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Research Report

A THRESHOLD CALORIC TEST: RESULTS IN NORMAL SUBJECTS*

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U. S. NAVAL SCHOOL OF AVIATION MEDICINE
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SUMMARY PAGE

THE PROBLEM

A threshold caloric test procedure is described and the results of the test in 104 subjects are presented.

FINDINGS

In a young male population, the threshold responses to hot and cold caloric stimulation will be found within 1.5°C either side of body temperature. Threshold values greater than 1.5°C from body temperature may indicate an abnormal labyrinth. Evidence is shown which suggests that repeated threshold caloric irrigations produce little or no habituation.

INTRODUCTION

The caloric test is one of the most frequently used methods of evaluating the function of the semicircular canals. The use of thermal stimulation enables the investigator to assess individual labyrinthine function, determine directional preponderance, and to study the effects of drugs, infection, and other extra-labyrinthine factors. Many improvements have been made in the caloric test procedure, including control of mental alertness (1), accurate head positioning to insure that the horizontal canal is vertical, elimination of ocular fixation (1,8), and the use of electro-nystagmography. Despite these improvements, many of the caloric tests currently in use (3,5) have limitations. Habituation to repeated caloric stimulation has been demonstrated in animal (4) and man (7), and small decreases in vestibular function may be masked when strong caloric stimulation is used to elicit a nystagmic response.

Kobrak (6) was the first to use the minimal stimulation technique, the test developing out of the need for a more sensitive method to evaluate neurological patients and those with Menière's disease. Kobrak was concerned primarily with avoiding giddiness which was frequently produced when ice water was used during the caloric irrigation. He felt this sensation influenced the response obtained. Since that time, improved methods for more accurate temperature regulation and awareness of other variables have provided means for improving a threshold caloric test.

The purpose of this report is to describe a threshold caloric test devised in this laboratory and to show results which have been obtained in normal subjects using this technique.

PROCEDURE

SUBJECTS

The subjects in this study were divided into two groups. Group A consisted of fourteen normal males between the ages of 18 and 37, and the screening procedure used in selecting subjects for Group A was a negative history for ear disease. Group B was made up of ninety enlisted personnel, predominantly between ages 17 and 25, who had passed the minimum medical requirements for military service. A past history of ear disease did not prevent a subject from inclusion in Group B.

APPARATUS

The apparatus consisted of a constant temperature regulator, a thermistor, and a telethermometer to maintain the water temperature bath constant. The thermistor was used in the tip of the irrigating nozzle to detect water temperature as it left the end of the irrigating tube, and the telethermometer recorded the thermistor

temperature to the nearest 0.2°C . The nozzle tip was 1 mm in diameter and delivered a water volume of 100 cc during the forty seconds of irrigation.

Horizontal nystagmus was recorded in Group A only, using a Sanborn polygraph recorder, by means of the corneo-retinal potential technique and the nystagmus was observed through Frenzel lens during the recording procedure.

METHOD

Each subject was positioned in an ENT chair so that a line drawn from the outer canthus of the eye to the tragus of the ear would be vertical. This placed the horizontal canals approximately in the vertical plane. When electronystagmography was used (Group A) 20-degree eye movement calibrations were obtained prior to caloric irrigation. Frenzel lens were placed over the subject's eyes in both Groups A and B to decrease ocular fixation and allow visual observation. The stimulus was 100 cc of water delivered against the ear drum in a period of forty seconds. Ten seconds prior to the cessation of stimulation, the subject was given a mathematical problem to maintain mental alertness, and the room was darkened. The Frenzel lens remained illuminated. The eyes were also observed for a nystagmic response for a period of forty-five to sixty seconds after cessation of irrigation. Visual observation and the findings on electronystagmography in Group A were recorded independently. A positive response was defined as a minimum of three nystagmic beats in succession in the appropriate direction. The subject was instructed to look straight forward, i.e., toward the ceiling, even though the lens and darkened room prevented vision.

In Group A, the initial temperature used in irrigation was 36.4°C and 38.0°C for the cold and hot thresholds, respectively. The temperature was adjusted down or up 0.4°C until a response was obtained and the threshold was determined to the nearest 0.2°C . Cold threshold determinations were made first.

