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Sensitivity of Romberg Test in Diagnosis of Peripheral Vestibular Disorders in Comparison with Caloric Test: Psychometric Study

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Original Article

Abstract

Introduction: Romberg test is one of the balance screening tests. Since this test does not require special equipment, it is widely used in the evaluation of people suffering from balance disorders. This study aimed to determine the sensitivity of the Romberg test for the diagnosis of peripheral vestibular dysfunction compared with the caloric test that is the gold standard for the diagnosis of horizontal semicircular canal/superior vestibular nerve disorders.

Materials and Methods: This study was a cross-sectional-comparative study and the sample was selected from those who referred to the audiology clinic of the School of Rehabilitation Sciences, Tehran University of Medical Sciences, Tehran, Iran. Romberg test with closed eyes was performed in 47 people suffering from unilateral or bilateral peripheral vestibular disorders (25 women and 22 men, mean age: 43.80 ± 4.46 years) whose lesion was confirmed by caloric test. The results were recorded in the participants' history files and the files were reviewed. Chi-square test was used to compare the results. The sensitivity of Romberg test was determined in comparison with their caloric test results.

Results: Only 5 participants had abnormal Romberg results, while 35 patients showed unilateral caloric weakness and 12 had bilateral deficits. Therefore, Romberg's sensitivity was 10.64%. There was no significant correlation between Romberg results and duration of disease.

Conclusion: Romberg test seems to have low sensitivity in diagnosis of peripheral vestibular disorders. Therefore, vestibular tests with higher sensitivity are recommended for the diagnostic purposes and caloric test may not be replaced by Romberg test.

Keywords: Romberg test; Peripheral vestibular disorders; Caloric test; Sensitivity

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Introduction

Vertigo and dizziness are the most common problems in the adult population with a prevalence of 3 to 10% and 17 to 30% lifelong, respectively (1). Vertigo is caused by peripheral or central vestibular diseases and imposes high cost on the health system (2, 3). Balance disorder that occurs with dizziness or dizziness can have a significant impact on the quality of life (QOL) and is a known risk factor for falling (1, 4).

Balance is a multidimensional concept. To maintain balance, information from the three systems of "sight, proprioception, and vestibular system" must be collected and processed and the necessary movement messages must be sent to the muscles to control posture and compensatory eye movements (5). The performance of the balance system can be assessed by screening using bedside balance tests (6). One of the most widely used tests, commonly used as a screening test in people who complain of dizziness, imbalance, or falls, is the various versions of the Romberg test (7). So far, various types of Romberg tests have been used to assess balance problems, including vestibular disorders (5,7,8). This test is used to quickly check the balance; While Baloh et al. have identified a variety of Romberg tests as useful as part of the vestibular disorder screening set (7), a number of others have reported low sensitivity to these tests. In a study, the sensitivity of 0.63-0.70 for the Romberg test on a soft surface compared to the sensory

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organization test (SOT) as the gold standard (9), and in another study, a sensitivity of 55% for the Romberg test on a hard surface compared to the Caloric and Vestibular Evoked Myogenic Potential (VEMP) tests (5) were reported. Additionally, in a study that used the Tandem Romberg test, it was found that this test could not be used to diagnose vestibular disease (8).

The SOT test, used as a gold standard in previous studies, measures the ability to coordinate the balance system following an injury to this system, but is a limited tool for screening for vestibular asymmetry (10,11). The VEMP test also assesses the saccular part, the lower vestibular nerve, and the lower part of the brainstem (12), but is unable to detect vestibular weakness. Among the diagnostic tests used to assess Unilateral Vestibular Loss (UVL), the Head Impulse Test (HIT) and the Caloric Test are valuable tests (13). Although the HIT test is easy to perform and does not require special equipment, it has a sensitivity of 34-45% relative to the Caloric test (14).

The Caloric test is one of the most common and sensitive tests for the detection of peripheral vestibular disorders and is used as the gold standard to indicate unilateral or bilateral vestibular loss (13). Therefore, the aim of this study was to determine the sensitivity of the Romberg test compared to the Caloric test as the gold standard (13) to identify peripheral vestibular dysfunction, especially the horizontal semicircular canal/superior vestibular nerve disorder.

