## Research Article

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# ASSESSING THE EFFECTS OF VESTIBULAR REHABILITATION IN SUBJECTS WITH UNILATERAL VESTIBULAR HYPOFUNCTION

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## ABSTRACT

**Background:** Surgical and pharmacological managements have limited efficacy for unilateral vestibular hypofunction increasing the use of vestibular rehabilitation. However, literature data is limited concerning the results of vestibular rehabilitation warranting further studies.

**Aim:** The present study aimed to assess the efficacy of physiotherapy vestibular rehabilitation on fall risk and balance parameters in subjects with UVH (unilateral vestibular hypofunction).

**Methods:** The study assessed 60 subjects diagnosed with unilateral vestibular hypofunction. In all subjects, dynamic visual acuity assessment, modified clinical test for sensory interaction in Tandem and balance, visual analog scale, and number of falls were recorded pre-treatment and post-treatment. All subjects were given an individual program of 8 weeks with physiotherapy at 2-week intervals. Also, a home exercise program of 10 repetitions three times a day was given to all subjects.

**Results:** Following vestibular rehabilitation of 8 weeks, a decreased number of falls and improved balance parameters were seen in all the subjects. Eyes-closed Tandem test showed statistically significant results with p=0.001. Modified Clinical Test results for Sensory Interaction in Balance showed significant results with p=0.001. Also, significant results were seen for dynamic visual acuity scores and vestibular symptoms with p=0.001.

**Conclusions:** The present study concludes that balance parameters are significantly improved and fall risks are positively affected when physiotherapy programs are applied to the subjects having unilateral vestibular hypofunction.

**Keywords:** Balance, fall, physiotherapy, unilateral vestibular hypofunction, vestibular rehabilitation.

## INTRODUCTION

UVH or unilateral vestibular hypofunction is a clinical condition representing partial or complete loss of unilateral vestibular hypofunction. Unilateral vestibular hypofunction is among the most common causes leading to instability and head movement related dizziness. Unilateral vestibular hypofunction is responsible for nearly 14% to 20% of all the pathologies of the inner ear. The most common causes attributed to unilateral vestibular hypofunction are vestibular labyrinthitis and neuritis caused by bacterial or viral infections.[1]

The symptoms of unilateral vestibular hypofunction are largely governed by the vestibular weakness severity which is often reflected as decreased visual acuity, falling, loss of balance, and dizziness. Subjects with unilateral vestibular hypofunction usually report gait disturbances, postural instability, dizziness, and oscillopsia. These complaints significantly limit the participation and activity of the subject affected with unilateral vestibular hypofunction.[2]

The loss of balance and dizziness in subjects with unilateral vestibular hypofunction greatly impair the walking and standing activities in the affected subjects. Considering this case, an increased risk of falling while walking or during holding and an increase in the desire not to walk is seen in subjects affected with unilateral vestibular hypofunction. Recent literature data with extensive assessment of the vestibule has reported an increased risk of falling in subjects affected with vestibular dysfunction.[3]

Surgical and pharmacological management of unilateral vestibular hypofunction has been reported to result in limited improvement outcomes. Hence, there is an increased application of vestibular rehabilitation in subjects with unilateral vestibular hypofunction. This includes vestibular rehabilitation exercises that are designed to allow the facilitation of plasticity of the central nervous system by creating adaptation, habituation, and substitution mechanisms that lead to postural stability in disorders that result in conflicting sensory data and information. These exercises are primarily aimed to decrease the severity of symptoms and improve the stabilization of the gaze, balance, and postural stability. Habituation exercises have the primary aim of decreasing nausea and dizziness by repeating the symptoms and aggravating head movements.[4]

Adaptation exercises include repetitive head movements while focusing on the target and help in gaze stabilization along with improvement in compensatory saccadic eye movements. Sensory substitution exercises help in using the non-vestibular sensory systems that help in achieving the postural controls. Recent literature data reported that vestibular rehabilitation largely helps and is effective in improving balance, quality of life, and dizziness in subjects with unilateral vestibular hypofunction. The existing literature data also reports that methods of vestibular rehabilitation are reported to positively affect the quality of life and gait by reducing anxiety, depression, and dizziness in unilateral vestibular hypofunction-affected subjects.[5]

Previous studies assessing the efficacy of vestibular rehabilitation in subjects with unilateral vestibular hypofunction are scarce in the literature owing to a lack of qualified person's limited academic studies, and lesser clinical experience in the field. Hence, the present clinical study aimed to assess the efficacy of physiotherapy vestibular rehabilitation on fall risk and balance parameters in subjects with UVH (unilateral vestibular hypofunction).

