THE HEALER
Journal of Physiotherapy & Rehabilitation Sciences

Original Article

Effects of Circuit Training on Vertigo, Oscillopsia and Dizziness in Patients with Vestibular Hypofunctions

Asna Waseem[1*], Mehak Hamna Zahra Gillani[2], Kiran Mushtaq[3], Fasiha Kamal[3], Danish Hassan[4], Arshad Nawaz Malik[5]

[1]Central Park Medical College, Lahore, Pakistan. [2]The University of Faislabad, Faislabad, Pakistan. [3]University Institute of Physical Therapy, The University of Lahore, Lahore, Pakistan, Lahore, Pakistan. [4]Riphah College of Rehabilitation and Allied Health Sciences, [5]Riphah International University, Lahore, Pakistan. [5]Riphah International University, Islamabad, Pakistan.*

ABSTRACT

Background: Vestibular hypofunctions are defined as partial or complete insufficiency of the function of the peripheral or central vestibular system. Vestibular rehabilitation is a type of physical therapy treatment that has been shown to reduce signs and symptoms in patients with vestibular hypofunctions. **Objective:** To compare the effects of structured circuit training and conventional physical therapy treatment in patients with vestibular hypofunctions. **Methods:** This study was a randomized controlled trial and was completed from January to November 2020 at Sante Care Clinic, Ghazi Road, Lahore, Pakistan. About 14 participants were selected through a convenient sampling technique and patients diagnosed by general physicians with vestibular hypofunctions were recruited in this study. The goldfish bowl method was used to randomly allocate the participants in the conventional physical therapy group (n=07) and circuit training group (n=07). The outcome measuring tools were the Berg balance scale, dizziness handicap inventory, oscillopsia severity questionnaire, vestibular disorders activities of daily living scale, visual vertigo analog scale, vertigo handicap questionnaire and nystagmus specific quality of life questionnaire at baseline, 2nd and 4th week. Independent sample t-test and repeated measure ANOVA were used to analyze the parametric difference across and within each group respectively. Mann Whitney-U test and Friedman ANOVA were used to analyze across and within-group differences for non-parametric distribution. Cohen's effect size was calculated and interpreted within-group from baseline to follow-up; and between groups on change scores. **Results:** The mean age of patients in this study was 41.85±11.27 years. A total of 13 females and 1 male were a part of this study. Comparison within the treatment group showed that scores of all the variables drastically improved after performing the circuit training for weeks by the treatment group. ($p<0.05$). There was a significant improvement from baseline to after four weeks of circuit training in all the outcome measuring tools in the interventional group ($p<0.001$) as compared to the control group. **Conclusion:** This study concluded that a structured circuit training plan has better outcomes as compared to the conventional group on all outcome measuring tools. There were no adverse effects reported during testing, circuit training in treatment group.

Access the article online

SCAN ME

***Corresponding Author:** Asna Waseem, Central Park Medical College, Lahore, Pakistan
Email: asna_waseem@yahoo.com

Keywords: circuit training; dizziness; oscillopsia; vertigo; vestibular hypofunctions; vestibular rehabilitation
DOI: 10.55735/hjprs.v3i7.112

Citations: Waseem A, Gillani MHZ, Mushtaq K, Kamal F, Hassan D, Malik AN. Effects of circuit training on vertigo, oscillopsia and dizziness in patients with vestibular hypofunctions. The Healer Journal of Physiotherapy and Rehabilitation Sciences. 2023;3(7):659-670.

INTRODUCTION

Vestibular hypofunction can be defined as partial or complete insufficiency of the peripheral or central vestibular system. About 50% of cases of vestibular hypofunctions have unknown etiology, while they might also have neurodegenerative, genetic, infectious, toxic and traumatic origins. We need vestibular input for spatial orientation during locomotion, gaze stabilization and dynamic stability of gait. Vestibular hypofunctions either unilateral or bilateral have many direct and indirect effects on our daily life and functioning.[1] The most common consequences include chronic dizziness which might be with or without oscillopsia, vertigo and issues with walking, maintaining balance and driving. Patients with vestibular hypofunctions might not be able to read signs while they walk or move, might fall often and might have difficulties while they walk in the dark or on uneven surfaces.[1] There is convincing evidence that Vestibular hypofunction affects higher cognitive functions[2] harms spatial memory and learning[3] and affects social cognition.[4] This might be the reason why patients with vestibular hypofunctions report a significant negative impact on quality of life and social involvement.[5,6]

