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Investigating the State of Sleep Disorders and the Factors Affecting Them in Patients with Multiple Sclerosis: Cross-Sectional Study

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Abstract

Background: Multiple sclerosis (MS) is a chronic disease that leads to non-traumatic disability and is influenced by both hereditary and environmental factors.
Objectives: This study aims to investigate the state of obstructive sleep apnea (OSA) syndrome and the factors affecting it in patients with multiple sclerosis.
Methods: This cross-sectional and descriptive study included 180 patients, selected based on previous studies on MS patients and the prevalence of sleep apnea syndrome. The STOP-BANG questionnaire, Epworth Sleepiness Scale (ESS), and Fatigue Severity Scale (FSS) were used for data collection. Additionally, a demographic profile form was utilized to gather information on age, sex, marital status, education level, and income status of the patients. Data were analyzed using SPSS 16 software, employing mean and standard deviation, chi-square test, ANOVA, correlation coefficient, and one-way analysis of variance.
Results: The results showed that among patients with a low risk of OSA, 87.3% were female, whereas among those with a high risk of OSA, 71.4% were male. This indicates that the risk of OSA is higher in men than in women with MS. Additionally, the mean ± SD of the Epworth score in high-risk individuals was 16.41 (1.56), compared to 14.27 (1.78) in low-risk individuals, indicating poorer Epworth scores in those at high risk of OSA.
Conclusions: The prevalence of OSA and other sleep disorders among patients with MS in Ilam was found to be high. Therefore, it is recommended that necessary therapeutic and rehabilitation interventions be implemented to reduce OSA and improve the sleep quality of these patients.

Keywords: Sleep Apnea Syndrome, Sleep Disorders, Multiple Sclerosis, Sleep

1. Background

Multiple sclerosis (MS) is a chronic disease (1) that is a leading cause of non-traumatic disability, influenced by hereditary and environmental factors (2). Among the non-genetic risk factors for this disease are infectious agents, smoking, hormonal factors, mental stress, and nutritional habits. Genetic factors also play a significant role, with a notable familial connection and higher prevalence among twins and siblings (3, 4). Multiple sclerosis is characterized by chronic inflammation in the central nervous system, leading to progressive and localized destruction of the myelin sheath, which disrupts the sensorimotor pathways (5).

Multiple sclerosis has a high global prevalence, with significant rates reported in Iran. The overall prevalence in Iran is 29.3 per 100,000 people, with 16.5 per 100,000 in men and 44.8 per 100,000 in women (6). In studies by Abdel Salam et al. and Sunter et al., the prevalence of high-risk obstructive sleep apnea (OSA) in MS patients was reported as 46.8% and 24.7%, respectively (7, 8). These findings highlight the necessity of investigating sleep disorders in MS patients.

The prevalence of MS is increasing worldwide, with at least 300 new cases reported daily. Approximately 400,000 people in the United States and 2.5 million people (9) globally suffer from MS. As MS often begins in early adulthood, it significantly impacts the development of family and social life, leading to

emotional, mental, and physical problems for patients (9, 10).

Sleep apnea is characterized by the complete or partial cessation of breathing during sleep, lasting more than 10 seconds (10). Obstructive sleep apnea syndrome (OSA) is a common disorder marked by repeated episodes of partial or complete obstruction of the upper airways during sleep (11). This disorder can lead to decreased arterial oxygen saturation or arousal, followed by a return to normal respiratory status with increased breathing effort (12). Key symptoms of OSA include nighttime snoring and daytime fatigue, as well as impaired concentration, pneumonia, hypoxemia, pulmonary embolism, hypotension, arrhythmia, pulmonary aspiration, asymptomatic daytime fatigue, irritability, mood disorders, and cognitive issues (13-15). The severity of OSA is determined by the frequency of apneas and hypopneas (16).

2. Objectives

Considering the importance and high prevalence of MS globally and in Iran, it is crucial to address the complications and problems associated with this disease. This study aims to investigate the prevalence of sleep apnea syndrome and other sleep disorders in patients with MS in Ilam city in 2022.

