

## Original Research Article

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# Comparative study between posturography and caloric test in balance disorders

Himanshu Swami<sup>1\*</sup>, Maneesha Sivan<sup>2</sup>, Bharath M.<sup>1</sup>

<sup>1</sup>Department of ENT, Command Hospital Airforce, Bangalore, India

<sup>2</sup>Department of ENT, Military Hospital, Binnaguri, Assam, India

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### \*Correspondence:

Dr. Himanshu Swami,

E-mail: [hswami2003@yahoo.com](mailto:hswami2003@yahoo.com)

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## ABSTRACT

**Background:** Vertigo is a common clinical problem encountered by otolaryngologist. There are various causes balance disorders including pathologies of inner ear, somatosensory system and visual disturbances to name a few. Caloric test is suitable for inner ear disorders. Posturography promises to be more holistic in diagnosis of balance disorders.

**Methods:** 50 patients suffering from imbalance were accrued. They were subjected to caloric test and posturography by using static balance platform. Canal paresis and directional preponderance were measured by caloric test and modified clinical test for sensory interaction on balance (mCTSIB was performed on static balance platform).

**Results:** Caloric test was found to be positive in 17 whereas static balance platform detected abnormalities in 28 patients.

**Conclusions:** Posturography by use of static balance platform can be an important tool in determining the cause of imbalance. The detection of abnormalities as compared to caloric test is statistically significant.

**Keywords:** Posturography, Caloric test, Balance platform

## INTRODUCTION

To maintain balance in upright posture, a complex and successful series of neurological mechanisms have evolved. These encompass visual, proprioceptive and vestibular systems. The information provided is then analysed by central nervous system. Additionally, if the general health of an individual is good it aids in balance and therefore preventing falls. Dysfunction of any part may result in imbalance or a feeling of spatial disorientation.<sup>1</sup>

As the global population ages, falls and their consequences are becoming a greater health concern.<sup>2</sup> The term dizziness covers a broad range of symptoms, including vertigo, sensations of unsteadiness and/or imbalance, and orthostasis.

There are five vestibular organs. Three in semicircular canal measuring angular acceleration and two in vestibule measuring linear acceleration. The challenge lies to assess each vestibular organ separately. It is even more difficult to devise test that further evaluates right vestibular system and the left vestibular system separately. However there are some tests that have been developed and utilized in the differential diagnosis of vestibular disorders.<sup>3</sup>

The bithermal caloric irrigation test is the gold standard for measurement of lateral SCC function.<sup>3</sup> This test depends primarily on convection setup in the relevant canal by thermal stimulation.<sup>1</sup>

There are other tests which are more adept in evaluating comprehensive balance of an individual posturography

being one of them. Posturography is a multisensory assessment of balance. The battery consists of two tests in different conditions namely sensory organization test (SOT) and motor co-ordination test (MCT). The SOT battery quantifies an individual's ability to maintain an upright stance when one or more sensory inputs are eliminated. The MCT battery provides information about an individual's response time to a perturbation. Though it is an important and more complete test posturography is often overlooked when balance is assessed.<sup>2</sup>

While balancing individual tries to control its center of gravity (COG). The purpose of this control is to evenly distribute the vertical forces resisting gravity throughout the body's support tissue. This causes the centroid of the pressures exerted at the support surface to be well within the base of support. This centroid is known as the centre of pressure (COP).<sup>4</sup> Balance platform utilizes a fixed force plate to measure the center of pressure.<sup>5</sup>

Centre of pressure and its normative data are important in assessing balance in disabled patient populations. To achieve balance COP has to be maintained near its midpoint.<sup>6</sup>

The balance screener encompass the modified clinical test of sensory interaction and balance (mCTSIB) and limits of stability (LOS) evaluates sensory contributions used for balance control mCTSIB measures the postural sway during four test conditions-eye open/closed on firm surface and eye open and closed on unstable surface(with foam cushion). LOS measures the ability to lean from the centre of gravity to eight different test positions.<sup>4</sup>

In this study we have evaluated patients with balance disorder symptoms using caloric test and posturography and compared the results. The aim of the study was to compare the posturography outcomes with the results obtained by caloric test in cases of vertigo. The objectives of the study were:

- To evaluate patients with dizziness and balance disorder symptoms using caloric test.
- To evaluate patients with dizziness and balance disorder symptoms using static balance plate.
- To compare the results obtained by static balance plate with the results obtained by caloric test.
- To evaluate the efficacy of static balance plate in the diagnosis of balance disorders and dizziness in comparison to caloric test.

