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**Original Research**

# The Comparison of Static Balance in COVID-19 Recovered Patients and Healthy Individuals

**Fereshteh Mehrjou[1], Mahdi Majlesi[2*]**

*1. Department of Sport Injuries and Corrective Exercises, Faculty of Physical Education and Sport Sciences, Department of Sport Sciences, University College of Omran_Toseeh, Hamedan, Iran. E-mail: f_mehrjou@yahoo.com, ORCID:0000_0003_2554_7355.*
*2. Department of Sport Biomechanics, Faculty of Humanities, Islamic Azad University, Hamedan Branch, Hamedan, Iran. Email: majlesi11@gmail.com, ORCID:0000-0003-2032-4937.*

**ABSTRACT**

This study aimed to compare the static balance between healthy Individuals and those affected by COVID-19, considering the effect of this disease on the central nervous system and the related neurological disorders, as well as the effect of the central nervous system on balance. This descriptive and comparative study was conducted on healthy Individuals and those with a history of COVID-19 aged 20-40 years in Hamedan, Iran. The statistical sample of this research included 60 people infected with corona virus from Hamadan city, whose balance was evaluated one month and three months after recovery (experimental group) and also 30 healthy people were selected as control group. Balance indicators (anterior-posterior and medial-lateral) were examined in eight static positions: double legs stance, single-leg stance with eyes open, and eyes closed conditions, as well as a tandem stance with eyes open and closed by removing visual inputs using a Kistler force plate. The results of the analysis of variance showed that there is a significant difference between the control group and the corona group in the sway and the range of COP in one and three months after recovery ($p<0.05$). The average scores in the control group were lower than one month after recovery and three months after recovery. Also, three months after recovery, the average deviations, fluctuations, and range of changes in the foot pressure center were higher than in the control group. According to these results, the balance in people with corona virus approaches the condition of the control group three months after the symptoms disappear, but there are still significant differences in some variables.

**Keywords**: Balance, Covid-19, Postural deviation, Postural sway, Center of pressure

**Corresponding Author:** Mahdi Majlesi, Department of Sport Biomechanics, Faculty of Humanities, Islamic Azad University, Hamedan Branch, Hamedan, Iran. Email: majlesi11@gmail.com. Tel: +989184077540

## INTRODUCTION

COVID-19 pandemic is a disease caused by SARS-Cov-2 from the coronavirus family, which rapidly outbroke worldwide in late December 2019 due to its dramatic transmission power [1, 2]. COVID-19 can cause a range of disorders in the human body depending on the site of infection [3, 4]. The effects of this virus on human health are widespread and long-lasting and cause damage to various systems, including the respiratory system [5], gastrointestinal tract [6], kidneys and central nervous system [7]. Peripheral and central nervous system disorders may occur in this disease [4] due to direct invasion of nerve tissues by inflammatory reactions [8], which may reach central nerves and cause inflammation and demyelination [9]. Neurological problems can be observed during active disease and after recovery from infection [10].

Balance on double legs results from coordination between the sensory-motor systems and the neural processor center, including the body motion control system [11]. Balance is a complex motor skill, which describes the postural dynamics of the body in preventing falls [12]. COP deviations are often determined in postural control assessments because they indicate the location of the ground reaction force in response to the body's action to maintain balance [13]. Static balance is the ability to maintain postural sway [14]. The motor system maintains balance through voluntary and postural automatic reactions, including motor strategies using pressure. Optional reactions are essential in the case of requiring to react quickly, appropriately maintain balance, and avoid falling in the face of a post-threat or challenge.

Negarestani et al. (2021) showed disorders in the static and dynamic balance and sense of knee joint status of women with COVID-19 [15]. Jafarnezhadgero and Hoseinpour (2021) compared the balance and strength of lower limb muscles between two groups of healthy and COVID-19. The results showed that the balance of Individuals with COVID-19 was significantly lower than the healthy group. In addition, the strength of lower limb muscles in patients with COVID-19 was not significantly different from healthy individuals [16]. Studies have shown the effect of COVID-19 on the central nervous system and musculoskeletal system, which may also affect the function of the proprioceptive system [17, 18]. Dizziness is one of the main problems observed in approximately one-third of patients with COVID-19 [19], and the imbalance may be due to the involvement of the vestibular and visual systems [20]. In a study, Quentin et al. (2021) examined vestibular neuritis as a clinical observation in patients with COVID-19. The results showed that vestibular system defects occur in patients with COVID-19 [21]. Therefore, disturbances in these systems may affect the balance.

