Vestibular rehabilitation in acute central vestibulopathy: A randomized controlled trial

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Abstract.
OBJECTIVE: To investigate the effects of two different rehabilitation programs in acute central vestibulopathy secondary to posterior circulation stroke.

METHOD: A prospective randomized controlled study was conducted on 25 patients with posterior circulation stroke. Patients were instructed in routine balance and mobility exercises during the acute hospitalization period. At discharge, patients were assigned to either a rehabilitation or home exercise group. The home exercise group was instructed to perform the same exercise program provided in the course of hospitalization period. The rehabilitation group was randomized into the visual feedback posturography training or vestibular rehabilitation group. The balance and gait performance were assessed with clinical and objective measurements before and after 6 weeks of training.

RESULTS: The balance and gait scores were significantly improved in both rehabilitation groups and in the home exercise group (p < 0.05), but no significant difference was found between the groups in terms of post-treatment values (p > 0.05).

CONCLUSION: The improvements of balance and gait function in rehabilitation groups did not differ from the home exercise group. Rehabilitation programs were equally effective to improve the recovery in acute central vestibulopathy.

Keywords: Acute stroke, posterior circulation, vestibular rehabilitation, balance

1. Introduction

Vestibular rehabilitation is an exercise program which aims to reduce vertigo and improving gaze stabilization, postural stabilization and functional activities. The main components are gaze stabilization exercises to retrain vestibuloocular reflex (VOR) function, balance retraining exercises as substitution exercises to retrain vestibulospinal reflex (VSR) function and habituation exercises to reduce motion induced dizziness or vertigo [19,31].

Vestibular rehabilitation is a highly accepted intervention used commonly in patients with peripheral vestibulopathy [6,9,32]. There is limited evidence about the effect of vestibular rehabilitation on the outcomes of central vestibular disorders. Due to different etiologies and differences in the neuropathology of central vestibular disorders, clinical symptoms and responses to treatment are very variable. For that reason, it is very difficult to determine the certain effects of vestibular rehabilitation with central vestibulopathy [11,18,30].

Patients with central vestibulopathy may have various symptoms, including vertigo, nausea, nystagmus, ataxia and disequilibrium. They may demonstrate visual field deficits, diplopia, impaired smooth pursuit eye movements and VOR cancellation, sensory loss and hemiparesis. Vestibular rehabilitation is the most...
efficient method when it is applied in a customized fashion. Exercises must be regulated according to the diagnosis and response of the patient. There may exist different mechanisms for the improvement with various pathologies and clinical symptoms. The components of vestibular rehabilitation for patients with central vestibulopathy are similar to designed for patients with peripheral vestibulopathy [40].

There are different studies investigating the use of vestibular rehabilitation in patients with central vestibulopathy. From the literature, it is impossible to determine if patients with acute central vestibular disorders improve after vestibular rehabilitation. Gill-Body et al. reported the rehabilitation outcomes of two patients with cerebellar involvement. Patients in their study had different etiologies, durations of disease and clinical presentations of cerebellar dysfunction. The outcomes of Dizziness Handicap Inventory (DHI) and postural stability parameters improved with home based balance exercises after 6 weeks [20]. Kruger et al. reported the rehabilitation results of two persons after severe brainstem stroke. The rehabilitation program consisted of standard physiotherapy exercises, also the ambulation level of patients improved significantly [11].

Some studies demonstrated the improvements after vestibular rehabilitation in both peripheral and central vestibulopathy patients in the same group without subgroup analysis related to diagnosis. The objective postural parameters, quality of life and emotional components were affected positively by vestibular rehabilitation [2,5,14]. Also, positive effects of vestibular rehabilitation have been demonstrated in previous case studies and retrospective reviews with cerebellar dysfunction [4, 20] and traumatic brain injury [1] and with various etiologies [18,25].

