

Can Type of Dizziness Influence the Vestibular Caloric Test Result?

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Abstract

Background: The broad range of vestibular tests used to diagnose labyrinth diseases allows for a functional assessment of the vestibular system. Among the many tests performed, the caloric test is considered the gold standard by providing an objective measurement of the vestibular function for each labyrinth. **Objective:** to correlate the different types of dizziness with the caloric test result. **Methods:** a descriptive study was performed based on the previous records of vestibular tests performed on patients with body balance disorders evaluated at Audiology Service between 2000 and 2020. The variables evaluated were sex, age, hearing loss, tinnitus, and caloric test result. **Results:** the sample was composed of 892 patients, 654 (73.4%) women, and 238 (26.6%) men. Normal results were obtained for 57.4% (N = 514) of the individuals, while peripheral disease 40.1% (N = 357), and central disease 2.5% (N = 21) accounted for the remaining. Complaint of vertigo was not common in central disorders ($P = .02$; OR = 0.17) and instability was associated with bilateral vestibular weakness ($P = 0.02$; OR = 5.92). Vertigo associated with tinnitus and/or hearing loss was more frequent in the caloric test with peripheral abnormality ($P = 0.008$). **Conclusion:** complaints of vertigo associated with tinnitus and/or hearing loss must be directed for clinical observation of unilateral peripheral lesion and instability to central disease or bilateral peripheral lesion.

Keywords

caloric test, dizziness, performance test, postural balance

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Introduction

A complaint of dizziness can be present in a variety of body balance disorders. It may be related to different abnormal sensations manifested as rotatory (vertigo), non-rotatory (instability), fleeting feelings of fainting (pre syncope), as well as fluctuating sensations known as nausea.^{1,2} The high frequency of complaints related to labyrinth disorders is largely due to the relationship of this organ with disorders in other body systems such as hormonal, metabolic, cervical, circulatory and psychological, as well as adverse reactions caused by the use of drugs, mainly suppressors of vestibular function.^{3,4}

The variety of vestibular tests used to diagnose labyrinth diseases allows for a functional assessment of the vestibular system, and assisting with determining the diagnosis of the lesion (central or peripheral). Among the tests performed, the caloric test is important because it offers objective measurement of the vestibular function of each labyrinth.⁵ Despite the objectivity of the caloric test, the data does not exclude the need for an accurate anamnesis that leads to exclusion or clinical observation of a vestibular involvement, prior to the

indication for the vestibular test. This is because the technique is uncomfortable for the patient(s) and can cause dizziness often associated with nausea and vomiting episodes.⁶ In the case of vestibulopathy, studies demonstrated varying results stating that *both* vertigo as instabilities may relate to the dysfunction of the vestibular system in its peripheral portion (labyrinth or vestibular nerve) or central portion (central connections with cerebellum or brainstem).^{6,7} Moreover, more studies are necessary for the predilection of these symptoms for the diagnosis of *the* unilateral or bilateral vestibular lesion.^{3,6-8}

The significance of this study is interconnected to controversies that remain in scientific literature about (1) distinguishing the types of dizziness and association

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Table 1. Types and Definitions of Dizziness.

Type of dizziness	Definition
Vertigo	Symptoms of self-motion perceived in the absence of head/body movements or altered perception of self-motion during normal head/body movements. ^{14,21}
Instability	Symptoms related to lack of postural control when sitting, standing or walking often accompanied by spatial disorientation. ^{14,21}
Pre syncope	Symptoms of pre transient loss of consciousness, characterized by rapid onset, short duration and spontaneous complete recovery. ¹⁵
Lightheadedness	Symptoms of brief dizziness, unsteadiness triggered with changes in position. ²¹

associate with a unilateral or bilateral vestibular disease, (2) to correlate the types of dizziness with peripheral or central injury; and (3) to associate the types of dizziness with the caloric test result.

Only the caloric test result was considered due to the representation the test offers for an objective measurement for the function of each labyrinth.⁹

The aim of this study was to correlate the types of dizziness to the results of the caloric test of patients with body balance disorders evaluated at the Audiology Service between 2000 and 2020. The results of the types of dizziness and the associated symptoms (tinnitus and hypoacusis) were correlated with the caloric test reports.

Material and Methods

The medical records of patients, male and female, evaluated from 2000 to 2020 with balance disorders were reviewed. The inclusion criteria were, the presence of complete data from the Videonystagmography (VNG) test and a report of only 1 type of dizziness. Individuals who underwent vestibular testing without caloric test or who had 2 or more types of dizziness concomitantly were disqualified. In addition to the exclusion criteria were: (1) history of hypertension (uncontrolled, acute, or de-compensated phase), (2) history of cardiac problems (arrhythmias especially bradycardia or Stokes-Adams attack; acute or de-compensated phase), or were undergoing cardiac investigations, (3) Psychotic/neurotic disorders (acute or de-compensated phase), (4) Epilepsy (acute or de-compensated phase), (5) Eye surgery, and (6) Ear surgery.¹⁰

All participants received a questionnaire at the time of the test, with the following items to be answered: age, gender, type of dizziness, frequency (constant, several times a day, several times a week or only a few episodes), duration of seizure (seconds, minutes, hours, or constants), presence or absence of tinnitus and/or hearing loss, and the existence of any underlying diseases.