While considering the effects on quality of life and the significant burden of this disease, it seems astonishing that Vestibular hypofunction is an impairment of a basic sensory system that does not get the same attention as given to impaired auditory and visual system.[1] Circuit training is a combination of six or more exercises performed with brief rest intervals between them for either a specified number of repetitions or a prescribed amount of time.[7] One circuit is when all of the selected exercises have been completed. Various circuits can be performed in one training session. Circuit training can usually involve six to twelve exercises and should be structured and customized in such a way that enables the patient to keep performing the exercises with proper technique and short relaxation intervals.[8] A study conducted by Ji Woon Kim et al. in June 2018 concluded that circuit training for twelve weeks might be effective and fruitful in refining physical health and preventing various metabolic diseases.[9] Gottshall et al. and others developed vestibular physical therapy procedures that were applied in best practices for vestibular patients, those physical therapies were customized for patients and their expected level of recovery.[10] So, customizing physical therapy procedures according to patient needs and placing them into a circuit training regime proved to be effective in this research. Awareness and understanding of the patient's disability and diagnosis are imperative to build the foundation for a return to normal activities, daily routine, work or sports.[10] Vestibular rehabilitation had shown effects on patients with vestibular hypofunctions but there was no circuit training plan customized specifically for signs and symptoms associated with vestibular hypofunctions.[11]

The goal of this study was to compare the effects of circuit training consisting of structured and customized vestibular rehabilitation exercises with traditional home-based exercise plans on vertigo, oscillopsia, dizziness, balance, activities of daily living and nystagmus in patients with vestibular hypofunctions. Our current study would add a lot more to the literature and evidence encouraging circuit training exercises which included vestibular rehabilitation exercises. There were no studies supporting vestibular rehabilitation exercises especially circuit training supporting the treatment of vestibular hypofunction especially in Pakistan.

METHODS

This study was a randomized controlled trial and was completed from January to November

2020 at Sante Care Clinic, Ghazi Road, Lahore, Pakistan. The trial protocol was prospectively registered at Clinicaltrials.gov, NCT04261283. Ethical approval was obtained before the conduction of the trial from the Research and Ethics Committee of Riphah International University, Lahore Campus (REC/RCRS/2001). Signed informed consent was obtained from each participant in the local language (Urdu) before his/her participation in this trial. About 14 participants were selected through a convenient sampling technique and screened for vestibular hypo-functions. This was a pilot study done to find out the effects of circuit training on vertigo, oscillopsia and dizziness in patients diagnosed with vestibular hypofunctions.

The sample size was calculated using Epi-tool software. A general physician first diagnosed the patients with vestibular hypofunctions and then the general physician screened all the participants with vestibular hypofunctions for their eligibility to take part in this trial. The eligibility criteria were that the patients must be diagnosed with vestibular hypo-functions, willing to participate in this study and were able to perform the vestibular rehabilitation exercises without aggravating the symptoms. The goldfish bowl method was used to randomly allocate the n=14 participants in the control and treatment groups. Fourteen sealed opaque small envelopes were placed in a glass bowl and were shuffled. The participants were treated as per their group allocation stated in sealed opaque envelopes. Each participant received one of the two treatments. A circuit training exercise program was developed from previous literature which consisted of:

- Habituation exercises
- Exercises for the gaze stability
- Exercises to improve saccade latency
- Adaptation exercises
- Substitution exercises, postural control exercises
- General conditioning activities
- Cawthrone-Cooksey exercises
- Ocular motor exercises
- Gait exercises
- Treatment to decrease sensitivity to motion in the environment.

The details of the exercises customized for the circuit training group and their objectives are listed in Table 2. The circuit training group was under the supervision of a neuro-therapist while the conventional physical therapy group was given medicines as prescribed by the ENT specialist and home-based exercise Programme. Details of exercises for both groups are listed in Table 1. Each participant in the experimental group received intervention for four weeks daily each session lasted for 40 to 45 minutes and it depended upon the patient's condition and how well he/she perceives the circuit training plan just to avoid worsening of the symptoms. Avoiding the worsening of the symptoms was the priority of the neuro-therapist. The control group was asked to perform their home-based exercises daily for four weeks.

The measuring tools used were the Berg balance scale which has also been used in previous studies to document balance in vestibular hypofunctions and the scale has also been reported concurrent valid with dynamic gait index in vestibular hypofunction patients[12], dizziness handicap inventory to quantify the impact of dizziness on daily life by measuring the self-perceived impairment[13] and has test-retest reliability (r = 0.92 to 0.97) and internal consistency (α = 0.72 to 0.89), oscillopsia severity questionnaire[14] to evaluate the patient's experience of oscillopsia in daily life, vestibular disorders activities of daily living scale[15] to assess the self-perceived level of disablement in patients with vestibular disorders, visual vertigo analog scale[16] for the quantification of visual vertigo by rating its intensity in nine challenging situations that provokes dizziness, vertigo handicap questionnaire[17] to measure the impact of

