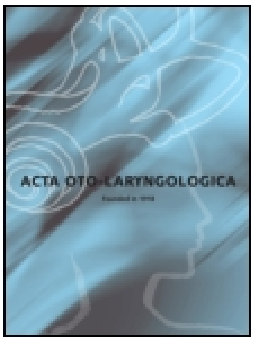

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Modification of Parameters in Vertical Optokinetic Nystagmus after Repeated Vertical Optokinetic Stimulation in Patients with Vestibular Lesions

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Eye movements were recorded in patients with unilateral and bilateral vestibular lesions after upward and downward optokinetic (OK) stimulation before and following 6 weeks' repeated exposure to OK stimulation. In control subjects there was no asymmetry between upward and downward slow-phase velocity (SPV). Before training, less subjects showed that upward and downward SPV was significantly lower than that of controls. There was no asymmetry between upward and downward SPV. After training, in unilateral cases, the values of both upward and downward SPV recovered to the control range. In bilateral cases, the downward SPV values returned to the control range, whereas the values of upward SPV exceeded the control range. The frequencies of both upward and downward OKN in controls were about 3.0 Hz. In unilateral and bilateral cases, before and after training, the OKN frequencies approximated 3.0 Hz, showing no significant differences. The recovery of the SPV in unilateral and bilateral cases after training suggests that OK stimulation acts to stabilize the body and consequently to provoke pronounced OKN, due to eye-head-body co-ordination. The asymmetry of SPV after training in bilateral cases might be a result of the lack of otolith function. *Key words: asymmetry of vertical OKN, slow phase velocity, human, vestibular lesions.*

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INTRODUCTION

It is well known that a moving visual environment induces an optokinetic nystagmus (OKN), and postural reactions during both circular and linear motions (1–3). Our previous study revealed that repeated horizontal optokinetic (OK) stimulation caused a remarkable improvement in OKN and body stabilization of patients with vestibular lesions (4).

During human movement, especially when walking, the surrounding vision induces vertical eye movements. The contribution of the vestibular system to OKN, and especially to vertical OKN, has been gradually elucidated in animal studies and human parabolic or space flight studies (5–8).

The purpose of this study was to explain the modifications in OKN following repeated OK stimulation in patients with unilateral or bilateral vestibular loss by measuring the parameters of eye movements before and after OK stimulation training.

METHODS

Optokinetic device and recording procedure

The optokinetic device was a planetarium (Simpson et al., 1981) mounted in a triple-axis system in order to project different stimulus patterns. In this study, vertical stimulation was applied. The angular velocity of the sphere was 40°/sec and the temporal frequency of dot presentation was 5.55 Hz. The angle separating projected white dots was 7.55°. The optokinetic device was located at the subject's head level. Walls, ceiling and floor in a completely darkened room were used as screens.

The subject stood constantly in an upright orthostatic position 2 m from the 'nearest wall' in front and was instructed to look at the passing dots, allowing the eyes to move freely (Stare OKN) without moving the head, and to try to maintain balance.

The sessions of eye movement recordings were conducted before and 6 weeks after the rehabilitation.

Vertical eye movements were recorded using the I.R.I.S. (Infra-Red light Eye-Movement Measurement) system. The DC signal of the vertical component of eye movement was amplified, processed on-line through an AD converter Data Translation card in a 286 micro computer. The sampling rate was 50 Hz and the signal was not filtered. Slow-phase velocity (SPV), frequency and amplitude of OKN were calculated using interactive software.

OK stimulation sessions (rehabilitation)

After recording the eye movements, the rehabilitation program commenced. The subjects were asked to stand in an upright position and to stabilize the gaze in front of their vision without following the dots and to try to keep their balance. The stimulus was maintained until the subject began to sway and stopped before the limit of stability was reached. The direction was then reversed.

Duration of the rehabilitation never exceeded 15 min. The therapy continued for 6 weeks and required two sessions per week. After the treatment, subjects were re-evaluated on the same tests.

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Patients

Two groups of patients were submitted to repeated OK stimulations. These patients were tested at the ENT Department of Hôpital Pitié-Salpétrière in Paris with the following neuro-otological examinations: pure-tone audiometory, impedance audiometry, caloric test, electro-oculographic recordings of smooth pursuit and saccades, and ocular counter rolling test under an infra red video camera. They were also submitted to high velocity step stimulations ($>400°/sec$) on a rotatory chair to measure the post-rotatory nystagmus. CT-Scan and MRI were carried out in order to rule out brain and/or hind brain lesions.

The first group comprised 2 unilateral labyrinthine-defective patients (2 males) in the age range 53–58 years (mean 56 years). None demonstrated any spontaneous nystagmus nor showed any caloric response on the surgical side.

The second group, of 5 bilateral labyrinthine-defective patients (1 female, 2 males), ranged in age from 34 to 62 years (mean 47 years). They showed no response to caloric stimulation on either side, and did not present any post-rotatory nystagmus. They did not show any counter rolling when examined with the infra red video camera. All these patients had been treated with aminoglycoside (gentamycin) for severe infections.

