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ORIGINAL CLINICAL RESEARCH

Optokinetic stimulation rehabilitation in preventing seasickness

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KEYWORDS
Seasickness;
Motion sickness;
Adaptation;
Optokinetic stimulation;
Prognostic factors

Summary
Objectives: Seasickness occurs when traveling on a boat: symptoms such as vomiting are very disturbing and may be responsible for discontinuing travel or occupation and can become life-threatening. The failure of classical treatment to prevent seasickness has motivated this retrospective study exploring optokinetic stimulation in reducing these symptoms.
Patients and methods: Experimental training of 75 sailors with optokinetic stimulation attempted to reduce seasickness manifestations and determine the factors that could predict accommodation problems.
Results: Eighty percent of the trained subjects were able to return on board. No predictive factors such as sex, occupation, degree of illness, number of treatment sessions, time to follow-up, and age were found to influence training efficacy.
Conclusion: Optokinetic stimulation appears to be promising in the treatment of seasickness. Nevertheless, statistically significant results have yet to demonstrate its efficacy.

Introduction

Seasickness, or naupathia, is defined as the clinical manifestations that an individual traveling aboard a sea vessel can present.

The manifestations of seasickness are characterized by the frequency and intensity of vomiting as the duration of boat travel extends or as the movements of the sea amplify. Most often, after 2—4 days at sea, the symptoms attenuate and disappear, after a period of adaptation or getting used to the sea. Otherwise, seasickness persists for the entire passage and repetitive vomiting can even threaten the vital prognosis. Therefore, the existence of vomiting that is resistant to all preventive measures can compel one to renounce sailing and incite veritable human and occupa-

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tional problems. In sailors presenting invalidating naupathia, optokinetic training seems to provide promising results. A prospective study was conducted between 1996 and 2008 at the Brest (France) Training Hospital of the Armies (*hôpital d'instruction des armées* [HIA]). The objectives of this study were to measure the failure rate after optokinetic rehabilitation in a cohort of subjects suffering from seasickness and to compare the population with successful results with the population failing rehabilitation in an attempt to determine the prognostic factors of failure of naupathia rehabilitation.

Patients and methods

This was a prospective study. All the patients presenting seasickness resistant to the classical preventive treatments [1] or side effects that were incompatible with sustained vigilance or a position of responsibility, with no cochleovestibular pathology, having consulted between 1996 and 2008 at the Brest HIA, were included in the study.

The first ENT consultation included:

- patient history: a history of infectious ORL or post-traumatic pathologies, of motion sickness in childhood, a history of medication or toxic substance consumption, and collection of functional signs and their position on the modified Graybiel and Miller scale [2];
- a clinical examination: an otoscopy, an acoumetry, and a vestibular examination to rule out any cochleovestibular involvement and a functional exploration grouping the threshold tonal audiometric test, a vocal audiometric test, a test of the subjective vertical, auditory and sacculocollic evoked potentials, a videonystagmography, and a dynamic posturography test: Equitest™ (NeuroCom International, Inc. Clackamas, Oregon, USA).

Rehabilitation protocol: if the workup results were normal, optokinetic stimulation was provided once a week for 10—14 weeks:

- the first two sessions were based on measuring ocular fixation time:
  - after undergoing five clockwise rotations at a speed of 100 rotations per second in a seated position, the subject was requested to fixate a point located 2 m ahead and to indicate when this point, set in motion with ocular saccades, again appeared static,
  - the test was reproduced in a counterclockwise direction, then the entire maneuver was repeated four times. At the end of the session, optokinetic stimulation lasting 3—5 min in a darkroom was carried out for an initial contact with the procedure;
- the following 8—12 sessions were based on optokinetic stimulation alone:
  - the optokinetic reflex was stimulated in the standing position, in a dark room, facing a wall with no markings. The light stimuli of a planetarium acting on the peripheral retina were applied horizontally, then more and more obliquely depending on the subject's tolerance. Initially at zero, the speed was progressively increased until an illusion of movement was produced causing postural deviation or vection that the subject was instructed to resist. During the sessions, the subject's adaptation allowed working with the same stimulation while instability was increased by adding a block of foam under the patient's feet, followed by an oscillating platform. Rehabilitation ended when the patient tolerated optokinetic stimulations without significant instability and no nausea for 20—30 min or when 14 sessions had been completed.

