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The purpose of this study was to validate the clinical usefulness of easy-to-assess clinical signs such as the Friedman tongue position (FTP), uvula size, and certain complementary examinations whose importance has not been clearly established, and to explore their potential value as predictors of the AHI.

### METHODS

#### PATIENTS

Patients who were naive for sleep studies were referred to the sleep laboratory for diagnosis and treatment of OSAS. Clinical suspicion of OSAS was established on the basis of snoring and daytime sleepiness recorded during the clinical interview with the Spanish version of the Epworth Sleepiness Scale. Patients with snoring history and clinical suspicion of OSAS entered the study protocol.

**Inclusion and Exclusion Criteria**

For inclusion, an individual had to be an adult patient (>18 years) referred to our Institution to diagnose or rule out OSAS. Exclusion criteria included (1) having other respiratory diseases, (2) having undergone a tracheostomy, (3) having a clinical suspicion of other sleep disorders, (4) having other comorbidities (chronic renal, cardiac, or hepatic failure), (5) having active neoplasms, or (6) refusal to follow the study protocol of our sleep disorders unit.

#### Sample Size

We divided patients into 4 groups: group 1 comprised individuals without OSAS; group 2, patients with mild OSAS; group 3, patients with moderate OSAS; and group 4, patients with severe OSAS. We planned to have a minimum of 30 patients in the smallest FTP group. We considered that many of the patients referred to our sleep laboratory would present some degree of sleep apnea; only a minority were expected to be snorers without sleep disorder (<10%). We also estimated a loss to follow-up of 10%. In view of our past experience, we expected the frequency of sleep apnea to be 3 times higher in groups 1 and 2 than in groups 1 and 4; we therefore aimed to include a minimum of 268 patients.

#### STUDY DESCRIPTION AND AIMS

This was a single-center, observational, cross-sectional study performed at the sleep disorders unit of a community hospital (Esperit Sant de Santa Coloma, Barcelona, Spain) with a reference area of 150,000 inhabitants. The study’s primary aims were (1) to determine the relationship between AHI values and potential explanatory variables (sex, age, body mass index [BMI]; calculated as weight in kilograms divided by height in meters squared), cervical perimeter, nasal flow [measured in decimeters cubed per second (dm³/s) at 150 Pa, hereinafter FL150], FTP, tonsil, and uvula scores); and (2) to investigate the role of these variables as predictors of the AHI. The secondary aim was to determine a predictive model to establish the diagnosis and severity of OSAS.

#### STUDY PROTOCOL AND INSTRUMENTATION

The following examinations were performed in all patients during the first visit: (1) BMI determination, (2) neck perimeter measurement, (3) oropharyngeal examination, (4) fiberrendoscopy, (5) phinomanometry, and (6) a sleep study.

At entry, after external physical examination, the otorhinolaryngologist (X.B.) conducted the oropharyngeal examination and the rhinopharyngolaryngoscopy or nasal fibroscopy. The oropharyngeal examination was performed by the same physician in all cases using a frontal light to establish the FTP and tonsil size (TS) score (Figure 2) using Friedman’s criteria with the patient seated. We added a uvula score predesigned for this study according to the following criteria:

<table>
<thead>
<tr>
<th>Uvula Score</th>
<th>Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Uvula clearly visible without hypertrophy</td>
</tr>
<tr>
<td>2</td>
<td>Uvula slightly hypertrophied without touching the tongue</td>
</tr>
<tr>
<td>3</td>
<td>Hypertrophic uvula in contact with the tongue base</td>
</tr>
<tr>
<td>4</td>
<td>Markedly hypertrophic uvula lying on the tongue base</td>
</tr>
</tbody>
</table>

Rhinomanometry was then performed the day before the sleep study. The fiberrendoscopy was performed with a Rhino-Laryngo fiberscope (model ENF-GP; Olympus Co, Tokyo, Japan) and the rhinomanometry with a Sibelmed Rhinospir pro (Sibel S.A., Barcelona, Spain) in accordance with international guidelines. The sleep study was performed using a previously validated portable respiratory recording device (PRRD) (Sibel home Plus; Sibel S.A.). The system records oronasal airflow by thermistor; nasal airflow via a nasal cannula, which acts as pressure transducer; chest and abdominal respiratory movements; tracheal sounds; heart rate; oxygen saturation; and body position. The PRRD was programmed to start 10 minutes after patients went to sleep. Sleep studies were performed at the patient’s home using the unattended mode.

