Original Research

Is Speech Frequency Thresholds Associated with STOP-BANG Score of Commercial Drivers?

Arezu Najafi[1], Nafiseh Naeem Abadi[1], Maryam Saraei[2], Khosro Sadeghniiat-Haghighi[1], Masoomeh Mahmoodi-Afsah[2], Ania Rahimi-Golkhandan[1]*

[1.] *Occupational Sleep Research Center, Baharloo Hospital, Tehran University of Medical Sciences, Tehran, Iran*
[2.] *Center for Research on Occupational Diseases, Tehran University of Medical Sciences, Tehran, Iran*

Received: 20 May 2018 Accepted: 07 Aug. 2018

Abstract

Background and Objective: Obstructive sleep apnea (OSA) is a common sleep-disordered breathing (SDB) characterized by intermittent hypoxemia (IH). OSA and IH are considered risk factors for increased hearing thresholds as well. Furthermore, thresholds of speech frequency affect personal fitness for driving. Thus, main purpose of this study was to assess the association between speech frequency thresholds and OSA among commercial drivers.
Materials and Methods: This cross-sectional study was conducted on 1000 commercial drivers who were referred to obtain a health license at the Occupational Medicine Clinic of Baharloo Hospital, Tehran, Iran. Blood pressure, neck size, weight, and height were recorded. Validated Persian version of Epworth Sleepiness Scale (ESS) and STOP-BANG questionnaire were completed by the participants. STOP-BANG score ≥ 3 was defined as high risk for OSA. Fast blood sugar (FBS), triglyceride (TG), and total cholesterol (TC) were measured for all drivers. Hearing threshold levels of all subjects were recorded by pure tone audiometry (PTA) in frequencies of 500, 1000, 2000, and 3000 Hz for each ear in decibels (dB).
Results: The mean age of the participants was 43.0 ± 9.9 years. The mean ESS and STOP-BANG scores of the participants were 3.1 ± 2.8 and 1.8 ± 0.8, respectively. 237 (23.7%) drivers were high-risk for OSA. Participants with OSA had significantly higher thresholds of speech frequencies compared to the low-risk ones ($P < 0.0001$).
Conclusion: OSA may be also considered as a risk factor for increased thresholds of speech frequency among commercial drivers. During drivers' periodic medical examination, evaluation of OSA as a strong risk factor for increasing hearing thresholds is recommended.

Keywords: Sleep apnea; Automobile driving; Hearing loss; Sleep

Citation: Najafi A, Naeem Abadi N, Saraei M, Sadeghniiat-Haghighi K, Mahmoodi-Afsah M, Rahimi-Golkhandan A. **Is Speech Frequency Thresholds Associated with STOP-BANG Score of Commercial Drivers?** J Sleep Sci 2018; 3(3-4): 63-67.

Introduction

Obstructive sleep apnea (OSA) is a common sleep-disordered breathing (SDB) which has been linked to several consequences such as cardiovascular problems, hypertension (HTN), insulin resistance (IR), diabetes mellitus (DM), and higher rates of accidents because of impaired cognition and daytime sleepiness (1-7). Some risk factors for OSA include male gender, advanced age, and obesity (8).

* ***Corresponding author**: A. Rahimi-Golkhandan, Occupational Sleep Research Center, Baharloo Hospital, Tehran University of Medical Sciences, Tehran, Iran*
Tel: +98 21 55460184, Fax: +98 21 55648189
Email: aniarahimi.g@gmail.com

OSA leads to intermittent hypoxemia (IH), reoxygenation, and oxidative stress that are associated with inflammatory cascade and activation of sympathetic nervous system (SNS). Furthermore, OSA leads to permanent hyperviscosity and increased interleukin 6 (IL-6) and C-reactive protein (CRP) (9-13). Thus, OSA and the consequent IH are speculated to be risk factors for hearing loss and increasing hearing thresholds (14). Furthermore, cochlear function impairment is also reported in patients with severe OSA (15). Several studies have reported auditory system alterations in these patients (16-20). Other cardiovascular risk factors such as high blood sugar and lipids are also associated with hearing loss; furthermore, these cardiovascular risk factors are considered as common factors for the development of OSA (21-23). Reports have shown an association between obesity, HTN, high fasting glucose levels, hypertriglyceridemia, and waist circumference (WC) with sensorineural hearing loss (SNHL) in drivers (24). Ototoxic drugs, neoplasms, systemic disorders, infections, and noise include the other risk factors of SNHL (14).