Evaluation of the results

As far as possible, the subjects were requested to come in or were contacted by telephone 1 month after the rehabilitation so as to assess the results of the rehabilitation after resuming sailing. For various reasons (not resuming sailing immediately, a trip abroad, relocation, etc.), certain subjects were not contacted in the time initially allotted. However, since this reevaluation time could not improve the effects of the rehabilitation (given this was a population that had spontaneously failed to become accustomed to boat travel), these subjects were nevertheless included in the study. Obtaining a score less than or equal to 2 on the modified Graybiel and Miller scale (Table 1) was synonymous with improvement, with disappearance of vomiting defining the success group.

The final evaluation questionnaire also included the following questions:

- did you feel an improvement while on a boat?
- if the rehabilitation were to be repeated, would you do it again?
- given your result, do you feel it was worth the effort?
- if necessary, would you recommend this method to a friend?

Statistical analysis

The data were analyzed using the Stata9 AS® software. The percentages were compared using the Fisher exact test, and the means were compared using the Student *t*-test.

Results

As for the initial workup, the notion of visual dependence promoting the onset of seasickness was not found during dynamic posturography. The tests with Equitest™ include standard parameterization for sensitivity and demonstrated normal results for all subjects.

Among the 88 patients initially retained, only 75 were included in the study and 13 were excluded:

- three because they stopped the rehabilitation before the end;
- four because a vestibular pathology was discovered secondarily (one case of neuronitis, one case of benign paroxysmal positional vertigo, and two cases of asymmetric cochlear hearing loss);
- four patients decided to stop sailing (one was assigned shore duty, one preferred to give up sailing, and the last two did not renew their contract at its term);

Table 1 Graybiel and Miller modified scale [2]. Symptoms experienced and scored.

Number of points Attributed to symptoms below	16	8	4	2	1
Digestive signs	Vomiting	Major or considerable nausea	Moderate nausea	Gastric discomfort	Epigastric discomfort
Skin color		Major or considerable paleness	Moderate paleness	Slight paleness	Flush
Cold sweats		Major or considerable	Moderate	Minor	
Increase in salivary secretions		Major or considerable	Moderate	Slight	
Somnolence		Major or considerable	Moderate	Slight	
Pain					Headaches
Central nervous system signs					Dizziness

Stage 1 (1—2 points): minor sickness; Stage 2 (3—7 points): moderate sickness; Stage 3 (8—15 points): severe sickness; Stage 4 ($\geq$ 16 points): malaise.

- two subjects could not be recontacted and were classed as lost to follow-up.

Of the 13 excluded subjects, 69.2% were males, with a mean age of 29.8 years with no statistically significant difference on the sex (P = 0.3) and age (P = 0.4) variables with the success group. The professional sailors were statistically more numerous in the excluded group (P = 0.01).

Of the 75 patients included in the study, 58.7% were males and 54.7% were recreational sailors. The mean age of the patients was 32.8 years (range, 10—75 years; median, 30 years); the mean age was not significantly different in men (34.6 years) than in women (31.4 years) (P = 0.3).

Before rehabilitation, 98.7% (74/75) of the patients had an initial score of 3 or 4 on the modified Graybiel and Miller scale.

The degree of seasickness severity estimated by this score was not significantly different for sex (P = 0.2), type of activity (P = 0.6), and subject age (P = 0.9).

The mean number of rehabilitation sessions was 8.4 (range, 5—14; median, 8).