The AHI was calculated as the sum of the number of episodes of apnea and hypopnea per hour of recording. The analysis was performed manually using the criteria recommended by the American Academy of Sleep Medicine. Respiratory events were characterized as apnea when there was a cessation or reduction of more than 90% of airflow lasting 10 seconds and as hypopnea when any clearly discernible reduction in airflow (>30% and <90%) lasting 10 seconds was observed, associated with a dip of at least 3% in pulse oximeter oxygen saturation.
To assess OSAS severity, patients’ AHI was classified as follows: an AHI value below 5.0/hour was considered normal; an AHI value of 5.0/hour to 14.0/hour, mild; an AHI value of 15.0/hour to 30.0/hour, moderate; and an AHI value higher than 30.0/hour, severe; in accordance with the guidelines of the American Academy of Sleep Medicine.11

**STATISTICAL ANALYSIS**

Data are given as mean (SD). The bivariate relationships between AHI values and potential explanatory variables (sex; age; BMI; cervical perimeter; FL150; and FTP, TS, and uvula scores) were assessed using the Spearman correlation coefficient or the Wilcoxon rank sum test as appropriate. A multivariate regression analysis was conducted to investigate the predictor role of potential explanatory variables in more depth. To achieve normality and homoscedasticity, a logarithm transformation was used, so that the logarithm of the AHI (log AHI) was modeled rather than the AHI itself. Two different strategies were used to select the best-fitting model from a total of 511 alternatives. First, we looked for the model with lowest Mallows’ *C*_p value. Second, we used a stepwise selection procedure with a 0.10 probability level of the *F* statistic entering or staying in the model. Once a model was selected, 2-way and 3-way interaction terms were also explored. The goodness of fit of the final model was assessed by inspecting residual plots. All statistical analyses were performed with SAS software (version 9.1; SAS Institute Inc, Cary, North Carolina).

The study protocol was approved by the hospital’s institutional review board. Only patients’ oral informed consent for the anonymous treatment of their data was required since the study protocol was the same as that used for the standard medical care of these patients in our institution.

We prospectively studied 301 consecutive patients from January 2006 to December 2009. Their ages ranged from 18 to 82 years (mean [SD], 51 [12] years),12 71.1% were male, and 28.9% were female, the mean (SD) BMI was 29.8 (4.6), the cervical perimeter was 40.6 (3.7) cm, and the FL150 was 0.80 (0.26) cm³/s.

The distribution of FTP, TS, and uvula scores, along with other patients’ characteristics, are displayed in Table 1. Note that for these 3 scores, the 2 middle categories accounted for about 80% of the sample. The AHI values ranged from 0.7/hour to 89.5/hour (mean [SD], 27.6/hour [19.4/hour]). Ninety-four percent had an AHI value higher than 5.0/hour.

**BIVARIATE ANALYSIS**

The AHI values showed a statistically significant correlation with FTP scores, TS scores, uvula scores, BMI, cervical perimeter, and age. In all cases, the correlation was positive, but its intensity varied markedly: while a high correlation was found in the case of the FTP score (Spearman *r* = 0.88) (Table 2), the correlation was only moderate for the cervical perimeter (*r* = 0.40) and very low for the TS scores, uvula scores, and age (Table 2). We
did not detect a significant correlation between AHI values and the FL150.