Table 1: Intervention Protocol in Treatment and Conventional Groups

	Experimental Group (Circuit Training Group)	Conventional Group (Conventional Physical Therapy Group)
Sr. #	Circuit Training Plan: Supervised vestibular rehabilitation exercises customized in the form of a circuit training plan	Medication and unsupervised home exercise program which includes simple Exercises for Dizziness and balance impairments:
1	Circuit Station 1: VOR X1 Reviewing Exercise	Sit down and rotate the head from side to side and up and down for 1- 2 minutes. (With the eyes open and 2-3 times a day). Start slowly at first and then speed up. As the dizziness improves perform this with eyes closed.
2	Circuit Station 2: VOR X2 Reviewing Exercise	Look up and down 20 times. (only eyes have to move, keeping the head still). Start slowly at first and then speed up eventually. As the dizziness improves perform this with eyes closed.
3	Circuit Station 3: Gaze Stability exercises:	Look from one side to the other 20 times. (only eyes have to move, keeping the head still). Start slowly at first, then speed up. As the dizziness improves perform this with eyes closed.
4	Circuit Station 4: Balance Improving Exercises	Bend forward as if you are picking an object from the ground. Perform this in a sitting posture initially and then try it in an erect posture if you can. (1-2 minutes 2-3 times a day)
5	Circuit Station 5: Oculomotor Exercise	Sit and rotate the head and trunk alternatively to the right and left sides 10-15 times. (2-3 times a day)
6	Circuit Station 6: Exercises to Improve Saccade Latency	Sit and rotate/ shrug shoulders forward and backward 15-20 times. (2-3 times a day)
7	Circuit Station 7: More specific balance exercises	Move from sitting to standing up, and back again, with your eyes open, 20 times. When you feel your symptoms are bearable repeat this exercise with your eyes closed.
8	Circuit station 8: Walking Exercises	Throw the ball to the wall and catch it repeatedly for 15-20 times tracking the movement of the visually.
9	Circuit Station 9: Treatment to Decrease Sensitivity to Motion in the Environment	Stand in front of a wall with your back towards the wall. Move your hip backward towards the wall, touch the wall with your hips and then return to erect posture. Do this repeatedly 8-10 times twice a day.
10	Circuit Station 10: Treatment for Physical Conditioning	Walk across the floor with your eyes open 20 times. Repeat this with your eyes closed.
11	-	Walk up and down a slope with your eyes open 20 times. Repeat this with your eyes closed.
12	-	Walk up and down the stairs 20 times with your eyes open. Repeat this if you can with your eyes closed.

vertigo on activities of daily living, social life and leisure activities and nystagmus-specific quality of life questionnaire to find out the impact of nystagmus on daily living concerning both psycho-social and physical aspects.[18] The total score of all variables was used for analysis. A baseline assessment of all variables was carried out before their randomization in the circuit training group or conventional physical therapy group then at

the end of the 2nd and 4th week. The duration of intervention in both groups was 4 weeks. The data was analyzed using SPSS v 25. The normality of the data was assessed using the Shapiro-Wilk test. As per the distribution of the data, independent sample t-test and repeated measure ANOVA were used to analyze the parametric difference across and within each group respectively. Mann Whitney-U test and Friedman ANOVA were used to analyze across and within-group differences for non-parametric distribution. The p-value less than 0.05 was considered a statistically significant difference. Cohen's effect size was calculated and interpreted within-group from baseline to follow-up and between groups on change scores.

RESULTS

The mean age of patients in this study was 41.85 ± 11.27 years. A total of 13 females and 1 male were a part of this study. The results showed us that the total score of every variable at the baseline, before performing the circuit training was compared with the total score of every variable after 4 weeks of circuit training, the $p<0.05$ was considered statistically significant (Table 3).