The postrehabilitation questionnaire was conducted a mean 15.5 months after rehabilitation (range, 1 month to 6.7 years; median, 12 months). During the reevaluation, 15 subjects (20%) still presented uncontrollable vomiting, making up the failure group.

The success group comprised 60 individuals who felt better when on a boat, with no vomiting, and presented clearly improved scores (grade I or II) on the modified Graybiel and Miller scale. In addition, 70 patients out of 75 reported improvement in their tolerance for another mode of transport.

No statistically significant difference was demonstrated between patients in therapeutic failure and those in therapeutic success in terms of the following variables: sex, type of activity, initial score on the modified Graybiel and Miller scale, number of sessions, time of follow-up, and patient age (Tables 2 and 3).

Finally, the patients for whom optokinetic rehabilitation was successful declared they were ready to recommend it to a friend and to undergo the treatment again if necessary. On this point, the difference with the failure group was statistically significant (Table 4).

Discussion

The incidence of naupathia varies according to the magnitude of the stimulus and the subject's susceptibility, but can reach nearly 100% on very rough seas.

As for kinetosis in general, women seem more affected than men (sex-ratio, 1.7/1), with shorter time to instigation and higher intensity of sensations and longer time to recu-

Table 2 Factors involved in success of treatment by optokinetic stimulation.

	Success (n = 60)		Failure (n = 15)		OR	95% CI[a]	P
	n	%	n	%			
Sex							
Male	36	60.0	8	53.3	1.3	0.4—4.1	0.6
Female	24	40.0	7	46.7	1.0	-	
Type of activity							
Professional sailor	32	53.3	9	60.0	0.8	0.2—2.4	0.6
Recreational sailor	28	46.7	6	40.0	1.0	-	
Initial score, modified Graybiel and Miller scale							
> 3	53	88.3	13	86.7	1.2	0.2—6.3	0.9
≤ 3	7	11.7	2	13.3	1.0	-	

[a] 95% confidence interval.

Table 3 Influence of age, length of treatment and follow-up on optokinetic stimulation results.

	Success ($n = 60$)	Failure ($n = 15$)	P
Mean age, years ($n = 75$)	32.2	35.0	0.4
Number of sessions required ($n = 75$)	8.4	8.2	0.7
Mean duration of treatment, months ($n = 75$)	15.3	16.3	0.8

peration [3,4]. No hormonal influence was demonstrated [4,5]. Other factors may intervene such as ethnic origin [6], fear or anxiety, fatigue, poor health, and/or medication or alcohol consumption, or even low blood pressure [7], or more specifically cerebral perfusion pressure [8]. Other authors suggest a possible aggravating role in the frequency and intensity of kinetosis played by serotonin insufficiency [9,10] or the importance of psychological conditioning, the vagal phase of nycthemeral rhythm, and gastric emptiness or fullness [11].

Finally, the frequency of naupathia can be increased by other factors such as the presence of odors, smoke vapors, carbon monoxide, as well as by inadequate ventilation [12].

In addition, purely visual stimulations are sufficient to induce kinetosis and the use of driving simulators or virtual reality systems has regularly verified this [13—15]. Nystagmus induced by movement may cause an influx of proprioceptive information to the brain, combined with nociceptive information related to ocular hypertension and relayed by ocular fibers of the trigeminal nerve, resulting in the onset of nausea [16]. In fact, it would seem that postural instability induced by these visual stimuli are increasingly pronounced the more the subject presents a visual dependence and a strong susceptibility to kinetosis [17].

Rehabilitation techniques aim to promote the adaptation process, which has been observed notably in fighter pilots [18]. The use of optokinetic stimulation can reproduce the manifestations of motion sickness with increasing rapidity [9,13,19]. This technique is based on the use of vestibulovisual conflict induced in the patient, but also on establishing a pseudo-Coriolis effect related to a defect in the subjective vertical [13]. Several studies on patients with susceptibility to kinetosis have demonstrated that adaptation appears after several sessions of optokinetic stimulations [2,20]. This adaptation can be assessed by comparing the scores obtained before and after rehabilitation on the modified Graybiel and Miller scale.

