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RESEARCH ARTICLE

Value of customized Vestibular and Balance Rehabilitation Therapy in Unilateral Peripheral Vestibular Disorders.

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Abstract

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INTRODUCTION

With unilateral lesions of the peripheral vestibular system, the normal symmetry of inputs from the right and left labyrinths becomes disordered, resulting in a decreased firing rate of the vestibular nuclei on one side. A unilateral lesion affects the system as if the intact side were being stimulated, thus generating an illusion of changingin head orientation and movement. The inherent disequilibrium then activates the vestibulo-ocular and vestibulo-spinal system to respond inappropriately, resulting in vertigo, nystagmus, and postural instability **[**1].

There is an increasing evidence that dynamic posturography is a useful tool for identifying disorders of the vestibular system. Dynamic posturography is not a direct assessment of peripheral or central vestibular function; it assesses balance rather than specific vestibular function [2].

There are two overall goals in a vestibular and balance rehabilitation therapy (VBRT) program: (1) to advance the central vestibular compensation process, resulting in reduction in symptoms under static and dynamic conditions, and improvement in the function of the vestibuloocular reflex; and (2) to improve the function of the vestibulospinal reflex which is important to the functionality of static and dynamic balance and gait [3].

Objectives:

- To assess the ability of patients with unilateral lesions of the peripheral vestibular system to maintain equilibrium under more challenging environmental circumstances by computerized dynamic posturography (CDP).

- To assess the efficiency of customized rehabilitation program in restoring balance.

Methods:

30 patients were included in this study.

Selection criteria:

1- All patients were neurologically free with no neuromuscular complaints.
2- All patients had normal hearing sensitivity as reflected by normal PTA in all tested frequencies (250 through 8000 Hz).
3- All patients had bilateral excellent speech discrimination scores in the range of (88-100%).
4- All patients had type (A) tympanogram indicating normal middle ear pressure and acoustic reflex thresholds were within normal.

Each patient was subjected to:

1- Full medical history:

All patients were with good general condition and alert for time, place and persons.

Emphasis on detailed history of vertiginous attacks: description of the first attack, course, duration of acute attack, postural instability, associated autonomic symptoms, and details about persistent imbalance and motion-provoked vertigo. History of medication taking during acute attack and if there is maintenance dose.

2- Otological examination: To detect any perforation or impacted cerumen.

3- Basic hearing tests:

- Pure Tone Audiometry:

Air conduction thresholds were tested at frequencies 0.25, through 8 KHz.

Bone conduction thresholds were tested at 0.5, through 4 KHz.

-Speech Audiometry:

This included speech reception threshold testing (SRT) using Arabic spondee words and word discrimination testing using Arabic phonetically balanced (PB) words at 40 dB sensation level **[4]**.

-Acoustic Immittance Testing:

It will include tympanometry and acoustic reflex threshold measurements at frequencies 0.5, through 4 KHz.

4- Vestibular Evaluation:

I) Videonystagmography (VNG):

VNG test battery using video-goggle was conducted to all patients participating in the study, searching for spontaneous, gaze evoked, positional and positioning nystagmus. Oculomotor test battery included saccade; eye tracking and optokinetic tests was done.

Bithermal caloric test was performed by using water temperature 30°C and 44° C respectively. Irrigation of 250 cc water / minute was done in 30 seconds and nystagmuswas recorded.

II) Dynamic Visual Acuity Test (DVA):

The patient read a Snellen's chart with the head stationary and visual acuity was recorded. Then the visual acuity was recorded during passive horizontal head oscillations at a frequency of about 2 Hz. Subjects with corrective lenses were instructed to wear them during the test. Subjects with normal (VOR) show no more than one-line decline in visual acuity with head movements. Subjects with abnormal (VOR) may show a drop of acuity of two lines or more from baseline.

III) Computerized Dynamic Posturography (CDP):

A) The Sensory Organization (SOT):

The first three conditions were done on fixed platform (C1) eyes opened, (C2) eyes closed, (C3) in a sway referenced visual enclosure. The other three conditions utilized a sway referenced platform with (C4) eyes opened, (C5) eyes closed, (C6) in a sway referenced visual enclosure. Three trials were done for each condition, each lasting for 20 seconds.