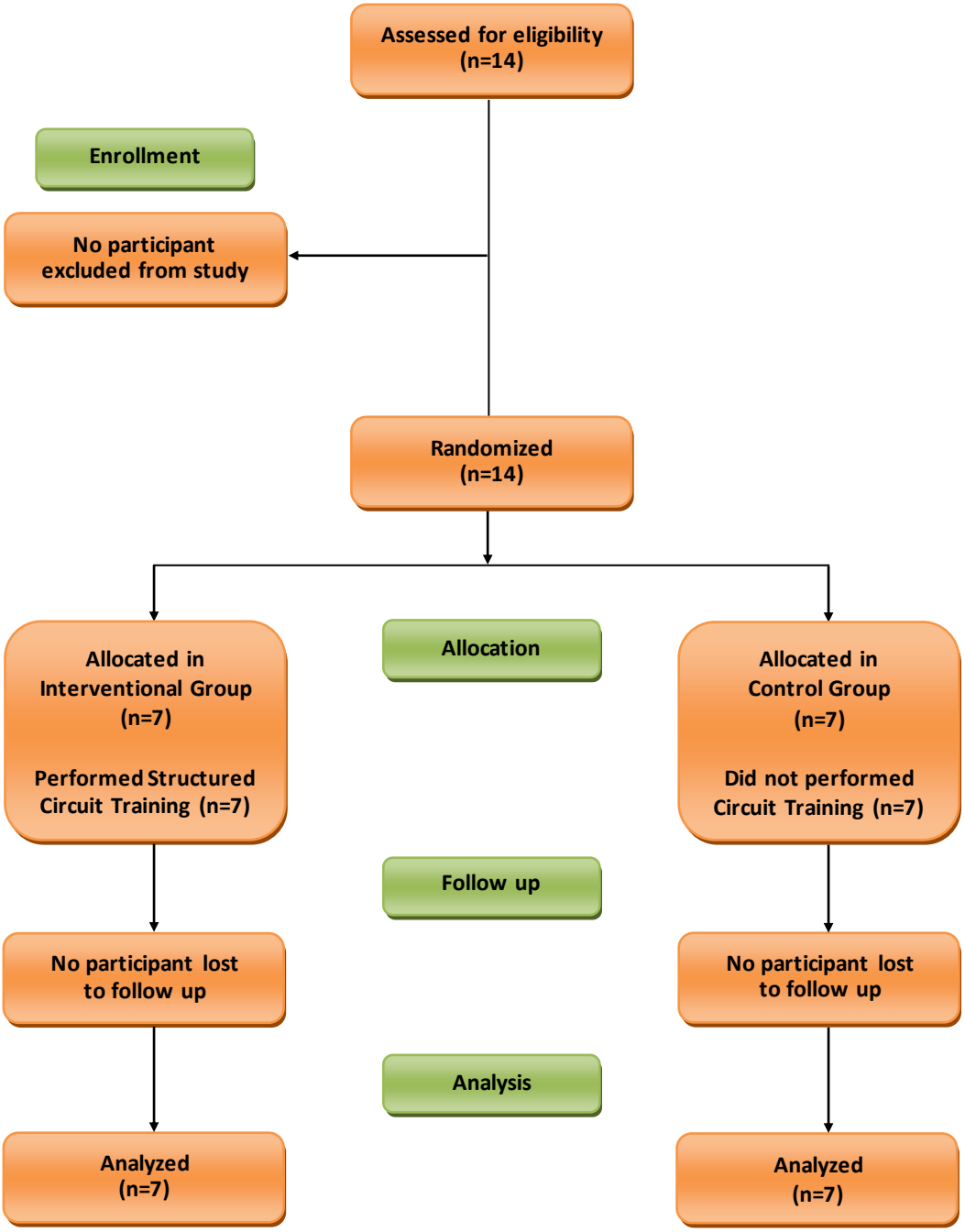
DISCUSSION

This study aimed to compare the effects of a customized circuit training plan which included vestibular rehabilitation exercises with traditional home-based physical therapy exercises and medications given by general physicians in patients with vestibular hypo-functions. There was a significant decrease in signs and symptoms concerned with the disease in the interventional group. There was a significant improvement in all the tool's functional status and activities of daily living of patients who were in the interventional group as supported by Table 3, vestibular disorders activities of daily living $p<0.05$.

Table 2: Circuit Training Stations Sequence, Exercises and Their Objectives

Circuit Station	Exercise to be performed	Objective
1	VOR X1 reviewing exercise[19] (Visual Ocular Reflex)	Reduction of oscillopsia
2	VOR X2 reviewing exercise[19] (Visual Ocular Reflex)	Reduction of oscillopsia
3	Gaze stability exercises[20]	To improve gaze stability
4	Balance improving exercises[21]	To improve balance
5	Oculomotor exercises[22]	To increase pursuit gain, the ability to track down objects
6	Exercises to improve saccade latency[23]	To improve saccade latency
7	More specific balance exercises[21]	This exercise is designed specifically for sharpening the stance
8	Walking exercises[24]	Patients will have severe gait impairments due to dizziness
9	Treatment to decrease sensitivity to motion in the environment[25]	To decrease patients' sensitivity to motion in a busy environment
10	Treatment for physical conditioning[26]	To prevent or to maintain cardiovascular endurance

Figure 1: CONSORT Diagram



The results of the within-group comparison show us that the scores of all the outcome measures drastically improved within the interventional group after performing circuit training. A systematic review[27] showed the most common symptom reported by patients with vestibular hypo-function is an imbalance, 91.4%, with oscillopsia being a less common symptom, 70.2% in clinical case reports and 50.1% in clinical studies. In this study, this symptom was reported relatively high at the baseline by patients in both the oscillopsia

