

Balance and Vestibular System Assessment in Post COVID-19 Patients

Original
Article

Mohamed Elsayed, Mohammed El-Deep, Eman Mohamed and Adel Abdel-Maksoud

Department of Audio-Vestibular Medicine, Armed Forces College of Medicine, Cairo, Egypt

ABSTRACT

Background: COVID-19 has been associated with various neurological symptoms, including dizziness and balance disorders, suggesting potential involvement of the vestibular system. Recent evidence indicates that the virus may directly affect inner ear tissues, leading to auditory and vestibular dysfunction. However, the mechanisms behind these symptoms remain unclear.

Aim: This study aims to assess balance function in post-COVID-19 patients by identifying abnormalities in sensory organization tests (SOT) and vestibular system evaluations.

Subjects and Methods: A cross-sectional study was conducted at the Audio-Vestibular Medicine Department, Kobry El-Koba Military Complex, Egypt, from November 2022 to April 2023. Forty-two patients who had been previously diagnosed with COVID-19 were recruited via convenience sampling. Participants completed a history questionnaire and the Arabic version of the Dizziness Handicap Inventory (DHI). Sensory organization testing was performed using computerized dynamic posturography (CDP).

Results: Significant correlations were found between COVID-19 severity and dizziness-related disability (DHI total: $p = 0.01$), with functional ($p = 0.03$) and emotional ($p = 0.05$) domains affected. SOT results revealed preserved balance overall (89.26 ± 5.2), but lower vestibular-reliant scores (C5: 86.55 ± 9.06 , C6: 87.52 ± 6.28). Vestibular function was mildly impaired (0.95 ± 0.13). Significant associations were observed with head shake ($p = 0.004$), Dix-Hallpike ($p = 0.02$), and Fukuda stepping tests ($p = 0.02$), indicating greater vestibular dysfunction in severe cases.

Conclusion: This study demonstrates significant vestibular impairments in post-COVID-19 patients, particularly those with severe illness. Further research is needed to explore the mechanisms behind these impairments and their potential for recovery.

Key Words: Assessment, balance, Post COVID-19 patients, vestibular system.

Received: 12 February 2025, **Accepted:** 12 May 2025

Corresponding Author: Mohamed Elsayed, Department of Audio-Vestibular Medicine, Armed Forces College of Medicine, Cairo, Egypt, **Tel.:** +2 010 6430 1337, **E-mail:** m.s453211@gmail.com

ISSN: 2812-5509, 2025

INTRODUCTION

The vestibular system, responsible for maintaining balance and spatial orientation, can be adversely affected by viral infections. There is an increasing recognition of the potential impact on the vestibular system and balance mechanisms. There have been reports of tinnitus, lightheadedness, vestibular neuritis, and sudden hearing loss among COVID-19 patients^[1-3].

COVID-19 has been found to significantly impact the vestibular system, with many patients experiencing symptoms like dizziness, vertigo, and balance issues. The virus may affect the vestibular system either directly, by invading the inner ear or central nervous system, or indirectly through inflammation or hypoxia. Vestibular dysfunction is not only common during the acute phase but can persist as part of long COVID. These symptoms can last for months, affecting patients' quality of life. Further research is needed to fully understand these long-term effects^[4]. Over one-third of the patients appear to have dizziness as one of their primary balance issues^[1].

Questionnaires rather than objective measurements have been used to evaluate balance in patients with COVID-19 illness. A thorough examination is still absent, necessitating an objective evaluation of the systems contributing to balance^[5,6].

A cross-sectional study examining balance and vestibular function in post-COVID-19 patients is crucial for understanding the extent of these impairments and their underlying mechanisms. By assessing patients who have recovered from COVID-19, in this study, we aim to investigate the relationship between COVID-19 and vestibular function by evaluating balance and other related parameters in individuals who have recovered from the virus. Through a series of tests and assessments,

PATIENTS AND METHODS

This cross-sectional study was conducted at the Audio-Vestibular Medicine Department, Kobry El-Koba Military Complex, Egypt, between November 2022 and April 2023. The study aimed to assess vestibular and balance function in individuals who had previously recovered from

COVID-19 infection. A total of 42 patients were recruited using a convenience sampling method. Sampling was conducted with the support of the Research Support Unit (RSU) at the Armed Forces College of Medicine (AFCM).

