

The Effects of COVID-19 on the Balance System

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Cite this article as: Acar M, Deniz R, Kara E, İsmailoğlu G, Karaman E, Ataş A. The effects of COVID-19 on the balance system. *Arch Health Sci Res.* 2022;9(3):149-153.

ABSTRACT

The new coronavirus disease-2019 is clearly showing its effect in our country and around the world. Dizziness or balance disorder is defined as a clinical manifestation of COVID-19 as of 2020. Balance disorders should not be underestimated as they have been shown to be a notable clinical finding in coronavirus disease-2019 patients. Coronavirus disease-2019 post-treatment and balance disorders should be thoroughly investigated. Non-specific symptoms, especially vestibular disorders, can be easily overlooked during evaluation. Therefore, this is a situation that requires attention in the clinic. The purpose of this review is to examine the studies in the literature on how the vestibular system is affected in people who are infected by coronavirus disease-2019.

Keywords: COVID-19, coronavirus, balance, vertigo, dizziness

Introduction

The new coronavirus disease-2019 (COVID-19), which spread rapidly around the world and appeared in December 2019 in the city of Wuhan in China's Hubei province, was declared a global pandemic in March 2020 by the World Health Organization (WHO).¹ Coronavirus disease is an infectious disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a highly pathogenic virus.² According to the data from WHO, 352.8 million cases and 5.6 million deaths have been reported worldwide as of January 25, 2022.³ The clinical presentations of COVID-19 infections range from asymptomatic or mildly symptomatic to severe respiratory failure requiring in the intensive care unit (ICU) care to septic shock and multiple organ dysfunction syndromes.⁴ In the clinical findings, the complaints of COVID-19 patients are generally associated with upper respiratory symptoms such as sore throat, cough, fever, and shortness of breath. The clinical symptoms are often severe in the case of elderly aged more than 70 years, patients with diabetes mellitus, chronic obstructive pulmonary disease, obesity, hypertension, and male sex. However, currently, there are no such valid risk factors for explaining the severity of the disease.⁵

For this review, the literature was investigated in detail. Literature sources from 2019 to 2022 in PubMed were searched by entering the words "COVID-19 and vertigo," "Coronavirus and vertigo," "COVID-19 and dizziness," and "Coronavirus and dizziness." There were 31 cross-sectional studies, 16 case studies, and 19 review articles published. Some of the cross-sectional studies describing the association between balance and COVID-19 are summarized in Table 1 by first author, country of study, objective, material methods, and conclusion.

In the literature review, it was found that COVID-19 can affect the central and peripheral nervous system, either by direct invasion of neural tissues or indirectly through inflammatory responses.⁶⁻⁹ It has been shown that the virus can invade the central nervous system via the olfactory bulb and cause inflammation and demyelination. It has been emphasized that neurological problems may occur not only during the course of the active disease, but also as postneurological problems after the infection has healed.¹⁰

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Received: March 14, 2022
Accepted: May 11, 2022
Available Online Date: June 30, 2022