The AHI values were significantly higher in males than in females (Wilcoxon rank sum test; \( P = .02 \)): the median AHI value was 24.3/hour for males and 18.0/hour for females.

**CRUDE DESCRIPTION OF AHI INDEX AND FTP CLASSIFICATION**

Almost three-quarters of patients (74.1%) had FTP scores of 2 and 3 (Table 1). Findings from 18 of 301 patient studies (6%) were considered normal (AHI < 5.0/hour): 16 were classified as FTP 1, and only 2 as FTP 2.

All patients with an FTP score of 1 had an AHI value lower than 16.0/hour; in most of them (64.0%), the AHI value was 5.0/hour to 10.0/hour. Most patients with an FTP score of 2 (58.7%) had an AHI value of 10.0/hour to 20.0/hour. Two patients had normal values, and only 5 had an AHI value of 30.0/hour (all of them with a uvula index of 3). The FTP scores and AHI categories are shown in Table 3.

One patient with an FTP score of 3 had an AHI value of 13.4/hour, but all the others had an AHI value of 16.0/

### Table 1. Characteristics for the 301 Patients in the Study Group

<table>
<thead>
<tr>
<th>Study Variable</th>
<th>No. (%) in Each Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTP score</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>43 (14.3)</td>
</tr>
<tr>
<td>2</td>
<td>114 (37.9)</td>
</tr>
<tr>
<td>3</td>
<td>109 (36.2)</td>
</tr>
<tr>
<td>4</td>
<td>35 (11.6)</td>
</tr>
<tr>
<td>Tonsil size score &lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>52 (17.3)</td>
</tr>
<tr>
<td>1</td>
<td>124 (41.2)</td>
</tr>
<tr>
<td>2</td>
<td>109 (36.2)</td>
</tr>
<tr>
<td>3</td>
<td>15 (5.0)</td>
</tr>
<tr>
<td>Uvula score</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>14 (4.6)</td>
</tr>
<tr>
<td>2</td>
<td>147 (48.8)</td>
</tr>
<tr>
<td>3</td>
<td>126 (41.9)</td>
</tr>
<tr>
<td>4</td>
<td>14 (4.6)</td>
</tr>
</tbody>
</table>

<sup>a</sup>Friedman classified tonsill size in 5 grades from 0 to 4 (grade 0, patients who have had their tonsils removed; grade 1, when the tonsils are inside the tonsillar fossa; grade 2, when they extend beyond the tonsillar pillars; grade 3, when they extend beyond the tonsillar pillars but do not reach the midline; grade 4, when they extend as far as the midline.  
<sup>b</sup>We did not include group 5 because there were no cases of grade 4 (group 5) in our series.

### Table 2. Spearman Correlation of AHI With Explanatory Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Spearman Correlation</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.16</td>
<td>.007</td>
</tr>
<tr>
<td>FL150</td>
<td>0.02</td>
<td>.71</td>
</tr>
<tr>
<td>Cervical perimeter</td>
<td>0.40</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>BMI</td>
<td>0.25</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>FTP score</td>
<td>0.88</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Tonsil size score</td>
<td>0.16</td>
<td>.005</td>
</tr>
<tr>
<td>Uvula score</td>
<td>0.17</td>
<td>.003</td>
</tr>
</tbody>
</table>

Abbreviations: AHI, apnea-hypopnea index; BMI, body mass index; FL150, nasal flow, measured in decimeters cubed per second at 150 Pa; FTP, Friedman tongue position.

### Table 3. FTP Scores and AHI Categories (AASM)

<table>
<thead>
<tr>
<th>FTP Score</th>
<th>Normal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16 (37.2)</td>
<td>24 (55.8)</td>
<td>3 (7.0)</td>
<td>0</td>
<td>43 (100)</td>
</tr>
<tr>
<td>2</td>
<td>2 (1.7)</td>
<td>48 (42.1)</td>
<td>59 (51.7)</td>
<td>5 (4.4)</td>
<td>114 (100)</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>1 (0.9)</td>
<td>29 (26.6)</td>
<td>79 (72.5)</td>
<td>109 (100)</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>35 (100)</td>
<td>35 (100)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: AASM, American Academy of Sleep Medicine; AHI, apnea-hypopnea index, measured as number of episodes of apnea and hypopnea per hour of recording (see “Methods” section); FTP, Friedman tongue position.