Patients were eligible for inclusion if they were adults aged between 18 and 60 years, had been diagnosed with COVID-19 through polymerase chain reaction (PCR) testing, and had recovered for at least one month before participation. Exclusion criteria included patients experiencing acute COVID-19 infection or those with neurological disorders that could affect vestibular or balance function. Such conditions included a history of stroke before COVID-19, microthrombi, embolic events, or any neurological or neuropsychiatric conditions.

The sample size of 42 patients was calculated to provide a two-sided 95% confidence interval with a margin of error of 2.992, assuming an estimated standard deviation of 9.600.

Each participant underwent a comprehensive evaluation that included three main components: history taking, completion of the Dizziness Handicap Inventory (DHI), and balance assessment using the Sensory Organization Test (SOT) through computerized dynamic posturography (CDP). Additional office-based vestibular function tests were also performed to ensure a thorough evaluation.

History taking encompassed four key domains. Personal data included age, gender, and smoking status. Medical history addressed past and current comorbidities. Otological history reviewed auditory or vestibular symptoms, exposure to noise, use of ototoxic medications, and any ENT-related surgical history. Finally, COVID-19 history detailed the onset, progression, symptoms (e.g., fever, cough, anosmia), investigations, and treatments received.

The Arabic version of the Dizziness Handicap Inventory (DHI) was used to assess the functional, emotional, and physical impact of dizziness. The questionnaire contained 25 items, each scored as follows: "Yes" = 4, "Sometimes" = 2, and "No" = 0, with higher scores indicating greater handicap (Figure 1).

Postural stability was assessed using the NeuroCom EquiTest system (version 8.4) to conduct the Sensory Organization Test (SOT). Participants were tested under six sensory conditions: eyes open on a stationary platform (C1), eyes closed on a stationary platform (C2), eyes open in a visually enclosed environment (C3), eyes open on a dynamic platform (C4), eyes closed on a dynamic platform (C5), and eyes open with both platform and visual enclosure in motion (C6). Each condition was repeated three times for 20 seconds, and patients were instructed to maintain upright posture throughout. The sway referencing setting was +1, indicating that a one-degree body sway resulted in a one-degree shift in the platform or visual surround.



Fig. 1: Sensory organization test (SOT)

Data analysis involved calculating the equilibrium score for each condition and a composite equilibrium score. Sensory ratios were derived from average equilibrium scores and presented on a sensory analysis graph. These ratios assessed the contributions of somatosensory, visual, and vestibular inputs, along with visual preference. Additional analyses included strategy assessment and center of gravity (COG) alignment.

Office vestibular testing was performed using video nystagmography (VNG) goggles. Oculomotor tests assessed eye movement disorders such as nystagmus, strabismus, and ptosis. Participants were asked to track moving targets and fixate gaze in specific directions to detect spontaneous or gaze-evoked nystagmus, which may indicate peripheral or central vestibular dysfunction. Additional bedside assessments included the Head Impulse Test, Head Shake Test, Dix-Hallpike Test, positional tests, and the Fukuda stepping test, providing further insight into vestibular performance following COVID-19 recovery.

Outcomes

Assess the balance system in post Covid -19. And detect any deviation from normal values of SOT (in full) and vestibular system tests in post Covid-19.

Statistical analysis

We collected data manually and inserted to a computer to be analyzed by SPSS Software version 22. Quantitative data were presented as (Mean $\pm$ SD). Qualitative data were presented as event and percentage. All coefficient intervals were set to 95%. Level of significance was measured according to *P* value (If *P* value <0.05 it implies statistical significance).

RESULTS

A total of 42 patients were included in the study, with a mean age of 35.33 ± 3.33 years, ranging from 23 to 55 years. The sample consisted of 23 males (54.7%) and 19 females (45.2%). Regarding comorbidities, hypertension was observed in 10 patients (23.81%), while 6 patients (14.29%) had diabetes mellitus and 3 patients (7.14%) had respiratory diseases. No cases of renal problems or neurological insults were reported (Tables 1-3).

In terms of overall comorbidity burden, 19 patients (45.24%) had at least one comorbid condition. A history

of ENT (ear, nose, and throat) operations was present in 18 patients (42.8%). Additionally, 7 patients (16.67%) reported noise exposure, 5 patients (11.9%) had experienced physical trauma, and 2 patients (4.67%) had a history of ototoxic drug use.