Table 1. Balance and COVID-19-Related Literature Studies

First Author	Country	Objective	Materials and Methods	Conclusion
Espinoza-Valdez et al ¹⁹	Mexico	To identify the neurotological symptoms and associated factors experienced by COVID-19-positive healthcare workers	A symptom questionnaire was administered to healthcare workers who were positive for COVID-19 between September and October 2020.	The most common neurotological symptoms are vertigo, tinnitus, and imbalance. The clinical features associated with the neurotological profile were asthenia, hyposmia, and taste perversion.
Bozdemir et al ²⁰	Turkey	To examine the effects of COVID-19 on the audiovestibular system	The audiovestibular findings of 24 patients with moderate/severe COVID-19 and 24 healthy controls were compared using pure tone audiometry, tympanometry, transient evoked otoacoustic emissions (TEOAE), distortion product otoacoustic emissions (DPOAE), caloric testing, and vHIT.	It has been stated that COVID-19 causes mild damage to the outer hair cells and lateral semicircular canals by affecting the inner ear functions.
Parrino et al ²¹	Italy	To assess the impact of the COVID-19 pandemic on the incidence of acute hearing and vestibular disorders	A retrospective analysis was performed on all patients evaluated for the acute cochleovestibular disorder at an audiology tertiary referral center between March 2020 and February 2021 (pandemic year period, PYP).	There was no difference in the absolute number of acute audiovestibular disorders during the pandemic compared to previous periods.
Almufarrij et al ¹⁴	UK	Systematic review of the literature as of December 2020 to provide a timely summary of the evidence on SARS-CoV-2, COVID-19, and audio-vestibular symptoms.	The protocol is registered in the International Prospective Register of Systematic Reviews.	It has been noted that there are numerous reports of audio-vestibular symptoms associated with COVID-19. However, it has been mentioned that the number of high-quality studies comparing COVID-19 cases and controls is insufficient.
Charpiot et al ²²	France	To assess possible comorbidity between acute peripheral vestibulopathy (APV) and COVID-19.	It was carried out in 5 hospitals in France between February and May 2020. Comparisons were made with 2018 and 2019 records for the same period.	No significant increase in the severity of APV cases was noticed. No cases of comorbidity between APV and SARS-CoV-2 infection have been reported.
Aljasser et al ²³	Saudi Arabia	To examine the auditory-vestibular symptoms of a person who has tested positive for COVID-19	Otological changes were evaluated in hospitalized and non-hospitalized COVID-19 patients during and after the acute phase of the disease.	There is no evidence that COVID-19 causes hearing loss or tinnitus during or after the acute phase. However, it has been noted that rotatory vertigo, which may be vestibular in origin, may be a clinical manifestation of COVID-19.
Jafari et al ²⁴	UK	To determine the incidence rate (IR) of hearing loss, tinnitus, and vertigo caused by SARS-CoV-2	Examined by current systematic review and meta-analysis.	COVID-19 has stated that it can cause hearing loss, tinnitus, and dizziness.
Yilmaz et al ¹⁶	Turkey	To answer the question of whether balance-related systems have been affected in adults who recovered from COVID-19 disease.	Thirty-seven patients who recovered from COVID-19 disease and 30 healthy controls were compared using Dizziness Handicap Inventory (DHI), Computerized Dynamic Posturography (CDP), Vestibular Evoked Myogenic Potentials (VEMP) and v-HIT.	It has been reported that COVID-19 Disease may cause dizziness rather than vertigo. In approximately one-fifth of adult outpatients with COVID-19, the complaint of dizziness has been found to be due to involvement of the vestibular and visual systems or their central connections.
Viola et al ²⁵	Italy	To examine the subjective prevalence of tinnitus and dizziness in a sample of COVID-19 patients	An online 10-item closed-ended questionnaire was used on 185 patients.	Thirty-two (94.1%) of the patients participating in the study reported dizziness and two (5.9%) acute vertigo attacks.
Gallus et al ¹²	Italy	To investigate auditory-vestibular symptoms and sequelae in recovered patients and look for any signs of permanent damage	Auditory-vestibular symptoms were investigated in 48 COVID-19 patients whose nasopharyngeal swabs were negative.	4 (8.3%) patients reported hearing loss, 2 (4.2%) tinnitus, 4 (8.3%) dizziness, 1 dynamic imbalance (2%), 3 static imbalance (6.3%). Most auditory-vestibular symptoms regressed.

vHIT, head impulse test; SARS-COV-2, severe acute respiratory syndrome-coronavirus-2; COVID-19, coronavirus disease-2019.