3. Methods

This cross-sectional and descriptive study was conducted on patients with multiple sclerosis referred to Shahid Mostafa Hospital, the only neurology center in Ilam Province. A total of 180 patients were selected based on sample size calculations from previous studies on MS patients and the prevalence of obstructive sleep apnea syndrome (OSA). The criteria for entering the study were that at least six months had passed since the definitive diagnosis of MS according to the opinion of a neurologist, clinical findings and medical documentation, and informed consent to participate in the study. Patients who underwent intervention with the necessary interventions to improve the symptoms of OSA, including pharmacological and non-pharmacological interventions, were excluded from the study. The STOP-BANG questionnaire, Epworth Sleepiness Scale (ESS) questionnaire, and Fatigue Severity Scale (FSS) questionnaire were used in this research. Also, a demographic profile form was used, which included demographic and disease information of patients with MS, such as age, sex, marital status, education level, and income status. Data were analyzed using SPSS version 16. Descriptive statistics (mean and standard deviation) were calculated, and inferential statistics, including chi-square tests, ANOVA, correlation coefficients, and one-way analysis of variance, were used to determine associations between variables.

3.1. STOP-BANG Questionnaire

This tool is designed to measure the risk of obstructive sleep apnea and has high sensitivity. This tool has a total of 8 questions, 4 questions about snoring, fatigue, daytime sleepiness, and sleep apnea, as well as 4 questions about demographic variables, including age, gender, neck circumference, and Body Mass Index. In this tool, which is scored as yes with a score of one and no with a score of zero, in case of a positive answer to 0 to two low-risk questions, in case of a positive answer to 3 - 4 questions, medium-risk and in case of a positive answer to 5 - 8 questions are considered high risk. In this tool, if there is a positive answer to 0 - 2 questions, it is low risk for OSA, a score of 3 - 4 is considered medium-risk, and a score greater than 3 is considered high-risk. Also, if the number of positive answers is equal or more than 2 plus male gender, BMI is more than 35 kg/m^2 or neck circumference is more than 43 cm in men or more than 41 cm in women, also placed in the high-risk group. If the STOP-Bang score is higher or equal to 3, it indicates a high risk of OSA (17, 18).

3.2. Epworth Sleepiness Scale

This tool is used to evaluate the state of sleepiness reported by patients in the last month across 8 daily activities, from 0 (I don't doze at all) to 3 (I probably doze). This tool, which uses a 4-option Likert scale, categorizes the total score as follows: 0 - 6 indicates sufficient sleep, 7 - 10 indicates mild to moderate sleepiness, 11 - 15 indicates severe sleepiness, and a score of 16 - 24 indicates dangerous drowsiness. A score higher than or equal to 11 in the ESS tool suggests a high risk for OSA and also a high risk for sleepiness (19, 20).

3.3. Fatigue Severity Scale Questionnaire

This instrument consists of nine questions, each of which can be assigned a score from 1 to 7. A score of 1 indicates disagreement, while a score of 7 indicates agreement with the selected item. The final score of the questionnaire is calculated by dividing the sum of the scores by nine, where a score of 7 indicates the highest level of fatigue and a score of 1 indicates the lowest level of fatigue (21, 22).

To collect information, a list of patients with MS referred to Shahid Mostafa Khomeini Hospital in Ilam

city was prepared. Patients meeting the inclusion criteria were identified, and the objectives of the study were explained to them. The sampling method was continuous, and sampling continued until the desired volume was reached. Upon obtaining informed consent from the patients, the questioning began. If the patients were literate and understood the questions, the questionnaire was completed by self-report; otherwise, it was completed by interview. Questions from the questionnaire that required checking height, weight, and waist circumference were measured by the researchers. Considering the conditions of Covid-19 and the prevention of infection, the entire study process was carried out in compliance with health protocols.

SPSS 16 software was used for data analysis, employing mean and standard deviation, chi-square test, ANOVA, correlation coefficient, and one-way analysis of variance.

4. Results

According to the findings in Table 1, the majority of patients were female (64.4%), married (68.9%), and had low-income satisfaction (69.4%). Additionally, the scores related to STOP-BANG and Epworth Sleepiness were higher in men compared to women and in individuals with lower income satisfaction compared to those with average income satisfaction, indicating a poorer quality of sleep in these patients. In relation to age, it was shown that the Epworth Sleepiness and STOP-BANG scores increased with age, indicating the inappropriate status of these variables in older patients (Table 1).