For the purposes of this study, only data on the type of dizziness and caloric test results were analyzed. All patients received prior information about the classification and sensation of the different types of dizziness. The types of dizziness and definition considered were instability, vertigo, presyncope (or near syncope) and lightheadedness (Table 1).

Guidance about discontinuing medication was given by the referring doctor during the pre-test consultation. The physician instructed the subject(s) to discontinue medication at least 48 h before the test and suspension of alcohol consumption.¹¹ The audiologist responsible for the evaluation checked, during clinical history, if the individual had adhered to the guidelines adopted. The subjects were instructed on each stage of caloric test. Both stimulations were performed by the same examiner, who maintained the systematization strategy for all stages of the test.

Prior to the caloric test and after each irrigation, all subjects were evaluated on otoscopy and tympanometry¹² to check the condition of the external ear and tympanic membrane (and after each irrigation). The position adopted for the caloric test was supine with either his/her head or head and back inclined at 30° to the horizontal.¹³

Spontaneous nystagmus with and without visual fixation were checked before the first irrigation and with the patient in the caloric test position. All participants were instructed to gaze ahead, the visual fixation removed, for the importance of performing mental tasks during each stimulation to minimize suppression of nystagmus.¹⁰

Bithermal caloric test with videonystagmography (VNG) (Micromedical Technologies, Inc., USA) were performed. For all 4 irrigations, it was adopted a minimum interval of 7 min between 1-stimulation and other was established.

The caloric stimulation was performed with water (Micromedical Technologies, Inc., USA), through the outer ear. Each irrigation lasted 30 s, with 250 ml of water, at temperatures of 44°C (warm) and 30°C (cold), completing 4 stimulations total.^{11,14} The total recording time, following cessation of irrigation, was at least 60 s.¹⁰

The 4 responses were: WR—warm stimulus in right ear, WL—warm stimulus in left ear, CR—cool stimulus in right ear, CL—cool stimulus in left ear. The most important parameter for the quantitative evaluation of caloric test is the maximum Slow-Phase Velocity (SPV) of the nystagmus in degrees per second.¹⁵⁻¹⁹

The 4 responses were represented by the subsequent codes: WR—warm stimulus in right ear; WL—warm stimulus in left ear; CR—cool stimulus in right ear; CL—cool stimulus in left ear.^{20,21}

Table 2. Meaning and Interpretation of Caloric Test Results.

Caloric result	Interpretation
Unilateral weakness or canal paresis	Quantified the difference between the caloric responses from the right and left ears. ^{11,14,17,18}
Directional preponderance	An abnormal directional preponderance exists when nystagmus responses in 1 direction are significantly stronger than nystagmus responses in the opposite direction. The clinical meaning of DP is controversial. DP is commonly seen in patients presenting spontaneous nystagmus, occurring towards the same direction. It may also be observed in central or peripheral vestibular diseases or in injuries of the cortex. ^{11,14,17,18}
Central abnormality	Minimum of 2 vestibular abnormal findings, according to the International Classification of Vestibular Disorders (ICVD). ²²
Hyperactivity/Hyperreflexia	Total responses from 1 or both ears exceed the normal limit. ^{11,14,17,18}
Hypoactivity/Hyporeflexia	Total caloric responses from both ears are absent or markedly weak. ^{11,14,17,18}

Unilateral Weakness (UW) or Canal Paresis (CP) and Directional Preponderance (DP) were characterized by the follow formulas.¹⁸

$$\text{Unilateral Weakness (\%)} = \frac{(\text{WR} + \text{CR}) - (\text{WL} + \text{CL})}{(\text{WR} + \text{WL} + \text{CR} + \text{CL})} \times 100$$

$$\text{Directional Preponderance (\%)} = \frac{(\text{WR} + \text{CL}) - (\text{WL} + \text{CR})}{(\text{WR} + \text{WL} + \text{CR} + \text{CL})} \times 100$$

The results were calculated by the average slow-phase velocity of the nystagmus for the period of maximum response. For the interpretation of the test, normative data for both UW and DP were 20 %.¹¹

The central vestibular findings were analyzed according to the International Classification of Vestibular Disorders (ICVD)²²: abnormal performance on pursuit and/or saccades, absence of ocular fixation inhibitory effect, nystagmus more likely enhanced with fixation present, nystagmus more likely to be pure vertigo or pure torsional, and direction-changing nystagmus.^{9,23}

Peripheral vestibular disease was defined when no signs of central nervous system impairment were present and the caloric test values of UW and DP were higher than the normal parameters.¹¹ Definitions about the conclusion of the caloric test are presented in Table 2.

