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Research article

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Sensitivity and specificity of the modified tandem walking test for vestibular hypofunction with chronic dizziness in young adults

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The study protocol was approved by the Ethics Committee of Marmara University Faculty of Medicine with the protocol number 092020633. All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

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Abstract

Background/Aim: Patient comfort is greatly affected during videonystagmography (VNG), and more comfortable tests are needed for diagnosis. This study aims to evaluate the modified tandem walking test (MTWT) as an alternative pre-assessment method to the VNG test.
Methods: A total of 3348 patients were recruited in this retrospective cohort study between 2015-2019 based on the inclusion criteria of having chronic dizziness (>3 months), being aged between 18-65 years, and having an interpretable VNG test result. All patients were examined by an otolaryngologist, and the examination phase consisted of three parts: Physical examination, VNG test, and performing MTWT. The sensitivity, specificity, and likelihood ratio of the MTWT were calculated with the relevant formulas.
Results: The female/male ratio was 2.19, and there was no significant difference between the groups in terms of age (P=0.334). The number of patients who were VNG positive (regardless of MTWT), both VNG and MTWT positive, both VNG and MTWT negative, and VNG negative (regardless of MTWT) were 2519, 2000, 699, and 2519, respectively. The sensitivity and specificity of MTWT were 79.37%, and 84.31%, respectively.
Conclusion: MTWT has good sensitivity and specificity, and we think that it can be a safe, simple, and accessible pre-diagnostic tool when VNG is not available or cannot be tolerated by the patients.

Keywords: Vestibular hypofunction, Videonystagmography, Modified tandem walking test

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Introduction

Vestibular hypofunction patients have impaired dizziness, postural control, and instability [1]. Balance assessment is a major component of pre-diagnosis, because balance loss stems from vestibular system pathologies. Different tests can be used for balance assessment [2], and tandem walking (TW) is one of the most common. It is frequently used to evaluate balance disorders due to vestibular diseases; however, its sensitivity for vestibular diseases is poor [3, 4]. Therefore, the sensitivity and specificity of the modified version of the TW should be evaluated.

The ability of finding balance depends on inputs from the somatosensorial, visual, and vestibular systems [5], and functional vestibulospinal reflexes are required to maintain an upright position [6]. The MTWT allows the evaluation of balance problems in chronic dizziness using these reflexes.

Chronic dizziness is the most common symptom in vestibular problems such as vestibular hypofunction [7]. Many differential assessment methods are used to find the source of dizziness. VNG testing is the most important of these differential diagnostic tools and the gold standard for diagnosing and screening vestibular diseases [8, 9].

VNG is based on the functional examination of vestibulo-ocular reflex pathways by recording eye movements created by visual or caloric stimuli [10]. The caloric test is the fundamental part of VNG as a 'reference standard' in deciding vestibular hypofunction [11]. During this test, warm and cold water or air is delivered into the ear by the examiner. Although the bithermal caloric test provides detailed and quantitative data from patients with dizziness and balance problems by examining the function of the vestibular system, the test involves some physiological difficulty [12]. About 44% of people suffer from fatigue, 31% have nausea, and 33% have headaches during the test [13], which may exceed the tolerance limits of patients, rendering them unable to complete the test [14]. Also, bithermal caloric test is costly, time-consuming, and needs qualified staff. Therefore, we need simpler, accessible, and comfortable diagnostic tests.

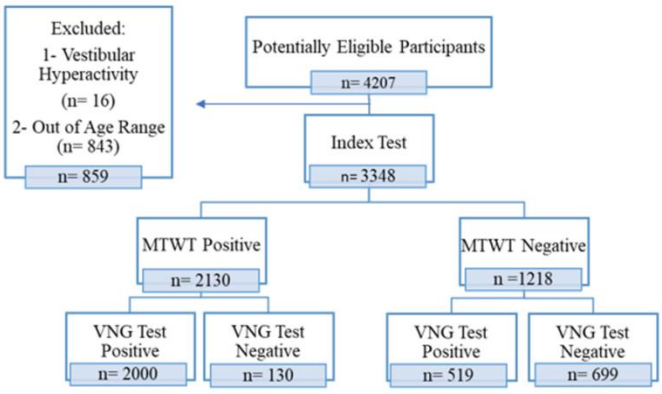
It is not known whether this test can be used instead of the VNG. Our hypothesis is that the MTWT can be used as an alternative pre-diagnostic assessment method in patients with vestibular hypofunction who have chronic dizziness.

Materials and methods

The study protocol was approved by the Ethics Committee of Marmara University Faculty of Medicine with the protocol number 092020633. The data in the patient files were evaluated retrospectively. Potentially eligible participants were taken to tests following self-reported complaints. The entire evaluation process was conducted by the same clinic and healthcare team between 2015-2019. Following the clinical history, all patients were taken to the VNG Caloric test and MTWT by the specialist. All patients were alert, cooperative, and able to follow commands during the assessment.