## METHODS

A tertiary level hospital based prospective study was carried out for a period of two years, on subjects presenting with dizziness and balance disorder symptoms in the outpatient department. A total of 50 subjects were included the study who met the inclusion criteria.

### *Inclusion criteria*

- All subjects presenting with dizziness and balance disorder symptoms.
- Willingness to undergo caloric and posturography trials.

### *Exclusion criteria*

- Subjects less than 20 years of age.
- Subjects presenting with acute symptoms and spontaneous nystagmus.
- Subjects with disease conditions of the external ear like otitis externa.
- Subjects with perforated tympanic membrane or atelectic tympanic membrane or evidence of middle ear fluid.
- Patients weighing more than 150 kg being the upper weight limit for the balance platform.
- Patients with history of ear surgery within the last 6 months.

### *Procedure*

1. Written and informed consent was obtained from all the subjects included in the study.
2. Detailed history was taken from all the patients
3. Evaluation of the selected subjects using caloric testing and static balance platform testing

### *Caloric testing*

- Fitzgerald-Hallpike Bithermal Caloric test was used for the caloric testing.
- Temperature of the water used for irrigation was warm 44 °C and cold 30°C.
- Patient was made to wear Frenzel glasses to abolish the optic fixation and was instructed to keep the eyes open.
- Each ear was then irrigated with warm water at 44°C and at 30 °C at the speed of 6ml/sec for 40 seconds with 240 ml of water with a gap of 5 mins between each stimulation.
- Order of irrigation followed in each case was-
  - Right ear with warm water at 44°C
  - Left ear with warm water at 44°C
  - Right ear with cold water at 30°C
  - Left ear with cold water at 30°C
- Time taken from the start of the irrigation to the end point of nystagmus was recorded and charted on a calorigram.

Two parameters were calculated namely canal paresis (CP) and directional preponderance (DP) using the under mentioned formulas.

\* CP  
Jongkees formula → 
$$\frac{(R44 + R30) - (L44 + L30)}{R44 + L44 + R30 + L30} \times 100$$

\*\* DP  
Right beating nystagmus = 
$$\frac{L30 + R44}{L30 + L44 + R30 + R44} \times 100$$

Left beating nystagmus = 
$$\frac{R30 + L44}{L30 + L44 + R30 + R44} \times 100$$

L30 - response from the left side with water at 30° C

L44 - response from the left side with water at 44 ° C

R30 - response from the right side with water at 30° C

R44 - response from the right side with water at 44° C

- An asymmetry of more than 24% between the two ears was considered as positive for canal paresis. If the nystagmus was more than 25% on one side then it was taken as directional preponderance to that side. Test was considered positive if either CP was present or there was evidence of DP

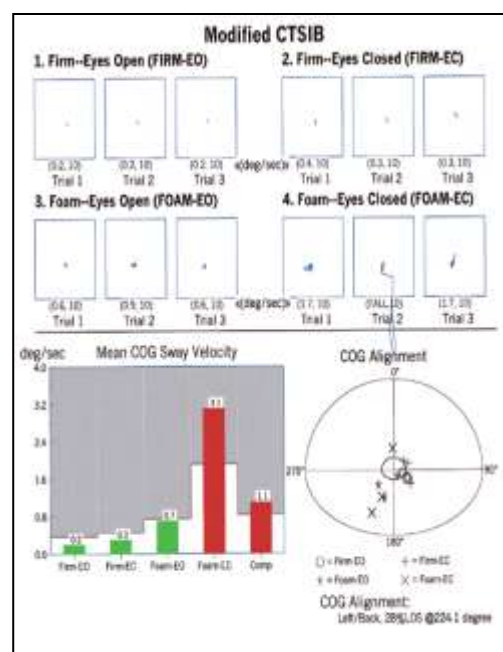
- Static balance platform- Modified Clinical Test for Sensory Interaction on Balance (mCTSIB):**

- All the subjects were evaluated using the static balance plate, the basic balance master by neurocom as per the protocol (Figure 1).



**Figure 1: Static balance platform test being conducted.**

- The mCTSIB consisted of four conditions
  - EO (eyes open); Firm surface (FO)
  - EC (Eyes Closed); Firm surface (FC)
  - EO Foam surface (FOAM O)
  - EC Foam surface (FOAM C)
- Once all the trials were completed the data was analyzed by the computer to calculate various parameters like the center of pressure (COP) and the centre of gravity (COG). After comparing the values with the age specific normative data fed in the system a final analysis report was displayed both in the comprehensive and the numeric report format. Any values within the normal range was displayed in green in the mean COG sway velocity graph and any values outside the normal range was represented in the grey region (Figure 2).