All individuals who participated gave consent following a detailed explanation of the procedures. The procedures followed were in accordance with the ethical standards of the responsible Institutional Review Board (xxx) and with the Declaration of Helsinki (2013).

Statistical Analysis

The data generated by this study was analyzed using the SPSS Statistical Program, SPSS Inc., IBM, Chicago, USA. In the statistical comparison, the difference between the means were compared using the test “*t*,” with a level of statistical significance of 5%.

The test “*t*” was adequate for the comparison of the groups since they are independent samples in which the studied variables are quantitative and have normal distribution and the same standard deviation. The results of the

types of dizziness and the associated symptoms (tinnitus and hearing loss) were correlated with the caloric test reports. The test “*t*” of *student* for variations held *behold* continuous, with the significance level value of 5%.

Results

The sample consisted of 892 individuals, ranging in age from 9 to 90 years. Of the 892 individuals, 654 (73.4%) were females and 238 were (26.6%) males. The largest number of individuals were observed in the age group, 41 to 60 years, corresponding to 381 subjects (42.7%) (Figure 1).

According to the type of dizziness (Figure 2), vertigo 553 (62%) and instability 295 (33%) were the most frequent in the population studied. Less frequent were complaints of presyncope 25 (2.8%) and lightheadedness 19 (2.2%).

Regarding the association of otologic symptoms, documented hearing loss was observed in 435 (48.8%) individuals and tinnitus was reported by 669 (75%) participants.

Considering the results of the caloric test, normal results were found in 512 (57.4%) and abnormal results in 42.6%. Analysis of the altered test results showed, the most frequent results were Unilateral Weakness (UW) 255 (28.6%) and Bilateral Hyperreflexia 48 (5.4%).

Correlation of the caloric test results with different types of dizziness was assessed to find, vertigo was uncommon in the central syndromes ($P = .02$) and the complaint of instability was associated with Bilateral Hyporeflexia ($P = .02$) (Table 3). Presyncope and lightheadedness did not indicate any association with a specific caloric test result.

Reports of vertigo concomitantly with tinnitus and/or hearing loss were statistically associated with caloric tests with peripheral abnormal results ($P = .008$; OR=2.68; CI= 1.25-5.82).

Discussion

The caloric test is part of an assessment for individuals with balance disorders, as it presents a measure of vestibular function from the horizontal semicircular canal. The base of

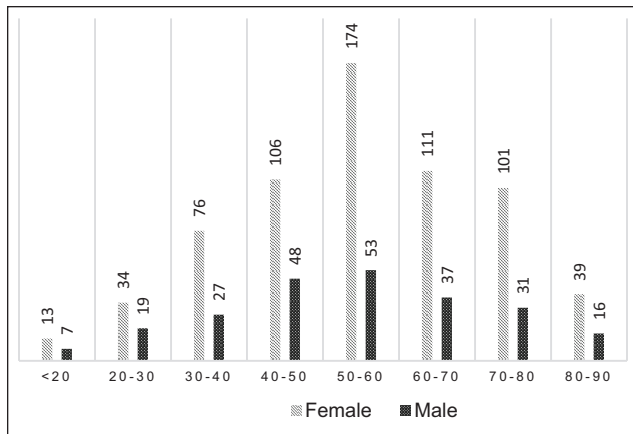


Figure 1. Demographic distribution gender and age. N=892.

caloric stimulation is that a normal system tends to work symmetrically and that the response after stimulation in a recognized range of normality.²⁴

In this study, the common findings in this sample for different dizziness types was vertigo (N=553, corresponding to 62%), and for the caloric test result was unilateral weakness (UW), supporting the objectivity of the caloric test where 1 side is compared against the other allowing for clarity on which 1 is compromised.²⁵⁻²⁷ Similarly, the low frequency of subjects with suspected diagnosis of a central vestibular disorder (N=18/2.01%) could be associated with the non-referral of these individuals for vestibular evaluation, since it is a test that evaluates the peripheral portion of the vestibular system.²⁸

Females prevailed in the sample (N=654/73.4%) of the total patients evaluated, which is consistent with other studies.²⁹⁻³¹ Possibly, hormonal variations and contraceptive use with changes in estrogen and progesterone concentration could influence the homeostasis of labyrinthine fluids, justifying the higher frequency of women in the study.³⁰⁻³⁴