The aim of this study was to investigate the outcomes of vestibular rehabilitation in patients with balance problems due to acute posterior cerebral stroke in a randomized trial. In this study, we also planned to explore the effect of visual feedback posturography training, which is also used for stroke survivors [28–30].

2. Methods

Twenty-five patients who had complaints of imbalance secondary to posterior circulation stroke were enrolled in the study. The basilar artery, posterior inferior cerebellar artery and superior cerebellar artery were involved. There were 18 females and 7 males. The diagnosis of stroke was defined as an acute event of cerebrovascular origin, diagnosed by a neurologist and confirmed by magnetic resonance imaging. All patients were treated by antiaggregant drugs during hospitalization. The inclusion criteria were having a posterior circulation stroke originated from a cerebellum or brainstem without history of an ischaemic or hemorrhagic infarct and neuromusculoskeletal, cardiovascular disease or polyneuropathy which could prevent participation in the rehabilitation program. The patients who had pretreatment score below 45/56 on the Berg Balance Scale (BBS) were included the study, defined as the risk of “independent safe ambulation” [16,17]. BBS accepted as an assessment parameter to activity component of ICF category.

All patients were instructed in an acute inpatient rehabilitation program with the routine balance and mobility exercises until discharge from the hospital. At discharge, patients were randomized to either a rehabilitation or control [home exercise] group by using a random number table. Then, the rehabilitation group were randomized by sealed envelopes into the visual feedback posturography training or the vestibular rehabilitation group (Fig. 1).

The same person (author BDB) performed the initial and final assessments and the exercise programs. This prospective randomized controlled trial was approved by the ethical committee of Dokuz Eylul University. All patients gave their written signed informed consent.

2.1. Outcome measurements

The patients were assessed with clinical and objective balance measures. The clinical balance measures were the Berg Balance Scale, the Timed “Up and Go” test, the Dynamic Gait Index and the Dizziness Handicap Inventory.

The Berg Balance Scale (BBS) has been used to evaluate static-dynamic balance impairment and the performance of functional tasks. BBS is a 14-item scale with each item scored on a scale from 0 to 4; the maximum is 56 points. Test items are representative of daily activities that require balance, such as sitting, standing, leaning over and stepping. A score of 45 or less indicates a greater risk of falls in older adults [16,17].

The Timed “Up and Go” (TUG) test measures the time taken by an individual to stand up from a standard armchair (approximate seat height of 46 cm, arm
Assessed for eligibility related to BBS score (<45 points) (n=25)

Enrollment:
acute inpatient rehabilitation (basic balance exercises)

Randomization by random number table (n=25)

Rehabilitation group (n=12)
Randomized by sealed envelopes
Allocated to VFPT group (n=6)
Received intervention (n=6)
Did not receive intervention (n=0)

Home exercise group (n=13)
Allocated to Vestibular Rehabilitation group (n=6)
Received intervention (n=6)
Did not receive intervention (n=0)

Allocated to Home Exercise group (n=13)
Received intervention (n=13)
Did not receive intervention (n=0)

Treatment for 6 weeks
Reassessed after treatment (n=6)

Treatment for 6 weeks
Reassessed after treatment (n=6)

Treatment for 6 weeks
Reassessed after treatment (n=13)

Fig. 1. Flow diagram of the study. *BBS: Berg Balance Scale; *VFPT: Visual Feedback Posturography Training.

height 65 cm), walk a distance of 3 meters, turn, walk back to the chair and sit down [36].

The Dynamic Gait Index (DGI) has been used to assess gait instability and to indicate risk of falling. The examiner rates performance from 0 (poor) to 3 (excellent) on 8 gait tasks. Higher scores indicate better performance, with a maximal score of 24 [3,39].

The Dizziness Handicap Inventory (DHI) was designed to assess the self-perceived level of handicap associated with the symptom of dizziness. DHI has 25 items. A “yes” response to an item is awarded 4 points, a “sometimes” 2 points, and a “no” 0 points. Possible scores range are 0–100 with higher scores indicating increased handicap [10,13].