## MATERIALS AND METHODS

The present prospective clinical study aimed to assess the efficacy of physiotherapy vestibular rehabilitation on fall risk and balance parameters in subjects with UVH (unilateral vestibular hypofunction). The study was done at Department of ENT, Sri Venkateswara Medical College, Tirupati, Andhra Pradesh after the clearance was given by the concerned institutional ethical committee. The study population was from subjects of the Department of ENT of the institute. Informed consent was taken from all the subjects before participation in the study.

The study included 60 subjects from both genders in the age range of 19-50 years who visited the institute with the chief complaints of loss of balance and dizziness. The inclusion criteria for the study were subjects in the age range of 18-50 years having confirmed diagnosis of unilateral vestibular hypofunction with detailed VNG (videonystagmography) vestibular examination, physical examination, and anamnesis. The exclusion criteria were subjects with coordination disorders, light touch sensory improvement, central involvement in VNG results, history of lower extremity injuries, inner ear disorders leading to imbalance including meningitis, trauma, vestibular neuritis, labyrinthitis, endolymphatic hydrops, and benign paroxysmal positional vertigo, dizziness, bilateral vestibular hypofunction, temporal bone pathologies on MRI, and cognitive dysfunction.

The first examination of study subjects was done by the otolaryngologist where they assessed the subject physically along with the evaluation of VNG recorded vestibular system. Later, the subjects were sent to the physiotherapist to assess dynamic and static visual acuity, number of falls, dizziness, and balance.

For VNG-assisted vestibular examination, a thermal caloric test was done along with gaze dynamic vestibular position tests, especially supine roll and Dix-Halpike test, tracking, saccade, and optokinetic test. Using an air-stimulated binaural thermal caloric test, a VOR (vestibulo-ocular reflex) test was done. The subject was kept in a lying position with $30^{o}$ head flexed, and 8 1 of air respectively at $50^{o}$ C and $24^{o}$C were sent to both the eardrums in 60 seconds at rest intervals of 5 minutes. Involuntary eye movements were recorded for 120-140 s and results were assessed on the graph.[6] The weakness of vestibular response was assessed with the following criteria where a value of ≥25% was considered pathological and DP (directional

preponderance) was measured with the formula: DP = ([RW + LC] - [LW + RC])/ (RW + LW + RC + LC) × 100. Average absolute values were taken at DP of below 30%.[7]

After a comprehensive initial assessment, subjects were enrolled in the rehabilitation program which comprised of the two phases. The first phase was about patient education where all subjects were provided verbal training for 30 minutes by physiotherapists where they were provided with the definition of unilateral vestibular hypofunction, prevention strategies, risk factors, and recommendations for prevention from falling. In the second phase, repetitive vestibular exercise programs were provided to all the subjects. The vestibular rehabilitation protocols were given to all subjects individually for 1 hour weekly for 8 consecutive weeks. Redundant exercise protocols comprised of 4 steps namely adaptation. Habituation, and substitution. In the first session, subjects did eye and head movements in a sitting position after fixing their eyes on an object and turned their head horizontally for 10 repetitions. Secondly, the first exercise was repeated with heads in still positions watching the object moving with their eyes. The exercises were repeated with eyes open and closed. Lastly, subjects walked for 40 minutes in a straight line.

In the second session, subjects moved their head in different directions in tandem, semi-tandem, and Romberg stances looking at fixed objects. Walking back and straight walking exercises were then done. All exercises were done in repetitions of ten with eyes closed and open in the third session. The level of training was increased gradually with a focus on dynamic movement. Subjects were asked to move their heads to left and right while they walked backward and the hands were kept to their sides clasped behind their backs. Later, a tandem walk was performed by the participants with their hands at the sides, back, and front respectively.