Commercial drivers may suffer from the aforementioned risk factors of hearing loss, most of which are overlooked and not fully elucidated. Commercial drivers have increased risk of metabolic syndrome and cardiovascular risk factors (25). They also have more risk of OSA development than the general population. Accordingly, they are more prone to increased hearing thresholds. According to standards, mean of speech frequency hearing thresholds have to be in normal range for health qualification of commercial drivers (26). Furthermore, hearing damage in professional drivers affects higher frequencies at first and then gradually affects lower frequencies (27). Increased hearing threshold in speech or lower frequencies affects fitness to drive and endangers safe driving.

Up to now, limited studies have been conducted to investigate OSA in drivers and its association with increased hearing thresholds that could adversely affect drivers' safety and occupational qualification. Currently, all drivers undergo audiometry of speech frequencies to obtain their health license in Iran (26). Considering OSA as a contributing factor of hearing loss in speech frequencies, it could have an important effect, both on drivers' examination standards and also management of drivers' increased hearing thresholds. It also could prevent early retirement of drivers because of hearing loss in speech frequencies. Moreover, speech frequency hearing loss is a serious social and health problem which can limit patient's communication and lead to lower quality of life and productivity (28).

Due to the limited information about the association of OSA and thresholds of speech frequencies in pure tone audiometry (PTA), this study aimed to assess the association between speech frequency hearing thresholds and OSA in commercial drivers.

Materials and Methods

This cross-sectional study was performed on 1000 commercial drivers who were referred to Occupational Medicine Clinic of Baharloo Hospital, Tehran University of Medical Sciences, Tehran, Iran. All drivers who were referred to the clinic for their health license during 2016-2017 were recruited. The informed consent form was obtained from all participants. Drivers were asked to fill out the validated Persian version of Epworth Sleepiness Scale (ESS) (29) and STOP-BANG questionnaire (30). Demographic characteristics, past medical history, and history of exposure to noise were recorded. Participants with a history of taking ototoxic drugs or those with chronic diseases with confirmed effect on hearing were excluded from the study.

Blood pressure, weight, height, and neck circumference were measured and audiologic examination as a part of drivers' general physical examination was done by trained physicians. A blood sample was collected in the morning of their visit from all drivers for measuring the level of fasting blood sugar (FBS), triglyceride (TG), and total cholesterol (TC) as risk factors of hearing loss (21-23).

PTA was performed by an expert audiologist using Alton interacoustics audiometer, USA. Hearing threshold levels of all drivers were measured in speech frequencies of 500, 1000, 2000, and 3000 Hz for each ear in decibels (dB) because of evaluating fitness for driving.

ESS is used for evaluating daytime sleepiness in different situations. ESS consists of eight questions with scores from zero to three for each item. Total score ≥ 10 is considered as abnormal daytime sleepiness (29).

STOP-BANG questionnaire consists of two parts of STOP and BANG. STOP part consists of four yes/no questions including snoring, daytime tiredness, observed apnea during sleep, and high blood pressure; and BANG part includes body mass index (BMI), age, neck circumference, and gender. BMI ≥ 35 kg/m^2, age ≥ 50 years, neck circumference ≥ 40 cm, and male gender are considered as positive scores. Drivers with total score of three or more in eight items of the STOP-BANG questionnaire are categorized as high-risk subjects for OSA (30).

Statistical analysis: The results are presented as mean ± standard deviation (SD) and frequency and percentage. Student t-test was used for comparing the continuous variables between high-risk and low-risk subjects for OSA. Regression analysis was done for evaluating the confounding effect of FBS, TG, and TC on hearing thresholds.

Table 1. Demographic and laboratory characteristics of the two groups of drivers

Characteristics	Drivers with STOP-BANG score ≥ 3 (n = 237)	Drivers with STOP-BANG score < 3 (n = 763)	P-value
Age (year)	49.6 ± 8.6	40.9 ± 9.3	< 0.0001
ESS score	3.5 ± 2.9	3.0 ± 2.8	0.0140
FBS (mg/dl)	101.0 ± 21.6	96.1 ± 15.2	< 0.0001
TG (mg/dl)	170.0 ± 92.0	158.0 ± 118.0	0.1300
TC (mg/dl)	184.0 ± 37.0	183.0 ± 78.0	0.8660

These values are represented as mean ± standard deviation (SD)
ESS: Epworth Sleepiness Scale; FBS: Fasting blood sugar; TG: Triglyceride; TC: Total cholesterol

P-value less than 0.0500 was considered statistically significant. Statistical analysis was performed by SPSS software (version 22, IBM Corporation, Armonk, NY, USA).

