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Assessing Impact of Water-Pipe Hookah Smoke, Vitamin D Deficiency, Sleeping Disorder and Mental Health on Hearing Loss Among Stroke Patients

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Abstract

Background: The role of water-pipe use on mental health, and hearing loss in stroke patients not studied.

Objective: This study aimed to investigate relationship and intersection between water-pipe (hookah) smoking, mental health, and hearing loss in stroke patients.

Methods: Conducted as a cross-sectional study, it involved 1,015 male and female patients aged 25 to 65 years, using Ear, Nose, and Throat and Neurology Departments The research utilized physical examinations, radiological assessments, biochemical tests, and Pure-Tone Audiometry (PTA) to evaluate hearing function.

Results: Out of the 1,140 patients studied, 180 (15.8%) were water-pipe use with hearing loss. Significant differences were observed among the three groups water-pipe with hearing loss in comparison to smokers without hearing loss and non-smokers with normal hearing regarding age, gender, BMI, MP3-use, hypertension and diabetes, metabolic-syndrome, tinnitus, vertigo, dizziness, headache and neuropathy. PHQ-15 ≥ 10 scores, sleepiness, depression, anxiety, and stress, vitamin D, hemoglobin, calcium, magnesium, fasting glucose, HbA1C, systolic-BP, diastolic-BP, and microalbuminuria, the Multivariate regression revealed use of water-pipe hookah as risk for vertigo, hypertension, and headaches and hearing loss among stroke patients.

Conclusion: The current study indicates that water-pipe effect on hypertension, lifestyle-related behaviors, as potential risk factors for hearing loss in stroke patients.

Keywords: Hearing loss; Stroke; Cigarette; Water-pipe hookah Smoking; Vitamin D; Obesity; Sleepiness

Abbreviations: IRB: Institutional Review Board; ENT: Ear Nose Throat; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; PTA: Pure-Tone Average; ABR: Auditory Brainstem Responses; VEMPs: Vestibular Evoked Myogenic Potentials; ANOVA: A One-Way Analysis of Variance; ESS: Epworth Sleepiness Scale

Introduction

Hearing loss constitutes one of the most common causes of hospital admissions and is estimated to affect approximately 20% of the population [1]. While the majority of the cases are considered idiopathic, a wide range of etiological factors including genetic predisposition, age-related degeneration, infectious, neoplastic or inflammatory processes may also be involved [1-2]. Cigarette consumption poses a substantial global threat to

public health [1]. Innumerable diverse studies have highlighted the association between smoking and hearing loss [1-6]. It has been observed repetitively that smokers have a greater likelihood of experiencing hearing loss as opposed to non-smokers [5-8]. Smoking poses a substantial threat to the sensitivity of the auditory system, compromising its vital functions [5-10]. The impact of both cigarette and water-pipe hookah smoking on hearing loss is extensively documented in the literature [1,5-10]. Several studies have established a link between long-term elevated blood pressure and hearing loss [8, 10-13]. More recent research has also found associations between hearing impairments and conditions such as hypertension [8, 9-13], stroke [10,14-16], sleepiness [2,12,17], and cigarette smoking [1-3-6,12]. However, the precise cause of hearing loss in many stroke patients who smoke cigarettes or water-pipes remains unidentified [8, 12, 13]. Evidence highly suggests that low vitamin D levels are associated with greater hearing impairment [17-23], making vitamin D levels a critical consideration in diet. Furthermore, frequent MP3 player usage has been linked to a heightened likelihood of hearing deterioration [24]. In this study, we aimed to thoroughly investigate and assess the relationship between water-pipe hookah smoking, and mental health with hearing loss in stroke patients.

Subjects and Methods

Participants

This cross-sectional study was conducted in the outpatient clinics' units of the Ear, Nose, and Throat (ENT) and Neurology Departments at Istanbul Medipol University Hospitals from June 2024 to April 2025. With a prevalence of 20% for smokers with hearing loss, a 99% confidence interval, and a 3% margin of error [2,12-13], the calculated sample size was 1,385 subjects, of which 1,040 agreed to participate (response rate = 75%). Patients with otologic conditions associated with tinnitus such as otosclerosis, cholesteatoma, and Ménière's disease were excluded from the study. Ethical approval was obtained from the Istanbul Medipol University Institutional Review Board (IRB) committee (IRB# 10840098-604.01.01-E.14180 and IRB# E-10840098-772.02-1411).