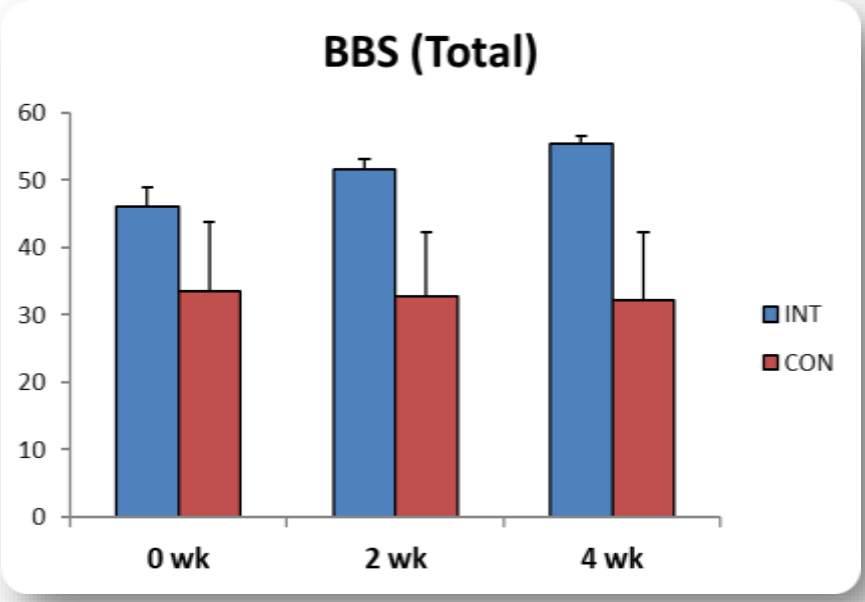
Table 3: Outcome Measures, Analysis of Mean Differences Between Treatment and Conventional Groups

Outcome Measure	Time Measure	Circuit Training (n=7) Mean ± SD	Conventional Group (n=7) Mean ± SD	p-value
BBS	Baseline	46.14 ± 2.85	33.57 ± 10. 27	0.009
	2nd Week	51.57 ± 1.51	32.71 ± 9.49	<0.001
	4th Week	55.42 ± 1.13	32.14 ± 10.18	<0.001
	Δ [95% CI]	9.28 [6.27,12.29]	1.42 [0.52,2.33]	<0.001
	P Value			<0.001
DHI	Baseline	66.57 ± 14.31	73.42 ± 10.62	0.329
	2nd Week	46.00 ± 7.57	77.14 ± 14.04	<0.001
	4th Week	22.57 ± 6.07	81.71 ± 12.51	<0.001
	Δ [95% CI]	44.00 [27.98,60.01]	8.28 [5.00,11.56]	<0.001
	P Value			<0.001
OSQ	Baseline	37.71 ± 2.49	36.00 ± 4.79	0.541
	2nd Week	27.71 ± 1.70	37.00 ± 4.16	<0.001
	4th Week	18.42 ± 2.22	38.57 ± 4.61	<0.001
	Δ [95% CI]	16.28 [12.33,20.23]	2.57 [0.65,4.48]	<0.001
	P Value			<0.001
VDADL	Baseline	61.57 ± 10.43	105.42 ± 46.26	0.09
	2nd Week	51.85 ± 7.17	105.85 ± 46.03	0.001
	4th Week	46.42 ± 5.19	105.71 ± 46.42	<0.001
	Δ [95% CI]	15.14 [8.95,21.33]	0.28 [0.59,1.16]	<0.001
	P Value			<0.001
VVAS	Baseline	67.00 ± 5.16	69.28 ± 7.97	0.536
	2nd Week	54.14 ± 3.43	70.85 ± 8.00	0.001
	4th Week	35.28 ± 4.02	73.28 ± 8.40	<0.001
	Δ [95% CI]	31.17 25.67,37.74	4.00 [2.48,5.51]	<0.001
	P Value			<0.001

VHQ	Baseline	61.14 ± 5.24	57.85 ± 2.96	0.175
	2nd Week	58.00 ± 5.53	59.28 ± 2.92	0.597
	4th Week	51.71 ± 3.59	60.42 ± 2.99	<0.001
	Δ [95% CI]	9.42 [5.29,13.55]	2.57 [0.65,4.48]	<0.001
	P Value			<0.001
NSQLQ	Baseline	110.71 ± 14.00	118.57 ± 18.42	0.387
	2nd Week	84.85 ± 8.68	123.71 ± 18.21	<0.001
	4th Week	54.85 ± 4.94	128.85 ± 21.81	<0.001
	Δ [95% CI]	55.85 [43.45,68.25]	10.28 [5.60,14.96]	<0.001
	P Value			<0.001