Additional balance measurements were obtained using the Balance Master System (NeuroCom System Version 8.1 Balance Master). Postural stability was assessed by the modified Clinical Test of Sensory Interaction on Balance (mCTSIB), quantified postural sway velocity of four different sensory conditions: (1) standing with eyes open (EO) on a firm surface, (2) standing with eyes closed (EC) on a firm surface, (3) standing with EO on a foam surface, (4) standing with EC on a foam surface. Patients were instructed to stand upright as steady as possible between the defined lines of a platform. The system analyzed the patient’s functional balance control to quantify postural sway velocity under these conditions. Center of gravity (COG) sway velocity was calculated as a ratio of distance travelled by the COG (in degrees) to the time of the trial. Sway velocities in all described conditions above and composite sway velocity, which was the mean sway velocity averaged over the twelve trials (EO, EC, firm and foam) were analysed. Center of Gravity (COG) alignment reflects the patient’s COG position relative to the center of the base of support at the start of each trial of the mCTSIB.

The clinical and objective balance impairments were measured in all of the patients at baseline (entry into the treatment programs) and after completing the balance program (after 6 weeks).
2.2. Treatment protocols

The rehabilitation group consisted of two programs as vestibular rehabilitation and visual feedback posturography training.

The vestibular rehabilitation (VR) program consisted of two major components: Vestibular adaptation and specific balance exercises under the supervision of a physiotherapist. There were six patients in the vestibular rehabilitation group. Each patient was given a written home program. Patients were instructed to do their exercises 2–3 times per day for 6 weeks. It took 20–30 minutes per day for patient. The program was reviewed weekly by the physiotherapist and/or by telephone interviews. Exercises included eye-head coordination exercises, balance and ambulation exercises.

Eye-head coordination exercises included VORx1, VORx2, VOR cancellation, smooth pursuits and saccades [31]. The exercises progressed under more challenging conditions (from sitting to standing with feet apart to feet together and walking).

Balance exercises were performed in two conditions: (1) Exercises in sitting position; the patients tried to maintain balance, while sitting upright, rotating of trunk to right and left, and weight shifting side to side. (2) Exercises in standing position were designed as follows: the patients were instructed to stand with feet in place while weight shifting to improve balance strategies forward-backward and side to side, to stand on one leg, to rise from chair and then sit again to the chair (sit to stand exercise) and to march in place. Ambulation exercises consisted of walking forward-backward and side to side. The surface was modified from stable to foam and uneven levels for balance and ambulation exercises. The difficulty of exercises were challenged by standing on different bases of support and on uneven surfaces (40×40×15 cm, medium density foam), and by having their eyes closed during standing and walking exercises. The base of support was modified from feet apart to feet together and tandem stance. These graded tasks require enhanced use of visual, proprioceptive and residual vestibular inputs to stimulate compensation [22,31].

The visual feedback posturography training (VFPT) group consisted of six patients and the patients exercised 3 times per week, for 25–30 minutes during the 6 weeks under the supervision of the physiotherapist. The Balance Master System was used as rehabilitation equipment. The system consists of 2 forceplates and provided continuous visual feedback of the position of the center of gravity in relation to the theoretical limits of stability during exercise. Patients had to maintain postural stability on a stable/unstable surface. The end-point excursion and type of supporting surface (firm/foam) were modified in several of the performed exercises. The exercises were grouped into three categories. The targets were set at positions approximating 30% of the Limits of Stability (LOS); then, the targets were removed from the initial position. The training protocols were individualized and progressed by increasing the LOS and the speed to challenge the patient’s weight-shifting abilities within their balance capacity throughout the study. The goals of the treatment were to teach control of the center of pressure during dynamic weight shifting, leaning plus stepping tasks with different bases of support with higher spatial and temporal demands (larger distances, different movement directions and faster speeds) [37].

