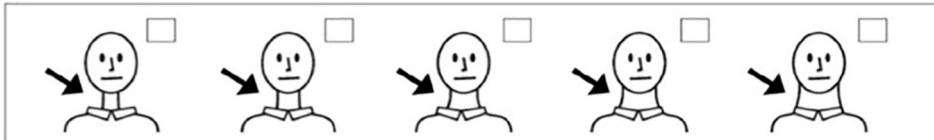


Now please tick **one box only in each series of pictures** that best represents you.

5. Body size



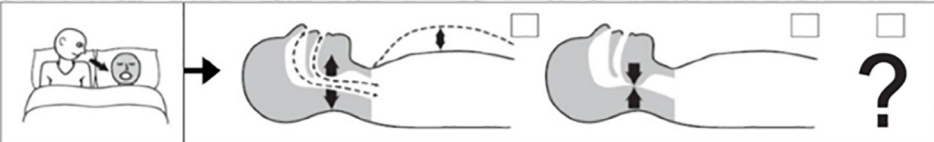
6. Neck size



7. Blood pressure: normal normal with medicine high don't know



8. Breathing when asleep: breathing normally when asleep stopping breathing when asleep don't know



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Figure S1 English version of the pSSAS questionnaire. Permission given by Professor Martyn R. Partridge.

Table S1 pSSAS scoring scheme

pSSAS item	Scoring
Q1–4: Daytime sleepiness	0, 1, 2, 3 and 4 points with increasing score indicating increasing daytime sleepiness
Q5: Body size	0, 1, 2, 3, 4 points with increasing score indicating increasing body size
Q6: Neck size	0, 1, 2, 3, 4 points with increasing score indicating increasing neck size
Q7: Blood pressure	Normal =0 point, normal on medication or high BP =4 points, don't know =0 point
Q8: Witnessed apnoea	Normal breathing = 0 points, breathing pauses occur=4 points, don't know = 0 points