Obstructive sleep apnea screening in young people: Psychometric validation of a shortened version of the STOP-BANG questionnaire using categorical data methods

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Abstract:

BACKGROUND: The STOP-BANG is an easily administrable questionnaire for the screening of obstructive sleep apnea in adults, which may be adapted for use by young people. Here, we assessed the psychometric properties of the STOP-BN, a shortened version of the STOP-BANG questionnaire, using categorical data methods.

METHODS: Four hundred and three young people (age 20.71 ± 1.93 years) were selected by random sampling to participate in this cross-sectional study. Participants completed the STOP-BN, a tool for recording social and demographic characteristics, and the Epworth Sleepiness Scale (ESS), a measure of daytime sleepiness. The obtained data were analyzed using categorical data methods.

RESULTS: A two-factor model was identified for the STOP-BN, using the Kaiser's criteria (eigenvalue >1) and the screen test. However, the parallel analysis based on minimum rank, and the cumulative variance criteria (>40%) identified an one-factor model. Factor loadings ranged from 0.364 to 0.745. The identified two-factor model showed acceptable fit as the reported goodness of fit index and weighted root mean square residual were in the ideal range, and the comparative fit index was close to the ideal range. Greatest lower bound to reliability for two factors of the STOP-BN was 0.67 and 0.67, indicating an acceptable internal consistency. A weak to a nonsignificant correlation between the ESS and the STOP-BN score was demonstrated, favoring STOP-BN's divergent validity.

CONCLUSION: Categorical methods support the psychometric validity of the STOP-BN in the study population.

Keywords:

Factor analysis, greatest lower bound to reliability, psychometric validity, questionnaire, screening, validation

Obstructive sleep apnea (OSA) is a sleep-related breathing disorder characterized by the collapse of the upper airways during sleep, resulting in intermittent hypoxemia. The prevalence of this significant problem is reported to range from 2% to 26% in the general population[1] and 7%–10% in patients undergoing surgeries.[2] Recent systematic reviews have reported a prevalence of OSA between 15% and 76% in children and adolescent populations.[3] OSA adversely affects an individual's health and may lead to significant health concerns

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including sudden cardiac death,[4] and increased risk of hypertension, diabetes, and mortality.[5] Previous studies have also reported OSA as a predictor of work disability[6] and a risk factor for occupational injuries.[7] These serious consequences can be prevented if OSA is identified and treated appropriately. However, OSA is continuing to be an under-diagnosed condition.[8]

The gold standard diagnostic test of OSA is polysomnography (PSG), usually conducted overnight in a specialized facility with costly equipment and trained staff. Waiting to get PSG performed may lead to significant delays in diagnosis. Screening tools provide a cheap and accessible method of identifying patients with OSA or those at risk of OSA. Several such screening tools are already developed and tested for utility;[9-11] however, they have been criticized as being lengthy, complicated, and requiring upper airway assessment.

In response to the need for a simple tool to identify those at risk of OSA, Chung *et al*. developed and validated a convenient, concise, and easy to administer questionnaire called the STOP-BANG.[12] Although this questionnaire was initially developed and validated in surgical patients, the tool was further tested and validated in several other clinical populations.[13] Moreover, the tool was cross-culturally adapted and validated for use in various linguistic and cultural groups.[14-17] Two shortened versions, namely STOP and BOAH, both having 4-item from the original STOP-BANG, have been validated in some populations.[12,18] The STOP questionnaire consists of items to record subjective reports of loud snores, tiredness, episodes of apnea/stopped breathing observed by others, and high blood pressure.[12] The BOAH questionnaire consists of items related to body mass index (BMI), observed apnea, age above 50 years, and high blood pressure.[18] Both versions have clinical usefulness in identifying cases of OSA.[12,18]

Previous studies on the psychometric characterization of the STOP-BANG and its shortened versions, however, are limited to the test-retest reliability, concurrent validity, and internal consistency assessments. Moreover, recent studies on the screening properties of the STOP questionnaire have shown inadequate diagnostic validity in a population of OSA patients with atrial fibrillation.[19] Hence, further investigations on its internal consistency, factorial validity, and divergent validity, especially taking consideration of the categorical nature of the STOP-BANG scoring, are needed. The factorial validity assessment helps to establish the relationship between item scores and the validity of the theoretical construct. Issues of multicollinearity, singularity, and redundancy of terms are addressed in factor analysis, which helps to establish an interpretation of item scores.[20] A systematic search of the literature did not retrieve studies that have thoroughly assessed the factorial validation of either the STOP-BANG or its shortened versions (i.e., STOP and BOAH), which identified a need for factorial validation of the tool. Moreover, we could not identify OSA assessment tools specifically designed to identify/screen young people populations who are at OSA risk.