Materials and Methods

This was a cross-sectional comparative study performed by data collection method of file reading in which the files of individuals referring to the Videonystagmography (VNG) Clinic of the School of Rehabilitation Sciences, Tehran University of Medical Sciences, Tehran, Iran were selected in the interval 2006-2010 and after checking the inclusion criteria, information of the individuals was extracted. 47 people (25 women and 22 men) with a mean age of 43.80 ± 4.46 years participated in the present study, who were selected from patients with vertigo referred to the Audiology Clinic, School of Rehabilitation, Tehran University of Medical Sciences. Since the study was retrospective based on the information recorded in the existing records eligible to enter the study, it was not possible to calculate the sample size and call individuals as needed. Before starting the study, its method was approved by the committee of ethics in research of Tehran University of Medical Sciences. The study inclusion criteria included age range between 21-60 years, suffering from vestibular-peripheral disorder, no middle ear disorders (due to its effect on the Caloric test) determined by the Pure Tone Audiometry (PTA) test (15) (AC 40, interacoustics, Denmark) and emittance acoustics (16,17) (AT239T, interacoustics, Denmark), no musculoskeletal disorders (MSDs) affecting the Romberg test (such as leg pain, history of back, knee, and ankle trauma and similar disorders) (18), neurological and metabolic diseases, and movement and environmental disorders of the eye. It should be noted that the use of drugs before the Caloric test is always checked due to the effect on the results and the use of affecting cases is stopped. Therefore, those who reported a caloric test were not affected by the drugs that affected the test results. Moreover, according to the instructions of the tests in VNG clinic, after obtaining informed consent from the individuals, first the PTA and acoustic emittance tests were performed for each individual and then they were evaluated for balance. Based on the information contained in the file, the clients were divided into three groups: acute (less than 3 months), subacute (3 months to one year), and chronic (more than one year) based on the duration of the lesion and self-declaration by the clients.

The Romberg test was performed for all participants and the results were recorded. To perform the test, the person was asked to stand barefoot on the floor (hard surface), put their feet together, and place their hands next to their bodies. If the person could remain in this position with a minimum fluctuation for 30 seconds (19) (no significant fluctuation or tendency to fall), he/she was asked to continue with their eyes closed (18). The test was performed only once and in case of significant imbalance with the eyes closed, exacerbation of the imbalance with closing the eyes, and in case of imbalance with the eyes open [degree of swaying as well as its position (swaying from the ankle, pelvis, or whole body) had to be considered], the Romberg test was considered abnormal. It should be borne in mind that normal people also fluctuate somewhat with their eyes closed during the test. The minimum normal performance includes the ability to stand Heel-to Toe, with the eyes closed for six seconds. Young adults should be able to perform this test for 30 seconds, but their performance is reported to decrease with age (20). The result of the Romberg test with the eyes closed was recorded as abnormal (deviation or falling to the right or left) or normal (postural stability for at least 6 seconds or the entire test period). It should be noted that throughout the test, the examiner took care of the person in order to prevent him/her from falling and possible injuries.

Then a complete VNG test including oculomotor, positional, and bithermal caloric was performed (21).

In this way, at first, lying in supine position, the subject's head was placed 30° above the horizon and the otoscopic examination was performed using an otoscope (Riester, 2110, Germany) to ensure the cleanliness of the external auditory canal and also to know the anatomical condition of the duct. Then, the Caloric test was explained to the participant to make the feel comfortable and relaxed, and the test was performed using an Amplaid otocalorimeter (Denmark). The individual's eye movements were recorded by the VNG infrared goggles (Eye Dynamics, USA). Each canal was stimulated with cold (24 °C) and hot (50 °C) air for 60 seconds (22). The maximum slow phase velocity of Caloric Nystagmus for each stimulation was calculated using the Internet connection sharing (ICS) device. Lateral weakness was determined using the Jongkees formula. If the lateral weakness value was more than 25%, the Caloric test was considered abnormal (22). If the nystagmus resulting from all four stimuli (cold stimulation in both ears and hot stimulation in both ears, as a total of 4 stimulations) was less than 8° per second, the weakness was considered to be bilateral. The results of all tests were recorded in the records of individuals and the records of those with unilateral or bilateral weakness in the Caloric test were reviewed with ethical considerations.

The sensitivity of the Romberg test was determined as Equation 1, in which the true positive was 5 and the false negative was 42. In the present study, all subjects who had vestibular weakness were included in the Caloric test. False positives included patients who tested positive for Romberg and false negative included patients who tested negative for Romberg.

Equation 1: How to calculate the sensitivity of the Romberg test

$$\text{Sensitivity} = 100 \times (\text{true positive}/[\text{True positive} + \text{false negative}])$$

To test the relationship between the results of the Romberg test and the Caloric test, the χ^2 test was used. Sensitivity less than 70%, was considered as low sensitivity and the significance level was considered 0.05. Data were analyzed using SPSS software (version 15.0, SPSS Inc., Chicago, IL, USA).

Results

The total number of cases reviewed was 300, of which 47 were eligible (given the inclusion criteria). The demographic information of the subjects and the results of their Romberg and Caloric tests are shown in table 1. More than half of the subjects had a history of more than three months. Out of the total of 47 participants, two-thirds (35) had unilateral weakness and one-third (12) had bilateral weakness, and only 5 showed abnormal Romberg, who were in the age range of 35 to 48 years. Based on the Caloric test results, in 3 and 2 of them, unilateral and bilateral vestibular weakness was observed, respectively.