Design and Smoking history

Participants were considered smokers if they had a lifetime consumption of 100 or more cigarettes and continued to smoke at the time of assessment. Similarly, smoking tobacco from a water-pipe (hookah) in the past 30 days was considered. The study compared cigarette smokers with hearing loss, cigarette smokers without hearing loss, and non-smokers without hearing loss, as well as the impact of water-pipe use among stroke patients.

Blood pressure and vitamin D assessment

Hypertension was identified by the systolic blood pressure (SBP) reaching 140 mm Hg or above and/or a diastolic blood pressure (DBP) of 90 mm Hg or more, or if the individual was consistently taking antihypertensive drugs [1-2,13, 19]. Serum 25(OH) D (25-hydroxy vitamin D) levels were measured using a competitive radioimmunoassay (RIA), a sensitive immunoassay technique involving antigen-antibody interaction in vitro, aided by radioisotopes (DiaSorin, Stillwater, Minnesota). Categorization of participants was done into three groups: those with vitamin D deficiency, those with insufficiency, and those with normal/optimal levels [13, 19, 22-23].

Hearing assessment - Audiological Investigation

All patients underwent a comprehensive audiological assessment, including bedside exams, pure-tone and speech audiometry, tympanometry with stapedial reflexes, auditory brainstem responses (ABR), Vestibular Evoked Myogenic Potentials (VEMPs), and MRI of the internal auditory canal with gadolinium. The air conduction pure-tone average (PTA) was obtained by averaging the air conduction thresholds at 0.25, 0.5, 1, 2, 3, 4 and 8 kHz. Audiometric testing was conducted during hospitalization, at discharge, and one month post-discharge. Hearing recovery was assessed using Siegel's criteria [21], with complete recovery defined as a final hearing level better than 25 dB. Hearing sensitivity was assessed using Pure-Tone Audiometry (PTA) with two clinical digital audiometers (Interacoustics AC40 Clinical Audiometer and Garson Stadler GSI 61). Hearing loss was classified as normal (≤ 26 dB) or impaired (>26 dB) [1-2, 12-13, 21].

Sleepiness assessment

Assessment of sleep-related drowsiness was carried out using the Epworth Sleepiness Scale (ESS) [8, 25]. This scale comprises of eight distinct items designed to assess the probability of falling asleep in various everyday situations, such as while watching television, sitting quietly, or engaging in conversation. Each item is scored on a scale from 0, indicating no tendency to fall asleep, to 3, indicating a high likelihood of dozing off. The total possible score ranges from 0 to 24, with classifications as follows: normal daytime alertness (0–7), mild drowsiness (8–9), moderate sleepiness (10–15), and severe sleepiness [2,17 25].

Statistical analysis

SPSS software was utilized to perform data analysis, version 25. The Chi-square test was applied to evaluate significant differences across categorical variables. A one-way analysis of variance (ANOVA) was executed to compare the means of all three groups. Furthermore, a multivariate stepwise linear regression analysis was performed with a significance level of $p<0.05$ to investigate the association between water-pipe hookah smoking and hearing loss in stroke patients.

Results

Out of the 1,140 patients studied, 180 (15.8%) were water-pipe smokers with hearing loss. Table 1 outlines the socio-demographic and clinical characteristics of water-pipe smokers

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with hearing loss in comparison to smokers without hearing loss and non-smokers with normal hearing. Significant differences were observed among the three groups regarding age (p<0.001), gender (p<0.001), BMI (p<0.001), MP3 use (p=0.004), family history of hypertension (p=0.008) and diabetes (p<0.001), ATP III metabolic syndrome (p<0.001), IDF metabolic syndrome (p<0.001), tinnitus (p<0.001), vertigo (p<0.001), dizziness (p=0.012), headaches/migraines (p<0.001) and neuropathy (p<0.001). No statistically significant differences were observed regarding gender, marital status, occupation or socioeconomic status. The frequency of mental health symptoms and sleep disturbances among water pipe users with hearing loss compared to those with normal hearing is displayed in Table 2. As can be seen, the prevalence of PHQ-15 ≥ 10 scores (p<0.001), Sleepiness was prominently higher among water-pipe smokers with hearing loss as compared to smokers without hearing loss and non-smokers without hearing loss (p<0.001).

Table 1: The general characteristics in addition to the clinical comparison of water-pipe use with hearing loss versus without among stroke patients (N= 1140).