Analysis of the results included:

a- Equilibrium Score: It quantifies the Center of Gravity (COG) sway or postural stability under each of the three trials of the six sensory conditions.

b- Sensory Analysis: patients were defined according to the default norms of the equipment.

c- Strategy Analysis: It quantifies the relative amount of movement about the ankle (ankle strategy) and about the hip (hip strategy) the patient used to maintain balance during each trial.

B) Tandem Walk (TW):

The TW quantifies characteristics of gait as the patient walks heel to toe from one end of the force plate to the other. Measured parameters are:

1- **Step Width:** It is the lateral distance in centimeters between the left and right feet on successive steps.

2- **The Speed**: It is the velocity in centimeters per second of the forward progression.

3- **The End Sway:** It is the velocity in degrees per second of the anterior/posterior component of COG sway for 5 seconds beginning when the patient terminates walking.

5- Vestibular Rehabilitation:

To study the role of different rehabilitation programs, patients were allocated randomly to receive different therapy programs:

- **Program (A)**: 15 patients were participated in this program. The program was explained and taught to each patient individually in the clinic, and then an instructive printed program was given to each patient to be done at home.

Vestibular rehabilitation home program included:

1- Exercise to improve gaze stability:

Gaze training included VOR X1 in the horizontal and vertical directions done for several minutes at least twice daily for 8 weeks.

2- Balance and Gait exercises:

Gait training includedTandem Walk (TW) done for several minutes at least twice daily for 8 weeks.

- **Program** (**B**): 15 patients were participated in this program. They were advised to walk for 30 min. daily with head moving to right and left.

- Patients were followed every 2 weeks by coming to clinic for more support, reassurance and answering questions.

6- Outcome measures:

This was performed 8 weeks following rehabilitation. This included the following items:

1- Dynamic Visual Acuity Test (DVA).

2- Computerized Dynamic Posturography(SOT& TW).

7- Statistical Plane:

Using SPSS Program version 17 IBM Corporation.

8- Ethical concepts:

Patients included in the study were informed about all the steps and procedures they were subjected to, including the rehabilitation plans , the advantages and disadvantages of each (if any) were presented. All patients were given a reasonable explanation to any questions that may arise. In case of agreement, the patient was kindly asked to sign a special consent form containing the same information

Results:

Vestibular results:

- All patients had normal occulomotor test battery results with abnormal caloric test results.

- Patients with unilateral peripheral vestibular disorders showed different results regarding SOT test results as in table (1)

- Table (1): Patients map for therapy.

Program	SOT results	Pt. no (30)	%
Program A No=15	Abnormal	10	33.3%
	Normal	5	16.7%
Program B No=15	Abnormal	8	26.7%
	Normal	7	23.3%

SOT: Sensory Organization Test

- For each patient, difference of his status pre- versus post- rehabilitation was estimated and this was termed **rehailitation effect**. This therapy effect was studied to compare different program and exercises.

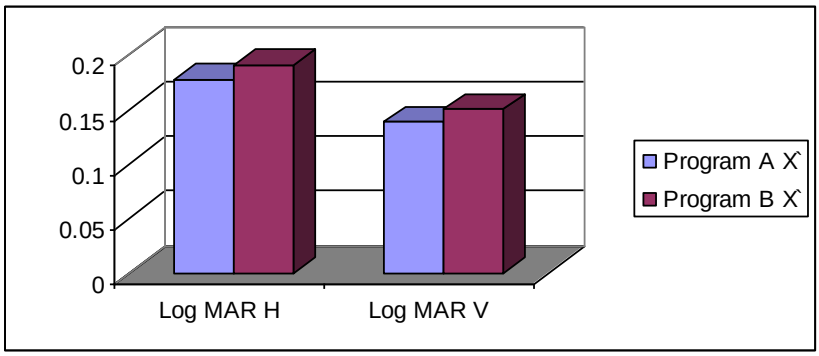
- Table (2): Mean, SD, F value & P value of the Dynamic Visual Acuity rehailitation effect regarding Program difference.

DVA	Program A		Program B		F value	P value
	$\bar{X}$	SD	$\bar{X}$	SD		
Log MAR H	-0.1779	0.9557	-0.1810	0.10511	0.290	0.581
Log MAR V	-0.1382	0.1131	0.1466	0.0838	0.220	0.633

DVA: Dynamic Visual Acuity.

This table showed no statistically significant difference in DVA **rehailitation effect** regarding Program difference.

Fig.(1): Histogram presenting DVA **rehailitation effect** regarding Program difference.



