Original Article

The Efficiency of the Sideways Stepping Test in Detecting Unilateral Vestibular Hypofunction

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Abstract.   [Purpose] This study investigated to determine whether the Sideways Stepping Test (SST) is a useful test to detect unilateral vestibular hypofunction (UVH). [Subjects and Methods] Twenty-eight subjects including both male and females between the ages of 25 and 55 who had been diagnosed with UVH were recruited for the study. All the subjects were tested with the SST and followed by the head-shaking nystagmus (HSN) test using video electronystagmography (VENG) to confirm the presence of UVH. The results of both tests were then compared with each other to determine the correlation, sensitivity, and specificity. [Results] The results showed that the SST is strongly correlated with the gold standard HSN test using VENG and is highly sensitive and specific. [Conclusion] The present study showed that the SST is a highly valid test that can be used as an alternative method to the gold standard HSN test using VENG in detecting UVH.
Key words: Unilateral vestibular hypofunction, Sideways Stepping Test, Video electronystagmography

INTRODUCTION

Unilateral vestibular hypofunction (UVH) is a vestibular disorder in which a total or partial decrease in vestibular function is observed, which is characterized by abnormally reduced responses to the caloric test unilaterally. Disorders, such as vestibular schwannoma, vestibular neuritis, infections, and trauma affecting the inner ear, that can lead to destruction of the sensorineural epithelium of the membranous labyrinth and/or vestibular nerve fibers are diagnosed as UVH. Besides dizziness, the clinical picture of UVH may include nystagmus, ocular torsion, oscillopsia, postural instability, gait disorders, anxiety, depression, and fear. UVH patients commonly share the same symptoms, in spite of differences regarding the etiology, onset, and clinical findings of dysfunction or the type and extent of the vestibular deficit[1, 2].

For a person with vestibular hypofunction, the main aims of treatment by the health-care providers are restoring function or preventing further dysfunction. To deliver an effective rehabilitation program to them, these patients need to be evaluated and diagnosed properly. Routine diagnosis of vestibular hypofunction has been based on the results of conventional methods such as the head thrust test (HTT), the horizontal head-shaking nystagmus test, and the

caloric test[3]. Other than these tests, previous studies have used a variety of outcome measures including dynamic posturography, the motion sensitivity quotient (for rapid head movements), and the self assessed Dizziness Handicap Inventory (DHI-Jacobson and Newman, 1990). Apart from these, advanced techniques like electronystagmography (ENG), videonystagmography (VNG), and rotational chair tests have also been used for measurement of vestibulo-ocular function, and computerized dynamic posturography (CDP) incorporates all three modalities to effect an assessment of static and dynamic stance. The Sensory Organization Test (SOT) protocol of CDP evaluates the patient's ability to use the three systems that are chiefly responsible for maintaining upright, volitional, balanced posture: vision, the vestibular system, and proprioception. But the cost and time required to perform these tests are factors that keep them from being used in general clinics[4–6].

Even though the sensitivity of the HTT for identifying individuals with vestibular hypofunction is relatively good, there are studies that prove that it is more sensitive in patients with bilateral vestibular hypofunction (BVH) than in patients with UVH[7]. While various clinical measures have been developed to document UVH, the limitations of these tests are in the lack of specificity for screening the unilateral vestibular deficit. Thus, there is a need for a simple quantitative objective test to screen for unilateral vestibular hypofunction, and for this reason, the Sideways Stepping Test (SST) or Fukuda Stepping Test (FST) could be a valid and reliable diagnostic tool for detecting UVH. Therefore, the purpose of this study was to investigate whether SST is both a sensitive and specific test for detection of UVH as it is effective, safe, and economical and therefore can be used

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Table 1. Baseline frequency characteristic of the study group (N =28)

	Valid	Frequency	Percent
Sex	Male	15	53.6%
	Female	13	46.4%
HSN	Positive	13	46.4%
	Negative	15	53.6%
SST	Positive	16	57.1%
	Negative	12	42.9%

Table 2. Data for sensitivity and specificity

True positive (TP)	False negative (FN)
13 (46%)	0 (0%)
False positive (FP)	True negative (TN)
3 (11%)	12 (43%)

widely throughout the world.