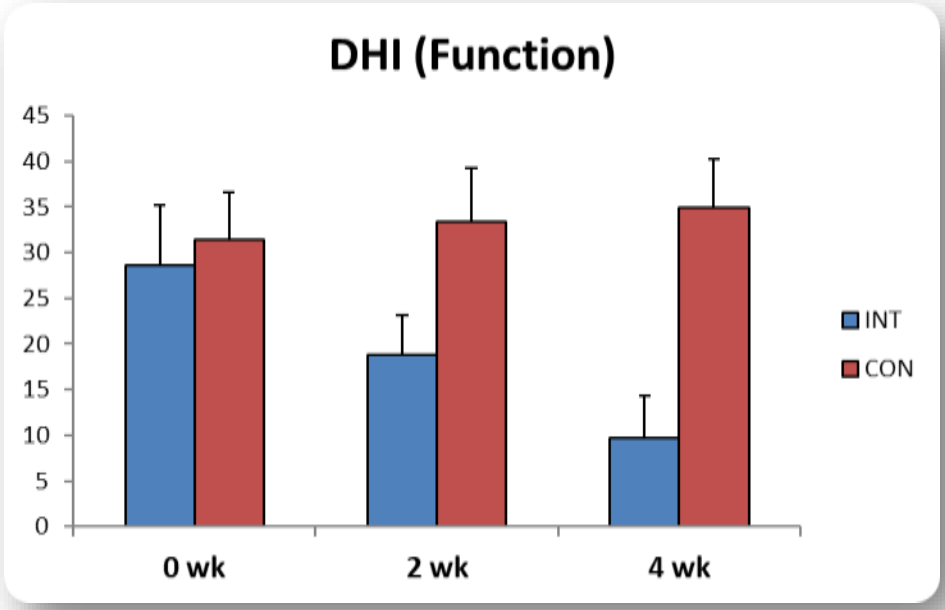
[a: Between Group] [b: Within Group] [Δ: Mean Change between baseline and post-training] [BBS: Berg Balance Scale] [DHI: Dizziness Handicap Inventory] [OSQ: Oscillopsia Severity Questionnaire] [VDADL: Vestibular Disorders Activities of Daily Living Scale] [VHQ: Visual Vertigo Analogue Scale] [NSQLQ: Nystagmus Specific Quality of Life Questionnaire]

Figure 2: Week-wise Comparison of Mean Score of Berg Balance Scale within Treatment and Conventional Groups



severity questionnaire, the mean score of the interventional group at the baseline was 34.71/45 and for the control group was 36/45. But after 4 weeks of circuit training, this score dropped drastically in the interventional group (Mean score: 18.42/ 45) as compared to the control group. Hayato Asai and his co-workers conducted an RCT to find out the effects

Figure 3: Week-wise comparison of Functional component of DHI within Treatment and Conventional Groups



of the walking program in patients who had chronic unilateral vestibular hypo-function.[28] They observed that there were significant differences in the aggregation of clinical signs and symptoms, self-perceived handicap and moderate to vigorous physical activity before and after the intervention was performed. Moreover, their results showed that anxiety levels were drastically reduced and stability in the posture was significantly improved in these patients. The result of the present study also proved that the walking program which was included in this study under balance-improving exercises (circuit station 8, Table 1), showed significant improvement in patients' balance and walking capabilities. One component of the outcome measuring tools was stress and anxiety caused by the signs and symptoms of Vestibular hypo-functions, which also showed improvement within the interventional group (Table 3). An RCT was conducted in 2019, which concluded that a customized, well-planned, structured and exclusively accustomed system of vestibular exercises leads to a significant decrease in clinical signs and symptoms, improvement of activities of daily living and functioning and improvement in confidence in patients with both chronic unilateral and bilateral vestibular hypofunctions.[29]

The present study also showed that a structured and customized circuit training plan including vestibular exercises led to a significant decrease in clinical signs and symptoms associated with vestibular hypo-functions. Mary Beth Badke and his co-workers conducted a retrospective study to find balance recovery and dizziness handicaps in thirty-two patients after a balance and vestibular rehabilitation program. They tested the patients with sensory organization test and dizziness handicap inventory before and after the rehabilitation program. The scores of vestibular and composite sensory organization tests and functional dizziness handicap inventory obtained before and after exercise showed significant improvement. Their outcome measures of vestibular rehabilitation protocols confirmed that there was

improvement in both, objective and subjective, balance and dizziness handicaps in patients with peripheral and central vestibular disorders.[30] The present study also showed significant improvement in the functional outcome measure of the dizziness handicap inventory score in the interventional group as compared to the control group after 4 weeks of the circuit training program, p-value <0.001 (Figure 3). The results of this study prove that a supervised circuit training plan is far more beneficial than unsupervised conventional physical therapy treatment. This study proves that the presence of a professional neuro-physical therapist with the patient while he performs the circuit training plan which consists of vestibular rehabilitation exercises benefits to improve the signs and symptoms accompanying vestibular hypo- functions.