In this study, young people were assessed, because at this ages the factors affecting balance are more limited than older adults. Therefore, probably the observed balance changes can be attributed to Corona. Decreased balance due to this disease can increase the risk of injury and falls in Individuals. Imbalance treatment costs can be reduced by exercising on time because balance and a sense of situation are essential in carrying out daily activities and having a good life, which reduces the risks and injuries caused by the complications of the disease with the timely diagnosis of those complications. This study assumed that COVID-19 could affect the static balance of individuals and, therefore, aimed to compare the static balance of individuals one and three months after recovery from COVID-19 with healthy ones.

## MATERIAL AND METHODS

### Participants

This cross-sectional and descriptive study was conducted in a sports biomechanics laboratory on all volunteers with a history of COVID-19 and healthy individuals aged 20 to 40 in Hamedan, Iran in, 2021. The inclusion criteria were PCR test that showed all of them have a delta coronavirus, no hospitalization history, no amputation or neurological and orthopedic disorders caused by other diseases, no limb abnormalities, and no history of lower limb surgery. Visual and auditory disorders, neurological diseases such as stroke and brain and musculoskeletal injuries affecting balance were among the exclusion criteria. A total of 60 patients (30 male and 30 female) were considered in the patient group and 30 healthy peers (15 male and 15 female) as the control group to determine the research samples with G* Power software with α = 0.05 and statistical power of 80% [22]. Subjects completed a consent form to participate in the test. Then, the steps of performing the tests and measuring the variables and the working method were fully explained to the subjects. The protocol of this study was approved by the Islamic Azad university medical ethics committee with the number IR.SSRI.REC.1401.1449.

## Procedure

The static balance of the subjects was evaluated using force plate 9286 BA, manufactured by Kistler (Kistler Instrument AG, Winterthur, Switzerland) with a frequency of 1000 Hz. The data collection on COP movements began after the individual was prepared on the force plate. The parameters of deviations of COP, COP sway and range of COP displacement were at two levels of medio-lateral (ML) and anterior-posterior (AP). Eight task were conducted, which included: 1) Standing with feet together and eyes-open (FGO). 2) Standing with feet together and eyes-closed (FGC). 3) Standing on the dominant leg with eyes-open (ODO). 4) Standing on the dominant leg with eyes-closed (ODC). 5) Standing on the non-dominant leg with eyes-open (ONO). 6) Standing on the non-dominant leg with eyes-closed (ONC). 7) Tandem standing with eyes-open (TOE) and 8) Tandem standing with eyes-closed (TCE) [23]. All tests were performed barefoot, and the hand was on the waist in all tests. In the open eye, the person looked at point as high as the subject on the wall at a distance of 1.5 meters at eyes level. In the single-leg test, the position of the non-dependent leg was 90 degrees flexion of the knee. In the tandem test, the toe of one leg was placed along the other leg's heel, and the dominant leg was placed behind the other leg [24]. In this study, each balance task was repeated three times, in which the individual was examined on a force plate for 20 seconds. The order of assignments for each participant was random [25]. Bioware software (Kistler Instrument AG, Winterthur, Switzerland) version 3.5.2 was used in this study for data analysis. The data were also filtered by a fourth-order Butterworth filter with a 20 Hz cut-off frequency [26].

## Data analysis

Kolmogorov-Smirnov test was used to check the normality of the data and the possibility of using parametric tests. One-way analysis of variance (ANOVA) was utilized for between group comparison, and post-hoc test was tukey. Statistical analysis of data was performed using SPSS software version 21 with a significance level of $p < 0.05$.

## RESULTS

Table 1 presents the mean and standard deviation of participants' demographic characteristics. The Independent T-test showed differences in these variables haven't significant.

**Table 1. Demographic characteristics of subjects (mean and standard deviation)**

| Variable | Patient group | Control group | Sig. |
|---|---|---|---|
| **Age (years)** | 23.90 ± 3.70 | 22.60 ± 3.43 | 0.23 |
| **Weight (kg)** | 71.09 ± 2.60 | 69.10 ± 2.99 | 0.32 |
| **Height (cm)** | 169.00 ± 3.59 | 173.60 ± 3.20 | 0.16 |
| **Body mass index (kg/m$^2$)** | 23.07 ± 1.10 | 27.20 ± 2.34 | 0.44 |

### Postural Deviations

The results of the between group comparison indicated that COP deviations had a significant difference in LCE task in the direction of ML (F=3.43, p=0.037, Eta=0.07), LOE in the direction of AP (F=3.49, p=0.035, Eta=0.07) and RCE in ML direction (F=3.10, p=0.05, Eta=0.06). The paired comparison results of Table 2 showed that postural deviations of LCE and RCE tasks decreased significantly in the third month after recovery compared to the first month. Moreover, the LOE task in the control group was significantly lower than in the first month in patients.

