



Investigation of Postural Stability in Patients Individuals Who Have Recovered COVID-19

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Received: 24 October 2023 / Accepted: 14 August 2024 / Published online: 11 September 2024
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Abstract

Objective The study aimed to examine postural stability changes in individuals who have recovered from COVID-19 infection.

Methods Fifty patients who recovered from the COVID-19 infection and 50 healthy controls were compared using the dizziness handicap inventory (DHI), a modified clinical test of sensory interaction balance (mCTSIB), limits of stability (LOS), rhythmic weight shift (RWS), and Romberg and fall risk (FR) tests.

Results Regarding mCTSIB, regardless of gender patients, female patients, or male patients, there were no significant differences from controls ($p > 0.05$). There was a significant difference in LOS between the patients and controls regarding ($p < 0.05$) in some parameters. There was a significant difference between the patients and controls concerning RWS ($p < 0.05$) for some parameters. There was a significant difference between the patients and controls regarding the Romberg test in some parameters ($p < 0.05$). There was no statistically significant difference between the patients and control groups regarding FR.

Conclusion Studies in which the effects of COVID-19 infection sequels have been evaluated on the vestibular system in the literature are subjective. The main concern is the prevalence of dizziness or vertigo in subjective studies. There may be a decrease in postural reflexes in female individuals who recovered from the COVID-19 infection in this study, thanks to the objective test measurement. Increased oscillations with eyes closed on regular ground and soft ground in the Romberg test may likely indicate vestibular problems.

Keywords COVID-19 · Limits of Stability · Postural Stability · Romberg · Rhythmic Weight Shift

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Background

The COVID-19 pandemic began in Wuhan, China, in December 2019. Rapidly, the outbreak has spread worldwide. The first Turkish patient who tested positive for COVID-19 in Turkey was reported on March 11, 2020. The patient contracted the virus while traveling to Europe. This was the first coronavirus case in Turkey. The COVID-19 pandemic was declared by the World Health Organization (WHO) in March 2020 [1, 2]. Coronavirus can damage the nervous system directly or through various mechanisms, such as infection, hypoxia, and the immune system [3]. COVID-19 may enter the body via air. COVID-19 can spread throughout the nervous system, gaining access via the olfactory nerve and bulb. Neurologic problems can be seen in the course of the active disease and post-neurological problems after recovery from the infection [3–6]. At this point, a thorough assessment of balance-related systems is required by using objective test batteries. Although the

pathophysiology of the audiovestibular disorder caused by COVID-19 is unknown, some potential mechanisms have been proposed, including [6, 7]. Labyrinthitis or neuritis is caused by viral involvement in the inner ear or the vestibulocochlear nerve, potentially leading to vertigo, tinnitus, and hearing loss. The sequels of such manifestations may result in inner ear thrombosis or hypoxia and could explain, for example, sudden hearing loss. Sequelae of immune-mediated disorders may negatively affect the audiovestibular system [8, 9].

Balance is critical in human life and is performed in the central nervous system, depending on the information detected by the proprioceptive, ocular, and vestibular systems. The impact of COVID-19 on balance systems has been speculated in a few case reports and clinical observations [10–17]. When the literature is examined, balance evaluations related to COVID-19 have been performed using questionnaires rather than objective measurements [6]. This study aimed to examine possible balance disorder sequels in individuals who recovered from COVID-19.

Methods

The evaluations were the Istanbul Medipol University Hospital. The study was approved by the Ethics Committee of Istanbul Medipol University on January 21, 2021 (Approval number:50). This study was carried out in compliance with the principles of the Helsinki Declaration. An informed consent form was obtained from the participants.

50 patients (25 males and 25 females with a mean age of 35.66 ± 9.97) who recovered from COVID-19 infection and 50 healthy gender-matched controls (25 males and 25 females with a mean age of 34.56 ± 8.56) were included in the study. The confirmation of COVID-19 infection was made by isolation of the virus in the nasal and pharyngeal swabs using a polymerase chain reaction test. The patients had mild COVID-19 disease with symptoms like cough, sub-febrile fever, arthralgia, headache, weakness, anosmia, taste disturbance, and myalgia. None of them had pulmonary involvement, or dyspnea necessitating hospitalization or intensive care unit facilities. Forty of 50 patients were treated with hydroxychloroquine or favipiravir in an outpatient setting and followed up by the COVID-19 staff of the Ministry of Health. The remainder did not receive a specific medical treatment. The balance test of the patients was performed 10 to 150 days after their recovery from the disease. This was confirmed by the evaluations of the COVID-19 staff and the negative polymerase chain reaction test.