SUBJECTS AND METHODS

The present study was conducted in a private Otolaryngology (ENT) Department in Jeddah, Saudi Arabia. Twenty-eight adults participated in the study (15 male and 13 females). Written informed consent was obtained from each subject prior to the start of the study. The study was conducted after obtaining approval from the Institutional Ethics Review Board of the Faculty of Applied Medical Sciences, King Abdul Aziz University, Jeddah. All the participants were required to complete and clear the following comprehensive screening tests: cervical instability test, modified vertebral artery test (mVAT), spontaneous (resting) nystagmus test, smooth pursuit test, saccadic eye movement test, and vestibular ocular reflex (VOR) cancellation test to rule out all central mediated problems. Only subjects complaining of peripheral dizziness who were between the ages of 25 and 55 years old and able to ambulate independently were included in the study. Subjects with central mediated problems such as stroke, acquired brain injury, multiple sclerosis, or peripheral neuropathy were excluded from the study. Moreover, subjects who could not ambulate independently, were blind, were profoundly deaf or had cervical spine pathology were also excluded. The major outcome variables for confirming the presence of UVH were obtained by the SST and the gold standard test, which is head-shaking nystagmus HSN test using video electronystagmography (VENG). Both tests were performed by blinded assessors.

After completing all the screening tests, the patients were evaluated for UVH, starting first with the SST. In this test, the subject is asked to stand with their feet together and their hands by their sides. The subject is then asked to close his/her eyes or is blindfolded. The test is positive if there is involuntary leaning to one side and hip sway. Sometimes, the subject lifts a hand to compensate. In that case, the subject is asked to take two steps sideways and stop, first with the eyes open and then with the eyes closed or blindfolded. The test was positive if there is any involuntary swaying and/or any steps taken to compensate. The suject is then asked to jog on the spot for 30 seconds with the eyes closed or blindfolded. There should be no deviation. The test is positive if there is any involuntary drifting to one side or, in some cases, forward or backward. A positive test should be repeatable on subsequent occasions[8].

After finishing the SST, the subject is then evaluated with the HSN test using VENG, which is the gold standard test used to determine whether a vestibular (inner ear) disease may be the causative factor for a balance or dizziness problem and is one of the only tests available today that can distinguish between a unilateral (one ear) and bilateral (both ears) vestibular dysfunction. VENG testing consists of a series of tests designed to document a person's ability to follow visual objects with their eyes and how well the eyes respond to information from the vestibular system. To monitor the movements of the eyes, infrared goggles are placed around the eyes to record eye movements during testing. However, during VENG testing, the therapist moves the patient's head and body into various positions to make sure that there are no inappropriate eye movements (nystagmus), when the patient's head is in different positions. HSN is a latent spontaneous vestibular nystagmus that can be recorded with VENG. During the test for HSN, the examiner turns the subject's head by about 45 degrees horizontally about 20 times. HSN is defined as the occurrence of at least 5 beats of nystagmus immediately after the head-shaking maneuver, which should be performed with Frenzel VENG goggles. There is good evidence that HSN reflects a dynamic (peripheral and/or central vestibular) asymmetry of the velocity storage mechanism. In peripheral lesions, the ipsilateral dynamic VOR deficits can lead to an asymmetric accumulation within the velocity storage, the discharge of which determines the direction of HSN, usually toward the unaffected ear[9]. The results of both tests were then compared with each other; the results should be the same in both tests. Differences would decrease the efficiency of the SST.

RESULTS

Data were analyzed using SPSS for Windows version 19.0 (SPSS, Inc., Chicago, IL, USA). Frequencies and relative frequencies were computed for nominal variables, and means and standard deviations (SD) were computed for the continuous variables. The χ^2 test of independence was used to assess the relationship between the SST and the gold standard HSN test using VENG. The level of statistical significance was set at $p < 0.05$. Sensitivity, specificity, positive predictive value and negative predictive value also were measured.

