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A ROTATORY MANEUVER TO REDUCE IMBALANCE OF THE VESTIBULAR SYSTEM IN PATIENTS WITH VESTIBULAR VERTIGO

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ABSTRACT

In an attempt to diminish the intensity of vertigo, this study was designed to reduce the imbalance between the vestibular system on the two sides. By rotating the subjects with a string-activated rotating chair in opposite direction of the dominant side, the dominant side would be inhibited and simultaneously the subordinate side would be stimulated. Eight patients with vestibular vertigo confirmed by ENG and rotatory test were subjected to a rotatory stimulus, the effect of which was evaluated by rotatory test. V_{max} of the two sides of all patients were compared before the stimulus and 10, 40, and 70 minutes afterwards. The results indicate a significant difference between directional preponderance (DP) values before and after stimulation, especially at 70 minutes. The initial values of DP in 5 of 8 patients were out of the normal range and were significantly reduced to lower levels after stimulation, especially after 70 minutes when DP fell within normal limits. In two of the remaining patients, a change in direction was observed at 40 minutes, and it remained so even after 70 minutes in one of them. By minimizing the inequality between the vestibular discharge on the two sides, a reduction in vertigo intensity is expected.

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Keywords: Vestibular vertigo; Rotation; Compensation; V_{max}; Directional preponderance.

INTRODUCTION

Vestibular vertigo is the result of an imbalance between the information received by the brain from the vestibular system on the two sides. Therefore, the intensity of vertigo is expected to diminish by reducing this imbalance.

Therapeutic strategies for idiopathic vertigo include medical therapies and rehabilitation programs. Medical therapies are used for symptomatic relief whenever vertigo interferes with the patient's daily life and has no effect on the etiology of the disease. Rehabilitation programs depend on the natural compensatory mechanisms which consist of two possible types, the first being the inhibition of the dominant vestibular nucleus by the cerebellum, and the second, which appears later, is the result of a new intrinsic activity in the subordinate nucleus.[1-3] It seems that imbalance and vertigo are essential for activation of the second mechanism. Rehabilitation programs used in therapy of vertigo depend on this natural compensation and their rationale is to provoke deliberately and systematically as many spells of vertigo as can be tolerated, on an outpatient

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basis. The evaluation of the effect of rehabilitation is made by a physical or occupational therapist based on subjective changes, and the program is changed according to the current status of the patient's symptoms.[4-9]

We proposed that in a patient with vestibular vertigo, the imbalance between the two sides can be reduced by rotating the patient in the direction of the subordinate side, during which the subordinate vestibular nucleus is stimulated and the dominant one is inhibited. The vertigo is expected to diminish as a result of reduction in the difference between discharges of the two sides. If so, this process can be used as a therapeutic strategy for patients suffering from vertigo. This study was designed to verify the validity of this supposition.

METHODS

The study was conducted as a sequential double-blind clinical trial and was performed on eight subjects referred by physicians to the electrodiagnostic center of the Day General Hospital, Tehran for evaluation of their vertigo. The patients were fully informed about the study and were not charged for any of the extra procedures. The ENG—including saccadic test, smooth pursuit tracking test, optokinetic test, gaze test, and caloric test–and rotatory test were done using a Nicolet Spirit device (made in USA, 1992) and its DC current recording with a two channel Nystar program.

The following conditions were considered in selecting the subjects:

1. Having vestibular vertigo confirmed by clinical investigations, ENG, and rotatory test;
2. Having vertigo for at least 2 months, and as such not likely to improve spontaneously;[6]
3. Discontinuing drugs 24 hours before the study with permission from the patient's doctor.
4. No sex or age limitations;
5. Ignoring the central or peripheral origin of vertigo. Since whatever its origin, the intensity of vertigo is expected to diminish by stimulation of the subordinate side and inhibition of the dominant side.

A string-activated oscillating chair that moves 90 degrees both clockwise and counterclockwise from its resting point was used. As an example, releasing it from a position of 90 degrees to the left of its resting point causes a clockwise movement of 180 degrees to a position of 90 degrees to the right, and continues a series of diminishing oscillating movements until it comes to the resting point. The frequency of rotation was between 0.08 and 0.16 Hz, depending on the patients' weights.

To evaluate the degree of changes in vertigo intensity a questionnaire was prepared. Patients were interviewed immediately after the initial ENG and rotatory test to see whether or not these tests had any effect on vertigo intensity and also 10, 40, and 70 minutes after the stimulation to see if any changes had occurred in vertigo.