In the case where the Caloric test was abnormal, the number of the true positive and the false negative was respectively 5 and 42 (Figure 1), with the false negative percentage reported as 89.36%. The sensitivity of the Romberg test according to the results of the Caloric test (as the gold standard) was obtained as 10.6% using the sensitivity formula.

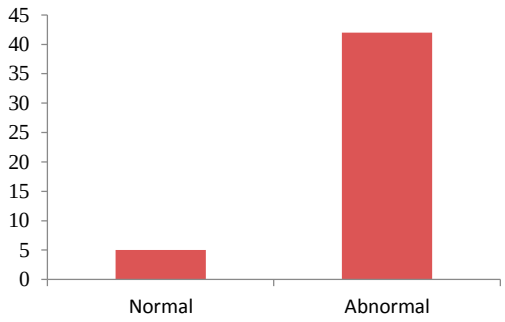

Figure 1. Romberg test results for people with vestibular disorder (n = 47) based on the result of the Caloric test as the gold standard

Examination of the relationship between the results of the Romberg test and the duration of the disorder using the χ^2 test showed that there was no significant relationship between these two variables ($P > 0.050$) (Table 2).

Discussion

The Romberg test is a simple clinical test that is often used to assess vestibulospinal (VS) reflexes and is commonly used in the screening of people with balance disorders.

This test evaluates the proprioceptive, visual, and vestibulocochlear systems to control balance. However, this test is of a qualitative nature and expresses the results as normal or abnormal, and the interpretation of the results can be influenced by the examiner's opinions (23). The current study was conducted with the aim to determine the sensitivity of the Romberg test using the Caloric test which is a quantitative test. On the basis of the present findings, the sensitivity of the Romberg test was low (10.6%).

Table 1. Demographic information and results of Romberg and Caloric tests in people with vestibular weakness (n = 47)

Age (year)	Gender	Duration of disorder	Abnormal result in Romberg test (%)	Unilateral weakness in Caloric test (%)	Bilateral weakness in Caloric test(%)
43.8 ± 4.6	25 women and 22 men	Acute: 5 people, subacute: 13 people, chronic: 29 people	10.64	74.46	25.53

Table 2. χ^2 test results to determine the relationship between Romberg test results and the duration of the disease

Romberg test	Duration of disorder			χ^2 value	P
	Acute	Sub-acute	Chronic		
Abnormal	0	2	3	0.905	0.636
Normal	5	11	26		

The Caloric test is one of the most common and sensitive clinical tests used to diagnose vestibular-peripheral system disorders affecting the horizontal semicircular canal/superior vestibular nerve, which evaluates the vestibular system at low frequencies (0.002-0.004) (24,25). In some previous studies (5,9), similar results have been observed with the present study. Hong et al. conducted a study to evaluate the clinical value of the Romberg test on soft surfaces with two different thicknesses in identifying vestibular weakness compared to the SOT as the gold standard (26, 9).

SOT is an extended version of the Romberg test in computerized dynamic posturography that facilitates an objective assessment of how the postural control system uses the components of sensory inputs to maintain balance and is performed in six modes: "Fixed surface: fixed vision environment and eyes open, fixed surface: fixed vision environment and eyes closed, fixed surface: moving vision environment and eyes open, moving surface: fixed vision environment and eyes open, moving surface: fixed visual environment and eyes closed, and moving surface: moving vision environment and eyes open. They concluded that the diagnostic performance of the Romberg test on the soft surface was poorer in various conditions and its sensitivity was low (0.63-0.70) compared to the SOT results, however the Romberg on the soft surface with the eyes closed had a significant relationship with conditions number five of SOT (9).

Comparing the results of the Romberg test with the findings of the Caloric and the VEMP tests performed by Jacobson et al, the sensitivity of the Romberg test on both hard and soft surfaces as a criterion for the diagnosis of individuals with horizontal semicircular canal/superior vestibular nerve, saccular, or inferior vestibular nerve disorders, was reported to be poor, with a total of 55%. In other words, given the results of the Romberg test, 45% of cases of peripheral vestibular dysfunction are mistakenly considered as normal (5). The difference in sensitivity obtained in their study and the present study can be attributed to the fact that in the study of Jacobson et al., the Romberg test was performed on both hard and soft surfaces and the subjects with horizontal semicircular canal/superior vestibular nerve, saccular, or inferior vestibular nerve disorders were identified (5); while in the present study, the Romberg test was performed on a hard surface and only the horizontal semicircular canal/superior vestibular nerve disorders were examined. Additionally, in the study of Jacobson et al., the age range of the participants was over 40 years with a mean age of 59.0 ± 12.0 (5); While in the present study, the age range was 21 to 60 years with a mean age of 43.8 ± 4.46 years. A study reported that individuals' performance on the Romberg test decreased with age (20). Therefore, it is possible that the difference in sensitivity reported in the two studies was due to the different mean age of the participants.