Group B received only cold threshold calorics, and 36.4°C was used as the arbitrary upper limit in order to shorten the procedure. This figure was selected because the results in earlier tests had indicated few responses above the 36.4°C to 36.6°C range. Visual observation alone was used in determining the threshold in Group B.

RESULTS AND DISCUSSION

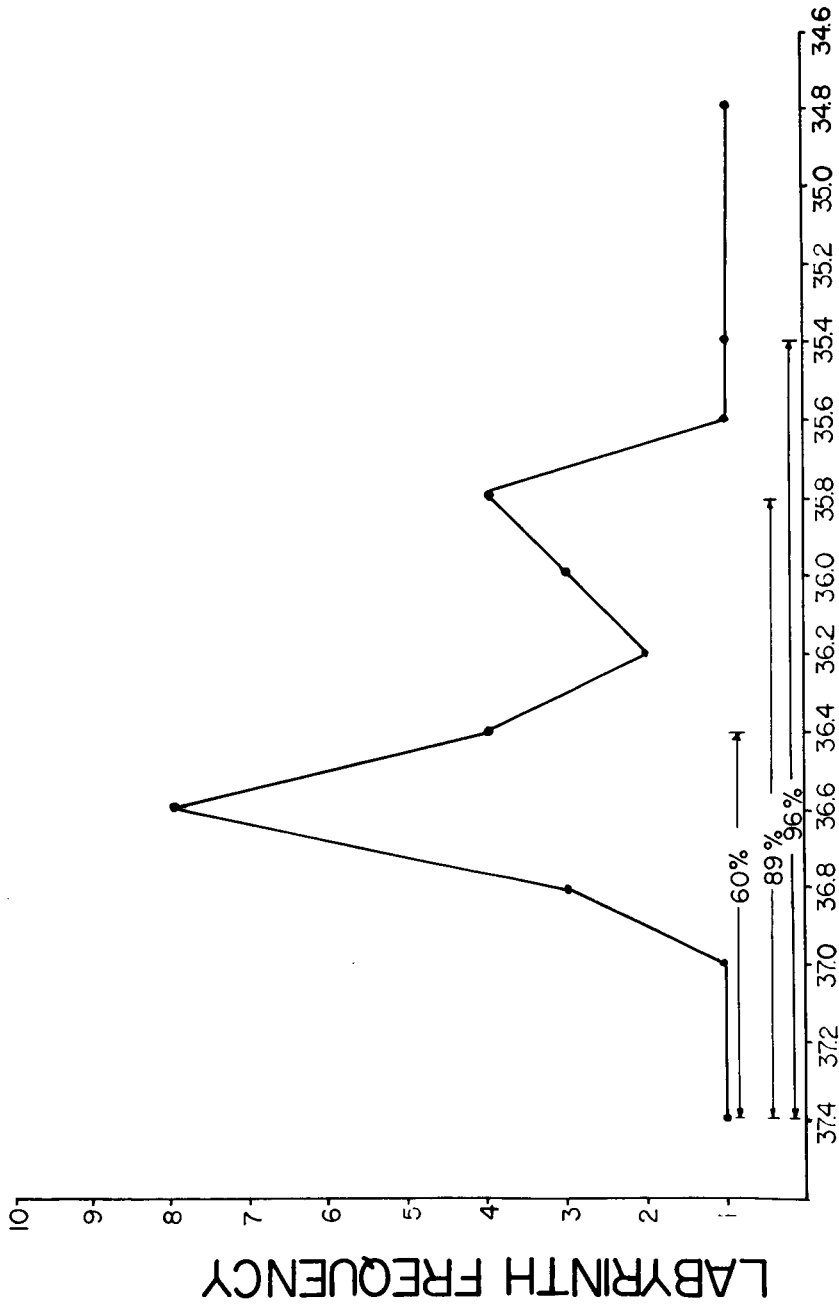
The values obtained by visual observation and electronystagmography for the cold and hot threshold caloric test in Group A were recorded separately and are presented in Table I. Frequency distribution of these threshold values for the cold and hot caloric test as determined by visual observation alone are shown in Figures 1 and 2, respectively. There was general agreement between the threshold values determined by visual observation and electronystagmography, but visual observation in general was more sensitive in detecting a minimal response. The difference