Immediately after a complete initial ENG (including caloric test) and rotatory test by which the dominant and subordinate sides were distinguished, the following procedure was performed. With covered but open eyes, the subjects were rotated by the chair towards the subordinate side for the first 180 degrees of its motion and were returned to the initial point slowly. This stimulation was repeated 10 times consecutively in a single session for each of the patients.

The V_{max} of each ear was recorded by rotatory test, with covered but open eyes, before the stimulation and 10, 40 and 70 minutes afterwards. All recordings were done while the subjects performed mental arithmetic, such as solving simple mathematical problems, to increase the state of alertness.

Samples of original recordings of one of the patients during the study are presented in Fig. 1.

Also, the directional preponderance (DP) was calculated

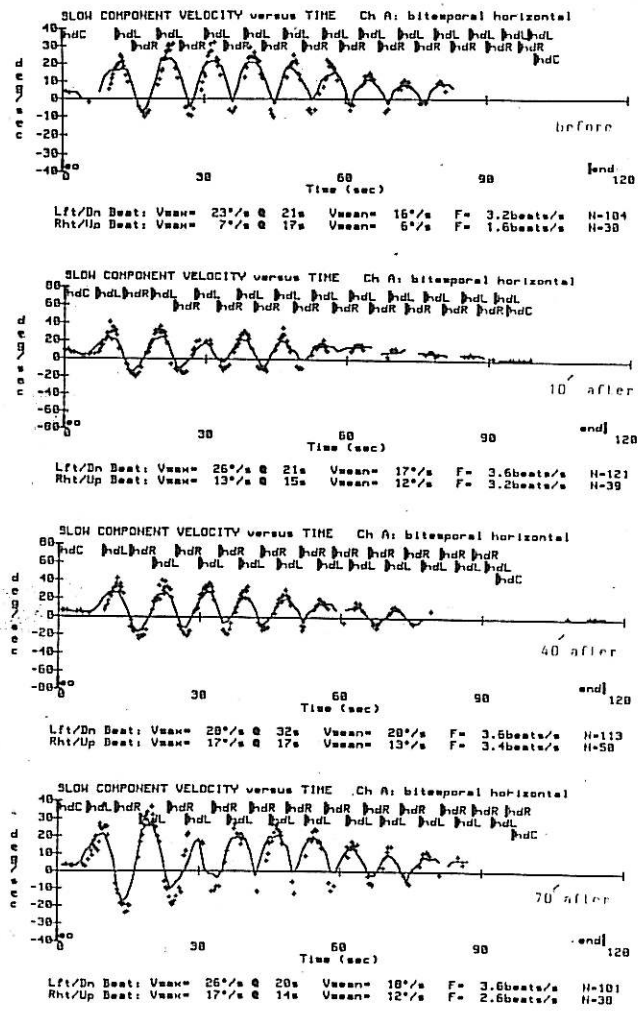

Fig. 1. Original recordings of patient no. 5 before the stimulation and 10, 40, and 70 minutes afterwards.

Table I. Specifications of patients before the study.

Patient no.	Sex	Age	Rotatory Test	
			ΔV_{max} (°/sec)	DP (%)
1	m	49	17	33.33
2	f	34	14	24.14
3	m	51	5	10.20*
4	m	24	34	48.57
5	f	45	16	53.33
6	m	25	5	5.38*
7	m	52	12	42.86
8	f	64	17	18.68*

f: female, m: male

$\Delta V_{max} = V_{max}$ (dominant) - V_{max} (subordinate); in which V_{max} is the maximum velocity of eye movement during the slow component of nystagmus.

$DP = 100 \times \Delta V_{max} / [V_{max}$ (dominant) + V_{max} (subordinate)]

*Within the normal range. The normal range for DP obtained by rotatory test is 0 to 23%.

by the formula:

$DP(\%) = 100 \times [V_{max}(D) - V_{max}(S)] [V_{max}(D) + V_{max}(S)]$ in which $V_{max}(D)$ represents V_{max} during rotation in the direction of the dominant side and $V_{max}(S)$ represents V_{max} during rotation in the direction of the subordinate side. The results show the intensity (%) but not the direction of DP. Normal range of DP for sinusoidal acceleration, using torsion swing chair, is 0-23%.

Statistical analysis

The analysis of DP values was based on analysis of variance in repeated measure design and comparison among the values obtained in different conditions was done. To confirm a normal distribution, the data was examined using the Shapiro and Wilks test (W statistics) and the normal probability plot of E. In all of the statistical comparisons, $p<0.05$ was chosen to denote significant differences.

RESULTS

The 8 patients in this study had a mean age of 43±13 years and a history of vertigo for 20 ± 26.63 months. Only 2 of the patients had been using medical therapy which had no effect on their vertigo. None of them had used rehabilitative physical exercises. Sex, age, ΔV_{max} and DP during initial rotatory test of patients are presented in Table I.