The baseline frequency characteristics of the study group are presented in Table 1. The results showed that the SST is strongly correlated with the gold standard HSN test using VENG (r =0.81, p<0.001). A stepwise linear regression was conducted to determine the effect of the SST on the gold standard (HSN test using VENG) results ($R^2 = 0.65$, $p < 0.001$). Sixty-five percent of the variability in the

Table 3. Summary of sensitivity, specificity, PPV, and NPV results

	Patients with UVH by the HSN test using VENG		
	Condition positive	Condition negative	
Outcome positive	True positive (TP) = 13	False positive (FP) = 3	Positive predictive value 81%
Outcome negative	False negative (FN) = 0	True negative (TN) = 12	Negative predictive value 100%
	Sensitivity 100%	Specificity 80%	

gold standard test result was explained by its relationship to the SST. The data used to measure the sensitivity and specificity in this study are presented in Tables 2 and 3, and the results show that SST has very high sensitivity (100%) and high specificity (80%).

DISCUSSION

The primary purpose of the current study was to examine whether the SST could be used to identify patients with UVH as an alternate method to the HSN test using VENG. Even though there are many tests in practice for detecting vestibular hypofunction, all of them are used to diagnose a bilateral vestibular hypofunction rather than UVH. As far as we know, this is the first paper published based on the use of SST, which is reliable, easy to apply, and cost effective, instead of the HSN test using VENG to diagnose a patient with UVH.

UVH is currently diagnosed using VENG, but some studies have shown that there is another test that can be used for diagnosing UVH, namely, the SST. In 1959, Fukuda proposed a variation of the Tretversuch test of *Unterberger* (1938) and the waltzing test of *Hirsch* (1940) named the stepping test; that test is intended to identify the weaker of the labyrinths (not necessarily the side with the lesion) by direction of rotation of a patient while walking on the spot with the eyes closed[10]. Actually, some researchers have suggested use of the SST in combination with other clinical tests (e.g., electronystagmography, rotational chair, head thrust, and head shaking tests) in the assessment of vestibular pathologies rather than using it in isolation[11, 12]. Therefore, the purpose of this study was to investigate whether the SST can be considered both a sensitive and specific test for detection of UVH.

Based on our study results, we found a strong positive relationship between the SST and the HSN test using VENG (65%), which indicates that the SST is an efficient test in the diagnosis of UVH. Also, we found that the SST is both sensitive (able to pick up the presence of any UVH in a person who has it) and specific (able to pick up the absence of any UVH in a person who does not have it). So, it can be used to include or exclude the dysfunction, but the results were better when it was used for inclusion. When using the HSN test using VENG as the standard reference, our results showed adequate sensitivity and specificity to support the use of SST as a screening test for unilateral vestibular hypofunction.

A prospective study by Zhang et al. concluded that the FST was unreliable in identifying the lesion side in acute vestibular dysfunction[12]. Even though some other studies also reported the same results and conclusions[13, 14], our study we found that the SST is a reliable and valid tool for detection of UVH. The possible reasons for higher SST sensitivity and specificity in our study than in other studies is the difference in the studied populations, with more subjects with UVH in our sample, and the previous studies not being compared with any objective standard method of testing.

The limitations of the present study were as follows. First, the number of subjects with UVH in the study was limited. Second, there was great difficulty accessing patients and VENG equipment, as there are very few otolaryngology (ENT) departments that are specialized in our area. Third, we were unable to take pictures of the subjects for personal privacy reasons. Therefore, we recommend that future research should be performed with a larger number of subjects, should be experimental rather than an observational, and should measure the sensitivity and specificity of the SST with regard to its ability to diagnose the side of the dysfunction.

In conclusion, the study results showed that the SST is useful as an objective measure in the evaluation of UVH in parallel with the HSN test using VENG. So the SST can be used as an alternative to the HSN test using VENG for detection of UVH.

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