The clinical severity of COVID-19 among the 42 studied patients was classified into four categories: mild, moderate, severe, and serious. The majority of patients experienced either mild or moderate illness, each accounting for 15 cases (35.71%). Severe cases were observed in 8 patients (19.04%), while 4 patients (9.52%) were categorized as serious. No asymptomatic or critical cases were reported in this cohort. These findings indicate that most patients had a non-critical presentation of COVID-19, with nearly three-quarters exhibiting mild to moderate symptoms. COVID-19 severity has been classified into five distinct levels: asymptomatic, mild, moderate, severe, and critical. Asymptomatic cases are those in which individuals do not exhibit any noticeable symptoms, with infection confirmed only through virologic testing. Mild cases involve the presence of symptoms such as fever, cough, or fatigue, but without signs of dyspnea, shortness of breath, or abnormalities on chest imaging. Moderate cases are characterized by clinical or radiological evidence of lower respiratory tract involvement, with oxygen saturation (SpO₂) remaining at or above 94% on room air. Severe cases present with a respiratory rate equal to or greater than 30 breaths per minute, lung infiltrates affecting more than 50% of lung fields, or marked respiratory distress. Critical cases are defined by the presence of life-threatening conditions such as respiratory failure, septic shock, or multi-organ dysfunction. The clinical spectrum of COVID-19 thus ranges from asymptomatic infection to critical illness, with acute respiratory distress syndrome (ARDS) representing the most severe manifestation (Figure 2).

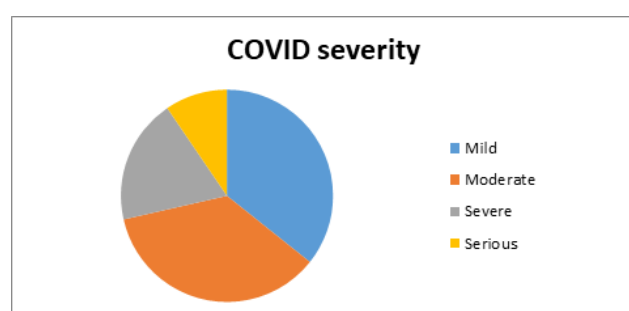


Fig. 2: Covid 19 severity among studied patients

This table showed that nearly half of our subjects (52.3%) lied within mild impairment score, only 5(11.9%) were normal (Tables 4,5).

The one-way ANOVA test revealed a significant correlation between COVID-19 severity and dizziness handicap inventory (DHI) scores. The functional and emotional scores showed statistical significance ($p = 0.03$ and 0.05 respectively), while the physical score was not significant (0.07). The total DHI score demonstrated a highly significant association ($p = 0.01$), indicating that increased COVID-19 severity is linked to greater overall dizziness-related disability, particularly in functional and emotional domains.

The analysis of office test results revealed a significant correlation between COVID-19 severity and the head shake test ($p = 0.04$, highly significant), indicating increased abnormalities in severe cases. Similarly, the Dix-Hallpike test showed a significant association ($p = 0.02$, significant), with a higher prevalence of abnormalities in severe COVID-19 cases. However, no significant correlation was found between COVID-19 severity and head thrust ($p = 0.74$, Not Significant) or positional tests ($p = 0.15$, Not Significant). These findings suggest that vestibular dysfunction, particularly affecting head movement and positional vertigo, may be more prevalent in patients with severe COVID-19.

The results demonstrate a significant correlation between COVID-19 severity and abnormalities in the head shake test ($p = 0.04$, highly significant), Dix-Hallpike test ($p = 0.02$, significant), and Fukuda stepping test ($p = 0.02$, significant), suggesting an increased prevalence of vestibular dysfunction in severe cases. However, no significant associations were found with the head thrust test ($p = 0.74$, Not Significant), positional tests ($p = 0.15$, Not Significant), or oculomotor tests (0.41 , Not Significant). These findings indicate that vestibular deficits, particularly those affecting dynamic balance and positional vertigo, may be more common in patients with severe COVID-19.