The initial objective of this study was to show the efficacy of optokinetic stimulation in rehabilitation of invalidating seasickness. This type of study rapidly turned out to be difficult to conduct for several reasons:

- establishing a randomly selected control group (self-rehabilitated by sailing) and an experimental group undergoing rehabilitation with optokinetic stimulation was detrimental to the nontreated group that had to wait 3 months before benefitting from the rehabilitation;
- the individuals concerned by this rehabilitation had already attempted, in vain, to continue to sail with recourse to most of the existing prevention methods and were waiting for results in as short a time as possible.

Since the results showed no significant difference in terms of sex, age, type of activity, number of rehabilitation sessions, and time to follow-up between the patients treated successfully and those who encountered treatment failure, we attempted to find an explanation:

- the current studies [3,4] do not allow one to draw conclusions on the predisposition of women to seasickness or on the role played by the menstrual cycle in these disorders.

  At the beginning of the study, women who were professional sailors seemed to present a better response to rehabilitation. These partial results suggested the possibility of a role played by stronger motivation in women working within an essentially male environment. The feminization of the Navy and the development of recreational sailing have extended the female population studied and contradicted this hypothesis. In our study, therefore, sex did not seem to be a predictive factor of rehabilitation failure;
- with the development of recreational sailing, the requests for treating the manifestations of seasickness are increasing in this category of nonprofessional sailors and today accounts for nearly 55% of our consultations. The predisposition of this population to rehabilitation failure, potentially less motivated than professional sailors, in whom the presence of naupathia could be a more important handicap, has been disproved. The analysis of these results concludes in the presence of similar values in the two groups in terms of rehabilitation success or failure;

Table 4 Patient's opinions on their treatment after optokinetic stimulation.

	Success ($n = 60$)		Failure ($n = 15$)		P
	n	%	n	%	
Patient willing to follow treatment again	60	100.0	7	46.7	0.0001
Patient willing to recommend this technique to another	60	100.0	12	80.0	0.007
Patient that the technique was worth trying	60	100.0	7	46.7	0.0001
Patient improved in other modes of transport	60	100.0	10	100	—

- finally, the difficulty of the rehabilitation is not a negative factor since most of the subjects questioned would be willing to do it again and to recommend it, and consider that it was worth the effort. Moreover, withdrawal from the rehabilitation because of vomiting sometimes caused by the optokinetic stimulations was rare.

Comparing these results with those reported in the literature is difficult because of the absence of a reference study. Certain investigations have reported efficacy of rehabilitation in pilots [18] and others report adaptation after optokinetic stimulation [20], but the publications on their application in treating seasickness are rare.

Setting up a new protocol based on establishing a nonrehabilitated control group of sailors over a 3-month period while the experimental group is treated is now underway. It should therefore be possible to test the efficacy of optokinetic rehabilitation versus self-rehabilitation, even if the application of a double-blind protocol is unachievable given the conditions in which the rehabilitation was conducted.

Finally, the search for predictive factors for rehabilitation success or failure (study of latency times, attempt to modify the parameters of dynamic posturography, etc.) is the subject of a completely separate study within a doctoral thesis currently underway in the department.

Conclusion

The rehabilitation technique for naupathia using optokinetic stimulation seems promising because more than 80% of the patients treated in our institution declared they were satisfied and no longer experienced vomiting, which was the main motive for consultation.

This procedure may seem long and unpleasant, but it presents few risks and is designed for individuals suffering from invalidating naupathia that was resistant to all preventive medications.

This study did not identify prognostic factors for success for optokinetic rehabilitation given the study conditions and the small numbers of subjects in each subgroup.

A new protocol based on inclusion of a control group exposed to self-rehabilitation consisting of continuation of sailing should allow a more reliable statistical analysis.

Conflict of interest statement

None.

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