The inclusion criteria of the study follow on COVID-19 group:

- A chronological age ranging from 18 to 65 years,
- The participant recovered COVID-19 infection.

The inclusion criteria of the study follow on the control group:

- A chronological age ranging from 18 to 65 years,
- The participant hasn't had a COVID-19 infection.

The exclusion criteria of the study follow:

- To ensure that any of the criteria for inclusion in this study, any orthopedic and/or systemic disease,
- Individuals with pre-COVID-19 hearing loss,
- Individuals with a history of vertigo, dizziness, or suffering from neurological disorders,
- A history of psychological disorders and systemic disorders.
- Using drugs that can affect hearing and balance system, physical or emotional symptoms that may prevent the individual from performing the tests.

All participants were evaluated through a DHI, mCTSIB, LOS, Rhythmic Weight Shift RWS, Romberg, and FR test. Firstly, DHI, The 25-item was developed to evaluate the self-perceived handicapping effects imposed by vestibular system disease. Individuals without balance problems, as determined by the results of this inventory, were included in the study. The postural sway velocity was measured under four sensory conditions in three sensor systems in mCTSIB. The conditions were as follows: eyes open, firm surface (EOFS); eyes closed, firm surface (ECFS); eyes open, unstable surface (EOUS) (foam); and eyes closed, unstable surface (ECUS) (foam). The sensor systems were as follows: proprioceptive system (PS), visual system (VSS), and vestibular system (VS). In this test, three 10s trials were conducted under each condition.

The participants could see the center-of-gravity point, which they could voluntarily move on the computer screen in LOS. They performed this task while viewing a real-time display of their COP position, with targets placed at the center of the base of support and the stability limits. The target directions of the protocol were front, front/right, right, back/right, back, back/left, left, and front/left. For each of these eight directions, the participants movement reaction time (RT), movement velocity (MV), movement distance, and movement directional control (DC) were measured. For each of the eight trials, each participant, on command, moved the COP cursor as quickly and

accurately as possible toward a second target located on the LOS perimeter, set at 100% of the theoretical limit of stability, and then held a position as close to the target as possible.

The transfer capacity of the center of pressure was evaluated rhythmically in the sagittal and anterior-posterior planes at three different speeds in RWS: slow (3s), moderate (2s), and fast (1s). During the execution of each task, each patient saw a real-time image of the COP position relative to a target moving at the desired speed and amplitude. In the Romberg test, the participants were asked to put their feet together on the platform in the foot position they saw on the computer screen and lock their hands at chest level. Then, the center of pressure displacement (COPD) was measured under the four sensory conditions: EOFS, ECFS, EOUS, and ECUS. A protocol was followed to measure the static balance under four conditions: comfortable stance with eyes open (CSEO), comfortable stance with eyes closed (CSEC), narrow stance with eyes open (NSEO), and narrow stance with eyes closed (NSEC). After all the conditions of the protocol were implemented, the value of the sway velocity index (SVI) for each condition appeared in FR. These measurements enabled fall risk prediction.

Statistical Analysis

Statistical Package for the Social Sciences version 20.0 (IBM Corp.; Chicago, IL, USA) software was used. Descriptive statistics were expressed as mean and standard deviation (mean $\pm$ SD). The normality analysis of all measurement parameters used in the study was performed with the Shapiro-Wilk and Kolmogorov Smirnov test. In cases where the data did not show normal distribution according to these tests, non-parametric (Mann-Whitney U- test for non-paired data) tests were used for statistical analysis. Parametric (t-test for parametric data) tests were used in cases with normal distribution. A p-value less than 0.05 was considered significant for all comparisons.

Results

mCTSIB

On mCTSIB center of gravity sway rate, EOFS, ECFS, EOUS, ECUS, PS, VS, and VSS scores regardless of gender, female patients or male patients were no significant difference than controls ($p > 0.05$).