**Table 2. Comparison of COP deviations in different tasks in research groups**

| Variable | Patient group | | Control group | P1 | P2 | P3 |
|---|---|---|---|---|---|---|
| | First month | Third month | | | | |
| FGC.AP | 2.50 ± 1.92 | 3.64 ± 6.97 | 2.37 ± 1.88 | 0.92 | 1.00 | 0.77 |
| FGC.ML | 1.29 ± 1.11 | 1.49 ± 0.95 | 1.36 ± 1.24 | 1.00 | 1.00 | 1.00 |
| FGO.AP | 2.66 ± 1.92 | 2.88 ± 2.11 | 2.97 ± 1.88 | 1.00 | 1.00 | 1.00 |
| FGO.ML | 2.08 ± 1.82 | 2.01 ± 2.29 | 1.35 ± 0.91 | 0.44 | 0.33 | 1.00 |
| ODC.AP | 2.06 ± 2.04 | 3.11 ± 1.72 | 2.17 ± 1.29 | 0.77 | 1.00 | 0.11 |
| ODC.ML | 7.81 ± 4.46 | 5.49 ± 3.14 | 6.13 ± 2.79 | 0.03* | 0.21 | 1.00 |
| ODO.AP | 3.05 ± 2.02 | 2.88 ± 1.52 | 1.94 ± 1.65 | 1.00 | 0.04* | 0.12 |
| ODO.ML | 7.60 ± 3.68 | 6.04 ± 2.40 | 7.12 ± 2.11 | 0.10 | 1.00 | 0.41 |
| ONC.AP | 3.02 ± 1.91 | 2.51 ± 2.42 | 1.91 ± 1.31 | 0.92 | 0.08 | 0.70 |
| ONC.ML | 3.75 ± 3.84 | 5.53 ± 3.57 | 6.30 ± 3.06 | 0.04* | 0.34 | 1.00 |
| ONO.AP | 2.47 ±1.80 | 2.96 ± 2.20 | 2.22 ± 1.81 | 1.00 | 1.00 | 0.43 |
| ONO.ML | 8.27 ± 3.33 | 8.66 ± 5.71 | 7.00 ± 3.14 | 1.00 | 0.74 | 0.40 |
| TCE.AP | 6.48 ± 3.21 | 6.43 ± 3.20 | 6.87 ± 3.24 | 1.00 | 1.00 | 1.00 |
| TCE.ML | 2.63 ± 1.91 | 2.65 ± 2.48 | 3.21 ± 2.57 | 1.00 | 1.00 | 1.00 |
| TOE.AP | 7.01 ± 3.89 | 8.09 ± 3.44 | 7.43 ± 3.12 | 0.71 | 1.00 | 1.00 |
| TOE.ML | 2.38 ± 1.77 | 3.68 ± 2.16 | 2.78 ± 2.92 | 0.10 | 1.00 | 0.42 |

Note: AP: Anterior-posterior direction, ML: medio-lateral direction, DCE: double leg with closed eyes, DOE: double leg with open eyes, LCE: left leg with closed eyes, LOE: left leg with open eyes, RCE: right leg with closed eyes, ROE: right leg with open eyes, TCE: tandem with closed eyes, TOE: tandem with open eyes, p1: Inter-group comparison of patients one and three months after recovery, p2: between group comparison of patients one month after recovery and control group, p3: between group comparison of patients three months after recovery and control group.

### Postural sway

The results of the between group comparison showed that the amount of COP sway in all cases was significant except DCE in the direction of ML, DOE in the direction of AP, and TOE in both directions of AP and ML. The paired comparison in Table 3 revealed that postural sway in all tasks in the first month were more than in the third month and the control group.