Balance integration is crucial in human life. This situation is performed in the central nervous system depending on the vestibular, visual, and proprioceptive systems. Although there is no objective consensus on the effects of COVID-19 on the vestibular system, studies suggest that the virus may affect the auditory and vestibular systems.¹¹ Although some patients may have auditory-vestibular symptoms, these are usually transient, and there is no clear evidence

of clinically significant permanent cochlear damage after recovery.¹² Otological manifestations in COVID-19 infections may be mild or severe to profound, unilateral or bilateral.¹³ Almufarrij and Munro¹⁴ noted in a systematic review of the auditory-vestibular symptoms in COVID-19 patients that the estimated prevalence of dizziness was 7.2%. However, some investigators also emphasized that the terms dizziness and vertigo are used interchangeably and that dizziness is

a commonly reported symptom in patients with COVID-19.¹⁴ In contrast, Korkmaz et al,¹⁵ examined the characteristics and frequency of otological COVID-19. Dizziness was found in 31% of 116 patients with positive polymerase chain reaction (PCR) tests. They also found that dizziness was more common in especially women younger than 60 years.¹⁵

In the study by Tan et al,¹¹ the vestibular systems of 26 patients who had survived the COVID-19 and had no previous hearing and balance complaints and the control group who did not have the COVID-19 were examined. The video head impulse test (VHIT) of the subjects who had survived COVID-19 was found to have lower gains in all semicircular canals compared with the control group. The asymmetry values of the VHIT test for the right anterior-left posterior and left anterior-right posterior were significantly different from those of the control group. A significant difference was observed for cervical vestibular evoked myogenic potential (cVEMP) asymmetry values compared with those of the control group. While there was a significant difference in ocular vestibular evoked myogenic potential (oVEMP) asymmetry values, no significant change was observed in amplitude and latency values. The changes in cVEMP latencies and amplitudes in COVID-19 patients suggest that this disease affects the brainstem and vestibulocollicular arch and slows arch communication. These effects have been observed in the literature in retro-labyrinthine lesions in the vestibulospinal pathway. The lack of large differences in gain asymmetries in the VEMPs demonstrated the importance of the compensatory mechanism of the central vestibular system. Thus, this study established that the audiovestibular system of people with COVID-19 infection might be affected.¹¹

Yilmaz et al¹⁶ compared 37 individuals who had survived COVID-19 disease and 30 age- and sex-matched healthy controls using the Dizziness Handicap Inventory, Computed Dynamic Posturography (CDP), VEMP, and VHIT tests. The composite score and general visual scores of CDP patients were significantly lower than controls, VHIT gains were significantly lower in the vertical semicircular canals compared with controls, oVEMP responses differed significantly between patients and controls, P1/N1 amplitudes decreased, and prolonged N1 latencies were observed in the cVEMP test. The results of this study indicate that COVID-19 may affect the vestibular system. Because vestibular disorders may persist after patients recover, it is thought that they may be irreversible.¹⁶

Hearing loss and vertigo are rare in COVID-19 patients, and it is difficult to explain the exact etiopathology in the current pandemic.¹³ Vertigo, which occurs in approximately one-fifth of adult COVID-19 patients not treated in the intensive care unit, may be due to the involvement of the visual and/or vestibular systems and central connections. It is suggested that the widespread hypercoagulation recently observed in COVID-19 patients may lead directly to neurologic or inner ear involvement. Because the inner ear is very sensitive to ischemia, it is suggested that disturbances of the audiovestibular system may be caused by vascular damage.¹⁷ Vascular involvement may be one of the clinical manifestations of COVID-19, as like various viral infections, including hepatitis B and C vasculitis.¹⁸

In the literature, vestibular symptoms were reported in 7 patients diagnosed with COVID-19 infection, but the direct vestibular origin was not mentioned. Acute thrombosis of intracranial arteries (vertebral artery and posterior inferior cerebellar artery) occurred in a patient with vertigo and nystagmus after COVID-19.¹⁴ Therefore, it is very important to distinguish people with dizziness from acute cerebrovascular involvement due to viruses. It should be considered that anxiety and stress can also trigger vertigo in patients.