REGARDLESS OF GENDER PATIENTS

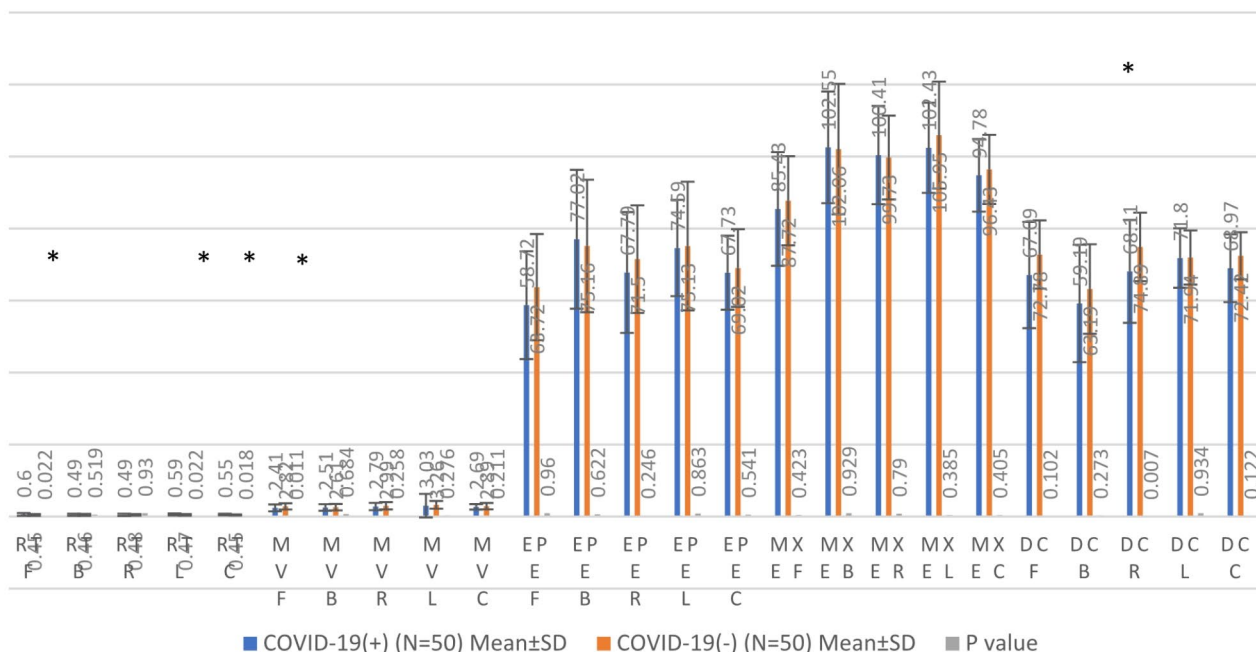


Fig. 1 LOS data regardless of gender patients and control groups
* $p < 0.05$.