The supervised circuit training group showed drastically better scores in all the outcome measures after 4 weeks of performance than the unsupervised conventional physical therapy group. The limitation of this study was that it did not include an equal number of male participants as female patients, as only 1 male patient was able to participate in this study. This might have affected the results or this gender difference might have masked the actual association of circuit training with improving the signs and symptoms of vestibular hypo- functions. The sample size of this study was also very less, only 7 patients were included in both the groups making a total of 14. Future researchers are recommended to conduct studies finding the effects of circuit training on male patients diagnosed with vestibular hypofunctions or they might include an equal number of males and females in their study to overcome gender biases that might have arrived. They are also recommended to work on a larger number of populations diagnosed with vestibular hypofunctions for more authentic results. However, future researchers are recommended to conduct this study by recruiting a larger sample size and more detailed insight into signs and symptoms associated with vestibular hypofunctions on a separate basis.

CONCLUSION

The customized and supervised circuit training plan (which included the vestibular rehabilitation exercises) which was made considering the signs and symptoms of vestibular hypofunctions was more effective than conventional physical therapy treatment (medication prescribed by the general physician and unsupervised home-based exercise plan). The mean scores of all the outcome measures drastically improved within the interventional group after performing the circuit training. This study concludes that customized and supervised circuit training which includes vestibular rehabilitation exercises proves to improve the signs and symptoms associated with vestibular hypofunctions.

DECLARATIONS

Consent to participate: Written consent had been taken from patients. All methods were performed following the relevant guidelines and regulations.

Availability of data and materials: Data will be available on request. The corresponding author will submit all dataset files.

Competing interests: None

Funding: No funding source is involved.

Authors' contributions: All authors read and approved the final manuscript.

CONSORT Guidelines: All methods were performed following the relevant guidelines and regulations.

REFERENCES

1. Grill E, Heuberger M, Strobl R, et al. Prevalence, determinants, and consequences of vestibular hypofunction. results from the KORA-FF4 survey. Frontiers in Neurology 2018; 9: 1076.

https://doi.org/10.3389/fneur.2018.01076
2. Popp P, Wulff M, Finke K, Rühl M, Brandt T, Dieterich M. Cognitive deficits in patients with a chronic vestibular failure. Journal of neurology 2017; 264(3): 554-63. https://link.springer.com/article/10.1007/s00415-016-8386-7
3. Kremmyda O, Hüfner K, Flanagin VL, et al. Beyond dizziness: virtual navigation, spatial anxiety and hippocampal volume in bilateral vestibulopathy. Frontiers in Human Neuroscience 2016; 10: 139. https://doi.org/10.3389/fnhum.2016.00139
4. Deroualle D, Borel L, Devèze A, Lopez C. Changing perspective: The role of vestibular signals. Neuropsychologia, 79 (Part B), 175–185. 2015. https://doi.org/10.1016/j.neuropsychologia.2015.08.022
5. Guinand N. Déficit vestibulaire bilatéral: impact sur la qualité de vie: University of Geneva; 2015. DOI: 10.13097/archive-ouverte/unige:74933
6. Ward BK, Agrawal Y, Hoffman HJ, Carey JP, Della Santina CC. Prevalence and impact of bilateral vestibular hypofunction: results from the 2008 US National Health Interview Survey. JAMA otolaryngology–head & neck surgery 2013; 139(8): 803-10. doi:10.1001/jamaoto.2013.3913
7. Scott A. Introduction to clinical exercise science. Clinical exercise science: Routledge; 2016: 1-16. https://www.taylorfrancis.com/chapters/edit/10.4324/9781315885995-1/introduction-clinical-exercise-science-andrew-scott
8. Tudor K, Sarkar M, Spray CM. Resilience in physical education: A qualitative exploration of protective factors. European Physical Education Review 2020; 26(1): 284-302. https://doi.org/10.1177/1356336X19854477
9. Kim J-W, Ko Y-C, Seo T-B, Kim Y-P. Effect of circuit training on body composition, physical fitness, and metabolic syndrome risk factors in obese female college students. Journal of exercise rehabilitation 2018; 14(3): 460. doi: 10.12965/jer.1836194.097
10. Gottshall K. Vestibular rehabilitation after mild traumatic brain injury with vestibular pathology. NeuroRehabilitation 2011; 29(2): 167-71. DOI: 10.3233/NRE-2011-0691
11. Abshirini H, Karkhaneh S, Bayat A. Investigating the effects of vestibular rehabilitation on balance function in Cochlear implant recipients. The International Tinnitus Journal 2020; 24(1): 36-9. https://www.tinnitusjournal.com/abstract/investigating-the-effects-of-vestibular-rehabilitation-on-balance-function-in-cochlear-implant-recipients-12221.html
12. Whitney S, Wrisley D, Furman J. Concurrent validity of the Berg Balance Scale and the Dynamic Gait Index in people with vestibular dysfunction. Physiotherapy Research International 2003; 8(4): 178-86. https://doi.org/10.1002/pri.288
13. Treleaven J. Dizziness handicap inventory (DHI). Aust J Physiother 2006; 52(1): 67. http://svc019.wic048p.server-web.com/AJP/vol_52/1/AustJPhysiotherv52i1Clinimetrics.pdf
14. Schubert MC, Ramat S, Kingma H. Functional Testing of Vestibular Function. Frontiers Media SA; 2020. p. 654. doi: 10.3389/fneur.2020.00654
15. Cohen HS, Kimball KT. Development of the vestibular disorders activities of daily living scale. Archives of Otolaryngology–Head & Neck Surgery 2000; 126(7): 881-7. doi:10.1001/archotol.126.7.881
16. Dannenbaum E, Chilingaryan G, Fung J. Visual vertigo analogue scale: an assessment questionnaire for visual vertigo. Journal of vestibular research 2011; 21(3): 153-9. DOI: 10.3233/VES-2011-0412
17. Yardley L, Masson E, Verschuur C, Haacke N, Luxon L. Symptoms, anxiety and handicap in dizzy patients: development of the vertigo symptom scale. Journal of psychosomatic research 1992; 36(8): 731-41. https://doi.org/10.1016/0022-3999(92)90131K