Table 1: baseline characteristics and history among studied patients

All included 42 patients		(Mean ±SD)	Age Range
Age (year)		35.33 ± 3.33	23 - 55
		No	%
Sex	Male	23	54.7 %
	Female	19	45.2 %
Hypertension		10	23.81 %
Diabetes mellitus		6	14.29 %
Respiratory disease		3	7.14 %
Renal problem		0	0
Neurological insult		0	0
Total comorbidities		19	45.24 %
ENT operations		18	42.8 %
Noise exposure		7	16.67 %
Physical trauma		5	11.9 %
Ototoxic drugs		2	4.67 %

Table 2: Distribution of severity of COVID-19 among studied patients

All included 42 patients		
	N	%
Mild	15	35.71 %
Moderate	15	35.71 %
Severe	8	19.04 %
Serious	4	9.52 %
Total	42	100 %

Table 3: Dizziness handicapped inventory (DHI-Arabic version) test scoring among studied patients

Normal		Abnormal					
		Mild impairment		Moderate impairment		Severe impairment	
Number	%	Number	%	Number	%	Number	%
5	11.9	22	52.3 %	9	21.4 %	6	14.3 %

Table 4: Correlation between COVID-19 severity and Dizziness handicapped inventory test (DHI):(One Way ANOVA test)

	Mild		Moderate		Severe/serious		F*	P value
	Mean	SD	Mean	SD	Mean	SD		
F score	8.53	5.26	9.07	5.75	14.83	8.02	3.93	0.03 S
E score	9.73	4.20	8.13	4.10	12.83	6.18	3.23	0.05 S
P score	10.80	5.54	10.53	7.54	16.33	7.48	2.92	0.07 NS
Total	29.07	9.85	27.73	14.04	44.00	20.31	4.73	0.01 HS

Table 5: Correlation between groups (according to COVID-19 severity) and computerized dynamic posturography (CDP) results: (One Way ANOVA test)

CDP \ COVID severity	Mild		Moderate		Severe/serious		F*	P value
	Mean	SD	Mean	SD	Mean	SD		
C1	90.87	4.05	89.40	5.63	92.17	4.86	1.08	0.35 NS
C2	89.00	4.77	88.00	3.84	91.08	3.58	1.90	0.16 NS
C3	89.40	4.15	90.40	4.81	90.00	3.95	0.20	0.82 NS
C4	89.53	4.42	88.67	4.30	89.83	5.27	0.24	0.79 NS
C5	88.07	7.13	89.73	7.32	80.67	10.88	4.25	0.02 S
C6	91.07	4.30	86.13	3.91	84.83	8.75	4.51	0.02 S
Composite	90.20	5.19	89.13	4.44	88.25	6.27	0.46	0.63 NS
SOM	.98	.06	.98	.08	.99	.07	0.03	0.97 NS
VIS	.98	.06	.99	.08	.97	.09	0.25	0.78 NS
VEST	.97	.09	1.00	.13	.87	.14	4.48	0.02 S
PREF	1.02	.04	.99	.05	1.00	.05	1.99	0.15 NS

Table 6: Correlations between COVID-19 severity and Office test

(Chi square test) FE (Fisher Exact)

Office Test \ COVID		Mild		Moderate		Severe/serious		X ² *	P value
		N	%	N	%	N	%		
Head shake test	Normal	15	100.0%	15	100.0%	8	66.7%	7.91 FE	0.004 HS
	Abnormal	0	0.0%	0	0.0%	4	33.3%		
Head thrust test	Normal	14	93.3%	15	100.0%	11	91.7%	1.48 FE	0.74 NS
	Abnormal	1	6.7%	0	0.0%	1	8.3%		
Positional tests	Normal	14	93.3%	14	93.3%	8	66.7%	4.07 FE	0.15 NS
	Abnormal	1	6.7%	1	6.7%	4	33.3%		
Dix Hallpike tests	Normal	15	100.0%	15	100.0%	9	75.0%	5.50 FE	0.02 S
	Abnormal	0	0.0%	0	0.0%	3	25.0%		
Oculomotor tests	Normal	14	93.3%	14	93.3%	9	75.0%	2.36 FE	0.41 NS
	Abnormal	1	6.7%	1	6.7%	3	25.0%		
Fukuda stepping test	Normal	15	100.0%	13	86.7%	7	58.3%	7.67 FE	0.02 S
	Abnormal	0	0.0%	2	13.3%	5	41.7%		

Discussion

This study aimed to evaluate the impact of COVID-19 on vestibular and balance function in post-infection individuals. Our findings provide evidence that a considerable proportion of recovered patients exhibit signs of vestibular dysfunction and dizziness-related disability, highlighting the broader neuro-otological consequences of COVID-19 beyond the acute respiratory phase. Importantly, the most affected domain of the Dizziness Handicap Inventory (DHI) in our cohort was the physical domain, with a mean score of 12.29 ± 7.18 , followed by

functional and emotional domains. The total DHI score (32.86 ± 16.19) indicated a moderate level of disability, and notably, more than half (52.3%) of the participants experienced mild disability, while only 11.9% had no disability. This distribution suggests that even patients who had recovered from COVID-19 with no overt neurological complications might still face persistent vestibular issues impacting daily life.