These unilateral and bilateral patients were enrolled for training 1–3 months after surgery or onset of incidence. Before training, they still had the complications dizziness while walking and balance disorders especially in the dark.

Control responses were obtained by recording 5 age-matched, normal healthy volunteers (2 females, 3 males) ranging in age from 35 to 58 years (mean 45 years).

RESULTS

Fig. 1 demonstrates a typical recording of eye movements during OK stimulation. Control subjects showed no visible body sway during recording. In contrast, before training, patients with unilateral or

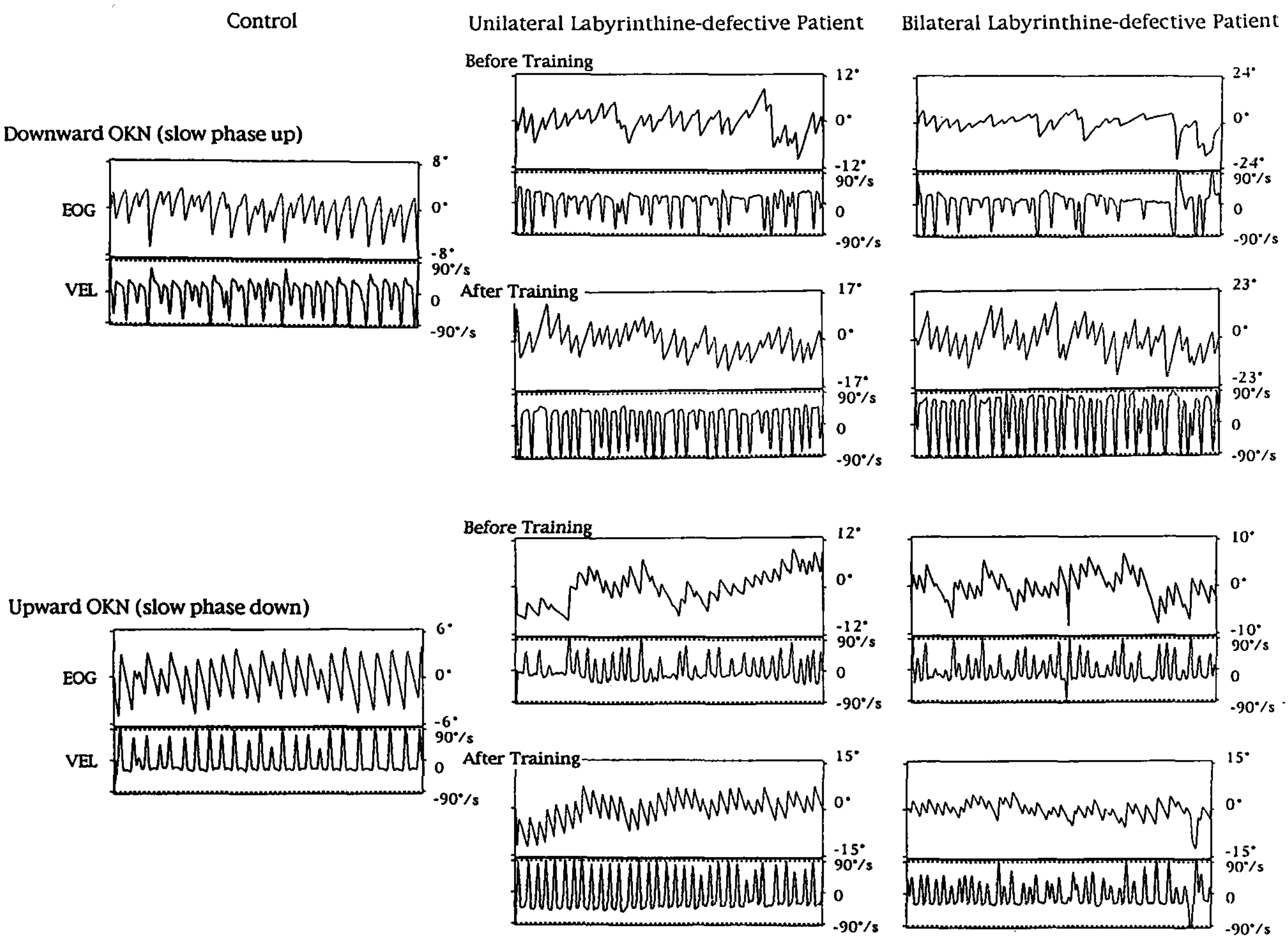

Fig. 1. Recording of typical eye movements during vertical optokinetic stimulation. Time constant is 10 sec. *EOG*: recording of eye movements. *VEL*: velocity of eye movements calculated from EOG. Note that the scale of EOG is not same.