### Table 4. Spearman Correlation of AHI With Explanatory Variables

Table 4 shows the correlation of the AHI with the explanatory variables. The model with the lowest \( C_p \) value included the FTP score, FL150, the cervical perimeter, age, and the TS score (Table 4). Despite the high correlation coefficient, the TS score did not enter into the model when using the stepwise selection procedure because it did not reach the specified significance level of 0.10.

PREDICTIVE MODEL FOR AHI VALUES

Just over three-quarters of patients (77.4%) had TS scores of 1 and 2 and only 15 had a TS score of 3 (5.0%). None had a TS score of 4. Tonsil size scores of 3 and 4 are common in the pediatric population but are rare in adult OSAS. Fifty-two of the 301 patients (17.3%) had previously undergone tonsillectomy (Table 1). Figure 4 shows the progression of OSAS severity related to TS.

All patients with TS scores of 2 and 3 had an AHI value higher than 15.0/hr; AHI values were higher in the group with a TS score of 3. Curiously, AHI values in patients who had undergone tonsillectomy were higher than in those with a TS score of 1 and quite similar to those with a TS score of 2. Most of these patients were classified as having moderate to severe OSAS. Fifty-two (67%) had an AHI value higher than 15.0/hour, and only 4 (7.6%) had an AHI value lower than 5.0/hour. Uvula scores of 2 and 3 were found in 90.7% of the population (Table 1).
2-way and 3-way interactions between the variables selected by the stepwise procedure were not significant (F tests) (Table 4).

The model finally selected included the FTP score, FL150, cervical perimeter, and age. The root mean square error for this model was 0.454, and the $R^2$ statistic was 0.748. The parameter estimates and F tests are shown in Table 4 along with partial $R^2$ values. Note that although F tests were significant, the partial contribution of FL150, age, and cervical perimeter to the fit (as measured by the partial $R^2$ statistic) was negligible. The final predictive equation for the expected log AHI was

$$-0.320/\text{FTP (score)} - 0.409 \times \text{FL150 (dm3/s)} + 0.033 \times \text{Cervical Perimeter (cm)} + 0.006 \times \text{Age (years)}.$$

### Table 4. Multiple Regression Analysis of Log AHI

<table>
<thead>
<tr>
<th>Terms in the Model</th>
<th>Parameter Estimate</th>
<th>Standard Error</th>
<th>F Value</th>
<th>P Value</th>
<th>Partial $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.320</td>
<td>0.332</td>
<td>-0.96</td>
<td>.34</td>
<td>NA</td>
</tr>
<tr>
<td>FTP score</td>
<td>0.815</td>
<td>0.036</td>
<td>22.42</td>
<td>&lt;.001</td>
<td>0.722</td>
</tr>
<tr>
<td>Cervical perimeter, cm</td>
<td>0.033</td>
<td>0.009</td>
<td>3.81</td>
<td>&lt;.001</td>
<td>0.012</td>
</tr>
<tr>
<td>FL150</td>
<td>-0.409</td>
<td>0.117</td>
<td>-3.50</td>
<td>&lt;.001</td>
<td>0.009</td>
</tr>
<tr>
<td>Age, y</td>
<td>0.006</td>
<td>0.002</td>
<td>2.46</td>
<td>.01</td>
<td>0.0061</td>
</tr>
</tbody>
</table>

Abbreviations: AHI, apnea-hypopnea index; FL150, nasal flow, measured in decimeters cubed per second at 150 Pa; FTP, Friedman tongue position; NA, not applicable.