Variables	Waterpipe smokers with hearing loss ≥26 dB n=180	Waterpipe smokers without hearing loss <26 dB n=86	None- Cigarette & None Water-pipe smokers without hearing loss<26 dB n=874	p-value
Age groups in years				
< 40 years old	86 (47.6)	10 (11.6)	263 (30.1)	
40-50 years old	40 (222)	33 (38.4)	224 (25.6)	0.001
>50 years old	54 (30.0)	43 (50.7)	387 (44.3)	
Gender				
Males	106 (58.9)	33 (38.4)	319 (41.0)	0.453
Females	74 (41.1)	53 (61.6)	555 (59.0)	
Marital status				
Single	6 (3.5)	3 (3.5)	49 (5.6)	0.353
Married	174 (96.5)	83 (96.5)	825 (94.6)	
Occupational level				
Housewife	17 (9.4)	4 (4.7)	82 (1.2)	
Sedentary	80 (44.4)	48 (55.8)	379 (8.1)	
Manual	56 (20.0)	16 (18.6)	203 (90.7)	0.163
Businessman	25 (13.9)	9 (10.5)	142 (31.4)	
Police/army/ Security forces	22 (12.2)	9 (10.5)	69 (1.2)	
Income				
Low	64 (35.6)	32 (37.2)	311 (35.6)	
Medium	60 (33.3)	29 (33.7)	330 (37.8)	0.692
Heigh	56 (311)	25 (29.1)	233 (26.7)	
Body Mass Index (kg/m^2)				
Normal (kg/m^2)	46 (23.7)	1 (1.2)	313 (33.3)	
Overweight (kg/m^2)	72 (39.5)	7 (8.1)	384 40.9)	0.001
Obese (kg/m^2)	62 (36.8)	78 (90.7)	243 (25.8)	
Physical exercise (Yes)	43 (23.9)	34 (39.5)	278 (31.8)	0.05
MP3 player use (Yes)	133 (73.9)	72 (83.7)	120 (13.7)	0.138
Do you hear TV sounds (Yes)	164 (91.1)	78 (80.7)	757 (78.6)	0.516
Family history of hypertension (Yes)	41 (22.8)	12 (14.0)	134 (14.3)	0.028
Family of diabetes (Yes)	46 (25.6)	11 (12.8)	121 (13.8)	0.001
ATP III Metabolic syndrome(Yes)	43 (23.9)	8(7.0)	144 (15.3)	0.001
IDF Metabolic syndrome(Yes)	32 (28.1)	5 (5.8)	167 (19.1)	0.001

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Tinnitus (Yes)	116 (64.4)	9 (10.5)	130 (14.9)	0.001
Vertigo (Yes)	86 (47.8)	11(12.8)	100 (11.4)	0.001
Dizziness (Yes)	60 (33.2)	14 (16.3)	125 (14.3)	0.001
Headache and Migraine (Yes)	121 (67.2)	18 (20.9)	161 (18.4)	0.001
Neuropathy(Yes)	41 (22.8)	12 (14.4)	120(13.7)	0.001

Table 2: Prevalence of GHQ-15, Epworth Sleepiness, mental health symptoms by Waterpipe smokers with hearing loss among stroke patients (N= 1,140).

Variables	Waterpipe smokers with hearing loss ≥26 dB n=180	Waterpipe smokers without hearing loss <26 dB n=86	None- Cigarette & None Water-pipe smokers without hearing loss<26 dB n=874	p-value signifi-cance
GHQ-15				
None	79 (43.9)	40 (46.57)	356 (40.7)	
Mild	35 (19.4)	21 (244)	214 (24.5)	
Moderate	20 (11.1)	17 (19.8)	169 (19.3)	0.002
Severe	46 (256)	8 (9.3)	135 (15.4)	
Epworth Sleepiness Scale				
Normal level	87 (48.3)	59 (67.4)	496 (56.8)	
Mild level	40 (22.2)	17 (19.8)	116 (16.7)	0.001
Moderate level	35 (19.4)	9 (10.5)	133 (22.1)	
Severe level	18 (10.0)	2 (2.3)	39 (4.5)	
DASS21 Depression				
Normal	42 (23.3)	31 (36.0)	213 (24.4	
Mild	34 (18.9)	17 (19.8)	214 (24.5)	
Moderate	50 (27.8)	19 (22.1)	198 (22.7)	0.001
Severe	25 (13.9)	14 (16.3)	171 (19.6)	
Extreme	29 (16.1)	5 (5.8)	78 (8.9)	
DASS21 Anxiety				
Normal	43 (23.9)	19 (22.1)	311 (35.6)	
Mild	58 (32.2)	30 (34.9)	283(32.4)	
Moderate	26 (14.4)	10 (11.6)	83 (14.8)	0.002
Severe	34 (18.9)	18 (20.9)	78 (8.9)	
Extreme	19 (10.6)	9 (10.5)	73 (8.4)	
DASS21 Stress				
Normal	45 (25.0)	28 (32.6)	325 (37.2)	
Mild)	47 (26.1)	23 (26.7)	160 (18.3)	
Moderate	24 (13.3)	16 (18.6)	145 (16.6)	0.001
Severe	29 (16.1	9 (10.5)	155 (17.7)	
Extreme	35 (19.4)	10(11.5)	89 (10.2)	