The control group received usual inpatient exercises which were instructed to perform the same exercise program given during the hospitalization period. The control group consisted of 13 patients. The patients were given written instructions with diagrams as home exercises. The patients had to perform basic balance and mobility exercises for 6 weeks. The exercises were focused on postural control with strengthening of pelvic stabilisation muscles and improvement of balance and gait ability. The exercise program consisted of weight shifting to right and left when sitting on the bed, sit to stand activity, weight shifting in standing with hip abduction and extension, gait training such as marching in place, forward and backward walking with a progressively narrowing base of support. Gait exercises as marching in place, walking forward-backward and side to side, gait with normal and narrowed base of support were instructed to do with eyes open only. The exercises with eyes closed condition were not given to control patients in order not to activate therapeutic effect of VOR. The home exercise program was therefore different from that of the vestibular rehabilitation group.

The program consisted of 4 categories: exercises in lying, sitting and standing position and ambulation exercises. The patients were instructed to perform the exercises 8–10 times daily during hospitalization period. The patients are monitored by the physiotherapist and the exercises are graded in difficulty based on progression of body positioning from lying to sitting, standing and walking, narrowing the base of support, and changing the surface from firm to soft. It took 20–30 minutes per day for patient. The exercises are designed to improve the organization of sensory informa-
Table 1
The characteristics of the patients

<table>
<thead>
<tr>
<th>Criterion</th>
<th>VFPT group value</th>
<th>VR group value</th>
<th>HE group value</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>58.0 (54.8–70.3)</td>
<td>56.0 (52.0–76.0)</td>
<td>64.0 (56.5–73.0)</td>
<td>0.58</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>26.6 (24.7–28.1)</td>
<td>30.7 (26.3–36.1)</td>
<td>28.5 (27.1–29.8)</td>
<td>0.11</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.7 (1.63–1.77)</td>
<td>1.69 (1.5–1.7)</td>
<td>1.68 (1.6–1.7)</td>
<td>0.96</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>77.0 (72.0–82.5)</td>
<td>84.5 (75.0–91.3)</td>
<td>80.0 (75.5–83.5)</td>
<td>0.32</td>
</tr>
<tr>
<td>Length of stay in hospital (day)</td>
<td>8.5 (6.8–10.5)</td>
<td>6.5 (5.0–10.0)</td>
<td>9.0 (6.5–11.0)</td>
<td>0.31</td>
</tr>
</tbody>
</table>

*Data is given as “Value = Median IQR 50% (25%–75%)”; VFPT: Visual Feedback Posturography Training; VR: Vestibular Rehabilitation; HE: Home Exercise; BMI: Body Mass Index.

Table 2
The outcomes for the Berg Balance Scale (BBS), Timed up and go test (TUG), Dizziness Handicap Inventory (DHI), Dynamic Gait Index (DGI) of the rehabilitation group and home exercise group

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Rehabilitation group value</th>
<th>HE group value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>BBS</td>
<td>17.5 (9.8–37.5)</td>
<td>48.0 (40.3–52.8)</td>
</tr>
<tr>
<td>TUG</td>
<td>17.3 (12.6–21.3)</td>
<td>10.1 (8.1–11.1)</td>
</tr>
<tr>
<td>DHI</td>
<td>71.0 (63.0–89.0)</td>
<td>11.0 (4.5–25.5)</td>
</tr>
<tr>
<td>DGI</td>
<td>1.0 (0.3–3.5)</td>
<td>16.0 (9.5–21.3)</td>
</tr>
</tbody>
</table>

*Data is given as “Value = Median IQR 50% (25%–75%)”, **p < 0.05; VFPT: Visual Feedback Posturography Training, VR: Vestibular Rehabilitation, HE: Home Exercise; Δ = (posttreatment score-pre-treatment score).