- Table (3): Mean, SD, F value & P value of the Equilibrium Score **rehailitation effect** regarding Program difference.

Es	Program A		Program B		F value	P value
	$\bar{X}$	SD	$\bar{X}$	SD		
C1	1.46	1.31	2.06	1.71	2.66	0.10
C2	3.48	2.43	4.19	1.90	1.71	0.21
C3	3.24	1.62	3.72	1.67	0.49	0.46
C4	6.22	6.85	7.90	5.90	0.86	0.33
C5	31.25	19.63	20.78	9.15	12.12	<.001***
C6	34.07	14.78	30.32	11.82	1.22	0.24
Comp.	18.45	8.95	15.75	8.90	2.50	0.11

ES: Equilibrium Score.
C: Condition.
Comp.: Composite Score.

This table showed very highly statistically significant difference in the Equilibrium Score (C5) **rehailitation effect** regarding Program difference.

Fig. (2): Histogram presenting SOT Equilibrium Score **rehailitation effect** regarding Program difference.

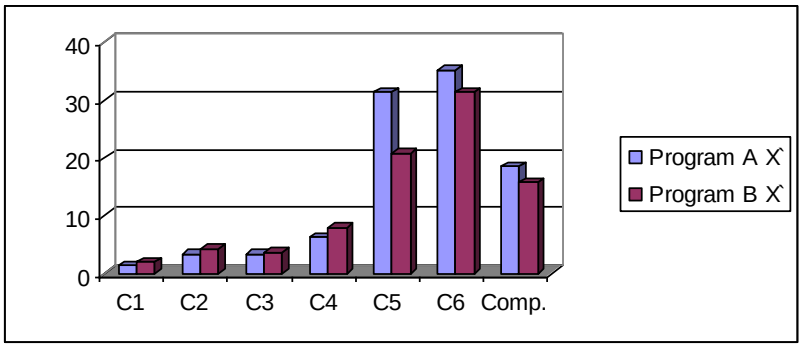
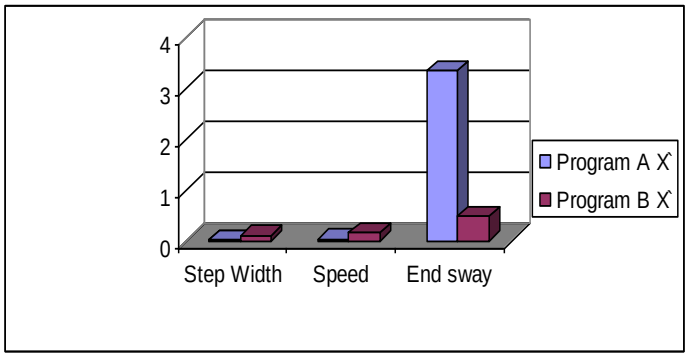


Table (4): Mean, SD, F value & P value of the Tandem Walk (TW) **rehailitation effect** regarding Program difference.

TW	Program A		Program B		F value	P value
	$\bar{X}$	SD	$\bar{X}$	SD		
Step Width	-0.11	0.26	0.11	0.33	2.16	0.13
Speed	0.03	0.25	0.15	0.30	2.60	0.12
End sway	-3.21	1.01	-0.45	0.36	180.24	<.0001***

TW: Tandem Walk Test.
This table showed very highly statistically significant difference in the Tandem Walk test (End sway) **rehailitation effect** regarding Program difference.

Fig (3): Histogram presenting TW rehailitation effect regarding Program difference



1- Effect of SOT results:

- In the following tables the **rehailitation effect** was studied statistically regarding SOT abnormality.

- **Dynamic Visual Acuity Test (DVA) results:**

Table (5): Mean, SD, F value & P value of the Dynamic Visual Acuity **rehailitation effect** regarding SOT abnormality.

DVA	Abnormal SOT		Normal SOT		F value	P value
	X`	SD	X`	SD		
Log MAR H	-0.19	0.89	-0.18	0.11	0.018	0.892
Log MAR V	-0.16	0.112	-0.14	0.08	0.253	0.628

SOT: Sensory Organization Test.
DVA: Dynamic Visual Acuity Test.

This table showed no statistically significant difference in DVA **rehailitation effect** regarding SOT abnormality.

Table (6): Mean, SD, F value & P value of the Equilibrium Score **rehailitation effect** regarding SOT abnormality.