**Figure 2: Graphical results of mCTSIB.**

- Results from only one of the four possible conditions from the mCTSIB i.e. condition (d) Eyes closed foam surface were analyzed and compared with caloric test since in the test condition foam with eyes closed is a situation wherein patient relies completely on the vestibular input as visual and somatosensory information are unavailable. It was compared with results of caloric test.

## RESULTS

The information was collected using a mastersheet. Nominal data such as gender, indications were presented as number (N) and percentage (%). Continuous variables (age, etc) were expressed as mean and standard deviation

(SD).p value of  $\leq 0.05$  was considered as statistically significant. The analysis of the data was performed using Microsoft excel, and MINITAB 15.

### Statistical analysis

#### Age and sex distribution

For statistical analysis we have used the statistical software MINITAB 15. We begin by giving the descriptive statistics for age by sex as well as overall. The

different statistics are presented in the Table 1 below. The table gives number of patients, mean, median, standard deviation (SD), standard error of mean(SEM), minimum value, maximum value as well as first and third quartiles.

Age of the females (20) varies between 20-67 years with mean age of 38.5 years and SD 13.71 years. For males (30) the age varies between 19-71 years with mean age of 41.60 years and SD of 12.73 years. Overall the range is from 19-71 yrs. Mean and SD are 40.38 years and 13.08 years respectively.

**Table 1: Descriptive statistics: age by sex, overall.**

Variable	Sex	N	Mean	Median	St dev	SE mean
Age	F	20	38.55	33.50	13.71	3.07
	M	30	41.60	39.50	12.73	2.33
	Overall	50	40.38	39.00	13.08	1.85
Variable	Sex	Minimum	Maximum	Q1	Q3	
Age	F	20.00	67.00	29.00	48.75	
	M	19.00	71.00	31.75	49.25	
	Overall	19.00	71.00	29.00	49.00	

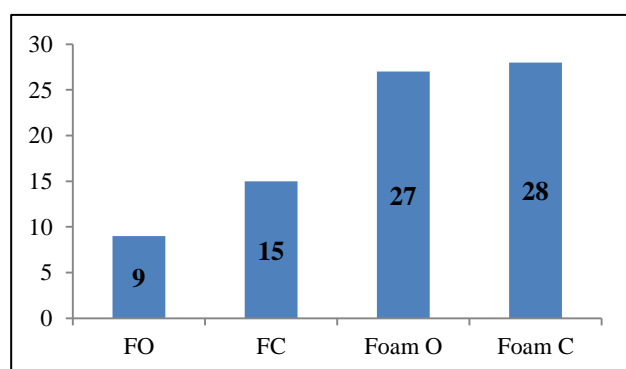
### Caloric test

Following results were noted with caloric test.

- Canal paresis (CP)-11
- Directional preponderance (DP)-9
- Total abnormal (either CP or DP)-17

### Static balance platform - mCTSIB

The results for various conditions are depicted in Figure 3. Positive test for condition (d) i.e. eyes closed with foam was seen in 28 patients.



**Figure 3: Results for mCTSIB in different conditions.**

Two proportion test was carried out between positive caloric test and positive static balance platform test in condition (d) ie foam with eyes closed. As seen in table we found that the % of the positive findings with respect to caloric test is 34.0% compared to 54% positive

findings in SBP test. This test is statistically significant. ( $Z = -2.06$ ,  $p = 0.040$ ).

**Table 2: Two proportions test and CI : CAL**

Test	Yes	N	Sample proportion	Z	P-value
CAL test(+)	17	50	0.340000	-2.06	0.040
SBP- fc(+)	28	50	0.540000		
estimate for p (cal test(+)) – p (sbp- fc(+)): -0.2					
95% ci for p (cal test(+)) – p (sbp- fc(+)): (-0.390591, -0.00940925)					

Test(+), SBP- FC(+), Success = Yes.