The present study was, therefore, designed to test the factorial validity, reliability, and divergent validity of an abridged version of the STOP-BANG, referred to as the STOP-BN, in a population of young people who may be at risk of developing OSA.

Methods

Ethics

The Institutional Ethics Committee, Mizan-Tepi University, Ethiopia, approved the design and implementation of this study. All participants were provided with a study information sheet and gave written informed consent after explanation of the procedures and objectives of the study, which followed the Helsinki guideline of 2002.

Participants and research design

In this cross-sectional research, a simple random sampling methodology was used to recruit adult participants from the students' pool of the main campus of the Mizan-Tepi University located at Mizan town, Ethiopia. All the questionnaires were in English, as it is the medium of instruction in the Ethiopian federal universities. Moreover, the use of questionnaires in Amharic, i.e., the official language of Ethiopia is practically difficult because reading proficiency of Amharic varies among students who come from different linguistic groups. Participants with <18 years of age were excluded from the study because this would have necessitated taking of consent from their parents. No other exclusion criteria were employed.

Procedures and measures

A tool to record social and demographic characteristics seeking data on participant age, gender, ethnicity (Amhara, Tigray, Oromo, Keffa, Bench, and Others), and areas of study. Participants also completed a paper-based Epworth Sleepiness Scale (ESS) and an English version of the STOP-BN questionnaire.

STOP-BN questionnaire

This study used the 6-item self-administered STOP-BN questionnaire [Figure 1]. The STOP-BN is a short version of the 8-item STOP-BANG questionnaire designed to screen patients with/at risk of OSA.[12] Items in the STOP-BN questionnaire assess for snoring, fatigue/tiredness during the day, reports of stopped breathings/apneas, high blood pressure, BMI, and

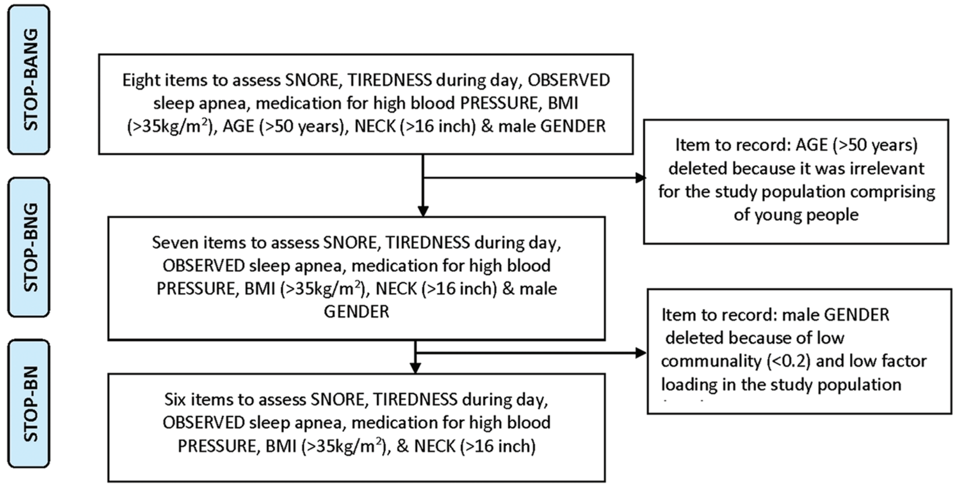

Figure 1: Schematic of questionnaire adaptation

neck circumference (NECK). All items are scored using dichotomous response options of yes/no. A count of 0 or 1 is assigned to NO and YES responses, respectively, resulting in a total score of 6.[12] As shown in Figure 1, two items were deleted from the original the STOP-BANG questionnaire; one item for irrelevance, i.e., age above 50 years is not applicable for young people.[12] The second item was deleted because of the statistical consideration of the low communality value of 0.04 which was less than 0.2 as well as low factor loadings, which were 0.17 and 0.09 for both factors, which were again less than the minimum recommended value of 0.3.[21,22]