### Range of COP displacement

The results of between group comparison showed that the range of COP displacement has a significant difference in DCE in AP direction (F = 4.33, p = 0.016, Eta = 0.09), LCE in AP direction (F = 7.75, p = 0.01, 75 Eta = 0.15), LCE in ML direction (F = 6.00, p = 0.04, Eta = 0.12), RCE in AP direction (F = 9.51, p = 0.00, Eta = 0.18) and in the ML direction (F = 8.38, p = 0.00, Eta = 0.16), ROE in the two directions AP (F = 7.02, p = 0.01, Eta = 0.14 ) And ML (F = 11.53, p = 0.00, Eta = 0.21), TCE in two directions: AP (F = 4.51, p = 0.14, Eta = 0.09) and ML (F = 7.25, p = 0.01, Eta = 0.14). According to table 4, the paired comparison represents that Individuals with COVID-19 had a more significant range of COP displacement in the first month of infection than in the third month, as well as in the control group.

**Table 3. Comparison of COP sway in different tasks in research groups**

| Variable | Patient group | | Control group | P1 | P2 | P3 |
|---|---|---|---|---|---|---|
| | First month | Third month | | | | |
| DCE.AP | 0.85 ± 0.46 | 0.38 ± 0.66 | 0.56 ± 0.23 | 0.14 | 0.01* | 0.56 |
| DCE.ML | 0.66 ± 0.53 | 0.59 ± 0.61 | 0.51 ± 0.54 | 0.90 | 0.57 | 0.83 |
| DOE.AP | 0.69 ± 0.38 | 0.76 ± 0.52 | 0.51 ± 0.36 | 0.79 | 0.27 | 0.07 |
| DOE.ML | 0.79 ± 0.56 | 0.69 ± 0.45 | 0.34 ± 0.23 | 0.85 | 0.04* | 0.15 |
| LCE.AP | 2.18 ± 0.70 | 1.91 ± 0.77 | 1.40 ± 0.87 | 0.39 | 0.00* | 0.03* |
| LCE.ML | 1.99 ± 1.13 | 2.11 ± 1.48 | 1.17 ± 1.03 | 0.92 | 0.03* | 0.01* |
| LOE.AP | 1.29 ± 0.80 | 1.07 ± 0.68 | 0.72 ± 0.23 | 0.37 | 0.00* | 0.08 |
| LOE.ML | 1.06 ± 0.59 | 0.88 ± 0.67 | 0.59 ± 0.14 | 0.38 | 0.00* | 0.09 |
| RCE.AP | 2.15 ± 0.79 | 2.01 ± 0.73 | 1.36 ± 0.73 | 0.76 | 0.00* | 0.00* |
| RCE.ML | 2.20 ± 1.43 | 2.33 ± 1.75 | 1.09 ± 0.67 | 0.92 | 0.00* | 0.00* |
| ROE.AP | 1.34 ± 0.87 | 0.85 ± 0.42 | 0.76 ± 0.31 | 0.00* | 0.00* | 0.81 |
| ROE.ML | 1.19 ± 0.63 | 0.72 ± 0.33 | 0.63 ± 0.20 | 0.00* | 0.00* | 0.71 |
| TCE.AP | 1.74 ± 1.40 | 1.33 ± 0.72 | 0.79 ± 0.40 | 0.21 | 0.00* | 0.07 |
| TCE.ML | 1.27 ± 0.45 | 1.21 ± 0.47 | 0.91 ± 0.44 | 0.89 | 0.00* | 0.03* |
| TOE.AP | 0.97 ± 0.61 | 1.04 ± 0.82 | 0.86 ± 0.60 | 0.90 | 0.80 | 0.54 |
| TOE.ML | 0.65 ± 0.26 | 0.70 ± 0.50 | 0.51 ± 0.20 | 0.83 | 0.25 | 0.08 |

Note: AP: Anterior-posterior direction, ML: medio-lateral direction, DCE: double leg with closed eyes, DOE: double leg with open eyes, LCE: left leg with closed eyes, LOE: left leg with open eyes, RCE: right leg with closed eyes, ROE: right leg with open eyes, TCE: tandem with closed eyes, TOE: tandem with open eyes, p1: Inter-group comparison of patients one and three months after recovery, p2: between group comparison of patients one month after recovery and control group, p3: between group comparison of patients three months after recovery and control group.