Likewise, levels of depression (p<0.001), anxiety (p=0.002), and stress (p<0.001) were found to be predominantly elevated in water-pipe smokers who experienced hearing loss as compared to both water-pipe users without hearing loss and non-smokers with normal hearing. Table 3 compares the clinical biochemical values of water-pipe smokers with hearing loss to those with normal hearing, highlighting differences in vitamin D (p<0.001), hemoglobin (p<0.001), calcium (p<0.001), magnesium (p<0.001), fasting glucose (p<0.001), HbA1C (p<0.001), systolic BP (p<0.001), diastolic BP (p<0.001), and microalbuminuria (p<0.001).

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Similarly, the analysis for water-pipe smokers identified vertigo (p<0.001), BMI (kg/m^2) (p<0.001), tinnitus (p=0.004), vitamin D deficiency (<20 ng/ml) (p=0.008), calcium (mmol/L) (p=0.022), hypertension (p=0.034), and headaches/migraines (p=0.039) as indicators of hearing loss-related to water-pipe – hookah use among stroke patients (Table 4).

Table 3: Clinical biochemical variables comparison water pipe smoker with hearing loss versus without among stroke patients (N=1140).

Variables	Water pipe smokers with hearing Loss ≥26 n=114 Mean ± SD	Water pipe smokers without hearing Loss ≥26 dB n=86 Mean ± SD	None-Cigarette smoker& None Water-pipe use No hearing loss <26 dB n= 940 Mean ± SD	p-value
Vitamin D (ng/ml)	16.70±8.23	20.17±8.07	21.16±9.01	<0.001
Hemoglobin (g/dL)	12.59± 1.82	12.84± 1.81	13.91±1.93	<0.001
Magnesium (mmol/L)	0.66±0.08	0.76±0.08	0.97±0.09	<0.001
Potassium (mmol/L)	3.56±073	3.51±0.90	3.53±0.56	0.937
Calcium (mmol/L)	1.94±0.10	195±0.11	1.97±0.11	0.002
Phosphorous (mmol/L)	1.31±0.27	1.29±0.21	1.25±0.33	0.524
Creatinine (mmol/L)	75.17±14.78	75.47±15.34	74.39±14.29	0.276
Fasting Glucose (mmol/L)	7.20±1.23	7.29±1.46	6.48±1.34	<0.001
HbA1c	7.28±1.32	7.21±1.34	6.41±1.10	<0.001
Cholesterol (mmol/L)	4.64±0.91	4.75±0.86	4.80±0.87	0.076
HDL (mmol/L)	1.05±0.21	1.11±0.30	1.11±0.29	0.082
LDL (mmol/L)	1.76±0.64	1.927±0.78	1.89±0.94	0.233
Albumin (mmol/L)	42.06±3.63	41.79±4.22	42.26±5.09	0.88
Billirubin (mmol/L)	7.64±2.64	7.06±2.09	7.33±2.60	0.272
Triglyceride (mmol/L)	1.68±0.77	1.65±0.79	1.64±0.69	0.511
Ferritin (mmol/L)	221.09±39.24	217.81±66.20	232.90±34.89	0.685
Uric acid (mmol/L)	273.43±65.556	295.79±60.28	2952.21±60.28	0.192
Systolic BP (mm Hg)	145.00±7.63	144.84±8.33	128.79± 6.82	<0.001
Diastolic BP (mm Hg)	87.89±8.33	87.55±8.25	80.17±7.96	<0.001
Microalbuminuria	11.73±3.358	11.32±3.22	8.18±2.56	<0.001
Vitamin D level	**n (%)**	**n (%)**	**n (%)**	
25(OH)D ng/ml				
Deficiency level<20	114 (63.3)	48 (55.8)	482 (55.2)	
Insufficiency level 20-29	45 (25.0)	27 (31.4)	27 (31.2)	0.037
Optimal level > 30	21 (11.7)	11 (12.8)	75 (8.6)	

Table 4: Multivariate stepwise regression analysis for associated factors of hearing impairment associated with water-pipe smoking in stroke patients (N=1140).