Epworth Sleepiness Scale

ESS is a self-administered questionnaire developed to assess the daytime sleepiness. The questionnaire has eight items, which assess a participant's usual chance of dozing off or falling asleep during eight different everyday activities. Scoring for each item is done on a 4-point scale with scores ranging from 0 to 3, resulting in an overall maximum ESS score of 24. Higher ESS scores represent higher daytime sleepiness. The acceptable psychometric characteristics of ESS have been confirmed in several previous studies.[23-25] ESS was found to have adequate psychometric validity for a unidimensional construct with good internal consistency, discriminant validity, and adequate item discrimination and distribution among Ethiopian university students.[26]

Statistical analysis

The Statistical Package for the Social Sciences version 23.0 (IBM® SPSS® Statistics V23.0., Chicago, IL, USA), and Factor version 10.8.04 developed by at the Rovira i Virgili University, Tarragona Spain were used for analyzing the data. Descriptive statistics (frequency, mean, percentages, range, and standard deviation) were used for examining and summarizing the participant characteristics. Univariate item distributional properties of the STOP-BN questionnaire were inspected using skewness and kurtosis, whereas, multivariate distribution was assessed using Mardia's skewness and Mardia's kurtosis. Homogeneity and item discrimination were tested using Spearman correlations between STOP-BN items and total score.

Factor analysis was conducted once the sample was found to be adequate and suitable for factor analysis. Suitability of the data for factor analysis was tested using Bartlett's Test, Determinant, Kaiser-Meyer-Olkin Test for assessing the adequacy of a sample (KMO) (95% confidence interval), communality, and the correlation coefficient between items, which confirmed that sample is suitable and adequate for factor analysis. Next, an exploratory factor analysis (EFA) was conducted using categorical data methods, followed by a fit indices analysis.

Given the dichotomous nature of the STOP-BN responses, the tetrachoric correlations matrix (estimated using bootstrap sampling) for inter-item scores was used for factor analysis. EFA was conducted using diagonally weighted least squares (RDWLS) with Promin rotation. Factor retention measures included Kaiser's criteria of Eigenvalue 1 or above, the Cumulative variance explained criteria (>40%), Scree test and the robust parallel analysis based on minimum rank. Reliability was evaluated by internal consistency using the measures of the greatest lower bound (GLB) to reliability. The divergent validity of the STOP-BN was assessed by evaluating the correlations with the ESS score.

The goodness of fit was tested on two models; a 1-Factor and a 2-Factor model, as two of the factor extraction measures favored the 1-Factor model, while two others supported the 2-Factor structure. The goodness of fit of the model to the data was tested using robust mean and variance-adjusted Chi-square (χ^2) and the χ^2 statistic to the degree of freedom ratio (χ^2/df). Besides, multiple fit indices were employed as per standard recommendations.[27-29] These indices included discrepancy functions, such as weighted root mean square residual (WRMR) and absolute fit index (the goodness of fit index [GFI] and comparative fit index [CFI]). The values indicating acceptable and/or excellent fit were determined by previously published guidelines.[28,30] These values included a $P > 0.05$ for χ^2, the χ^2/df <5, the GFI > 0.95, the CFI > 0.95, and the RMSEA < 0.05. To be considered statistically significant, $P < 0.05$ was used in all analyses.

Results

Participant characteristics and the STOP-BN descriptive statistics

The summary details of the participants' demographic and sleepiness (ESS) characteristics are shown in Table 1. A total of 403 university students, both males and females, with a mean age of 20.71 ± 1.93 participated in the study. Male participants constituted 68% of enrolled young people participants. According to the ESS, the majority of the participants (68%) reported a normal level of daytime sleepiness (ESS < 10), whereas a minority (17%) reported mild-to-severe excessive daytime sleepiness [Table 1].

Table 1: Participant characteristics

Characteristics	Mean±SD/range/ frequency (%)
Age	20.71±1.93
Gender	
Male	274 (68.0)
Female	115 (28.5)
Unreported	14 (3.5)
Ethnicity	
Amhara	113 (28.0)
Tigray	5 (1.2)
Oromo	157 (39.0)
Keffa	4 (1.0)
Bench	3 (0.7)
Others	71 (17.6)
STOP-BN: Factor-1	1.02±0.92 (0-3)
STOP-BN: Factor-2	0.28±0.58 (0-3)
STOP-BN total score	1.30±1.14 (0-5)
Sleepiness*	
0-5 lower normal daytime sleepiness	152 (37.7)
6-10 higher normal daytime sleepiness	119 (29.5)
11-12 mild excessive daytime sleepiness	34 (8.4)
13-15 moderate excessive daytime sleepiness	25 (6.2)
16-24 severe excessive daytime sleepiness	11 (2.7)
Unreported	62 (15.4)
Smoking	
Yes	24 (6.0)
No	377 (93.5)
Unreported	2 (0.5)