**Table 4. Comparison of range of COP displacement in different tasks in research groups**

| Variable | Patient group | | Control group | P1 | P2 | P3 |
|---|---|---|---|---|---|---|
| | First month | Third month | | | | |
| DCE.AP | 2.56 ± 4.45 | 3.56 ± 1.74 | 2.99 ± 1.25 | 0.18 | 0.01* | 0.49 |
| DCE.ML | 4.69 ± 5.01 | 4.98 ± 5.49 | 3.56 ± 4.76 | 0.97 | 0.66 | 0.53 |
| DOE.AP | 3.29 ± 1.43 | 3.72 ± 2.09 | 2.78 ± 2.23 | 0.68 | 0.55 | 0.15 |
| DOE.ML | 4.90 ± 6.67 | 5.35 ± 6.50 | 2.46 ± 2.60 | 0.94 | 0.21 | 0.11 |
| LCE.AP | 13.55 ± 4.34 | 11.74 ± 5.07 | 8.48 ± 5.65 | 0.35 | 0.00* | 0.03* |
| LCE.ML | 9.66 ± 5.32 | 11.47 ± 6.73 | 6.16 ± 5.95 | 0.47 | 0.07 | 0.03* |
| LOE.AP | 7.02 ± 4.03 | 22.08 ± 89.52 | 3.82 ± 1.51 | 0.50 | 0.96 | 0.36 |
| LOE.ML | 5.60 ± 3.57 | 12.21 ± 43.81 | 2.98 ± 0.59 | 0.57 | 0.91 | 0.34 |
| RCE.AP | 12.87 ± 4.94 | 13.33 ± 4.75 | 8.31 ± 5.06 | 0.92 | 0.00* | 0.00* |
| RCE.ML | 11.52 ± 7.30 | 10.58 ± 7.03 | 5.46 ± 3.35 | 0.82 | 0.00* | 0.00* |
| ROE.AP | 7.90 ± 4.96 | 5.01 ± 3.62 | 4.41 ± 2.61 | 0.01* | 0.00* | 0.81 |
| ROE.ML | 6.74 ± 4.21 | 3.78 ± 2.00 | 3.49 ± 1.84 | 0.00* | 0.00* | 0.92 |
| TCE.AP | 10.96 ± 7.74 | 9.51 ± 5.44 | 5.45 ± 3.41 | 0.59 | 0.00* | 0.02* |
| TCE.ML | 6.24 ± 2.93 | 6.47 ± 3.27 | 4.49 ± 2.00 | 0.94 | 0.04* | 0.02* |
| TOE.AP | 5.66 ± 3.45 | 6.92 ± 6.29 | 5.41 ± 6.17 | 0.64 | 0.98 | 0.53 |
| TOE.ML | 3.39 ± 1.15 | 3.81 ± 2.86 | 3.18 ± 1.77 | 0.70 | 0.91 | 0.41 |

**Note**: AP: Anterior-posterior direction, ML: medio-lateral direction, DCE: double leg with closed eyes, DOE: double leg with open eyes, LCE: left leg with closed eyes, LOE: left leg with open eyes, RCE: right leg with closed eyes, ROE: right leg with open eyes, TCE: tandem with closed eyes, TOE: tandem with open eyes, p1: Inter-group comparison of patients one and three months after recovery, p2: between group comparison of patients one month after recovery and control group, p3: between group comparison of patients three months after recovery and control group.

## DISCUSSION

The purpose of this study was to compare the static balance in Individuals affected by COVID-19 one and three months after recovery and healthy ones. The results indicated that the balance variables in the first month after infection were higher than the third month and the control group in most tasks. The postural deviation in some tasks in the third month after the disease was higher than in the first month, but no significant difference was observed between groups despite the smaller postural deviations in the control group. According to these results, COVID-19 has little effect on the postural deviation of patients. The effects of this disease indicate the presence of musculoskeletal pain in patients with COVID-19 compared with healthy individuals [27]. Muscle pain in this disease is general and bilateral and has little effect on the postural deviation in the vertical direction.

Despite the decrease in postural sway in the third month after COVID-19 compared to the first month, the difference is insignificant in most tasks. The amount of COP sway in the patient and control groups in the first month indicates a significant difference in most tasks. In the third month, the amount of this difference was insignificant in some tasks. Therefore, COP sway with the control group still shows a significant difference despite the decrease in postural sway in the third month after COVID-19. Consistent with the results of this study, Lee et al. [28] showed a significant difference between static and dynamic balance variables and quality of life in healthy Individuals and those with COVID-19. Some studies have reported the effect of COVID-19 on the vestibular system [29, 30]. In Individuals with COVID-19, the virus invades the inner ear directly and causes involvement of the central vestibular system and its connections, hypoxia, vascular changes such as vasculitis, and coagulation events [31, 32]. Specific utricle and saccule disorder may cause symptoms such as tingling, wavering, and feeling of falling in individuals with COVID-19 [33]. Evaluation of neurological observations in patients with COVID-19 showed that the balance in these patients is reduced [34]. Therefore, one of the reasons for the decrease in balance in these patients may be due to the decrease in vestibular system function, which increases postural sway. Postural sway is more sensitive to the function of the sensory systems [24], and weakness in the vestibular system may cause dizziness [32] and ultimately impair postural control. Imbalance is possible with the onset of the disease due to decreased efficiency of the visual, vestibular, and proprioceptive systems and increases the likelihood of falling [35, 36].