Independent variables	Regression Coefficients		Beta	t-test	P–value Significance
	B	Standard error			
Obesity Body Mass Index (kg/m^2)	0,015	0,003	0,171	6,030	<0.001
Vertigo and/or dizziness (Yes)	0,424	0,071	0,414	6,012	<0.001
Tinnitus (Yes)	-0,211	0,074	-0,197	-2,862	0,004
Vitamin D deficiency (<20 ng/ml)	0,304	0,102	0,075	2,651	0,008
Calcium (mmol/L)	0,239	0,104	0,065	2,299	0,022
Hypertension (Yes)	0,751	0,32	0,063	2,125	0,034
Headache and migraine (Yes)	0,730	0,35	0,056	2,064	0,039

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Discussion

The analysis of this study showed a significant association between cigarette smoking, water-pipe use, and hearing loss among stroke patients, consistent with previous studies [3-10, 12]. Exploring the factors related to smoking and hearing loss in stroke patients can help improve understanding of hearing loss. Reducing or quitting smoking could potentially prevent hearing issues [3-10, 12]. Hu et al. [5] discovered that individuals who had quit smoking faced a lower risk of hearing loss compared to those who continued to smoke. Recently, Bener et al. [1-2, 12-13] confirmed the association between smoking cigarette and hearing loss within patients with hypertension and stroke, aligning with this study's findings. This study further investigates and identifies a strong correlation between obesity, comorbidities, and hearing impairment in both cigarette and water-pipe smokers, aligning with results from earlier studies [8,12-13, 20-21]. The results of this study align with previous research concerning stroke, hypertension, and tinnitus [2-4, 8, 9, 12-13]. Emerging evidence distinctively suggests that individuals with hypertension and diabetes experience a higher incidence of hearing loss compared to those without these health conditions [1-2, 12–13, 20]. Metabolic syndrome (MetS) and hearing loss are both recognized as stroke risk factors, particularly when hearing loss is accompanied by vertigo [2, 13-14]. This study evaluated the relationship between MetS and hearing loss, finding that patients with hearing loss met significantly more MetS criteria compared to control subjects.

The current survey indicated a significant positive correlation between hearing loss and obesity, which is in line with previously reported studies [1, 8, 12, 22]. Dietary management in this patient group may contribute to the prevention of hearing loss [1-2, 22]. The popularity of MP3 players for listening to music, as noted in this study, is consistent with another research [24]. Research by Dawes et al. [11], Bener et al. [1, 12-13, 19], and Bigman [20] suggested that increasing vitamin D levels can reduce hearing problems. Additionally, vitamin D deficiency has been linked to both low and high-frequency hearing loss in adults and the elderly [18-20]. These findings align with the present study. Vitamin D has an integral role in the human auditory system, and its deficiency negatively affects the ears, particularly the inner ear [18-20]. Overall, this study found that hypertension, vitamin D deficiency, and sleepiness were potential risk factors for hearing loss among smokers, suggesting that raising public awareness and implementing preventive measures may be beneficial. Some studies have also observed a relationship between sleep disorders, hearing loss, and tinnitus [26]. Overall, water-pipe hookah smoking is linked to a higher risk of lung cancer [27]. With the growing use of smokeless tobacco in developing countries and the rising popularity of waterpipe smoking worldwide, these findings highlight the need for public health policies, legislation, and tobacco control measures to raise awareness and reduce usage at both national and international levels. There is increasing evidence linking water-pipe hookah use to various adverse health effects [1-2, 8, 12-13].

Limitations of study

However, this study has limitations. First, the cross-sectional nature of the study limits the ability to establish cause-and-effect relationships. Second, patients were recruited from the outpatient clinics of the ENT and Neurology Departments of a single center over a period of 11 months, which may limit the generalizability of the findings to other settings or populations. Third, although several potential confounders were adjusted for, residual confounding by unmeasured factors such as genetic predisposition or dietary habits cannot be excluded. Fourth, some patients were excluded due to the time required for audiometric assessments. Fifth, the smoking information was self-reported, which may introduce bias. Finally, the sleepiness data extracted from the Epworth scale is subjective and may lack complete precision.

Conclusion

This study proposes that cigarette smoking and water-pipe hookah smoke, along with factors like hypertension, obesity, vitamin D deficiency, and sleepiness, serve as significant risk factors for hearing loss among stroke patients. There is increasing evidence linking water-pipe, tobacco smoking to various adverse health effects.

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