Results

The mean of age was 43.0 ± 9.9 years, and the mean of BMI was 27 ± 4 kg/m^2. 237 (23.7%) of the subjects had STOP-BANG score ≥ 3 and none of them reported ESS ≥ 10. The mean ESS and STOP-BANG scores were 3.1 ± 2.8 and 1.8 ± 0.8, respectively. Drivers were categorized into high and low risk for OSA according to the STOP-BANG score. Demographic characteristics and laboratory data of 1000 subjects is shown in table 1.

The mean of FBS and ESS scores were significantly higher in subjects who were high-risk for OSA compared to the low-risk group (P < 0.0010 and 0.0140, respectively). There was no statistically significant difference between blood levels of TG and TC in the two study groups.

Speech frequency thresholds at 500, 1000, 2000, and 3000 Hz in dB were compared between two study groups. There was a significant difference between each speech frequency threshold in subjects who were high-risk and low-risk for OSA (e.g., 21.0 ± 16.8 vs. 15.4 ± 13.5 in 3000 Hz in high-risk and low-risk groups, respectively) (P < 0.0010) (Table 2).

The mean speech frequency thresholds in right and left ears were 11.7 ± 9.0 Hz and 12.3 ± 11.4 Hz, respectively. Furthermore, there was a statistically significant difference between mean speech frequency threshold of each ear in high-risk and low-risk subjects for OSA (14.1 dB vs. 10.9 dB in right ear and 15.8 dB vs. 11.2 dB in left ear) (P < 0.0001). After controlling for confounders such as FBS, TG, and TC, the difference of mean speech frequency thresholds between the two study groups remained statistically significant in right ear (P < 0.0001) and left ear (P < 0.0001).

Discussion

This study indicated that OSA was associated with increased threshold of speech frequencies in both ears of commercial drivers. The high-risk drivers also had higher reported score of ESS and measured level of FBS.

Consistent with Ballacchino et al., current study also found higher thresholds of hearing among the patients with OSA (18). Two more detailed studies that used polysomnography (PSG) for OSA diagnosis showed that there were significantly higher thresholds of hearing in patients with severe sleep apnea compared to non-OSA snorers (16). In the other study, the authors stated that moderate to severe OSA could result in some degrees of SNHL (19).

Table 2. Speech frequency thresholds between two groups of drivers

Speech frequency	Drivers with STOP-BANG score ≥ 3	Drivers with STOP-BANG score < 3	P-value
500 Hz RE	10.1 ± 9.5	8.3 ± 6.4	0.0010
1000 Hz RE	11.7 ± 11.6	8.9 ± 7.8	< 0.0001
2000 Hz RE	14.6 ± 13.8	10.9 ± 10.4	< 0.0001
3000 Hz RE	21.0 ± 16.8	15.4 ± 13.5	< 0.0001
500 Hz LE	10.3 ± 13.3	8.0 ± 8.1	0.0020
1000 Hz LE	11.5 ± 14.2	8.3 ± 9.4	< 0.0001
2000 Hz LE	18.4 ± 36.5	11.5 ± 12.2	< 0.0001
3000 Hz LE	24.4 ± 19.6	16.9 ± 15.2	< 0.0001

These values are in dB, and are represented as mean ± standard deviation (SD).
RE: Right ear; LE: Left ear

Despite the current challenge for the association between OSA and hearing loss, one study found the link between OSA and sudden SNHL, which proposed ischemic insults to auditory system and cochlea resulting to hearing loss in OSA. In this report, it was hypothesized that OSA could lead to metabolic syndrome (characterized by central obesity, hyperglycemia, dyslipidemia, and HTN) by oxidative stress as a result of IH that occurs during sleep apnea (17, 31).

