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Original Research Article

Association Between Friedman Tongue Position and Respiratory Disturbance Index in Patients with Obstructive Sleep Apnea

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Abstract

Background: Obstructive sleep apnea (OSA) is characterized by repeated episodes of complete or partial upper airway obstruction during sleep. This sleep disorder is often ignored or undiagnosed because it is often underdiagnosed due to non-specific symptoms, even though it can cause health problems and interfere with the quality of life. The gold standard for diagnosing OSA is polysomnography (PSG), but PSG is not available in all healthcare facilities. The Friedman Tongue Position (FTP) examination is a simple method for estimating upper airway obstruction and is expected to serve as a screening tool for OSA risk.

Objective: To determine the association between Friedman Tongue Position and the Respiratory Disturbance Index (RDI) in obstructive sleep apnea. To determine the association between body mass index, age, and sex with the respiratory disturbance index in obstructive sleep apnea.

Methods: The study was conducted from August to October 2024 at Dr. Kariadi Central General Hospital Semarang, with a total sample of 44 adults (>18 years), comprising 22 OSA and 22 non-OSA subjects. This was a cross-sectional study involving patients who had undergone PSG. The RDI values were obtained from PSG results. FTP was assessed through tongue examination. Data were analyzed using the Chi-square test.

Results: Chi-square analysis revealed significant associations between BMI ($p = 0.013$) and FTP ($p < 0.001$) and RDI. Meanwhile, Fisher's Exact test for age ($p=0.697$) and Chi-square test for sex ($p=0.203$) indicated no significant association with RDI.

Conclusion: FTP and BMI showed significant associations with RDI, where higher FTP grades and obesity increased the likelihood of OSA. In contrast, age and sex were not significantly associated with RDI, indicating that they do not independently influence respiratory disturbance severity.

Keywords: *Tongue; Sleep apnea; Obstructive*
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INTRODUCTION

Obstructive Sleep Apnea (OSA) is a common sleep disorder, many people may suffer from it but do not realize it. OSA is characterized by repeated episodes of upper airway obstruction that are complete or partial during sleep.[1] Snoring is a symptom of OSA.[2] OSA is a form of sleep-disordered breathing that is characterized by apnea episodes lasting at least 10 seconds.[3] This sleep disorder is often ignored or undiagnosed because some people consider it a normal condition, whereas it can lead to complications such as impaired cognitive function, reduced sleep quality, decreased work productivity, and diminished quality of life.[4]

Obesity is a well-established risk factor for OSA because it contributes to anatomical alterations that

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promote upper airway obstruction during sleep. Increased neck circumference and adipose tissue deposition around the upper airway reduce airway calibre, making the airway more prone to collapse and impairing airflow during sleep.[7] Most population-based studies show a two- to three-fold greater prevalence of OSA among men compared to women. [8–10] Age and BMI are risk factors for OSA in both men and women, though the degrees of their impact vary between the sexes.[10]

Oral cavity examination is an important component of the physical examination for OSA. Friedman Tongue Position (FTP) is a simple method to estimate hypopharyngeal obstruction, developed as a modification of the Mallampati score and consists of four classifications.[11] The Friedman Tongue Position (FTP) is divided into four grades. Grade I indicates full visualization of the tonsils, uvula, soft palate, and hard palate. Grade II is subdivided into IIa, where the upper portion of the tonsils, uvula, soft palate, and hard palate are visible, and IIb, where the entire soft palate, hard palate, and the tip of the uvula can be seen. Grade III reflects visualization of only the posterior half of the soft palate along with the hard palate, while Grade IV indicates that only the hard palate is visible.[12] Polysomnography is the gold standard for diagnosing OSA.[13] Polysomnography is defined as the simultaneous monitoring and recording of physiological activities during sleep. PSG can function as a diagnostic tool when clinical history alone is insufficient to establish the diagnosis.[14] Sleep apnea test results are assessed using the apnea-hypopnea index (AHI) and the respiratory disturbance index (RDI).[15]

The RDI was selected as the primary metric for assessing sleep-disordered breathing severity rather than the traditional Apnea–Hypopnea Index (AHI). As described by Malhotra et al., AHI has notable limitations because it includes only apneas and hypopneas and excludes respiratory effort–related arousals (RERAs), which contribute significantly to sleep fragmentation. This narrow definition may fail to capture the full physiological burden of obstructive sleep apnea. In contrast, RDI incorporates RERAs in addition to apneas and hypopneas, providing a more comprehensive and clinically meaningful representation of upper-airway instability. Using RDI allows for a more complete evaluation of respiratory disturbances and offers greater sensitivity in identifying clinically relevant impairment.[16]

Various studies show that there is a relationship between OSA and FTP. A study using the Epworth Sleepiness Scale (ESS) questionnaire demonstrated a relationship between AHI scores and FTP grades.[17] Another study using the Berlin and ESS questionnaire reported that FTP and OSA are not directly associated but may still serve as a useful screening tool.[18] However, previous studies have not examined the relationship between FTP and RDI values in patients with OSA.