Es	Abnormal SOT		Normal SOT		F value	P value
	X`	SD	X`	SD		
C1	1.10	1.10	2.33	1.51	1.11	0.34
C2	3.73	2.41	3.55	1.44	0.12	0.87
C3	3.05	1.40	4.04	1.40	4.90	0.03
C4	8.10	7.33	6.15	3.50	1.11	0.32
C5	40.88	14.97	12.35	5.07	93.25	<.001***
C6	42.61	12.68	23.88	7.45	28.32	<.001***
Comp.	23.86	7.13	10.29	4.50	55.90	<.001***

SOT: Sensory Organization Test
ES: Equilibrium Score.
C: Condition.
Comp.: Composite Score.

This table showed very highly statistically significant difference in the Equilibrium Score (C5, C6 & Comp.) **rehailitation effect** regarding SOT abnormality.

Tandem Walk test (TW):

Table (7): Mean, SD, F value & P value of the Tandem Walk **rehailitation effect** regarding SOT abnormality.

TW	Abnormal SOT		Normal SOT		F value	P value
	X`	SD	X`	SD		
Step Width	0.09	0.29	0.01	0.29	0.95	0.33
Speed	0.07	0.30	0.11	0.27	0.31	0.58
End sway	-1.68	1.61	-2.13	1.70	3.84	0.05

TW: Tandem Walk Test.

This table showed no statistically significant difference in Tandem Walk test **rehailitation effect** regarding SOT abnormality.

Discussion:

All patients in this study had normal hearing thresholds and excellent speech discrimination scores. Patients in this study revealed a true vestibular insult. This vestibular insult was unilateral. This was supported by typical history of unilateral vestibulopathy (intense sense of spinning of the surrounding accompanied by nausea, sometimes vomiting lasts for few days), and normal oculomotor tests, unilateral caloric weakness **[5]**. VNG is the cornerstone for vestibular assessment which helps to identify site and side of lesion with precision **[6]**.

The DVA quantifies the impact of unilateral peripheral vestibular pathology on a patient's ability to maintain visual acuity while moving **[7]**. Meanwhile, information provided by the DVA test is complementary to and not a substitute for VNG. On the other hand, computerized dynamic posturography (CDP) is a measure for the effective use of sensory cues (somatosensory, visual and vestibular) to maintain balance and postural control.

Vestibular rehabilitation therapy is an exercise program designed to help dizzy patients to compensate for a loss or imbalance within the vestibular system **[8].**The rationale beyond VRT originated from the fact that patients who are active, recover faster. This was based on the supposition that the head movements that provoke the patient's dizziness play an important role in hastening the recovery process **[9].**

Rehabilitation therapy whether program **A** or program **B** was shown to be effective to reduce perceived dizziness as measured by SOT, DVA and TW tests.For each patient, difference of his status pre- versus post-rehabilitation is estimated and this is termed **rehailitation effect**. This rehailitation effect is studied to compare different program and exercises.

Program (A) was proved to be more effective in helping patients to recover better or restore normal postural control on objective measures. There was astatistical significant difference in the post-rehabilitation Equilibrium Scores (C5 & Comp.) for patients who received **program (A)** especially those with abnormal SOT results (table 3 & 6). Balance could be tested more specifically when the equilibrium scores was measured in patients with eyes closed (this eliminates the visual contribution), while standing on moving platform (this reduces the contribution of foot ankle proprioception) i.e. condition (C5) **[10&11]**. **[12]** Reported that specific physiotherapy in the acute stage of the disease improves vestibulospinal compensation in vestibular neuritis patients.

Both programs were of equal value for outcome for gaze stabilization.Head movements during walking in program B help in restoring vestibule-ocular functions (table 2).

Also, **program (A)** was highly effective for rehailitation effect scores for TW test (End sway) (table, 4). This would support that VRT should not be inclusive to gaze training exercises only and patients' disabilities should be probed to provide specific therapy. These results were in agreement with **[12]** who reported that specific physiotherapy improves vestibulospinal compensation in patients with vestibular neuritis.

Our study helped in recognizing the value of addressing customized VBRT in patients with unilateral peripheral vestibular disorders in improving residual disabilities in those patients. In conclusion, results support the value of customized VBRT that should be individually tailored according to the patient's complaints, site of lesion and abilities affected. In this way, VRT could have better image among patients as well as physicians.

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