*Based on ESS. ESS=Epworth sleepiness scale, SD=Standard deviation

Univariate descriptive statistics along with communality and factor loading values are presented in Table 2. The values of skewness and kurtosis indicated the applicability of categorical data analysis methods for factor analysis.[31] As shown, four STOP-BN questionnaire items had skewness more than 1.0 and five had a kurtosis index of more than 1.0. As a high proportion of items, i.e., 4 out of 6 items had skewness issues, therefore, GLB to reliability was estimated for assessing internal consistency.[32] Next, the correlations were statistically significant ($P < 0.05$) between individual STOP-BN item scores and total STOP-BN score with a range of $r = 0.17–0.66$ [Table 2].

Factorial validity

As shown in Table 3, the results of Bartlett's test (X^2(df = 15) = 148.7, $P < 0.001$), determinant score (0.69), and KMO test of sampling adequacy (0.58) indicated that the STOP-BN scores in the studied sample fulfilled the conditions for factor analysis.[33] To further confirm the suitability of factor analysis, problems of multicollinearity and singularity were tested with inter-item correlations.[34] The inter-item correlations correlations were found to be significant with weak-to-moderate coefficients between the STOP-BN questionnaire items ($r = 0.07–0.54$, $P < 0.05$). Moreover, as presented in Table 2, all the STOP-BN questionnaire items showed sufficient communality values of above 0.2, for retention in the factor analysis.[21]

The results of the EFA are presented in Table 4. A 2-Factor model was identified using the following test and criteria: The Kaiser's criteria and the screen test. However, the parallel analysis based on minimum rank, which is one of the robust measures of factor retention, and the cumulative variance criteria (>40%) identified a 1-Factor model [Table 4]. Factor loadings are reported in Table 2; the loadings ranged from 0.364 to 0.745.

The results of model fit indices are presented in Table 5. The identified 2-Factor model showed an acceptable fit, as the reported GFI and WRMR were in the ideal range and the CFI was close to the ideal range [Table 5]. However, the χ^2 was significant, indicating no absolute fit.[30] However, the χ^2/df was lower for the 2-Factor model.

Internal consistency

Internal consistency results are presented in Table 6. The GLB for 1-Factor, and 2-Factor models were 0.67 and 0.67, respectively. The value of GLB (0.82) indicated acceptable to adequate internal consistency of the STOP-BN.[35,36]

Table 2: Univariate descriptive statistics, communality, and factor loadings of the STOP-BN Questionnaire scores in young people

Items of the STOP-BN questionnaire	Skewness	Kurtosis	Item-total correlations	Item-factor correlations#		Communality (h^2)	Factor loading¥	
				Factor-1	Factor-2		Factor-1	Factor-2
Snore	0.865	−1.252	0.657*	0.669*		0.542	0.678	
Tiredness during day	−0.129	−1.981	0.544*	0.718*		0.205	0.364	
Observed sleep apnea	1.664	0.764	0.580*	0.594*		0.571	0.745	
Medication for high blood pressure	2.517	4.322	0.414*		0.571*	0.493		0.616
BMI (>35 kg/m^2)	1.876	1.512	0.167*		0.693*	0.235		0.482
Neck (>16 inch)	2.067	2.265	0.393*		0.675*	0.552		0.742

*P<0.01, #Spearman's correlation coefficient, ¥Diagonally weighted least squares (RDWLS) with Promin rotation. RDWLS=Robust diagonally weighted least square, BMI=Body mass index

Table 3: Multivariate descriptive, sample size adequacy, and reliability measures of the STOP-BN Questionnaire scores in young people

Measures	Values
Multivariate descriptive	
Mardia's skewness	χ^2 (df=56)=1241.466, P=1.00
Mardia's kurtosis	χ^2=14.162, P<0.001
Sample size adequacy	
Bartlett's test of Sphericity	χ^2 (df=15)=148.7, P<0.001
Determinant	0.69
KMO	0.58
Internal consistency	
GLB: STOP-BN	0.82
GLB: Factor-1	0.67
GLB: Factor-2	0.67

KMO=Kaiser-Meyer-Olkin test of sampling adequacy, GLB=Greatest Lower Bound to Reliability

Divergent validity

The correlation between STOP-BN scores and the ESS scores was either nonsignificant (for three items) or significant but weak, such as those between ESS score and tiredness during the day (r = 0.26, P < 0.01), observed apnea (r = 0.14, P < 0.01), STOP-BN: factor- 1 (r = 0.23, P < 0.01), and the total STOP-BN score (r = 0.18, P < 0.01) [Table 5].