18. McLean RJ, Maconachie GD, Gottlob I, Maltby J. The development of a nystagmus-specific quality-of-life questionnaire. Ophthalmology 2016; 123(9): 2023-7. https://doi.org/10.1016/j.ophtha.2016.05.033
19. Roller RA, Hall CD. A speed-based approach to vestibular rehabilitation for peripheral vestibular hypofunction: A retrospective chart review. Journal of Vestibular Research 2018; 28(3-4): 349-57. DOI: 10.3233/VES-180633
20. Gaikwad SB, Johnson EG, Nelson TC, et al. Effect of gaze stability exercises on chronic motion sensitivity: a randomized controlled trial. Journal of Neurologic Physical Therapy 2018; 42(2): 72-9. https://doi.org/10.1097/NPT.0000000000000216
21. Cabanas-Valdés R, Bagur-Calafat C, Girabent-Farrés M, et al. Long-term follow-up of a randomized controlled trial on additional core stability exercises training for improving dynamic sitting balance and trunk control in stroke patients. Clinical rehabilitation 2017; 31(11): 1492-9. https://doi.org/10.1177/0269215517701804
22. Correia A, Pimenta C, Alves M, Virella D. Better balance: a randomised controlled trial of oculomotor and gaze stability exercises to reduce risk of falling after stroke. Clinical Rehabilitation 2021; 35(2): 213-21. https://doi.org/10.1177/0269215520956338
23. Navari E, Cerchiai N, Casani AP. Assessment of vestibulo-ocular reflex gain and catch-up saccades during vestibular rehabilitation. Otology & Neurotology 2018; 39(10): e1111-e7. doi: 10.1097/MAO.0000000000002032
24. Suh JH, Kim H, Jung GP, Ko JY, Ryu JS. The effect of lumbar stabilization and walking exercises on chronic low back pain: A randomized controlled trial. Medicine 2019; 98(26). doi: 10.1097/MD.0000000000016173
25. Koch A, Cascorbi I, Westhofen M, Dafotakis M, Klapa S, Kuhtz-Buschbeck JP. The neurophysiology and treatment of motion sickness. Deutsches Ärzteblatt International 2018; 115(41): 687. doi: 10.3238/arztebl.2018.0687
26. Cordellat A, Padilla B, Grattarola P, et al. Multicomponent exercise training combined with nutritional counselling improves physical function, biochemical and anthropometric profiles in obese children: a pilot study. Nutrients 2020; 12(9): 2723. https://doi.org/10.3390/nu12092723
27. Batuecas-Caletrio A, Trinidad-Ruiz G, Rey-Martinez J, Matiño-Soler E, Sanz EM, Fernandez NP. Oscillopsia in bilateral vestibular hypofunction: not only gain but saccades too. Ear and hearing 2020; 41(2): 323-9. doi: 10.1097/AUD.0000000000000760
28. Asai H, Murakami S, Morimoto H, et al. Effects of a walking program in patients with chronic unilateral vestibular hypofunction. Journal of Physical Therapy Science 2022; 34(2): 85-91.https://doi.org/10.1589/jpts.34.85
29. Maslovara S, Butkovic-Soldo S, Peric M, Pajic Matic I, Sestak A. Effect of vestibular rehabilitation on recovery rate and functioning improvement in patients with chronic unilateral vestibular hypofunction and bilateral vestibular hypofunction. NeuroRehabilitation 2019; 44(1): 95-102. DOI: 10.3233/NRE-182524
30. Badke MB, Miedaner JA, Grove CR, Shea TA, Pyle GM. Effects of vestibular and balance rehabilitation on sensory organization and dizziness handicap. Annals of Otology, Rhinology & Laryngology 2005; 114(1):48-54.https://doi.org/10.1177/000348940511400109