SUBJ.	RIGHT			EAR			LEFT			EAR		
	COLD			HOT			COLD			HOT		
	VIS	ENG	ENG	VIS	ENG	ENG	VIS	ENG	ENG	VIS	ENG	ENG
1	FR	36.2	36.2	38.6	39.0		36.6	36.6	37.4	37.4	37.4	37.4
2	DA	36.0	36.0	38.2	38.4		36.2	35.8	38.4	38.4	38.6	38.6
3	WE	35.8	35.4	38.4	38.4		35.8	35.8	38.2	38.2	38.4	38.4
4	GI	37.0	37.0	38.4	38.4		37.4	37.4	38.6	38.6	38.6	38.6
5	KU	36.8	36.8	38.2	38.4		36.4	36.4	38.2	38.2	38.2	38.2
6	LE	36.0	35.8	37.8	37.8		36.8	36.6	38.4	38.4	38.4	38.4
7	GIL	36.0	36.0	38.0	38.2		35.8	35.6	37.8	37.8	38.0	38.0
8	OV	36.4	36.2	38.0	38.0		36.4	36.2	37.6	37.6	37.8	37.8
9	PO	36.8	36.8	38.2	38.6		34.8	34.5	37.8	37.8	37.8	37.8
10	SA	36.6	36.4	37.4	37.4		36.6	36.2	37.8	37.8	37.8	37.8
11	JO	36.6	36.6	38.2	38.2		36.6	36.6	37.6	37.6	37.8	37.8
12	POE	35.8	35.4	38.4	38.4		35.4	35.0	38.4	38.4	38.4	38.4
13	TR	36.6	36.6	38.2	38.2		36.6	36.4	38.0	38.0	38.0	38.0
14	HA	36.4	36.2	38.2	38.2		36.6	36.6	38.0	38.0	38.0	38.0

ENG = THRESHOLD TEMPERATURE IN DEGREES CENTIGRADE BY ELECTRONYSTAGMOGRAPHY
 VIS = VISUAL OBSERVATION

Table I

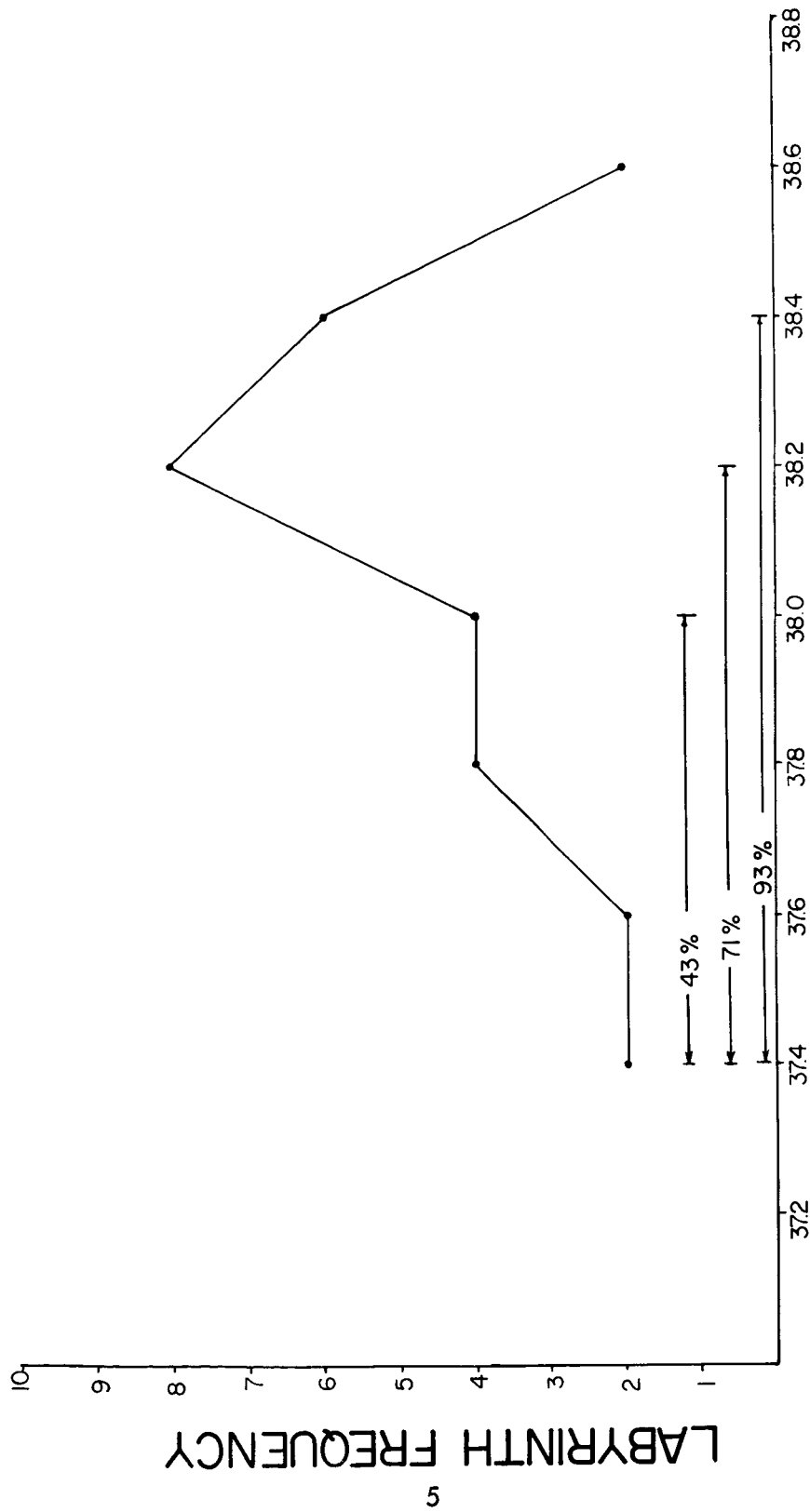
Cold and Hot Threshold Values in Group A (14 Subjects) As Determined by Visual Observation and Electronystagmography
 (The Threshold Response, 37.4 °C, in Subject Gi Occurred with a Body Temperature of 37.9°C.)