One of the reasons for the low sensitivity of the Romberg test in identifying vestibular dysfunction compared to the Caloric test as the gold standard, is that maintaining balance depends on the coordination of the three senses of vision, vestibular function, and proprioception. Vestibular function is just one of the three essential senses for maintaining balance. Since to establish balance in the event of a system failure, the two remaining systems compensate for the defective system and balance the person, even with damage to the vestibular system and the Caloric test, the person may be able to use the other two senses to establish properly and perform the Romberg test correctly (5,27).

In order to maintain balance properly, in addition to the optimal functioning of the three systems of vision, vestibular, and proprioception, one must be healthy in terms of the central processing system as well as the motor pathways (5,28,29); Vestibular function, on the other hand, relies solely on the integrity of the sensory organs located in the distal vestibular organ and its afferent and efferent pathways. The Romberg test, as a test to assess balance, evaluates the entire path and dependent systems (5); While the Caloric test for the

detection of vestibular lesions in the horizontal semicircular canal and the superior vestibular nerve is limited to a small part of this pathway (25).

Another reason for the inconsistency of the Caloric test results with those of the Romberg test in the present study is the vestibular compensation process. The vestibular system contributes to the postural and eye control (30). So, vestibular dysfunction can cause vertigo/dizziness, nausea, movement disorders, and eye movement defects. This functional impairment gradually improves in humans over three months with almost no vestibular regeneration. This healing phenomenon is called vestibular compensation (31-34). In this case, the person shows an abnormal result on the Caloric test, but may have a normal Romberg test. In the present study, most subjects had a history of more than three months, and more than half (29 people) in the group had a history of more than one year, which could be a reason for the reduced sensitivity obtained for the Romberg test.

Limitations

Most of the participants in the present study had a history of more than three months, which in turn leads to vestibular compensation and affects the sensitivity of the Romberg test. Due to the fact that the study was an archival study, it was not possible to select the required number of samples and control some factors affecting the result.

Recommendations

It is recommended to do research on people with a history of less than three months and compare the results with the group with a history of more than three months. Performing tests on participants during the study and preventing factors affecting the result that cannot be controlled in archival studies, which is among the points that can be considered in future studies. Due to the different characteristics of the Caloric test with the Video Head Impulse Test (vHIT) and since the results of these two tests can complement each other (13), it is suggested that in future research these two tests be used together as a gold standard.

Conclusion

The Romberg test is a simple clinical test to assess balance in terms of VS reflexs, and although it is commonly used to assess people with balance disorders, given the findings of the present study and previous studies, it has very low sensitivity compared to the Caloric test results. Therefore, it does not have the necessary sensitivity to diagnose vestibular-peripheral lesions, and more accurate tests should definitely be used to diagnose these lesions.

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The present study was extracted from a research design with registration number and ethics code 12874, approved by the Student Research Committee, Tehran University of Medical Sciences.

Authors' Contribution

Fatemeh Moghadasi-Boroujeni: providing study equipment and samples, data collection, analysis and interpretation of results, specialized statistics services, manuscript preparation, specialized evaluation of manuscripts in terms of scientific concepts, approval of the final manuscript to be sent to the journal office, responsibility for maintaining the integrity of the study process from beginning to publication, and responding to the referees' comments; Mansoureh Adel-Ghahraman: study design and ideation, attracting financial resources for the study, study support, executive, and scientific services, providing study equipment and samples, specialized statistics services, manuscript preparation, manuscript evaluation in terms of scientific concepts, approval of the final manuscript to be sent to the journal office, responsibility for maintaining the integrity of the study process from beginning to publication, and responding to the referees' comments.

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The present study was conducted based on the analysis of information extracted from a research design with registration number and ethics code 12874, approved by the Student Research Committee, Vice Chancellor for Research, Tehran University of Medical Sciences and under the auspices of this university. Tehran University of Medical Sciences has not commented on data collection, analysis, and reporting, manuscript preparation, and final approval of the article for publication.

Conflict of Interest

The authors do not have a conflict of interest. Dr. Mansoureh Adel-Ghahraman received the funds required for the present study from Tehran University of Medical Sciences and is working as an assistant professor of audiology at this university. Fatemeh Moghadasi-Boroujeni is a graduate of Tehran University of Medical Sciences and an audiology instructor at Isfahan University of Medical Sciences, Isfahan, Iran.

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