Hyperglycemia is a result of IR which increases with age (32). In the current study, higher levels of FBS in OSA group may be due to older age, or OSA, or both. Intermittent episodes of apnea can lead to sleep fragmentation causing excessive daytime sleepiness (EDS) (33). ESS is a tool that measures self-reported sleepiness (34) and in our study, it was significantly higher in the high-risk group for OSA compared to the low-risk group. The lower score of ESS might be because of not reporting sleepiness symptoms by drivers in order to obtain their health license.

This study was conducted with a large sample size of commercial drivers and the results could lead to more attention of health system towards OSA as a disease which influences safety of transportation system in many ways. OSA increases risk of sleepiness and cardiovascular and metabolic diseases, and also hearing thresholds at speech frequencies affecting fitness to drive. Therefore, more attention of health system authorities to OSA warrants safer transportation system, as we suffer from lots of deaths annually because of road traffic crashes.

It is noteworthy that using gold standard of OSA diagnosis, i.e., PSG, would come to more detailed results in this population; however, the test costs a lot of money and time. Thus, we used STOP-BANG questionnaire with high specificity and sensitivity for screening of OSA.

Conclusion

Drivers with OSA had higher thresholds of speech frequency. OSA needs to be evaluated and managed more in commercial drivers as a leading cause of sleepiness and road traffic crashes. It also needs more novel investigations. Hearing loss could lead to both drivers' disqualification for driving and also increased road traffic accidents.

Conflict of Interests

Authors have no conflict of interests.

Acknowledgments

The authors would like to thank staff of Occupational Health Clinic and Occupational Sleep Research Center of Baharloo Hospital for their kind cooperation. Also, our sincere thanks go to Dr. Ahmad Khajeh-Mehrizi for his collaboration in data analysis of this research.

References

1. Sadeghniiat-Haghighi K, Mohajeri-Tehrani MR, Khajeh-Mehrizi A, et al. Insulin resistance and leptin levels in patients with obstructive sleep apnea. J Sleep Sci 2017; 2: 7-2.
2. Qian Y, Xu H, Wang Y, et al. Obstructive sleep apnea predicts risk of metabolic syndrome independently of obesity: A meta-analysis. Arch Med Sci 2016; 12: 1077-87.
3. Rajan P, Greenberg H. Obstructive sleep apnea as a risk factor for type 2 diabetes mellitus. Nat Sci Sleep 2015; 7: 113-25.
4. Sadeghniiat-Haghighi K, Mohajeri-Tehrani MR, Khajeh-Mehrizi A, et al. Obstructive sleep apnea and excessive daytime sleepiness among patients with type 2 diabetes mellitus: A single-center study from Iran. Int J Diabetes Dev Ctries 2015; 35: 189-93.
5. Uyar M, Davutoglu V. An update on cardiovascular effects of obstructive sleep apnoea syndrome. Postgrad Med J 2016; 92: 540-4.
6. Khajeh-Mehrizi A, Rahimi-Golkhandan A, Sedaghat M. Obstructive sleep apnea among individuals admitted for myocardial infarction. J Sleep Sci 2016; 1: 23-7.
7. Xu S, Wan Y, Xu M, et al. The association between obstructive sleep apnea and metabolic syndrome: A systematic review and meta-analysis. BMC Pulm Med 2015; 15: 105.
8. Franklin KA, Lindberg E. Obstructive sleep apnea is a common disorder in the population-a review on the epidemiology of sleep apnea. J Thorac Dis 2015; 7: 1311-22.
9. Gozal D, Kheirandish-Gozal L. Cardiovascular morbidity in obstructive sleep apnea: oxidative stress, inflammation, and much more. Am J Respir Crit Care Med 2008; 177: 369-75.
10. Fanfulla F, Grassi M, Taurino AE, et al. The relationship of daytime hypoxemia and nocturnal hypoxia in obstructive sleep apnea syndrome. Sleep 2008; 31: 249-55.
11. Chin K, Ohi M, Kita H, et al. Effects of NCPAP therapy on fibrinogen levels in obstructive sleep apnea syndrome. Am J Respir Crit Care Med 1996; 153: 1972-6.
12. Vgontzas AN, Papanicolaou DA, Bixler EO, et al. Circadian interleukin-6 secretion and quantity and depth of sleep. J Clin Endocrinol Metab 1999; 84: 2603-7.
13. Muchnik C, Rubel Y, Zohar Y, et al. Auditory