Our findings resonate with previous studies, such as that of Eğilmez *et al.* (2021)^[7], who also reported elevated disability scores in COVID-19 survivors, particularly in

those with severe illness. However, while Eğılmez *et al.* identified the functional domain as most affected, our study found that physical disability was more prominent. This discrepancy could reflect population-specific factors or methodological differences, including the time elapsed post-recovery and differences in healthcare access or rehabilitation.

The prevalence of audio-vestibular symptoms in our cohort also adds to the growing body of evidence that COVID-19 may have otologic and vestibular sequelae. The most commonly reported symptom was aural fullness (19%), followed by tinnitus, lightheadedness, and imbalance (each 16.67%). Notably, no participants reported hearing loss, contrasting with Eldeeb *et al.* (2023)^[8], who reported hearing loss in 13.9% of post-COVID-19 patients in Egypt. The lower prevalence of hearing-related symptoms in our cohort could be attributed to differences in study design, time since infection, or the selection of patients without known auditory pathologies. Our findings also diverge from Zaubitzer *et al.* (2023)^[9], who found dizziness to be the most frequent symptom post-COVID, while tinnitus was less common. Such variations underscore the heterogeneity in post-COVID-19 vestibular involvement and suggest that patient-specific or geographic factors may influence symptom profiles.

Interestingly, the majority of symptoms in our study were reported during the acute illness phase. This contrasts with the findings of Kökoğlu *et al.* (2021)^[10], who argued that most neuro-otological symptoms were transient and resolved after recovery. The persistence of symptoms in our sample highlights the potential for longer-term vestibular dysfunction, necessitating follow-up and possibly rehabilitation even in non-critical COVID-19 cases.

The Sensory Organization Test (SOT) results revealed generally preserved postural stability; however, vestibular-reliant conditions (C5 and C6) showed relatively reduced scores compared to other conditions. Specifically, the vestibular ratio (0.95 ± 0.13) was slightly lower than somatosensory and visual ratios (both 0.98 ± 0.07), indicating mild vestibular impairment. Although these differences may seem modest, they suggest that vestibular contributions to balance remain vulnerable even after clinical recovery. The reduced vestibular performance under dynamic conditions could indicate lingering central or peripheral vestibular dysfunction or deconditioning due to reduced physical activity during illness and recovery.

Our office vestibular tests further supported the presence of subclinical vestibular impairment. The head shake test, Dix-Hallpike test, and Fukuda stepping test were significantly associated with COVID-19 severity, suggesting that more severe cases are more likely to experience persistent vestibular dysfunction. This pattern supports the hypothesis that SARS-CoV-2 may exert dose-dependent or severity-linked neurotropic effects on the vestibular system. However, the lack of significance in

tests such as the head thrust and oculomotor assessments suggests that not all components of the vestibular system are equally affected, and damage may be localized rather than global.

The pathophysiological basis of these findings could involve multiple mechanisms. SARS-CoV-2 may directly invade the vestibular apparatus or its central connections due to its known neurotropic properties. Indirectly, inflammatory cytokine release, endothelial dysfunction, microvascular thrombi, and prolonged hypoxia may compromise the inner ear's delicate structures or central vestibular pathways. Additionally, conditions such as benign paroxysmal positional vertigo (BPPV) may arise from prolonged immobilization or bed rest during illness, as well as from ischemic insults to the otolithic organs. These mechanisms could explain both transient and persistent vestibular dysfunction post-COVID-19.

From a clinical perspective, our findings underscore the importance of vestibular screening in patients recovering from COVID-19, especially those with moderate to severe disease. Given the significant association between COVID-19 severity and DHI total score ($p = 0.01$), early identification of patients at risk for balance-related disability could guide rehabilitation interventions. Vestibular rehabilitation therapy (VRT) may offer a low-cost, effective strategy to improve functional outcomes and quality of life in this population.