FEMALE PATIENS AND FEMALE CONTROL

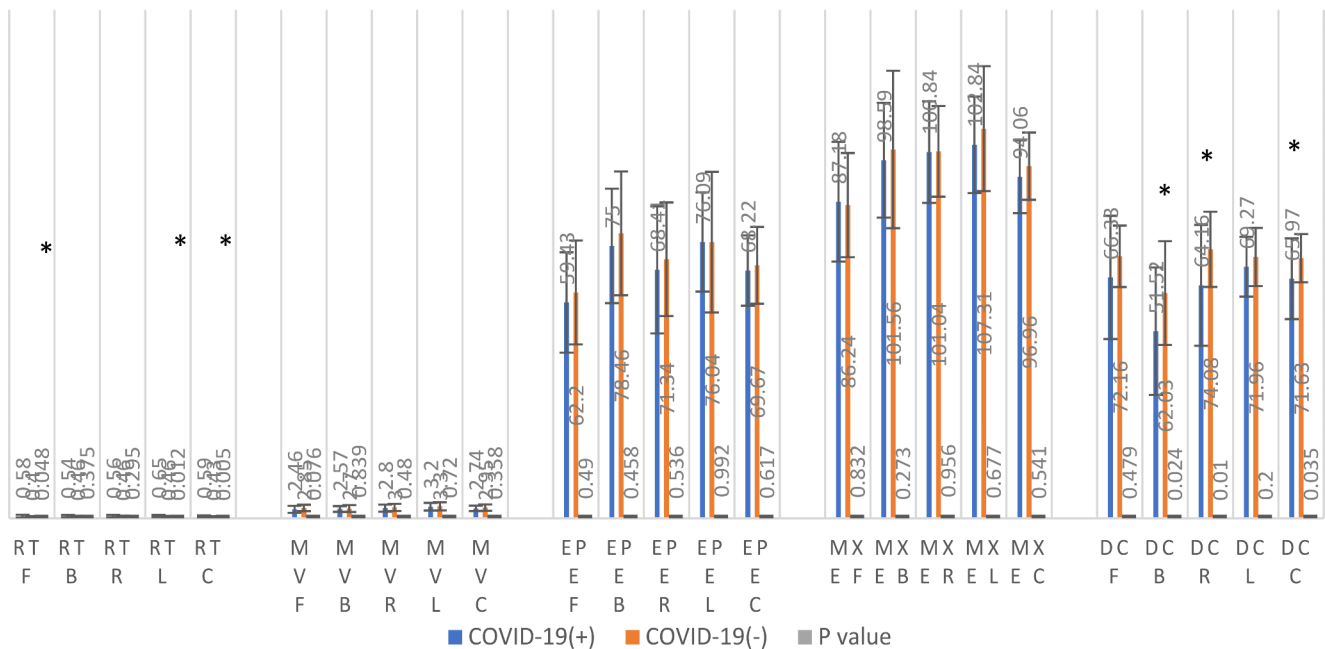


Fig. 2 LOS data by female patients and female control groups

* $p < 0.05$.

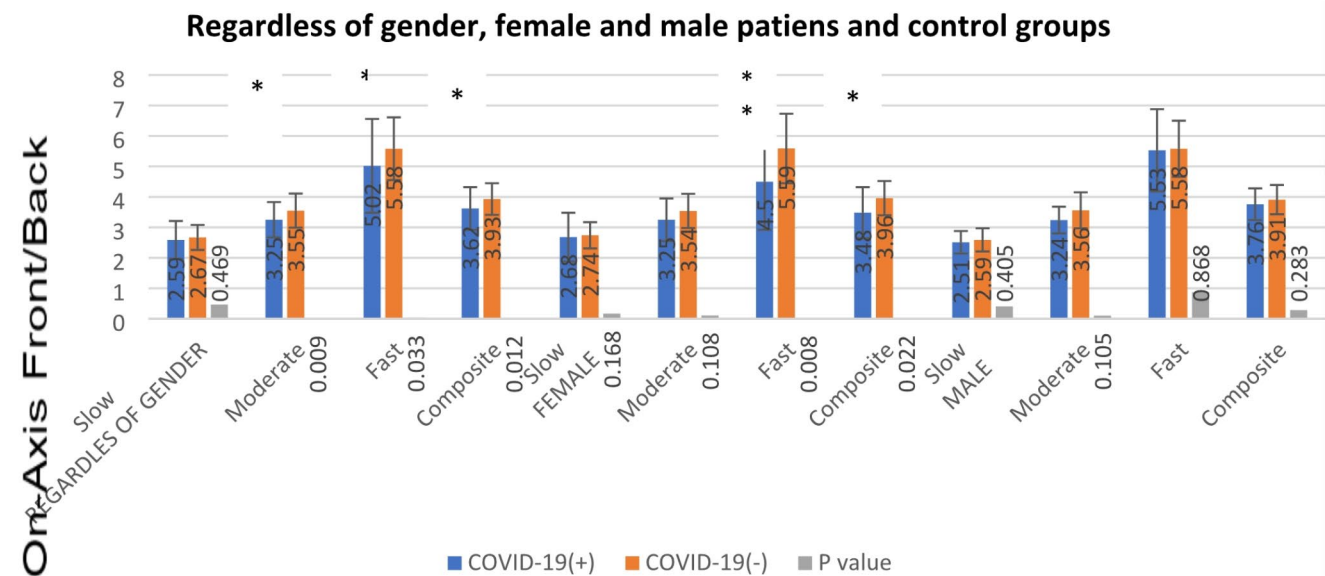


Fig. 3 On-Axis Front/Back data by all, female and male patients and control groups

* $p < 0.05$. ** $p < 0.01$.

LOS

On LOS, The RT F, RT L, RT C, MV F, and DC R scores regardless of gender were significantly higher than controls ($p < 0.05$) (Figure 1). The RT F, RT L, RT C, DC B, DC R, and DC C scores of female patients were significantly

higher than the female controls ($p < 0.05$) (Figure 2). The scores of male patients were not significantly different than male controls ($p > 0.05$).