A brief description of exercise categories is included as below:

a) Exercises in lying position consisted of pelvic elevation and pelvic rotation to improve weight shifting, to control of motion in pelvis, hip and knee. These exercises help to reduce stiffness and useful rolling over and moving in bed [27,38].

b) Exercises in sitting position consisted of weight shifting forward-backward and side to side to reduce stiffness in the trunk and promote the body rotation for walking, of bending forward and reaching with the hands toward the outside of foot, while rotating the trunk and then the patient moves the body upright, repeats the exercise to other side. Then the patient instructed to rotate the trunk side to side, while the fingers interlaced and reached forward with the hands. Later on, the patient should rise from sitting position to standing, then returning to sitting.

c) Balance exercises in standing position consisted of extending the leg while the patient stands with feet in place and shifts the weight onto one leg. The patient repeats this exercise 8–10 times, with alternating lifts. The exercise stimulates proper weight shift while strengthening hip and pelvis muscles. Later, the patient marches in place.

d) Ambulation exercises were instructed to walk forward-backward and side by side [21].

The control group consisted of 10 females and 3 male patients; the rehabilitation groups (visual feedback posturography training and vestibular rehabilitation group) consisted of 8 female and 4 male patients. The characteristic profiles of the patients are given in Table 1.

2.3. Statistical analysis

Non parametric statistics were used to compare the assessment characteristics of the groups. Change scores for all balance and gait outcome measures were computed by subtracting posttreatment from pretreatment scores. Change scores were then compared between the groups using the Mann-Whitney U test and Kruskal-Wallis variance analysis. The Mann-Whitney U test was used to compare differences between pre- and post-treatment balance parameters of the groups. The outcome differences between the 3 groups were assessed by the Kruskal-Wallis variance analysis. The Chi-square test was used to evaluate the distributions of the categorical variables.

The statistical method was selected as mean interquartile range because of the small sample size. Medians are often regarded as a more appropriate measure of location than the mean when variables have a highly skewed distribution.

All statistical tests were performed at a 0.05 significance level using the Statistical Package for Social Sciences (SPSS, version 15.0).
3. Results

The mean age of the rehabilitation group was 61.0 ± 10.1 years and 65.6 ± 9.3 years for the control group. There were no significant differences between the two groups in age.

There were also no differences between the three groups in height, weight, body mass index, length of stay in hospital (p < 0.05).

Ten patients had infarcts in the pons, 8 in the bulbus, 7 in the cerebellum. In visual feedback posturography training (VFPT) group, 2 patients had infarcts in the pons, 3 in the bulbus, 1 in the cerebellum (vermis). In the vestibular rehabilitation group, 4 patients had infarcts in the pons, 1 in the bulbus, 1 in the cerebellum (vermis). In the control group, 4 patients had infarcts in the pons, 4 in the bulbus, 5 in the cerebellum (vermis).

The physiotherapy outcome values of the BBS, the TUG test, the DGI, and the DHI are shown in Tables 2 and 3.

The BBS scores were improved in VFPT group, vestibular rehabilitation and control group significantly (Table 3) (p < 0.05). There were significant improvements in BBS scores of rehabilitation and control groups with exercise programs (Table 2) (p < 0.05). There was a marked reduction in the measure of Δ BBS scores (Δ: the difference of scores= posttreatment score- pretreatment score) for rehabilitation group (28.00) and control group (13.0), but due to the small sample size and the large variability, it was not statistically significant (Table 2). There were 8 of 12 patients in rehabilitation group, who passed the cut off point 45 in BBS after treatment. The increased number of patients was 5 of 13 in control group, who passed the cut off point 45 in BBS after treatment. The results showed that the enhancement of BBS was more in rehabilitation groups but it was not statistically significant (p = 0.069). There was no significant improvement of TUG values in VFPT group (p = 0.249) but the TUG values were improved significantly in vestibular rehabilitation (p = 0.043) and control group (p = 0.007) (Table 3). The DHI and DGI scores were improved in VFPT, vestibular rehabilitation and control group significantly after 6 weeks (Tables 2 and 3) (p < 0.05). The posttreatment scores of DHI and DGI were not statistically different between three groups (DHI p = 0.540, DGI p = 0.650). There was no significant improvement of the center of gravity (COG) sway velocity outcomes and Δ scores in three groups (Tables 4 and 5) (p > 0.05). The COG alignment values, measured by the limits of stability parameter, were statistically improved in all groups (Tables 4 and 5) (p < 0.05). There was no statistically significant difference at the post-treatment values of COG alignment between three groups (p = 0.58)