COLD CALORIC THRESHOLD TEMPERATURE IN DEGREES CENTIGRADE

Figure 1

Frequency Distribution of Cold Thresholds Determined Visually for 28 Labyrinths (14 Subjects in Group A). 89 Per Cent of Threshold Responses between 35.8 and 37.4°C and 96 Per Cent between 35.4 and 37.4°C.



HOT CALORIC THRESHOLD TEMPERATURE IN DEGREES CENTIGRADE

Figure 2

Frequency Distribution of Hot Thresholds Determined Visually for 28 Labyrinths (14 Subjects) in Group A.

between the visual threshold and recorded threshold never exceeded 0.4°C in Group A. In Figure 1, 89 per cent of the canalicular responses were between 35.8°C and body temperature in the cold threshold determination; and 96 per cent were between 35.4°C and body temperature. Figure 2 shows that 93 per cent of the hot threshold values as determined by visual observation were between 37.4° and 38.4°C .

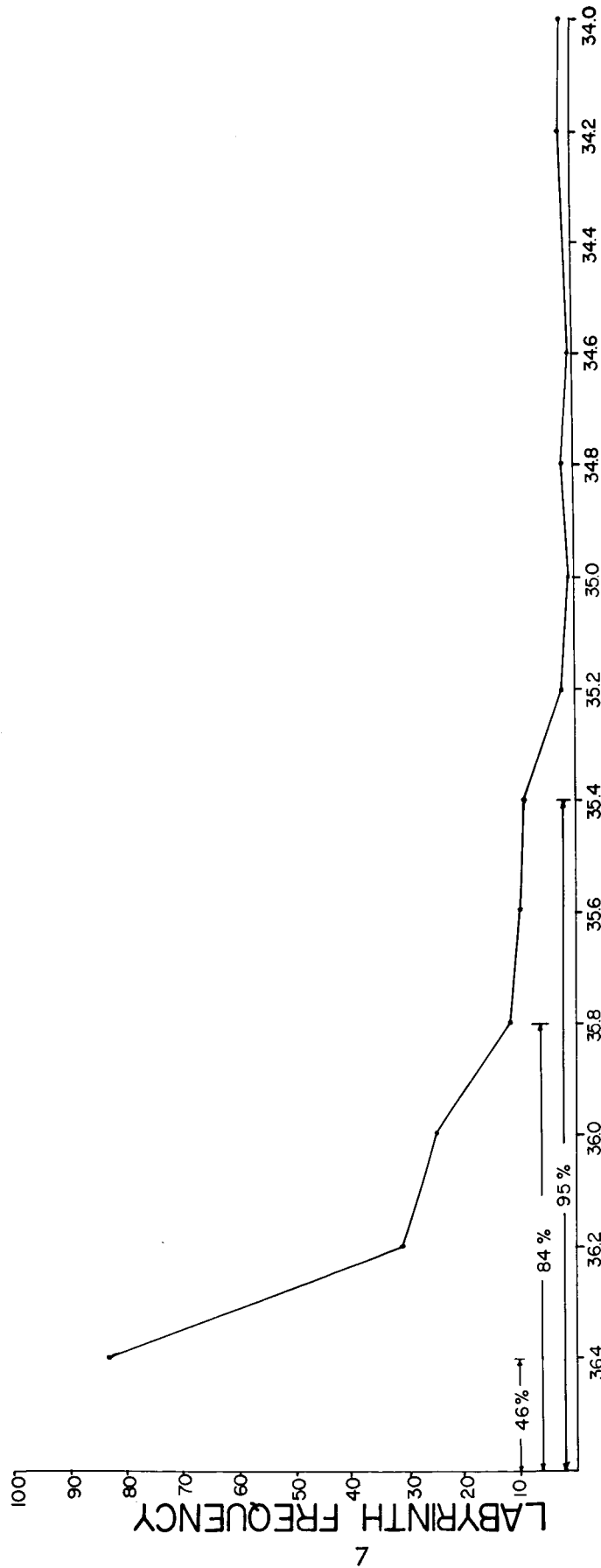
The findings in Group B are demonstrated in Figure 3 in a frequency distribution. Although Group A was more carefully screened by medical history than Group B, the findings were about the same for the two groups in regard to frequency distribution of threshold responses. The generally higher values in the fourteen subjects in Group A may be explained by the selection procedure used in these subjects; i.e., a past history of ear disease excluded subjects from Group A but not from Group B. The similar findings in Group A and B support the use of 36.4°C as a reasonable arbitrary starting point in Group B.

In this study, with the head properly positioned and the subject mentally alert, 95 per cent of all subjects had threshold values between 35.4°C and body temperature. On a statistical basis, it is reasonable to believe that values outside this range may be indicative of an abnormal labyrinth. Using the threshold technique, preliminary testing in a few patients with Menière's disease and positional vertigo with values below 35.8°C in the suspected abnormal ear lends support to this contention.