In the last session, 1 week of exercise was done, and subjects did the exercise with ten repetitions once a day for one month. After clinical assessment, a home exercise protocol was given to the subjects. The exercises for 1$^{st}$ three sessions were done thrice a day in repetitions of ten till the next session, and the last session exercises were done for ten repetitions a day for 4 weeks.

The outcomes assessed were several falls, postural control with a modified clinical test of sensory interaction in balance (m-CTSIB), static balance with the tandem test, dizziness with VAS, and dynamic visual acuity. The demographic data recorded for study subjects included alcohol use, smoking, dizziness-provoking conditions, gender, and age of study participants.

For the tandem test, subjects were asked to stand with one foot in front of the other, and the heel of one foot touching the toe of the other. The subjects were asked to place their hands in crosswire over the shoulders and were asked to maintain their position with eyes closed and open separately. Measurements were made using a stopwatch. The first second for which the subject could not maintain their position was noted. The test was considered complete in subjects that could stand for 30 seconds.[8]

The modified clinical test of sensory interaction in balance assessed the effect of visual, somatosensory, and vestibular inputs on the control of posture. After standing on the soft ground and with eyes closed, m-CTSIB eliminates the visual input and modifies the somatosensory input. Subjects with uncompensated peripheral vestibular loss may have difficulty maintaining an upright posture when support and visual surface information are changed. In m-CTSIB, separate assessments were made on hard and soft surfaces with eyes closed and open.[9] In this test, seconds for which the subject stood were recorded. The test was done thrice with a mean of 3 applications.

The number of falls in the past 6 months were recorded and assessed. Subjects that reported falls were recorded monthly. Falls were considered unintentional falls to the ground or a lower level with no attributed cause.

Dizziness severity was rated on a 10-cm VAS (visual analog scale) for no symptom of dizziness, a score of zero was given at 0 cm, and for the worst possible symptom, a 10-cm score was allotted.[10]

Considering dynamic visual acuity, it was performed with the Snellen visual acuity chart where the subject was first asked where they can read on the eye board on the wall with their head fixed, and the recording was made. The subject was then asked to turn their heads left and right rapidly twice a second and asked to continue reading on the eye board, and a recording of answers was done.[11] In normal subjects, visual acuity was different by 3 or four lines in unilateral vestibular losses.[12]

The data gathered were analyzed statistically using the SPSS software version 21. O (IBM Corp., Armonk, NY, USA) along with student-t-test. The data were expressed in mean and standard deviation and frequency and percentages. The significance level was considered at a p-value of <0.05.

**RESULTS**

The present prospective clinical study aimed to assess the efficacy of physiotherapy vestibular rehabilitation on fall risk and balance parameters in subjects with UVH (unilateral vestibular hypofunction). The study included 60 subjects from both genders with a mean age of 40.12±9.22 years. There were 73.33% (n=44) females and 26.66% (n=16) males in the present

study, vestibular hypofunction of the right side was reported in 43.33% (n=26) subjects, whereas, vestibular hypofunction of the left side was reported in 56.66% (n=34) subjects. Migraine was reported in 16.66% (n=10) subjects, diabetes mellitus in 20% (n=12) subjects, hypertension in 16.66% (n=10) subjects, and smoking in 30% (n=18) study subjects. Alcohol intake was not reported in any subject as shown in Table 1.

The study results showed that the most common aggravating factor for vertigo in study subjects was sudden movements in 70% (n=42) study subjects, stress was the reason in 28.33% (n=17) study subjects, lean forward and stand up was reported in 30% (n=18) study subjects, crowded places, supine lying, head positions and movements were all reported in 23.3% (n=14) study subjects each. Walking was the cause of vertigo in 16.66% (n=10) study subjects, turning from side to side was reported in 13.3% (n=8) study subjects, and fatigue was reported in 6.66% (n=4) study subjects respectively as summarized in Table 2.