RWS

On RWS, The on-axis left/right in slow, moderate, and fast scores regardless of gender, female patients or male patients were no significant difference from controls ($p > 0,05$). The on-axis velocity front/back in moderate, fast, and composite scores regardless of gender were significantly lower than controls ($p < 0,05$). The fast and composite scores of female patients were significantly lower than female controls ($p < 0,05$)(Figure 3). The scores of male patients were not significantly different from male controls ($p > 0,05$). The directional control left/right and front/back in slow, moderate, and fast scores regardless of gender, female patients, or male patients were no significant difference than controls ($p > 0,05$).

Romberg Test

On the Romberg Test, The COPD in ECFS scores regardless of gender were significantly higher than those controls ($p < 0,05$). The ECFS and ECUS scores of female patients were significantly higher than controls ($p < 0,05$)(Figure 4). The male patients were not significantly different from than controls ($p > 0,05$).

FR

On FR, the evaluation SVI in the of regardless of gender was no significant difference than controls ($p > 0,05$). The

NSEO score of female patients was significantly lower than female controls ($p < 0,05$) (Figure 5). The male patients had a significant difference from than controls ($p > 0,05$).

Discussion

The proprioceptive, visual, and vestibular systems are essential for controlling balance and orientation information. Balance-related tasks of locomotor movements, such as walking, running, jumping, and jumping during gravity, are performed by these systems, creating appropriate responses after sensory integration to maintain static balance [18]. The impact of COVID-19 on balance systems has been speculated in a few cases reports and clinical observations [10–17]. As a result, many symptoms and deficiencies associated with COVID-19 have emerged since the onset of the pandemic. Among these, cases related to hearing and balance have been described in asymptomatic COVID-19 patients. Gallus et al. used pure tone audiometry, a video head impulse test (vHIT), a suppression head impulse test, and an anamnesis form to investigate COVID-19 symptoms and subsequent sequels. In this examination, a decrease in gain was obtained in the right anterior canal in the vHIT test compared to the control group [19]. Yilmaz et al. used computerized dynamic posturography on the composite, and the general visual scores of the patients were significantly lower than those of the controls [20]. This study aimed to examine possible sequels of balance disorders in individuals who

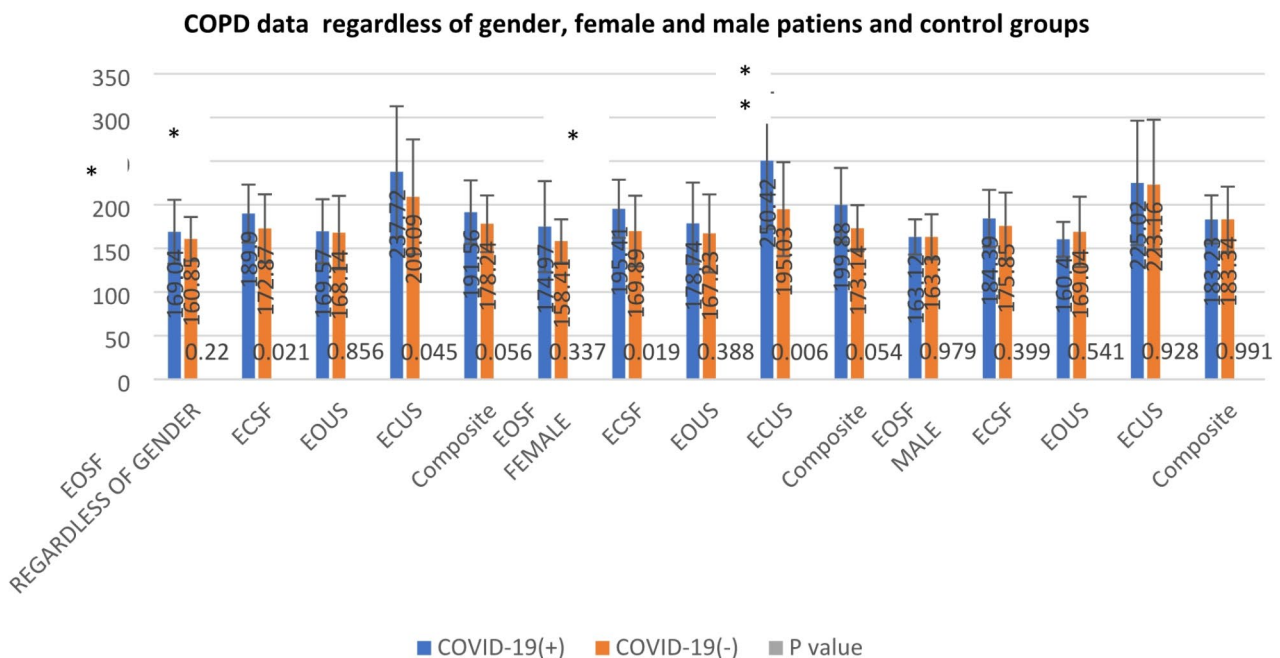


Fig. 4 COPD data regardless of gender, female and male patients and control groups