brainstem response in obstructive sleep apnea patients. J Basic Clin Physiol Pharmacol 1995; 6: 139-48.
14. Mohammadi AH, Mehrparvar AH, Soltani-Gerdfaramarzi R, et al. Evaluation of the association between obstructive sleep apnea and hearing loss. J Sleep Sci 2016; 1: 94-100.
15. Matsumura E, Matas CG, Sanches SGG, et al. Severe obstructive sleep apnea is associated with cochlear function impairment. Sleep Breath 2018; 22: 71-7.
16. Casale M, Vesperini E, Potena M, et al. Is obstructive sleep apnea syndrome a risk factor for auditory pathway? Sleep Breath 2012; 16: 413-7.
17. Sheu JJ, Wu CS, Lin HC. Association between obstructive sleep apnea and sudden sensorineural hearing loss: a population-based case-control study. Arch Otolaryngol Head Neck Surg 2012; 138: 55-9.
18. Ballacchino A, Salvago P, Cannizzaro E, et al. Association between sleep-disordered breathing and hearing disorders: Clinical observation in Sicilian patients. Acta Medica Mediterranea 2015; 31: 607-14.
19. Deniz M, Ciftci Z, Ersozlu T, et al. The evaluation of auditory system in obstructive sleep apnea syndrome (OSAS) patients. Am J Otolaryngol 2016; 37: 299-303.
20. Martines F, Ballacchino A, Sireci F, et al. Audiologic profile of OSAS and simple snoring patients: The effect of chronic nocturnal intermittent hypoxia on auditory function. Eur Arch Otorhinolaryngol 2016; 273: 1419-24.
21. Sachdeva K, Azim S. Sensorineural hearing loss and type II diabetes mellitus. Int J Otorhinolaryngol Head Neck Surg 2018; 4: 499-507.
22. Das A, Sumit AF, Ahsan N, et al. Impairment of extra-high frequency auditory thresholds in subjects with elevated levels of fasting blood glucose. J Otol 2018; 13: 29-35.
23. Tan HE, Lan NSR, Knuiman MW, et al. Associations between cardiovascular disease and its risk factors with hearing loss-A cross-sectional analysis. Clin Otolaryngol 2018; 43: 172-81.
24. Aghazadeh-Attari J, Mansorian B, Mirza-Aghazadeh-Attari M, et al. Association between metabolic syndrome and sensorineural hearing loss: A cross-sectional study of 11,114 participants. Diabetes Metab Syndr Obes 2017; 10: 459-65.
25. Izadi N, Malek M, Aminian O, et al. Medical risk factors of diabetes mellitus among professional drivers. J Diabetes Metab Disord 2013; 12: 23.
26. Occupational and Environmental Health Center, Deputy of Health, Ministry of Health and Medical Education. Guideline of drivers' medical examination and standards of issuing health license [Online]. [cited 2014]; Available from: URL: http://mboh.umsha.ac.ir/uploads/d_moayenat_pezeshki.pdf. [In Persian].
27. Karimi A, Nasiri S, Kazerooni FK, et al. Noise induced hearing loss risk assessment in truck drivers. Noise Health 2010; 12: 49-55.
28. Ciorba A, Bianchini C, Pelucchi S, et al. The impact of hearing loss on the quality of life of elderly adults. Clin Interv Aging 2012; 7: 159-63.
29. Sadeghniiat HK, Montazeri A, Khajeh MA, et al. The Epworth Sleepiness Scale: Translation and validation study of the Iranian version. Sleep Breath 2013; 17: 419-26.
30. Sadeghniiat-Haghighi K, Montazeri A, Khajeh-Mehrizi A, et al. The STOP-BANG questionnaire: Reliability and validity of the Persian version in sleep clinic population. Qual Life Res 2015; 24: 2025-30.
31. Alberti KG, Zimmet P, Shaw J. The metabolic syndrome--a new worldwide definition. Lancet 2005; 366: 1059-62.
32. Petersen KF, Befroy D, Dufour S, et al. Mitochondrial dysfunction in the elderly: Possible role in insulin resistance. Science 2003; 300: 1140-2.
33. Strohl KP, Redline S. Recognition of obstructive sleep apnea. Am J Respir Crit Care Med 1996; 154: 279-89.
34. Johns MW. A new method for measuring daytime sleepiness: The Epworth sleepiness scale. Sleep 1991; 14: 540-5.