Obstructive sleep apnea syndrome is very common and affects a considerable portion of the population. If untreated, it causes considerable increases in cardiac and cerebrovascular morbidity and mortality. Patients with obstructive OSAS remain undiagnosed owing to inadequate resources for case detection and investigation, a situation that has clear repercussions for their quality of life. Moreover, OSAS represents a considerable socioeconomic burden, owing to comorbidity, increased health care utilization in the primary and secondary health care sectors, increased use of medication, impact on employment, and loss of income. Treatment of OSAS reduces morbidity, mortality, and hospitalization rates, and its cost-effectiveness has been demonstrated. So, there is a clear need to establish optimal procedures to identify patients at risk.

Traditionally, OSAS diagnosis has been performed using in-hospital, overnight polysomnography. This procedure is time consuming and expensive, and, since its capacity is limited, waiting lists tend to lengthen.

In recent decades, several attempts have been made to find predictive models based on clinical examination of the upper airway, combined or not with clinical data such as the Epworth Sleepiness Score and/or specific radiological examinations. These models have proved difficult to implement, at least to some extent because the description of the anatomical regions involved has not been uniform.

Several studies have shown a statistical relationship between certain morphological abnormalities and OSAS severity. Tonsil size and cervical perimeter seem to be related to OSAS severity, although their specific weight in the pathophysiological mechanisms of the disease is not clear. The Mallampati score seems to be the only parameter that is strongly related to OSAS severity.
endotracheal intubation. Friedman et al9 definitively re-
termined that the position of the palate with respect to
the cervical perimeter shows the second largest
between the FTP (frequently called the modified Mallampati
ventive but in fact seemed to favor the development of
specific as a measure of local obesity).
model, possibly because cervical perimeter is more spe-
significantly correlated with AHI but did not enter the
which may point to obesity as a risk factor (BMI was also
grades A and B in Fujita’s classification.34 Interestingly,
ning to the AASM criteria.12 Note that all patients with an
FTP scores and AHI values categorized accord-
sidered to be normal. The strength of the association be-
tween age and the cervical perimeter jointly explained 1.6% of
the log AHI variation (see partial $R^2$ values in Table 4).
We also considered a uvula score and performed a rhi-
nomanometry to explore their potential usefulness as pre-
dictors. The FL150 explained only 0.9% of the log-AHI
variation (Table 4), and the uvula score did not signifi-
cantly improve the prediction.

The low contribution of the nasal flow to the model
suggests that the degree of nasal obstruction has a neg-
ligible influence on the pathophysiological mechanisms
of the disease. These results question the usefulness of
grades A and B in Fujita’s classification.34 Interestingly,
the cervical perimeter shows the second largest $R^2$ value,
which may point to obesity as a risk factor (BMI was also
significantly correlated with AHI but did not enter the
model, possibly because cervical perimeter is more spe-
cific as a measure of local obesity).

Similarly, TS was irrelevant. Curiously, tonsillectomy
performed during childhood did not seem to be pre-
bventive but in fact seemed to favor the development of
OSAS (Figure 4).

Previous studies have shown a statistical relationship be-
tween the FTP (frequently called the modified Mallampati
score) and sleep disturbances.9,27,29-33 To our knowledge,
our study is the first to quantify the specific weight of these
maneuvers in a multivariate regression model. Our results
suggest that a patient with an FTP score of 3 or 4 is un-
likely to have an AHI value within the normal range. In other
words, findings from a correct oropharyngeal physical ex-
amination may contradict those from a sleep study con-
sidered to be normal. The strength of the association be-
tween the FTP scores and the OSAS severity is further
illustrated in Figure 3, in which we show the joint distri-
bution of FTP scores and AHI values categorized accord-
ging to the AASM criteria.12 Note that all patients with an
FTP score of 4 had severe OSAS; most of the patients with an
FTP scores of 3 (71.6%) also had severe OSAS, and all
the remaining patients but 1 had moderate OSAS. Almost
all patients with an FTP score of 2 were evenly split between
mild and moderate categories, with only 2 cases (1.7%) being
normal and 4 cases (3.5%) being severe. Finally, patients
with an FTP score of 1 had either normal or mild OSAS but
very rarely moderate and hardly ever severe OSAS.