Ninety-three per cent of Group A had hot threshold determinations between 37.4 and 38.4°C . Experience with the hot threshold caloric test is limited, and more work is needed to define the normal range as well as explore its use with the cold threshold caloric test in determining directional preponderance.

An indication that this test procedure avoids some variability due to habituation was obtained from four subjects who were exposed to constant rotation on the Pensacola Slow Rotation Room (2). Daily cold water threshold determinations during the ten-day experiment revealed no tendency toward habituation to the caloric procedure, the threshold values showing little or no change from day to day.

The threshold caloric test as discussed in this report can be modified, if necessary, to meet the requirements of the investigator. The clinician, lacking the equipment required for electronystagmography, can use this test to evaluate the canal function by direct visual observation and to follow progressive vestibular pathology without adaptation to repeated caloric irrigation. This test has been used by the authors in studying the effect of streptomycin on squirrel monkeys and in following the course of recovery from damage induced by streptomycin. Electronystagmography can be used in order to provide permanent records. However, normal values established with electronystagmography will differ from those determined by visual inspection, particularly if the Frenzel lens are eliminated and no light is present, or the subject's eyes are closed.



COLD CALORIC THRESHOLD TEMPERATURE IN DEGREES CENTIGRADE

Figure 3

Frequency Distribution of Cold Thresholds Determined Visually for 180 Labyrinths (90 Subjects) in Group B

The results of the threshold caloric test in this experiment reveal that the threshold values for a population of young males fall within a narrow range, and a value outside this range suggests the presence of a labyrinth abnormality. The findings indicate little or no adaptation to repeated threshold caloric irrigations of the type used in the present study.

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