Recent literature highlights the increasing clinical relevance of the RDI in the assessment of sleep-disordered breathing. Gaspar et al. noted that RDI encompasses apnea, hypopnea, and respiratory effort–related arousals (RERAs), making it a more comprehensive index of upper-airway obstruction compared with the traditional AHI. Because RERAs reflect subtle airflow limitation and sleep fragmentation, RDI may better capture the full spectrum of respiratory abnormalities, particularly in patients with milder or anatomically driven obstruction.[19] The importance of RDI is further emphasized in the 2024 Australasian Sleep Association guidelines, which formally define RDI as the sum of apnea, hypopnea, and RERA events and acknowledge its value in clinical evaluation and decision-making. [20] Despite these advances, most studies investigating anatomical predictors such as FTP continue to rely exclusively on AHI, resulting in limited evidence regarding the association between FTP and the broader respiratory disturbances captured by RDI. This creates a clear research gap that supports the need to evaluate FTP using RDI as the severity measure.

In addition to its anatomical relevance, the Friedman Tongue Position (FTP) has been increasingly evaluated as a potential diagnostic marker for obstructive sleep apnea (OSA). As polysomnography remains limited in availability, especially in resource-constrained settings, simple bedside predictors are valuable for early risk stratification. FTP reflects tongue size relative to the oral cavity and the degree of oropharyngeal narrowing, both of which contribute to upper airway collapsibility during sleep. Previous studies have demonstrated that higher FTP grades are associated with increased OSA likelihood, suggesting that FTP may serve as a useful clinical indicator to guide the need for further sleep evaluation. Incorporating a diagnostic test analysis of FTP may therefore enhance understanding of its predictive performance and support its application as a practical screening tool in routine clinical practice.

MATERIALS AND METHODS

The research was conducted from August to October 2024 at Dr. Kariadi Central General Hospital Semarang. This study employed an analytical observational design with a cross-sectional approach and included two groups: the OSA group and the non-OSA group. The OSA group consisted of subjects who underwent polysomnography (PSG) and had an RDI value >5, while the non-OSA group consisted of subjects with an RDI value <5. The sample size in this study was determined using the standard sample size formula for proportions. Based on this calculation, the minimum required sample was 44 participants, consisting of 22 subjects in the OSA group and 22 subjects in the non-OSA group, all of whom were aged over 18 years.

The data used in this study were obtained from secondary sources, namely medical records of patients who had undergone polysomnography (PSG) and Friedman Tongue Position (FTP) assessments. FTP measurements were extracted from the medical records, where they had been previously performed and documented by clinicians as part of routine clinical evaluation. All data were anonymized prior to analysis. FTP was categorized into two groups: low and high. Grades I and II were classified as low, whereas Grades III and IV were classified as high. RDI was used instead

Table 1. Characteristics of Research Respondents

Variable	PSG Examination			
	OSA		Non OSA	
	n	%	n	%
Group	22	100	22	100
Age				
18-59 years	20	90,9	20	90,9
≥ 60 years	2	9,1	2	9,1
Sex				
Men	17	77,3	12	54,5
Women	5	22,7	10	45,5
BMI				
Obesity	18	81,8	9	40,9
Non obese	4	18,2	13	59,1
FTP				
High	18	81,8	4	18,2
Low	4	18,2	`18	81,8
RDI				
Normal	0	0	22	100
Light	3	13,6	0	0
Medium	3	13,6	0	0
Heavy	16	72,7	0	0

of AHI because it includes respiratory effort–related arousals (RERAs), providing a more comprehensive measure of upper-airway obstruction. This makes RDI more sensitive in detecting clinically relevant respiratory disturbances than AHI.

Data analysis was performed using univariate, bivariate, and multivariate approaches. Univariate analysis was conducted to describe the frequency distribution of the data. Bivariate analysis was used to assess the relationship between each independent variable and the outcome using the chi-square test, with statistical significance determined by a p-value ≤ 0.05. Variables with a bivariate p-value < 0.25 were considered eligible for inclusion in the multivariate model. Accordingly, BMI, sex, and FTP were included in the analysis. Multivariate logistic regression was selected because it allows evaluation of the independent effect of each variable on the likelihood of OSA while simultaneously controlling for potential confounding factors.

An additional diagnostic test analysis was conducted to further evaluate the predictive value of the Friedman Tongue Position (FTP), as recommended in previous studies. This analysis assessed the ability of FTP to detect OSA using polysomnography as the gold standard. The evaluation included calculating sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy. This approach aimed to determine the practical utility of FTP as a screening tool for identifying individuals at increased risk of clinically significant respiratory disturbances.