The FTP score is a modification of the Mallampati
score, established by Friedman.9 Mallampati et al 9 de-
termined that the position of the palate with respect to

to the tongue was an indicator of the ease or difficulty of
endotracheal intubation. Friedman et al 9 definitively re-
related the position of the palate and the tongue with the
risk of OSAS. Friedman et al 9 made changes to Mallam-
pati’s procedure: whereas Mallampati et al 9 performed the examination with the tongue outside the oropharyn-
geal cavity, Friedman et al 9 maintained the tongue in-
side the oral cavity in a neutral position. Initially, they
called their observations the modified Mallampati grade9
but later adopted the term Friedman tongue position90 be-
cause it is, in fact, the position of the tongue in relation
to the palate that is assessed. Friedman et al 9 believed that
this modification provides a natural and physiological
tongue position similar to the one achieved during sleep.

The FTP score is assessed with the patient in a sitting
position (the supine position increases the Mallampati
score, as Tham et al37 observed) by opening the mouth
in a natural, nonforced manner, with the tongue inside
without swallowing or inspiring. We repeated the maneu-
ver 5 times and took the most frequent result. A correct
performance of the examination is time consuming
but is necessary to avoid significant errors in determin-
ing the FTP score. In our cohort, those with FTP scores
of 2 and 3 accounted for 74.1% of the whole population,
but the severity of OSAS in the 2 groups was quite dif-
ferent. These results emphasize the importance of cor-
rect performance of the maneuver.

Our study has several limitations. First of all, the sleep
studies are performed on an ambulatory basis and might
underestimate the severity of sleep disorders. Nonethe-
less, these procedures are accepted in the literature, and
our experience shows their reliability in clinical prac-
tice.26,39 The second point applies to the target population.
Our study was performed in a white population; because
some studies have reported higher prevalence and severity
levels in Asian and African American populations,22,80 there
is no guarantee that our results apply to these populations.
Furthermore, because the sleep studies were not full poly-
sonomographic studies, the AHI may have been underes-
imated. Finally, the oropharyngeal examination was per-
fomed by a specialist and may not be so accurate when
implemented in primary care. The reproducibility of the
examination has to be widely implemented.

Despite increasing awareness of the condition and im-
provements in diagnostic procedures, most patients with
OSAS in the community remain undiagnosed and un-
treated. In the primary care sector there is considerable po-
etial for improved diagnosis. In high-risk groups, such
as patients with acute and chronic cardiovascular or cere-
brovascular disease or those with diabetes mellitus, easy
and inexpensive tests are necessary to help primary care
physicians to detect patients at risk of OSAS. The com-
plexity and cost of diagnosis is high, and many patients who
are candidates for sleep studies may not receive adequate
care owing to geographical or economic limitations. More-
over, the morbidity associated with the disease is dramati-
cally reduced when patients are treated.22 All these char-
acteristics reinforce the importance of our results. We
advocate the use of a protocolized oropharyngeal exami-
nation at primary care level to diagnose and categorize the
severity of the disease and thus to optimize the decision to
send a patient to a sleep unit for further evaluation.

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Author Contributions: All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Barceló and Domingo. Acquisition of data: Barceló and Bugés. Analysis and interpretation of data: Barceló, Mirapeix, Cobos, and Domingo. Drafting of the manuscript: Barceló. Critical revision of the manuscript for important intellectual content: Mirapeix, Bugés, Cobos, and Domingo. Statistical analysis: Mirapeix, Cobos, and Domingo. Administrative, technical, and material support: Barceló and Bugés. Study supervision: Mirapeix and Domingo.

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