4. Discussion

In the current study, patients with posterior circulation stroke were provided with one of the three different rehabilitation programs. This is the first prospective, randomized vestibular rehabilitation study in acute central vestibulopathy due to posterior stroke. Our results demonstrated that all patients’ postural and balance outcomes were significantly improved. However there were no significant differences between the two rehabilitation groups and the home exercise group in posttreatment and delta scores. The small sample size is thought as a main reason of this result. Therefore, it is difficult to differentiate the certain effects of exercise programs.

The patients in vestibular rehabilitation program were instructed to perform vestibular exercises which are believed to achieve functional improvements via mechanisms of habituation, enhanced adaptation of VOR and VSR, and increased substitution [12,24]. Although some studies have suggested that patients benefit more when vestibular rehabilitation is started as early as possible [5,8,35], little is known about the results of early vestibular rehabilitation in peripheral and central vestibular disorders. Thus, our study was designed to enroll patients in the acute phase.

Mruzeck and Cohen studied the effects of vestibular rehabilitation in acute period. They found improvements in objective and subjective measurements after rehabilitation but there were no differences between the rehabilitation and control groups [15,23]. Cohen explained the results with central compensation which occurs immediately and the therapy has no effect on it [15]. Mruzeck and Cohen’s studies included of peripheral vestibulopathy patients but the outcomes were similar with our results.

We chose vestibular rehabilitation exercises as intentional principle for central vestibulopathies [33,34]. Also, Hain attracted attention to balance and functional retraining activities. These activities stimulate VOR and VSR function simultaneously, such as walking with head rotations, which require that the patient maintain gaze stability during a dynamic balance activity [41]. We found improvements in all outcomes with vestibular rehabilitation. The improvements could
### Table 3
The outcomes for Berg Balance Scale (BBS), Timed up and go test (TUG), Dizziness Handicap Inventory (DHI), Dynamic Gait Index (DGI) of VFPT, Vestibular Rehabilitation and home exercise group

<table>
<thead>
<tr>
<th></th>
<th>VFPT group value*</th>
<th>VR group value*</th>
<th>HE group value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>Post</td>
<td>p (pre-post)</td>
<td>∆</td>
</tr>
<tr>
<td>BBS</td>
<td>17.5 (10.0–23.5)</td>
<td>47.0 (38.0–49.3)</td>
<td>0.027**</td>
</tr>
<tr>
<td>TUG</td>
<td>17.0 (11.6–20.8)</td>
<td>9.9 (8.2–12.1)</td>
<td>0.249</td>
</tr>
<tr>
<td>DHI</td>
<td>71.0 (66.5–87.0)</td>
<td>11.0 (8.5–30.5)</td>
<td>0.025*</td>
</tr>
<tr>
<td>DGI</td>
<td>10.0 (8.8–20.0)</td>
<td>13.5 (10.0–19.3)</td>
<td>0.028**</td>
</tr>
</tbody>
</table>

* Data is given as “Value = Median IQR 50% (25%–75%)”, ** p < 0.05, VFPT: Visual Feedback Posturography Training, VR: Vestibular Rehabilitation, HE: Home Exercise; ∆ = (posttreatment score - pretreatment score).