Ethical approval for this study was obtained from the Health Research Ethics Commission of the Faculty of Medicine, Diponegoro University (No. 261/EC/KEPK/FK-UNDIP/V/2024). The identity of all research participants was kept confidential and was not disclosed without their permission. All costs related to the conduct of this research were borne by the researchers.

Table 2. Relationship between BMI, Age, and Sex with RDI Values

Variable	PSG Examination				p
	OSA		Non OSA		
	n	%	n	%	
BMI					
Obesity	18	81,8	9	40,9	0,013*
Non Obese	4	18,2	13	59,1	
Age					
18-59 years	20	90,1	20	90,9	0,697[£]
≥ 60 years	2	9,1	2	9,1	
Sex					
Men	17	77,3	12	54,5	0,203[¥]
Women	5	22,7	10	45,5	

Note : * Significant (p<0,05); [£] Fisher's Exact; [¥] Continuity Correction

Table 3. Relationship between FTP with RDI value

FTP	PSG Examination				p
	OSA		Non OSA		
	n	%	n	%	
High	19	86,4	4	18,2	<0,001*
Low	3	13,6	18	81,8	

Note : *Significant (p<0,05)

Table 4. Multivariate Logistic Regression Analysis

Variable	Beta	p	OR	95%CI
BMI	0,517	0,604	1,677	0,237-11,846
Sex	0,969	0,279	2,635	0,456-15,212
FTP	3,350	<0,001*	28,50	5,585-145,440

Note : Significant (p<0,05)

Table 5. Diagnostic Accuracy of the FTP for OSA

FTP	OSA	Non OSA
High	19	4
Low	3	18

RESULTS

In this study, a total of 44 subjects were included, divided equally into the OSA and non-OSA groups. The majority of participants in both groups were adults aged 18–59 years. The OSA group consisted predominantly of males, whereas the non-OSA group showed a more balanced distribution between sexes. Obesity was more common among individuals with OSA, while most subjects without OSA were not obese. A clear difference in airway anatomy was also observed: the OSA group largely exhibited high FTP scores, indicating a greater risk of upper-airway obstruction, whereas the non-OSA group mostly demonstrated low FTP scores. As expected, RDI values in the OSA group ranged from mild to severe, while all subjects in the non-OSA group showed normal RDI values. These findings highlight distinct demographic and clinical differences between individuals with and without OSA.

Further analysis identified specific variables associated with RDI severity. BMI showed a significant relationship with RDI (p=0.013), supporting the role of obesity as an important contributor to increased respiratory disturbance during sleep. In contrast, age did not demonstrate a meaningful association with RDI (p=0.697), suggesting that, within this study population, the severity of sleep-related breathing

disturbances is not primarily influenced by age. Similarly, sex was not significantly associated with RDI (p=0.203), indicating that men and women experience comparable levels of respiratory disturbance when other factors are taken into consideration. Overall, these findings emphasize BMI and upper-airway anatomy (reflected by FTP) as key factors linked to OSA severity, while age and sex do not independently affect RDI in this sample.

The analysis of FTP categories revealed a strong association between upper-airway anatomy and respiratory disturbance severity in patients with OSA. When FTP was classified into low (grades I–II) and high (grades III–IV), individuals with higher FTP grades exhibited substantially greater RDI values. The chi-square test showed a highly significant relationship ($p<0.001$), indicating that increased tongue position and airway narrowing are closely linked to more severe respiratory disturbances during sleep. These findings support the role of FTP as an important anatomical indicator for identifying patients at higher risk of OSA severity.

The multivariate logistic regression analysis, which included BMI, sex, and FTP, demonstrated that FTP was the strongest predictor of OSA. Among the three variables tested, only FTP showed a statistically significant association with the occurrence of OSA ($p<0.001$). The odds ratio of 28.50 (95% CI: 5.585–145.440) indicates that individuals with a high FTP grade are approximately 28 times more likely to develop OSA compared to those with a low FTP grade. These findings highlight the dominant influence of upper-airway anatomy on OSA risk, even after controlling for BMI and sex.

Diagnostic test analysis demonstrated that the Friedman Tongue Position (FTP) had a sensitivity of 86.36% and a specificity of 81.82% in detecting OSA. The positive predictive value was 82.61%, while the negative predictive value was 85.71%. The overall diagnostic accuracy was 84.09%, indicating that FTP has substantial potential as a simple clinical screening tool for identifying individuals at risk of OSA.