Table 1. Status of Scores Related to Sleep Quality of Patients with Multiple Sclerosis Based on Demographic Characteristics [a]

Variables	No. (%)	STOP-BANG	Epworth Sleepiness	Fatigue Severity
Gender				
Man	64 (35.6)	4.35 (1.93)	16.89 (1.40)	6.04 (0.68)
Female	116 (64.4)	1.75 (1.54)	14.12 (1.53)	4.85 (1.09)
P	-	0.001	0.36	0.001
F	-	97.92	0.811	61.60
Marital status				
Having a wife	124 (68.9)	2.65 (2.23)	15.00 (2.12)	5.23 (1.22)
Without wife	56 (31.1)	2.73 (1.78)	15.33 (1.67)	5.38 (0.86)
P	-	0.089	0.22	0.40
F	-	2.92	1.46	0.71
Education				
Illiterate	42 (23.3)	2.97 (1.89)	15.5 (1.74)	5.58 (0.89)
Diploma	110 (61.1)	2.5 (1.87)	14.87 (2.00)	5.24 (1.17)
Bachelor's degree	26 (14.4)	2.96 (3.10)	15.42 (2.30)	4.95 (1.15)
Diploma and above	2 (1.1)	2.5 (3.53)	15.5 (2.12)	5.07 (1.31)
P	-	0.55	0.27	0.13
F	-	0.70	1.29	1.86
Satisfaction with income				
Low	125 (69.4)	2.92 (2.23)	15.33 (2.03)	5.38 (1.02)
Medium	55 (30.6)	2.12 (1.66)	14.58 (1.82)	5.05 (1.29)
Excellent	0 (0)	0 (0)	0 (0)	0 (0)
P	-	0.01	0.019	0.07
F	-	5.68	5.59	3.31
Age	37.58 ± 5.40	0.001	0.001	0.010
P	-	10.46	11.47	6.75
F	-	0.056	0.061	0.037

[a] Values are expressed as mean ± SD or No. (%).

Table 2 shows the score status based on high and low risk. According to the findings, among patients with low OSA risk, 87.3% were female. In contrast, among patients with a high risk of OSA, 71.4% were male, indicating that the risk of OSA is higher in men than in women with MS. Additionally, the findings show that the mean ± SD Epworth score in high-risk individuals was 16.41 (1.56), while in low-risk individuals it was 14.27 (1.78), indicating a poorer status of the Epworth score in individuals with a high risk of OSA (Table 2).

Table 2. The Status of Sleep Quality According to the Investigated Variables in Patients with Multiple Sclerosis [a]

Variables	Low OSA Risk		High OSA Risk	
Gender				
Man	1.78 ± 0.89	14 (12.7)	5.08 ± 1.46	50 (71.4)
Female	1.26 ± 1.21	96 (87.3)	4.10 ± 0.30	20 (28.6)
Marital status				
Having a wife	1.22 ± 1.17	76 (69.1)	4.91 ± 1.54	48 (68.6)
Without wife	1.55 ± 1.21	34 (30.9)	4.54 ± 0.59	22 (31.4)
Education				
Illiterate	1.62 ± 1.24	24 (21.8)	4.77 ± 0.73	18 (25.7)
Diploma	1.31 ± 1.17	70 (63.6)	4.57 ± 0.63	40 (57.1)
Bachelor's degree	1 ± 1.13	15 (13.6)	5.63 ± 2.94	11 (15.7)
Diploma and above	0.00	1 (0.9)	5.00 ± 0.	1 (1.4)
Satisfaction with income				
Low	1.28 ± 1.30	67 (60.9)	4.81 ± 1.44	58 (82.9)
Medium	1.39 ± 1.00	43 (39.1)	4.75 ± 0.45	12 (17.1)
Excellent	0 ± 0	0 (0)	0 ± 0	0 (0)
Fatigue	4.87 ± 1.15		5.92 ± 0.69	
Without		0 (0)		0 (0)
Moderate		22 (22)		0 (0)
Severe		88 (80)		70 (100)
Epworth	14.27 ± 1.78		16.41 ± 1.56	

Variables	Low OSA Risk	High OSA Risk
Mild	2 (2.8)	0 (0)
Intense	84 (76.4)	24 (34.3)
Dangerous	24 (21.8)	46 (65.7)

[a] Values are expressed as mean ± SD or No. (%).