Changes in mean values of V_{max} of the dominant and subordinate sides are shown in Fig. 2. The results of DP changes showed that the factor of "time" has a significant effect on DP ($p<0.02$) (Table IIa). DP values in time intervals after the stimulation showed significant differences with the initial value, which was most prominent at 70 minutes after the stimulation ($p<0.003$) (Table IIb), but did not show any significant differences with each other.

The values of W and P are 0.959 and 0.312, respectively, therefore the null hypothesis failed to be rejected and the data had a normal distribution, which was also proved by using the normal probability plot (Fig. 3).

DP values in 5 patients were out of the normal range initially, but fell within the normal range 70 minutes after the stimulation in 3 of them and decreased in the other 2

Table II-a,b. The analysis of variance for DP.

Table IIa.

Source of Variation	DF	SS	MS	F Value	P>F
Time after rotation	3	1064.91	354.97	4.38	0.015
Patients	7	6098.56	871.22		
Error	21	1700.03	80.95		

Table IIb.

Contrast	DF	SS	MS	F Value	P>F
Before vs. 10' after	1	560.98	560.98	6.93	0.016
Before vs. 40' after	1	559.56	559.56	6.91	0.016
Before vs. 70' after	1	920.36	920.36	11.37	0.003

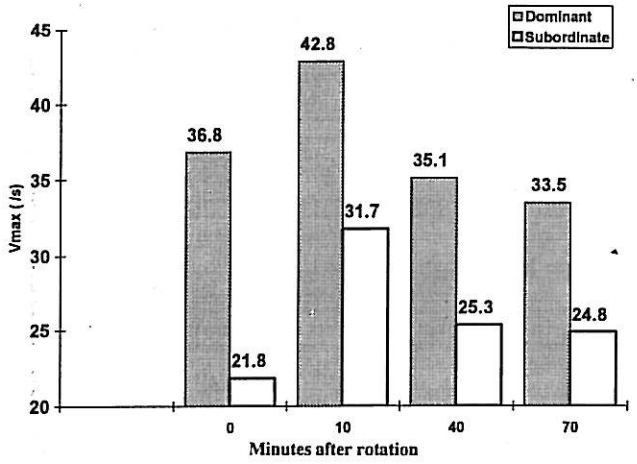

Fig. 2. Changes in mean values of V_{max} of dominant and subordinate sides in 8 patients before (0 time) and 10, 40 and 70 minutes after rotatory stimulation.

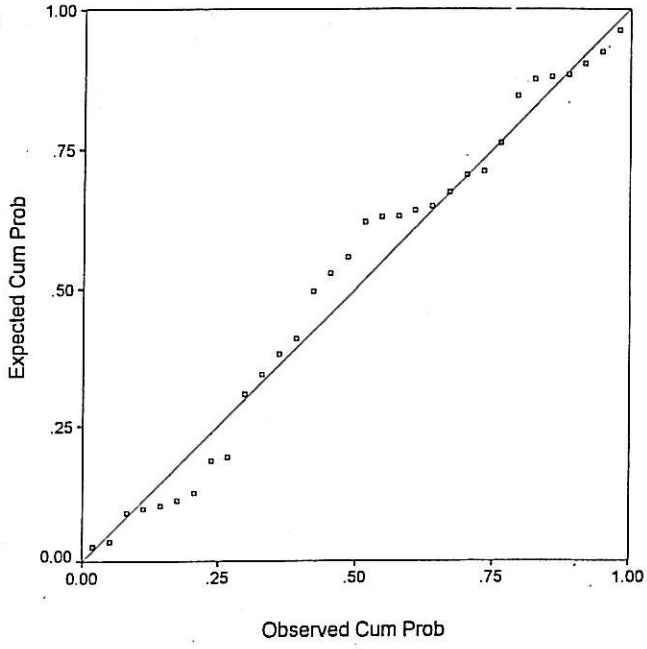

Fig. 3. Normal probability plot of E.

patients (Table III). In 2 of the remaining 3 patients with initial values in the normal range, DP became negative at 40 minutes; in one of them it still remained so 70 minutes after the stimulation (Table IV).

As shown in Table V, it can be concluded from the interview of patients that this unilateral stimulation of the vestibular system had no effect on the intensity of vertigo as perceived by them.

DISCUSSION

During rotation, the vestibular apparatus in the direction of rotation is stimulated and the one in the opposite direction

Table III. Values of directional preponderance obtained by rotatory test in 5 patients with initial values out of the normal range (0-23%).