On assessing the various tests in study subjects, dynamic visual acuity decreased significantly from 0.45±0.26 to 0.17±0.24 pretreatment to post-treatment with p=0.001. VAS also decreased significantly from 5.94±2.95 to 0.83±1.17 pretreatment to post-treatment with p=0.001. Number of falls also reduced to zero from 2.41±2.75 with p=0.001. The head impulse test also decreased significantly from 1.94±0.16 to 1.12±0.32 postoperatively with p=0.000. Unterberger test with eyes closed reduced significantly from 1.81±0.35 to 1.14±0.35 postoperatively with p=0.000. Unterberger test with eyes open was also significantly used postoperatively to 1.02±0.00 from 1.21±0.41 with p=0.007. m-CTSIB also significantly reduced to 0.91±0.13 postoperatively with p=0.001. OLST soft eyes closed left side, OLST soft eyes closed right side, OLST soft eyes open left side, and OLST soft eyes open right side increased significantly postoperative with p-values of 0.000, 0.000, 0.000, and 0.000 respectively (Table 3).

OLST firm eyes closed left side, OLST firm eyes closed right side, OLST firm eyes open left side, and OLST firm eyes open right side significantly increased from preoperative values to postoperatively with p-values of 0.000, 0.000, 0.000, and 0.000 respectively. Romberg test values increased significantly from 6.11±6.06 preoperatively to 27.62±6.02 postoperatively with p=0.000. Tandem test eyes closed increased from 1.65±1.23 preoperatively to 10.62±7.81 postoperatively with p=0.000. Similar results were seen for tandem test eyes closed with a value of 5.67±2.82 preoperatively to 19.62±8.95 postoperatively with p=0.000 as summarized in Table 3.

## DISCUSSION

The present study included 60 subjects from both genders with a mean age of 40.12±9.22 years. There were 73.33% (n=44) females and 26.66% (n=16) males in the present study, vestibular hypofunction of the right side was reported in 43.33% (n=26) subjects, whereas, vestibular hypofunction of the left side was reported in 56.66% (n=34) subjects. Migraine was reported in 16.66% (n=10) subjects, diabetes mellitus in 20% (n=12) subjects, hypertension in 16.66% (n=10) subjects, and smoking in 30% (n=18) study subjects. Alcohol intake was not reported in any subject. These data were similar to Shah P et al[13] in 2004 and Yardley I et al[14] in 2004 where authors assessed subjects with demographic data comparable to the present study.

It was seen that the most common aggravating factor for vertigo in study subjects was sudden movements in 70% (n=42) study subjects, stress was the reason in 28.33% (n=17) study subjects, lean forward and stand up was reported in 30% (n=18) study subjects, crowded places, supine lying, head positions and movements were all reported in 23.3% (n=14) study subjects each. Walking was the cause of vertigo in 16.66% (n=10) study subjects, turning from side to side was reported in 13.3% (n=8) study subjects, and fatigue was reported in 6.66% (n=4) study subjects respectively. These results were consistent with the previous studies of Jung JY et al[15] in 2009 and Fallahzadeh Abarghuei A et al[16] in 2018 where authors suggested similar aggravating factors leading to vertigo as reported in the present study.

The study results showed that for the various tests in study subjects, dynamic visual acuity decreased significantly from 0.45±0.26 to 0.17±0.24 pretreatment to post-treatment with p=0.001. VAS also decreased significantly from 5.94±2.95 to 0.83±1.17 pretreatment to post-treatment with p=0.001. Number of falls also reduced to zero from 2.41±2.75 with p=0.001. The head impulse test also decreased significantly from 1.94±0.16 to 1.12±0.32 postoperatively with p=0.000. Unterberger test with eyes closed reduced significantly from 1.81±0.35 to 1.14±0.35 postoperatively with p=0.000. Unterberger test with eyes open was also significantly used postoperatively to 1.02±0.00 from 1.21±0.41 with p=0.007. m-CTSIB also significantly reduced to 0.91±0.13 postoperatively with p=0.001. OLST soft eyes closed left side, OLST soft eyes closed right side, OLST soft eyes open left side, and OLST soft eyes open right side increased significantly postoperative with p-values of 0.000, 0.000, 0.000, and 0.000 respectively. These results were in agreement with the findings of Herdman SJ et al[17] in 2012 and Kao CL et al[18] in 2010 where authors reported improvement of all the functional tests following vestibular rehabilitation as in the present study in their studies.