SWAY VELOCIT INDEX

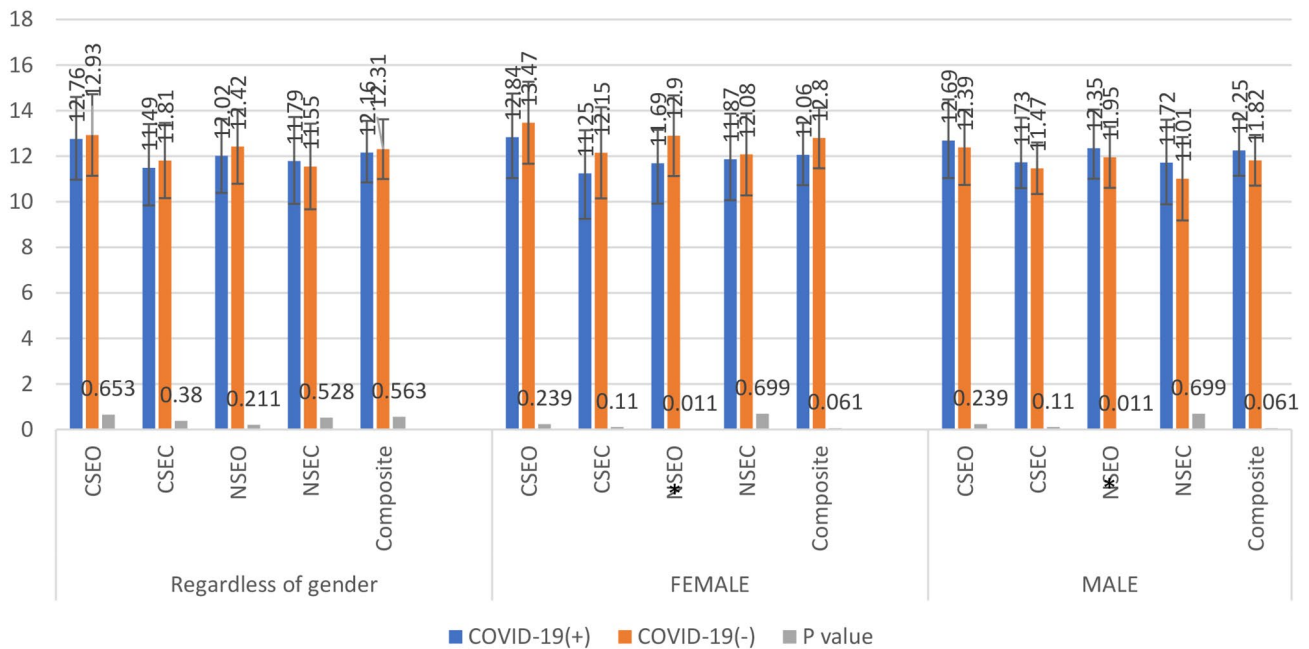


Fig. 5 SVI data by all, female and male patients and control groups
* $p < 0.05$.

have recovered from COVID-19 on objective vestibular findings by applying a posturography test.

In clinical conditions, access to a dynamic posturography test may not be available in some cases. Therefore, there is a need for alternative methods for quantitatively measuring the sensory organization of balance [21]. mCTSIB can be considered a valid method for measuring sensory organization in people with balance disorders [22]. Whitney and Mancini reported that mCTSIB is correlated with SOT [23, 24]. Given the PhysioSensing device portability and COVID-19 characteristics, mCTSIB was preferred in the clinical conditions of this study. As a result, there was no significant difference from controls regardless of gender, female patients, or male patients ($p > 0.05$).