The literature highlights that vertigo is a notable clinical finding in COVID-19 patients. Vestibular rehabilitation therapy with promising results is recommended for these patients. In one study, a 56-year-old female patient was evaluated with dizziness and a sense of imbalance. The symptoms began after infection with COVID-19. The results of routine hearing tests, vestibular assessment (videonystagmography (VNG)), and neurological tests were within normal limits, but otolith assessments such as cVEMP and subjective visual vertical tests showed abnormal results. The patient was offered an individualized vestibular rehabilitation program of 10 sessions (1 session per week). After completing the rehabilitation sessions, her main complaints were relieved, her performance on CDP improved, and the abnormal cVEMP amplitude asymmetry between the ears disappeared.²⁶ In another study, vestibular assessment and rehabilitation were applied to 3 cases infected with vestibular neuritis caused by COVID-19. Unilateral dysfunction was observed in the caloric and VHIT tests. Home-based vestibular rehabilitation (VR) was used for their treatment. One patient still had a mild episode of vertigo, although symptoms improved significantly. The other 2 patients recovered completely. Based on this study, it was concluded that VR may be effective in treating vestibular neuritis caused by COVID-19.²⁷ Functional evaluation of the vestibular system is very important in patients with dizziness after COVID, and vestibular rehabilitation can be very helpful in these patients.

COVID-19 and Vestibular Neuritis

Mat et al²⁸ published a case report of a 13-year-old girl who presented to the clinic with complaints of sudden onset, continuous rotatory vertigo, and persistent vomiting. On examination of the patient, who had never balance and hearing problems and no complaints of dyspnea or olfactory disturbances, right spontaneous rotatory nystagmus, left deviation in the Fukuda step test, decreased vestibulo-ocular reflex gain for the left anterior and lateral canals in the VHIT, and catch-up saccades were observed. The patient was diagnosed with vestibular neuritis (VN) with a normal hearing test and cranial nerve examinations. In addition, PCR testing performed on the patient has proven positive for COVID. Therefore, the patient was diagnosed with vestibular neuritis due to COVID-19.²⁸ In another case report, Giannantonio et al²⁹ diagnosed VN based on the detailed tests they performed after a 13-year-old COVID-positive male patient presented with complaints of sudden fever, dizziness, and recurrent vomiting.²⁹ In another case report, they concluded that the patient had COVID-induced VN based on the history and detailed testing they performed on a 20-year-old COVID-positive female patient who reported with complaints similar to those reported in the previously mentioned literature.³⁰ Although larger cross-sectional and population-based studies are needed to further investigate such cases, VN caused by COVID-19 was found to be common in healthy women and symptoms resolved with corticosteroids.³¹

COVID-19 and Labyrinthitis

Bokhary et al³² reported that a 23-year-old female patient presented to the clinic with complaints of vertigo, hearing loss, tinnitus, and fullness 9 days after positive detection for COVID. As a result of the thorough examination, they came to the diagnosis of labyrinthitis caused by SARS-CoV-2. They treated the patient with the standard treatment of viral labyrinthitis.³² Another case reported is an 84-year-old male patient who presented to the emergency department with rotational vertigo, vomiting, and sudden hearing loss in the right ear. It was stated that the patient had no fever and respiratory symptoms and had nystagmus on the left side. Cerebral magnetic resonance imaging ruled out a neurovascular problem. The diagnosis of right labyrinthitis was made by highlighting the increased signal in the vestibule, right semicircular canals, and cochlear fluid-attenuated inversion recovery. Based on the swab sample collected during the

application, the PCR test was positive. Oral corticosteroid therapy (70 mg prednisone daily) was administered, followed by progressive clinical improvement.³³

COVID-19 and Benign Paroxysmal Positional Vertigo

Maslovara and Kosec³⁴ noted in their case report that 2 different patients presented with severe short-lived vertigo attacks with nausea and vomiting that developed within 2 weeks after the COVID-19 infection. The history indicated that the patients' complaints occurred while lying in bed, turning over, and standing up. Posterior semicircular canal involvement was observed in the Dix Hallpike test. The patient whose PCR test was positive was suspected to have COVID-19-related BPPV disease. They noted that the pathophysiology of post-COVID BPPV is similar to that of other viral infections, with some features such as induction of hypercoagulation and microthrombus formation, which can cause significant circulatory disturbances that affect pathogenesis.³⁴

Piccioni et al³⁵ diagnosed BPPV due to COVID-19 in 8 covid-positive patients and found that the lateral canal was affected in 2 of 3 patients treated in the ICU had lateral canal involvement. Bed rest, ototoxic effects of covid treatment medications, the direct cytopathic effect of the virus, inflammatory response of the inner ear, or vascular involvement have been mentioned as pathogenetic factors of BPPV.³⁵