5. Discussion

In the present study, 64.4% of the investigated patients were female, and the overall age range of the patients was 37 years. In the study by Koltuniuk et al., the average age of the patients was around 36 years, and 80% of the patients were female (23). In Johansson et al.'s study, the average age was 38 years, and most patients were female (24). In the study by Ma et al., the average age of the patients was 40 years, and most of them were women (25), which is consistent with the results of this study.

According to the findings, the prevalence of OSA was higher in men than in women. In the study by Bearpark et al., it was 4.7% in men (26), in the study by Simpson et al., it was 12.4% in patients aged 18 to 80 and male, and 5.7% in women of this age range (27). In the study of Cunningham et al., this rate was 20.2% in men and 10% in women (28). In Howard et al.'s study, 99% of men (29), in Pack et al.'s study, 93% of men (30), and in a study by Huhta et al., 96.5% of male patients had OSA (31). This is consistent with the results of this study, showing that the prevalence and risk of OSA were higher in men than in women.

According to the results, the mean ± SD score of the ESS questionnaire was 15.10 (1.99), with 108 (60%) of the patients having intense sleep quality and 70 (38.9%) having dangerous sleep quality. In the study by Aljundi et al., mean ± SD was 8 (5.6) (32), and in the study by Ma et al., it was 12.78 (5.14%) (25), which is lower than the results of this study. On the other hand, in the study by Kołtuniuk et al., pathological sleepiness was present in 12.5% of patients, moderate sleepiness in 28.9% of patients, and severe sleepiness in 58.55% of patients (23). The ESS questionnaire score of the present study is in the intense range, which is lower than the results of the study by Kołtuniuk et al., and it is not in line with this study (23).

In the present study, the mean ± SD STOP-BANG score is 2.67 (2.10), and 110 people (61%) have a score higher than 3, indicating they are at risk of OSA, while 70 people (39.9%) have a score less than 3, indicating a low risk of developing OSA. In the study by Singh et al., 70% of MS patients had a score higher than 3 (33). Similarly, in the study by Dias et al., 43 people (42%) of the patients were at risk of infection (34), which aligns with the results of this study. On the other hand, in Yazdchi et al.'s study, the mean ± SD STOP score was 0.66 (0.65), and 93 (90.29%) of the patients were at low risk for OSA, which is much lower than the results of this study. Yazdchi et al.'s study examined patients with a disability score of less than 4 (35), while the current study examined patients at all levels of disability, which seems to be one of the reasons for the difference in the STOP score results.

5.1. Conclusions

The prevalence of OSA and other sleep disorders in patients with MS in Ilam was reported to be high. Therefore, it is suggested that the necessary therapeutic and rehabilitation interventions be carried out to reduce OSA and increase the sleep quality of patients.

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Footnotes

Authors' Contribution: F. M., F. Sh., A. R., M. R., and E. B. conceived the study, performed data analysis, and wrote the manuscript; F. M., F. Sh., A. R., M. R., and E. B. collected data and wrote the manuscript; F. M., F. Sh., A. R., M. R., and E. B. interpreted the results and wrote the manuscript; F. M., F. Sh., A. R., M. R., and E. B. designed the study, wrote, and edited the manuscript.

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Data Availability: The data presented in this study are uploaded during submission as a supplementary file and are openly available for readers upon request.

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References

1. Saadat M, Malekloo R, Davoodi M, Sadat Afraz E, Vaez A, Asadi I, et al. Beneficial effects of nano-phytosome of Quercetin on inflammatory parameters in mouse model of multiple sclerosis. *Eurasian Chem Commun*. 2022;**4**:432-40. https://doi.org/10.22034/ecc.2022.331138.1335.
2. Abdollahpour I, Sormani MP, Nedjat S, Mansournia MA, van der Mei I. The role of nutritional factors during adolescence in multiple

sclerosis onset: A population-based incident case-control study. *Nutr Neurosci*. 2021;**24**(7):500-7. [PubMed ID: 31362644]. https://doi.org/10.1080/1028415X.2019.1647689.