LOS is a test with which the maximum distance that a person can voluntarily take the center of gravity without losing balance and the ability to bend in different directions is evaluated [25]. These abilities include many daily activities, such as picking up clothes from the closet, picking up objects from the floor, or putting on shoes [26]. The LOS test can be used to evaluate this voluntary motor control performance [25]. The evaluations for RT F, RT L, and RT C scores regardless of gender were significantly longer than those of the controls ($p < 0.05$). It has been reported to leave sequels in the musculoskeletal system in individuals who have recovered from COVID-19 [27]. In this study, the decrease in postural reflex responses was evaluated,

and accordingly, the reaction time might be prolonged in individuals who recovered from COVID-19. The MV F score regardless of gender was significantly slower than in controls ($p < 0.05$). This deceleration was believed to occur to maintain and protect postural stability as the body moved forward. The RT F, RT L, and RT C scores of the female patients were significantly higher than those of the female controls ($p < 0.05$). Therefore, there may have been a decrease in the postural reflex responses of female individuals who had recovered from COVID-19; accordingly, the reaction time may be longer. The statistically significant differences observed in the DC B, DC R, and DC C values of the female individuals who had recovered from COVID-19 indicated difficulties in direction control.

The RWS test evaluates voluntary motor control performance; the directional control of the body on an axis is provided rhythmically from left to right and from back and front [25, 28]. The on-axis front/back velocities regardless of gender, as suggested by their moderate, fast, and composite scores, were significantly lower than those of the controls ($p < 0.05$). The fast and composite scores of the female patients were significantly lower than those of the female controls ($p < 0.05$). Maki et al. reported that movements in RWS may evoke fear of falling in individuals and therefore harm their postural stability [29]. Dalbaere et al. stated that individuals avoid backward and forward movements in RWS because they are afraid of falling [30]. In this study,

a possible reason for the decrease in the ideal speeds of the individuals who had COVID-19 was that the device used did not have a safety belt, which may have worsened their fear of falling when swinging forward and backward.

The Romberg test is a popular bedside examination approach used to determine any postural stability problem and whether the proprioceptive, visual, or both systems are involved in maintaining balance [31, 32]. In this study it was thought that proprioceptive, visual, and vestibular system responses are evaluated under the EOSF condition; proprioceptive and vestibular system responses under ECFS; visual and vestibular system responses under EOUS; and vestibular system responses under ECUS [31]. The center of pressure displacement (COPD) under ECFS scores regardless of gender was significantly higher than those of the controls ($p < 0.05$). The ECFS and ECUS scores of the female patients were significantly higher than those of the controls ($p < 0.05$). This change in the center of gravity under ECFS and ECUS in the female individuals who had recovered from COVID-19 infection suggested that their vestibular systems were negatively affected.

Falls are a common occurrence among older people, even for those who are in good health and have no apparent balance problems. The fall risk test is used to evaluate individuals with the potential to fall. When the result exceeds the normative values, a detailed evaluation of the proprioceptive, visual, or vestibular system is recommended [33]. The sway velocity index (SVI) is a determinant of the risk of falling. The SVI values regardless of gender did not significantly differ from those of the controls ($p > 0.05$). The NSEO scores of the female patients were significantly lower than those of the female controls ($p < 0.05$). These findings suggested that there was no risk of falling in both groups.

Conclusion

Studies evaluating the effect of COVID-19 infection sequelae on the vestibular system are not objective. Subjective studies are concerned with the prevalence of dizziness or vertigo. In this study, objective test measurement revealed a possible decrease in the postural reflexes of female individuals who had recovered from COVID-19 infection. The increase in oscillations with the eyes closed on normal ground and eyes closed on soft ground in the Romberg test suggested the potential occurrence of vestibular problems. Considering these findings, during vestibular evaluation, the COVID-19 infection status should be questioned during the anamnesis for a certain period, and more detailed test measurements of individuals exposed to this infection should be obtained.

Abbreviations

DHI	Dizziness Handicap Inventory.
mCTSIB	Modified Clinical Test of Sensory Interaction Balance.
LOS	Limits of Stability.
RWS	Rhythmic Weight Shift.
FR	Fall Risk (FR).

Acknowledgements Not applicable.

Author Contributions EG: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Visualization and Writing. BT: Review, Visualization, Writing, and Editing. OY Supervision; Validation, Original draft, Review, and Editing. GA: Review & Editing. MBS: Supervision,

Funding None.

Data Availability The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics Approval and Consent to Participate Written informed consent was obtained from the study participants, and the Ethics Committee of Istanbul Medipol University approved the study proposal (Approval number: 50).

Consent for Publication Not applicable.

Competing Interests The authors declare that they have no competing interests.

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