This study has several strengths, including the comprehensive vestibular assessment using both subjective (DHI) and objective (SOT, office tests) measures, and the inclusion of a relatively well-defined post-COVID population. However, limitations must be acknowledged. The small sample size ($n = 42$) and use of convenience sampling may limit generalizability. The cross-sectional design precludes causal inference or assessment of long-term recovery trajectories. Furthermore, the absence of a matched control group prevents comparison with non-COVID patients or the general population. Future studies with longitudinal follow-up and larger cohorts are essential to confirm our findings and better characterize the natural history of vestibular dysfunction after COVID-19.

In conclusion, our study highlights a noteworthy burden of vestibular and balance impairment in post-COVID-19 patients, particularly in those with severe illness. These findings not only emphasize the multi-systemic impact of COVID-19 but also support the need for routine vestibular evaluation and individualized rehabilitation strategies as part of post-COVID care protocols.

LIMITATIONS OF THE STUDY

1. Small sample size ($n = 42$): Limits the generalizability of findings to the wider post-COVID-19 population.

2. Lack of control group: It was not feasible to definitively determine that an individual had never contracted COVID-19, as asymptomatic or undiagnosed cases could not be entirely ruled out.
3. Subjective measures (DHI questionnaire): Self-reported data could be influenced by personal perceptions, anxiety, or mood disorders.
4. No long-term follow-up: Lack of assessment on the progression or resolution of symptoms over time.

CONCLUSION

this study highlighted significant vestibular impairments in post-COVID-19 patients, particularly in those with severe illness, indicating that COVID-19 may have long-lasting effects on the vestibular system, which can affect balance. Further research is needed to explore the mechanisms behind these impairments and their potential for recovery

ABBREVIATIONS

BPPV: Benign paroxysmal positional vertigo, **CDP:** Computerized dynamic posturography, **COG:** Center of gravity, **COP:** Centre of pressure, **COVID-19:** Corona Virus Disease of 2019, **HCoV:** Human coronavirus, **SV:** Herpes simplex virus, **PCR:** polymerase chain reaction, **VN:** Vestibular neuritis, **VEST:** Vestibular, **VOR:** Vestibulo-ocular reflex, **VR:** Vestibular rehabilitation, **WHO:** World Health Organization.

ACKNOWLEDGMENTS

Authors thank all participants for their contribution and cooperation throughout the study.

CONFLICT OF INTERESTS

There are no conflicts of interest.

REFERENCE

1. Almufarrij U, Munro KJ. Does coronavirus affect the audio-vestibular system? A rapid systematic review. *Int J Audiol*. 2020;59(7):487-491.
2. Jeong J. Vestibular neuritis after COVID-19 vaccination. *Hum Vaccin Immunother*. 2021;17(12):5126-5128.
3. Koumpa FS, Forde CT, Manjaly JG. Sudden irreversible hearing loss post COVID-19. *BMJ Case Rep*. 2020;13(11):e236442.
4. Rizzo G, Gagliardi GM, Esposito M. The impact of COVID-19 on the vestibular system: Mechanisms, clinical features, and long-term consequences. *J Neurol*. 2021;268(4):1182-1191. doi: 10.1007/s00415-020-10151-x.
5. El-Gohary N, El-Fawzy M, El-Sherif A. Translation and validation of the Arabic version of the Dizziness Handicap Inventory. *Egypt J Otolaryngol*. 2000;16(1):1-7.
6. Jacobson GP, Newman CW. The development of the Dizziness Handicap Inventory. *Arch Otolaryngol Head Neck Surg*. 1990;116(4):424-427.
7. EĞİLMEZ OK, KORKMAZ MO, GÜVEN M. Evaluation of COVID-19 patients complaining of balance disorders with the Dizziness Handicap Inventory. *Sakarya Tıp Derg*. 2021;11(3):500-506.
8. Eldeeb M, Eldeeb D, Elsherif M. Prevalence of self-perceived audiovestibular symptoms in Egyptian COVID-19 patients. *J Egypt Public Health Assoc*. 2023;98(1):18.
9. Zaubitzer L, Ludwig S, Berkemann M, Walter B, Jungbauer F, Held V, Hegemann SCA, Rotter N, Schell A. The effects of COVID-19 on the vestibular system. *Front Neurol*. 2023;14:1134540.
10. Kökoğlu K, Tektaş N, Baktir-Okcesiz FEM, *et al*. Mild and moderate COVID-19 disease does not affect hearing function permanently: A cross-sectional study involving young and middle-aged healthcare givers. *Eur Arch Otorhinolaryngol*. 2021;278:3299-3305.