Patient no.	Directional Preponderance (%)			
	Before rotation	Minutes after rotation		
		10	40	70
1	33.33	10.71	16.28	0
2	24.14	34.29	29.73	22.80
4	48.57	18.45	35.59	36.99
5	53.33	33.33	24.44	20.93
7	42.86	25.49	42.86	33.33
Mean(±SD)	40(±10.53)	24(±8.96)	30(±9.12)	20(±10.93)

Table IV. Values of directional preponderance obtained by rotatory test for 3 patients with initial values in the normal range (0-23%).

Patient no.	Directional Preponderance (%)			
	Before rotation	Minutes after rotation		
		10	40	70
3	10	12	-5	-14
6	5	0.8	4	5
8	19	7	-5	7

is inhibited. This happens as a result of not only the direct effect of rotation, but also an indirect effect of the contralateral vestibular apparatus. There are two types of central neurons participating in this effect: type I excitatory neurons which become stimulated by ipsilateral rotation of the head, and type II inhibitory ones which become stimulated by contralateral rotation of the head.[3] These two cell types have connections ipsilaterally as well as contralaterally. In a patient with unequal neural discharges from the two sides, the inhibition of the dominant side, during rotation in the direction of the subordinate side, is obtained as a result of both direct ipsilateral inhibitory effect and indirect contralateral excitatory stimulation of inhibitory neurons. The subordinate side is also stimulated with the same mechanisms. Therefore, even a patient with a complete unilateral peripheral vestibular lesion can be affected on that side by contralateral connections. In those who have central lesions a reduction is also expected because of a decrease in activity of the intact nucleus. We measured this reduction by observing the decrease in the difference of Vmax of the two sides and the reduction in percentage of DP during the rotatory test, before and after the rotatory stimulus.

In this study we evaluated the effect of such a stimulation on diminishing the initial imbalance between the vestibular

Table V. Subjective changes of vertigo intensity in patients under study after the initial tests and in the time intervals after the rotatory stimulation.

Change of vertigo intensity	Minutes after rotation			
	Before rotation*	10	40	70
Decrease	0	2	1	1
No change	6	4	5	5
Increase	2	2	2	2

-The numbers signify the frequency of patients.
*"Before rotation" denotes subjective changes of vertigo intensity after the initial ENG and rotatory test as compared with the intensity before coming to the electrodiagnostic center.

discharges of the two sides in patients with vestibular vertigo. It is important to note that the goal of this stimulation was not to normalize DP or ablate the imbalance between the two sides, but only to diminish the imbalance and DP towards normal.

The results of V_{max} changes as shown in Fig. 1 imply that manipulation of the vestibular system in this study decreased the difference between discharges on the two sides, nearing the equilibrium necessary for the vertigo to become suppressed. Since the increase in V_{max} of the dominant sides at 10 minutes after the study coincides with the peak response of the subordinate side, it could be considered as a rebound phenomenon which is resolved later after 40 and 70 minutes (Fig. 2).

Mean values of DP during the study show significant reductions after stimulation, especially after 70 minutes (Table IIb), which demonstrates that the imbalance is reduced. To determine the duration of this effect, measurements of the V_{max} values for longer periods are required.

To eliminate the influence of the 3 subjects with initial normal DPs, the V_{max} of the other 5 subjects are presented in Table III which shows that the mean value has fell within the normal range (0-23%) 70 minutes after stimulation.

In 2 of the 3 patients with initial DP values within the normal range obtained by rotatory test, a change in the direction of DP is observed (Table IV). This is the result of an increase in V_{max} of the initial subordinate side to values greater than that of the initial dominant side showing the effect of the stimulus in suppressing the dominant side and activating the subordinate side.

As seen from data in Table V, the initial ENG and rotatory test had not increased the intensity of vertigo from the patients' point of view. Although objective changes were seen after the unilateral stimulation of the vestibular system (Fig. 2 and Table IIb), there were no subjective changes in the population under study, which can be explained by many factors such as psychological ones. In addition, to see any significant subjective effects there is a need for more samples.

In rehabilitation programs there are difficulties, such as relying on patient compliance and performance at home, which have significant effects on the final results. In this study, the procedure was performed and followed by an expert, quantitatively and objectively, thus providing more accurate and desirable results. Thus, unilateral stimulation of the vestibular system might be used as a therapeutic strategy for vertigo, especially for patients with types of vertigo that are responsive to the usual rehabilitation programs such as labyrinthectomized patients or those who have benign paroxysmal vertigo.

Additional studies are needed to identify the proper spacing and the sufficient number of times necessary for the above procedure to produce a more lasting effect on the imbalanced output of the vestibular system. Also, a subjective investigation can be done on more patients so that the results can be analyzed statistically.

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