Inclusion criteria were (1) having chronic dizziness (>3 months), (2) being aged 18-65 years, (3) having an interpretable VNG test result. The individuals who (1) were diagnosed with benign paroxysmal positional vertigo or Meniere disease, (2) had an unclear psychological pathology or illness in the central nervous system, (3) were unable to stand independently, (4) had a visual impairment that can't be corrected with lens or glass, (5) had used medication for dizziness, (6) had a vestibular hyperactivity disorder, (7) had a history of orthopedic injury/surgery, (8) had missing data were excluded. This article adheres to STROBE criteria and the flow diagram is presented in Figure 1.

Figure 1: The flow diagram of the study



Videonystagmography Test: VNG - is the gold standard evaluation method for vestibular disorders. Bithermal caloric test is the most used form of the VNG test. It is the hardest as a technique, but most informative for diagnosis. The bithermal caloric test was conducted using the ICS Chart 200 VNG/ENG (otometrics) device. During the caloric test, patients laid in the supine position, and at 30° flexion to bring the horizontal semicircular canal to the vertical plane. The test was applied to both ears 5 minutes apart. The outer ear canal tympanic membrane was irrigated with 24°C air and 50°C air for 60 seconds, and 8 liters of air were consumed during the irrigation process. The highest value of the slow phase nystagmus velocity was calculated automatically with the Jongkees formula [15]. Channel paresis was accepted if the result was above 25%. The sum of the slow phase velocities formed with the cold and warm stimuli was less than 12 degrees/sec for complete paresis.

Modified Tandem Walking Test: Modification of tandem walking is challenging enough for the vestibular system simulation and testing. Every patient was shown the correct performance of the MTWT before they attempted it. Failures of MTWT included taking a sidestep or being unable to walk heel-to-toe with eyes closed. These failures were noted as a gross abnormality during MTWT. When the patient took a side-step, he/she started the next trial from scratch.

At the beginning of each trial, the patient stood in the Romberg test position with the feet together. The tandem walking test was modified by placing each palm on the opposite shoulder, and the elbows were kept parallel to the ground. Every patient was asked to walk on a straight line for ten steps forward, touching his/her heel of the front foot to his/her toe of the back foot with each step (heel-to-toe), wearing shoes, with arms folded across the chest and kept parallel to the ground, palms placed on the opposite shoulders. The trial involved performing the test once with eyes open, and thrice afterwards with the eyes closed. The test was considered negative when the patient opened his eyes or took a sidestep during the test. At least two

people were available near the patient during the test to provide manual assistance for safety when necessary [16].

Statistical analysis

Descriptive statistics were used for demographic variables with Statistical Package for the Social Sciences (SPSS v11.5). A 2x2 table was created to reflect the number of "MTWT positive", "MTWT negative", "VNG Test positive" and "VNG Test negative" patients. Methods for estimating measures of diagnostic accuracy were sensitivity, specificity, and likelihood ratio of MTWT.

Results

Among 4207 patients, the data of 3348 patients met the study criteria. Only young adults' data (18-65 years) were included to eliminate age-related loss of balance. Therefore, there is no drop-out data. However, patients with missing data were excluded from the study. Among females and males, 68.36% and 31.64% had positive VNG test results. The females were similar in terms of age (P=0.564) but the males significantly differed (P=0.009).

While 2098 patients had a unilateral weakness, 421 patients had a bilateral weakness according to VNG test results. The distribution of the gender-based age and classifications of vestibular hypofunction is shown in Table 1.

The sensitivity and specificity of the MTWT were 79.39%, and 84.31%, respectively. The positive likelihood ratio was 5.05, which indicates that despite every 5.05 persons are correctly diagnosed, one person is misdiagnosed. All results are presented in Table 2.

Table 1: Characteristics of Patients

Parameter		VNG Test (+) n	%	Mean (SD)	VNG Test (-) n	%	Mean (SD)	*P*-value*
Age	Female	1722	68.36	44.66 (12.41)	577	69.60	45.00 (11.81)	0.564
	Male	797	31.64	43.79 (11.85)	252	30.40	41.42 (12.63)	0.009
	P-value**	-		0.100	-		0.001	-
	Total	2519	100	44.38 (12.24)	829	100	43.91 (12.17)	0.334
Type of vestibular hypofunction	Left	1167	46.33	-	-	-	-	
	Right	931	36.96	-	-	-	-	
	Bilateral	421	16.71	-	-	-	-	
	Total	2519	100	-	-	-	-	

* Age differences of gender-based comparison between groups, ** Age differences of gender-based comparison in intra group analysis

Table 2: Coherence of sensitivity, specificity, and likelihood ratio of Modified Tandem Walk Test compared to VNG Test

	VNG Test (+)	VNG Test (-)	Total	Sensitivity (%)	Specificity (%)	Likelihood Ratio
MTWT (+)	2000 (a)	130 (b)	2130 (a+b)	79.39	84.31	5.05
MTWT (-)	519 (c)	699 (d)	1218 (c+d)			
Total	2519 (a+c)	829 (b+d)	2234 (a+b+c+d)			

MTWT: Modified tandem walking test, VNG Test: Videonystagmography Test, Sensitivity= (a/(a+c)), Specificity= (d/(b+d)), Likelihood Ratio= (sensitivity/(1-specificity))

Discussion

Dizziness is one of the most common symptoms that occur due to middle ear pathologies. The early detection of pathology in the vestibular system facilitates the rehabilitation process. For this reason, there is a need to develop usable, and accessible evaluation methods which help to keep patient comfortable. According to our results, the MTWT had good sensitivity and specificity, similar to those of the VNG test in patients with vestibular hypofunction.