### DISCUSSION

Deficits in the vestibular function causes dizziness, loss of balance and reduced functional independence and symptom of vertigo is generally thought to accompany vestibular dysfunction. The presence of vertigo, in combination with unidirectional nystagmus or an abnormal caloric response, is highly suggestive of a peripheral vestibular disease.<sup>7,8</sup>

Another common abnormality in patients with vestibulopathy is postural instability. The quantification of this postural control has been studied for many years by various investigators since the introduction of Romberg test in 1853.<sup>9-12</sup>

Postural stability is affected by visual, somatosensory and vestibular dysfunction. The introduction of static balance platform posturography has made it possible to test upright balance under varying sensory contexts by



manipulation of available visual and proprioceptive cues during stance. Black et al also had reported specific patterns of performance in patients with vestibular loss. But to date it has not been shown whether patients with non-vestibular disorders of balance like central brainstem disease, cerebellar dysfunction, diffuse cerebrovascular disease and musculoskeletal disorders would not fall under similar test conditions. Hence the impression was that posturography is a functional test of combined multisensory interactions in postural control and not a “site of lesion” examination.<sup>11,12</sup>

The present study evaluated patients with dizziness symptoms with both caloric test and static balance platform posturography. This study included a total of 50 patients. The descriptive statistics for age by sex as well as overall are presented in Table 1. The table gives the no of patients, mean, median, standard deviation (SD), standard error of mean (SEM), minimum value, maximum value as well as first quartile and third quartiles. Age of the females (20) varied between 20-67 years with mean age of 38.5 years and SD 13.71 years. For males (30) the range for age was between 19-71 years and mean was 41.60 years and SD being 12.73 years.

The proportion of patients with positive findings between the two tests is statistically significantly different. For this we have used a Z-test in Table 2. From the table we find that the % of the positive findings with respect to caloric test is 34.0% compared to 54% positive findings in SBP test. This test is statistically significant. ( $Z = -2.06$ ,  $p = 0.040$ ). This is in agreement with the study by Richard PD et al who found that posturography can detect abnormalities in even those patients who had normal results with other vestibular tests.<sup>13</sup> The results are also in agreement with the results from the study by Miguel A et al which showed that the test condition foam-eyes closed correlated best with the clinical tests.<sup>14</sup> This result is also in agreement with the results obtained from the study by Joel A et al. who found that posturography detects abnormality in more percentage of patients with vertigo probably because posturography is sensitive to non-vestibular disorders in addition to vestibular loss and posturography could identify patients with abnormal posture control despite normal calorics.<sup>7</sup>

The above analysis shows that the static balance platform testing is more sensitive towards identification of abnormality in patients with regard to the positivity of the test when compared to caloric testing. Both the tests are able to detect an abnormality as given by canal paresis and directional preponderance in caloric test and an abnormal value outside the normal range for the age as per SBP-FC but the proportion of patients detected with abnormality is more with SBP-FC indicating that it is a superior test, as it can detect non-vestibular causes of vertigo also.

Caloric test is considered to be the gold standard test for the identification of peripheral vestibular diseases and at

times it helps giving a diagnosis like in the case of Meniere's disease and cases of acoustic neuroma. But in cases of vertigo due to other causes peripheral origin and central causes, it may not be of much use.

Posturography on the other hand is sensitive to non-vestibular disorders in addition to vestibular loss. Certain patients may not experience significant vertigo and yet due to central nervous system disease, musculoskeletal disease, functional balance disorders etc would have normal caloric responses, but poor postural stability. But the role of posturography in the cases of peripheral vestibular disorders is unclear. Caloric testing is easily available in a clinical setting, however static balance plate is still not widely available. But platform abnormalities do enhance the examiner's ability to identify dysfunction. The possible explanation for abnormal posturographic findings despite normal calorics could be that these patients may be having non-vestibular causes of vertigo and this remains consistent with the premise that posturographic localization of abnormality remains elusive.

## CONCLUSION

It is generally believed that vertigo is a symptom of acute vestibular dysfunction. The symptoms of vertigo and associated physical findings typically decline and disappear over time following vestibular lesions and it reflects the nervous system's capacity to adapt or to compensate for these lesions. In clinical assessment of the vestibular function emphasis has been placed on electronystagmography and specifically on the caloric response asymmetry.

With the introduction of platform posturography a new measure of postural control under varying visual and somatosensory conditions has become available. When placed under conditions of absent visual and support surface cues, patients with active vestibular loss become less stable. However postural instability under these conditions, while consistent with vestibular dysfunction, has not been proven to be a specific sign of vestibulopathy. In the study conducted above, the analysis of data obtained shows that the percentage of patients identified with abnormal findings was more with static balance posturography than with caloric testing. Caloric test is easily available in all the clinical settings but static platform is still not common. And more number of studies are required to assess the usefulness of static plate for the evaluation of cases of dizziness and balance disorders especially comparing it with the traditional tests like caloric test.

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