The results showed a significant difference between the patient and control groups regarding the range of COP displacement. The highest difference was observed between the control group and patients in the first month after the disease. The range of COP displacement decreased in the third month. However, there was a significant difference in some tasks, especially more difficult tasks in which the base of support or vision was manipulated. Muscle weakness due to hospitalization, and fast twitch muscle fibers earlier under the influence of disease complications, can increase the range of COP displacement and COP sway in these individuals [37]. Weakness and loss of muscle strength, changes in posture settings, decreased voluntary movement, mechanical changes, visual and vestibular disorders, proprioceptive system, pain, and psychological consequences can affect the range of motion and displacement of the COP in patients with COVID-19 [37, 38]. According to the results obtained in this research, it is suggested to include strength and balance interventions in the rehabilitation programs of people after recovering from Covid-19.

## CONCLUSION

This study compared the static balance in patients with COVID-19 one and three months after recovery and healthy ones. According to the results, the postural deviations from the vertical direction are less affected by the disease. However, the postural sway and range of COP displacement significantly differed from the control group and one and three months after recovery in patients. Thus, the static balance did not return to normal even three months after recovery, which may lead to falls and even permanent disability or death from falls. Rehabilitation and occupational therapy should be considered, especially in patients who have been hospitalized for a long time.

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**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** Data will be available at request.

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# ارزیابی تعادل ایستا افراد پس از بهبودی بیماری کووید-۱۹ و مقایسه آن با افراد سالم

فرشته مهرجو[۱]، مهدی مجلسی*[۲]

۱.گروه تربیت‌بدنی، دانشکده تربیت‌بدنی و علوم ورزشی، موسسه آموزش عالی عمران و توسعه (غیرانتفاعی- غیردولتی)، همدان، ایران.

۲.گروه بیومکانیک ورزشی، دانشکده علوم انسانی، دانشگاه آزاد اسلامی واحد همدان، همدان، ایران.

**چکیده:**

با توجه به اثرات کرونا ویروس (کووید-۱۹) بر سیستم عصبی مرکزی و اختلالات عصبی ناشی از این ویروس و تاثیر سیستم عصبی مرکزی بر تعادل، لذا هدف از انجام این پژوهش مقایسه تعادل ایستا افراد بین افراد مبتلا به کرونا ویروس (کووید-۱۹) و سالم می‌باشد. پژوهش حاضر توصیفی و از نوع مقایسه‌ای است. نمونه آماری این پژوهش شامل ۶۰ فرد مبتلا به ویروس کرونا از شهر همدان بود که تعادل آنها یک ماه و سه ماه پس از بهبودی ارزیابی شد (گروه تجربی) و همچنین ۳۰ فرد سالم به عنوان گروه کنترل انتخاب شدند. شاخص‌های تعادل (قدامی- خلفی و داخلی- خارجی) در چهار وضعیت ایستاده (با دو پا، با یک پا، با چشم باز و بسته) و تندم با چشم باز و بسته با استفاده از تخته نیرو (kistler) بررسی شدند. نتایج تحلیل واریانس نشان داد که در نوسانات و دامنه‌ی تغییرات مرکز فشار پا تفاوت معنی‌داری بین گروه کنترل و گروه کرونا در آزمون یک و سه ماه بعد از بهبودی وجود دارد ($p<۰/۰۵$). میانگین نمرات در گروه کنترل نسبت به یک‌ماه پس از بهبودی و سه ماه پس از بهبودی، کمتر بود. هم‌چنین سه ماه پس از بهبودی میانگین انحرافات، نوسانات و دامنه‌ی تغییرات مرکز فشار پا نسبت به گروه کنترل بیشتر بود. با توجه به این نتایج، تعادل در افراد مبتلا به کرونا، سه ماه بعد از رفع علائم به وضعیت گروه کنترل نزدیک می‌شود اما هنوز در برخی متغیرها اختلافات معنی‌دار است.

**واژه های کلیدی**: تعادل، کووید-۱۹، انحرافات قامت، نوسانات قامت، مرکز فشار پا