3. Moosazadeh M, Esmaeili R, Mehdi Nasehi M, Abedi G, Afshari M, Farshidi F, et al. Prevalence of familial multiple sclerosis in Iran: A systematic review and meta-analysis. *Iran J Neurol*. 2017;**16**(2):90-5. [PubMed ID: 28761631]. [PubMed Central ID: PMC5526783].
4. Faraji F, Mohaghegh P, Talaie A. Epidemiology of familial multiple sclerosis and its comparison to sporadic form in Markazi Province, Iran. *Mult Scler Relat Disord*. 2022;**68**:104231. [PubMed ID: 36270251]. https://doi.org/10.1016/j.msard.2022.104231.
5. Pashaei S, Mohammadi P, Yarani R, Haghgoo SM, Emami Aleagha MS. Carbohydrate and lipid metabolism in multiple sclerosis: Clinical implications for etiology, pathogenesis, diagnosis, prognosis, and therapy. *Arch Biochem Biophys*. 2021;**712**:109030. [PubMed ID: 34517010]. https://doi.org/10.1016/j.abb.2021.109030.
6. Azami M, YektaKooshali MH, Shohani M, Khorshidi A, Mahmudi L. Correction: Epidemiology of multiple sclerosis in Iran: A systematic review and meta-analysis. *PLoS One*. 2019;**14**(7). e0219466. [PubMed ID: 31287842]. [PubMed Central ID: PMC6615610]. https://doi.org/10.1371/journal.pone.0219466.
7. Abdel Salam OA, Ghonimi NAM, Ismail MH. Risk of obstructive sleep apnea in multiple sclerosis: Frequency, clinical and radiological correlates. *Mult Scler Relat Disord*. 2019;**28**:184-8. [PubMed ID: 30616225]. https://doi.org/10.1016/j.msard.2018.12.015.
8. Sunter G, Omercikoglu Ozden H, Vural E, Ince Gunal D, Agan K. Risk assessment of obstructive sleep apnea syndrome and other sleep disorders in multiple sclerosis patients. *Clin Neurol Neurosurg*. 2021;**207**:106749. [PubMed ID: 34126453]. https://doi.org/10.1016/j.clineuro.2021.106749.
9. Files DK, Jausurawong T, Katrajian R, Danoff R. Multiple sclerosis. *Prim Care*. 2015;**42**(2):159-75. [PubMed ID: 25979578]. https://doi.org/10.1016/j.pop.2015.01.007.
10. Khattak HK, Hayat F, Pamboukian SV, Hahn HS, Schwartz BP, Stein PK. Obstructive sleep apnea in heart failure: Review of prevalence, treatment with continuous positive airway pressure, and prognosis. *Tex Heart Inst J*. 2018;**45**(3):151-61. [PubMed ID: 30072851]. [PubMed Central ID: PMC6059510]. https://doi.org/10.14503/THIJ-15-5678.
11. Azagra-Calero E, Espinar-Escalona E, Barrera-Mora JM, Llamas-Carreras JM, Solano-Reina E. Obstructive sleep apnea syndrome (OSAS). Review of the literature. *Med Oral Patol Oral Cir Bucal*. 2012;**17**(6):e925-9. [PubMed ID: 22549673]. [PubMed Central ID: PMC3505711]. https://doi.org/10.4317/medoral.17706.
12. Gottlieb DJ, Punjabi NM. Diagnosis and management of obstructive sleep apnea: A review. *JAMA*. 2020;**323**(14):1389-400. [PubMed ID: 32286648]. https://doi.org/10.1001/jama.2020.3514.
13. Setareh J, Mehrnia M, Mirabi A. [The risk of obstructive sleep apnea and daytime sleepiness in patients with cardiovascular disease]. *J Mazandaran Univ Med Sci*. 2018;**28**(167):29-41. Persian.
14. Abbasi A, Gupta SS, Sabharwal N, Meghrajani V, Sharma S, Kamholz S, et al. A comprehensive review of obstructive sleep apnea. *Sleep Sci*. 2021;**14**(2):142-54. [PubMed ID: 34381578]. [PubMed Central ID: PMC8340897]. https://doi.org/10.5935/1984-0063.20200056.
15. Wang S, Li S, Zhao Y, Zhao X, Zhou Z, Hao Q, et al. Preoperative screening of patients at high risk of obstructive sleep apnea and postoperative complications: A systematic review and meta-analysis. *J Clin Anesth*. 2022;**79**:110692. [PubMed ID: 35217467]. https://doi.org/10.1016/j.jclinane.2022.110692.
16. Gabryelska A, Lukasik ZM, Makowska JS, Bialasiewicz P. Obstructive sleep apnea: From intermittent hypoxia to cardiovascular complications via blood platelets. *Front Neurol*. 2018;**9**:635. [PubMed ID: 30123179]. [PubMed Central ID: PMC6085466]. https://doi.org/10.3389/fneur.2018.00635.
17. Braley TJ, Segal BM, Chervin RD. Obstructive sleep apnea and fatigue in patients with multiple sclerosis. *J Clin Sleep Med*. 2014;**10**(2):155-62. [PubMed ID: 24532998]. [PubMed Central ID: PMC3899317]. https://doi.org/10.5664/jcsm.3442.