### Table 4
The Center of Gravity (COG) outcomes of rehabilitation group and home exercise group

<table>
<thead>
<tr>
<th></th>
<th>Rehabilitation group value*</th>
<th>HE group value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>COG SV (°/sec)</td>
<td>1.2 (1.0–1.4)</td>
<td>1.2 (0.9–1.4)</td>
</tr>
<tr>
<td>COG LOS (%)</td>
<td>47.0 (26.8–62.5)</td>
<td>26.0 (24.0–42.0)</td>
</tr>
</tbody>
</table>

* Data is given as “Value = Median IQR 50% (25%–75%)”, ** p < 0.05, HE: Home Exercise; COG: Center of Gravity, SV: Sway Velocity, LOS: Limits of Stability, ∆ = (posttreatment score - pretreatment score).

### Table 5
The Center of Gravity (COG) outcomes of VFPT, Vestibular Rehabilitation and home exercise group

<table>
<thead>
<tr>
<th></th>
<th>VFPT group value*</th>
<th>VR group value*</th>
<th>HE group value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>p (pre-post)</td>
</tr>
<tr>
<td>COG SV (°/sec)</td>
<td>1.30 (1.00–1.40)</td>
<td>1.30 (0.90–1.45)</td>
<td>0.009</td>
</tr>
<tr>
<td>COG LOS (%)</td>
<td>40.5 (22.0–54.3)</td>
<td>25.5 (21.8–31.3)</td>
<td>0.046**</td>
</tr>
</tbody>
</table>

* Data is given as “Value = Median IQR 50% (25%–75%)”, ** p < 0.05, VFPT: Visual Feedback Posturography Training, HE: Home Exercise; COG: Center of Gravity, SV: Sway Velocity LOS: Limits of Stability, ∆ = (posttreatment score - pretreatment score).
be explained with central compensation mechanisms which results from active neuronal changes in the cerebellum and brainstem in response to sensory conflict produced by vestibular pathology [26].

The limited number of studies related to vestibular rehabilitation in central vestibulopathy revealed improvements in balance after rehabilitation [2,5,14,18]. Badaracco, Meli and Suarez showed improvements in postural control after vestibular rehabilitation but they did not separate central vestibulopathy patients from peripheral vestibulopathy and subgroup analyses were not completed. Cheng and Walker et al. found improvements with balance rehabilitation on the Balance Master but the studies consisted of hemispheric lesions, not brainstem and cerebellar lesions [7,28]. The VFPT by Balance Master System is the second intervention group of our study. The posturography group did not show any superiority to other groups and it suggests that an alternative therapy with lower costs is as effective as the VFPT. It is a high cost rehabilitation technique which is typically available only in research or tertiary care setting.

Geiger et al. found that weight-shifting training on a forceplate system don’t correspond to improvements in gait and other higher level of mobility and balance tasks [29]. The Δ DGI score is higher in control group than rehabilitation group in our study. In contrary to, Δ BBS was higher in rehabilitation group than control group. It is considered as VFPT improved the stance abilities, in parallel with literature [29]. The main difference of rehabilitation group from control group is the number of patients who passed the cut off point 45 in BBS, defined as the risk of “independent safe ambulation”. Eight of 12 patients in rehabilitation group and 5 of 13 patients in control group passed the cut off point in BBS. When the Δ scores of COG values were analyzed, sway velocity and LOS scores were higher in vestibular rehabilitation than VFPT and control group. The COG values were improved more in vestibular rehabilitation group, objective and subjective balance outcomes were more improved in VFPT group. There was no significant difference in scores between the groups because of the small sample size in each groups. A trend was identified according to the results; gait abilities were improved more in control group and balance abilities were improved more in VFPT and vestibular rehabilitation group.

In conclusion, all patient’s functional capacity with posterior ischaemic stroke improved after 3 different exercise programs in acute phase. The small sample size prevents to generalize the results as the effects of rehabilitation because of the limited statistical power. Studies with larger samples might have been found the differences because early rehabilitation might not make any difference. Also a well designed combination of different rehabilitation methods can improve the residual deficits after acute period.

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