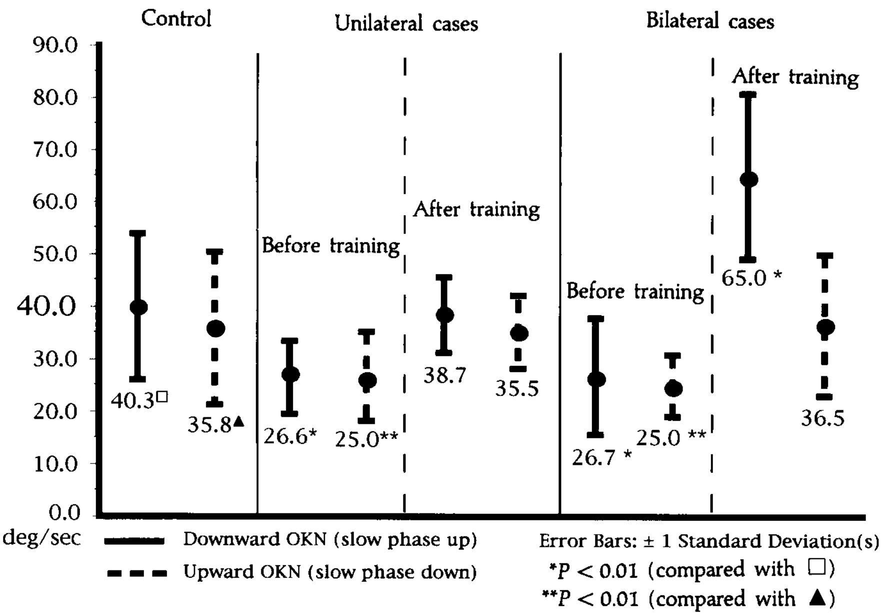

Fig. 2. Averaged slow-phase velocity during vertical OK stimulation.

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bilateral vestibular loss showed severe body sway and difficulty in maintaining an upright stance. After training, both these groups showed an improvement of body sway during vertical OK stimulation or dizziness while walking and balance disorders especially in the dark.

1. Slow-phase Velocity (SPV) of OKN (Fig. 2)

Control subjects

The mean upward SPV (Downward OKN) was 40.3°/sec (±S.D. = 14.0). The downward SPV (Upward OKN) was 35.8°/sec (±S.D. = 14.6). The difference between upward and downward SPV was small. In the t-test, no difference was found between these two values when the probability value was 1%; with a probability value 5% there was some difference.

Unilateral vestibular defect patients

Before training: The mean upward SPV was 26.5°/sec (±S.D. = 6.99). The downward SPV was 25.0°/sec (±S.D. = 7.21). The values of both upward and downward SPV were significantly lower than that of the control range ($p < 0.01$) in the t-test. In comparison with upward and downward SPV, no significant statistical difference were detected.

After training: The mean upward SPV was 38.7°/sec (±S.D. = 7.23). The downward SPV was 35.6°/sec (±S.D. = 6.67). The values of upward and downward SPV returned to the control range. No asymmetry was observed between the values of upward and of downward SPV.

Bilateral vestibular defect patients

Before training: The mean upward SPV was 26.7°/sec (±S.D. = 11.1). The downward SPV was 25.0°/sec (±S.D. = 5.75). The values of both upward and downward SPV were significantly lower than that of the control range ($p < 0.01$) in the t-test. In comparison with upward and downward SPV, no significant statistical difference were found.

Table I. *Frequency of nystagmus*

		Unilateral cases		Bilateral cases	
	Control	Before training	After training	Before training	After training
Downward OKN (slow phase up)					
Mean (Hz)	2.8	2.6	3.0	2.8	3.3
S.D.	0.53	0.37	0.26	0.23	0.30
Upward OKN (slow phase down)					
Mean (Hz)	2.9	2.8	3.2	3.1	3.4
S.D.	0.46	0.18	0.57	0.35	0.32

After training: The mean upward SPV was 65.0°/sec (±S.D. = 15.8). The downward SPV was 36.5°/sec (±S.D. = 13.4). Though the values of downward SPV returned to the control range, the values of upward SPV significantly and statistically exceeded the control range ($p < 0.01$) in the t-test. Considerable asymmetry was observed between the values of upward and downward SPV.

2. OKN frequency (Table I)

The frequencies of upward and downward OKN in controls were about 3.0 Hz. In unilateral and bilateral cases before and after training, the frequencies of upward and downward OKN were about 3.0 Hz, showing no significant differences.

COMMENTS

We have observed marked improvements in both OKN and posture control after 6 weeks of optokinetic stimulation. These improvements could be part of the recovery and compensatory process brought on by optokinetic stimulation. It is well known that patients with unilateral or bilateral labyrinth lesions take at least one year in order to regain complete recovery, especially from the dizziness experienced while walking, or a disturbed sense of balance in darkness (9).

The results of the large degree of asymmetry between upward and downward SPV in bilateral cases after training are though to be due to the lack of otolith function. Clinical examinations in our bilateral cases indicated that the otolith of these patients was lost or severly damaged. Igarashi et al. (5) reported that in squirrel monkey, following bilateral macular ablation, upward SPV exceeded downward SPV. Under the influence of normal gravity, the otolith acts to inhibit the vertical optokinetic system, especially upward SPV (5, 6). Moreover, human parabolic flight and space flight studies (7, 8) have also assumed this hypothesis.

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