18. Chung F, Yang Y, Brown R, Liao P. Alternative scoring models of STOP-bang questionnaire improve specificity to detect undiagnosed obstructive sleep apnea. *J Clin Sleep Med*. 2014;**10**(9):951-8. [PubMed ID: 25142767]. [PubMed Central ID: PMC4153119]. https://doi.org/10.5664/jcsm.4022.
19. Wang YG, Menno D, Chen A, Steininger TL, Morris S, Black J, et al. Validation of the Epworth Sleepiness Scale for Children and Adolescents (ESS-CHAD) questionnaire in pediatric patients with narcolepsy with cataplexy aged 7-16 years. *Sleep Med*. 2022;**89**:78-84. [PubMed ID: 34920345]. https://doi.org/10.1016/j.sleep.2021.11.003.
20. Amra B, Javani M, Soltaninejad F, Penzel T, Fietze I, Schoebel C, et al. Comparison of Berlin Questionnaire, STOP-bang, and epworth sleepiness scale for diagnosing obstructive sleep apnea in persian patients. *Int J Prev Med*. 2018;**9**:28. [PubMed ID: 29619152]. [PubMed Central ID: PMC5869953]. https://doi.org/10.4103/ijpvm.IJPVM_131_17.
21. Jerkovic A, Prorokovic A, Matijaca M, Katic AC, Kosta V, Mihalj M, et al. Validation of the fatigue severity scale in Croatian population of patients with multiple sclerosis disease: Factor structure, internal consistency, and correlates. *Mult Scler Relat Disord*. 2022;**58**:103397. [PubMed ID: 35216780]. https://doi.org/10.1016/j.msard.2021.103397.
22. Armutlu K, Korkmaz NC, Keser I, Sumbuloglu V, Akbiyik DI, Guney Z, et al. The validity and reliability of the Fatigue Severity Scale in Turkish multiple sclerosis patients. *Int J Rehabil Res*. 2007;**30**(1):81-5. [PubMed ID: 17293726]. https://doi.org/10.1097/MRR.0b013e3280146ec4.
23. Koltuniuk A, Kazimierska-Zajac M, Poglodek D, Chojdak-Lukasiewicz J. Sleep disturbances, degree of disability and the quality of life in multiple sclerosis patients. *Int J Environ Res Public Health*. 2022;**19**(6). [PubMed ID: 35328966]. [PubMed Central ID: PMC8950227]. https://doi.org/10.3390/ijerph19063271.
24. Johansson K, Wasling P, Axelsson M. Fatigue, insomnia and daytime sleepiness in multiple sclerosis versus narcolepsy. *Acta Neurol Scand*. 2021;**144**(5):566-75. [PubMed ID: 34278566]. https://doi.org/10.1111/ane.13497.
25. Ma S, Rui X, Qi P, Liu G, Yang J. Sleep disorders in patients with multiple sclerosis in China. *Sleep Breath*. 2017;**21**(1):149-54. [PubMed ID: 27730345]. https://doi.org/10.1007/s11325-016-1416-y.
26. Bearpark H, Elliott L, Grunstein R, Cullen S, Schneider H, Althaus W, et al. Snoring and sleep apnea. A population study in Australian men. *Am J Respir Crit Care Med*. 1995;**151**(5):1459-65. [PubMed ID: 7735600]. https://doi.org/10.1164/ajrccm.151.5.7735600.
27. Simpson L, Hillman DR, Cooper MN, Ward KL, Hunter M, Cullen S, et al. High prevalence of undiagnosed obstructive sleep apnoea in the general population and methods for screening for representative controls. *Sleep Breath*. 2013;**17**(3):967-73. [PubMed ID: 23161476]. https://doi.org/10.1007/s11325-012-0785-0.
28. Cunningham J, Hunter M, Budgeon C, Murray K, Knuiman M, Hui J, et al. The prevalence and comorbidities of obstructive sleep apnea in middle-aged men and women: The busselton healthy ageing study. *J Clin Sleep Med*. 2021;**17**(10):2029-39. [PubMed ID: 34606440]. [PubMed Central ID: PMC8494083]. https://doi.org/10.5664/jcsm.9378.
29. Howard ME, Desai AV, Grunstein RR, Hukins C, Armstrong JG, Joffe D, et al. Sleepiness, sleep-disordered breathing, and accident risk factors in commercial vehicle drivers. *Am J Respir Crit Care Med*. 2004;**170**(9):1014-21. [PubMed ID: 15317672]. https://doi.org/10.1164/rccm.200312-1782OC.
30. Pack AI, Maislin G, Staley B, Pack FM, Rogers WC, George CF, et al. Impaired performance in commercial drivers: Role of sleep apnea and short sleep duration. *Am J Respir Crit Care Med*. 2006;**174**(4):446-