Discussion

The present study is the first to use factor analysis to determine the dimensionality of an abridged form of the STOP-BANG in a population of young people. This is also the first study to investigate psychometric characteristics of the STOP-BN tool using the framework of categorical data analytical methods, considering the dichotomous nature of the tool. The results indicate that the STOP-BN tool follows a two-dimensional model and that it has acceptable internal consistency and factorial validity, adequate internal homogeneity, adequate divergent known group validity, and strong item discrimination in the studied population. The psychometric validity of the STOP-BN suggests that a measure based on the consideration of snoring, tiredness, apnea, medication for high blood pressure, BMI limit (>35 kg/m^2), and the neck circumference limit (>16 inches) may be adequate to screen OSA in the study population. However, this need to be further established by evaluating diagnostic validity of the STOP-BN vis-a-vis a concurrent measure of a standard polysomnographic assessment.

Factorial validity

Factorial validation confirmed a two-dimensional construct of the STOP-BN in the study population with three items loading on each of the two factors. The moderate-to-strong level of correlation between the factors and their respective items further support the 2-Factor structure of the STOP-BN in the population. A closer examination of the two factors and their respective items do seem to support the statistical conclusion. All three items, i.e., SNORE, TIREDNESS during the day, and OBSERVED sleep apnea, that load together on Factor-1 can be broadly classified as symptoms that are associated with OSA. Whereas, the three items, i.e., medication for high blood pressure, BMI (>35 kg/m^2) and NECK (>16 inches) are risk factors of OSA, supporting the 2-Factor theoretical construct (symptoms and risk factors) based on pathophysiological considerations. This 2-Factor solution in our study population is somewhat contrary to the conclusions by Chung *et al*. (2008) that all four questions of the STOP represent different dimensions.[12] Moreover, the values of factor loadings satisfy the criteria of Comrey and Lee, for the adequate level of correlation between item scores and their respective factors.[22] Interestingly, there are no previous studies that have investigated the factorial validity of the STOP-BANG. Chung *et al*. (2008) performed the factor analysis on items of the STOP together with items of the Berlin questionnaire[12] and used the factor loadings to finally select the four items for the STOP tool.[12] The limited number of studies investigating the factorial validity over the last decade is surprising given that dimensionality evaluations are very important in tool development and cross-cultural validity assessment.[37]

Internal consistency and item-discrimination

In terms of internal consistency, our results demonstrated that STOP-BN items provide a reliable measure for the tested sample, with a GLB value of 0.82. This estimate

Table 4: Fit statistics of the of the STOP-BN questionnaire scores in young people

Models	CFI	GFI	WRMR	χ^2*	df	*P*	χ^2/df
1-Factor model	0.738	0.923	0.083	48.684	9	<0.001	5.409
2-Factor model	0.925	0.959	0.041	15.500	4	0.004	3.875

*Robust mean and variance-adjusted χ^2. CFI=Comparative fit index, GFI=Goodness of fit index, WRMR=Weighted root mean square residual

Table 5: Divergent validity: Correlation between the STOP-BN questionnaire and Epworth sleepiness scale scores in young people

STOP-BN measures	ESS score
Snore	0.03
Tiredness during day	0.26**
Observed sleep apnea	0.14**
Medication for high blood pressure	–0.06
BMI (>35 kg/m^2)	–0.01
Neck (>16 inch)	0.11*
STOP-BN: Factor-1	0.23**
STOP-BN: Factor-2	0.02
STOP-BN total score	0.18**