A tandem walking test is frequently used by clinicians and usually performed with the eyes open. However, studies have reported that the test assesses balance better without visual feedback. The fact that the test can be performed in a short time and is suitable for pre-evaluation increases its clinical importance and allows the review of advanced examination options based on its results. Because the optimal cut-point is 2 steps, requirements are minimum for performing the test. On the other hand, evaluators must be careful because the strategies that individuals develop to maintain balance are different from each other. Therefore, its use as an alternative evaluation method will alleviate the burden of the clinicians.

The VNG test, which provides detailed and quantitative data by examining vestibular system function, has its own temporal and physiological difficulties [12, 17]. Most patients cannot complete the test due to symptoms such as dizziness, nausea, vomiting, and sweating [14]. Therefore, the development of more comfortable alternative diagnostic tests instead of the VNG test will facilitate patients' comfort and clinic conditions. The MTWT is a simple assessment test that can help identify an early diagnosis of vestibular disorder. In this study, we evaluated the sensitivity and specificity of the modified tandem walking test to support the VNG test results and help assist in making a preliminary diagnosis.

Based on our results, the MTWT is shorter, cheaper, comfortable, and easier to apply than the VNG test, with 79.39% sensitivity, 84.31% specificity, and 5.05% positive likelihood ratio. There are different rapid screening tests used in the clinic. A retrospective study reported a correlation between the head thrust test, and the dizziness disability inventory. In the same study, the VNG test was considered the reference for unilateral vestibular hypofunction patients, and the sensitivity, and specificity of the head thrust tests were 31%, and 96%, respectively. The head thrust test has enough sensitivity to be used as an uncompensated vestibulopathy screening [18]. A different study reported that tandem walking test, walking with head turns and functional mobility tests were unable to detect vestibular problems [19].

Another easy-to-apply screening test is the head-shaking test. In one study, patients with unilateral hypofunction and benign paroxysmal positional vertigo (BPPV) had lower head-shaking test results than healthy individuals. When the completion duration of the functional mobility test in subjects diagnosed with unilateral vestibular hypofunction was evaluated, it was observed that they took longer steps than healthy individuals. Besides, the number of eyes-closed steps of individuals in the same disease group was evaluated by the tandem walking test, and it was found that these patients took fewer steps than healthy people. However, the sensitivity of the tandem test with eyes open was very low, at 14%. When the same test was repeated with the eyes closed, its sensitivity was relatively higher at 23%. According to the ROC analysis results of the tandem test, if the person can take five or more steps in the open eye test, the sensitivity of the test is 14%, and the specificity is 99%. Likewise, when the test was performed with the eyes closed if the person can only take two or fewer steps, the

sensitivity was 23%, and the specificity was 92%. It is suggested that clinicians can use the tandem walking test only to assist other tests, not for a diagnosis. Also, some state that this test would be more suitable for use in the performance evaluation of previously diagnosed patients [19]. Another study investigated the usability of tandem walking as a rapid screening test for vestibular diseases. Ninety patients diagnosed with vestibular dysfunction and 292 healthy individuals were included in the study. The tandem walking test had 77% sensitivity and 72% specificity in patients diagnosed with a vestibular dysfunction under 50 years of age [3].

The BPPV patients had impaired performance on tests of standing balance and subjective visual vertical [20–22]. This impairment is caused by the effects of vestibular nucleus signal changes on loading of the posterior semicircular canal and unloading of the utricles. Step counts in tandem test are useful in detecting changes in dynamic postural stability [23]. The test is useful for examining motor performance, treatment effectiveness, time-dependent changes, and primary care physicians for assessing the influence of rehabilitation interventions.

Clinical challenges in VNG testing practice encourage the research and development of alternative assessment methods. We used the test for this purpose and found that it had a higher level of sensitivity and specificity than other field tests used to evaluate individuals with vestibular hypofunction. Because this test is useful, easy to apply, less time-consuming than the VNG test, and has sufficient specificity and sensitivity, we think that it can be appropriate for preliminary diagnosis.

Limitations

We presented real-time clinical data. While collecting these data, the primary aim was to determine whether the treatment outcome of our patients was positive. Therefore, MTWT results were reported as positive/negative, and the number of steps was ignored. Since our sample size was large and the results had significant sensitivity and specificity, it was deemed appropriate to share the data. Determining the cut-off value by recording the number of steps will contribute to the widespread clinical use of the test in future studies.

Conclusion

Our results suggest that MTWT can be used for preliminary diagnosis in clinical conditions where there is no VNG test. It can be widely used in clinics due to its ease of practice, accessibility, and simple nature; therefore, the evaluator can perform the test without the need for more instruction. It can provide fast, low-cost, and reliable results. However, the cut-off values need to be determined for patients with vestibular hypofunction and should be used as reference values in order to share the results of treatment efficacy in future studies.

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