The study results also showed that OLST firm eyes closed left side, OLST firm eyes closed right side, OLST firm eyes open left side, and OLST firm eyes open right side significantly increased from preoperative values to postoperatively with p-values of 0.000, 0.000, 0.000, and 0.000 respectively. Romberg test values increased significantly from 6.11±6.06 preoperatively to 27.62±6.02 postoperatively with p=0.000. Tandem test eyes closed increased from 1.65±1.23 preoperatively to 10.62±7.81 postoperatively with p=0.000. Similar results were seen for tandem test eyes closed with a value of 5.67±2.82 preoperatively to 19.62±8.95 postoperatively with p=0.000. These results were in line with Karapolat H et al[19] in 2010 and Macias JD et al[20] in 2005 where results similar to the present study were reported by the authors in their studies.

## CONCLUSIONS

Considering its limitations, the present study concludes that balance parameters are significantly improved and fall risks are positively affected when physiotherapy programs are applied to the subjects having unilateral vestibular hypofunction. Vestibular rehabilitation also helps in decreasing psychological concerns and helps them in being involved in social life. Vestibular rehabilitation also helped in improving the conditioning, gait, and balance.

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**TABLES**

| **Characteristics** | | **Number (n=60)** | **Percentage (%)** |
|---|---|---|---|
| **Mean age (years)** | | 40.12±9.22 | |
| **Gender** | Females | 44 | 73.33 |
| | Males | 16 | 26.66 |
| **Vestibular hypofunction side** | Right | 26 | 43.33 |
| | Left | 34 | 56.66 |
| **Conditions** | **Migraine** | 10 | 16.66 |
| | **Diabetes mellitus** | 12 | 20 |
| | **Hypertension** | 10 | 16.66 |
| | **Alcohol** | 0 | - |
| | **Smoking** | 18 | 30 |

**Table 1: Demographic and disease characteristics of the study subjects**

| **Aggravating factors** | **Number (n)** | **Percentage (%)** |
|---|---|---|
| **Fatigue** | 4 | 6.66 |
| **Stress** | 42 | 70 |
| **Crowded place** | 14 | 23.3 |
| **Walking** | 10 | 16.66 |
| **Lean forward and stand up** | 18 | 30 |
| **Supine lying** | 14 | 23.3 |
| **Head positions and movements** | 14 | 23.3 |
| **Sudden movements** | 17 | 28.33 |
| **Turn from side to side** | 8 | 13.3 |

**Table 2: Conditions triggering vertigo in study subjects**

| **Test** | **Pretreatment** | **Post-treatment** | **p-value** |
|---|---|---|---|
| **Dynamic visual acuity** | 0.45±0.26 | 0.17±0.24 | **0.001** |
| **VAS** | 5.94±2.95 | 0.83±1.17 | **0.001** |
| **Number of falls** | 2.41±2.75 | 0.00±0.00 | **0.001** |
| **Head impulse test** | 1.94±0.16 | 1,12±0.32 | **0.000** |
| **Unterberger test EC** | 1.81±0.35 | 1.14±0.35 | **0.000** |
| **Unterberger test EO** | 1.21±0.41 | 1.02±0.00 | **0.007** |
| **m-CTSIB** | 0.35±0.17 | 0.91±0.13 | **0.001** |
| **OLST soft EC left foot** | 1.47±1.16 | 7.23±5.75 | **0.000** |
| **OLST soft EC right foot** | 1.36±1.12 | 5.92±4.07 | **0.000** |
| **OLST soft EO left foot** | 4.53±3.06 | 23.21±7.84 | **0.000** |
| **OLST soft EO right foot** | 3.74±2.51 | 22.03±7.02 | **0.000** |
| **OLST firm EC left foot** | 1.67±1.45 | 11.13±8.54 | **0.000** |
| **OLST firm EC right foot** | 1.56±0.97 | 9.97±8.74 | **0.000** |
| **OLST firm EO left foot** | 6.43±4.86 | 23.57±7.32 | **0.000** |
| **OLST firm EO right foot** | 6.36±5.76 | 21.22±8.04 | **0.000** |
| **Romberg test** | 6.11±6.06 | 27.62±6.02 | **0.000** |
| **Tandem test EC** | 1.65±1.23 | 10.62±7.81 | **0.000** |
| **Tandem test EO** | 5.67±2.82 | 19.62±8.95 | **0.000** |

**Table 3: Difference in mean results of different tests in study subjects**