***P*<0.01, **P*<0.05. BMI=Body mass index, ESS=Epworth sleepiness scale

was selected instead of the commonly reported Cronbach's alpha or McDonald's Omega, due to the categorical nature of the STOP-BN items and asymmetric distribution of four out of the six-item scores of this scale in the study population.[32] Trizano-Hermosilla and Alvarado recommended use of the GLB in such cases.[32] Most of the previous studies investigating the psychometric properties of the STOP-BANG or STOP have reported values of Cronbach's alpha and did not report GLB; therefore, a direct comparison is not possible. GLB in our study is more than the Cronbach's alpha reported for the Portuguese version of the STOP-BANG.[38] BaHammam *et al*.(2015) reported a Cronbach's alpha (0.70) for the Arabic version of the STOP-BANG.[17] However, there are two significant differences to note. First, Cronbach's alpha is not the same as GLB, and second, STOP-BANG has two more items than STOP-BN. Tools with a larger number of items tend to have higher values than Cronbach's alpha.[39] The item-total correlations (correlations between individual STOP-BN items and total score) for all except one item in this study were above the recommended cutoff value of 0.3. This indicates that all STOP-BN items measure the same construct, while demonstrating sufficient item discrimination.[40]

Divergent validity

Sleepiness during daytime is a symptom usually associated with OSA. However, sleepiness and OSA represent different constructs,[41] because sleepiness may also be present in individuals without OSA, in such cases, it is associated with neuropsychological and cardiopulmonary reasons other than OSA.[41] Similarly, deficits in sleep and its quality, and periodic limb movement disorder are also commonly associated with sleepiness.[41] Moreover, in young people, insufficient sleep resulting from intrinsic or extrinsic factors often leads to daytime sleepiness.[42] All these illustrations of sleepiness associated with non-OSA conditions, explicably indicate that sleepiness and OSA are different constructs. For establishing divergent validity, scores on two measures designed to evaluate these conditions, i.e., the STOP-BN and the ESS, i.e., are expected not to correlate strongly. Therefore, the results of this study, i.e., non-significant and/or a significant but weak correlation between the ESS scores, a measure of daytime sleepiness, and the STOP-BN score, favors STOP-BN's divergent validity in the studied population.

The current study has several strengths and limitations. Given the reported high prevalence of OSA in children and young people,[3] routine screening of OSA in this population is reasonable. We believe that the results of the present study can be translated to the youth populations of similar ethnicity to screen and evaluate the presence of OSA and can also be used in situations where the use of nocturnal PSG is limited because of the cost or unavailability. However, further research validating the STOP-BN questionnaire in clinical populations of young people with OSA is needed to test and confirm the diagnostic validity and clinical usefulness of the tool in this and in other ethnic groups. An analysis of sensitivity, specificity, positive and negative predictive values in clinical populations, may be needed for the STOP-BN to be recommended for its widespread use in the screening of OSA in young people. It is suggested that psychometric validation in the future may benefit from the presentation of patterns across some of the important characteristics which may influence OSA. Nevertheless, we believe that the results presented in this study will be a valuable start point for further validations of the STOP-BN in young people and similar populations. The study objectives were to validate the STOP-BN in a population of young people in general, not specifically on people at risk of OSA. Although Ethiopian health care is burdened with infection-borne diseases, recent research shows an alarming increase in sleep-related disorders as well.[43-45] Therefore, this study's finding of adequate psychometric validation for a readily accessible and easily administrable tool to screen apnea in this population of young people from Ethiopia may be very helpful.

Conclusion

The STOP-BN questionnaire has demonstrated a variety of acceptable psychometric characteristics in the youth population. Results of diagnostic validation measures such as sensitivity, specificity, predictive values, and likelihood ratios may be conducted in the future to test

Table 6: Summary of the factor extraction measures used in exploratory factor analysis of the STOP-BN Questionnaire scores in young people

Number of factors	Real data Eigen value	Cumulative VE*	Above point of inflection on scree plot	PA based on principle component analysis		Decision to extract			
				Real data percentage of variance	95 percentile of random percentage of variance	Kaiser's criteria (Eigen value ≥1)	Cumulative VE rule (>40%)	Scree test	95th percentile of random percentage of variance > real-data percentage of variance
1	2.249	37.49	Yes	49.450*	50.137	√	√	√	√
2	1.472	62.02	Yes	25.762	35.546	√	X	√	X
3	0.986	78.46	No	16.766	25.184	X	X	X	X

*Values in percentage. √=Extraction criteria fulfilled, X=Otherwise, VE=Variance explained, PA=Parallel analysis

and confirm the clinical utility of the tool in the screening of young people with OSA.

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Conflicts of interest

There are no conflicts of interest.

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