Vestibular Symptoms After COVID-19 Disease

Post-COVID-19 syndrome is a series of chronic signs and symptoms that may appear after SARS-CoV-2 infection, including fatigue, dyspnoea, chest pain, palpitations, anxiety, depression, and joint and muscle pain.³⁶ In a study investigated the prevalence of balance disorders such as vertigo and dizziness after recovery from COVID-19 patients. Otolological examination, pure tone audiometry, and VNG test were performed on 20 patients with COVID-19 who complained of dizziness after complete recovery. Half of the patients had a history of sense of imbalance attacks, and most patients showed positional nystagmus and bilateral weakness on caloric testing.³⁷ Ferreira et al³⁸ on the other hand, studied the auditory and vestibular symptoms of the Brazilian population after COVID-19 disease. The sample consisted of 173 people. After the COVID-19 disease, decreased smell in 126 patients, headache in 76 patients, tinnitus in 76 patients, and dizziness in 72 patients were reported.³⁸

Post-COVID-19 syndrome may present after mild or even asymptomatic SARS-CoV-2 infection, causing limitations in activities of daily living and in quality of life. Further research will clarify the origin and most appropriate management of these balance alterations.

Dizziness Related to COVID-19 Treatment

Chloroquine and hydroxychloroquine, azithromycin, lopinavir-ritonavir, interferon, ribavirin, and ivermectin used in the treatment of COVID-19 have been found to cause ototoxic side effects.³⁹ It has been mentioned that these effects of the drugs may cause symptoms such as hearing loss, tinnitus, and imbalance/dizziness in patients and that the symptoms may be irreversible. Therefore, the use of these drugs should be closely monitored.^{40,41}

The COVID-19 vaccine is an important and urgent research topic worldwide because of the rapid spread of COVID-19 and the high mortality and morbidity rates. Studies of new or worsening otologic symptoms associated with the COVID-19 vaccine have noted that there may be only some side effects that do not correlate with the vaccine and otologic symptom.^{42,43} In a study, a 54-year-old man developed VN within 3 days of administration of the COVID-19 vaccine. Although the relationship between VN and COVID-19 vaccination remains unclear, this case study established that one should

be aware that VN can occur as a negative consequence of COVID-19 vaccination.⁴⁴

In another study, the existing literature on cochleovestibular dysfunction after COVID-19 vaccination was reviewed and 33 patients (mean age, 54.3 ± 14.1) with "acute vertigo" after COVID-19 vaccination had evaluated. Symptoms had included 16 patients (48.5%) with objective vertigo, 14 patients (42.4%) with subjective vertigo, and 3 patients (9.1%) with dizziness.⁴⁵ However, due to the small sample size, a definite cause-effect relationship between vaccination and vertigo cannot be inferred. In light of the expected third dose, large-scale and well-designed studies are needed to better define possible adverse reactions of the COVID-19 vaccine.

Conclusion

Dizziness is a non-specific symptom of COVID-19. Comprehensive research is needed to determine the primary cause of vertigo, particularly acute labyrinthitis, vestibular neuritis, acute otitis media, or secondary stroke following COVID-19. Studies on the effects of COVID-19 on the balance system include a limited population. However, the results of the studies suggest that the COVID-19 may affect the vestibular system. In this regard, several reasons include coagulation in the vessels supplying the vestibular system, prolonged bed rest due to the virus, damage to the vestibular nerve or brainstem by the virus, and the ototoxicity of the drugs used in treatment have been considered. Since no consensus has yet been reached, more comprehensive studies on this topic are needed.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – M.A.; Design – M.A., R.D.; Supervision – M.A., R.D., E.K.; Literature Research- M.A., R.D., E.K., G.I., E.K.; Writing Manuscript – M.A., R.D., G.I., E.K.; Critical Review – A.A.

Declaration of Interests: The authors have no conflicts of interest to declare.

Funding: The authors declared that this study has received no financial support.

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