DISCUSSION

Based on the research results, there is a significant relationship between BMI and RDI in patients with OSA. The mechanism of OSA in obesity involves narrowing of the upper airway due to the accumulation of adipose tissue within the muscles and soft tissues surrounding the airway.[3]According to Hargens et al., the main predisposing factor for OSA is obesity, as increased cervical adipose tissue leads to fat tissue infiltration into the pharyngeal structure, resulting in airflow obstruction during sleep.[21]

Based on the results of the study, there was no significant relationship between age and RDI values. This finding is consistent with a study by Zadra, which also reported no significant association between age and OSA.[22] However, it differs from other studies suggesting that advancing age increases OSA risk due to age-related weakening of the pharyngeal dilator muscle.[21] The lack of a significant association in this study may be explained by the influence of other factors particularly BMI which is a major predisposing factor for OSA. Individuals with higher BMI have a greater likelihood of developing OSA due to increased fat deposition in the chest and neck, which contributes to upper airway narrowing and breathing disturbances during sleep.

The results of bivariate also showed no significant association between sex and RDI values in patients with OSA. This finding aligns with the study by Valeriana et al., which found no significant relationship between sex and OSA risk.[23] Similarly, Fraire et al. reported no significant association between sex and OSA among children and adolescents.[24] However, these findings differ from those of Zaman et al., who reported that men are at a higher risk of developing OSA than women.[25] Polysomnographic characteristics of OSA also vary between the sexes. Men typically exhibit more frequent apneas (compared with hypopneas), longer apnea duration, and more severe oxygen desaturation. In contrast, women are more likely to experience events during REM sleep. [6] Several studies show that women tend to have less NREM events, but similar or greater REM events compared to age and BMI-matched men. [6] The relationship between sex and OSA risk therefore remains unclear and warrants further investigation. Additionally, some studies note that sleep disorders in women may be underrecognized and underreported compared with men.

Based on the results of this study, there is a significant relationship between FTP and RDI value in patients with OSA. This finding is consistent with the study by Yuniarti et al., which also reported a significant association between FTP and OSA.[26] Schwab et al. likewise found that higher FTP grades are associated with an increased risk of OSA.[27] Several literature reviews have demonstrated that the FTP grade is positively and significantly correlated with OSA severity, as measured by the AHI, indicating a greater likelihood of developing severe OSA.[18] An enlarged tongue may contribute to oropharyngeal obstruction, resulting in airflow cessation despite ongoing respiratory effort during sleep. Although several studies support the association between FTP and OSA risk, debate remains regarding its clinical applicability. Nevertheless, FTP continues to be relevant in the clinical assessment of patients and holds potential as a screening tool for OSA.[11]

The diagnosis of OSA is established through in-laboratory polysomnography or home-based portable monitoring. However, polysomnography is not widely accessible across all healthcare facilities. The Home Sleep Apnea Test (HSAT) provides a more convenient alternative for evaluating OSA, although its availability is still limited. As a result, clinicians often rely on clinical history and physical examination findings to determine the need for further diagnostic testing. Examination of the oral cavity is one of the commonly assessed physical parameters used to estimate the risk of OSA.[11]

Based on the findings of Luzzi et al., FTP offers clinically valuable information by reflecting anatomical factors that contribute to upper airway narrowing and by demonstrating correlations with anthropometric risk indicators such as BMI and neck circumference. Therefore, FTP represents a practical bedside tool for

early risk stratification of OSA, especially in settings with limited access to polysomnography.[18]

This study has several limitations that should be acknowledged. First, the sample size was relatively small, which may limit the statistical power and generalizability of the findings. Second, the use of retrospective medical record data may introduce information bias due to variability in documentation quality and possibility of incomplete or missing data. Third, several important confounding variables, such as neck circumference, craniofacial anatomical variations, and smoking status were not controlled for in the analysis, which may affect the observed relationship between FTP and RDI. These limitations should be considered when interpreting the study results and highlight the need for future studies with larger samples and more comprehensive data collection.

CONCLUSION

There is a significant relationship between FTP and RDI in individuals with OSA. Those with high FTP grades have a 28.5-fold greater likelihood of experiencing OSA compared to those with low FTP scores. Although FTP can serve as a useful screening tool, it has limitations in predicting OSA severity. BMI also demonstrated a significant association with RDI, indicating that higher BMI contributes to increased upper-airway obstruction and greater respiratory disturbance during sleep. These findings reinforce the role of obesity as an important clinical factor influencing OSA severity.

In addition, the diagnostic test analysis showed that FTP demonstrated acceptable sensitivity, specificity, and predictive values, supporting its potential role as a simple clinical screening tool for identifying individuals at risk of OSA. However, its diagnostic performance remains insufficient to replace polysomnography, and FTP should be interpreted alongside other clinical factors. Further studies with larger sample sizes are needed to confirm its clinical applicability.

Further research using prospective study designs is needed to establish a direct causal relationship between these variables and OSA. In addition, future studies should compare pre-operative and post-operative RDI values in patients undergoing uvulopalatopharyngoplasty to evaluate the impact of surgical intervention on respiratory disturbance severity.

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