Regarding the caloric test result, normal values was verified for the majority of the individuals (N=512, corresponding to 57.4%). This finding can be explained due several conditions that can cause dizziness²¹ and because the caloric test, even being one of the most accepted methods of evaluating peripheral vestibular function, has well known limitations such as: it only stimulates the lateral semicircular canal at low frequencies, whereas everyday head movements occur at higher frequencies and along all 3 planes.³⁵

Once the disorder or impairment responsible for a symptom is localized or primarily affects the balance system or the labyrinth specifically, a caloric test can present an abnormal result.^{10,17} In the subjects with abnormal results (N=380), it was observed that the Unilateral Weakness N=255 (67.1%) was the most frequent finding, with no distribution discrepancy between males and females. This finding points to the unilateral loss of vestibular function,

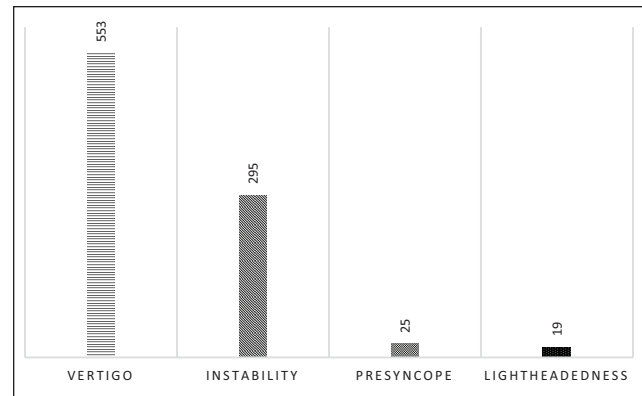


Figure 2. Type of dizziness in individuals with balance disorders evaluated by caloric test. N=892.

causing labyrinthine predominance in caloric test, as an important cause of peripheral vestibular disease.²⁵⁻²⁷

When indicating the symptom(s) reported by the patient with Unilateral Weakness, vertigo was more observed in exams with unilateral peripheral alterations (Table 3). The instability complaint, on the other hand, was observed in cases suggestive of central involvement ($P=.02$) and in bilateral peripheral alterations ($P=.02$). These results reaffirm the concept that the rate of vertigo without neurological signs on clinical examination suggests unilateral peripheral vestibular involvement and that instability is related to vestibular involvement in its central or bilateral peripheral portion.^{25,36}

Presyncope, like dizziness and lightheadedness, did not reveal a statistically significant association with any specific altered caloric test results, in agreement with other studies.³⁸ Pre-syncope is related to cardiovascular causes or vasovagal syncope (caused by orthostatic stress, pain, cough, medication use). Lightheadedness, on the other hand, are frequently reported by patients with depression or those who discontinue drug treatment, a fact justified by the decreased concentration of serotonin.³⁹⁻⁴¹ In this context, the indication of a vestibular test would not be the first assessment conducted as the primary approach for patients with presyncope.

Concerning the individuals with vertigo, who presented with otoneurological symptoms (tinnitus and/or hearing loss) and consideration of the caloric test results ($P=.008$), several studies have shown that a peripheral disorder can affect both the vestibular and hearing systems simultaneously due to their connection with the labyrinth. These results reaffirm the importance of an accurate evaluation to guide the diagnostic, with the combination of other tests.^{25,33,36}

In conclusion, the present study reaffirms the importance of clinical history in guiding the expected results in the caloric test and the correlation between the complaint and result. It demonstrated a strong association of vertigo and unilateral weakness in caloric test.

Table 3. Distribution of Caloric Test Results in Relation to the Types of Dizziness.

Caloric test	Vertigo N (%)	Types of dizziness N (%)			Total N (%)
		Instability	Presyncope	Lightheadedness	
Normal result	308 (55.9)	169 (57.3)	20 (80)	15 (79)	512 (57.6)
Unilateral weakness	175 (31.7)	74 (24.7)	4 (16)	2 (10.5)	255 (28.5)
Directional prevalence	16 (2.9)	14 (4.8)	1 (4)	2 (10.5)	33 (3.5)
Bilateral hyperreflexia	42 (7.5)	6 (2.3)	0 (0)	0 (0)	48 (5.4)
Bilateral hyporeflexia	5 (0.8)	14 (4.8)	0 (0)	0 (0)	19 (2.1)
Bilateral areflexia	2 (0.4)	4 (1.3)	0 (0)	0 (0)	6 (0.8)
Central	5 (0.8)	14 (4.8)	0 (0)	0 (0)	19 (2.1)
Total	553 (100)	295 (100)	25 (100)	19 (100)	892 (100)

N=892.

Study Limitations

The caloric test gives the healthcare professional an assessment of whether the peripheral vestibular end organs are functioning symmetrically and/or whether the peripheral vestibular end organs are providing the brain with enough sensory information. But it is not common a subject refers just 1 type of dizziness. It will be important to quantify is it is a relationship among different types of dizziness and the caloric test.

Declaration of Conflicting Interests

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