54. [PubMed ID: 16690976]. [PubMed Central ID: PMC2648121]. https://doi.org/10.1164/rccm.200408-1146OC.

31. Huhta R, Hirvonen K, Partinen M. Prevalence of sleep apnea and daytime sleepiness in professional truck drivers. *Sleep Med*. 2021;**81**:136-43. [PubMed ID: 33676284]. https://doi.org/10.1016/j.sleep.2021.02.023.

32. Aljundi NA, Kelly M, Zeineddine S, Salloum A, Pandya N, Shamim-Uzzaman QA, et al. Sleep disorders, daytime symptoms, and quality of life in veterans with multiple sclerosis: Preliminary findings. *Sleep Adv*. 2022;**3**(1):zpac012. [PubMed ID: 37193412]. [PubMed Central ID: PMC10104398]. https://doi.org/10.1093/sleepadvances/zpac012.

33. Singh M, Gavidia R, Dunietz GL, Washnock-Schmid E, Romeo AR, Hershner S, et al. Validation of an obstructive sleep apnea symptom inventory in persons with multiple sclerosis. *Mult Scler*. 2022;**28**(2):280-8. [PubMed ID: 34048308]. [PubMed Central ID: PMC8627523]. https://doi.org/10.1177/13524585211013014.

34. Dias RA, Hardin KA, Rose H, Agius MA, Apperson ML, Brass SD. Sleepiness, fatigue, and risk of obstructive sleep apnea using the STOP-BANG questionnaire in multiple sclerosis: A pilot study. *Sleep Breath*. 2012;**16**(4):1255-65. [PubMed ID: 22270686]. https://doi.org/10.1007/s11325-011-0642-6.

35. Yazdchi M, Khanalizadeh R, Nasiri E, Naseri A, Talebi M, Talebi M. Sleep status in multiple sclerosis: Role of vitamin D and Body Mass Index. *Curr J Neurol*. 2022;**21**(2):66-73. [PubMed ID: 38011482]. [PubMed Central ID: PMC9860209]. https://doi.org/10.18502/cjn.v21i2.10489.